YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

MODELS

4JHE
4JH-TE
4JH-HTE
4JH-DTE

FOREWORD

This service manual has been compiled for engineers engaged in sales, service, inspection and maintenance. Accordingly, descriptions of the construction and functions of the engine are emphasized in this manual while items which should already be common knowledge are omitted.

One characteristic of a marine diesel engine is that its performance in a vessel is governed by its applicability to the vessel's hull construction and its steering system.

Engine installation, fitting out and propeller selection have a substantial effect on the performance of the engine and the vessel. Moreover, when the engine runs unevenly or when trouble occurs, it is essential to check a wide range of operating conditions—such as installation on the hull and suitability of the ship's piping and propeller—and not just the engine itself. To get maximum performance from this engine, you should completely understand its functions, construction and capabilities, as well as proper use and servicing.

Use this manual as a handy reference in daily inspection and maintenance, and as a text for engineering guidance.

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Models 4JH(B)E • 4JH-T(B)E
4JH-HT(B)E • 4JH-DT(B)E

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CHAPTER 1

GENERAL

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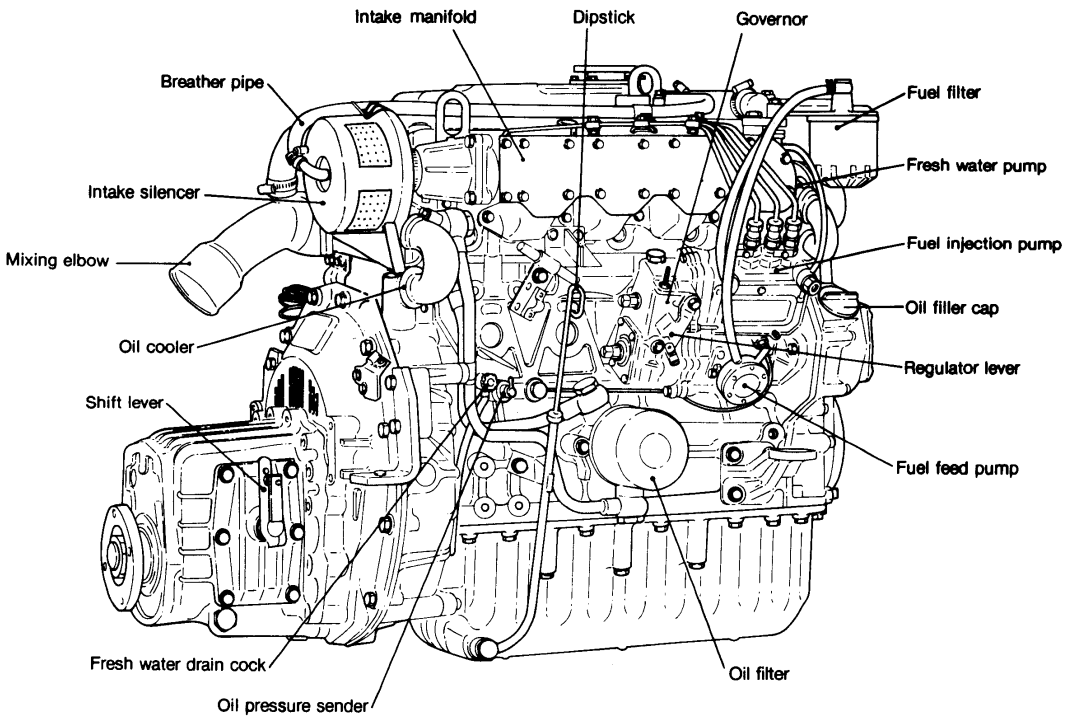
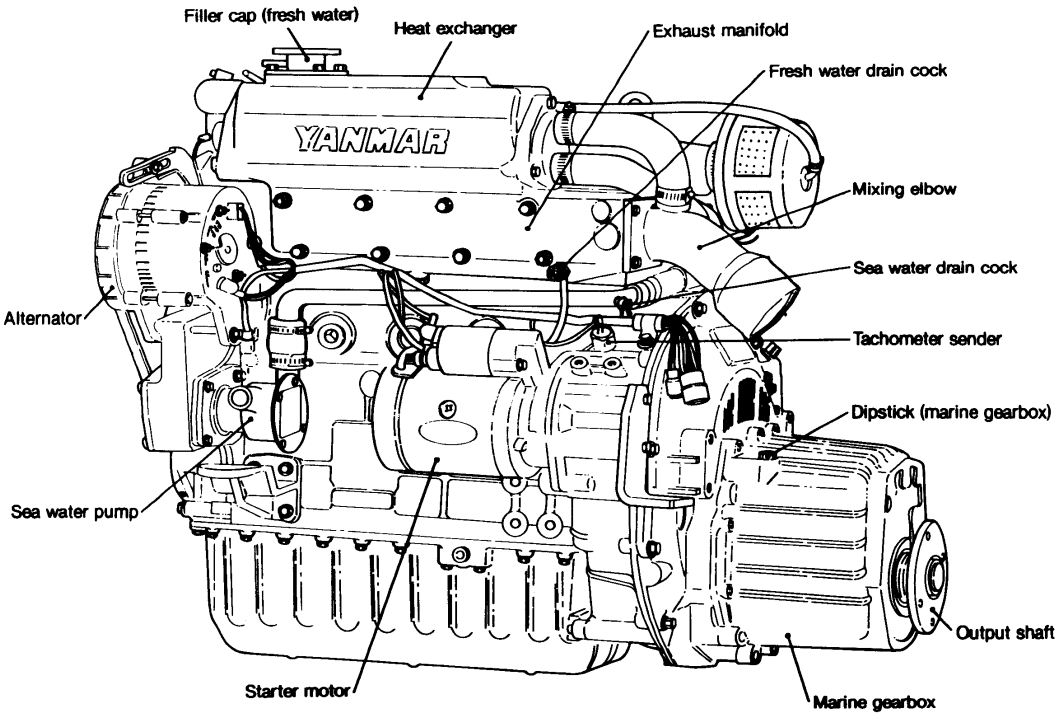
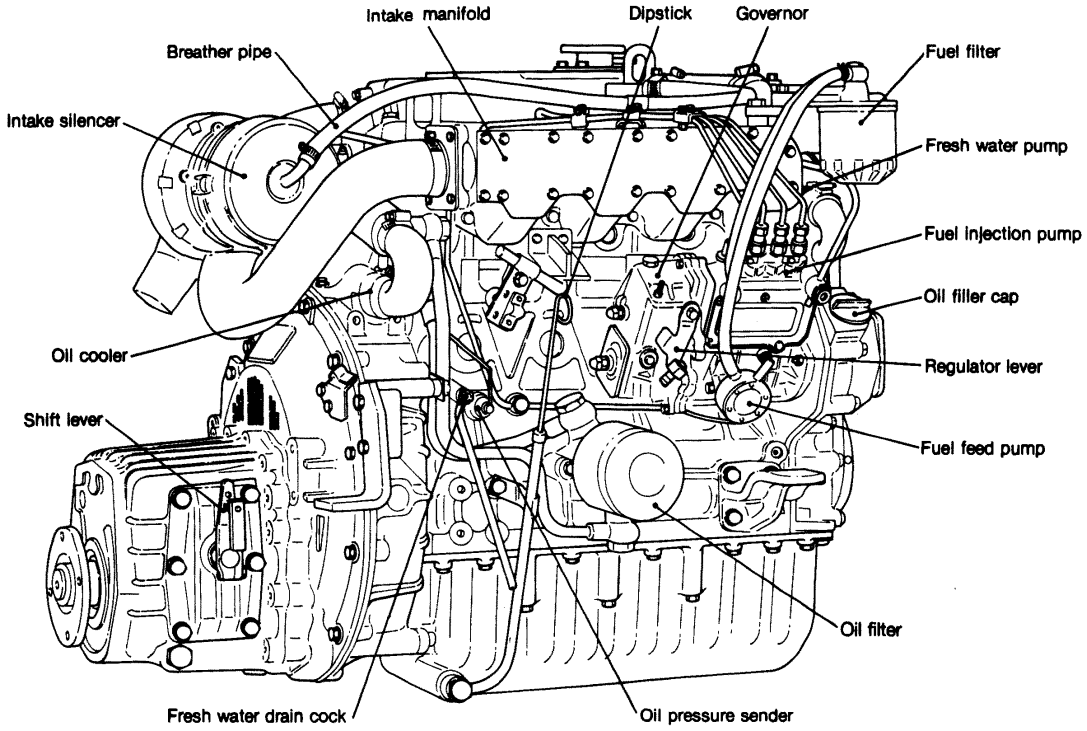
1. Exterior Views

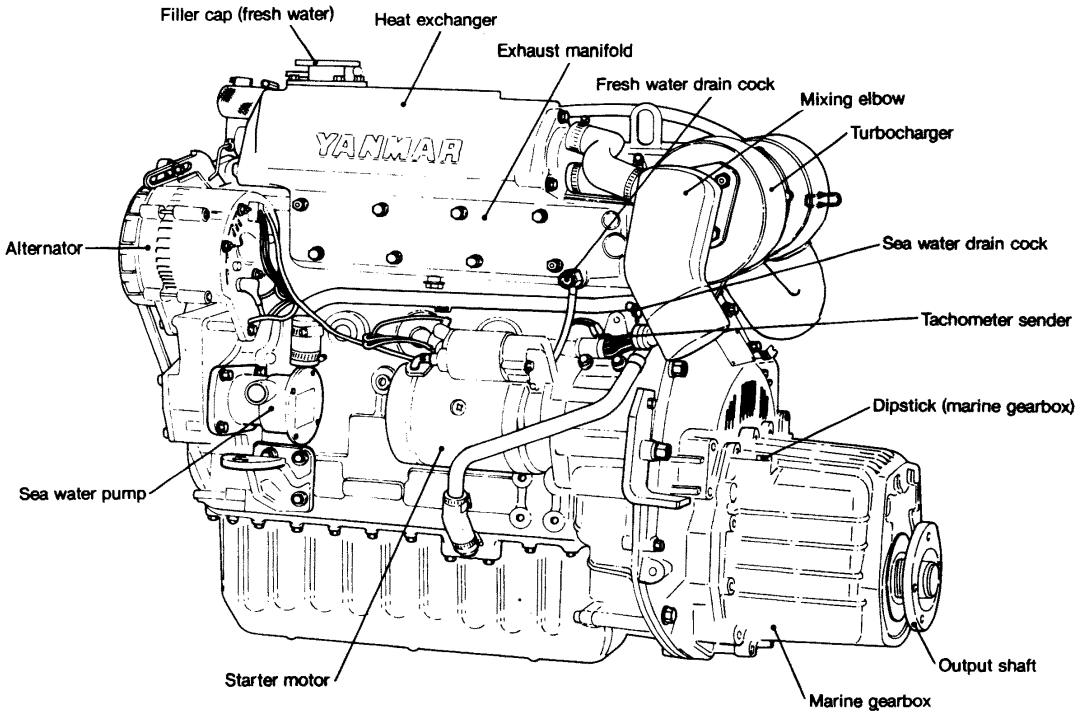
1-1 4JHE





1-2 4JH-TE





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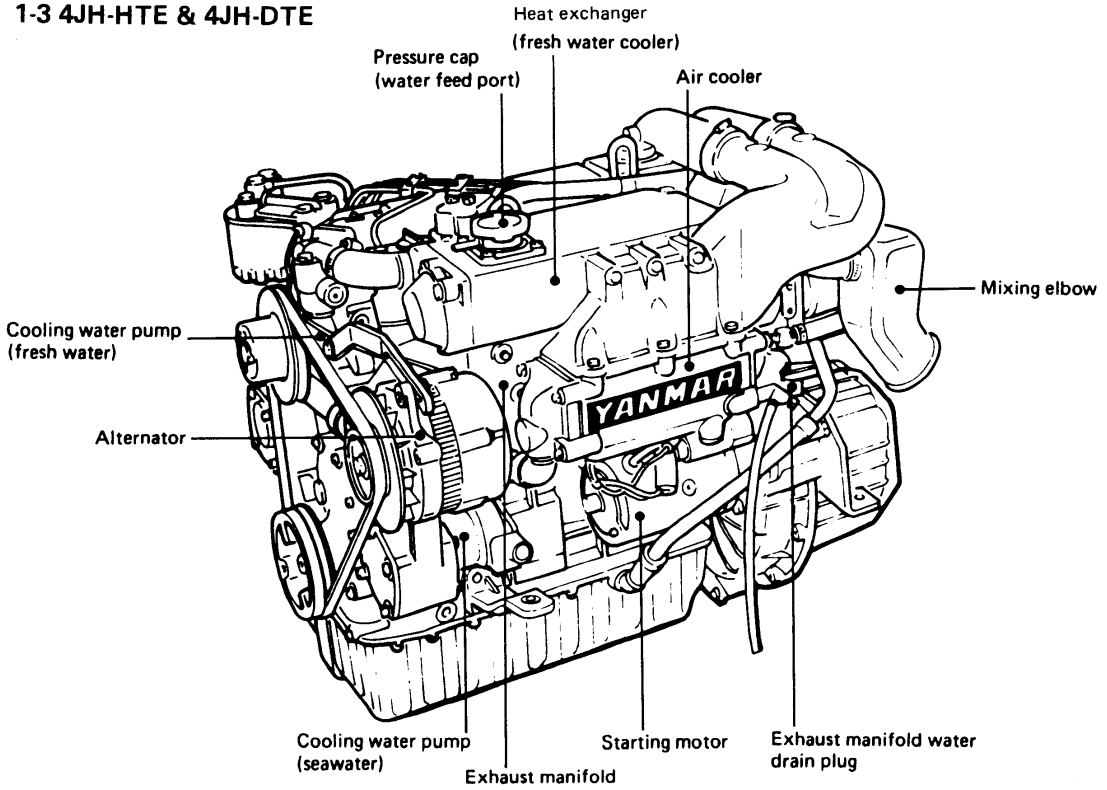
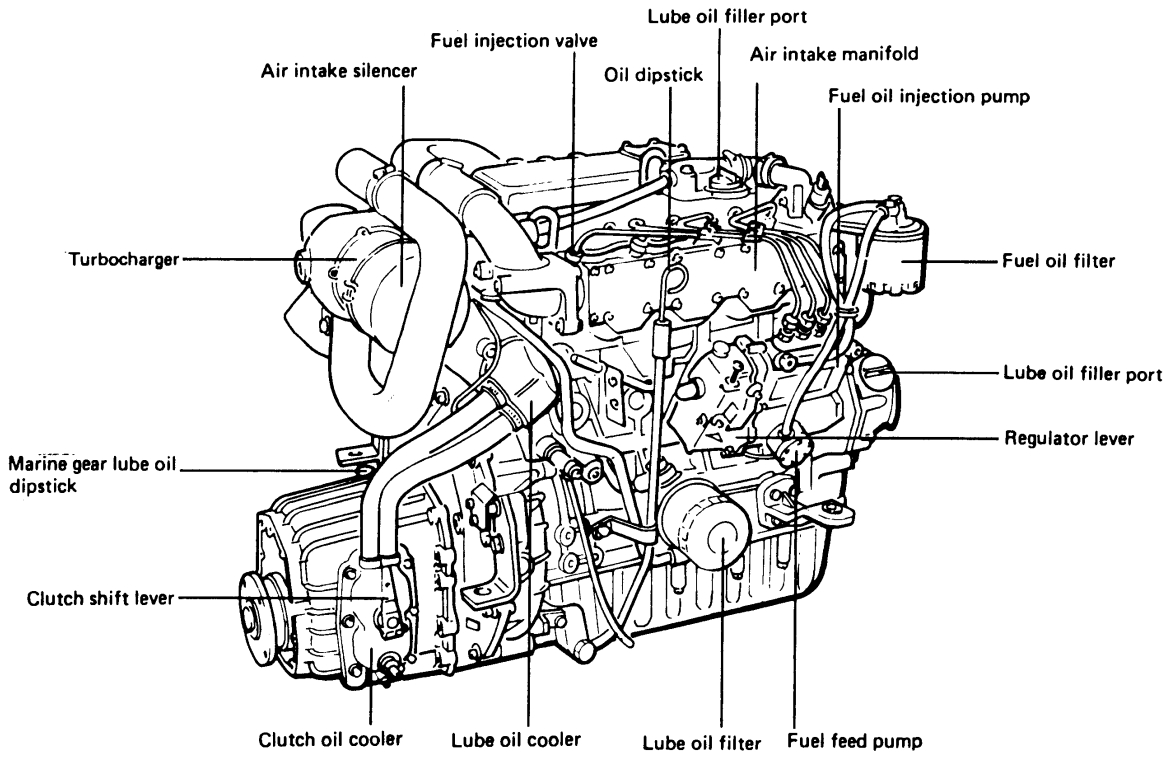
1-3 4JH-HTE & 4JH-DTE





2. Specifications

Model			4JHE	4JH-TE	4JH-HTE	4JH-DTE
Type			Vertical 4-cycle water cooled diesel engine			
Combustion system			Direct injection			
Aspiration			Normal aspiration	Exhaust gas turbine turbocharger	Exhaust gas turbine turbocharger with intercooler	
Number of cylinders			4			
Bore x stroke		mm (in.)	78 x 86 (3.07 x 3.39)			
Displacement		ℓ (cu.in.)	1.644 (100.33)			
One hour rating output (DIN6270B)	Output/crankshaft speed	HP/rpm (kW/rpm)	44/3600 (32.4/3600)	55/3600 (40.5/3600)	66/3600 (48.6/3600)	77/3600 (56.7/3600)
	Brake mean effective pressure	Kg/cm^2 ($lb./in.^2$)	6.69 (95.15)	8.36 (118.91)	10.0 (142.20)	11.7 (166.37)
	Piston speed	m/sec. (ft./sec.)	10.3 (33.79)	10.3 (33.79)	10.3 (33.79)	10.3 (33.79)
Continuous rating output (DIN6270A)	Output/crankshaft speed	HP/rpm (kW/rpm)	40/3500 (29.5/3500)	50/3500 (36.8/3500)	60/3500 (44.2/3500)	70/3500 (51.5/3500)
	Brake mean effective pressure	kg/cm^2 ($lb./in.^2$)	6.26 (89.04)	7.82 (111.23)	9.39 (133.53)	11.0 (156.42)
	Piston speed	m/sec. (ft./sec)	10.0 (32.81)	10.0 (32.81)	10.0 (32.81)	10.0 (32.81)
Compression ratio			17.8	16.2	15.9	15.9
Fire order			1 — 3 — 4 — 2 — 1 (180° each)			
Fuel injection pump			Bosch in-line type YPES-CL			
Fuel injection timing (FID)		degree	12° ±1° (*9° ±1°) bTDC	12° ±1° bTDC	12° ±1° bTDC	12° ±1° bTDC
Fuel injection pressure		kg/cm^2 ($lb./in.^2$)	200 ±5 (2844 ±71)			
Fuel injection nozzles			Hole type			
Direction of rotation	Crankshaft		Counter-clockwise viewed from starn			
	Propeller shaft (Forward)		Clockwise viewed from starn			
Power take off			At flywheel side			
Cooling system			Constant high temperature fresh water cooling Fresh water: Centrifugal pump Sea water: Rubber impeller pump			
Lubrication system			Forced lubrication with trochoid pump			
Starting system	Starting motor		DC 12V, 1.8kW			
	AC generator		12V, 55A			
Turbocharger	Type			RHB52 (IHI)	RHB52HW (IHI)	
	Model			MY29	MY31	MY34
	Cooling system			Air cooling	Water cooling	
Air cooler system	Type				Sea-water cooled, Plate fin type	Sea-water cooled, Corrugated fin type
	Radiation area	m^2 ($in.^2$)			0.76 (1178)	0.67 (1038)
Clutch	Model		KBW20		KBW21	KBW21
	Type		Constant mesh gear with multiple friction disc clutch			
	Reduction ratio (Forward/Reverse)		2.17/3.06, 2.62/3.06, 3.28/3.06			2.17/3.06, 2.62/3.06
	Propeller speed DIN6270A rating (Forward/Reverse)		1615/1145, 1336/1145, 1068/1145			1615/1145, 1336/1145
	Lubricating oil capacity Effect/max	ℓ (cu.in.)	0.15/1.2 (9.15/73.22)			
	Clutch weight	kg (lb.)	26 (57.33)		30 (66.15)	30 (66.15)
Dimensions	Overall length	mm (in.)	906.3 (35.68)		906.3 (35.68)	906.3 (35.68)
	Overall width	mm (in)	561 (22.09)		561 (22.09)	561 (22.09)
	Overall height	mm (in.)	659 (25.94)		668 (26.30)	668 (26.30)
Engine weight with clutch (dry)		kg (lb.)	226 (498)	232 (511)	246 (542)	246 (542)
Lubricating oil capacity Effect/max.		ℓ (cu.in.)	3.0/6.5 (183.06/396.63)			
Cooling water capacity (Fresh water)	Fresh water tank	ℓ (cu.in.)	6.0 (366.12)			
	Sub tank	ℓ (cu.in.)	0.8 (48.82)			

Note: *Applicable engine number #/E 00101 ~ 00574

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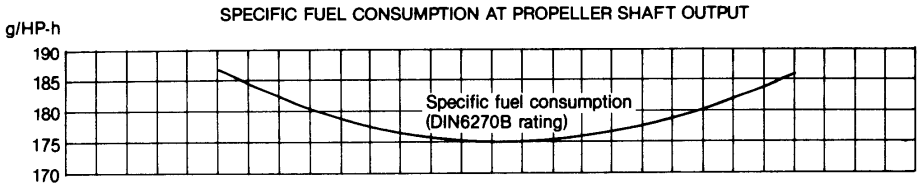
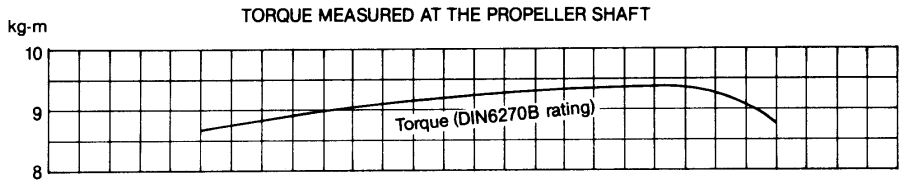
3. Construction

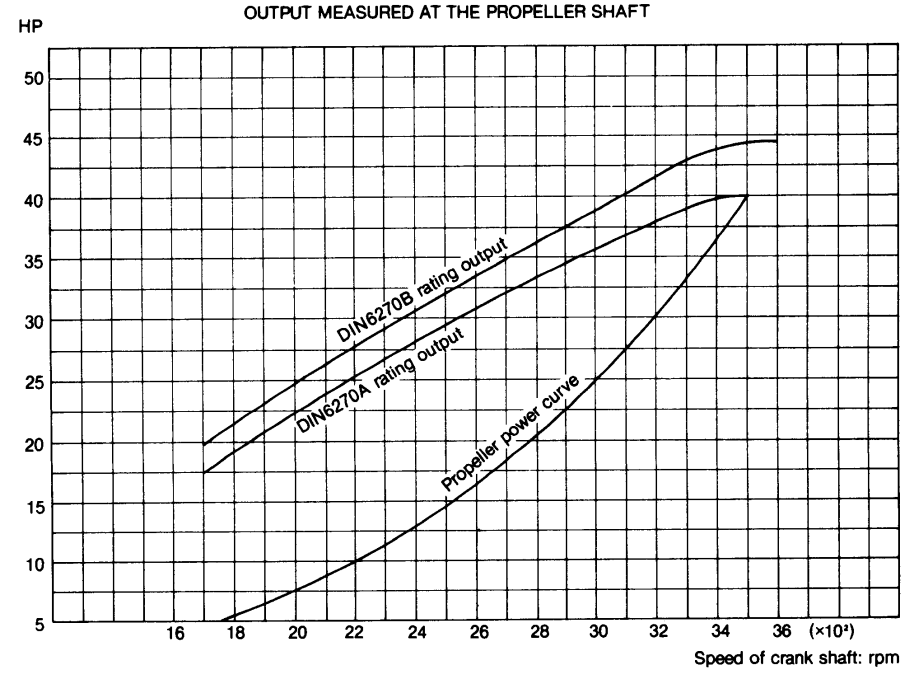
ENGINE MODEL		4JH	4JH-TE	4JH-HTE	4JH-DTE
Group	Part	Construction			
Engine Proper	Cylinder block	Integrally-cast water jacket and crankcase			
	Cylinder liner	Dry sleeve			
	Timing gear case	Cast aluminum			
	Oil sump	Cast aluminum, oil pan			
	Main bearings	Hanger-type bearings supports			
	Engine feet	Cylinder block and Flywheel mounting side			
Intake/Exhaust, Valve Drive	Cylinder head	Integrally-cast type, jet cooling between valves, Intake/exhaust valve seat inserts			
	Intake/exhaust valves	Mushroom shaped, seat angle: Intake: 120° Exhaust: 90°			
	Intake manifold	Aluminum diecast integral			
	Exhaust manifold	Water cooled integral with water tank			
	Air cooler			Plate fin type	Corrugated fin type
	Turbocharger	–	IHI RHB52 exhaust gas turbo	IHI RHB52HW exhaust gas turbo, Water cooled type.	
	Valve drive	Overhead valve push rod rocker arm system			
	Timing gear	Helical gear			
Main Moving Parts	Crankshaft	Stamped forging			
	Flywheel	Cast iron static balance with ring gear			
	Pistons	Cast aluminum, oval type			
	Piston rings	2 compression rings, 1 oil ring			
	Piston pin	Floating type			
	Connecting rod	Forged steel			
	Crank pin bushings	Aluminum bushings			
Lube Oil System	Lube oil pump	Trochoid type			
	Oil filter	Full flow paper element cartridge type			
	Oil cooler	Sea water cooled pipe type		Sea water cooled multi-pipe type	
	Control valve	Cylindrical type with external adjusting shims			
Cooling Water System	Fresh water pump	V-pulley driven, centrifugal type			
	Sea water pump	Gear driven, rubber impeller type			
	Thermostat	Wax pellet type			
	Fresh water cooler	Multi-tube type integral with exhaust manifold			
Bilge	Bilge pump	Electric			
Fuel Injection Equipment	Fuel injection pump	YANMAR YPES-CL type integral with governor			
	Fuel injection nozzles	Hole type			
	Fuel feed pump	Diaphragm type			
	Fuel filter	Paper element cartridge type			
Governor	Governor	Centrifugal all-speed mechanical type			
Remote Control Equipment	Engine speed & marine gearbox	Single control lever type with push-pull cable			
Starting Equipment	Electric starter	DC 12V, 1.8kW starter motor			
	Generator	12V, 55A with built-in IC regulator			
Marine Gearbox	Clutch	Multi-disc mechanical wet type			
	Reduction gear	Helical gear constant mesh type			

4. Performance Curves

4-1 4JHE







THE ENGINE FLYWHEEL OUTPUT IS APPROX. 3% HIGHER

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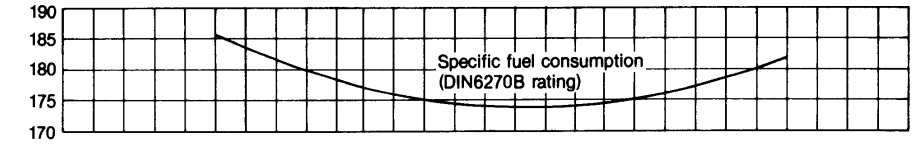
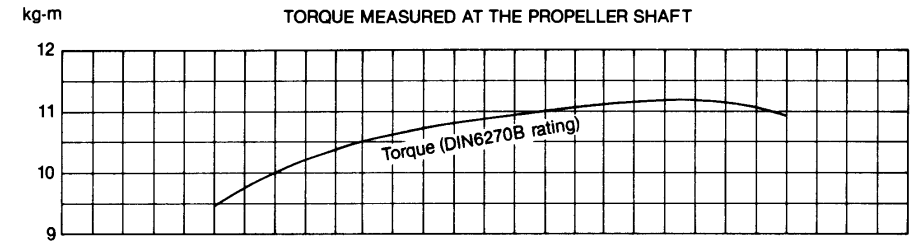
4-2 4JH·TE

SPECIFIC FUEL CONSUMPTION AT PROPELLER SHAFT OUTPUT



TORQUE MEASURED AT THE PROPELLER SHAFT



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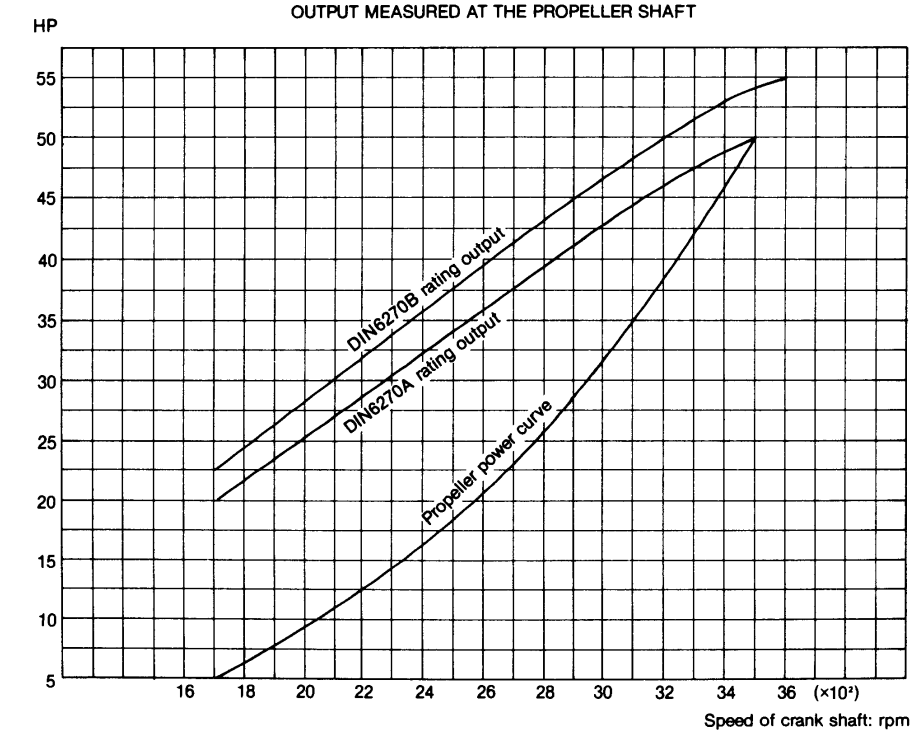
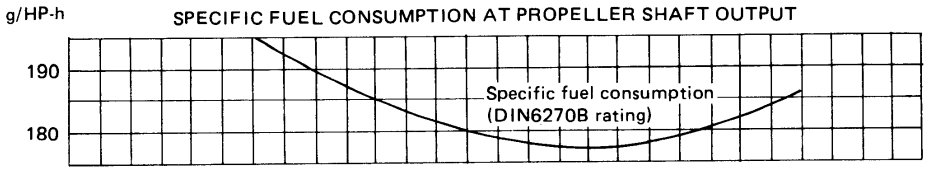
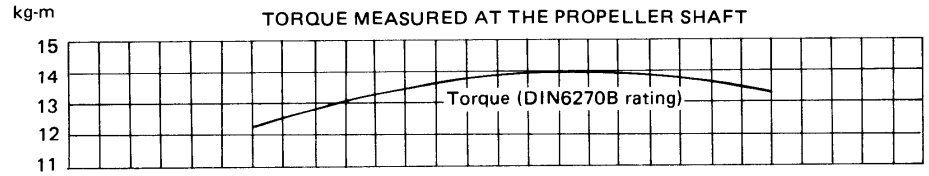
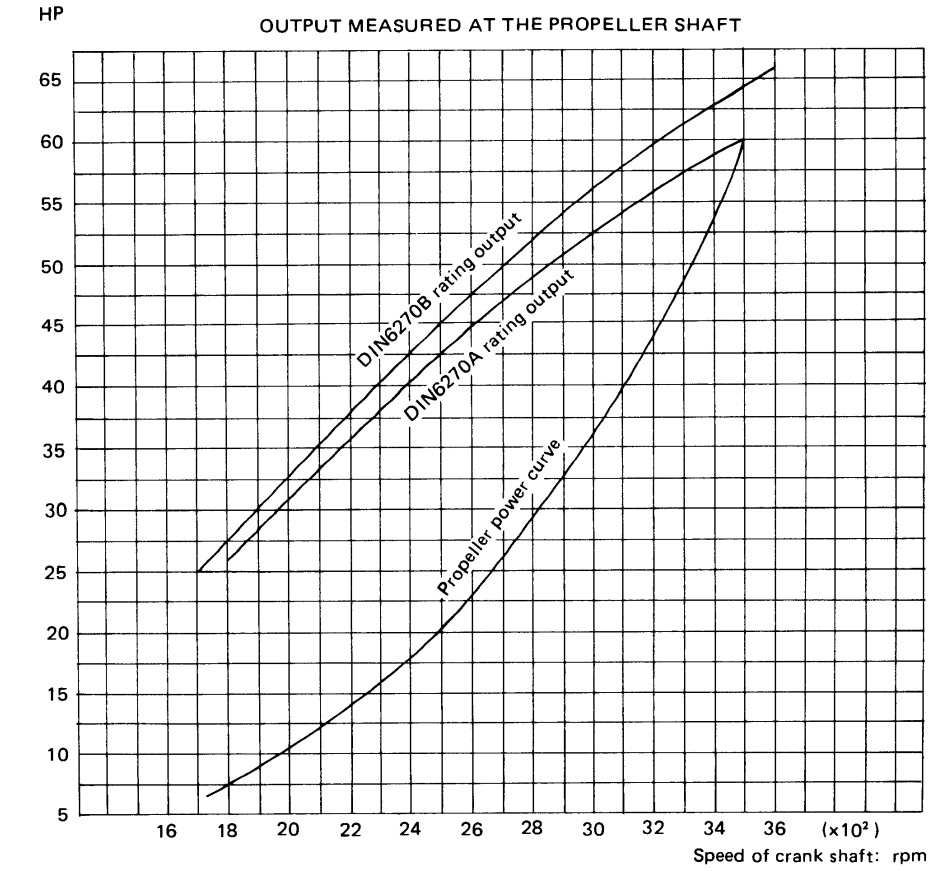


THE ENGINE FLYWHEEL OUTPUT IS APPROX. 3% HIGHER

4-3 4JH-HTE







THE ENGINE FLYWHEEL OUTPUT IS APPROX, 3% HIGHER.

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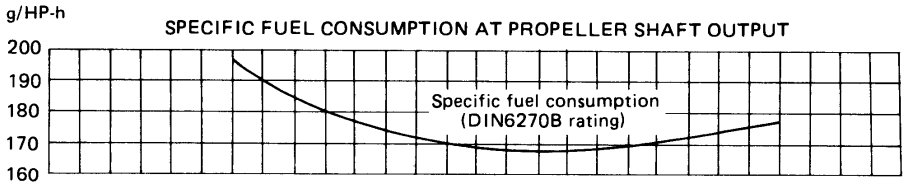
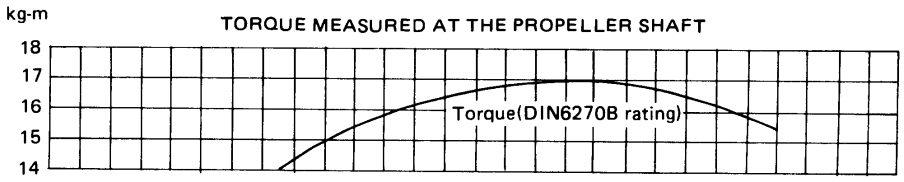
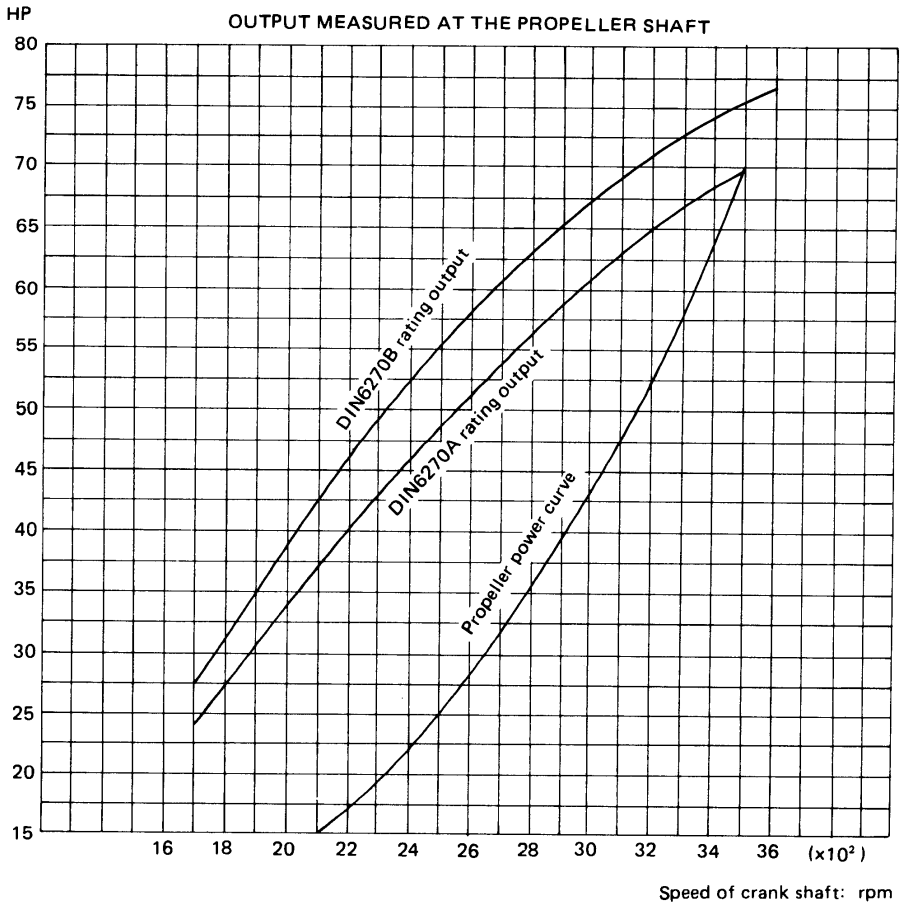
4-4 4JH-DTE

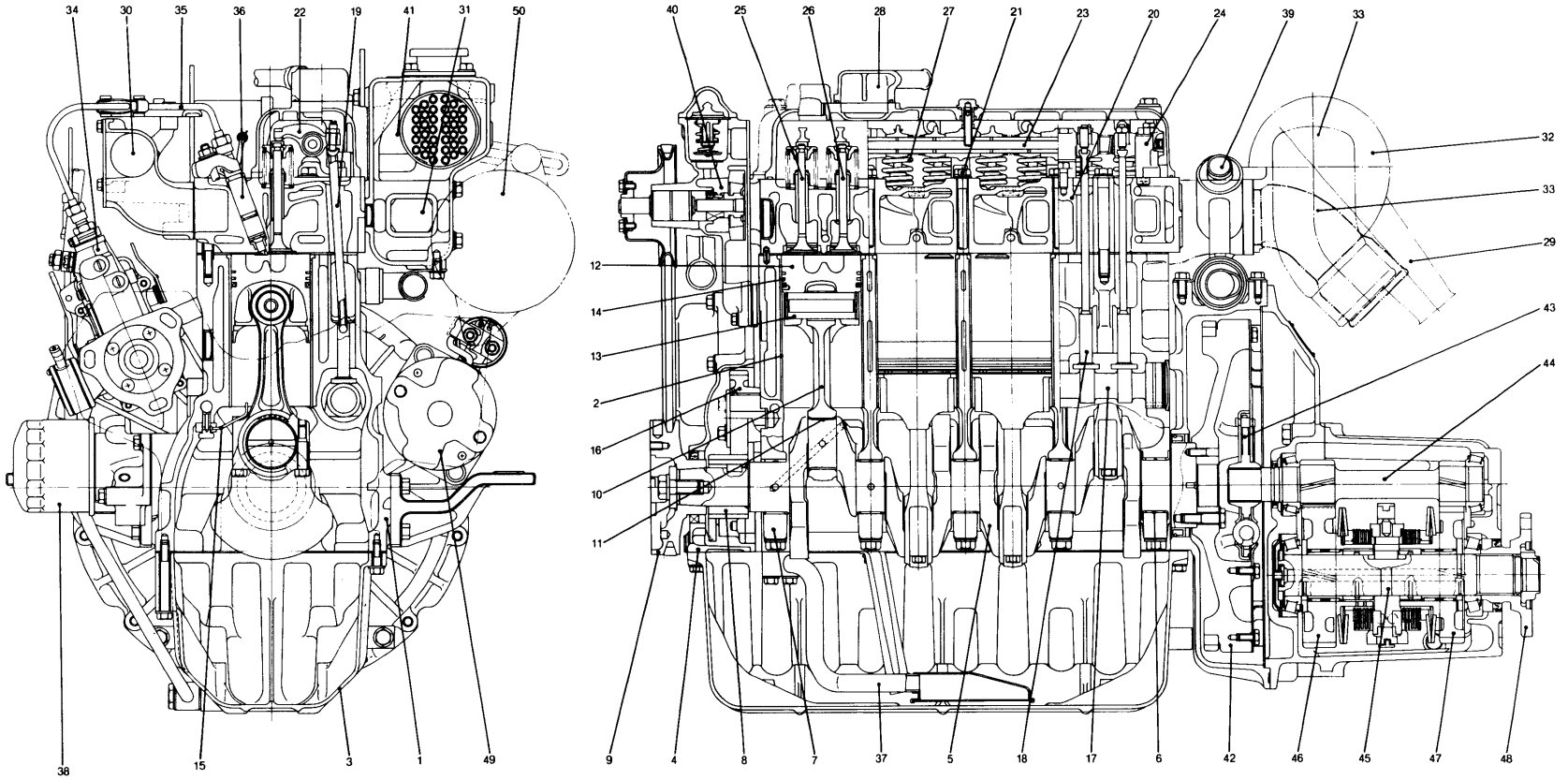






THE ENGINE FLYWHEEL OUTPUT IS APPROX, 3% HIGHER.

5. Engine Cross Section



1. Cylinder block
2. Cylinder liner
3. Oil pan
4. Timing gear case
5. Crankshaft
6. Main bearing bushing
7. Main bearing cap
8. Crank gear
9. Crankshaft V-pulley
10. Connecting rod
11. Crank pin bushing
12. Piston
13. Piston pin
14. Piston ring
15. Piston cooling nozzle
16. Idle gear
17. Camshaft
18. Tappet
19. Push rod
20. Cylinder head
21. Cylinder head bolt
22. Valve rocker arm
23. Valve rocker arm shaft
24. Valve rocker arm shaft support
25. Intake valve
26. Exhaust valve
27. Valve spring
28. Breather
29. Intake silencer
30. Intake manifold
31. Exhaust manifold
32. Turbocharger
33. Mixing elbow
34. Fuel injection pump
35. Fuel pressure pipe
36. Fuel injection nozzle
37. Lubricating oil inlet pipe
38. Lubricating oil filter
39. Lubricating oil cooler
40. Cooling water pump
41. Heat exchanger
42. Flywheel
43. Damper disc
44. Input shaft
45. Output shaft
46. Forward gear
47. Reverse gear
48. Output shaft coupling
49. Starting motor
50. Alternator

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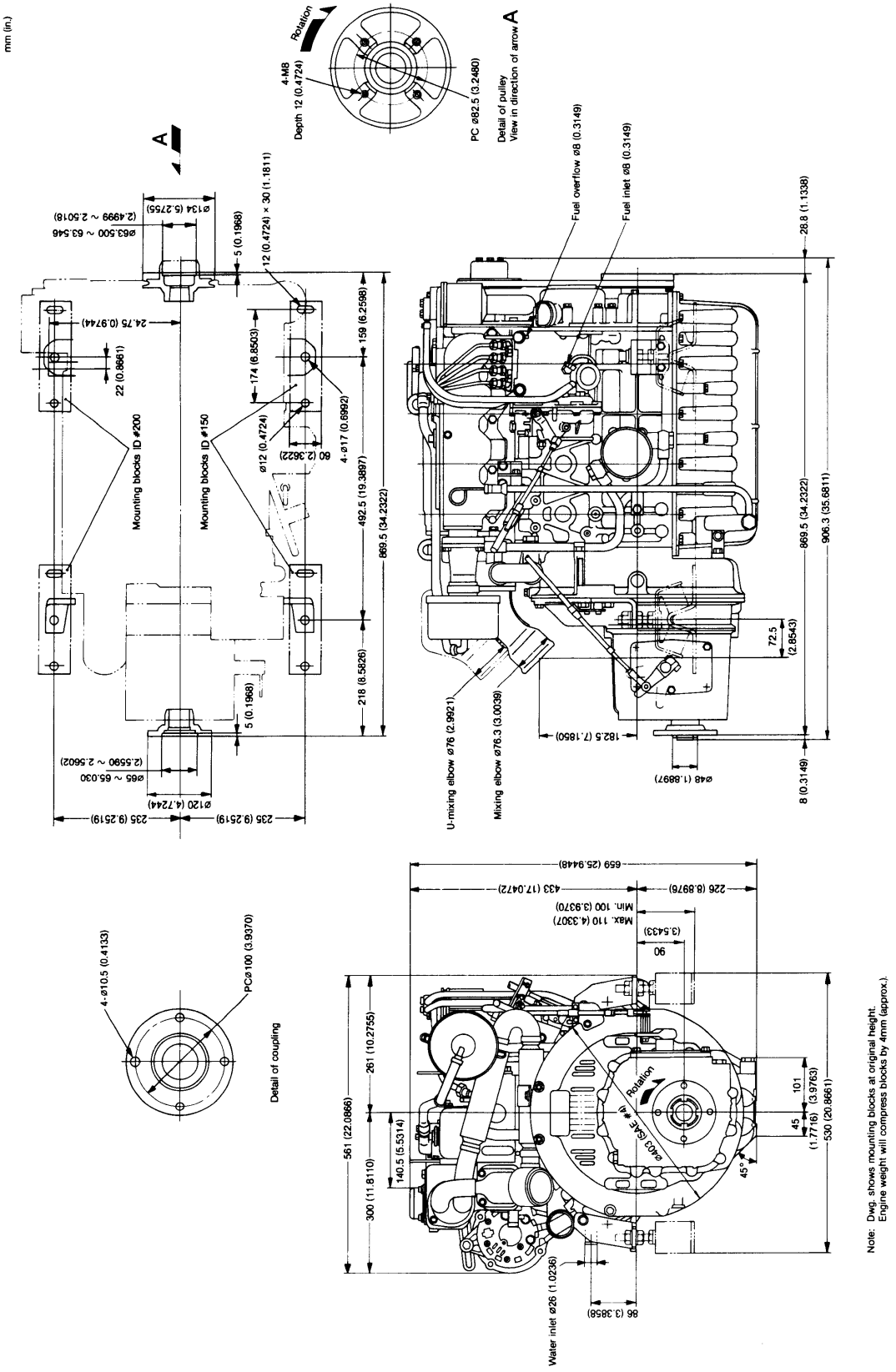
6. Dimensions

6-1 4JHE



Note: Dwg. shows mounting blocks at original height.
Engine weight will compress blocks by 4mm (approx.).

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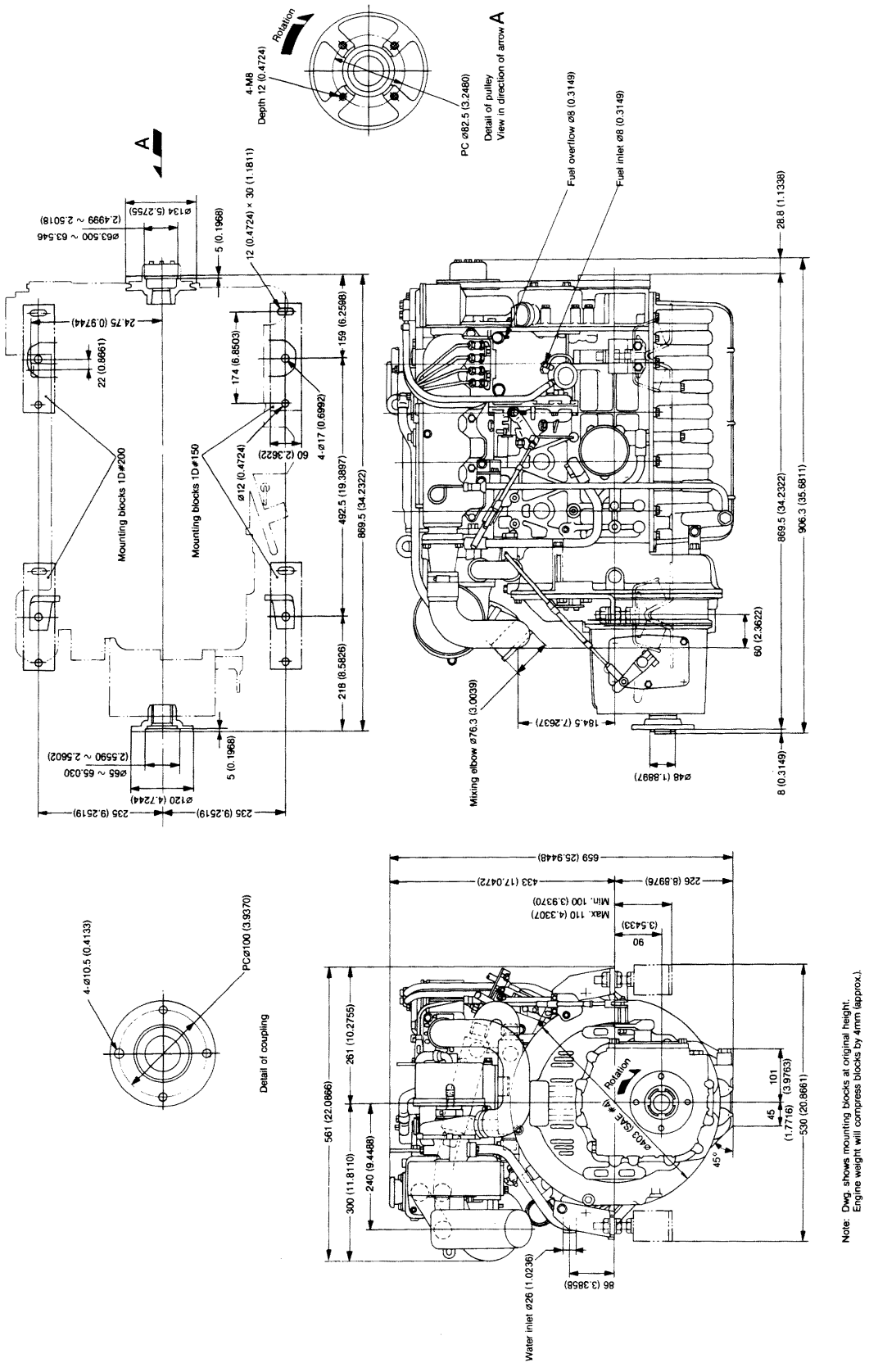
6-2 4JH-TE

mm (in.)



Note: Dwg. shows mounting blocks at original height.
Engine weight will compress blocks by 4mm (approx.).

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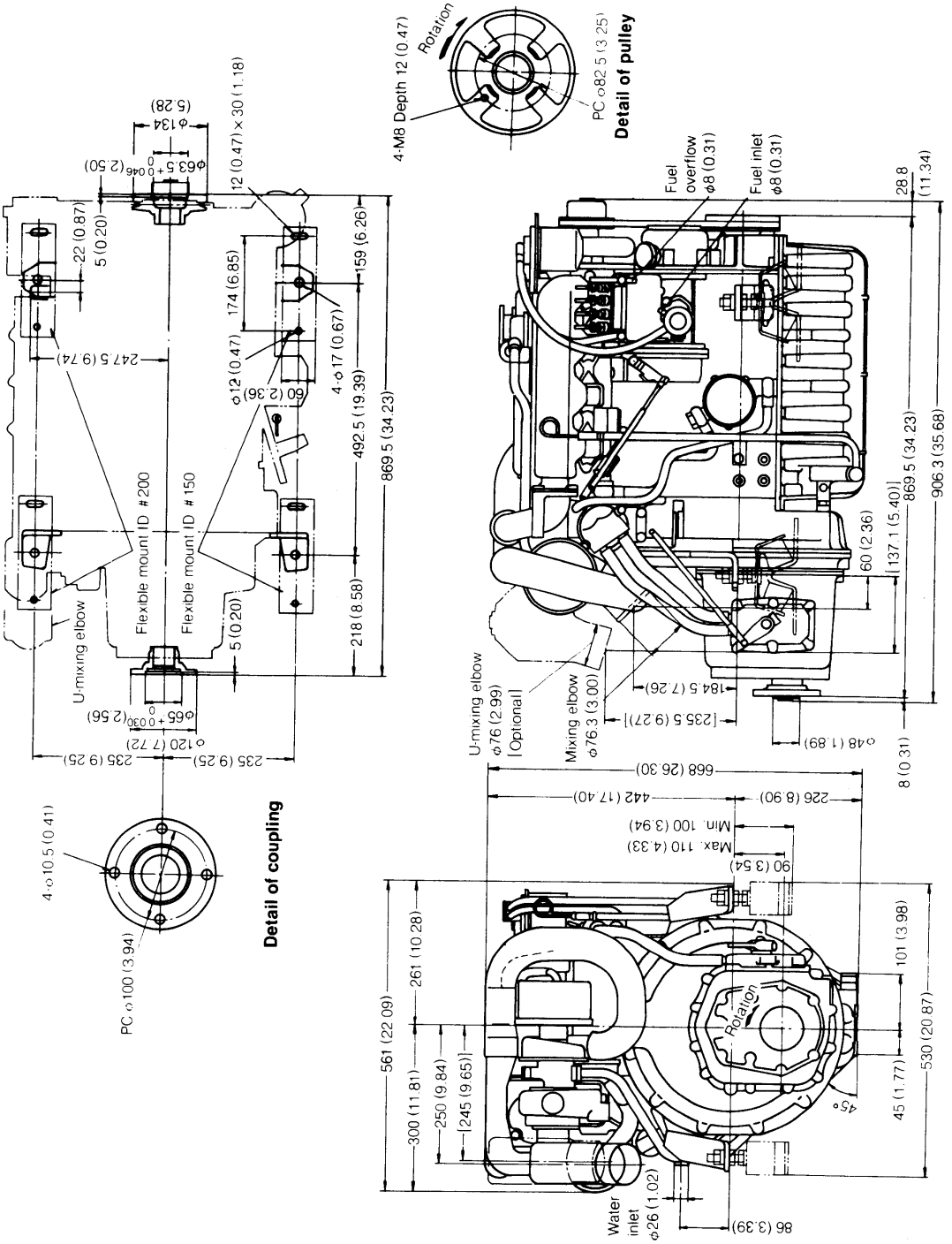
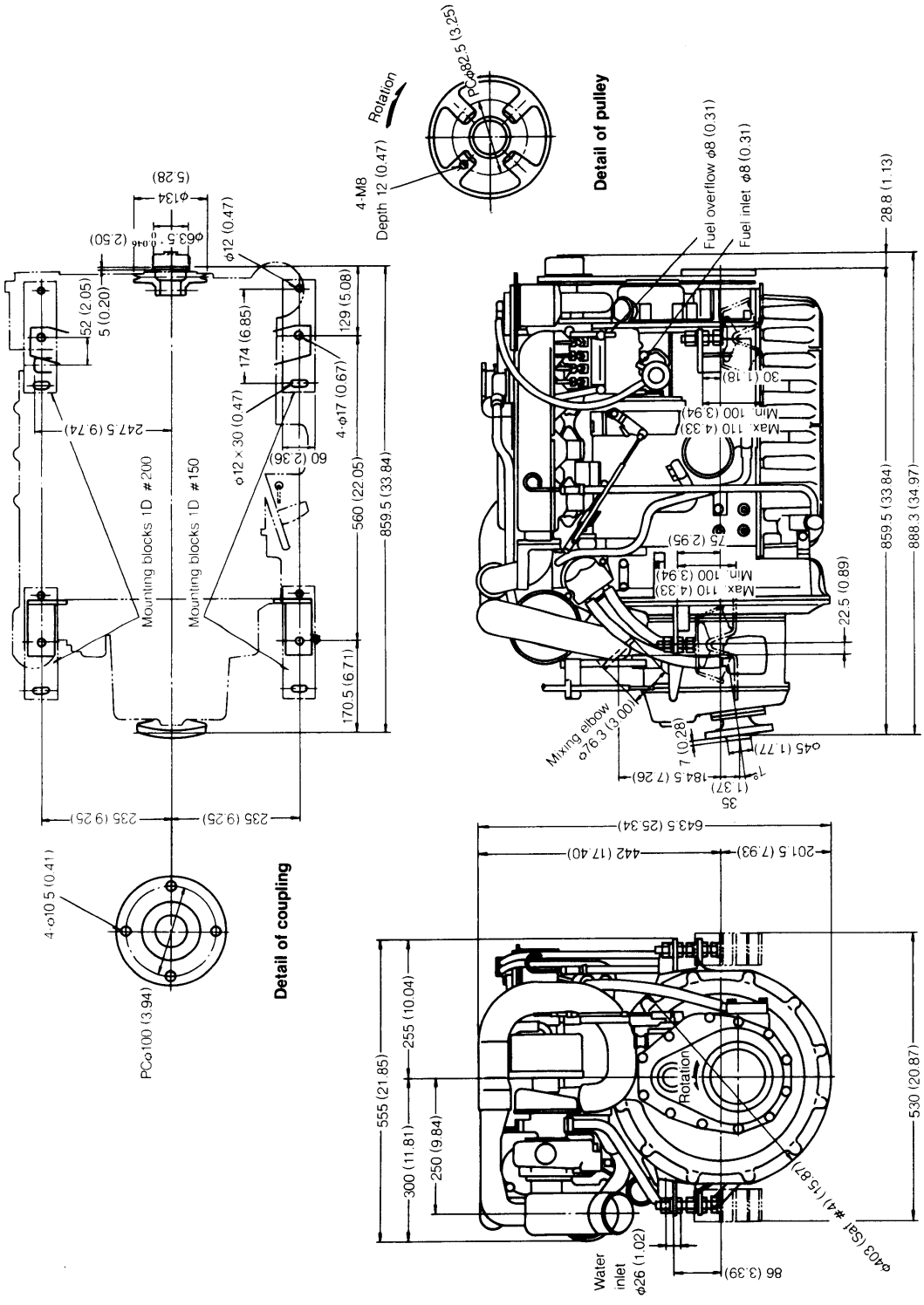
6-3 4JH-HTE



6-4 4JH-DTE



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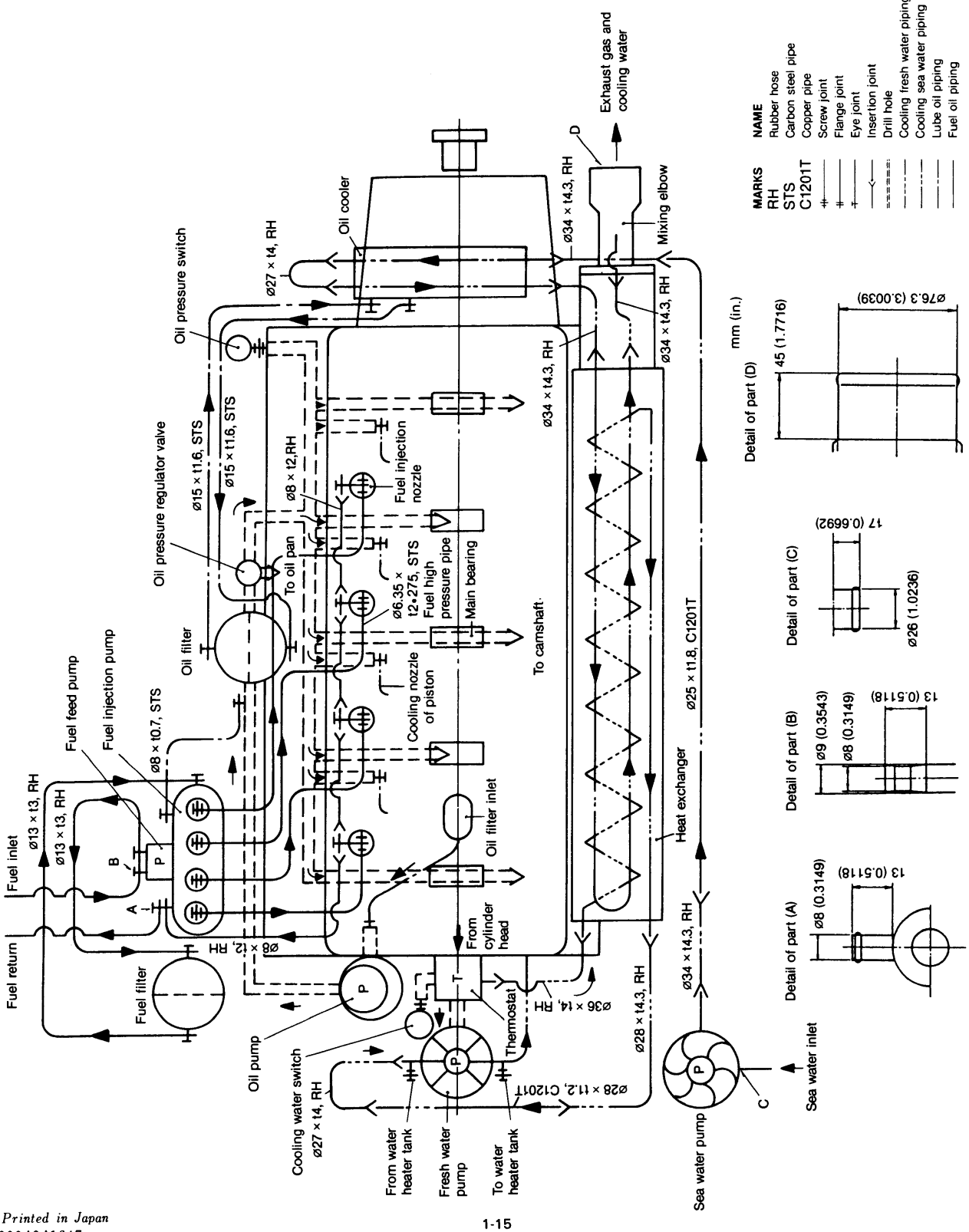
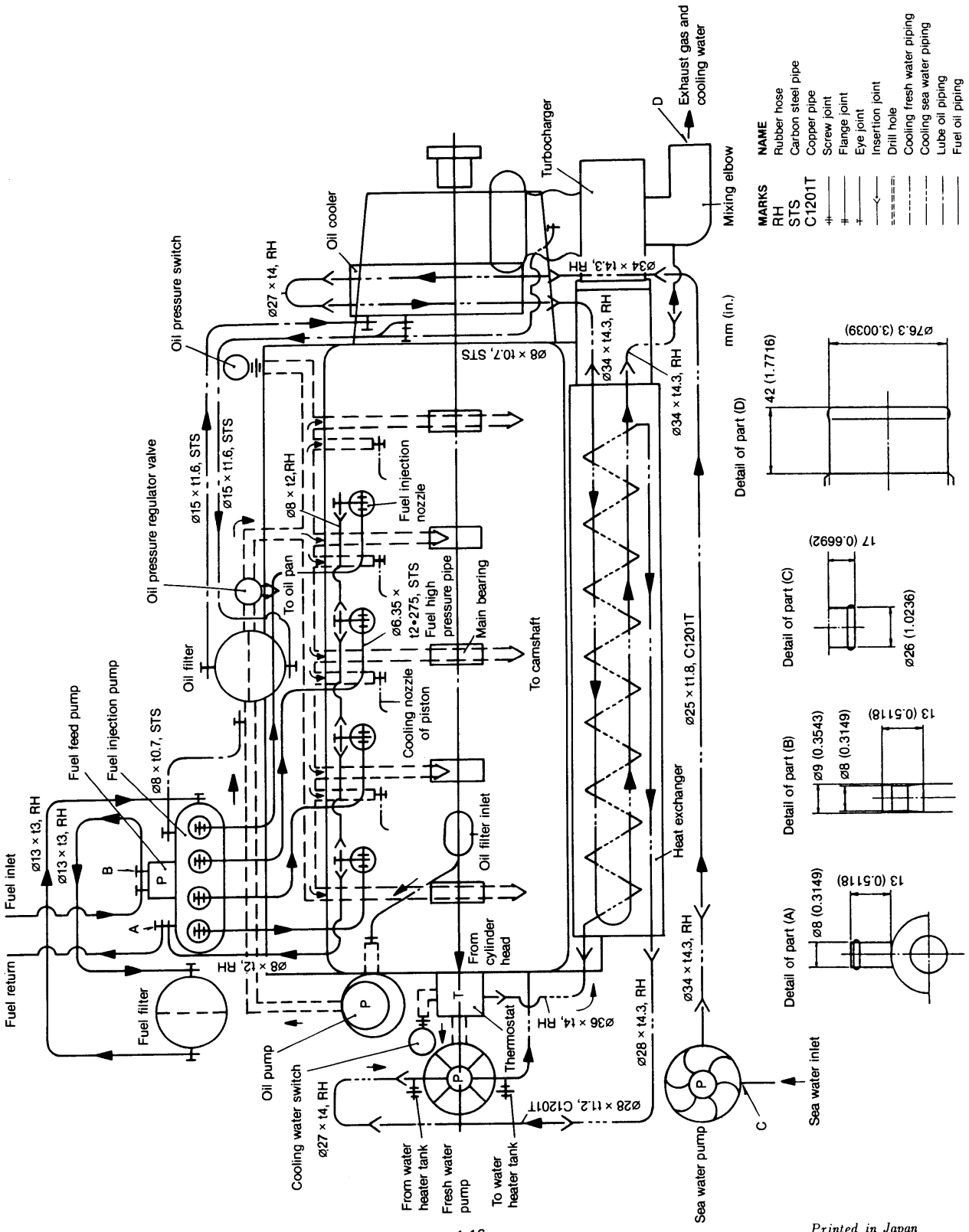
7. Piping Diagrams

7-1 4JHE



7-2 4JH-TE



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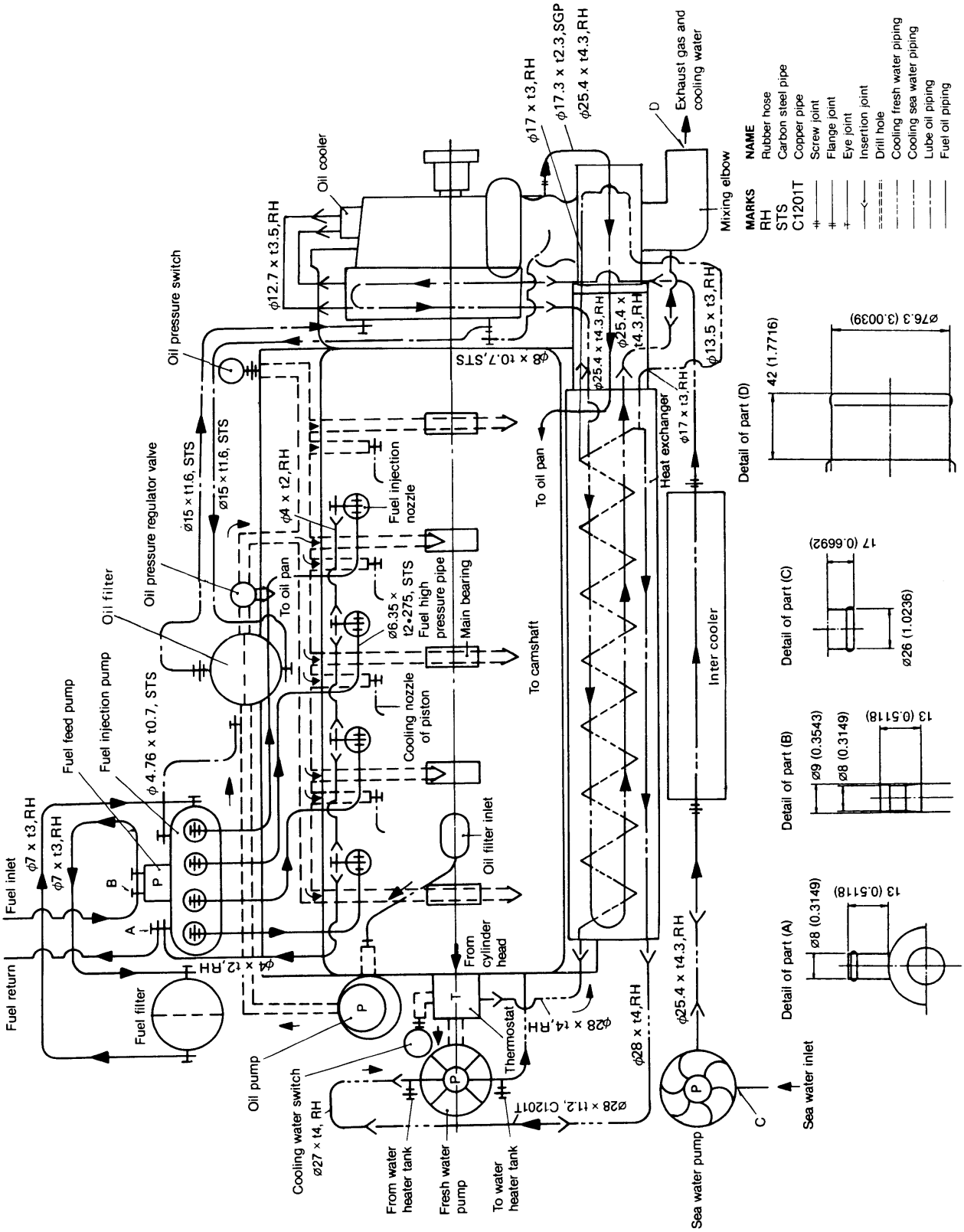
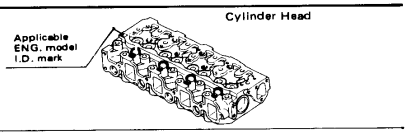
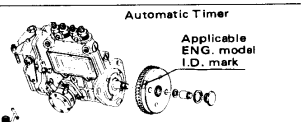
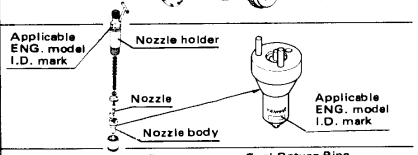
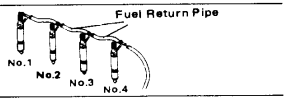
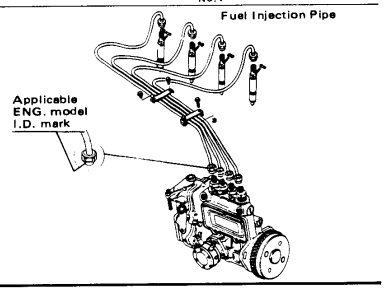
7-3 4JH-HTE & 4JH-DT(B)E



8. Parts Interchangeability

4JH-Series Parts Interchangeability (Cylinder Head Assembly, Piston and FIE)

IMPORTANT:
There is no interchangeability between the old type and the new type parts.
To ensure the parts interchangeability among the 4JH series engines, be sure to change all the relative parts as follows.

CHANGE PARTS \ ENGINE MODEL				4JHE	4JH-TE	4JH-HTE	4JH-DTE	Note.
1) Cylinder Head Ass'y		Old type	Part code: Swirl radio: Identification mark:	729470-11700 2.25 1	◇	729474-11700 2.0 5	✕	
		New type	Part code: Swirl radio: Identification mark:	729470-11701 2.8 SL	729474-11701 2.0 SG	◇	◇	
2) Piston		Old type	Part code: Identification mark:	129400-22020 1	129472-22010 2	129474-22010 5	✕	
		New type	Part code: Identification mark:	129400-22021 A	129472-22011 B	129474-22010 C (only changed I.D. mark)	◇	
3) Fuel Injection Equipment	3) - 1 Automatic Timer Ass'y (Automatic Advancing Timer)	Old type	Part code: Advanced angle: Cam. deg. Identification mark:	729470-54101 5.5° JH-A1	729472-54100 3.5° JH-B0	729499-54100 2.5° JH-C0	✕	
		New type	Part code: Advanced angle: Cam. deg. Identification mark:	729100-54100 4° TN-A0	729499-54100 2.5° JH-C0	◇	◇	
	3) - 2 Fuel Injection Nozzle A'ssy	Old type	Part code: Identification mark: Nozzle Identification mark:	729470-53101 E 155P244J1	729472-53100 B 150P284JO	729499-53100 D 145P265J1	✕	
		New type	Part code: Identification mark: Nozzle Identification mark:	129470-53102 F 155P244J2	729499-53102 G 140P255J2	◇	◇	
	3) - 3 Fuel Return Pipe	Old type	Part code: Length:	129470-59550 90mm	◇	◇	✕	
		New type	Part code: Length:	121250-59550 120mm	◇	◇	◇	
	3) - 4 Fuel injection Pipe (Pump to Nozzle)	Old type	Part code: (No. 1. Cylinder) (No. 2 . Cylinder) (No. 3 . Cylinder) (No. 4 . Cylinder) Size: Inner dia, Length, Identification mark:	129470-59810 129470-59820 129470-59830 129470-59840 φ1.8 400mm None	◇	129499-59810 129499-59820 129499-59830 129499-59840 φ 2.0 400mm None	✕	
		New type	Part code: (No. 1. Cylinder) (No. 2. Cylinder) (No. 3. Cylinder) (No. 4. Cylinder) Size: Inner dia, Length, Identification mark:	129470-59811 129470-59821 129470-59831 129470-59841 φ1.8 400mm 18	◇	129499-59811 129499-59821 129499-59831 129499-59841 φ 2.0 400mm 20	◇	

Applicable Engine Model and Engine Number:
4JHE, E/#01001 and after (Jun. , 21'85 YANMAR Plant)
4JH-TE, E/#11001 and after (Jun. , 21'85 YANMAR Plant)
4JH-HTE, E/#21001 and after (Jun. , 21'85 YANMAR Plant)
4JH-DTE, E/#30101 and after (Jun. , 21'85 YANMAR Plant)

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CHAPTER 2

INSPECTION AND SERVICING OF BASIC ENGINE PARTS

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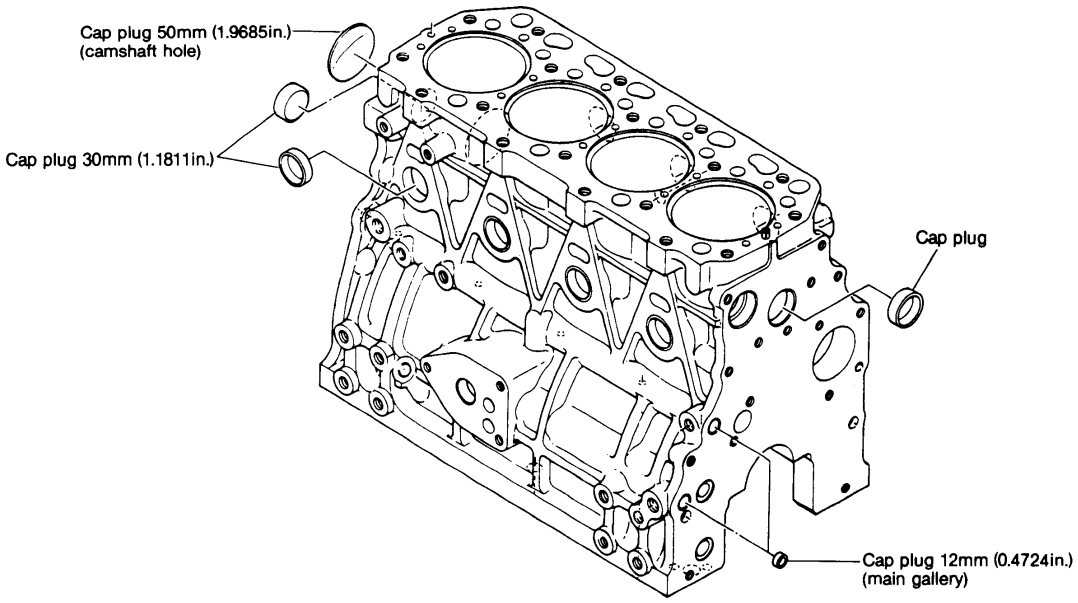
1. Cylinder Block

The cylinder block is thin-skinned, (low-weight), short skirt type with rationally placed ribs. The side walls are wave shaped to maximize ridigity for strength and low noise.



1-1 Inspection of parts

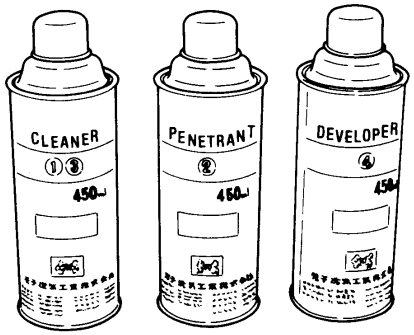
Make a visual inspection to check for cracks on engines that have frozen up, overturned or otherwise been subjected to undue stress. Perform a color check on any portions that appear to be cracked, and replace the cylinder block if the crack is not repairable.

1-2 Cleaning of oil holes

Clean all oil holes, making sure that none are clogged up and the blind plugs do not come off.

Color check kit
Part code No. 97550-004560

	Quantity
Penetrant	1
Developer	2
Cleaner	3



1-3 Color check procedure

(1) Clean the area to be inspected.
(2) Color check kit
The color check test kit consists of an aerosol cleaner, penetrant and developer.
(3) Clean the area to be inspected with the cleaner.
Either spray the cleaner on directly and wipe, or wipe the area with a cloth moistened with cleaner.
(4) Spray on red penetrant
After cleaning, spray on the red penetrant and allow 5 ~ 10 minutes for penetration. Spray on more red penetrant if it dries before it has been able to penetrate.
(5) Spray on developer
Remove any residual penetrant on the surface after the penetrant has penetrated, and spray on the developer. If there are any cracks in the surface, red dots or a red line will appear several minutes after the developer dries.
Hold the developer 300 ~ 400mm (11.8110 ~ 15.7480in.) away from the area being inspected when spraying, making sure to coat the surface uniformly.
(6) Clean the surface with the cleaner.

NOTE: Without fail, read the instructions for the color check kit before use.

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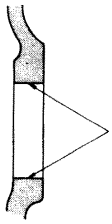
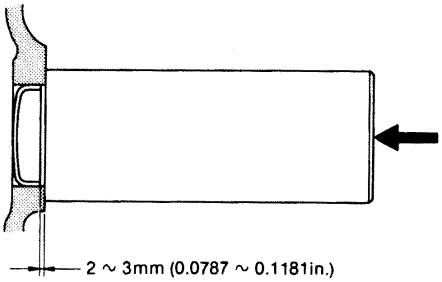
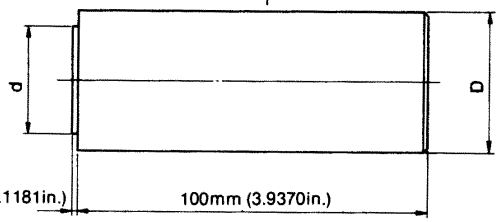
1-4 Replacement of cup plugs

Step No.	Description	Procedure	Tool or material used
1.	Clean and remove grease from the hole into which the cup plug is to be driven. (Remove scale and sealing material previously applied.)	 Remove foreign materials with a screw driver or saw blade.	•Screw driver or saw blade •Thinner
2.	Remove grease from the cup plug.	Visually check the nick around the plug.	•Thinner
3.	Apply Threebond No. 4 to the seat surface where the plug is to be driven in.	Apply over the whole outside of the plug.	•Threebond No. 4
4.	Insert the plug into the hole.	Insert the plug so that it sits correctly.	
5.	Place a driving tool on the cup plug and drive it in using a hammer.  2 ~ 3mm (0.0787 ~ 0.1181in.) *Using the special tool, drive the cup plug to a depth where the edge of the plug is 2mm (0.0787in.) below the cylinder surface.	Drive in the plug parallel to the seating surface. 	•Driving tool •Hammer

mm (in.)

Plug dia.	d	D
ø12	ø11.9 ~ 12.0 (ø0.4685 ~ 0.4724)	ø20 (ø0.7874)
ø30	ø29.9 ~ 30.0 (ø1.1770 ~ 1.8110)	ø40 (ø1.5748)

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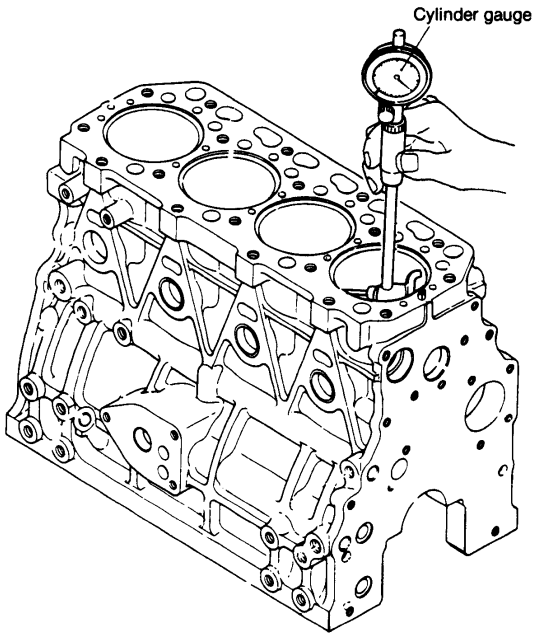
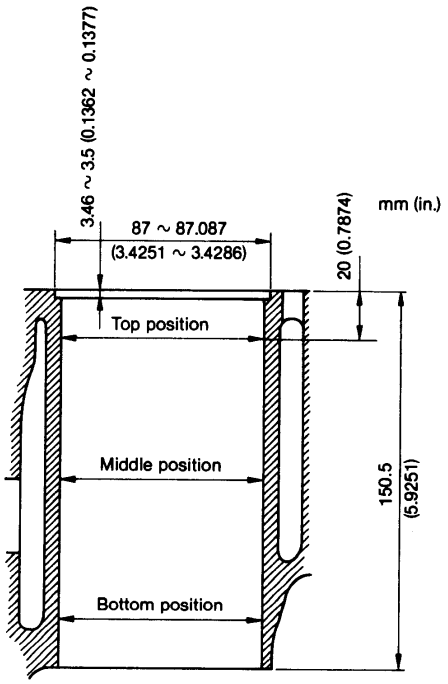
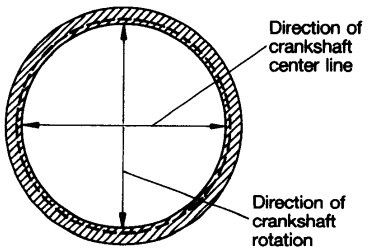
1-5 Cylinder bore measurement

Measure the bore diameter with a cylinder gauge at the positions shown in the figure.
Replace the cylinder bore when the measured value exceeds the wear limit. Measurement must be done at least at 3 positions as shown in the figure, namely, top, middle and bottom positions in both directions along the crankshaft rotation and crankshaft center lines.







mm (in.)

	Standard	Wear limit
Cylinder bore dia.	ø82.00 ~ 82.03 (3.2283 ~ 3.2295)	ø82.06 (3.2307)
Cylinder roundness	0 ~ 0.01 (0 ~ 0.0004)	0.02 (0.0008)

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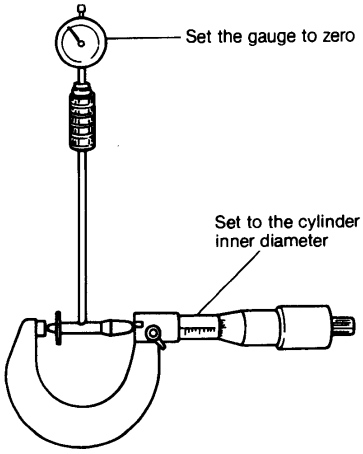
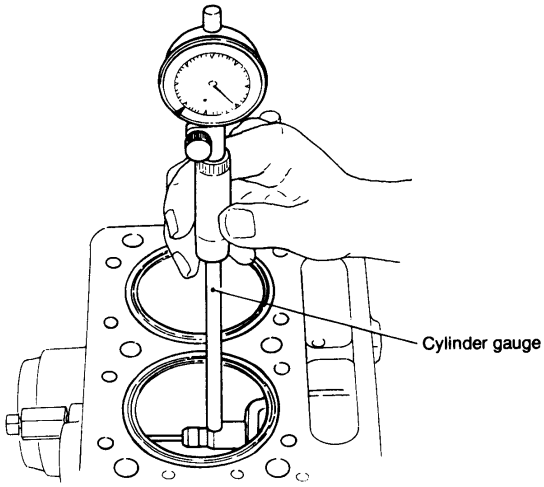
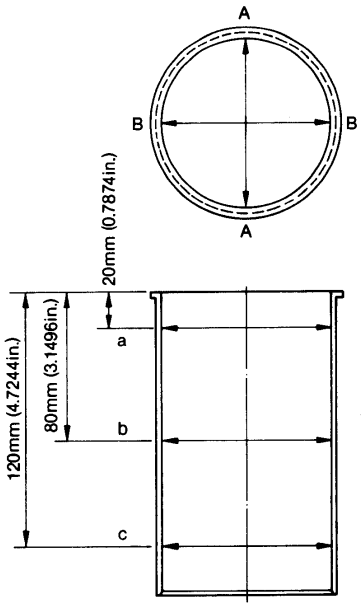
2. Cylinder Liners

2-1 Measuring cylinder liners

Measure the inner diameter of each cylinder with a cylinder gauge and replace the cylinder liner if it exceeds the wear limit.







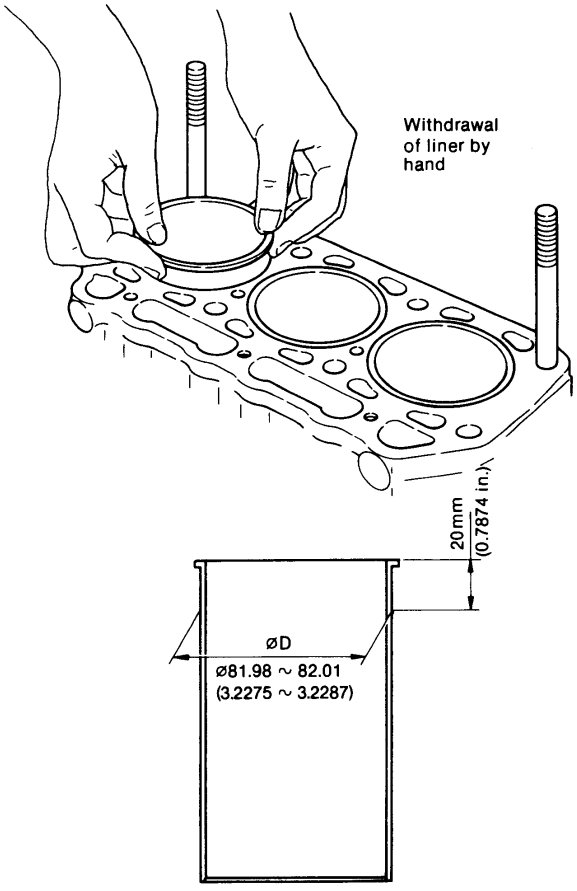
mm (in.)

	Standard	Wear limit
Cylinder liner	ø78.00 ~ 78.03 (ø3.0708 ~ 3.0720)	ø78.12 (ø3.0755)

NOTE: Be sure to measure A-A, B-B and a, b and c

2-2 Inserting cylinder liners

Coat the outside of the liner with oil, and insert lightly by hand. Do not tap with a wooden hammer as this may deform the liner.



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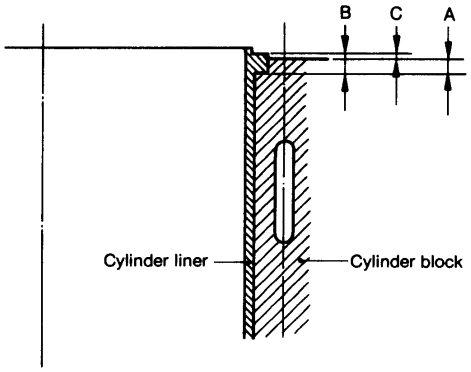
2-3 Measuring cylinder liner projection

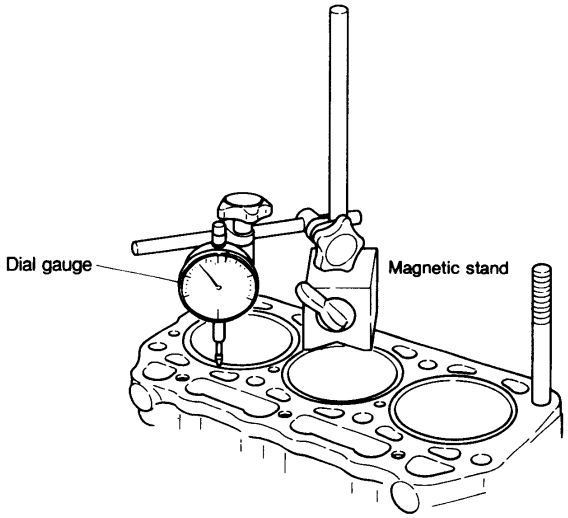
Make sure the cylinder liner flange projects only slightly above the block.



mm (in.)

A	3.46 ~ 3.50 (0.1362 ~ 0.1378)
B	3.53 ~ 3.55 (0.1390 ~ 0.1398)
C	0.03 ~ 0.09 (0.0011 ~ 0.0035)

NOTE: Excessive cylinder liner projection is frequently caused by incomplete removal of the rust on the ledge (Part D of figure) of the cylinder block.



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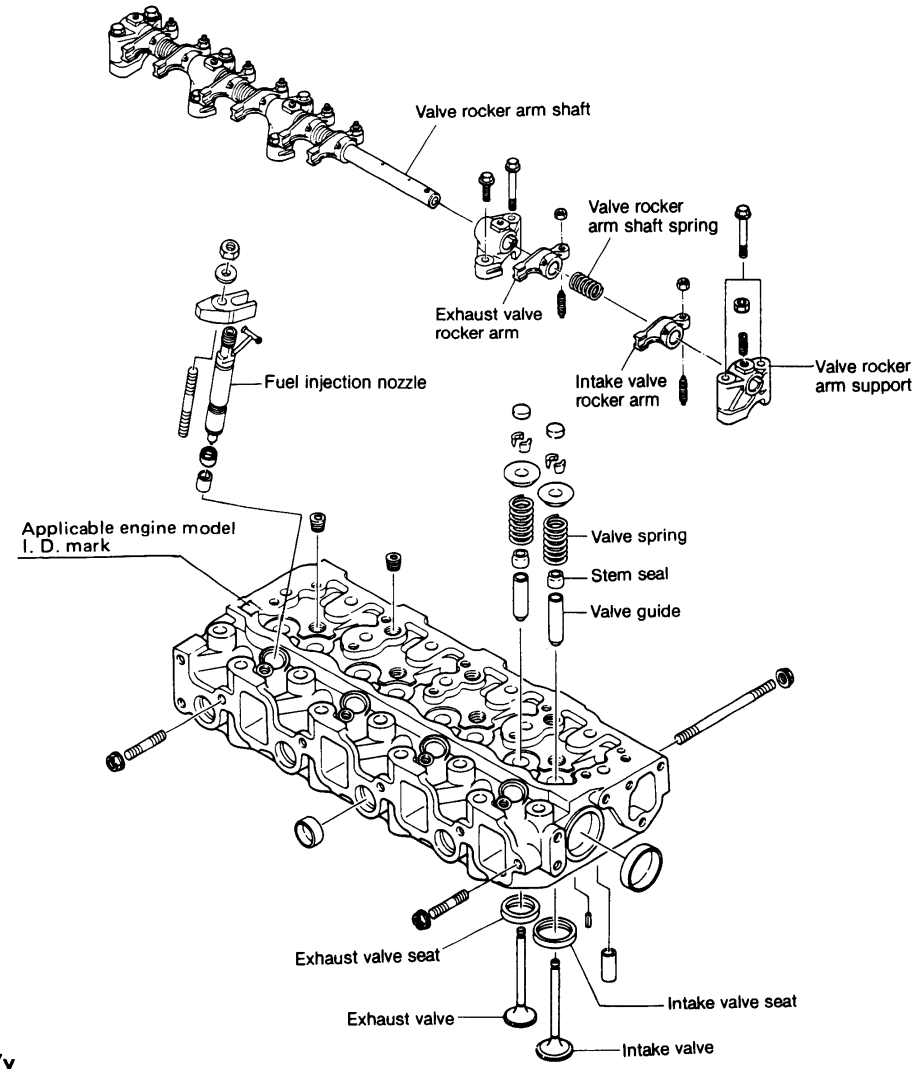
3. Cylinder Head

The cylinder head is of 4-cylinder integral construction, mounted with 18 bolts. Special alloy stellite with superior resistance to heat and wear is fitted on the seats, and the area between the valves is cooled by a water jet.

IMPORTANT:
Cylinder head assembly differs among engine models. If an incorrect cylinder head is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark (I. D. Mark) on the cylinder head assembly to insure use of the correct part.



Cylinder Head Ass'y

	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	1	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	SL	4JHE	E/#01001 and after
	SG	4JH-TE	E/#11001 and after
	SG	4JH-HTE	E/#21001 and after
	SG	4JH-DTE	E/#30101 and after

*Engines produced at YANMAR plant on and after June 21, 1985

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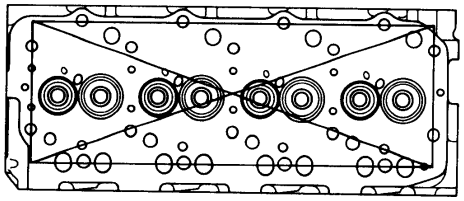
3-1 Inspecting the cylinder head

The cylinder head is subjected to very severe operating conditions with repeated high pressure, high temperature and cooling. Thoroughly remove all the carbon and dirt after disassembly and carefully inspect all parts.



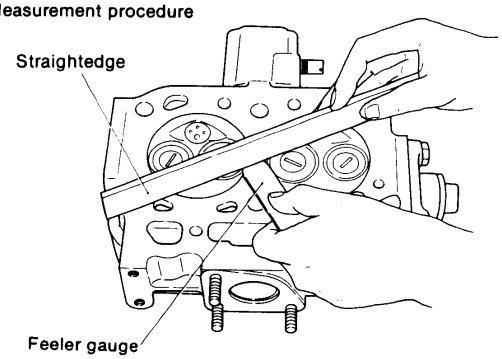
3-1.1 Distortion of the combustion surface

Carefully check for cylinder head distortion as this leads to gasket damage and compression leaks.

(1) Clean the cylinder head surface.

(2) Place a straight-edge along each of the four sides and each diagonal. Measure the clearance between the straight-edge and combustion surface with a feeler gauge.

Measurement procedure

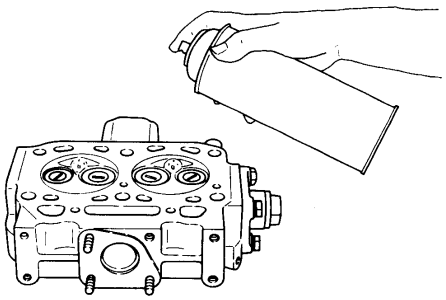


mm (in.)

	Standard	Wear limit
Cylinder head distortion	0.05 (0.0019) or less	0.15 (0.0059)

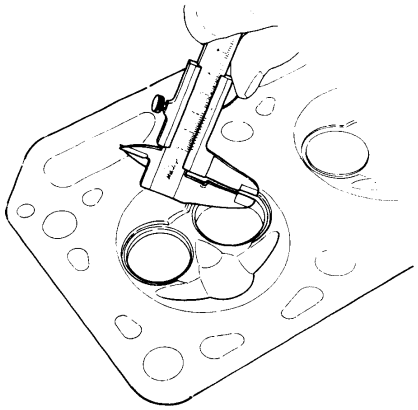
3-1.2 Checking for cracks in the combustion surface

Remove the fuel injection nozzle, intake and exhaust valve and clean the combustion surface. Check for discoloration or distortion and conduct a color check test to check for any cracks.



3-1.3 Checking the intake and exhaust valve seats

Check the surface and width of the valve seats.
If they are too wide, or if the surfaces are rough, correct to the following standards:

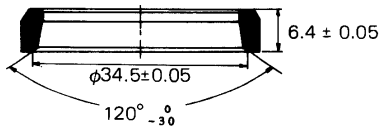


Seat angle	Intake	120°
	Exhaust	90°

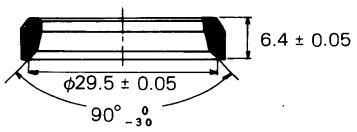
mm (in.)

Seat width	Standard	Wear limit
Intake	1.28 (0.0504)	1.78 (0.0700)
Exhaust	1.77 (0.0697)	2.27 (0.0894)

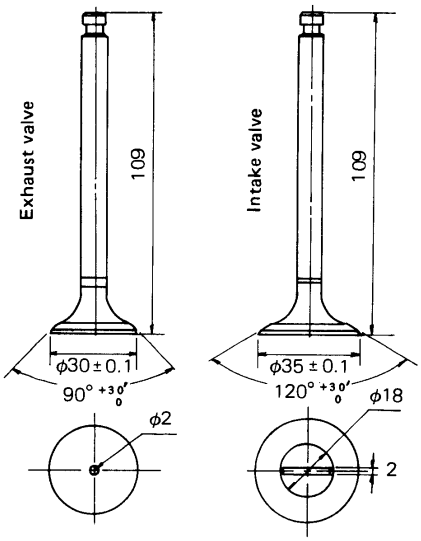
Intake valve seat



Exhaust valve seat



Standard dimension



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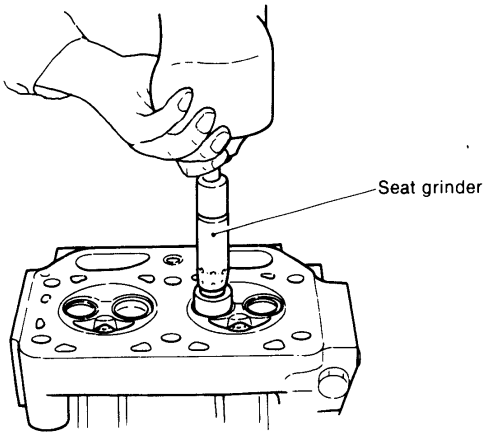
3-2 Valve seat correction procedure

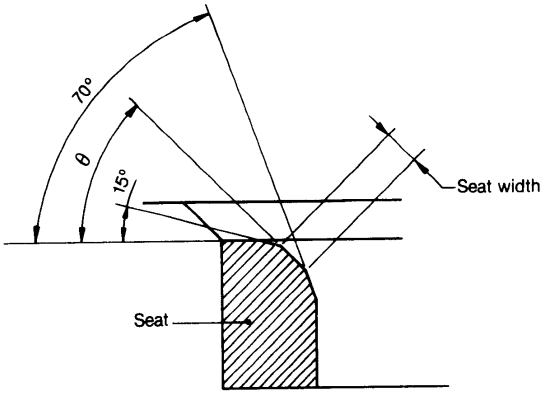
The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

(1) Use a seat grinder to make the surface even.
As the valve seat width will be enlarged, first use a 70° grinder, then grind the seat to the standard dimension with a 15° grinder.



Seat grinder	Intake valve	30°
	Exhaust valve	45°

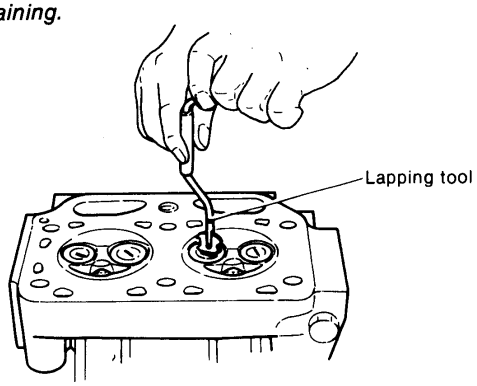
NOTE: When seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.



(2) Knead valve compound with oil and finish the valve seat with a lapping tool.
(3) Final finishing should be done with oil only.

Lapping tool
Use a rubber cap type lapping tool for cylinders without a lapping tool groove slit.

NOTE: Clean the valve and cylinder head with light oil or the equivalent after valve seat finishing is completed, and-make sure that there are no grindings remaining.

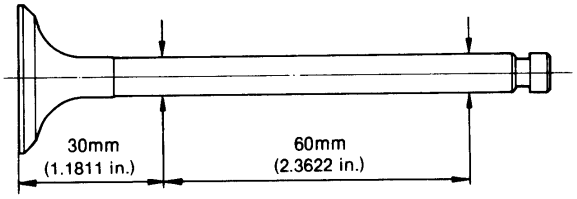


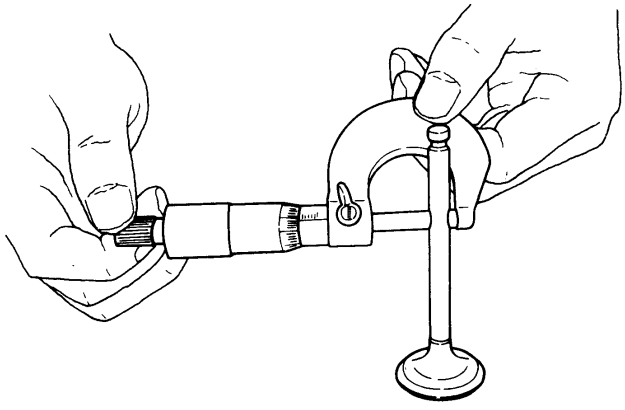
NOTE: 1. Insert adjusting shims between the valve spring and cylinder head when seats have been refinished with a seat grinder.
2. Measure valve distortion after valve seat refinishing has been completed, and replace the valve and valve seat if it exceeds the tolerance.

3-3 Intake/exhaust valves, valve guides

3-3.1 Wearing and corrosion of valve stem

Replace the valve if the valve stem is excessively worn or corroded.





mm (in.)

Valve stem outside dia.	Standard	Wear limit
Intake	ø7.960 ~ 7.975 (ø0.3134 ~ 0.3140)	−0.13 (−0.0051)
Exhaust	ø7.955 ~ 7.970 (ø0.3132 ~ 0.3138)	−0.13 (−0.0051)

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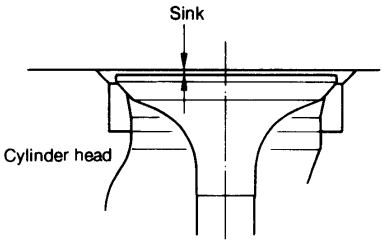
3-3.2 Inspection of valve seat wear and contact surface

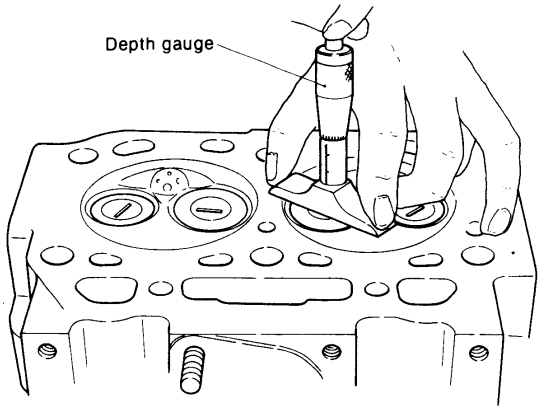
Inspect for valve seat scratches and excessive wear. Check to make sure the contact surface is normal. The seat angle must be checked and adjusted if the valve seat contact surface is much smaller than the width of the valve seat.

NOTE: Keep in mind the fact that the intake and discharge valve have different diameters.

3-3.3 Valve sinking

Over long periods of use and repeated lappings, combustion efficiency may drop. Measure the sinking distance and replace the valve and valve seat if the valve sink exceeds the tolerance.





mm (in.)

	Standard	Wear limit
Valve sink	0.4 ~ 0.6 (0.0157 ~ 0.0236)	1.5 (0.0590)

3-3.4 Valve guide

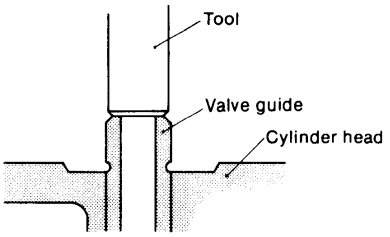
(1) Measuring inner diameter of valve guide.
Measure the inner diameter of the valve guide and replace it if it exceeds the wear limit.

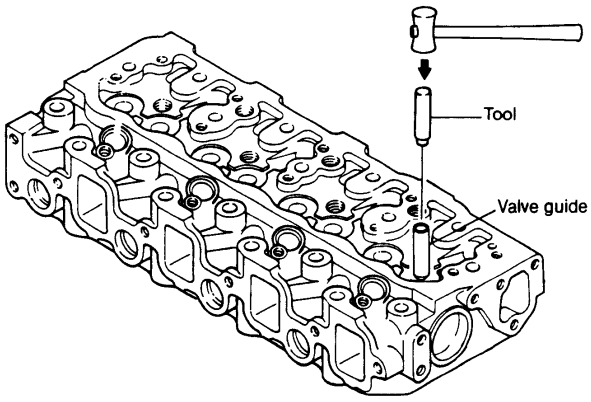
mm (in.)

		Standard	Wear limit
Valve guide inside dia.	Intake	ø8.015 ~ 8.030 (ø0.3156 ~ 0.3161)	+0.2 (0.0079)
	Exhaust	ø8.015 ~ 8.030 (ø0.3156 ~ 0.3161)	+0.2 (0.0079)

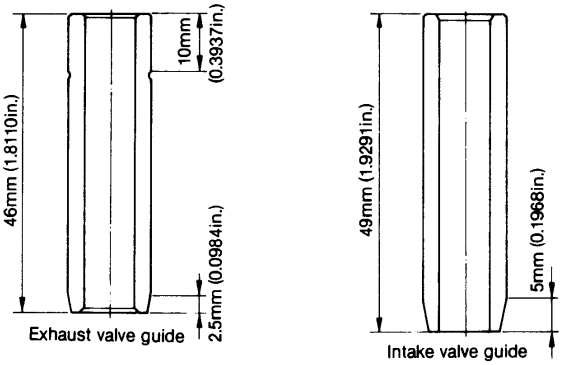
NOTE: The inner diameter standard dimensions assume a pressure fit.

(2) Replacing the valve guide
Use the insertion tool and tap in the guide with a mallet.

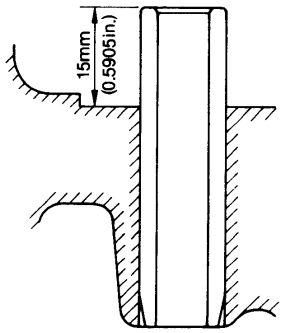




The intake valve guide and exhaust valve guide are of different shapes/dimensions. The one with a groove around it is the exhaust valve guide and the one without is the intake valve guide.



(3) Valve guide projection
The valve guide should project 15mm from the top of the cylinder head.



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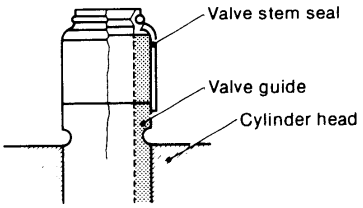
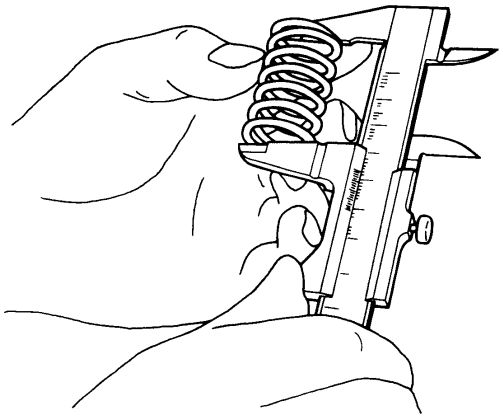
(4) Valve stem seals
The valve stem seals in the intake/exhaust valve guides cannot be re-used once they are removed—be sure to replace them.
When assembling the intake/exhaust valves, apply an adequate quantity of engine oil on the valve stem before inserting them.



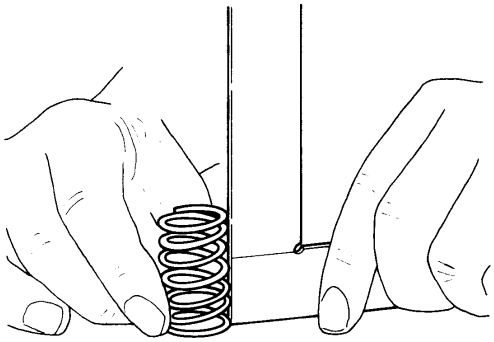
3-4 Valve springs

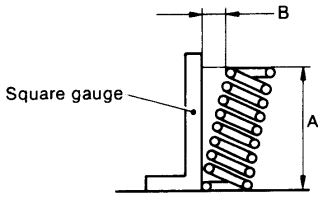
3-4.1 Checking valve springs

(1) Check the spring for scratches or corrosion.
(2) Measure the free length of the spring.

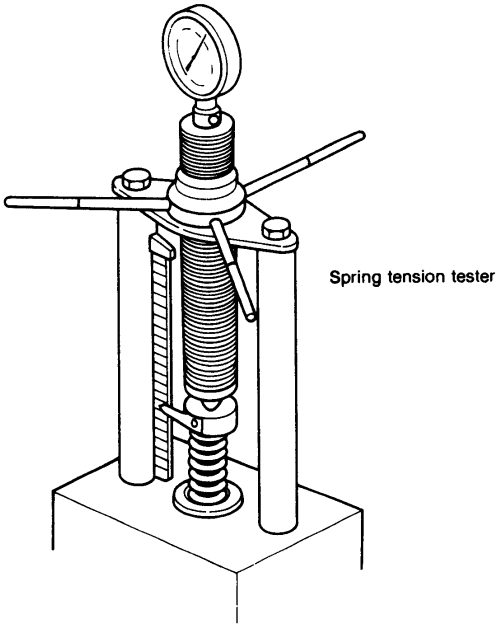


(3) Measure inclination.





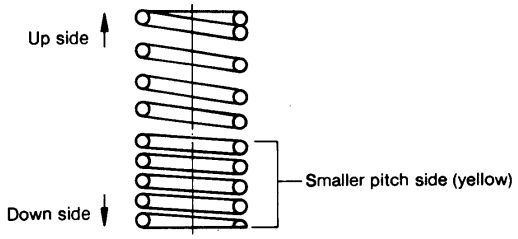
(4) Measure spring tension.



mm (in.)

Valve spring	Standard	Wear limit
Free length	44.4 (1.7480)	43 (1.6929)
Length when attached	40 (1.5748)	—
Load when attached	12kg (26.46 lb.)	10kg (22.05 lb.)

Assembling valve springs
The side with the smaller pitch (painted yellow) should face down (cylinder head).



NOTE: The pitch of the valve spring is not even. The side with the smaller pitch (yellow) should face down (cylinder head) when assembled.

(5) Spring retainer and spring cotter
Inspect the inside face of the spring retainer, the outside surface of the spring cotter, the contact area of the spring cotter inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter when the contact area is less than 70%, or when the spring cotter has been recessed because of wear.

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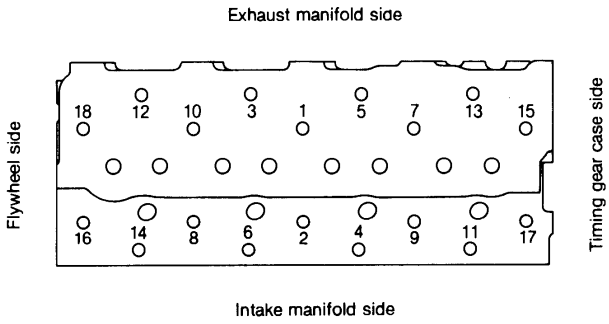
3-5 Assembling the cylinder head

Partially tighten the bolts in the specified order and then tighten to the specified torque, being careful that head does not get distorted.

(1) Clean out the cylinder head bolt holes.
(2) Check for foreign matter on the cylinder head surface that comes in contact with the block.
(3) Coat the head bolt threads and nut seats with lube oil.
(4) Use the positioning pins to line up the head gasket with the cylinder block.
(5) Match up the cylinder head with the head gasket and mount.

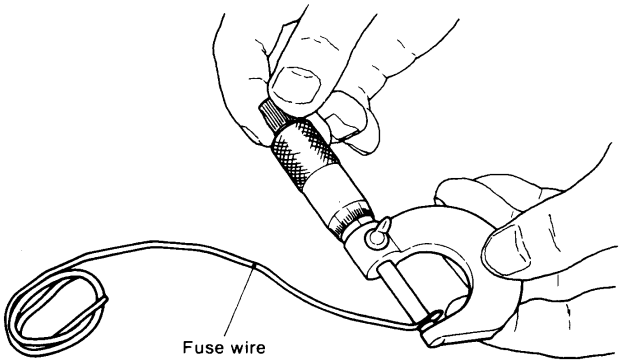


kg-m (ft-lb)

	First	Second
Tightening torque	3.5 ~ 4.5 (25.32 ~ 32.55)	7.5 ~ 8.5 (54.25 ~ 61.48)

3-6 Measuring top clearance

(1) Place a high quality fuse (ø1.5mm (0.0591in.), 10mm (0.3937in.) long) in three positions on the flat part of the piston head.
(2) Assemble the cylinder head gasket and the cylinder block and tighten the bolts in the specified order to the specified torque.
(3) Turn the crank, (in the direction of engine revolution), and press the fuse against the piston until it breaks.
(4) Remove the head and take out the broken fuse.
(5) Measure the three positions where each fuse is broken and calculate the average.
(0.71 ~ 0.75mm (0.0280 ~ 0.0295in.) is ideal)

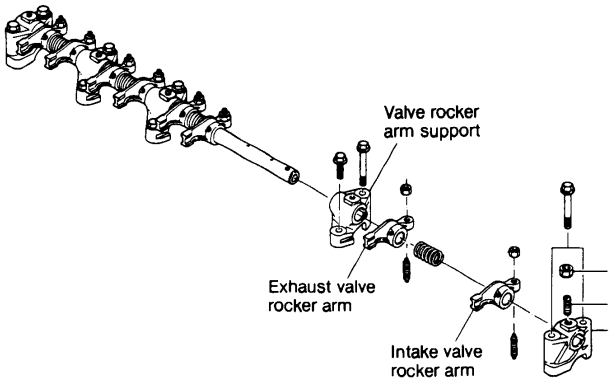


mm (in.)

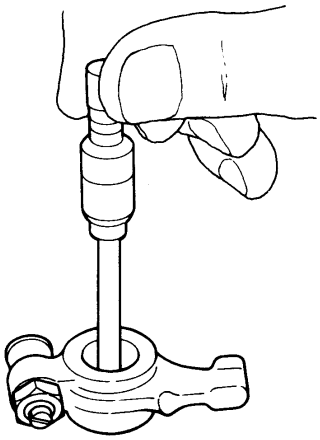
Top clearance	0.71 ~ 0.89 (0.0280 ~ 0.0350)

3-7 Intake and exhaust valve arms

Valve arm and valve arm bushing wear may change opening/closing timing of the valve, and may in turn affect engine performance according to the extent of the change.



(1) Valve arm shaft and valve arm bushing
Measure the outer diameter of the shaft and the inner diameter of the bearing, and replace if wear exceeds the limit.



mm (in.)

		Standard	Wear limit
Intake and exhaust valve rocker arm shaft outside dia.	A	15.966 ~ 15.984 (0.6285 ~ 0.6292)	15.955 (0.6281)
Intake and exhaust valve rocker arm bushing inside dia. (assembled)	B	16.000 ~ 16.018 (0.6299 ~ 0.6306)	16.090 (0.6334)
Valve rocker arm shaft and bushing clearance at assembly		0.016 ~ 0.052 (0.0006 ~ 0.0020)	0.135 (0.0053)

Replace the valve arm shaft bushing if it moves and replace the entire valve arm if there is no tightening clearance.

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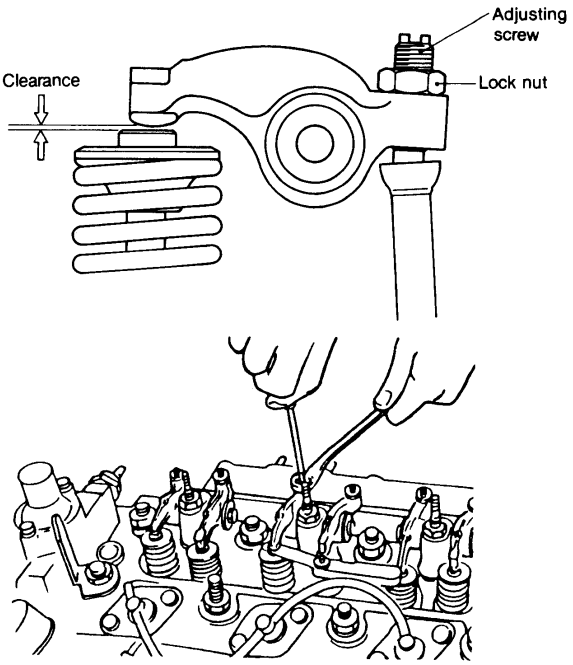
(2) Valve arm spring
Check the valve arm spring and replace it if it is corroded or worn.
(3) Valve arm and valve top retainer wear
Inspect the contact surface of the valve arm and replace it if there is abnormal wear or flaking.
(4) Inspect the contact surface of the valve clearance adjustment screw and push rod and replace if there is abnormal wear or flaking.

3-8 Adjustment of valve head clearance

(1) Make adjustments when the engine is cool.

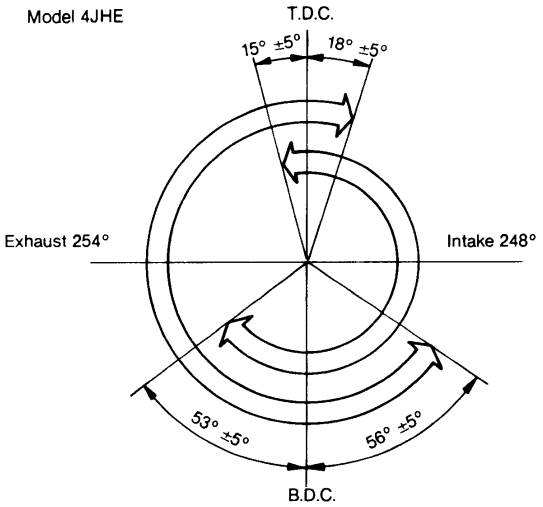
mm (in.)

Intake and exhaust head clearance	0.2 (0.0079)

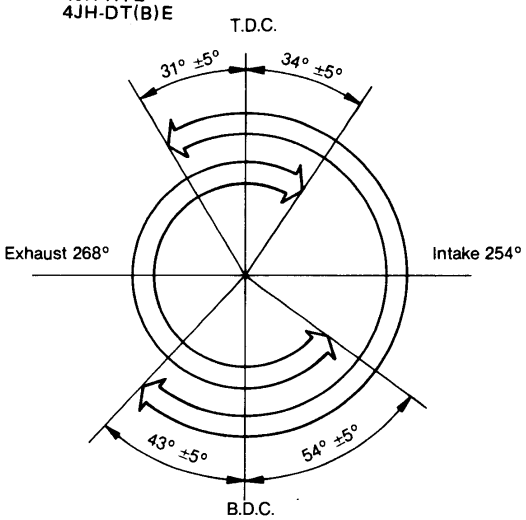


(2) Be sure that the opening and closing angles for both the intake and the exhaust valves are checked when the timing gear is disassembled (The gauge on the flywheel is read when the push rod turns the flywheel).

Model 4JHE



Model 4JH-TE
4JH-HTE
4JH-DT(B)E



		4JHE	4JH-TE 4JH-HTE 4JH-DT(B)E
Intake valve open	b.TDC	10° ~ 20°	26° ~ 36°
Intake valve closed	a.BDC	48° ~ 58°	38° ~ 48°
Exhaust valve open	b.BDC	51° ~ 61°	49° ~ 59°
Exhaust valve closed	a.TDC	13° ~ 23°	29° ~ 39°

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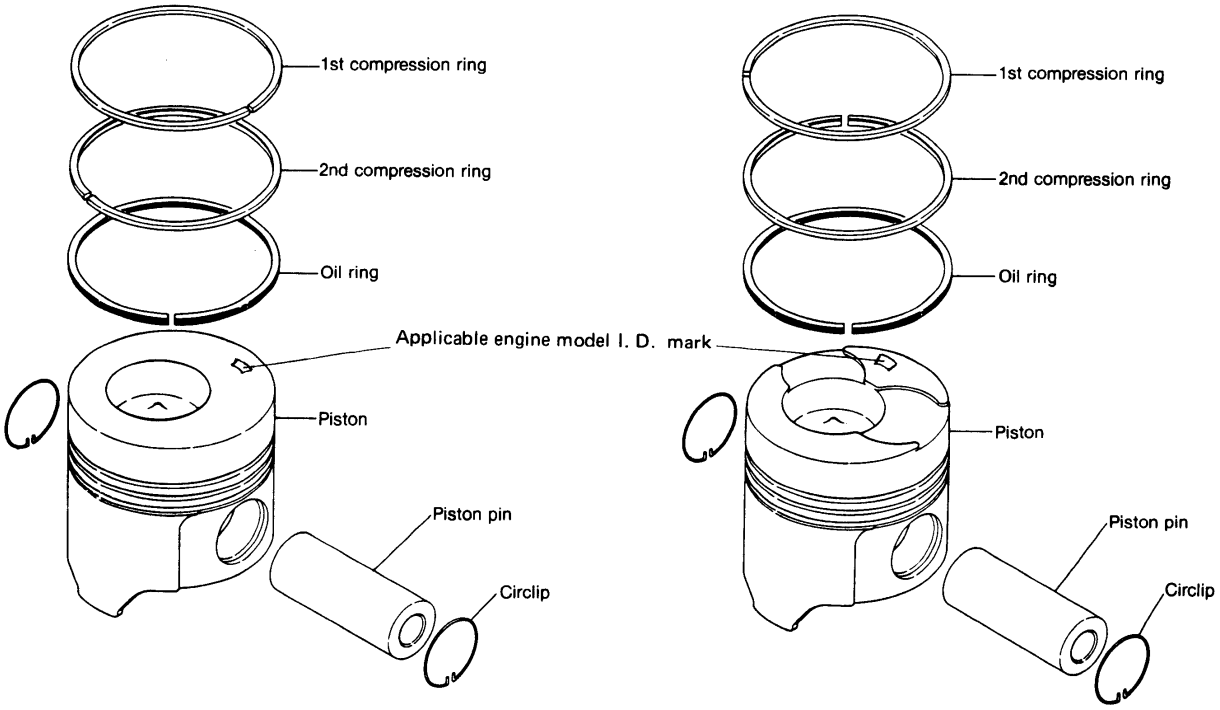
4. Pistons and Piston Pins

Pistons are made of a special light alloy with superior thermal expansion characteristics, and the top of the piston forms a swirl type toroidal combustion chamber. The opposite face of the piston combustion surface is oil-jet cooled.
Pistons for engines with superchargers have a valve recess for the intake and exhaust valves.
The clearance between the piston and cylinder liner is kept at the proper value by the piston and cylinder liner property fit effected during assembly at the Yanmar factory.

IMPORTANT:
Piston shape differs among engine models. If an incorrect piston is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark (I. D. Mark) on the piston to insure use of the correct part.



I. D. Mark for Piston

	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	2	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	A	4JHE	E/#01001 and after
	B	4JH-TE	E/#11001 and after
	C	4JH-HTE	E/#21001 and after
	C	4JH-DTE	E/#30101 and after

*Engines produced at YANMAR plant on and after June 21, 1985

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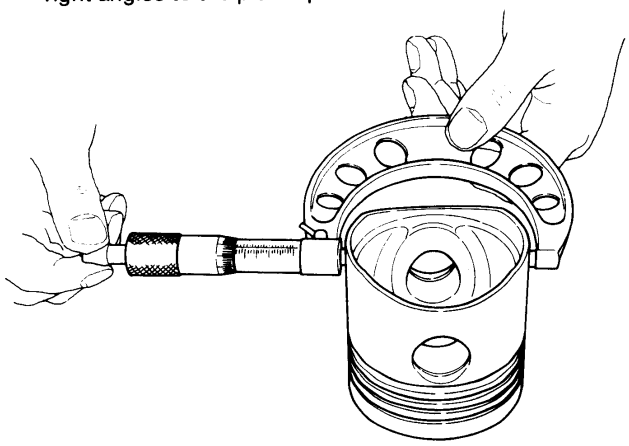
4-1 Piston

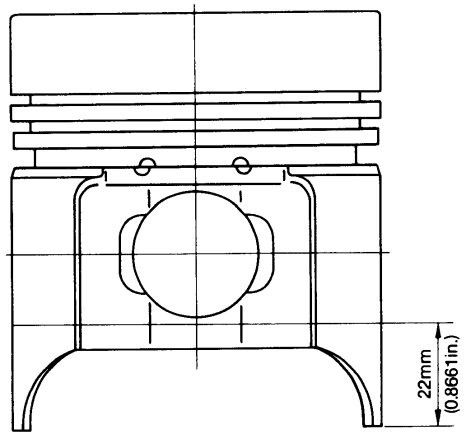
4-1.1 Piston head and combustion surface

Remove the carbon that has accumulated on the piston head and combustion surface, taking care not to scratch the piston. Check the combustion surface for any damage.

4-1.2 Measurement of piston outside diameter/inspection

(1) Replace the piston if the outsides of the piston or ring grooves are worn.
(2) Measure the piston 22mm (0.8661in.) from the bottom at right angles to the piston pin.



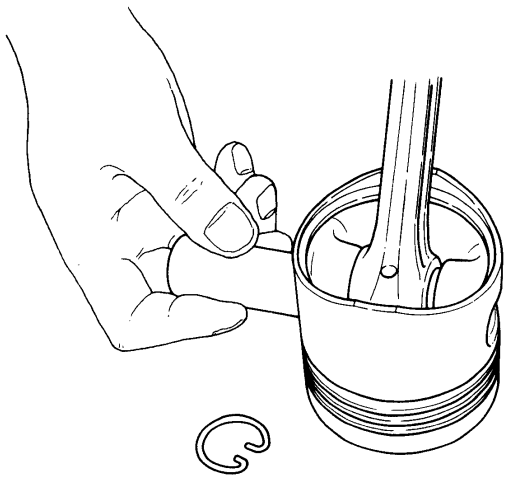


mm (in.)

Standard	Wear limit
77.91 ~ 77.94 (3.0673 ~ 3.0685)	77.81 (3.0633)

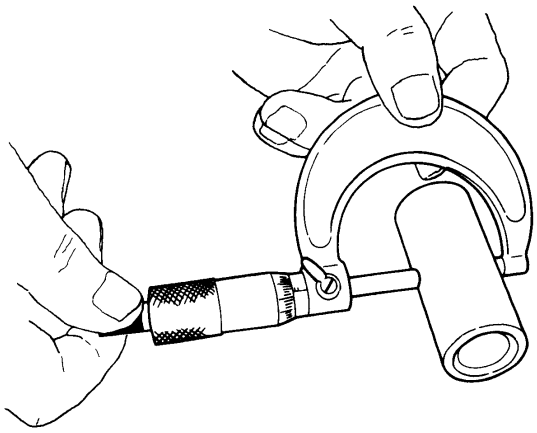
4-1.3 Replacing the piston

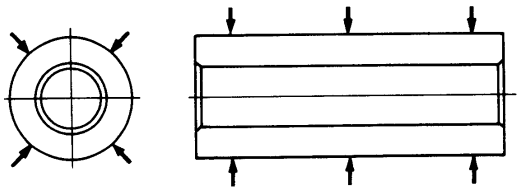
A floating type piston pin is used in this engine. The piston pin can be pressed into the piston pin hole at room temperature (coat with oil to make it slide in easily).



4-2 Piston pin

Measure the outer diameter and replace the pin if it is excessively worn.





mm (in.)

	Standard	Wear limit
Piston pin insert hole dia.	ø26.000 ~ 26.009 (ø1.0236 ~ 1.0240)	+0.020 (0.0008)
Piston pin outside dia.	ø25.987 ~ 26.000 (ø1.0231 ~ 1.0236)	−0.025 (0.0009)
Standard clearance	0 ~ 0.022 (0 ~ 0.0009)	0.045 (0.0018)

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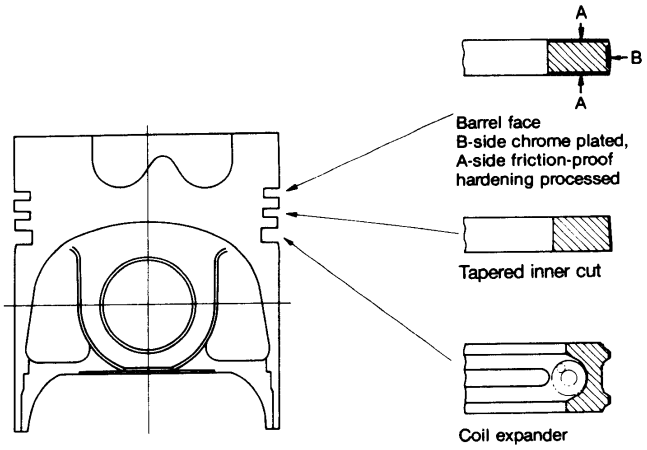
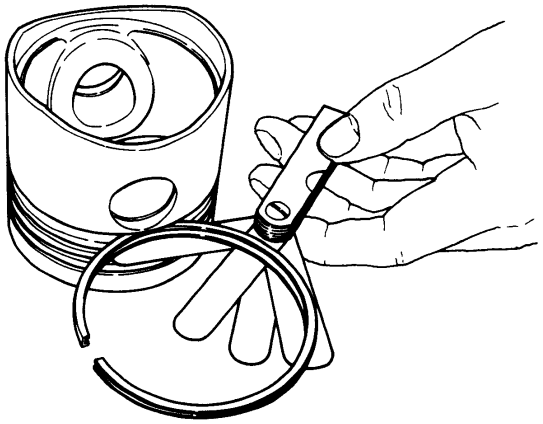
4-3 Piston rings

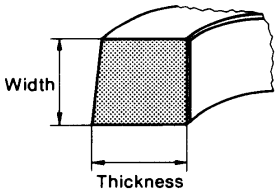
There are 2 compression rings and 1 oil ring.
The absence of an oil ring on the piston skirt prevents oil from being kept on the thrust surface and in turn provides good lubrication.



4-3.1 Measuring the rings

Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceeds the limit.



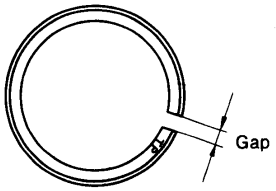


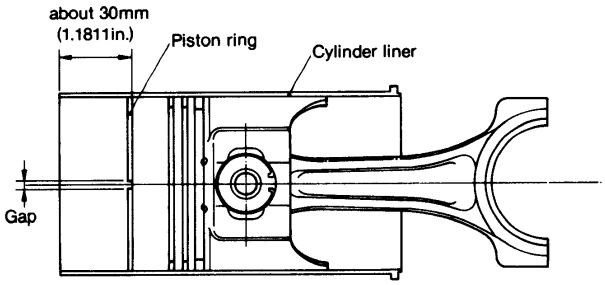
mm (in.)

		Standard	Wear limit
First piston ring	Groove width	2.060 ~ 2.075 (0.0811 ~ 0.0816)	—
	Ring width	1.975 ~ 1.990 (0.0777 ~ 0.0783)	—
	Groove and ring clearance	0.070 ~ 0.100 (0.0027 ~ 0.0039)	0.2 (0.0078)
Second piston ring	Groove width	2.025 ~ 2.040 (0.0797 ~ 0.0803)	—
	Ring width	1.975 ~ 1.990 (0.0777 ~ 0.0783)	—
	Groove and ring clearance	0.035 ~ 0.065 (0.0013 ~ 0.0025)	0.2 (0.0078)
Oil ring	Groove width	4.020 ~ 4.035 (0.1582 ~ 0.1588)	—
	Ring width	3.975 ~ 3.990 (0.1564 ~ 0.1570)	—
	Groove and ring clearance	0.030 ~ 0.060 (0.0011 ~ 0.0023)	0.2 (0.0078)

4-3.2 Measuring piston ring gap

Press the piston ring onto a piston liner and measure the piston ring gap with a gauge. Press on the ring about 30mm (1.811in.) from the bottom of the liner.





mm (in.)

	Standard	Wear limit
First piston ring gap	0.25 ~ 0.40 (0.0098 ~ 0.0157)	1.5 (0.0590)
Second piston ring gap	0.25 ~ 0.40 (0.0098 ~ 0.0157)	1.5 (0.0590)
Oil ring gap	0.20 ~ 0.40 (0.0078 ~ 0.0157)	1.5 (0.0590)

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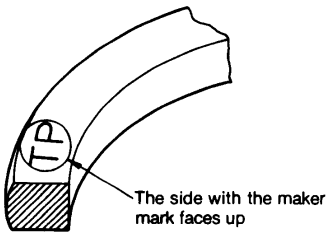
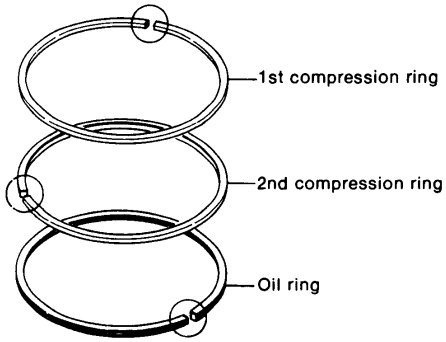
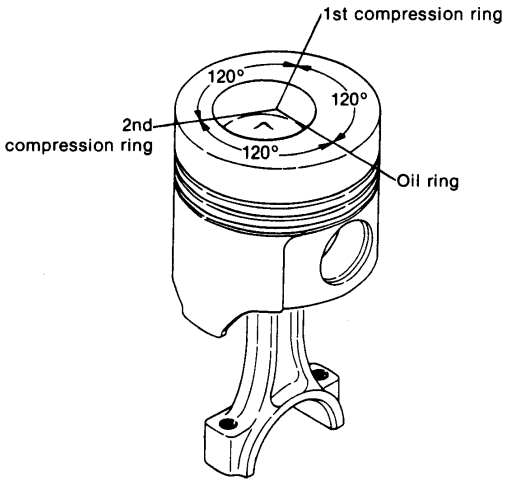
4-3.3 Replacing the piston rings

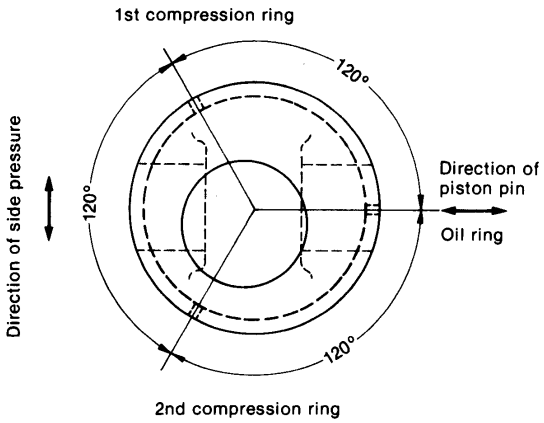
(1) Thoroughly clean the ring grooves when replacing piston rings.
(2) The side with the manufacturer's mark (near piston ring gap) should face up.



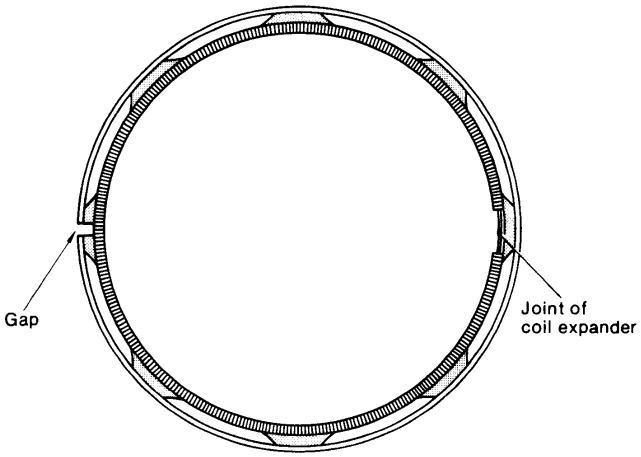
(3) After fitting the piston ring, make sure it moves easily and smoothly.
(4) Stagger the piston rings at 120° intervals, making sure none of them line up with the piston.







(5) The oil ring is provided with a coil expander. The coil expander joint should be opposite (staggered 180°) the oil ring gap.



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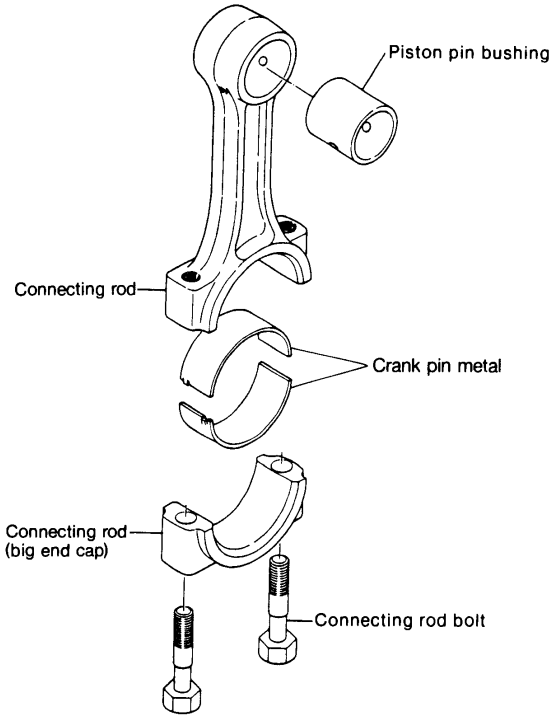
5. Connecting Rod

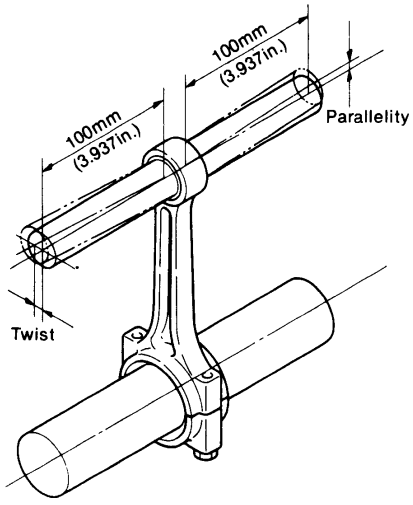
The connecting rod is made of high-strength forged carbon steel.
The large end with the 3-layer kelmet can be separated into two and the small end has a 2-layer copper alloy coil bushing.

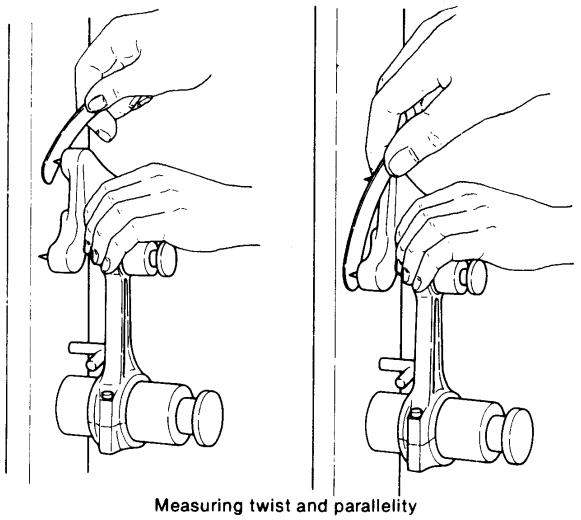


5-1 Inspecting the connection rod

5-1.1 Twist and parallelism of the large and small ends

Insert the measuring tool into the large and small ends of the connecting rod. Measure the extent of twist and parallelism and replace if they exceed the tolerance.



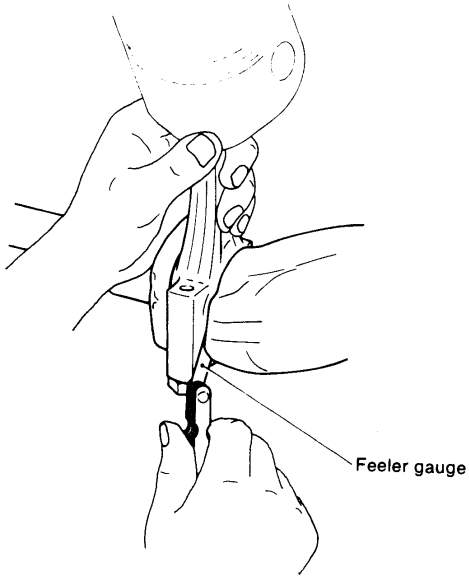

Measuring twist and parallelity

mm (in.)

	Standard	Wear limit
Connecting rod twist and parallelity	0.05 (0.0019)	0.07 (0.0027)

5-1.2 Checking thrust clearance

Fit the respective crank pins to the connecting rod and check to make sure that the clearance in the crankshaft direction is correct.



mm (in.)

	Standard	Wear limit
Connecting rod side clearance	0.20 ~ 0.40 (0.0078 ~ 0.0157)	0.55 (0.0216)

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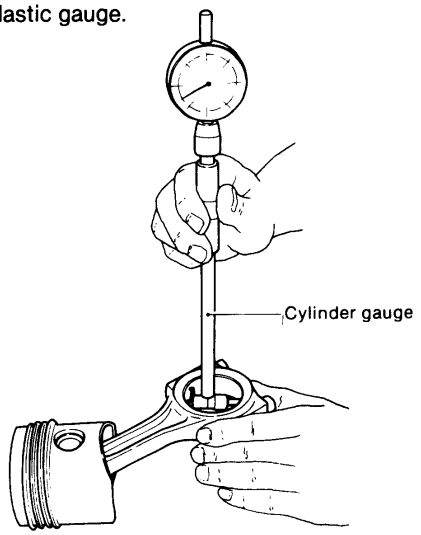
5-2 Crank pin bushing

5-2.1 Checking crank pin bushing

Check for flaking, melting or seizure on the contact surface.

5-2.2 Measuring crank pin oil clearance

Use a plastic gauge.



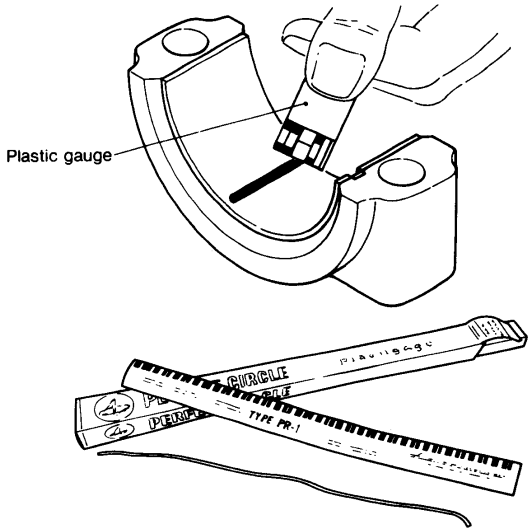
Procedure

(1) Use the press gauge (Plastigage) for measuring oil clearance in the crank pin.

(2) Mount the connecting rod on the crank pin (tighten to specified torque).

Connecting rod tightening torque	4.5 ~ 5.0 kg-m (32.5 ~ 36.1 ft-lb)

(3) Remove the connecting rod and measure the broken plastic gauge with measuring paper.

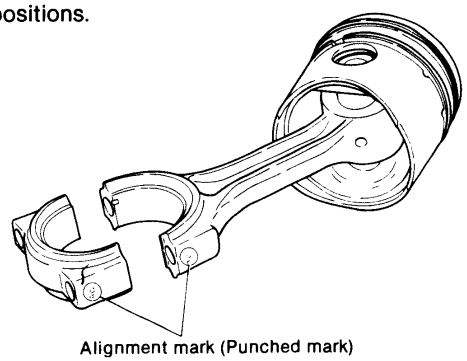


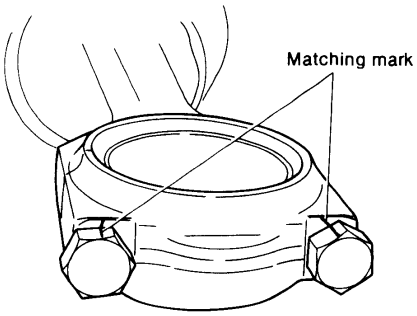
5-2.3 Precautions on replacement of crank pin bushing

(1) Wash the crank pin bushing.

(2) Wash the large end cap, mount the crank pin bushing and make sure that it fits tightly on the large end cap.

(3) When assembling the connecting rod, match up the large end and large end cap number. Coat the bolts with engine oil and gradually tighten them alternately to the specified torque.
If a torque wrench is not available, make match marks on the bolt heads and large end cap (to indicate the proper torque position) and retighten the bolts to those positions.

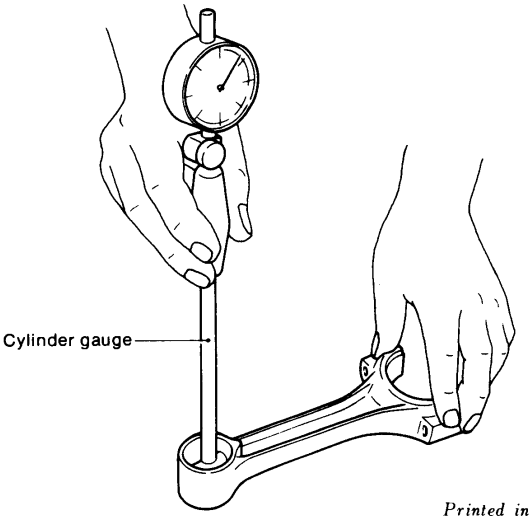




(4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.

5-3 Piston pin bushing

(1) Measuring piston pin clearance
Excessive piston pin bushing wear may result in damage to the piston pin or the piston itself.



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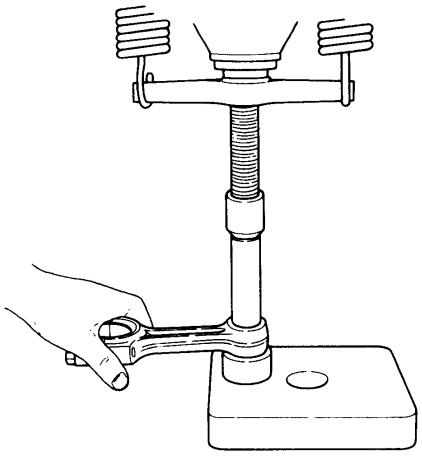
mm (in.)

	Standard	Wear limit
Piston pin bushing inside dia.	26.025 ~ 26.038 (1.0246 ~ 1.0251)	26.1 (1.0275)
Piston pin and bushing oil clearance	0.025 ~ 0.051 (0.0009 ~ 0.002)	0.11 (0.0043)

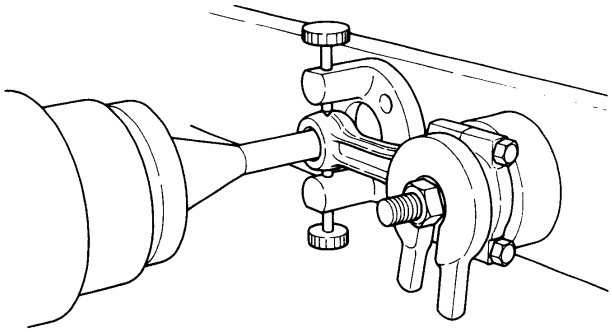
(2) Replacing piston pin bushing

1) When the bushing for the connecting rod piston pin is either worn out or damaged, replace it by using the "piston pin extracting tool" installed on a press.

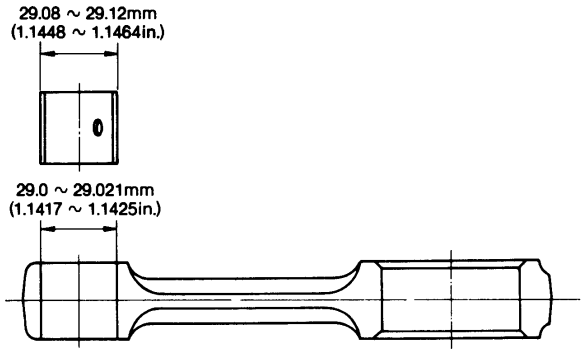


NOTE: Force the piston pin bushing into position so that its oil hole coincides with the hole on the small end of the connecting rod.

2) After forcing the piston pin bushing into position, finish the inner surface of the bushing by using a pin honing machine or reamer so that it fits the piston pin to be used.

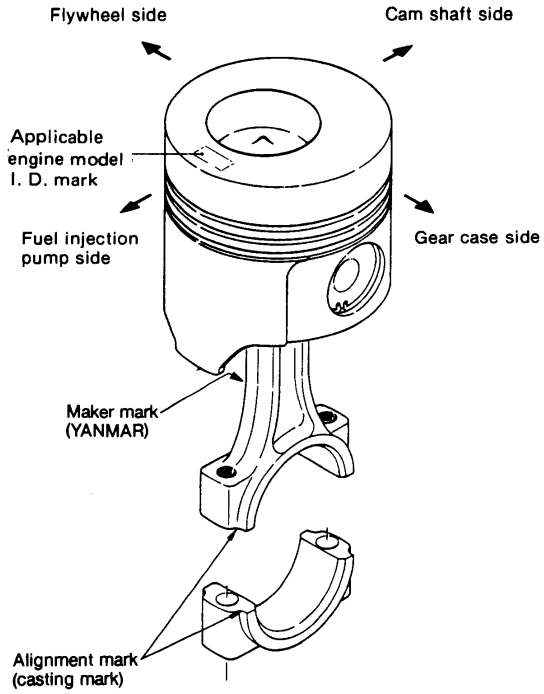


NOTE: Attach the bushing to the piston pin so that a pin, coated with engine oil can be pushed into position with your thumb.



5-4 Assembling piston and connecting rod

The piston and connecting rod should be assembled so that the match mark on the connecting rod large end faces the fuel injection pump side and the combustion chamber above the piston is close to the fuel injection pump.



I. D. Mark for Piston

	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	2	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	A	4JHE	E/#01001 and after
	B	4JH-TE	E/#11001 and after
	C	4JH-HTE	E/#21001 and after
	C	4JH-DTE	E/#30101 and after

*Engines produced at YANMAR plant on and after June 21, 1985

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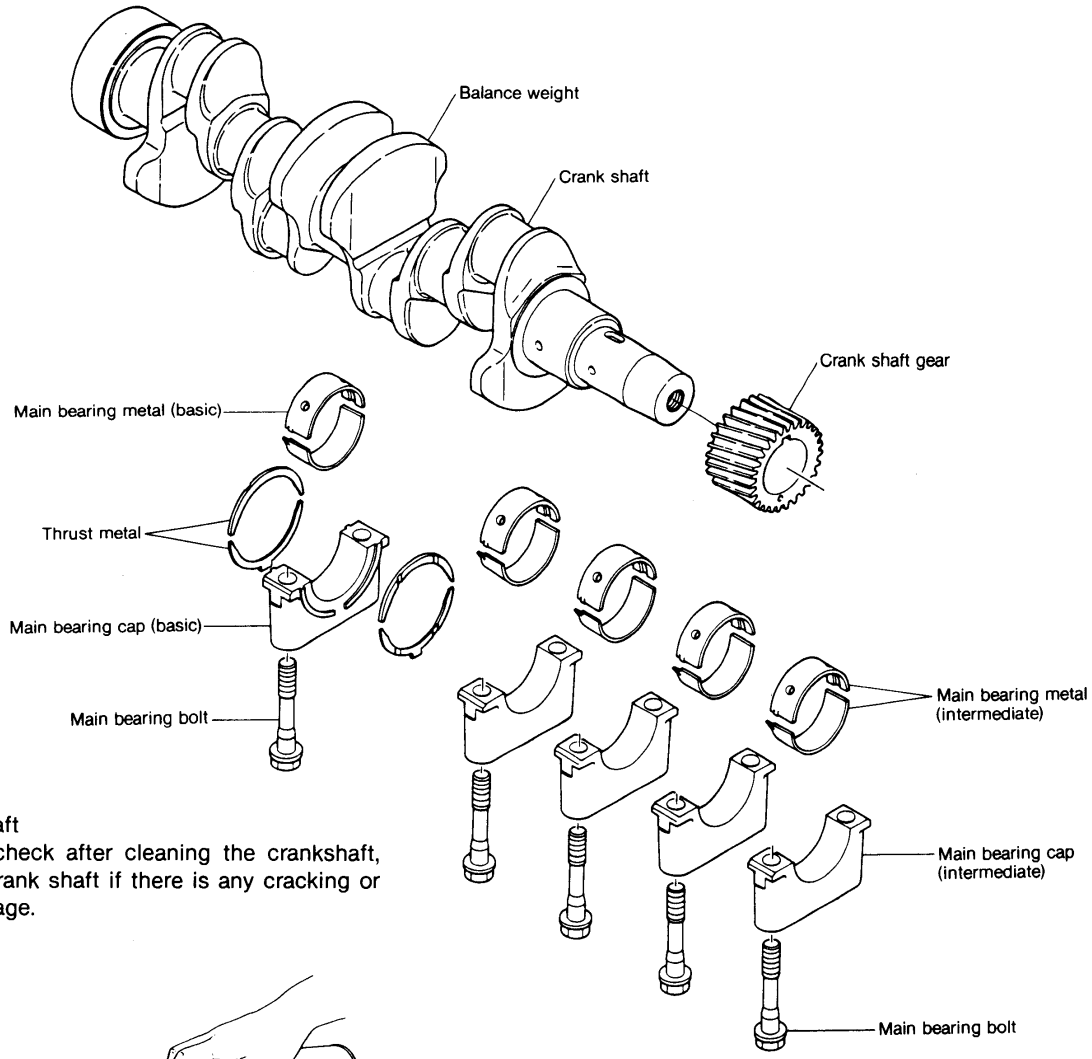
6. Crankshaft and Main Bearing

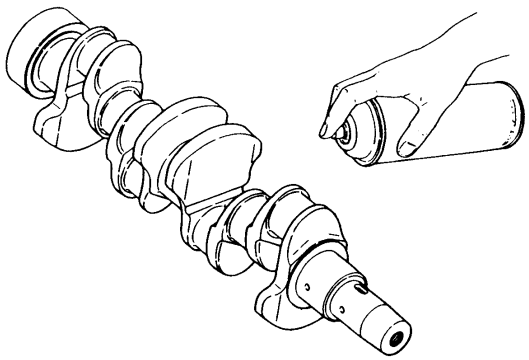
The crank pin and crank journal have been induction hardened for superior durability, and the crankshaft is provided with four balance weights for optional balance. The crankshaft main bearing is of the hanger type. The upper metal (cylinder block side) is provided with an oil groove. There is no oil groove on the lower metal (bearing cap side). The bearing cap (location cap) of the flywheel side has a thrust metal which supports the thrust load.

IMPORTANT:
Although the size is identical, the crankshaft material of models 4JHE and 4JH-TE differ from that used in models 4JH-HTE and 4JH-DTE.
Please note that the crankshaft for models 4JHE and 4JH-TE cannot be used for models 4JH-HTE and 4JH-DTE since the crankshaft is not durable enough.



6-1 Crankshaft

(1) Color check of shaft
Perform a color check after cleaning the crankshaft, and replace the crank shaft if there is any cracking or considerable damage.



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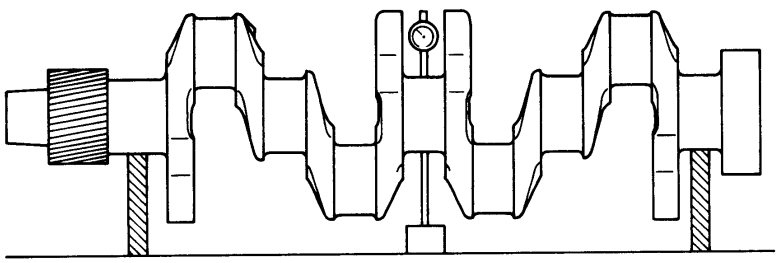
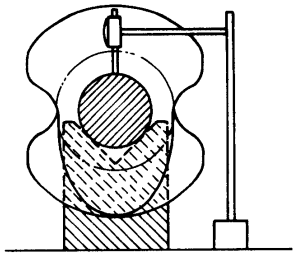
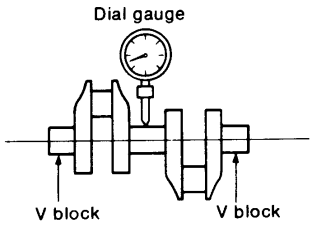
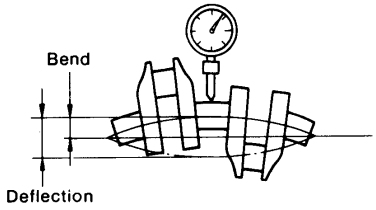
(2) Bending of the crankshaft
Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check the extent of crankshaft bending.



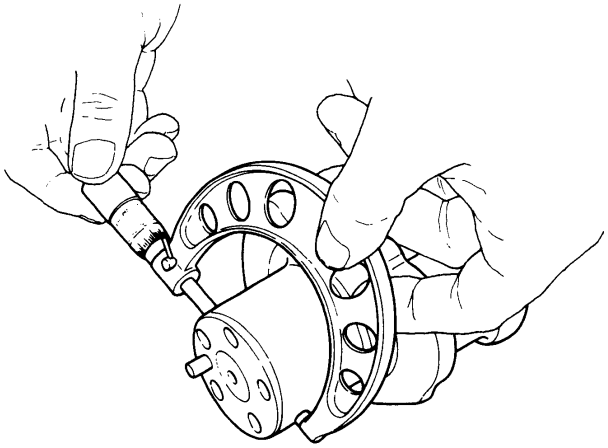


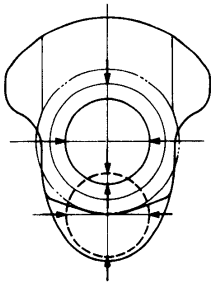


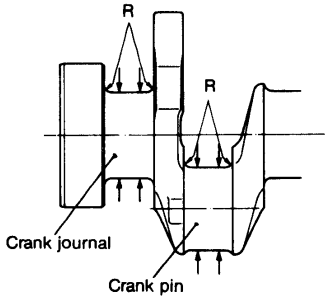


Crankshaft bend	Less than 0.02mm (0.0007 in.)

(3) Measuring the crank pin and journal
Measure the extent of journal wear (roundness, taper). Regrind it to the proper shape if it is within the outer diameter limit, and replace if not.







mm (in.)

		Standard	Wear limit
Crank pin	Outside dia.	47.952 ~ 47.962 (1.8878 ~ 1.8882)	47.75 (1.8799)
	Bushing inside dia.	48.000 ~ 48.045 (1.8897 ~ 1.8915)	48.10 (1.8937)
	Crank pin and bushing oil clearance	0.038 ~ 0.093 (0.0014 ~ 0.0036)	0.25 (0.0098)
Crank journal	Outside dia.	49.952 ~ 49.962 (1.9666 ~ 1.9670)	49.75 (1.9586)
	Bushing inside dia.	50.000 ~ 50.045 (1.9685 ~ 1.9702)	50.10 (1.9724)
	Crank journal and bushing oil clearance	0.038 ~ 0.093 (0.0014 ~ 0.0036)	0.25 (0.0098)
Fillet rounding of crank pin and journal		3.500 ~ 3.800 (0.1377 ~ 0.1496)	

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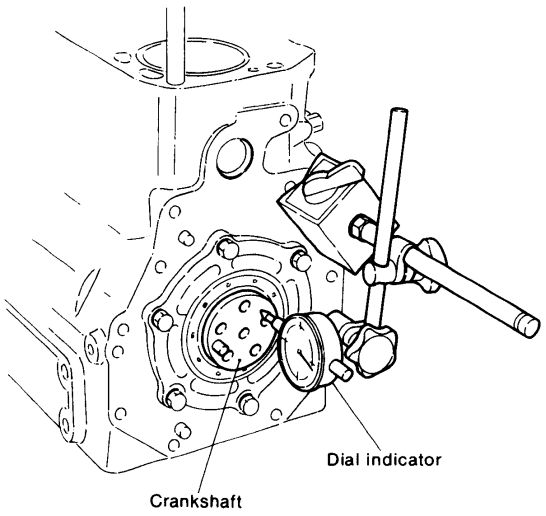
(4) Checking side clearance of the crankshaft
After assembling the crankshaft, tighten the main bearing cap to the specified torque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.
This measurement can also be effected by inserting the gauge directly into the clearance between the thrust bearing and crankshaft thrust surface.
Replace the thrust bearing if it is worn beyond the limit.

mm (in.)

	Standard	Wear limit
Crankshaft side gap	0.090 ~ 0.271 (0.0035 ~ 0.0106)	0.30 (0.0118)

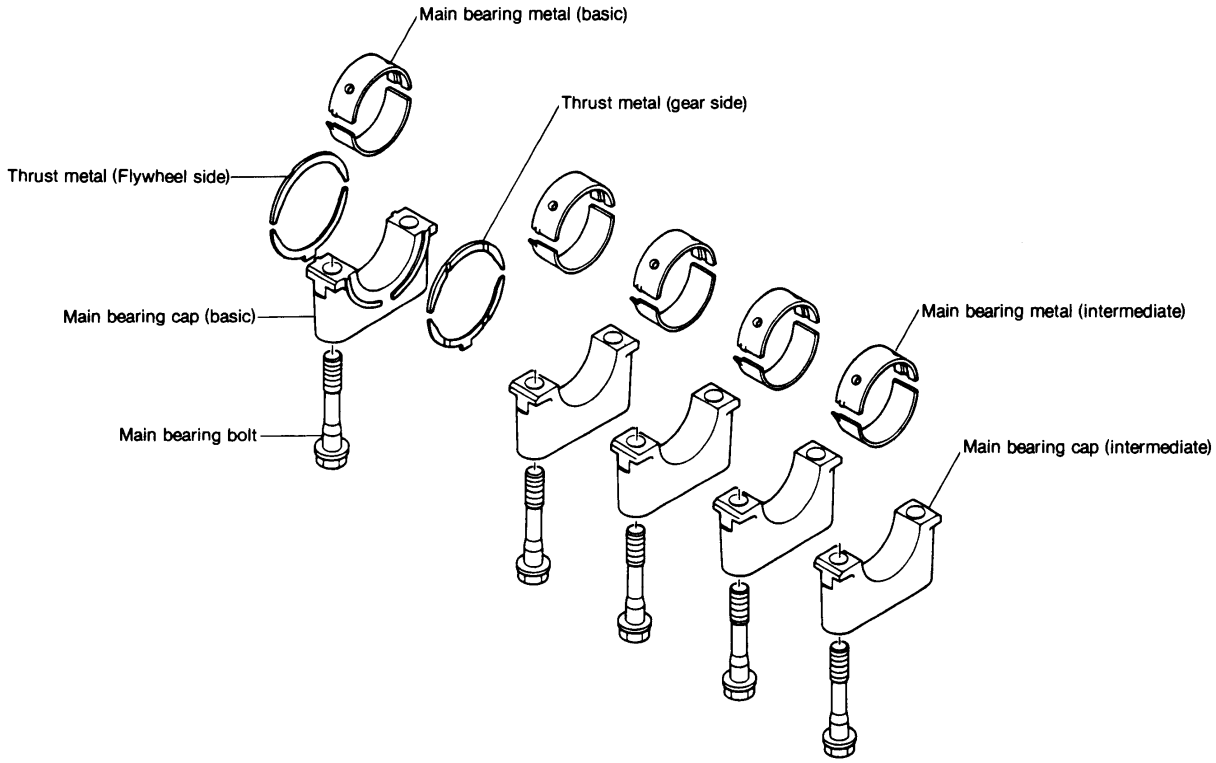


6-2 Main bearing

(1) Inspecting the main bearing
Check for flaking, seizure or burning of the contact surface and replace if necessary.
(2) Measuring the inner diameter of metal
Tighten the cap to the specified torque and measure the inner diameter of the metal.

Bearing cap bolt tightening torque	9.5 ~ 10.5 kg-m (68.71 ~ 75.84 ft-lb)

NOTE: When assembling the bearing cap, keep the following in mind.
1) The lower metal (cap side) has no oil groove.
2) The upper metal (cylinder block side) has an oil groove.
3) Check the cylinder block alignment No.
4) The "FW" on the cap lies on the flywheel side.



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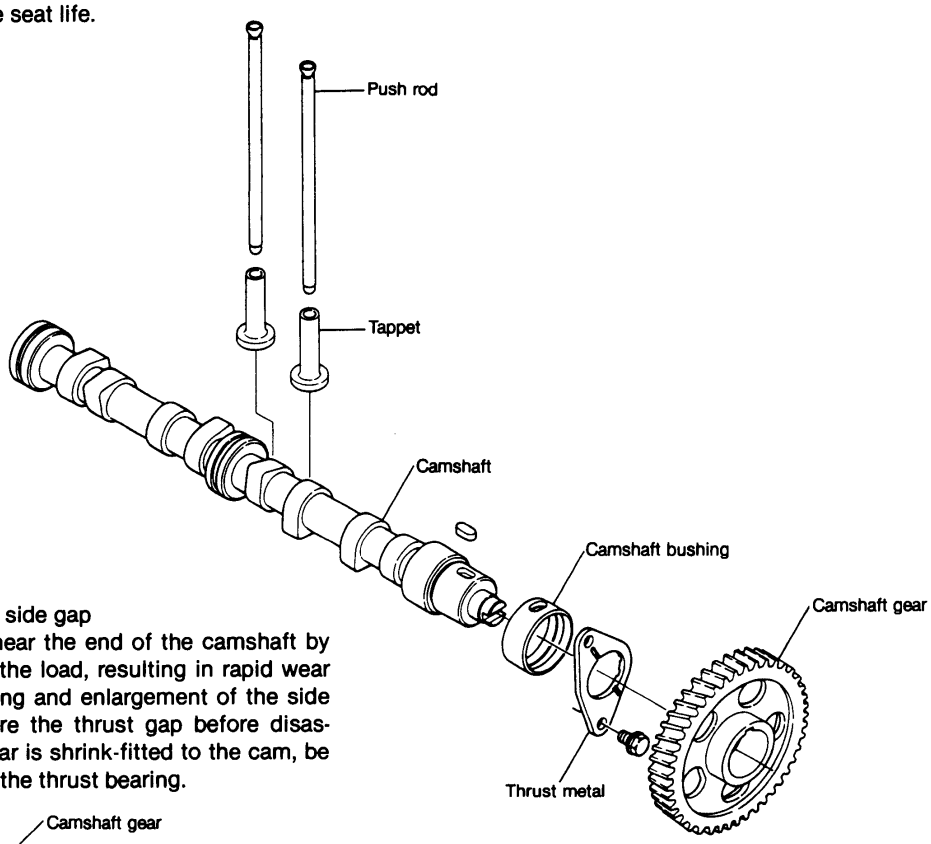
7. Camshaft and Tappets

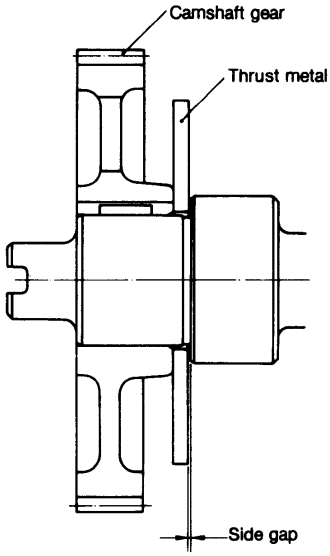
7-1 Camshaft

The camshaft is normalized and the cam and bearing surfaces are surface hardened and ground. The cams have a curve that minimizes the repeated shock on the valve seats and maximizes valve seat life.



(1) Checking the camshaft side gap

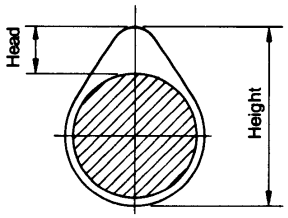
The standard bearing near the end of the camshaft by the cam gear receives the load, resulting in rapid wear of the end of the bearing and enlargement of the side gap. Therefore, measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the thrust bearing.



mm (in.)

	Standard	Wear limit
Camshaft side gap	0.05 ~ 0.25 (0.0019 ~ 0.0098)	0.4 (0.0157)

(2) Measure the camshaft height, and replace the cam if it is worn beyond the limit.



Camshaft height mm (in.)

Engine model		Standard	Wear limit
4JHE	Intake cam	38.66 ~ 38.74 (1.5220 ~ 1.5251)	38.4 (1.5118)
	Exhaust cam		
4JH-TE 4JH-HTE 4JH-DT(B)S	Intake cam	38.66 ~ 38.74 (1.5220 ~ 1.5251)	38.4 (1.5118)
	Exhaust cam	38.86 ~ 38.94 (1.5299 ~ 1.5330)	38.6 (1.5196)

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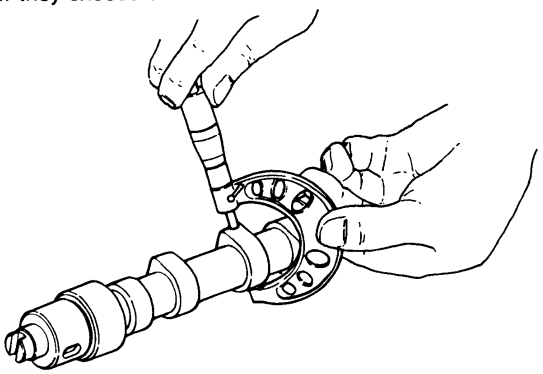
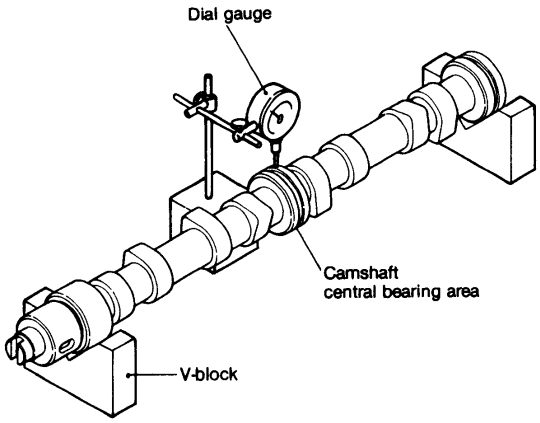
(3) Measure the camshaft outer diameter and the camshaft bearing inner diameter. Replace if they exceed the wear limit or are damaged.



mm (in.)

	Standard			Wear limit
	Gear case side	Intermediate	Flywheel side	
Camshaft journal outside dia.	44.925 ~ 44.950 (1.7687 ~ 1.7696)	44.910 ~ 44.935 (1.7681 ~ 1.7690)	44.925 ~ 44.950 (1.7687 ~ 1.7696)	44.8 (1.7637)
Camshaft journal bushing inside dia.	44.990 ~ 45.050 (1.7712 ~ 1.7736)	—	—	—
Cylinder block bearing inside dia.	—	45.000 ~ 45.025 (1.7716 ~ 1.7726)	45.000 ~ 45.025 (1.7716 ~ 1.7726)	—
Oil clearance	0.040 ~ 0.130 (0.0015 ~ 0.0050)	0.065 ~ 0.115 (0.0025 ~ 0.0045)	0.050 ~ 0.100 (0.0019 ~ 0.0039)	0.2 (0.0078)

(4) Bending of the crankshaft
Support both ends of the crankshaft with V-blocks, place a dial gauge against the central bearing areas and measure bending. Replace if excessive.



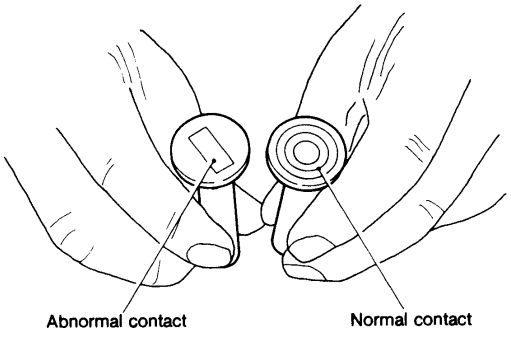
NOTE: The reading on the dial gauge is divided by two to obtain the extent of bending.

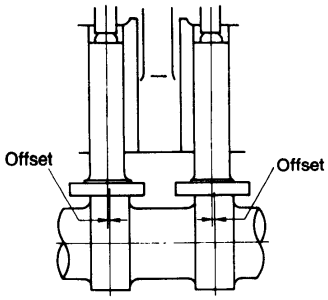
mm (in.)

	Wear limit
Camshaft deflection	0.02 (0.0007)

7-2 Tappets

(1) The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.





NOTE: When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.

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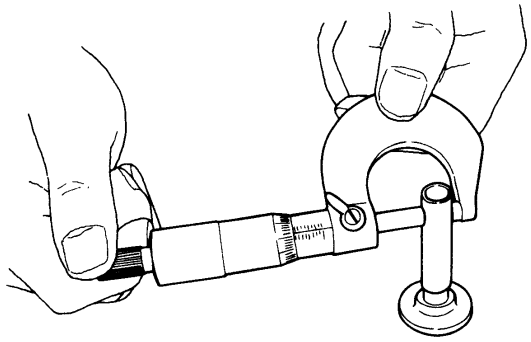
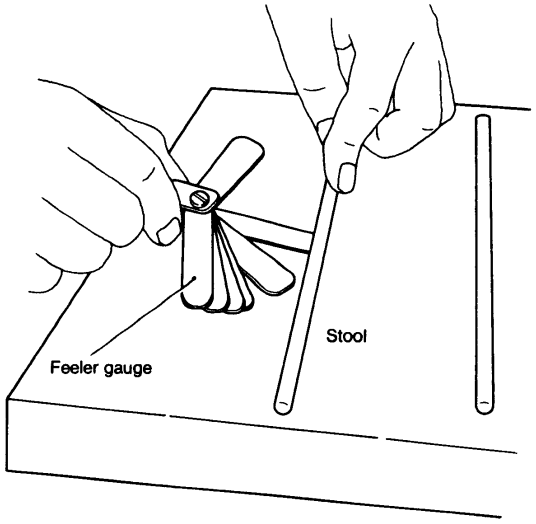
(2) Measure the outer diameter of the tappet, and replace if worn beyond the limit.



mm (in.)

	Standard	Wear limit
Tappet stem outside dia.	11.975 ~ 11.990 (0.4714 ~ 0.4720)	11.93 (0.4696)
Tappet guide hole inside dia. (cylinder block)	12.000 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)
Tappet stem and guide hole oil clearance	0.010 ~ 0.043 (0.0003 ~ 0.0016)	0.10 (0.0039)

(3) Measuring push rods.
Measure the length and bending of the push rods.

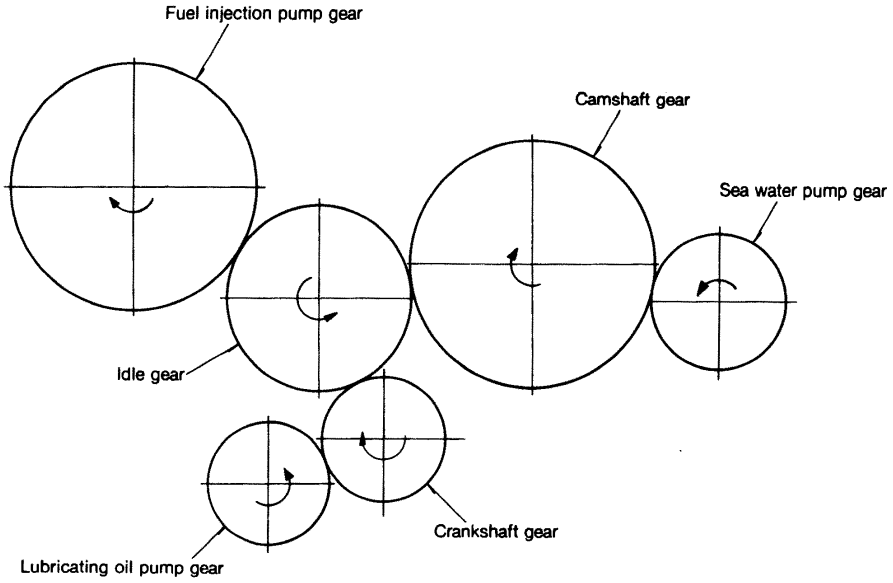


mm (in.)

	Standard	Wear limit
Push rod length	178.25 ~ 178.75 (7.0177 ~ 7.0374)	—
Push rod bend	Less than 0.03 (0.0011)	0.3 (0.0118)
Push rod dia.	8 (0.3149)	—

8. Timing Gear

The timing gear is helical type for minimum noise and specially treated for high durability.



mm (in.)

	No. of teeth	Face width	Spiral angle	Center distance	Back lash	Back lash Wear limit
Sea water pump gear	31	12.0	right	92.544 ~ 92.592 (3.6434 ~ 3.6453)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Camshaft gear	56	18.0	left	105.318 ~ 105.380 (4.1463 ~ 4.1488)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Idle gear	43	18.0	right	75.525 ~ 75.573 (2.9734 ~ 2.9753)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Crankshaft gear	28	40.0	left	60.629 ~ 60.677 (2.3869 ~ 2.3888)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Lubricating oil pump gear	29	8.0	right			
Idle gear	43	18.0	right	105.254 ~ 105.316 (4.1438 ~ 4.1462)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Fuel injection pump gear	56	10.0	left			

8-1 Inspecting the gears

(1) Inspect the gears and replace if the teeth are damaged or worn.

(2) Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

NOTE: If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.

(3) Idling gear

The bushing is pressure fitted into the idling gear. Measure the bushing inner diameter and the outer diameter of the shaft, and replace the bushing or idling gear shaft if the oil clearance exceeds the wear limit.

A, B and C are inscribed on the end of the idling gear. When assembling, these marks should align with those on the cylinder block.

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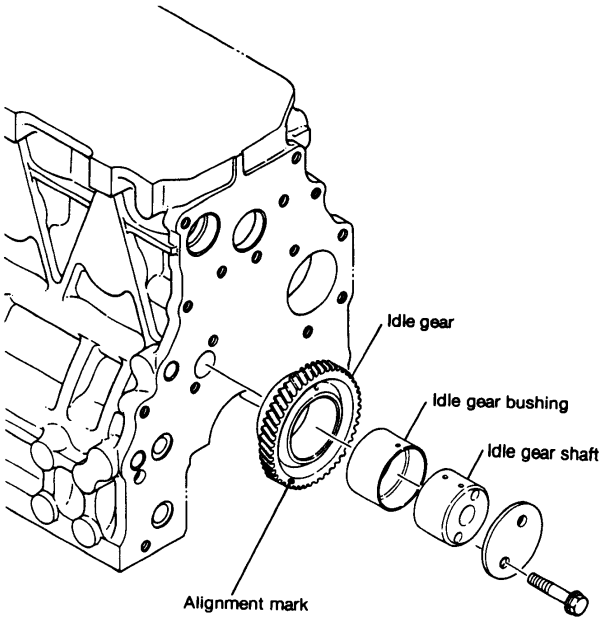
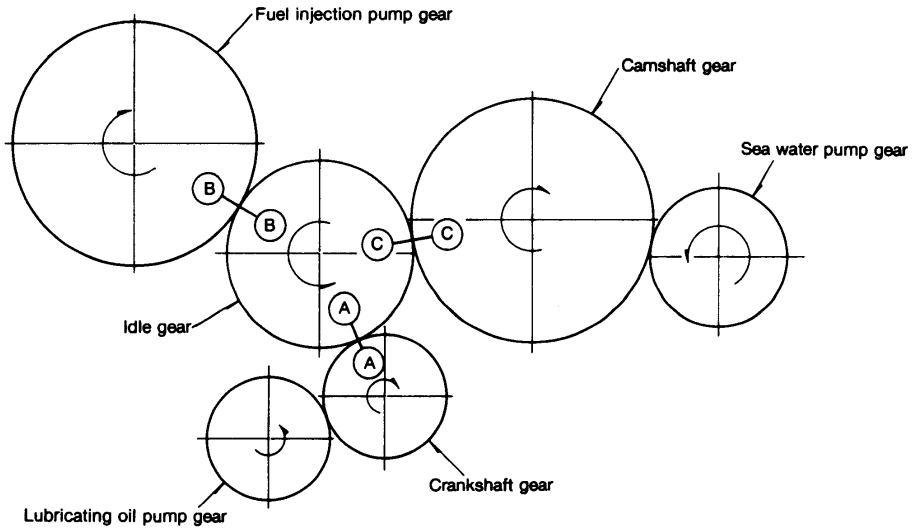


mm (in.)

	Standard	Wear limit
Idle shaft dia.	45.950 ~ 45.975 (1.8090 ~ 1.8100)	45.88 (1.8062)
Idle shaft bushing inside dia.	46.000 ~ 46.025 (1.8110 ~ 1.8120)	—
Idle shaft and bushing oil clearance	0.025 ~ 0.075 (0.0009 ~ 0.0029)	0.15 (0.0059)

8-2 Gear timing marks

Match up the timing marks on each gear when assembling (A, B and C).



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9. Flywheel and Housing

The function of the flywheel is, through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.
The flywheel is mounted and secured by 6 bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.
On the crankshaft side of the flywheel is the fitting surface for the damper disc, through which the rotation of the crankshaft is transmitted to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.
The flywheels unbalanced force on the shaft center must be kept below the specified value for the crankshaft as the flywheel rotates with the crankshaft at high speed. To achieve this, the balance is adjusted by drilling holes in the side of the flywheel, and the unbalanced momentum is adjusted by drilling holes in the circumference.
The ring gear is shirink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.
The stamped letter and line which show top dead center of each cylinder are positioned on the flywheel circumference, and by matching these marks with the arrow mark at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

9-1 Specifications of flywheel

Outside dia. of flywheel		mm	ø330
Width of flywheel		mm	47
Weight of flywheel (including ring gear)		kg	13.17
GD^2 value		$kg\text{-}m^2$	1.10
Circumferential speed		m/s	62.2 (3600rpm)
Speed fluctuation rate		δ	1/346 (3600rpm)
Allowable amount of unbalance		g-cm	22
Fixing part of damper disc	Pitch circle dia. of bolts	mm	170
	No. of bolts × bolt dia.		6-M8 thread equally spaced
Fixing part of crankshaft	Pitch circle dia. of bolts	mm	66
	No. of thread holes	mm	6-M10
	Fit joint dia.		ø85.000 ~ 85.035
Model of reduction and reversing gear			KBW-20 & KBW-21
Mounting flange No.			SAE No.4 (in metric unit)
Ring gear	Center dia.	mm	322.58
	No of teeth		127

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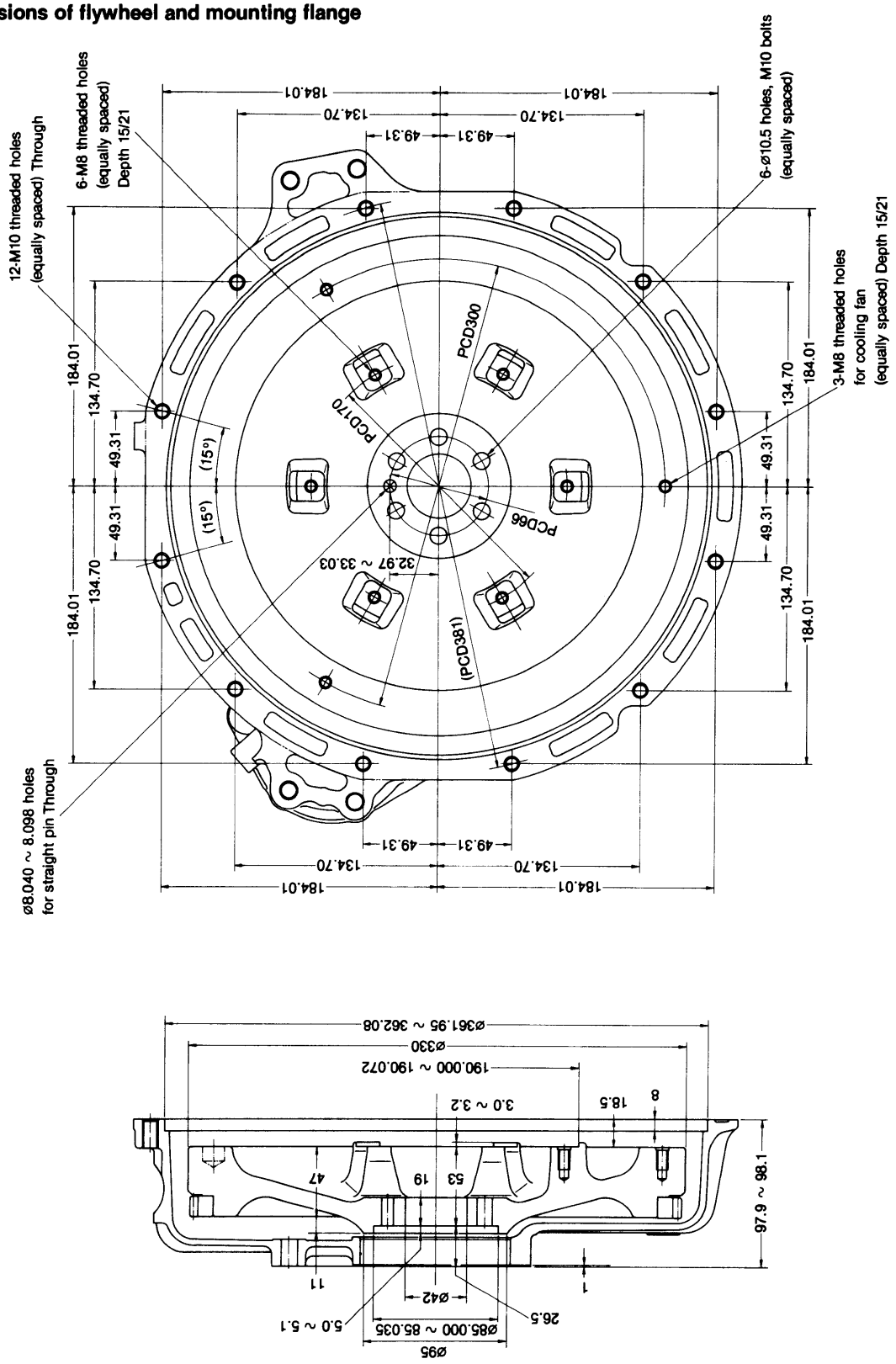
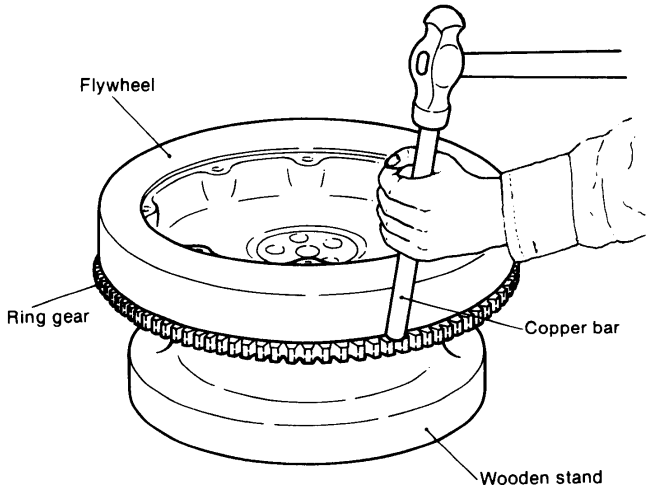
9-2 Dimensions of flywheel and mounting flange



9-3 Ring gear

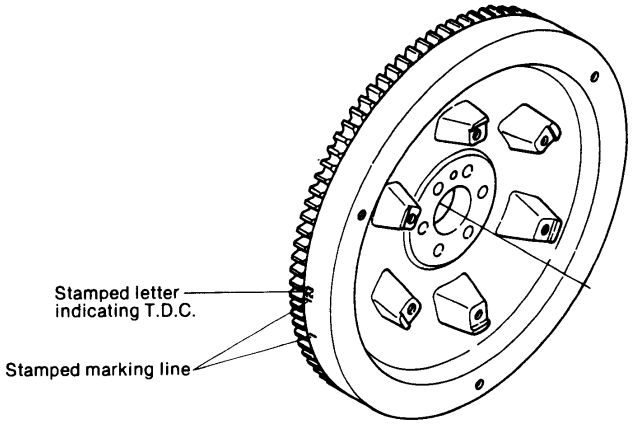
When replacing the ring gear due to excessive wear or damaged teeth, heat the ring gear evenly at its circumference, and after it has expanded drive it gradually off the flywheel by tapping it with a hammer, a copper bar or something similar around the whole circumference.

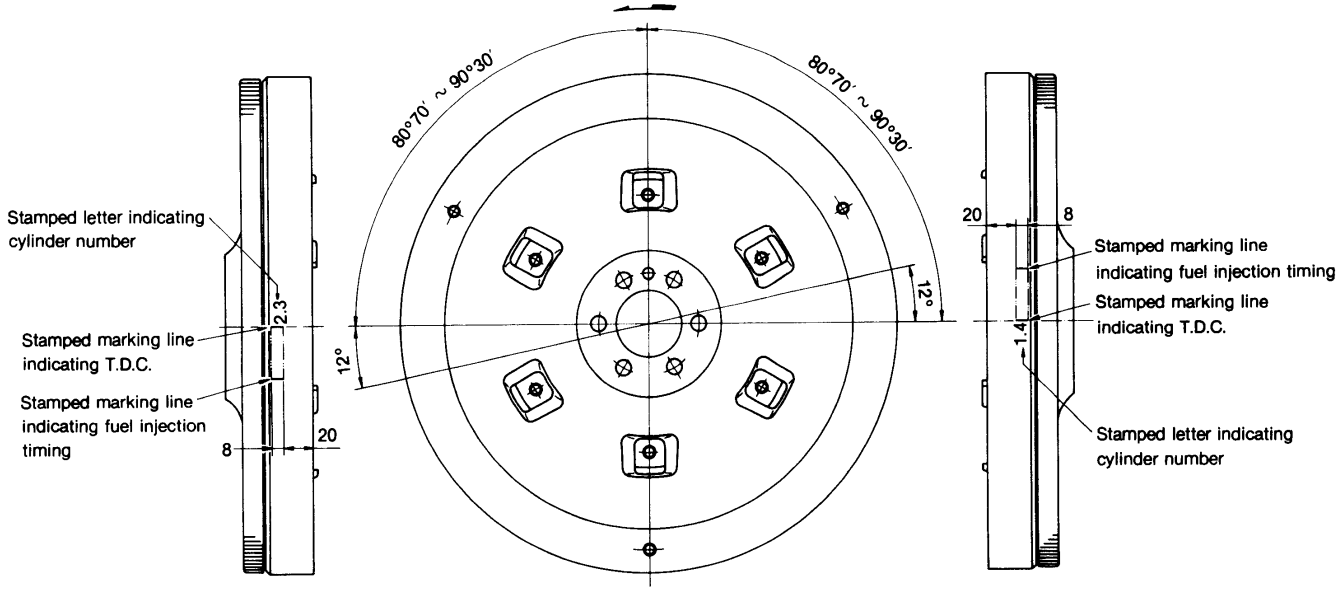
	mm (in.)
Interference of ring gear	0.158 ~ 0.250 (0.0062 ~ 0.0098)



9-4 Position of top dead center and fuel injection timing

(1) Marking





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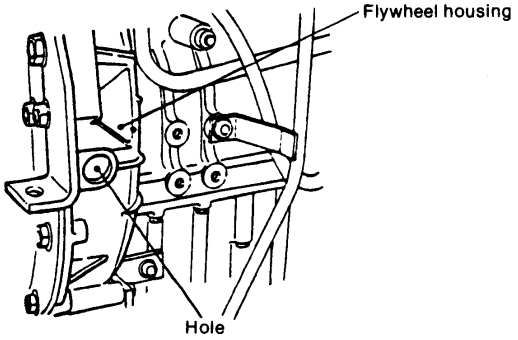
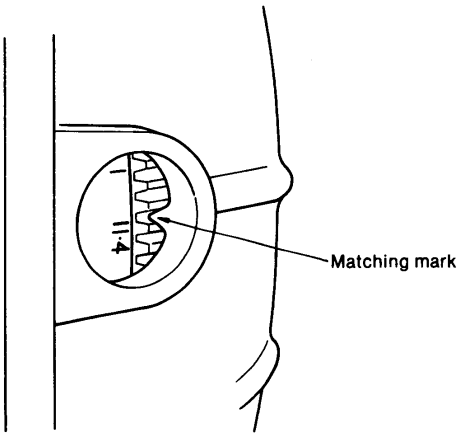
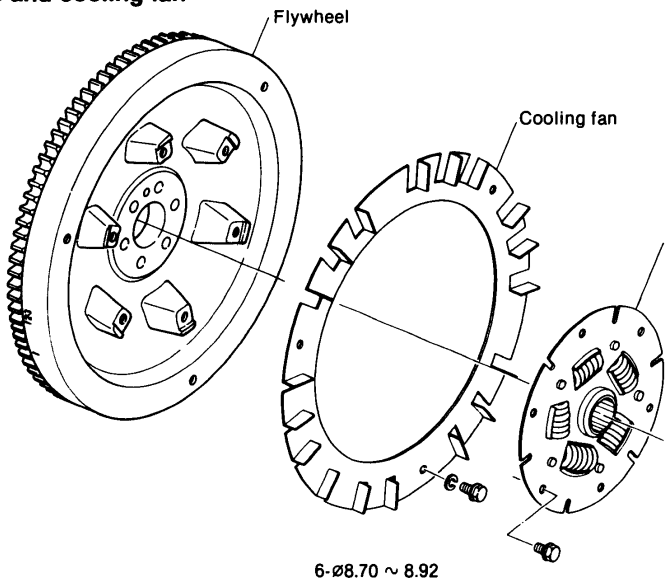
(2) Matching mark



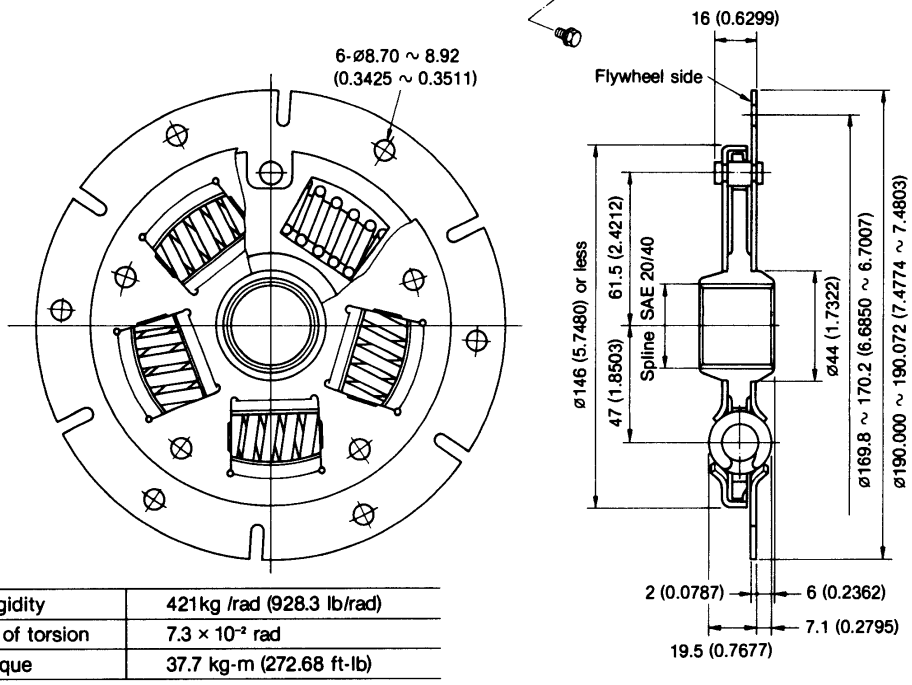


The matching mark is made at the hole of the flywheel housing.

9-5 Damper disc and cooling fan



mm (in.)



Torsional rigidity	421kg /rad (928.3 lb/rad)
Max. angle of torsion	7.3 × 10^{-2} rad
Stopper torque	37.7 kg-m (272.68 ft-lb)

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CHAPTER 3

FUEL INJECTION EQUIPMENT

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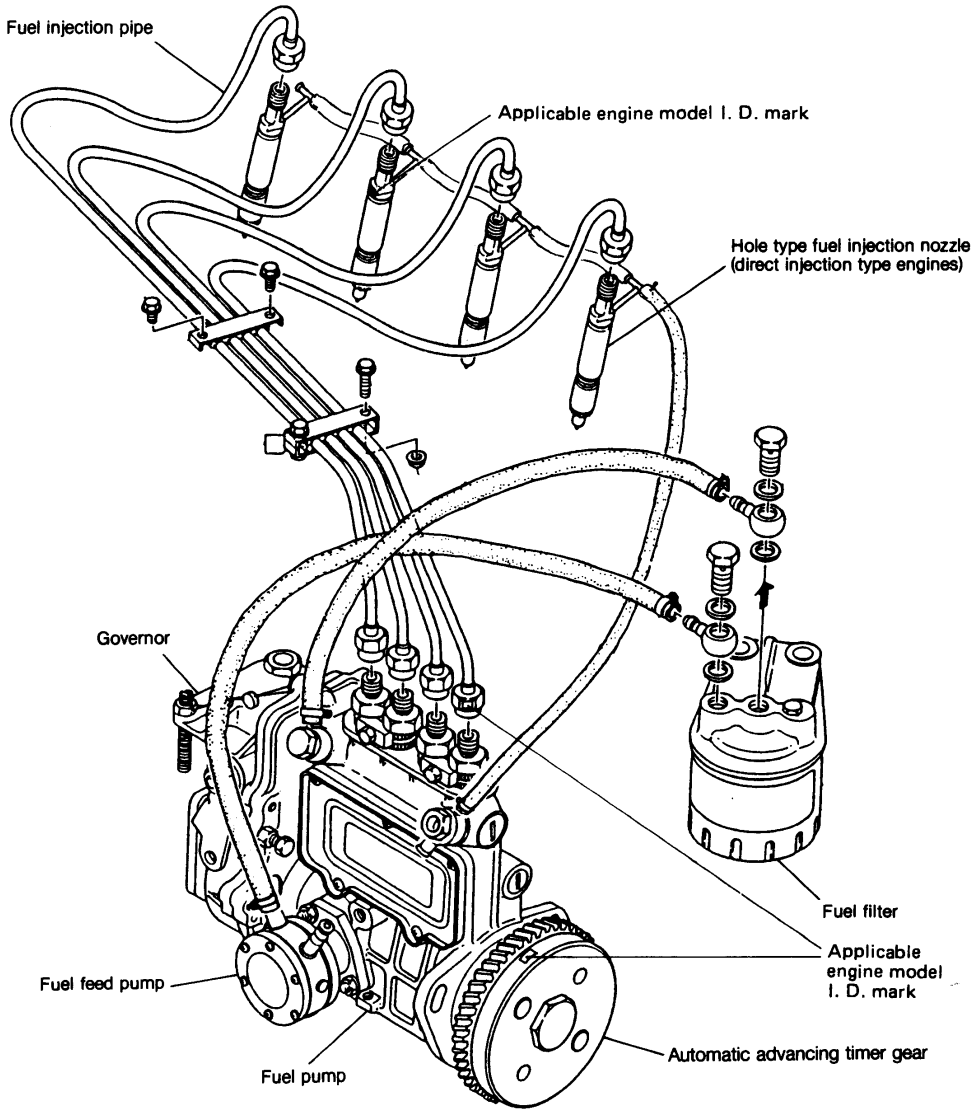
1. Fuel Supply System

The Yanmar fuel injection pump is Bosch cluster type, the cam shaft of which is driven by the engine gears through the timing gear. The feed pump, driven by the cam shaft, pumps fuel oil from the fuel tank to the fuel filter at a pressure of 0.3kg/cm². The filtered fuel is supplied to the reservoir in the pump housing, the plunger increases the pressure, and the fuel goes through the injection pipe to be injected into each cylinder by the fuel injection nozzles.

IMPORTANT:
Automatic timer assembly, fuel injection nozzle assembly and injection pipe differ among engine models. When incorrect parts are installed, engine performance will drop.
Be sure to check the applicable engine model identification marks (I. D. Marks) provided on each part to insure use of the correct part.



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I. D. Marks for Automatic Timer Assembly

		I. D. Mark	Applicable Engine Model & E/#	
Automatic Timer Ass'y (Automatic Advancing Timer)	Old type	JH-A0	4JHE	E/# 00101 ~ 00574
		JH-A1	4JHE	E/# 01000 and before
		JH-B0	4JH-TE	E/# 11000 and before
		JH-C0	4JH-HTE	E/# 21000 and before
	New type	TN-A0	4JHE	E/# 01001 and after
		JH-C0	4JH-TE	E/# 11001 and after
			4JH-HTE	E/# 21001 and after
			4JH-DTE	E/# 30101 and after

I. D. Marks for Fuel Injection Nozzle Assembly and Fuel Injection Pipe

		I. D. Mark	Applicable Engine Model & E/#		Nozzle I. D. Mark
Fuel injection nozzle ass'y	Old type	A	4JHE	E/# 00101 ~ 00574	150P244J0
		E	4JHE	E/# 01000 and before	155P244J1
		B	4JH-TE	E/# 11000 and before	150P284J0
		D	4JH-HTE	E/# 21000 and before	145P265J1
	New type	F	4JHE	E/# 01001 and after	155P244J2
		G	4JH-TE	E/# 11001 and after	140P255J2
			4JH-HTE	E/# 21001 and after	
			4JH-DTE	E/# 30101 and after	

I. D. Marks for Fuel Injection Pipe

		I. D. Mark	Applicable Engine Model & E/#		Pipe Inner Dia
Fuel Injection Pipe (Pump to Nozzle)	Old type	None	4JHE	E/# 01000 and before	ϕ1.8
			4JH-TE	E/# 11000 and before	
		None	4JH-HTE	E/# 21000 and before	ϕ2.0
	New type	18	4JHE	E/# 01001 and after	ϕ1.8
			4JH-TE	E/# 11001 and after	
		20	4JH-HTE	E/# 21001 and after	ϕ2.0
			4JH-DTE	E/# 30101 and after	

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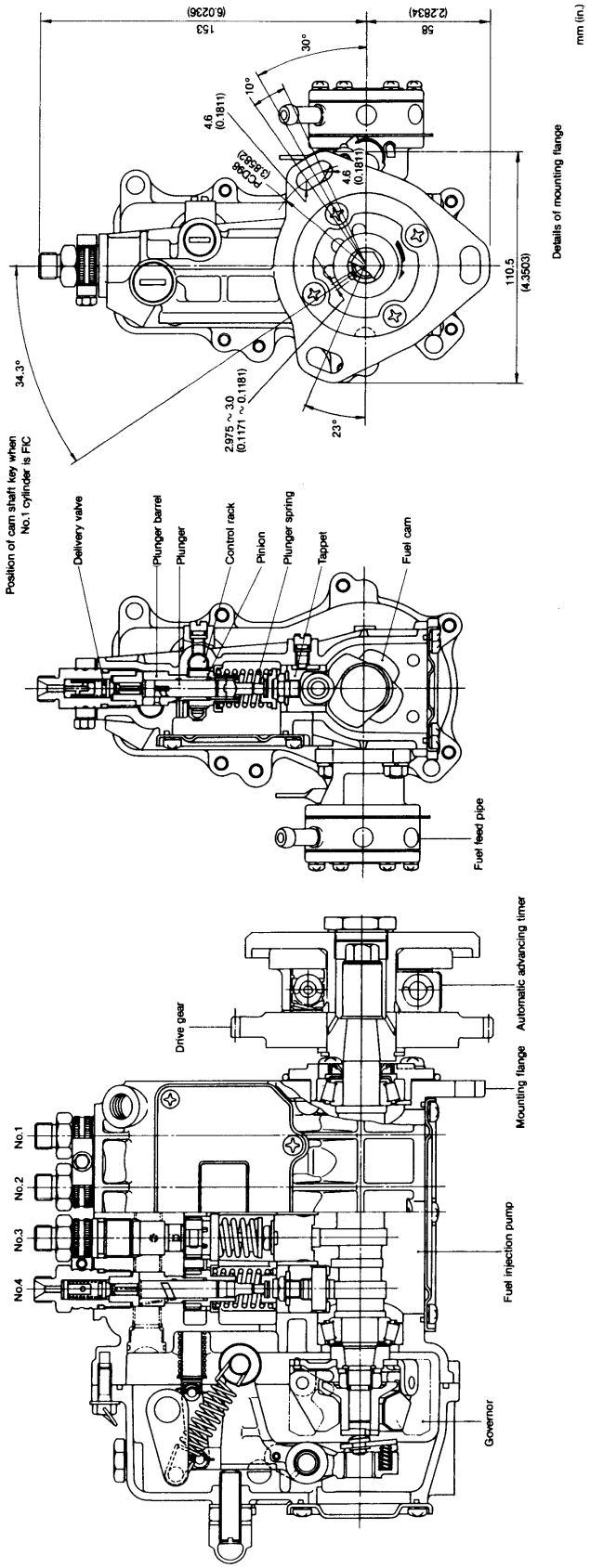
1-1 Fuel injection pump construction

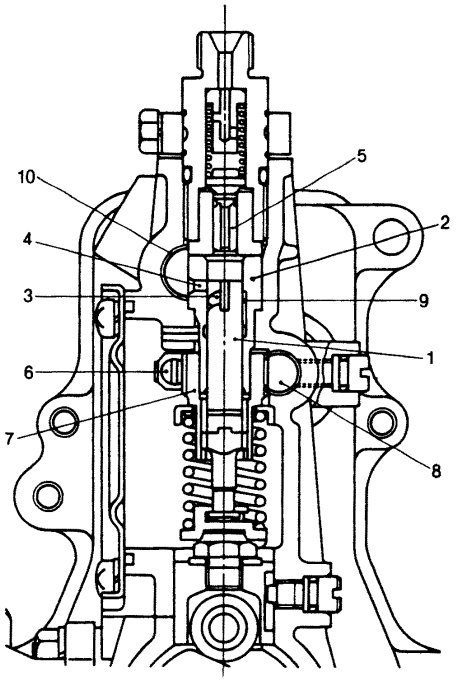


The Yanmar Model YPES Bosch type fuel injection pump is an in-line cluster type pump with a governor and timer incorporated.
A cam shaft is built into the fuel injection pump, which has a drive cam for the fuel supply pump and a tappet drive cam for the plunger. A timing gear and drive gear are mounted on the drive side of the cam shaft, and a governor weight on the opposite side.
As the plunger rises, the fuel oil opens the delivery valve and goes through the high pressure pipe to the fuel injection nozzles.
When the control rack connected to the governor lever moves, the pinion turns the plunger. This changes the fuel discharge and intake positions and in turn controls the amount of fuel injected.

1-2 Fuel injection pump specifications

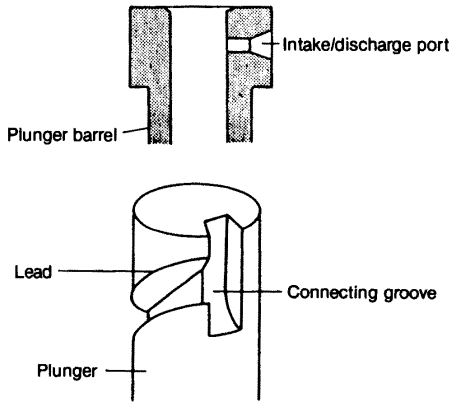
Type		YPES-CL
No of cylinders		4
Plunger dia.	mm (in.)	8 (0.3149)
Cam lift	mm (in.)	7 (0.2755)
Max. fuel injection volume	mm^3/st	65 (0.0039)
Max. fuel injection press.	kg/cm^2 ($lb/in.^2$)	450 (6399)
Max. cam shaft	rpm	2200
Direction of revolution		right (looking from drive side)

1-3 Functioning of fuel injection pump



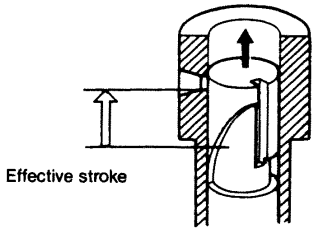
1. Plunger
2. Plunger barrel
3. Lead groove
4. Intake port
5. Delivery valve
6. Control sleeve
7. Control pinion
8. Control rack
9. Fuel leak return groove
10. Protector

The fuel injection pump supplies pressurized fuel to the injection nozzles through the action of the plunger. The plunger reciprocates in the plunger barrel through a fixed stroke and is lapped for a precise fit. A lead groove is helically cut in the plunger, and this leads to a connecting groove which goes to the top of the plunger.
There is a port in the plunger barrel which serves as both an intake and discharge port. The fuel comes through this port into the plunger chamber, is pressurized by the plunger, opens the delivery valve, flows to the fuel injection nozzle through the fuel injection pipe and is injected into the combustion chamber. Fuel injection terminates after the pressurized fuel has been discharged. This happens when the lead groove lines up with the discharge groove as the plunger rises and the pressure in the fuel injection pipe drops.
The control sleeve groove is fitted to the plunger flange. The control sleeve is secured to the control pinion and the pinion teeth and rack gear teeth are engaged.
The plunger is controlled by the rack, enabling continuous changing of the volume of fuel injected from zero to maximum. A fuel leak return hole is provided in the plunger barrel. This returns fuel leaking from the gap between the plunger and the barrel to the fuel lines. This prevents dilution of the lubricant in the cam chamber.



1-4 Injection volume control

(1) Full injection volume position
When the rack is set at the maximum setting, fuel injection starts earlier. It occurs when the widest part of the lead groove on the upper part of plunger lines up with the intake port in the barrel. At this time, the nar-



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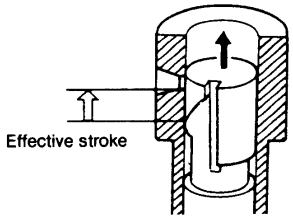
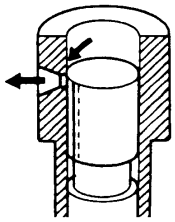
rowest part of the lower lead groove lines up with the discharge port, prolonging the length of injection and increasing the volume of fuel injected.
This setting is normally used for starting and max. output operation.

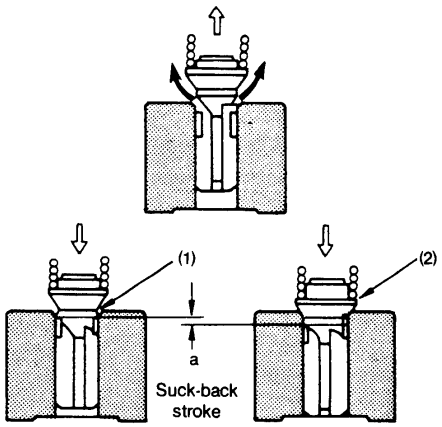
(2) Half injection volume position
When the rack is returned towards zero from the maximum setting, discharge starts later and ends earlier, decreasing the volume of fuel injected.



(3) No fuel injection
When the rack is set near zero, the intake/discharge port in the barrel is always open, so no fuel is pressurized (even though the plunger continues to reciprocate).



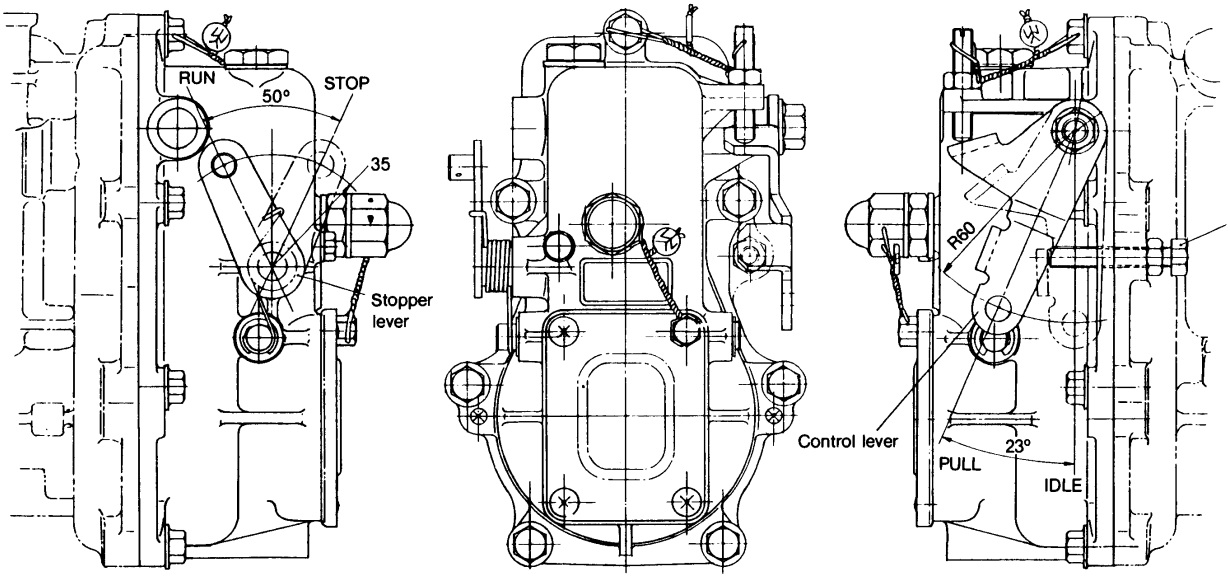
The delivery valve at the top of the plunger prevents fuel in the fuel injection pipe from flowing back to the plunger and sucks up fuel from the nozzle valve to prevent after drip.
When the plunger lead lines up with the discharge port of the plunger barrel, the injection pressure drops, and the delivery valve is brought down by the delivery valve spring.



At this time, the suck-back collar (1) blocks off the fuel injection pipe and the delivery chamber, and the valve continues to descend until the seat (2) comes in contact with the barrel. The fuel oil pressure in the fuel injection pipe decreases proportionately with the lowering of the valve (due to increased volume).
This accelerates closing of the nozzle valve, and sucks up fuel from the nozzle to prevent it from dripping.
This increases nozzle life and improves combustion efficiency.

1-5 Governor construction

Usage conditions of diesel engines are extremely varied, with a wide range of loads and rpms. The governor plays an important role in the operation of the engine by quickly adjusting the position of the control rack to control the amount of fuel injected according to changes in rpm.
It also automatically controls the engine to prevent engine rpm from exceeding the maximum, and keeps the engine from stopping.



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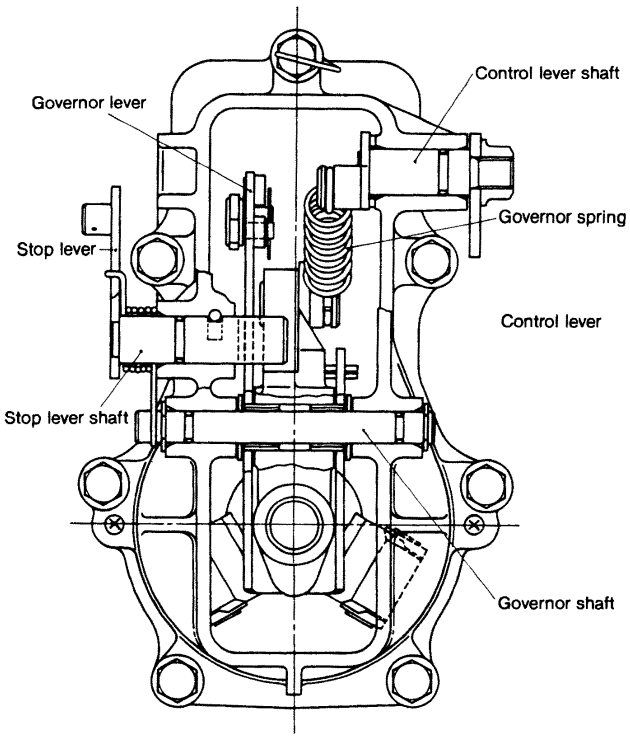
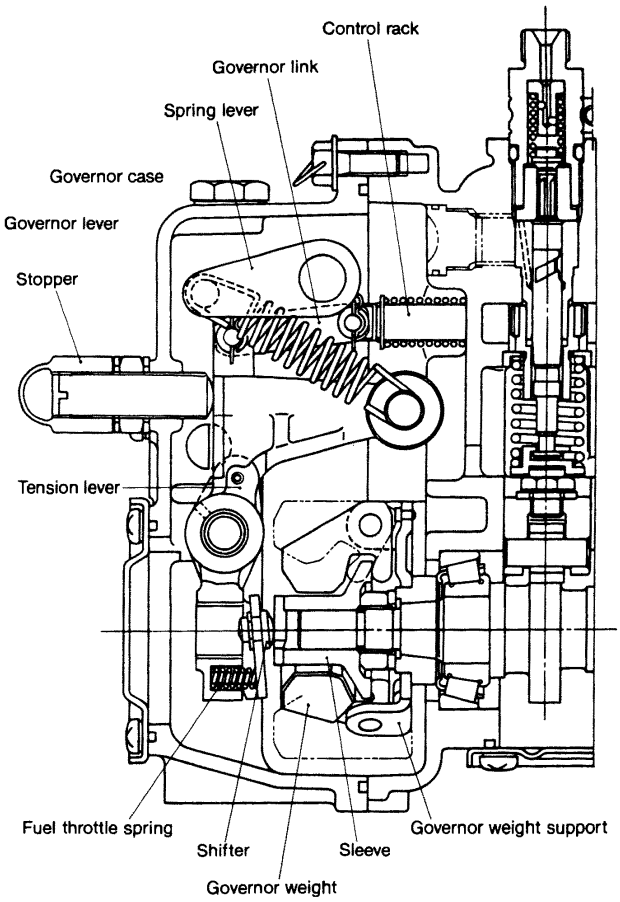
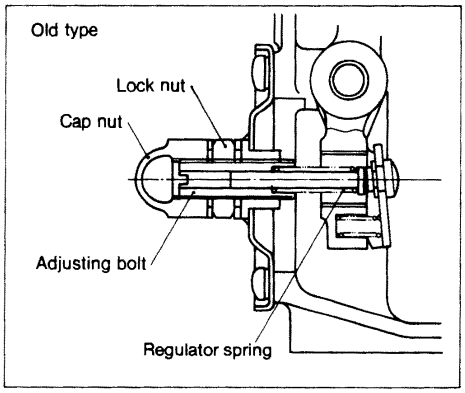
(1) A-type governor (without angleich spring)







This governor is all-speed, directly connected to the YPES-CL fuel injection pump. The construction will be explained with the cutaway views.

The governor weight mounted on the end of the fuel injection pump cam shaft rotates around the governor support pin, driven by the cam shaft, and is forced outwards by the centrifugal force acting on the weight.

The thrust force acting on the cam shaft due to this centrifugal force acts on the lower part of the tension lever through the sleeve. A starting throttle spring is mounted on the bottom of the tension lever.
One end of the governor spring is hooked to the right upper end of the tension bar, and the other end to the spring lever of the control lever shaft.

As the spring lever and control lever are mounted on the same shaft, when the control lever is turned towards full, the governor spring is pulled and the load gradually increases.
As the lever is turned, the spring force acting on the upper end of the tension lever and the thrust force acting on the lower end of the tension lever come into equilibrium, to obtain the specified rpm.

Since the tension bar can move freely around the governor shaft on the player bearing, as rpm increases and the shifter is pushed to the left, the tension bar rotates clockwise, and when rpm decreases, the tension bar rotates counterclockwise.

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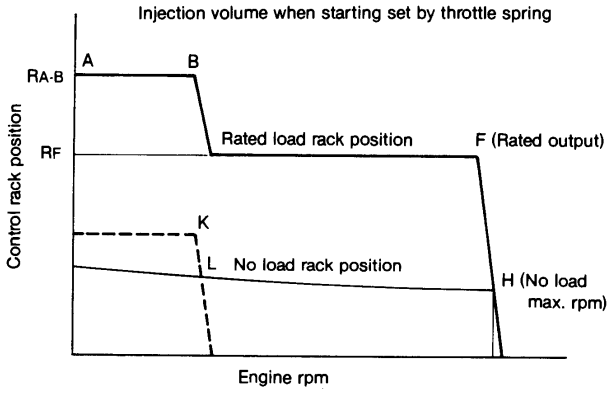
The governor lever rotates smoothly on the same governor shaft. The bottom part of this lever is in contact with the sleeve througn the shifter, which is in contact with the bottom of the tension lever through the throttle spring. It therefore moves with the tension lever according to increases/decreases in engine rpm.

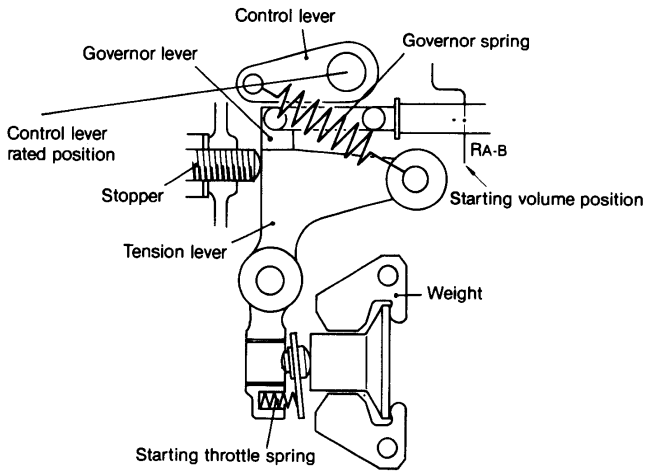
The top of the governor is connected to the fuel pump control rack by a link. The movement of the lever controls the volume of fuel injected by the pump. When rpm increases the lever rotates clockwise to cause the control rack to reduce fuel, and when rpm decreases the lever rotates counterclockwise to cause the control rack to increase fuel, thus controlling engine rpm.

The top of the tension bar comes in contact with the stopper built into the top of the governor case to limit the maximum fuel injection volume.

Function of governor (on 4JH Series)



(1) Starting control

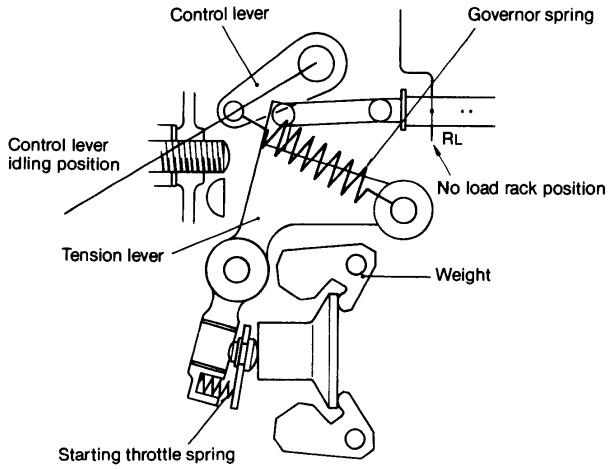


The control lever is set at the max. rpm position. The tension lever connected to the control lever is pulled as far as the stopper. The starting throttle spring mounted inbetween the tension lever and governor lever increases the governor weight thrust load, and the control rack is set at the max. injection volume position, to attain the starting volume.

(2) Idling control

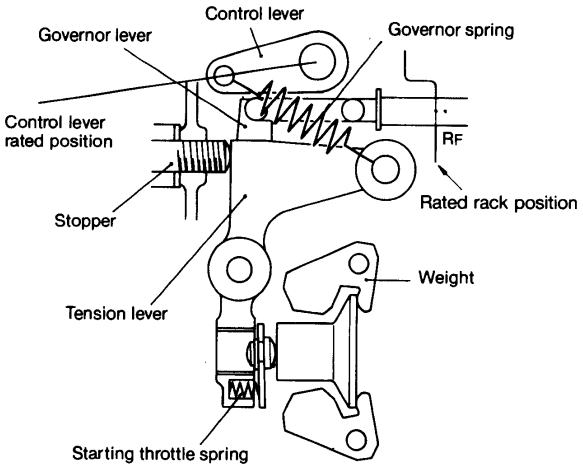
Idling control is effected by the governor spring as this engine is not provided with an idling spring.

When the control lever is returned to the idling position after starting, almost no tension acts on the governor spring. The thrust force of the governor weight, and the starting throttle spring and governor spring load, come into equilibrium, effecting idling speed control.

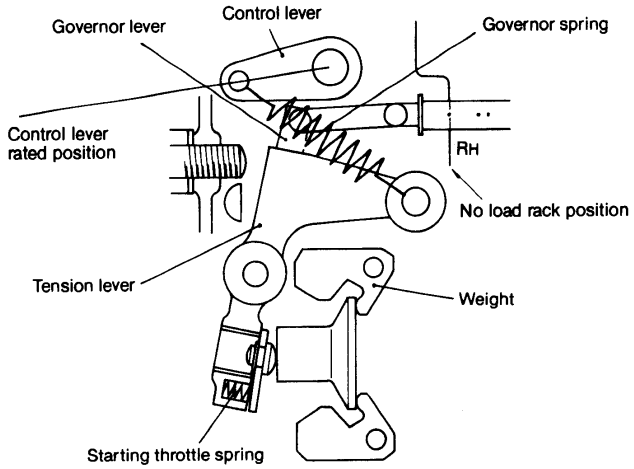


(3) Rated load max. rpm control

At rated load, the thrust load of the governor weight and the governor spring load are in equilibrium. The tension lever and governor lever come together and are limited by the stopper. The control rack is maintained at the position necessary for the rated load.



(4) No load max. rpm control
When rpm increases further from the max. load rpm control position, the thrust load of the governor weight exceeds that of the governor spring load, and causes the control rack to decrease injection volume through the tension lever and governor lever.



(5) Stopping engine
When you turn the stop handle, the governor causes the rack to decrease injection volume and stop the engine, regardless of the governor spring load.

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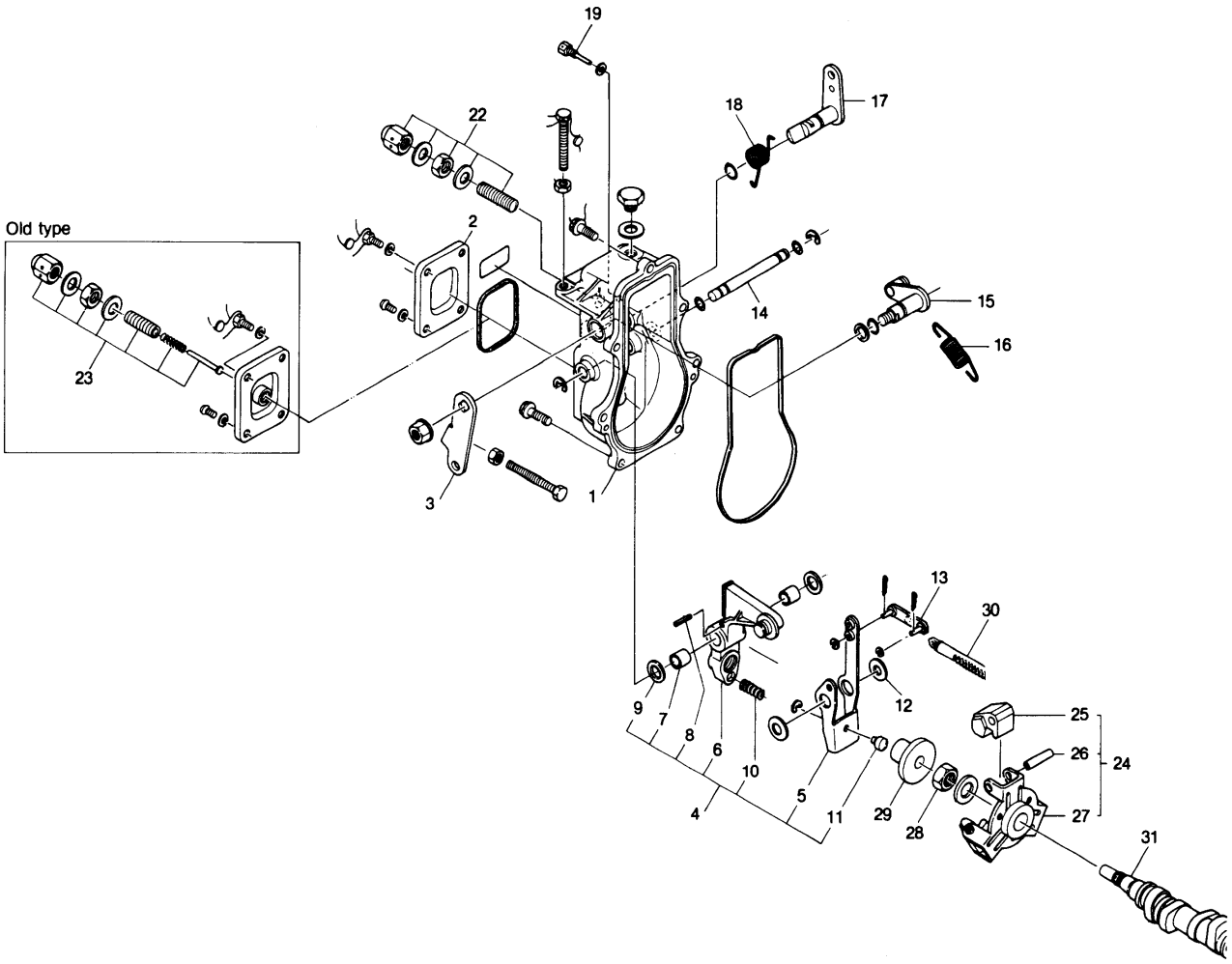
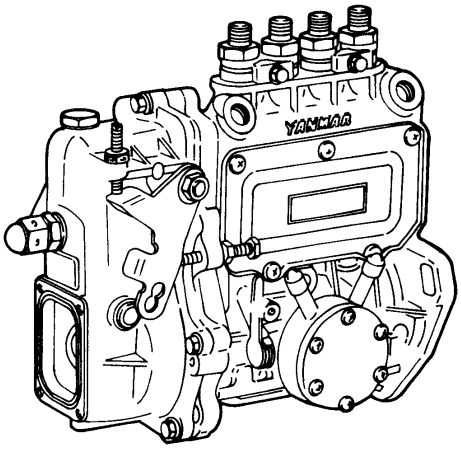
2. Disassembly, Reassembly and Inspection of Governor

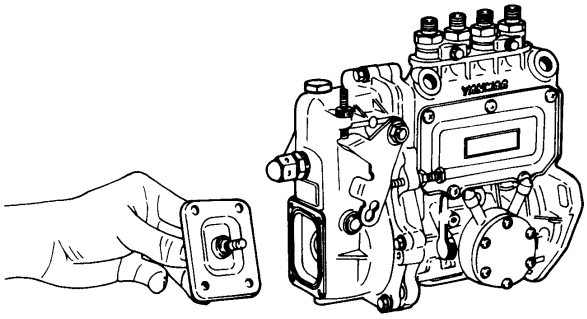


1. Governor case
2. Governor case cover
3. Control lever
4. Governor lever assembly
5. Governor lever
6. Tension lever
7. Bushing
8. Spring pin
9. Shim
10. Throttle spring
11. Shifter
12. Washer
13. Governor link
14. Governor shaft
15. Control lever shaft
16. Governor spring
17. Stop lever
18. Stop lever return spring
19. Stop lever stop pin
22. Fuel stopper (limit bolt) assembly
23. Adjusting spring assembly
24. Governor weight
25. Governor weight
26. Pin
27. Governor weight support
28. Governor weight nut
29. Governor sleeve
30. Control rack
31. Fuel pump cam shaft

2-1 Governor disassembly

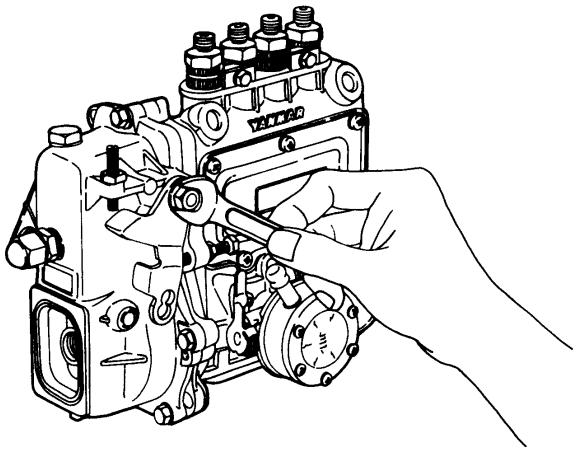
(1) Remove the governor case.



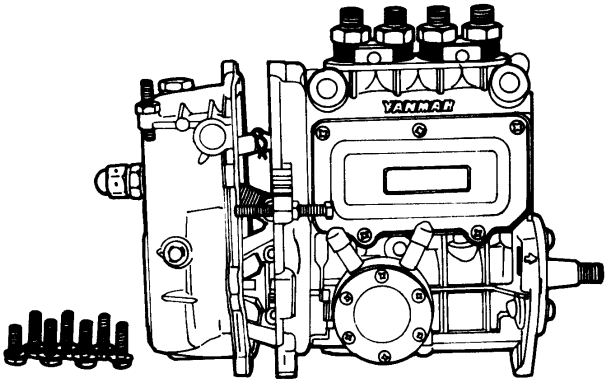


NOTE: Loosen the hex bolt on models with an angleich spring.

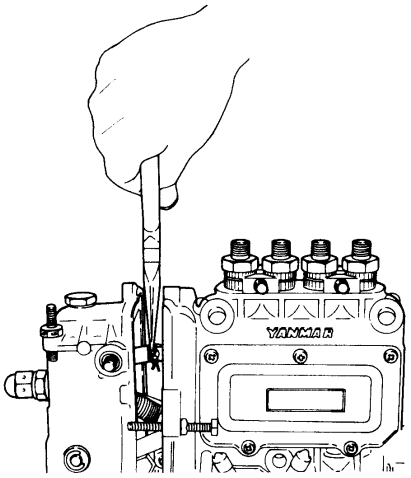
(2) Remove the control lever hex nut, and pull out the control lever from the control lever shaft.



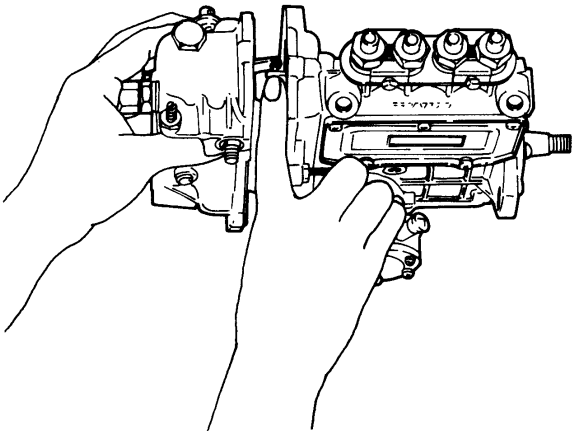
(3) Remove the governor case bolt. Remove the governor case (parallel pin) from the fuel pump unit while lightly tapping the governor case with a wood hammer. Create a gap between the governor case and fuel pump by moving only the moving parts of the governor lever.



(4) Pull out the governor link snap pin by inserting needle nosed pliers between the fuel pump and governor case. case.



(5) The governor and fuel pump come apart by sliding the governor case and fuel pump apart and pulling out the link pin of the fuel control rack.



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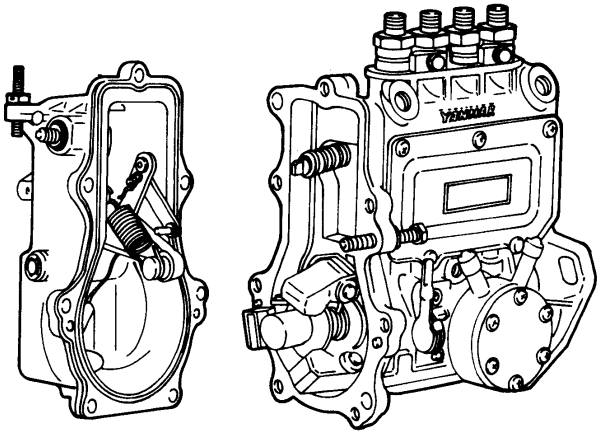
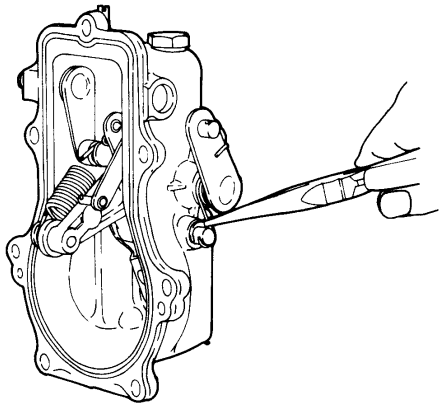
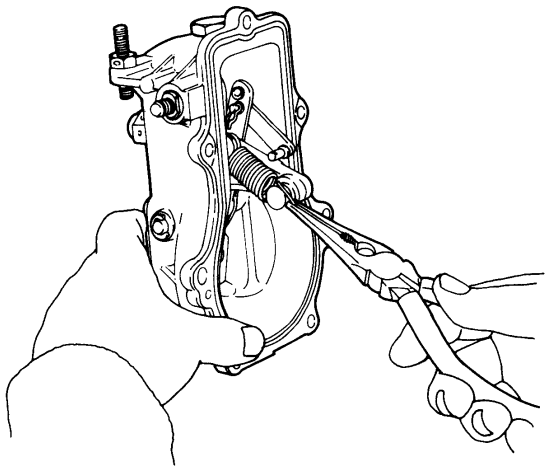


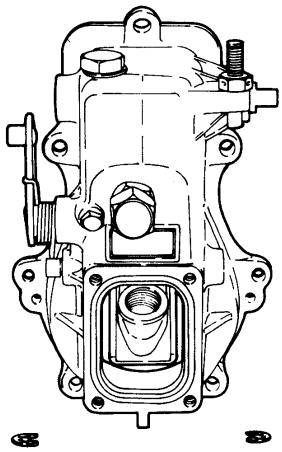
(6) Remove the stop lever return spring from the governor lever shaft.



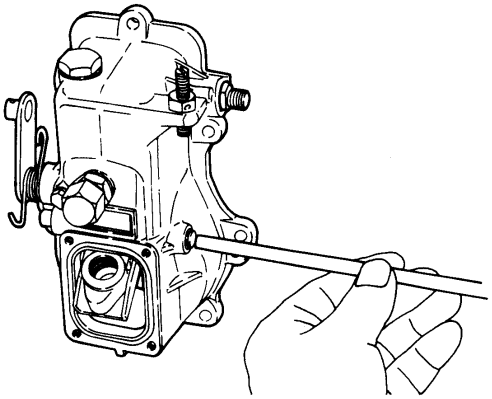
(7) Use needle nose pliers to unhook the governor spring from the tension lever and control lever shaft.



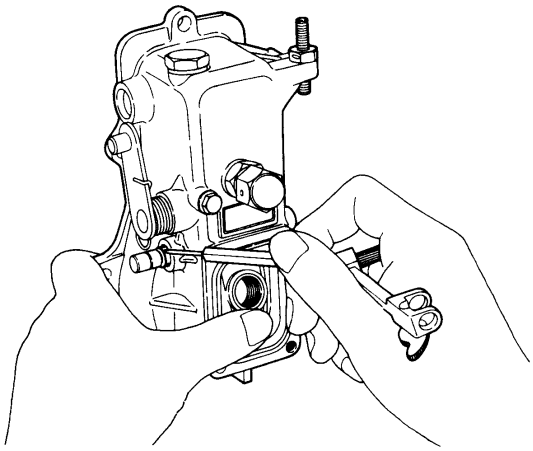
(8) Remove the snap-rings on both ends of the governor lever shaft.

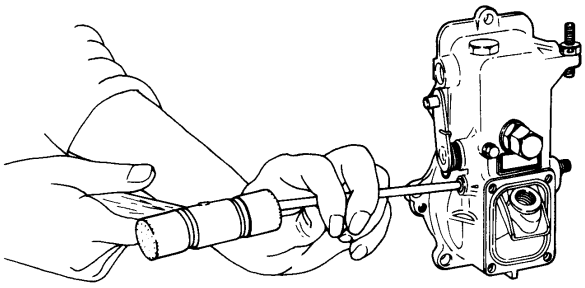


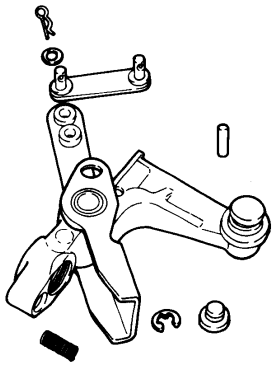
(9) Put a rod 8mm (0.3150in.) in dia. or less in one end of the governor lever shaft, and tap the governor shaft until the O-ring comes out the other side of the governor case.



(10) After you remove the O-ring, lightly tap the end of the shaft that you removed the O-ring from, and remove the governor lever shaft. Then remove the governor shaft assembly and washer.

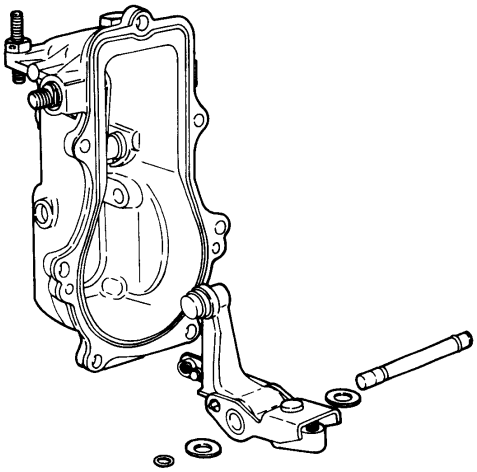


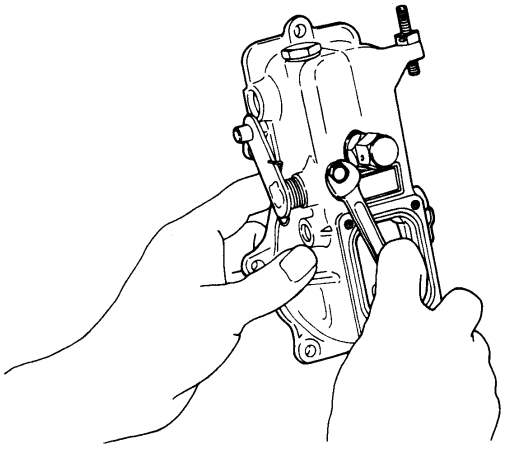




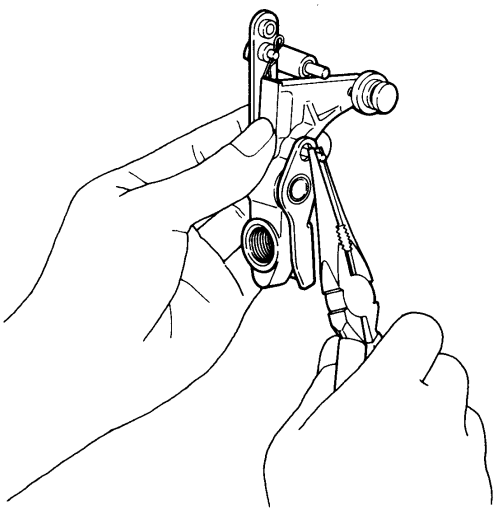
NOTE: The governor assembly consists of the governor lever, tension bar, bushing, throttle spring and shifter, and is normally not disassembled.
The spring pin is removed when you replace the shifter or throttle spring.

(12) When you need to pull out the stop lever, remove the stop lever shaft stop pin, and lightly tap the inside of the governor case.

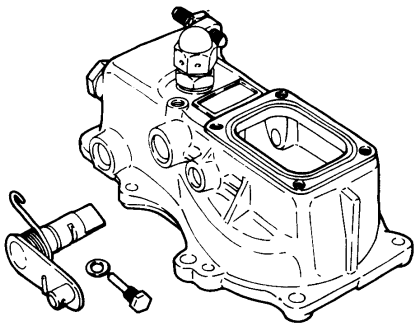




(11) Remove the governor link from the governor lever.



(13) When you need to pull out the control lever shaft, tap the end of the shaft with a wood hammer.



NOTE: 1. Do not remove the fuel limit nut from the governor case unless necessary.

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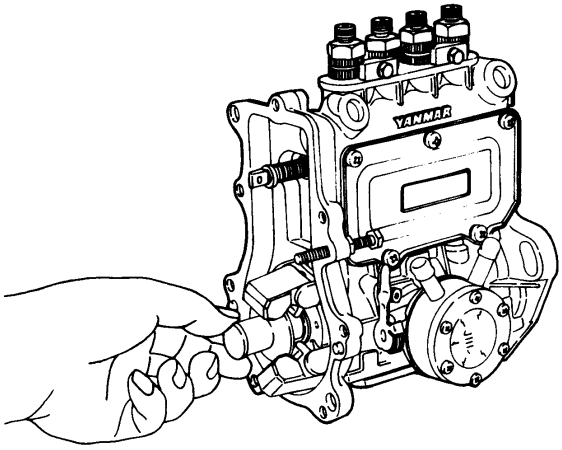
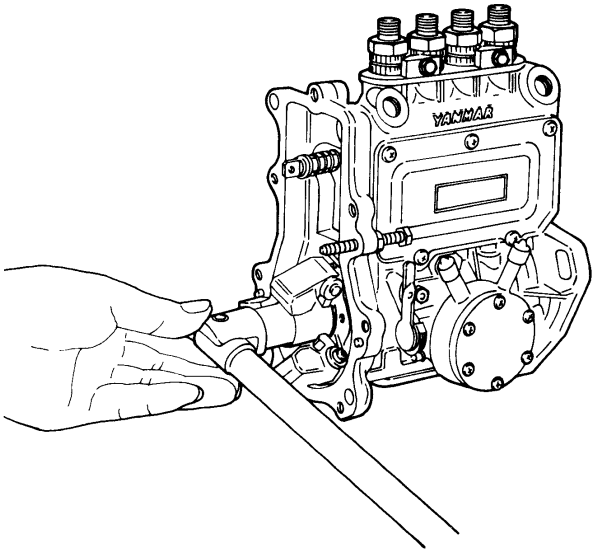
(14) Pull out the governor sleeve on the end of the fuel camshaft by hand.

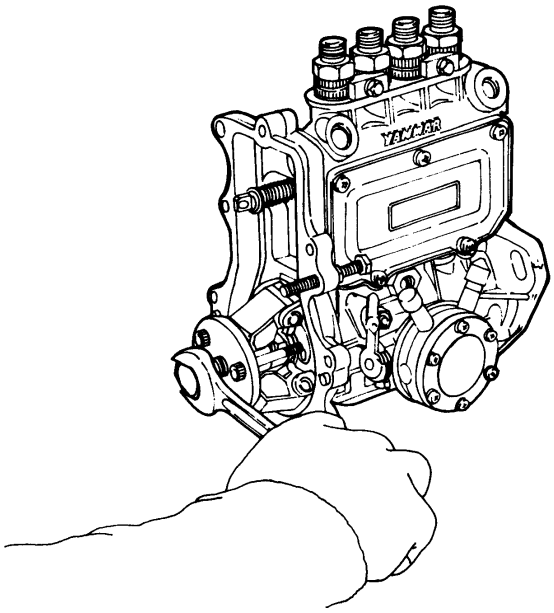


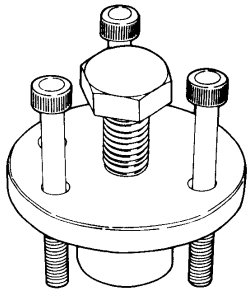
(15) Turn the governor weight with a box spanner two or three times to loosen it, stopping it with the hole in the fuel coupling ring or holding the coupling with a vise.

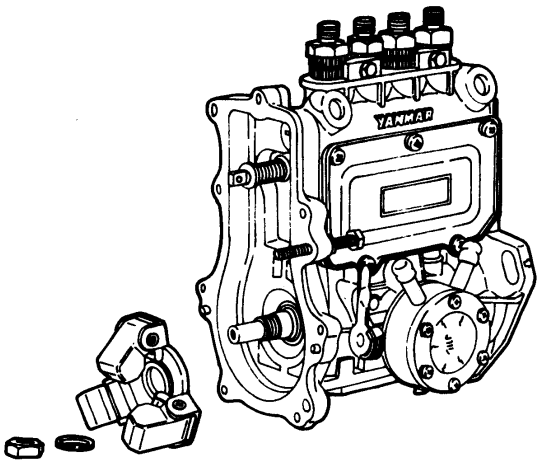


NOTE: When the taper fit comes apart after you have removed the nut, the governor weight may fly out —Be Careful.

(16) Remove the governor weight assembly from the fuel pump cam using the governor weight pulling tools.







NOTE: The governor weight assembly is made up of the governor weight, support and pin. Do not disassemble.

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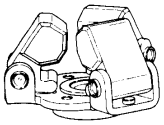
2-2 Inspection of governor

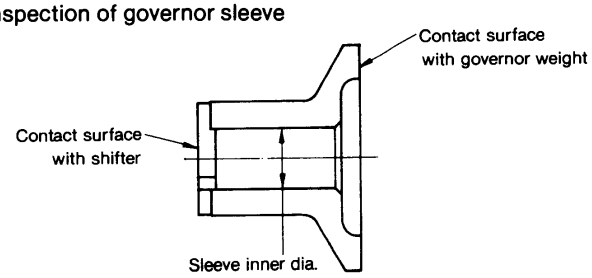
Inspection of governor weight assembly

(1) Replace the governor weight if it does not open and close smoothly.



(2) Replace the governor weight if the contact surface with governor sleeve is extremely worn.
(3) Replace if there is governor weight support/pin wear or the caulking is loose.
(4) Replace if the governor weight support stopper is excessively worn.

Inspection of governor sleeve



(1) Replace the governor sleeve if the contact surface with governor weight is worn or there is pitching.
(2) Replace the governor sleeve if the contact surface with shifter is considerably worn or there is pitching.
(3) If the governor sleeve does not move smoothly above the cam shaft due to governor sleeve inner dia. wear or other reasons, replace.

Inspection of governor shaft assembly

(1) Measure the clearance between the governor shaft and bushing, and replace if it exceeds the limit.

mm (in.)

	Standard Dimension	Standard Clearance	Limit
Governor shaft outer dia.	7.986 ~ 7.995 (0.3144 ~ 0.3147)	0.065 ~ 0.124 (0.0025 ~ 0.0048)	0.5 (0.0196)
Bushing inner dia.	8.060 ~ 8.110 (0.3173 ~ 0.3192)		

(2) Inspect the shifter contact surface, and replace the shifter (always by removing the pin to disassemble) if it is worn or scorched.
(3) Disassemble and replace throttle springs that are settled, broken or corroded by pulling the spring pin.
(4) Check link parts for bends or kinks that will cause malfunctioning, and replace any parts as necessary.

NOTE: 1. Side gap on top of governor lever shaft.

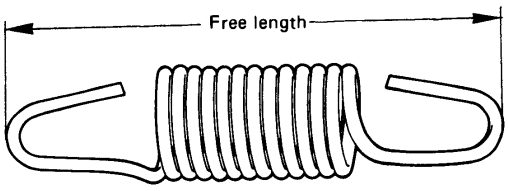
mm (in.)

Standard side gap	0.4 (0.0157)

2. Replace the governor lever, tension bar, bushing, shifter and throttle spring as an assembly.

(5) Inspection of springs

1) Check the governor spring and other springs and replace if they are broken, settled or corroded.
2) Measure the free length of the governor spring, and replace if it exceeds the limit.
See service data sheet for free length of governor spring.



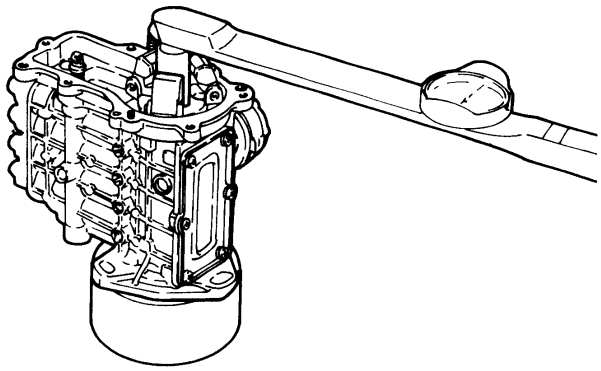
Governor spring spec. table

Engine model		4JHE, 4JH-TE	4JH-HTE, 4JH-DTE
Part No.		129470-61700	129473-61700
Spring constant	kg/mm	0.479	0.431
Free length	mm	54.0	52.5

2-3 Assembling governor

Inspect all parts after disassembly and replace any parts as necessary. Before starting reassembly, clean new parts and parts to be reused, and put them in order.
Make sure to readjust the unit after reassembly to obtain the specified performance.

(1) Insert the governor weight assembly in the taper portion at the end of the fuel pump camshaft, stopping it with the hole in the fuel coupling ring or holding the coupling with a vise, mount the rest, and tighten the governor weight nut.



kg-m (ft-lb)

Governor weight nut tightening torque	4.5 ~ 5.0 (32.54 ~ 36.16)

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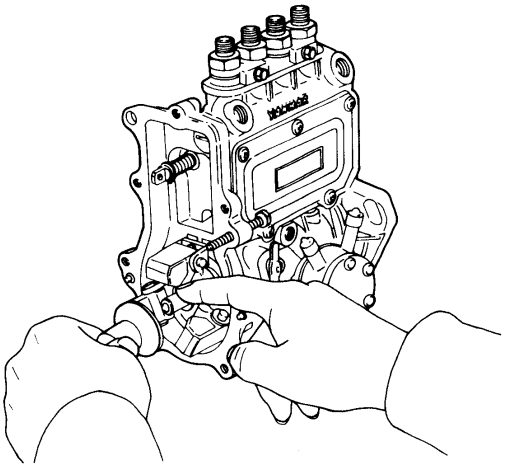
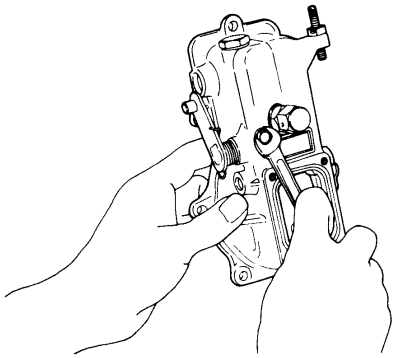
(2) Open the governor weight to the outside, and insert the sleeve in the end of the fuel pump camshaft.



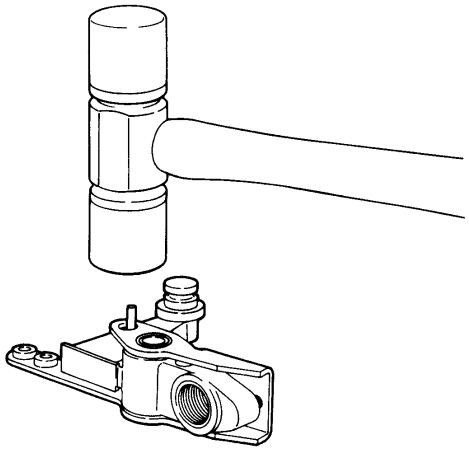
NOTE: Make sure that the sleeve moves smoothly after inserting it.

(3) When the stop lever has been disassembled, mount the stop lever return spring on the stop lever, tap the stop lever lightly with a wooden hammer to insert it, and tighten the stop lever stop pin.

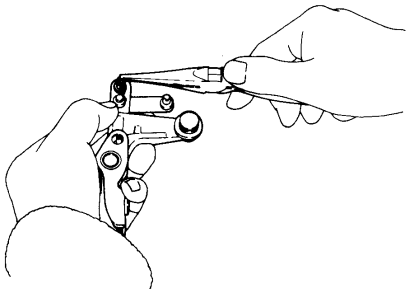


(4) When the control lever shaft has been removed, lightly tap the control lever shaft and washer from inside the governor case, using an appropriate plate.

(5) If the governor has been disassembled, tap in the spring pin.

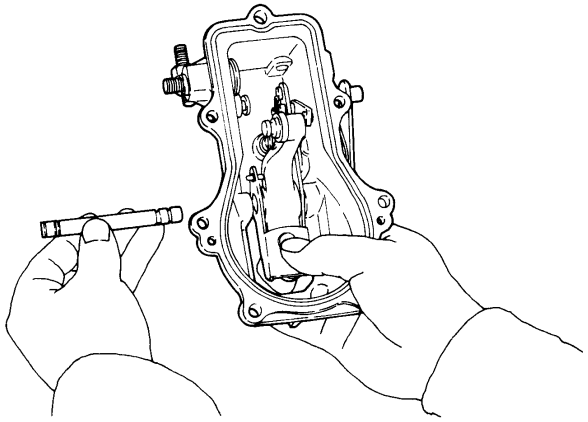


(6) Mount the governor lever assembly to the governor link.

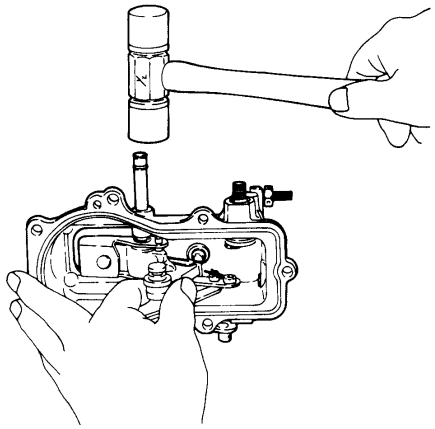


NOTE: 1. Make sure that the correct governor link mounting holes are used, and that it is mounted in the correct direction.
2. Make sure that the governor link moves smoothly.

(7) Put the governor lever shaft assembly in the governor case, insert the governor lever shaft, and tap it in until the O-ring groove comes out the opposite side of the governor case.



NOTE: 1. Fit the O-ring to the side you have tapped in.



2. Make sure to insert the governor lever shaft in the correct direction.

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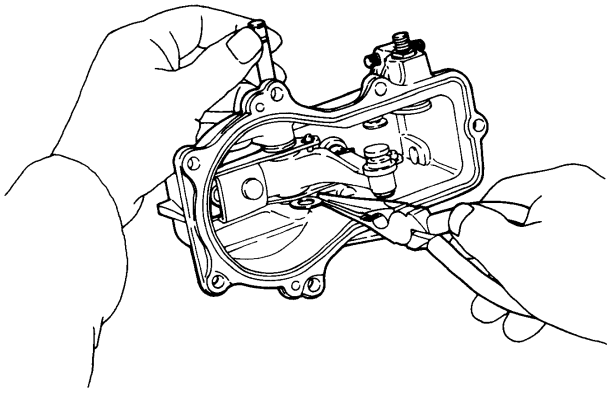
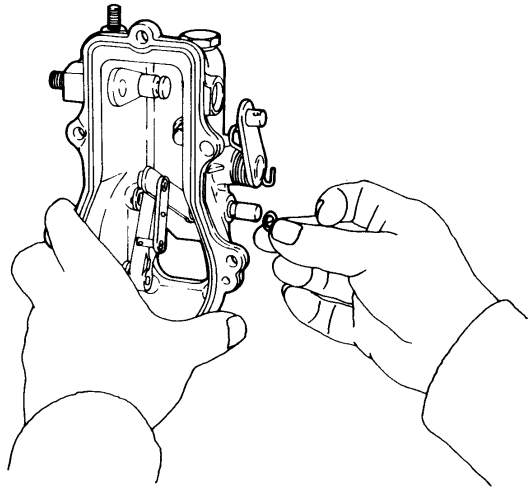
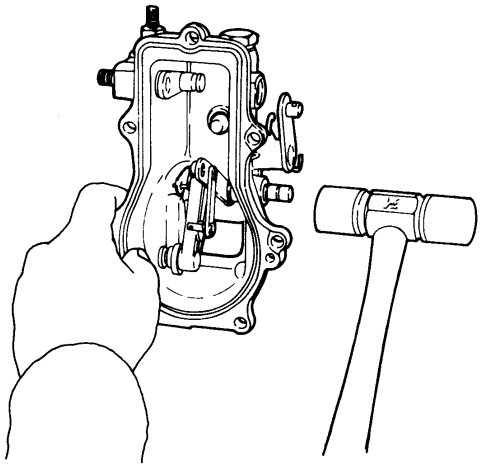
3. Don't forget to mount the washers to both sides of the governor lever.



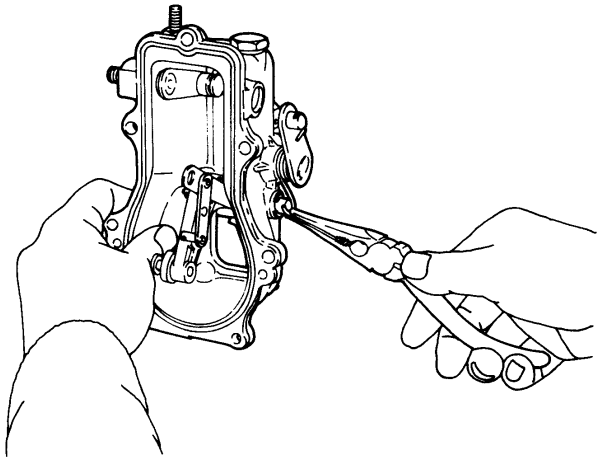
(8) After you have mounted the O-ring, tape the governor lever in the opposite direction, and mount the E-shaped stop rings on the grooves at both ends.



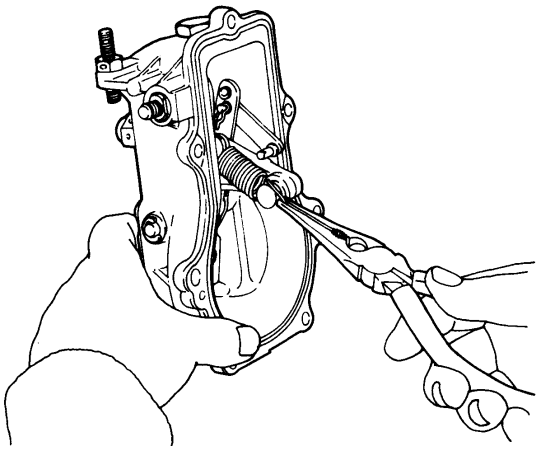


NOTE: After mounting the governor lever assembly, make sure the governor lever assembly moves smoothly.

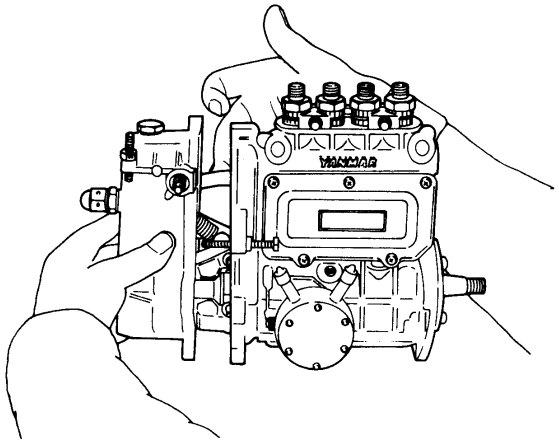
(9) Fit the stop lever return spring to the end of the governor lever shaft.



(10) Hook the governor spring on the control lever shaft and tension lever hook with radio pliers.



(11) Pull the governor link as far as possible towards the governor case mounting surface, insert the governor link pin in the fuel control rack pin hole and fit the snap pin on it.



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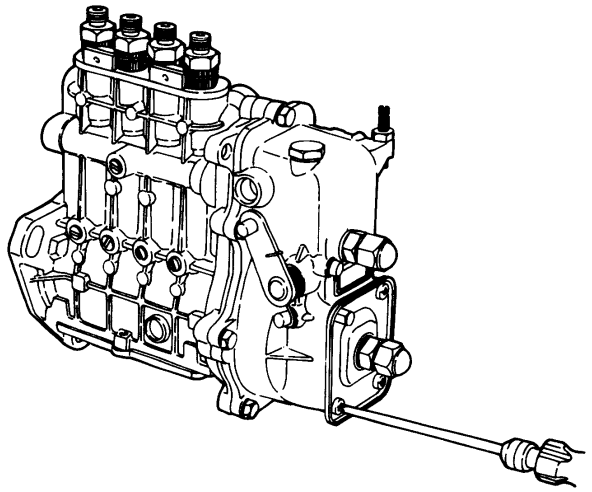
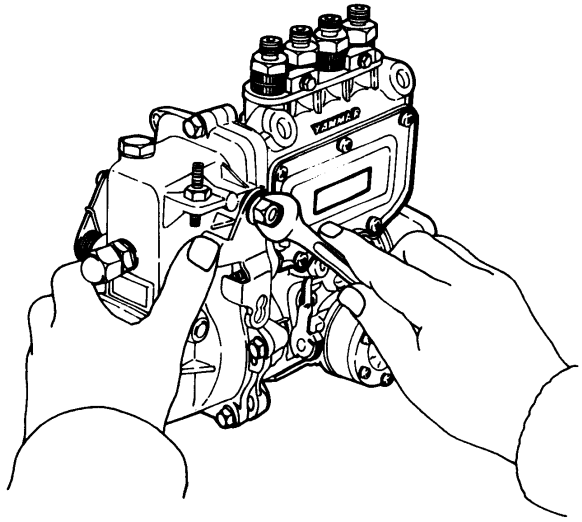
(12) Mount the governor case to the fuel pump unit while lightly tapping it with a wooden hammer, and tighten the bolts.
(13) Place the adjusting spring and adjusting rod on the governor case cover adjusting bolt, and mount the governor case cover.

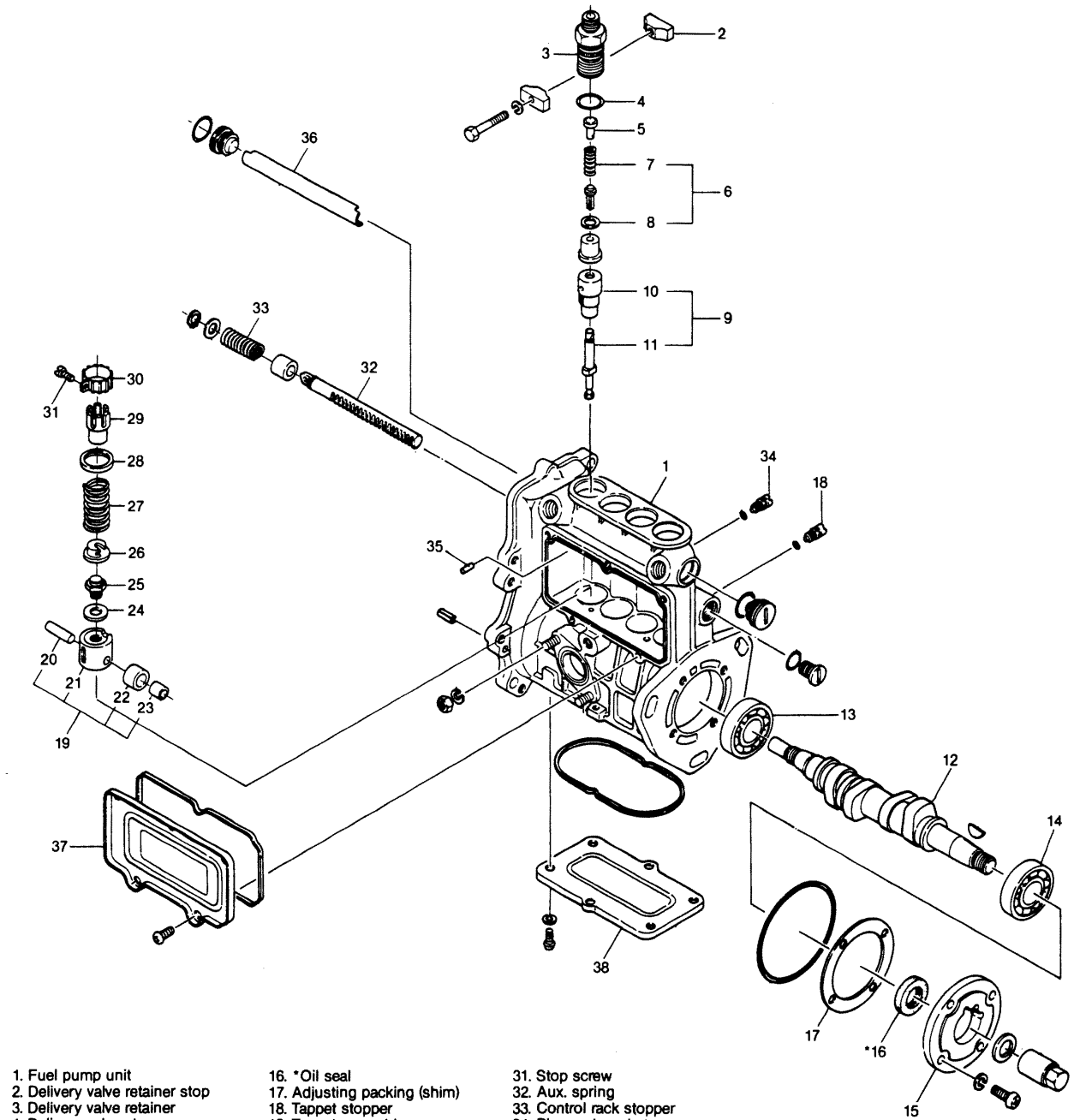


(14) Insert the control lever in the control lever shaft, and tighten the nut.



NOTE: Move the control lever back and forth to make sure that the entire link moves smoothly.

3. Disassembly, Reassembly and Inspection of Fuel Injection Pump



1. Fuel pump unit
2. Delivery valve retainer stop
3. Delivery valve retainer
4. Delivery valve stopper
5. Delivery valve spring
6. Delivery valve assembly
7. Delivery valve
8. Delivery valve seat
9. Plunger assembly
10. Plunger barrel
11. Plunger
12. Fuel pump camshaft
13. Bearing
14. Bearing
15. Bearing holder
16. *Oil seal
17. Adjusting packing (shim)
18. Tappet stopper
19. Tappet assembly
20. Pin
21. Roller guide
22. Roller (outer)
23. Roller (inner)
24. Adjusting shim
25. Adjusting bolt
26. Plunger spring rest B
27. Plunger spring
28. Plunger spring rest A
29. Control sleeve (reduction ring)
30. Control pinion B
31. Stop screw
32. Aux. spring
33. Control rack stopper
34. Plunger barrel stopper
35. Deflector
36. Pump side cover
37. Pump bottom cover

NOTE: 1. Some models are equipped with ball bearings and some with taper roller bearings.
*2. *Oil seal: Some models are equipped with oil seals and some are not. The shape of the bearing holder differs for models with and without oil seals.*

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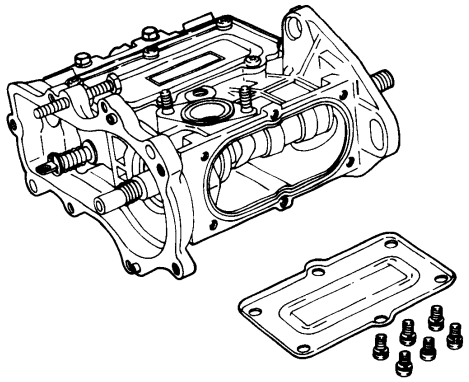
3-1 Disassembly of fuel injection pump

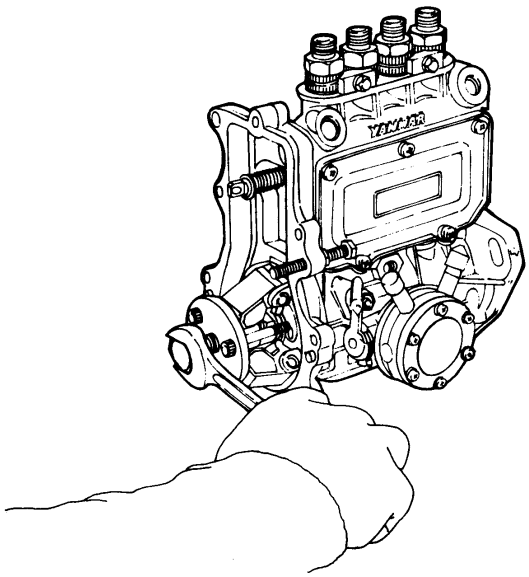
When disassembling the fuel pump, separate the parts for each cylinder and be careful not to get them mixed up.
Be especially careful to keep the plunger/plunger barrel, delivery valve/delivery valve seat and other assemblies separate for each cylinder (the parts of each assembly must be kept with that assembly and put back in the same cylinder).

Preparation

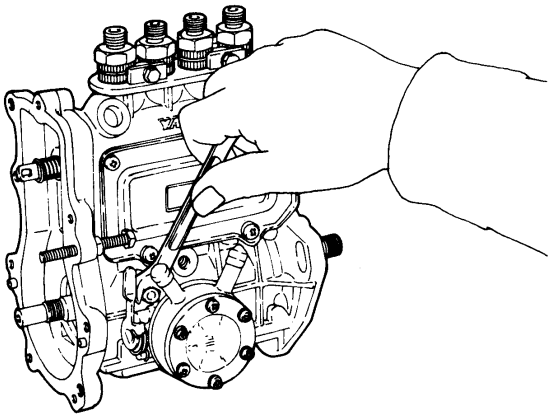
1. Wash off the dirt and grease on the outside of the pump with cleaning oil (kerosene or diesel oil) before disassembly.
2. Perform work in a clean area.
3. Take off the fuel pump bottom cover and remove lubricant oil.
4. Turn the fuel pump upside down to drain fuel oil.

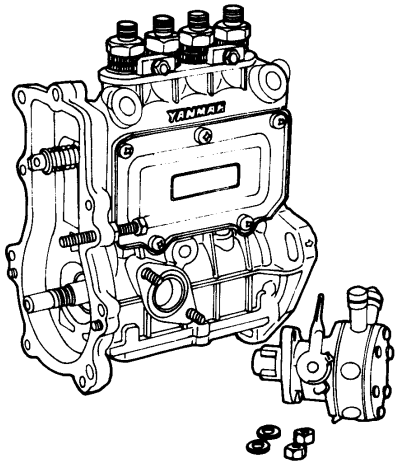


(1) Loosen the nut with a box spanner and take it off, holding it with the hole in the fuel coupling ring or holding the coupling with a vise and take out the governor weight assembly.

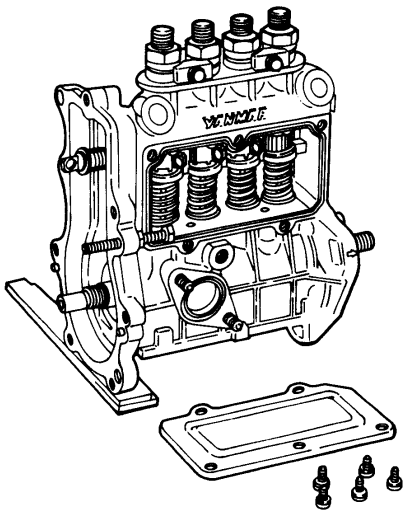


(2) Remove the fuel feed pump.
NOTE: Do not disassemble the fuel feed pump. See instructions for fuel feed pump for details.





(3) Remove the fuel pump side cover.



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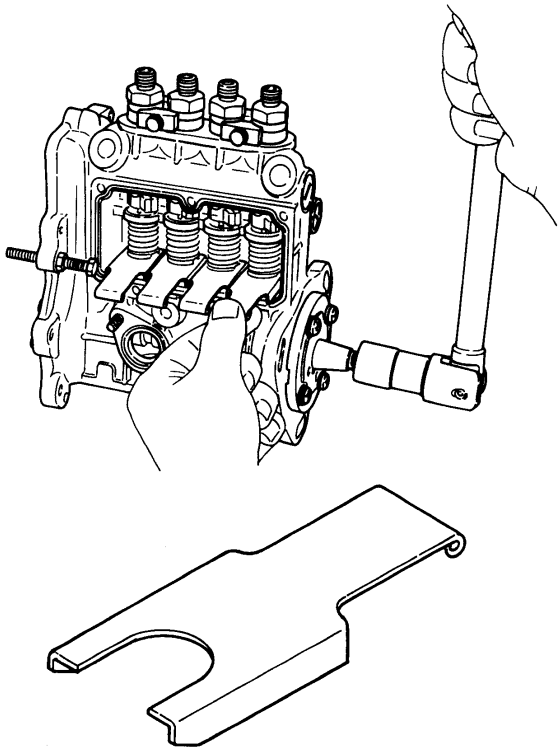
(4) Turn the camshaft until the roller guide is at the maximum head, and insert the plunger spring support plate in between the plunger spring washer B (lower side) and fuel pump unit.

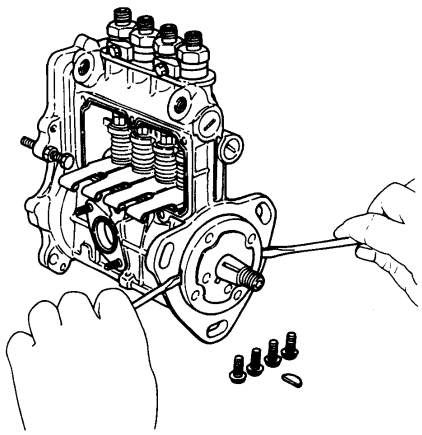


Plunger spring support plate

NOTE: If the camshaft does not turn, put double nuts on the end of the cam shaft or remove the coupling.

(5) Remove the camshaft wood ruff key.

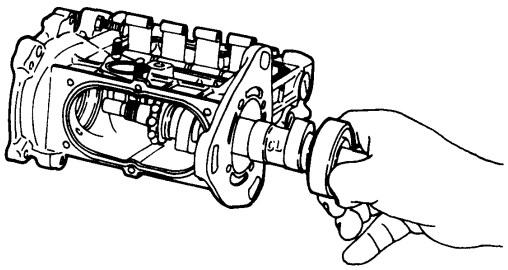
(6) Put a screwdriver in the two grooves on the camshaft bearing holder mounting surface, and pull out the camshaft bearing holder.



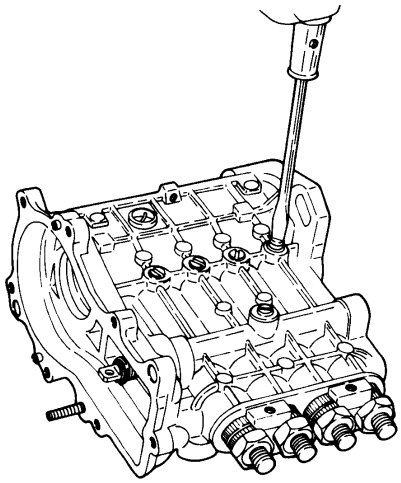
NOTE: 1. Make sure not to damage the oil seal with the threaded part of the camshaft.
2. Be careful not to loose the shims in between the pump and bearing holder.

(7) Turn the fuel pump upside down, move all the roller guides to the plunger side, and then put the pump on its side. Turn the camshaft to a position so that none of the cylinder cams hit the tappets.

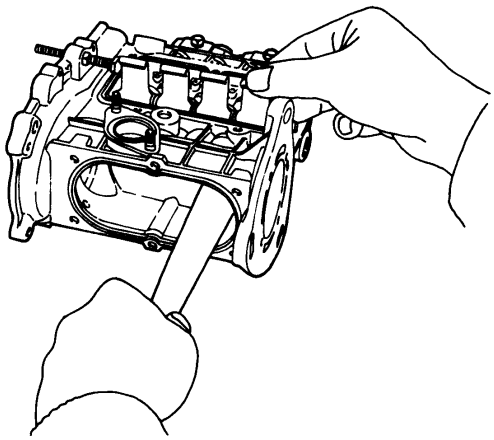
(8) Put a plate against the governor end side of the camshaft and lightly tap it, and pull out the camshaft and drive side bearing.



(9) Remove the roller guide stop.



(10) Use a hammer handle or the like to push up the roller guide from the bottom of the pump, and remove the plunger spring support plate.



NOTE: The plunger spring may make the roller guide and plunger, etc. fly out when the plunger support plate is removed.

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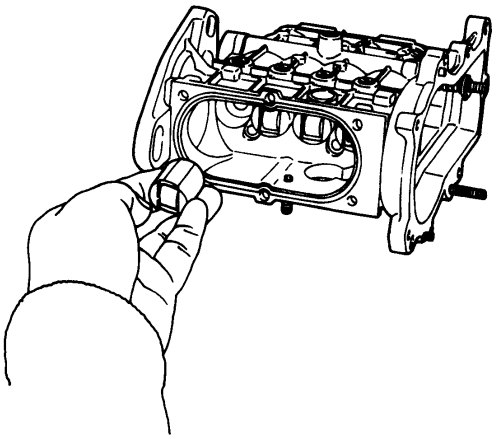
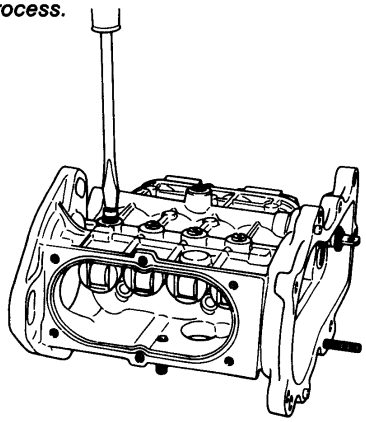
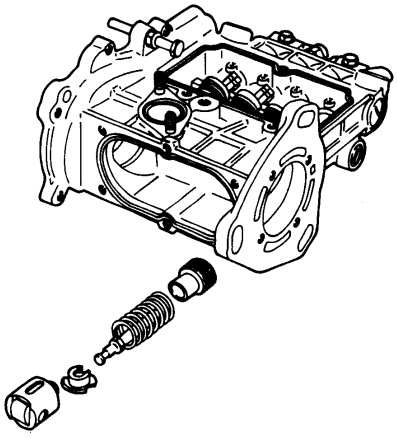
(11) Remove the roller guide.



NOTE: When you stand the fuel pump up, all of the roller guides drop out at one time. Therefore, first remove the stop bolt for one cylinder at a time, and then the roller guide for each cylinder—continue this process.

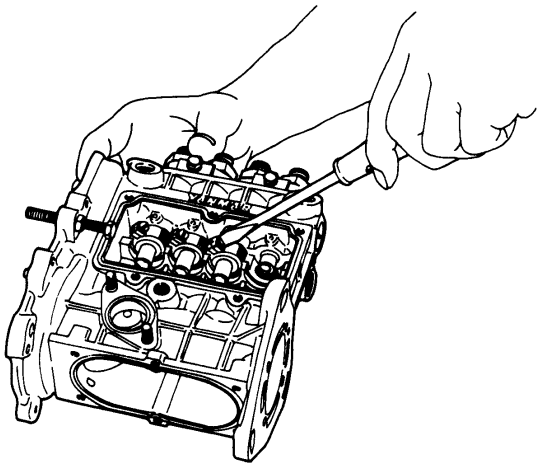


(12) Remove the plunger, plunger spring and lower washer from the lower part of the pump.

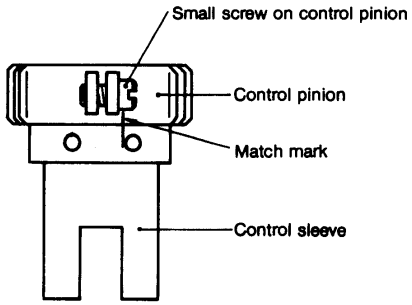


NOTE: Keep the parts separate for each cylinder.

(13) Loosen the small screw on control pinion.

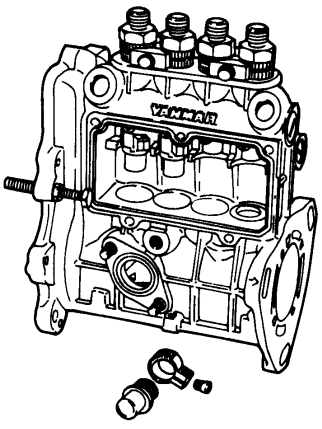


NOTE: 1. Check to make sure the match marks on the pinion/sleeve are correct before loosening the small screw on the control pinion, as the pinion and sleeve come apart when the screw is loosened. If the mark is hard to read or off center, lightly inscribe a new mark. This will serve as a guide when adjusting injection volume later.



2. Keep parts separate for each cylinder.

(14) Remove the control pinion, sleeve and upper rest.



NOTE: Keep parts separate for each cylinder.

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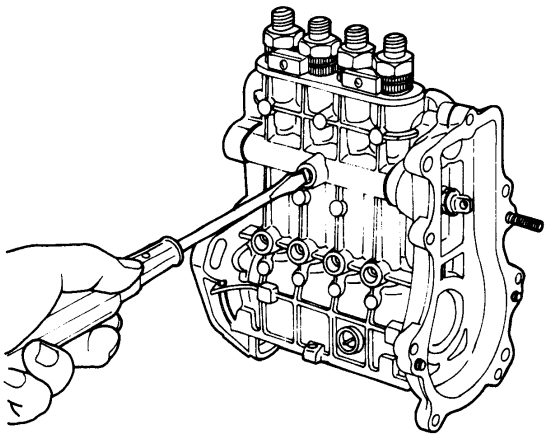
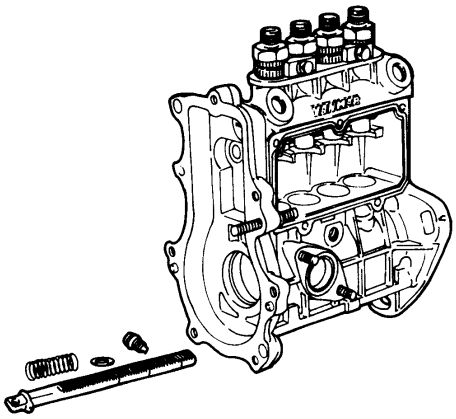
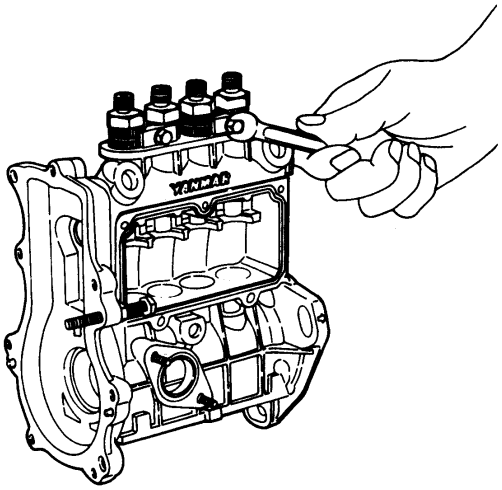
(15) Remove the control rack stop bolt and remove the rack.



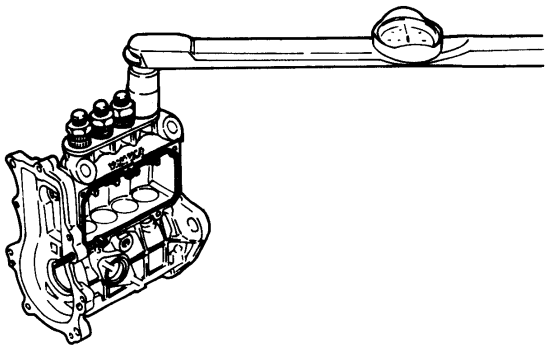
NOTE: Be careful not to lose the spring or rest on the control rack.



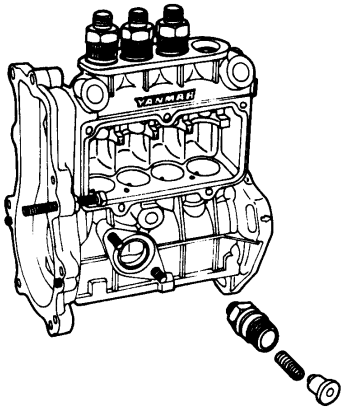
(16) Loosen the delivery valve retainer stop bolt, and remove the delivery valve holder stop.



(17) Remove the delivery valve holder.

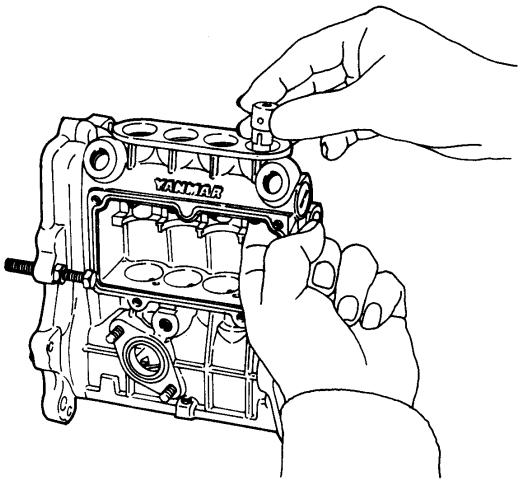


(18) Remove the delivery valve assembly.



NOTE: 1. Be careful not to lose the delivery valve packing, delivery valve spring, delivery valve stopper or other small parts.
2. Keep the delivery valve assemblies for each cylinder clearly separated.

(19) Take the plunger barrel out from the top of pump.



NOTE: Keep it as a set with the plunger that was removed earlier.

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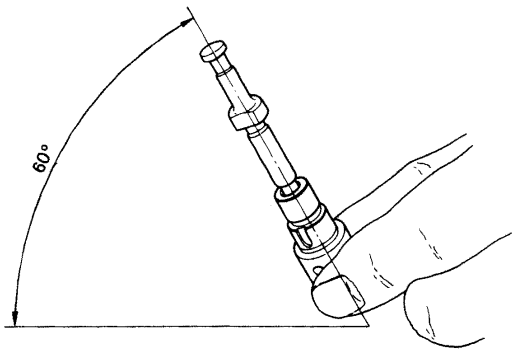
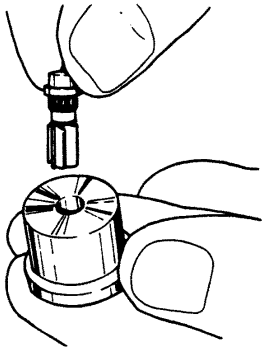
3-2 Inspection of fuel injection pump

(1) Inspection of plunger

1) Thoroughly wash the plungers, and replace plungers that have scratches on the plunger lead or are discolored.
2) The plunger is in good condition if it slides down smoothly when it is tilted about 60°. Repeat this several times while turning the plunger. Repair or replace if it slides down too quickly or if it stops part way.



(2) Inspection of delivery valve



1) Replace as a set if the delivery valve suck-back collar or seat are scratched, scored, scuffed, worn, etc.
2) The valve is in good condition if it returns when released after being pushed it down with your finger (while the holes in the bottom of the delivery guide seat are covered). Replace if necessary.
3) Likewise, the valve should completely close by its own weight when you take your finger off the holes in the bottom of the delivery guide sheet.

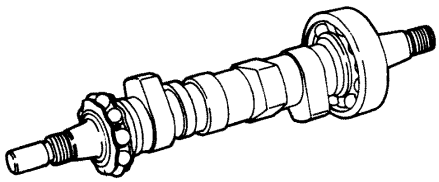
NOTE: When fitting new parts, wash with diesel oil and perform the above inspection.

(3) Inspection of pump

1) Inspect for extreme wear of roller guide sliding surface. Scratches on the roller pin sliding surface are not a problem.
2) Inspect the plunger barrel seat.
If there are burrs or discoloration, repair or replace as this will lead to dilution of the lubricant.

(4) Inspection of fuel camshaft and bearings

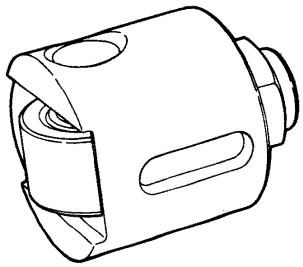
1) Fuel camshaft
Inspect for scratches or wear of camshaft, deformation of key grooves and deformation of screws on both ends, and replace if necessary.
2) Bearings
Replace if the taper rollers or outer race surface is flaked or worn.



NOTE: Replace fuel camshafts and bearings together.

(5) Inspection of roller guide assembly

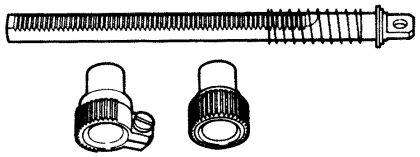
1) Roller



Replace if the surface is worn or flaked.
2) Roller Guide
Replace if the outer roller pin hole is extensively worn or there are many scratches.
3) Replace if the play of the roller guide assembly pin/roller is 0.2mm (0.0078in.) or more.
4) Injection timing adjustment bolt
Replace if the surface in contact with the plunger side is unevenly or excessively worn.

(6) Inspection of rack and pinion

1) Rack



Inspect for bending of rack and wear or deformation of fit with pinion.
2) Pinion
Inspect for wear or deformation of fit with rack.

NOTE: If the tooth surface or sliding surface is not in good working order, rack resistance increases, affecting the condition of the engine (rough rpm, over running, etc.).

(7) Inspection of plunger spring and delivery spring
Inspect springs for scratches, cracks, breakage, uneven wear and rust.

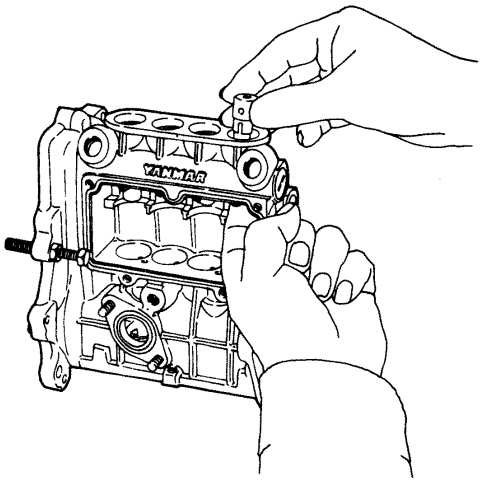
(8) Inspection of oil seals
Inspect oil seals to see if they are burred or scratched.
(9) Inspection of roller guide stop
Inspect the side of the tip, replace if excessively worn.
(10) Inspection of O-rings
Inspect and replace if they are burred or cracked.

3-3 Reassembly of fuel injection pump

Preparation

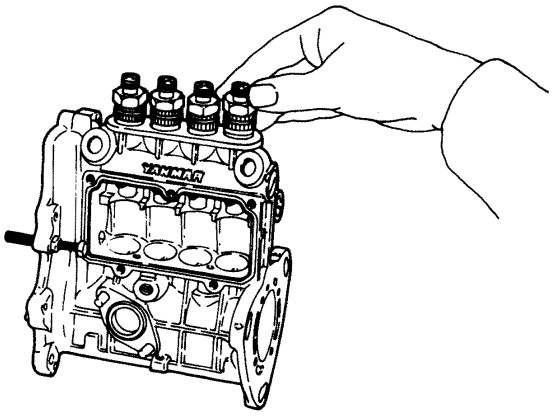
After inspection, put all parts in order and clean.
See Inspection of Fuel Pump for inspection procedure.

(1) Put in the plunger barrel from the top of pump.



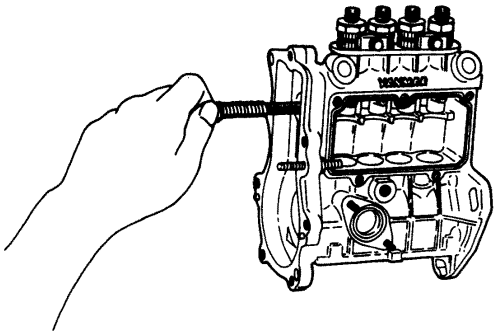
NOTE: Make sure the barrel key groove is fitted properly to the barrel stop pin.

(2) Place the delivery valve assembly, packing, spring and stopper from the top of the pump, in this order.



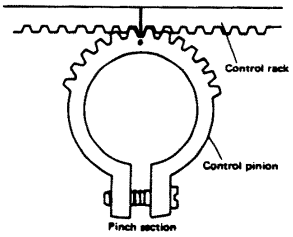
NOTE: Replace the delivery valve packing and O-ring.

(3) Place the control rack, and tighten the control rack stop bolt.

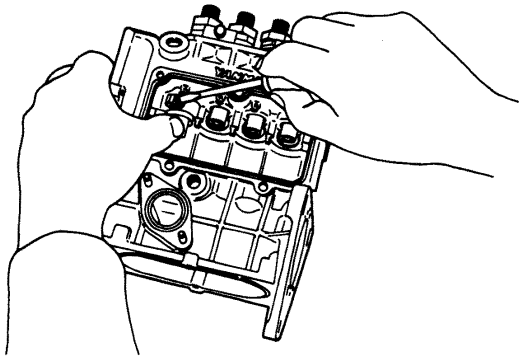


NOTE: 1. Do not forget the rack aux. spring.
2. Make sure the rack moves smoothly through a full cycle.

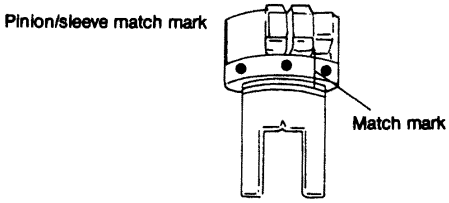
(4) Place the rack set screw (using the special tool) in the rack stop bolt screw hole to fix the rack.
(5) Looking from the bottom of pump, align the match marks on the rack and pinion.



(6) While holding the pinion with one hand and keeping it aligned with the match mark, fit in the sleeve, and lightly tighten the small pinion screw.



NOTE: Fitting of sleeve; Face towards small pinion screws and align with match mark.



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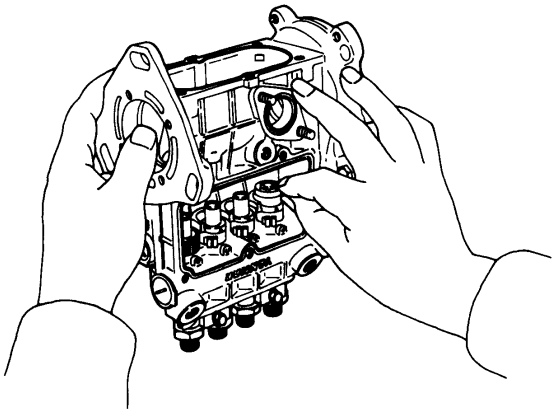
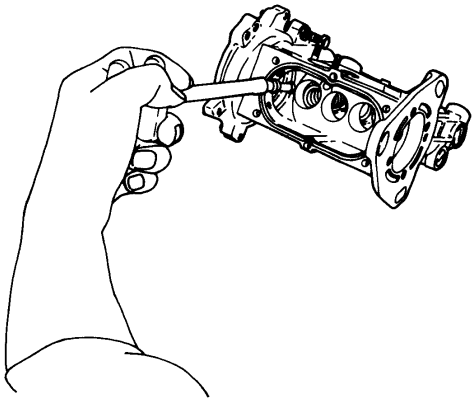
(7) Mount the plunger spring upper rest.



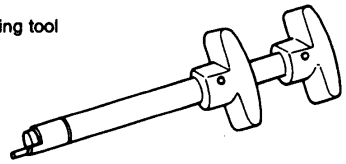
NOTE: 1. Make sure to mount the upper rest with the hollow side facing down.
2. Recheck to make sure that the rack moves easily.

(8) Mount the plunger spring.

(9) Mount the lower rest on the head of the plunger, and fit the plunger in the lower part of pump while aligning the match marks on the plunger flange and the sleeve.

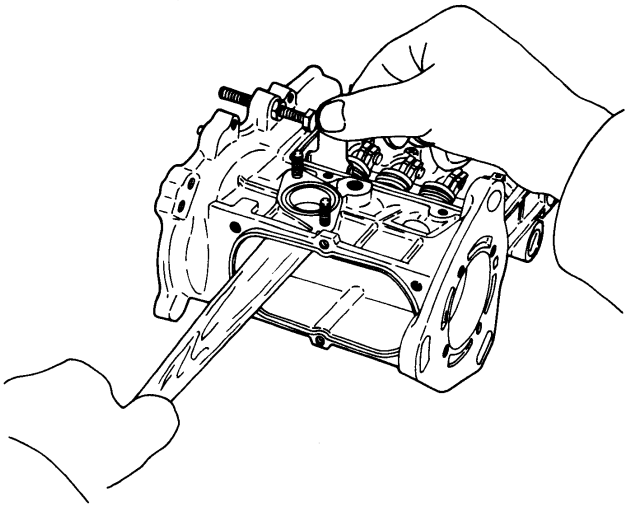


Plunger inserting tool

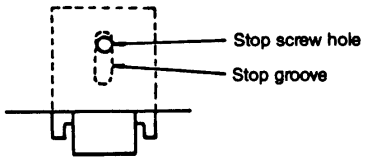


NOTE: If the plunger is mounted in the opposite direction, the injection volume will increase abnormally and cannot be adjusted.

(10) Insert the plunger spring support plate between the plunger spring seat B (lower) and fuel pump, by putting the handle of a hammer in the lower part of pump and pushing the roller guide up.



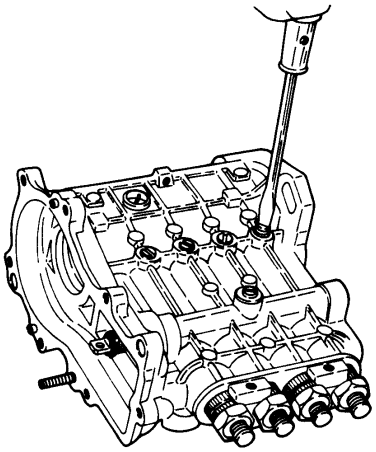
NOTE: 1. Face the roller guide stop groove up, and align with stop screw hole on pump.



2. Check movement of rack. The plunger spring may be out of place if movement is heavy—insert a screwdriver and bring to correct position.
3. When replacing the roller guide assembly, fit shims and lightly tighten:

Standard shim thickness	1.2 mm (0.0472 in.)
Part code number	129155-51600

(11) Make sure that roller guide stop groove is in correct position, and tighten roller guide stop bolt.



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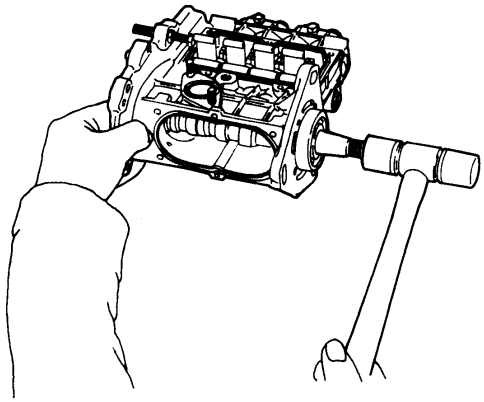
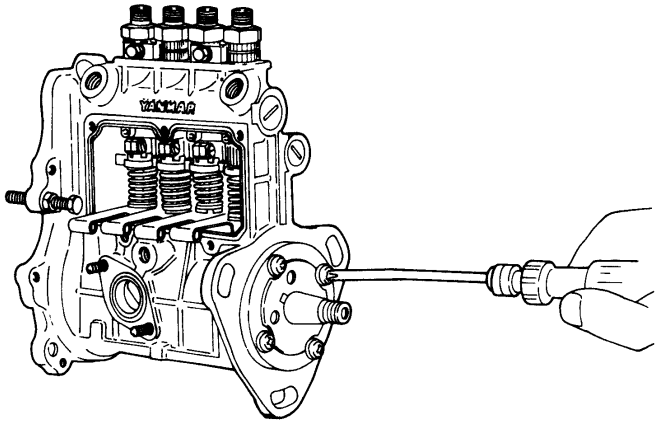
(12) Fit the bearings to both ends of the camshaft, and insert from drive side by lightly tapping.



NOTE: Turn pump upside down, and tap camshaft in while moving roller guide to plunger spring side.

(13) Fit the oil seal on the inside of the bearing retainer and mount the bearing retainer.



NOTE: Coat the camshaft and oil seal with oil to prevent the oil seal from being scratched.

(14) Fix the pump, lightly tap both ends of the cam shaft with a wood hammer, and adjust the cam shaft side clearance with the adjustment shims while checking with side clearance gauge.

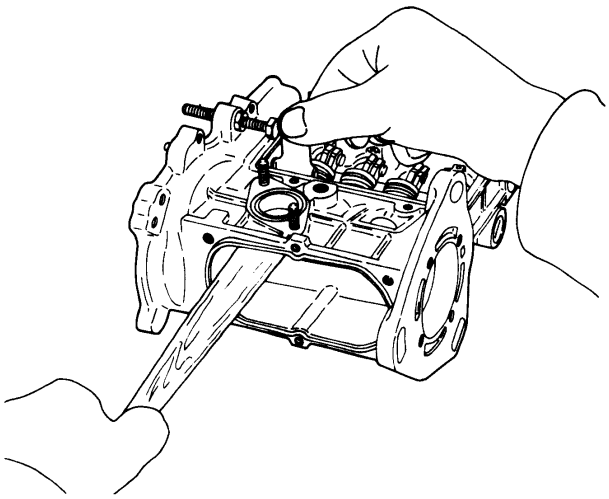
mm (in.)

Camshaft side clearance	0.02 ~ 0.05 (0.0007 ~ 0.0019)

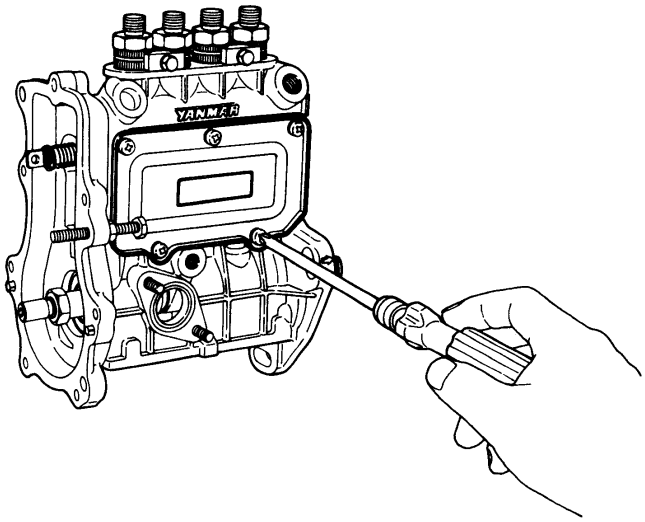
Adjusting
Pull out adjusting shims if clearance is too small, and add adjusting shims if it is too large.

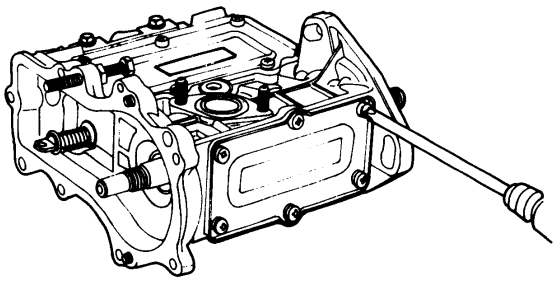
mm (in.)

Adjusting shim thickness	0.50 (0.0196) 0.40 (0.0157) 0.30 (0.0118) 0.15 (0.0059)



(15) Mount the fuel pump side cover.
(16) Tap in the camshaft wood ruff key.
(17) Turn the camshaft, and pull out the plunger spring support plate.





NOTE: Fit double nuts to turn the camshaft.

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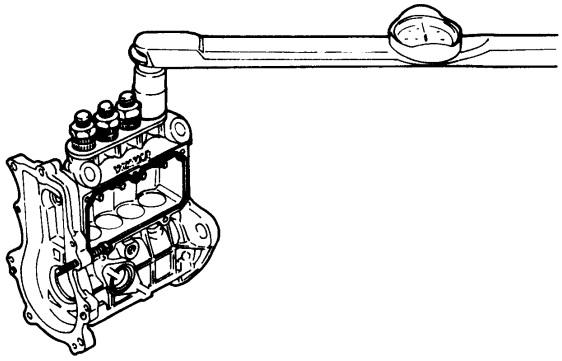
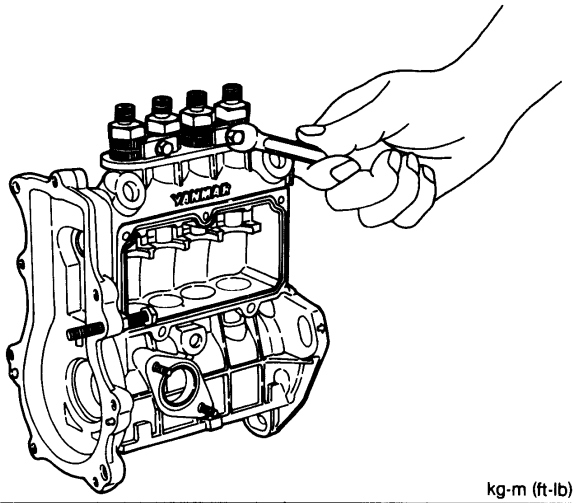
(18) Tighten delivery valve retainer.



	kg-m (ft-lb)
Tightening torque	3.5 ~ 4.0 (25.31 ~ 28.93)

NOTE: 1. Tighten the retainer as far as possible by hand—if the bolt gets hard to turn part way, the packing or delivery valve are out of place. Remove, correct, and start tightening again.
2. Overtightening can result in malfunctioning of the rack.

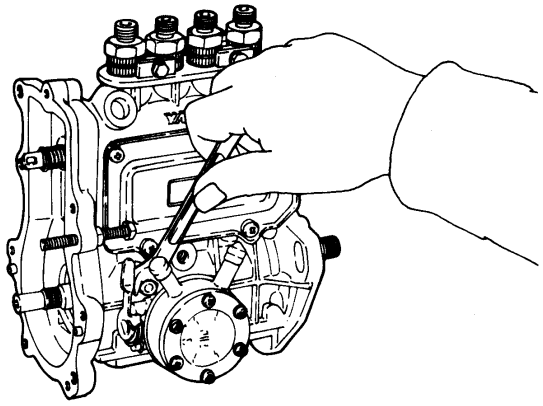
(19) Fit the delivery retainer stop and tighten the stop bolt.



	kg-m (ft-lb)
Tightening torque	0.3 (2.16)

NOTE: Overtightening can upset the delivery retainer and cause oil leakage.

(20) Mount the fuel feed pump



NOTE: See the item explaining reassembly of the fuel feed pump.

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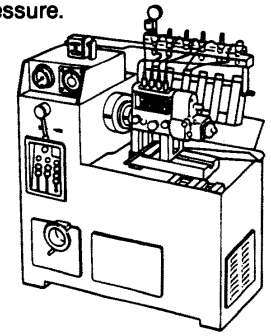
4. Adjustment of Fuel Injection Pump and Governor

Adjust the fuel injection pump after you have completed reassembly. The pump itself must be readjusted with a special pump tester when you have replaced major parts such as the plunger assembly, roller guide assembly, fuel camshaft, etc. Procure a pump tester like the one illustrated below.

4-1 Preparations

Prepare for adjustment of the fuel injection pump as follows:

(1) Adjusting nozzle assembly and inspection of injection starting pressure.



kg/cm² (lb/in.²)

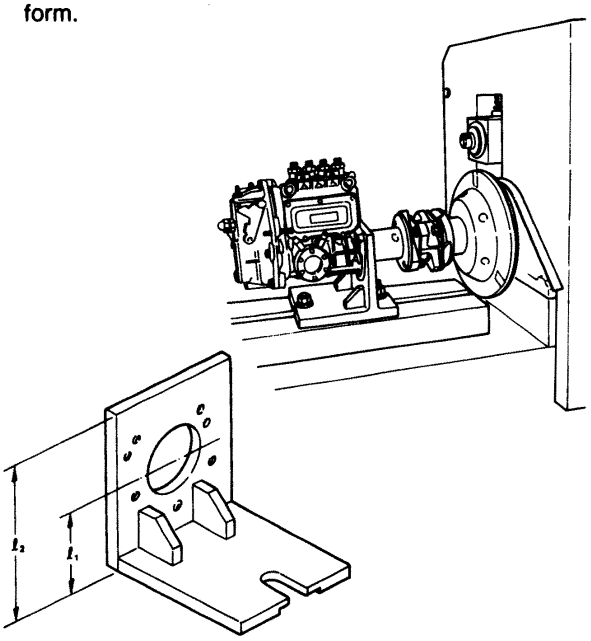
Adjusting nozzle type	YDN-12SD12
Injection starting pressure	165 ~ 175 (2346.85 ~ 2489.08)

(2) Adjusting injection pipe.

mm (in.)

Inner dia./outer dia. × length	2.0/6.0 × 600 (0.0787/0.2362 × 23.6220)
Minimum bending radius	25 (0.9842)

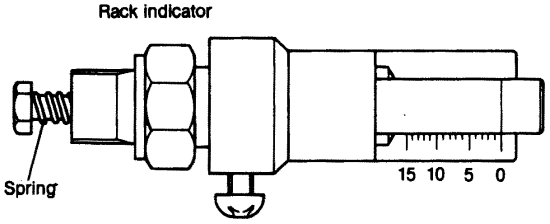
(3) Mount the fuel injection pump on the pump tester platform.

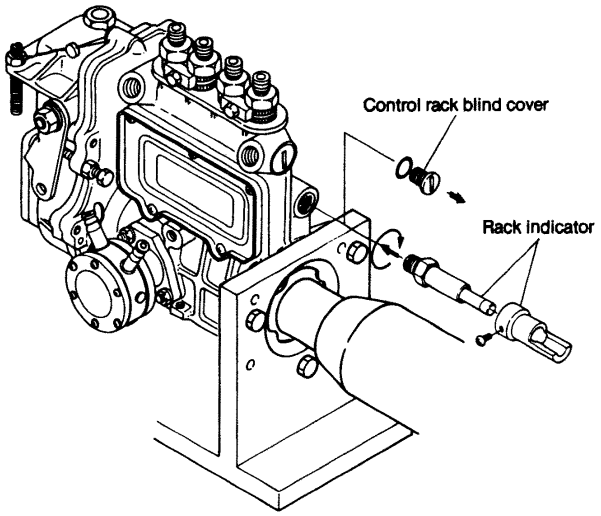


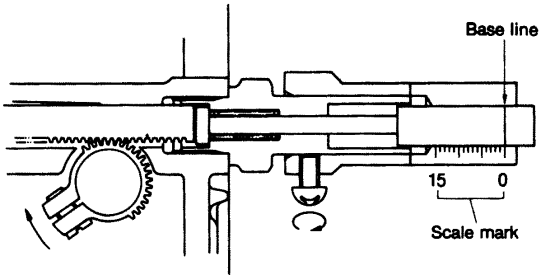
mm (in.)

Tester used	l_1	l_2	Part code number
Yanmar	110 (4.3307)	150 (5.9055)	158090-51010
Robert Bosch	125 (4.9212)	165 (6.4960)	158090-51020

(4) Remove the control rack blind cover and fit the rack indicator.
Next, turn the pinion from the side of the pump until the control rack is at the maximum drive side position, and set it to the rack indicator scale standard position.
Then make sure that the control rack and rack indicator slide smoothly.







Part code number	158090-51500

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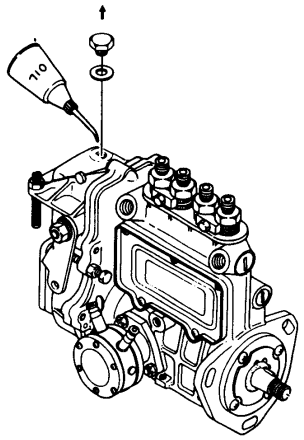
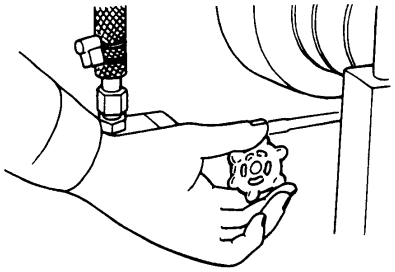
(5) Check control rack stroke
Make sure the rack position is at 11.5 ~ 12.5mm (0.4527 ~ 0.4921in.) on the indicator scale when the governor control lever is set at the maximum operating position. If it is not at this value, change the link connecting the governor and control rack to adjust it.

NOTE: Links are availabe in 1mm (0.0394in.) increments.

(6) Remove the plug in the oil fill hole on the top of the governor case, and fill the pump with about 200cc of pump oil or engine oil.

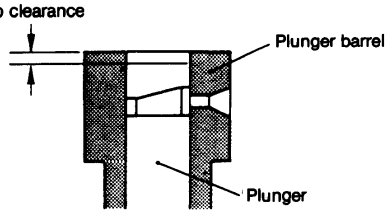


(7) Complete fuel oil piping and operate the pump tester to purge the line of air.
(8) Set the pressure of oil fed from pump tester to injection pump at 0.2 ~ 0.3kg/cm² (2.84 ~ 4.26 lb/in.²).



4-2 Adjustment of top clearance

Adjust the top clearance (clearance between top of plunger and top of barrel with cam at top dead point) of each cylinder plunger to bring it to the specified value by changing the thickness of the shims.



mm (in.)

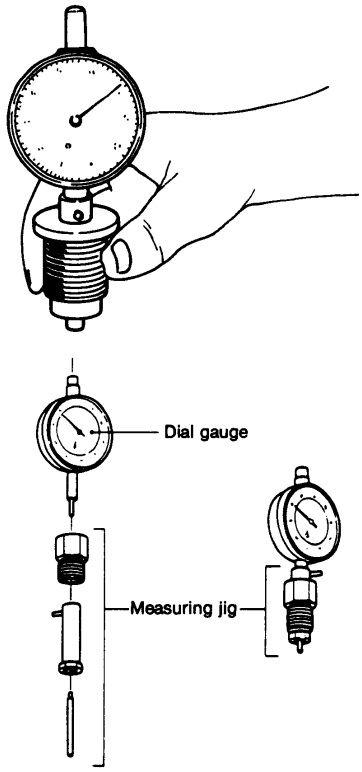
Top clearance	0.95–1.05 (0.0374–0.0413)
Pre-stroke	2.5 (0.0984)
Standard shim thickness	1.2 (0.0472)

Relation between top clearance, standard shim thickness and pre-stroke.

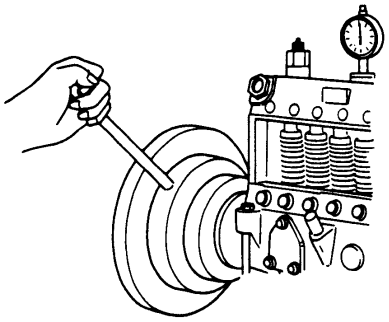
mm (in.)

Adjusting shim thickness	1.0 (0.0394) 1.2 (0.0472) 1.3 (0.0512) 1.4 (0.0551) 1.5 (0.0591) 1.6 (0.0630)
Part Code No.	129155–51600

(1) Place the top clearance gauge on a level surface and set the gauge to zero.



(2) Remove the injection pump delivery retainer, take out the delivery valve assembly, insert the top clearance gauge and tighten by hand.



(3) Turn the camshaft, and bring cam to top dead point while watching gauge needle.

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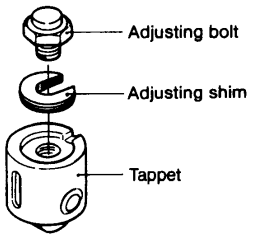
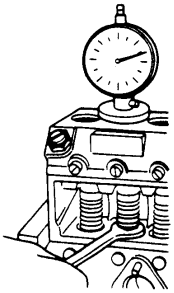
(4) Read the gauge at this position, and adjust until the clearance is at the specified value by changing adjusting shims.
Tighten the adjusting screw after completing adjustment.



(Greater shim thickness decreases top clearance and smaller shim thickness increases top clearance).



NOTE: Adjust while watching gauge, and then tighten.

(5) After adjustment is completed, insert the delivery valve assembly and tighten the delivery retainer.

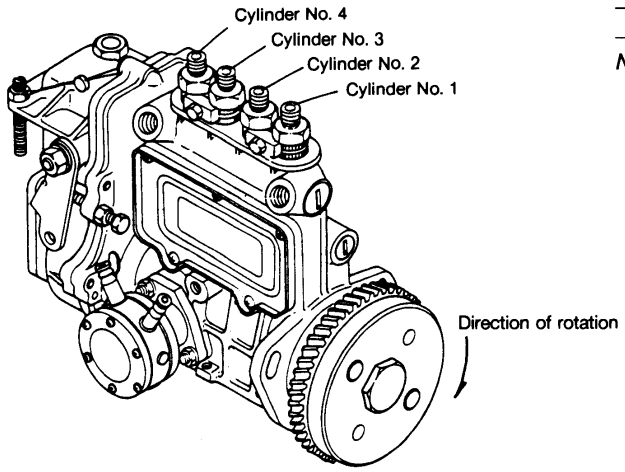
kg-m (ft-lb)

Delivery retainer tightening torque	3.5 ~ 4.0 (25.31 ~ 28.93)

Repeat the above procedure to adjust the top clearance of each cylinder.

4-3 Adjusting of injection timing

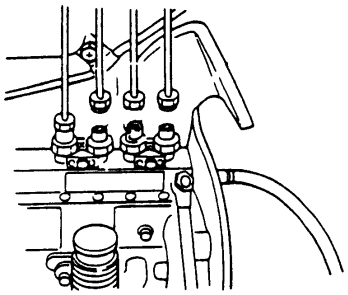
After adjusting the top clearance for all cylinders, check/adjust the injection timing.



(1) Set the governor control lever to the operating position and fix (bring plunger to the effective injection range), turn the camshaft clockwise, and check the injection starting time (FID) of cylinder No.1 (start of discharge of fuel from the delivery retainer).

Cylinder no.	Count from the drive side
Direction of rotation	Right looking from drive side

(2) In the above state, set the tester needle to a position easy to read on the flywheel scale, and check the injection timing several times by reading the flywheel scale, according to the injection order.



Injection order	1—3—4—2—1
Injection timing	90°
Allowable deviation	±30′

(3) Readjust the top clearance of cylinders that are not within the allowable deviation (increasing adjusting shim thickness makes injection timing faster, and decreasing makes it slower).
The change in injection timing effected by adjusting shims is as follows:

Change in shim thickness	Change in injection timing	
	Cam angle	Crank angle
0.1mm (0.0039in.)	0.5°	1.0°

(4) When you have readjusted top clearance, make sure it is within allowable values after completing adjustment.

mm (in.)

Allowable top clearance	0.3 (0.0118)

NOTE: 1. All cylinders must be readjusted if one shows less than the allowable value.
2. If the top clearance is less than the allowable value, the plunger will hit the delivery valve or the plunger flange will hit the plunger barrel.

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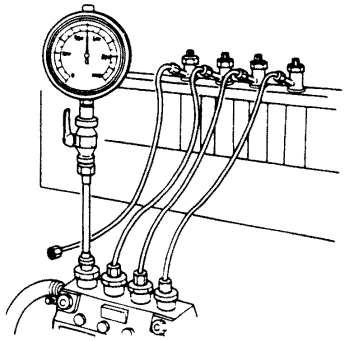
4-4 Plunger pressure test

(1) Mount the pressure gauge to the delivery retainer of the cylinder to be tested.



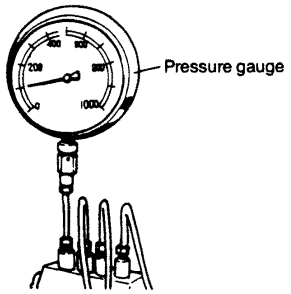
Max. pressure gauge reading	1000 kg/cm² (14223 lb/in.²)
Connecting screw dimensions	M12 × 1.5

(2) Set the governor control lever to the stop position, operate the injection pump at about 200 rpm, and make sure that the pressure gauge reading is 500 kg/cm² (7110 lb/in.²) or more while lightly moving the control pinion gear towards full throttle (drive side) from the pump.
Replace the plunger if the pressure does not reach this value.

(3) Immediately release the gear after pressure rises to stop injection.
At the same time, check to see that oil is not leaking from the delivery retainer or fuel injection piping, and that there is no extreme drop in pressure.

4-5 Delivery valve pressure test

(1) Perform the plunger pressure test in the same way, bringing the pressure to about 120 kg/cm² (1706 lb/in.²), and then stopping injection.



(2) After pressure rises to the above value, measure the time it takes to drop from 100 ~ 90 kg/cm² (1422 ~ 2702 lb/in.²).

100 → 90 kg/cm² (1422 ~ 1280 lb/in.²)	5 seconds (to drop 10 kg/cm² (142 lb/in.²))

If the pressure drops faster than this, wash the delivery valve, and retest. Replace the delivery valve if the pressure continues to drop rapidly.

4-6 Adjusting injection volume (uniformity of each cylinder)

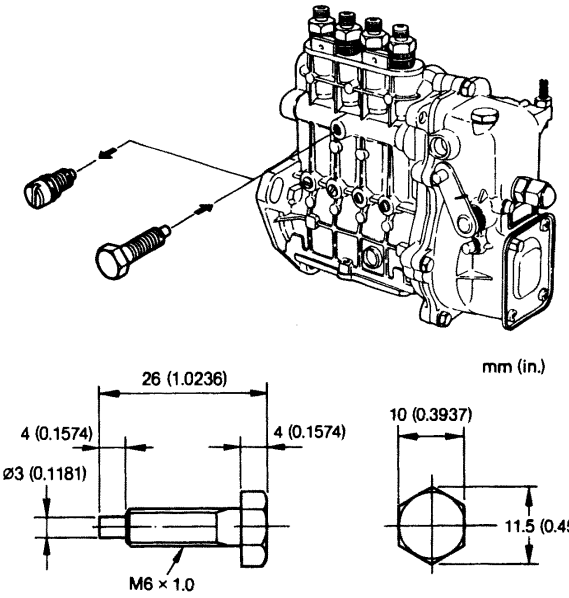
The injection volume is determined by the fuel injection pump rpm and rack position. Check and adjust to bring to specified value.

4-6.1 Measuring injection volume

(1) Preparation
Set the pump rpm, rack position and measuring stroke to the specified value and measure:

Pump RPM	1800 rpm
Pump rotating direction	Right looking from drive side
Rack indicator scale reading	7mm (0.2756 in)

Remove the rack stop bolt behind the pump and screw in the rack fixing bolt to fix rack.



Part Code No.	158090-51510

(2) Measuring injection volume
Measure the injection volume at the standard stroke, and adjust as follows if it is not within the specified value.

Measuring stroke	1,000 st
Specified injection volume at standard rack position	See injection pump service data
Nonuniformity of cylinders	±3%

4-6.2 Adjustment of injection volume

Compare the injection volume collected in measuring cylinders for each cylinder, and adjust if necessary to obtain specified value.

(1) Push the control rack all the way to the drive side, stop with rack fixing bolt, and loosen the pinion/sleeve fixing bolt 1/3 revolution.

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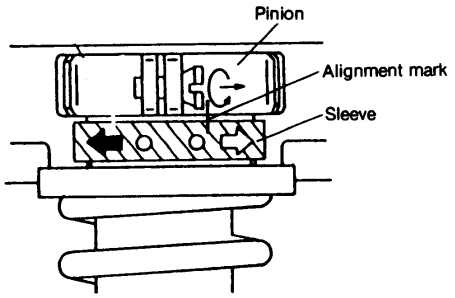
(2) When the control sleeve is turned to the right or left, the plunger is turned through the same angle to increase or decrease injection volume.
The injection volume is increased when the control sleeve is turned in the direction of the → and is decreased when turned in the direction of the ← on the following figure.



(3) Measure the injection volume of each cylinder again. Repeat this process until the injection volume for every cylinder is the same (within specified limit).
(4) Next, measure the injection volumes under different conditions, and make sure the injection volume for every cylinder is within specifications.
Replace the plunger if the injection volume is not within specifications.

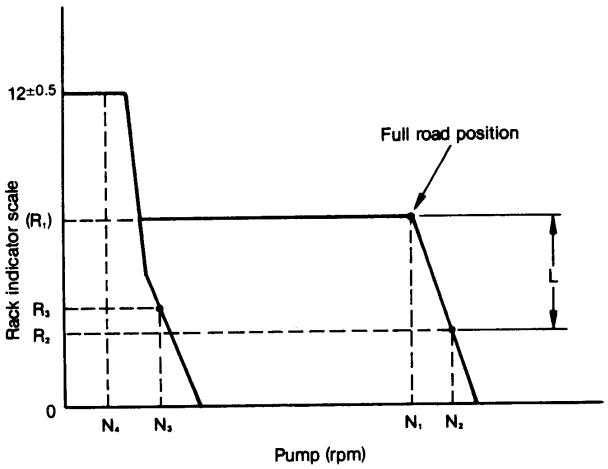
NOTE: See adjustment data for the specified injection volume value at other measuring points.

(5) After completing measurement, firmly tighten the piston/sleeve fixing screw.
(6) If not aligned with match mark, make a new match mark.

4-7 Adjustment of governor

4-7.1 Adjusting fuel limit bolt

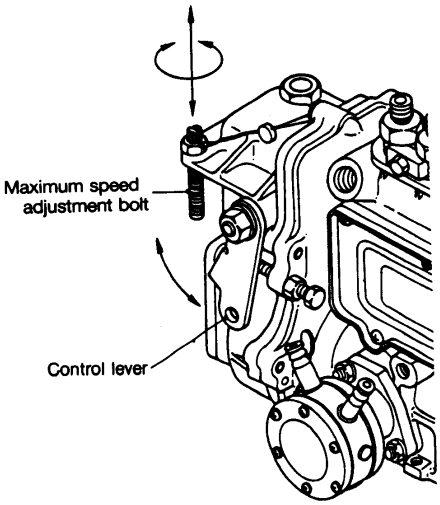
(1) Adjust the tightness of the fuel limit bolt to bring the rack position to the specified value (R_1) with the governor control lever all the way down towards the fuel increase position, while keeping the pump at rated rpm N_1.



(2) Measure fuel injection volume at rack position (R_1). Tightening of fuel limit bolt.
(3) If the injection volume is at the specified value, tighten the fuel limit bolt lock nut at that position.

4-7.2 Adjusting RPM limit bolt

(1) Gradually loosen the governor control lever while keeping the pump drive condition in the same condition as when the fuel limit bolt was adjusted, and adjust the tightness of the RPM limit bolt to the point where the rack position just exceeds the specified value (R_1).

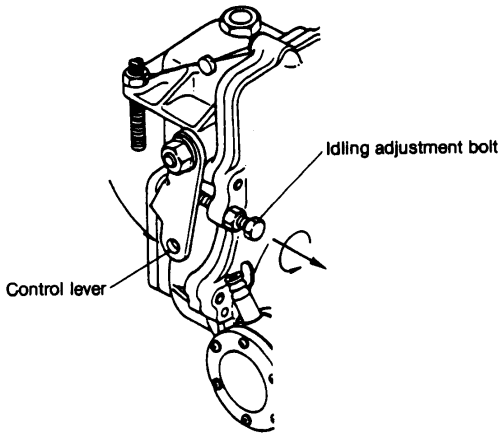


(2) Check maximum RPM at no load
Further increase rpm, and make sure that rack position ($R_2 = R_1 - L$) corresponding to maximum rpm at no load is within specified value (N_2).

No load max. RPM (Pump RPM)	1950 rpm

4-7.3 Adjusting idling

(1) Maintain the pump rpm at specified rpm (N_3).



Idling rpm (Pump RPM)	325 rpm

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(2) Measure the injection volume while lowering the governor control lever to the idling position, and adjust the position of the control lever with the idling adjustment bolt to bring it to specified value.

Measuring stroke	1000 st
Idling injection volume	See injection pump service data

4-7.4 Check injection volume when starting

(1) Make sure the control rack moves smoothly while gradually reducing idling rpm.
(2) Next, fix the governor control lever at full load position with the pump at specified rpm (N_4). Make sure that control rack is at maximum rack position (11.05 ~ 12.05).
Measure the injection volume and check to make sure it is within the specified value.

Pump rpm (N^4)	200 rpm
Rack indicator scale	11.5~12.5mm(0.4527~0.4921 in.)
Measuring stroke	1000 st
Injection volume	See injection pump service data

Check injection stop
Drive the pump at rated rpm (N_1) and standard rack position (R_1) with governor control lever at full load position, operate the stop lever on the back of the governor case, and make sure that injection to all cylinders is stopped.

NOTE: Be sure to remove the rack fixing bolt when doing this.

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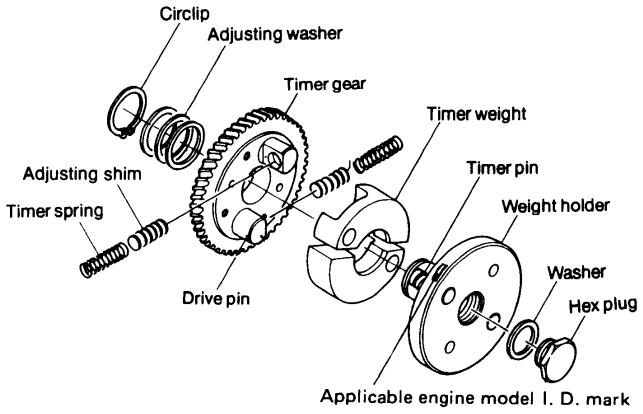
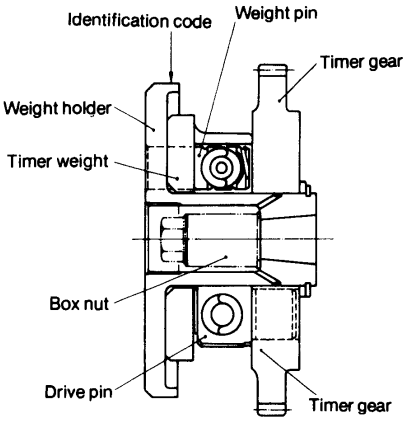
5. Automatic Timer (Automatic Advancing Timer)

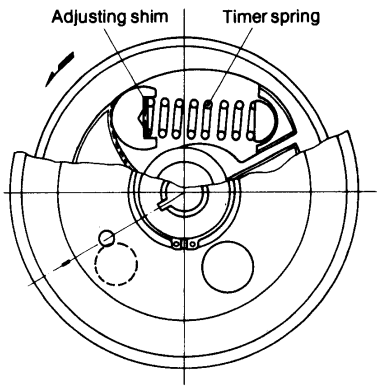
5-1 Timer construction

The faster the engine rpm, the larger the crank angle is during ignition delay. This results in a delay in ignition time and thus a decrease in engine output.
When an engine is used from low to high rpm, the injection timing must be changed according to engine rpm to maintain it at the optimum timing.
The automatic timer uses centrifugal force to automatically adjust injection timing.



		I. D. Mark	Applicable Engine Model & E/#		Advanced angle
Automatic Timer Ass'y (Automatic Advancing Timer)	Old type	JH-AO	4JHE	E/# 00101 ~ 00574	7°
		JH-A1	4JHE	E/# 01000 and before	5.5°
		JH-BO	4JH-TE	E/# 11000 and before	3.5°
		JH-CO	4JH-HTE	E/# 21000 and before	2.5°
	New type	TN-A0	4JHE	E/# 01001 and after	4°
		JH-CO	4JH-TE	E/# 11001 and after	2.5°
			4JH-HTE	E/# 21001 and after	
			4JH-DTE	E/# 30101 and after	





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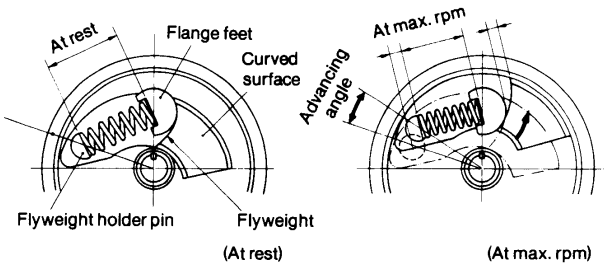
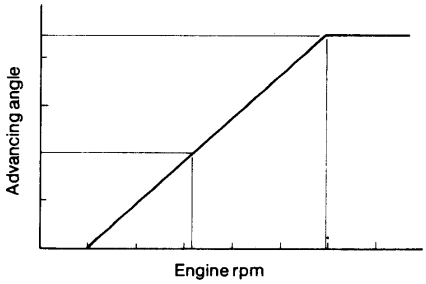
5-2 Functioning and characteristics of timer

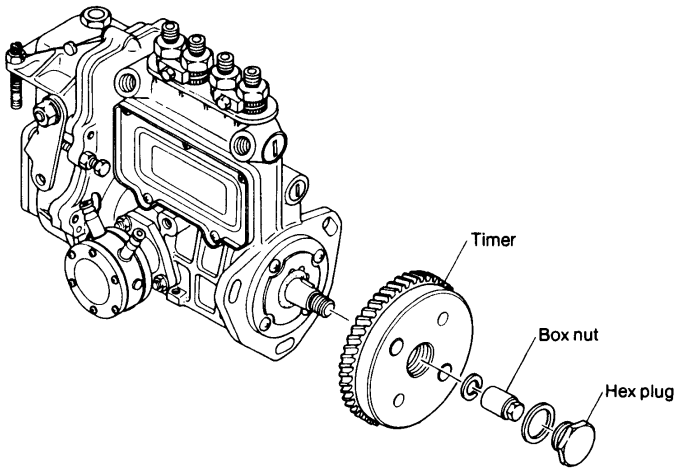


The spring is pressed against the center of the flyweight. As rpm increases, the centrifugal force of the two flyweights increases, compresses the timer spring, and the position of the weight holder and flange changes due to the movement of the curved surface of the weight, changing the injection timing. Accordingly, as the spring is compressed (according to the rise in rpm advancing the timing), the advancing angle remains proportional to rpm.



The advancing characteristics can be changed by changing the profile of the side of the weight and the spring constant of the spring.

5-3 Timer disassembly



(1) Remove the hex plugs from both ends of timer.
(2) Use a box spanner to remove the cam shaft box nut.
(3) Use a gear pulling tool to remove the timer assembly.
(4) The spring, shim and weight can be removed when you take off the gear circlip and separate the timer and weight holder.

NOTE: As the advancing angle has been set at the factory, do not disassemble the timer unless necessary.

5-4 Timer inspection

(1) Inspect the timer ring, and replace if there is excessive settling or corrosion.
(2) Inspect the curved surface of the timer weight and the portion of drive pin it comes in contact with, and replace if wear is excessive or movement is not smooth.

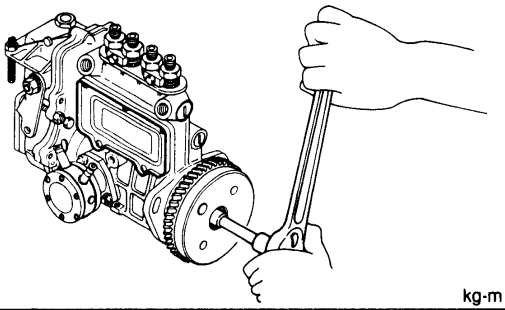
NOTE: 1. Recheck advancing angle when replacing weight or spring, and readjust as necessary with adjusting shims.
2. If you change weight holders, measure the shaft side clearance, and adjust with washers.

mm (in.)

Standard side clearance	0.02 ~ 0.10 (0.0007 ~ 0.0039)

5-5 Timer reassembly

(1) Mount the timer assembly on the fuel injection pump camshaft, and tighten the box nut with a box spanner.

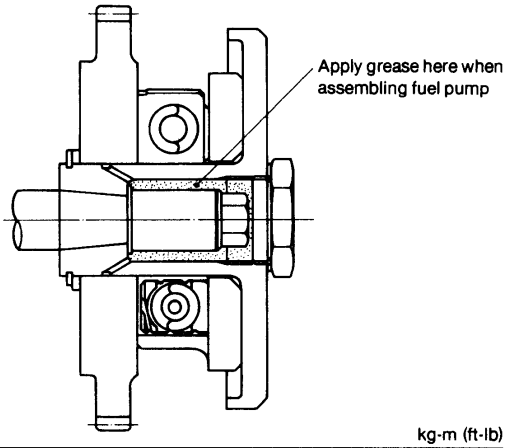


kg-m (ft-lb)

Tightening torque	6 ~ 7 (43.3 ~ 50.6)

NOTE: The box nut is tightened by turning it right looking from the drive side.

(2) Apply grease around the box nut, and tighten the hex plug.



kg-m (ft-lb)

Tightening torque	0.8 ~ 1.20 (1.30 ~ 8.67)

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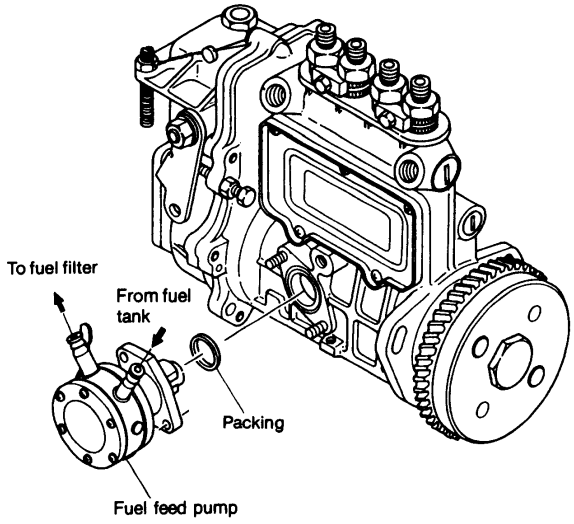
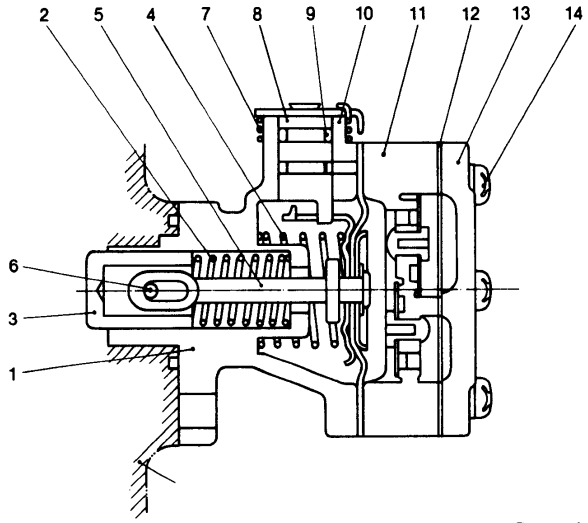
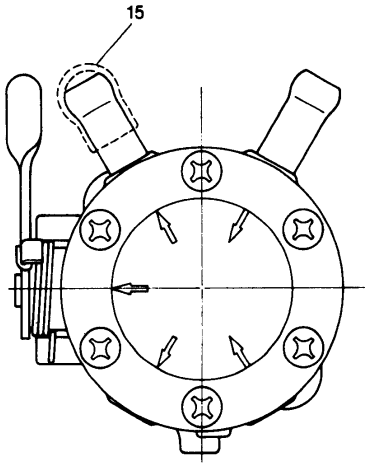
6. Fuel Feed Pump

The fuel feed pump pumps fuel from the fuel tank, passes it through the fuel filter element, and supplies it to the fuel injection pump.
The fuel feed pump is mounted on the side of this engine and is driven by the (eccentric) cam of the fuel pump camshaft. It is provided with a manual priming lever so that fuel can be supplied when the engine is stopped.



6-1 Construction of fuel feed pump





1. Bottom body
2. Piston spring
3. Piston
4. Diaphragm spring
5. Diaphragm assembly
6. Pin
7. Lever return spring
8. Lever assembly
9. O-ring
10. Stop pin
11. Top body assembly
12. Packing
13. Cover
14. Small screw
15. Cap

6-2 Fuel feed pump specifications

Head	1m (3.28 ft)
Discharge volume	230 cc/min (14.03 in.³/min) at 1500 cam rpm, discharge pressure of 0.2 kg/cm² (2.84 lb/in.²)
Closed off pressure	0.3 kg/cm² (4.26 lb/in.²) or more (at 400 cam rpm)

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6-3 Disassembly and reassembly of fuel feed pump

6-3. 1 Disassembly

(1) Remove the fuel feed pump mounting nut, and take the fuel feed pump off the fuel injection pump.
(2) Clean the fuel feed pump assembly with fuel oil.
(3) After checking the orientation of the arrow on the cover, make match marks on the upper body and cover, remove the small screw, and disassemble the cover, upper body and lower body.

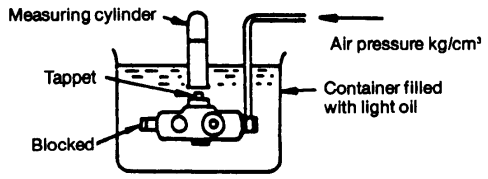
6-3. 2 Reassembly

(1) Clean all parts with fuel oil, inspect, and replace any defective parts.
(2) Replace any packings on parts that have been disassembled.
(3) Make sure that the intake valve and discharge valve on upper body are mounted in the proper direction, and that you don't forget the valve packing.
(4) Assemble the diaphragm into the body, making sure the diaphragm mounting holes are lined up (do not force).
(5) Align the match marks on the upper body of the pump and cover, and tighten the small screws evenly.

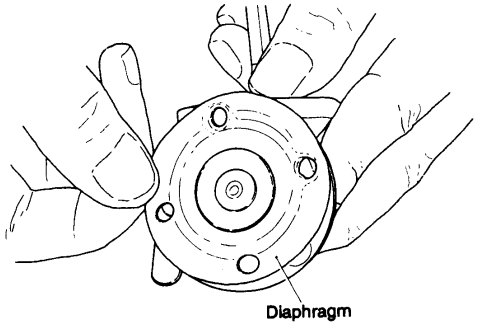
	kg-cm (ft-lb)
Tightening torque	15 ~ 25 (1.08 ~ 1.80)

6-4 Fuel feed pump inspection

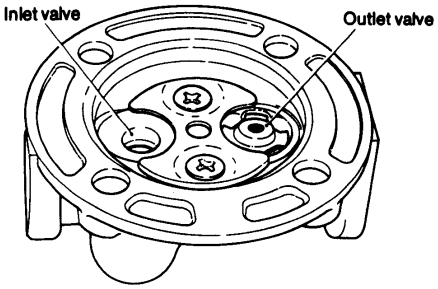
(1) Place the fuel feed pump in kerosene, cover the discharge port with your finger, move the priming lever and check for air bubbles (Repair or replace any part which emits air bubbles).



(2) Attach a vinyl hose to the fuel feed pump intake, keep the pump at the specified depth from the fuel oil surface, move the priming lever by hand and check for sudden spurts of fuel oil from the discharge port. If oil is not spurted out, inspect the diaphragm and diaphragm spring and repair/replace as necessary.
(3) Diaphragm inspection
Parts of the diaphragm that are repeatedly burned will become thinner or deteriorate over a long period of time. Check diaphragm and replace if necessary.



(4) Valve contact/mounting
Clean the valve seat and valve with air to remove any foreign matter.



(5) Inspect the diaphragm spring and piston spring for settling and the piston for wear, and replace as necessary.

NOTE: Replace parts as an assembly.

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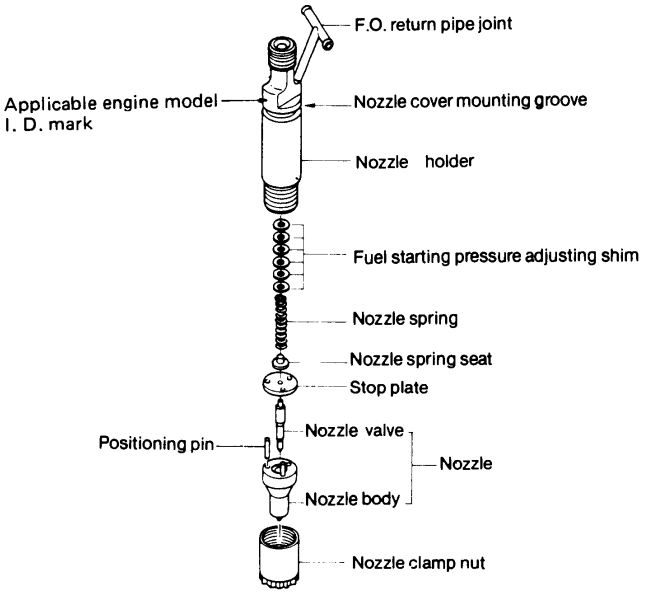
7. Fuel Injection Nozzle

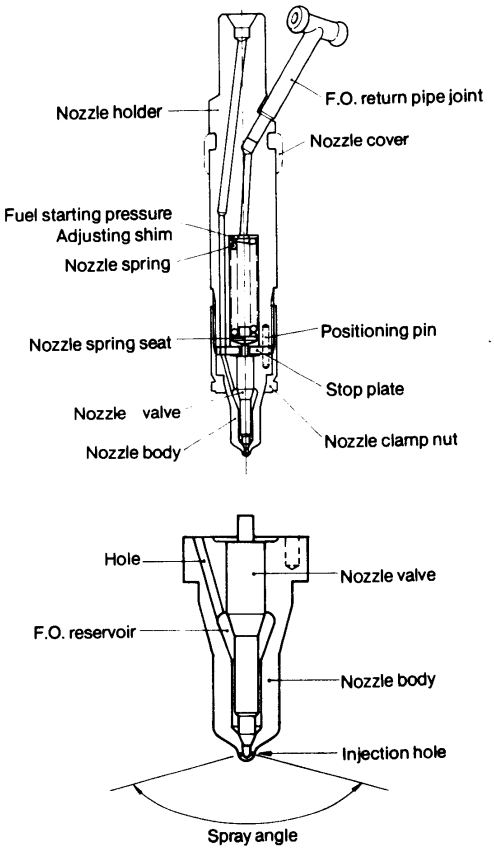
When fuel oil pumped by the fuel injection pump reaches the injection nozzle, it pushes up the nozzle valve (held down by spring), and is injected into the combustion chamber at high pressure.
The fuel is atomized by the nozzle to mix uniformly with the air in the combustion chamber. How well the fuel is mixed with high temperature air directly affects combustion efficiency, engine performance and fuel economy.
Accordingly, the fuel injection nozzles must be kept in top condition to maintain performance and operating efficiency.

7-1 Functioning of fuel injection nozzle

Fuel from the fuel injection pump passes through the oil port in the nozzle holder, and enters the nozzle body reservoir.
When oil reaches the specified pressure, it pushes up the nozzle valve (held by the nozzle spring), and is injected through the small hole on the tip of the nozzle body.
The nozzle valve is automatically pushed down by the nozzle spring and closed after fuel is injected.
Oil that leaks from between the nozzle valve and nozzle body goes from the hole on top of the nozzle spring through the oil leakage fitting and back into the fuel tank.
Adjustment of injection starting pressure is effected with the adjusting shims.

(1) Hole type fuel injection nozzle





Fuel Injection Nozzle Ass'y I. D. Mark	A	E	B	D	F	G		
Spray angle	150°	155°	150°	145°	155°	140°		
Nozzle opening pressure	195 ~ 205 kg/cm² (2,773 ~ 2,915 lb/in.²)							
No. of injection hole x dia	4 x 0.24mm (0.0094 in.)		4 x 0.28mm (0.0110 in.)	5 x 0.26mm (0.0102 in.)	4 x 0.24mm (0.0094 in.)	5 x 0.25mm (0.0098 in.)		
Nozzle I. D. mark	150P244J0	155P244J1	150P284J0	145P265J1	155P265J1	140P255J2		
Applicable engine model	4JHE		4JH-TE	4JH-HTE	4JHE	4JH-TE	4JH-HTE	4JH-DTE
Applicable engine No.	#00101 ~ 00574	#00575 ~ 01000	#00101 ~ 11000	#20101 ~ 21000	#01001 and after	#11001 and after	#21001 and after	#30101 and after

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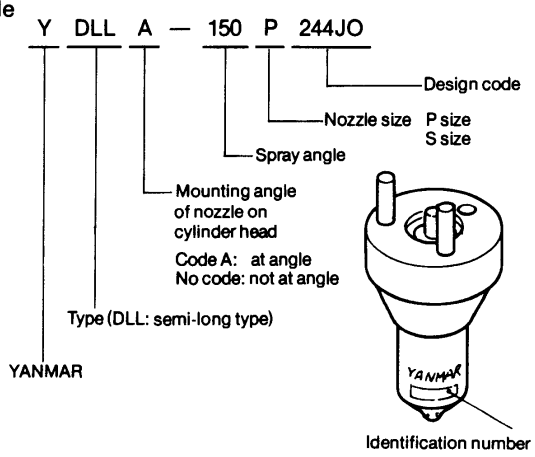
(3) Nozzle body identification number
The type of nozzle can be determined from the number inscribed on the outside of the nozzle body.
1) Hole type fuel injection nozzles

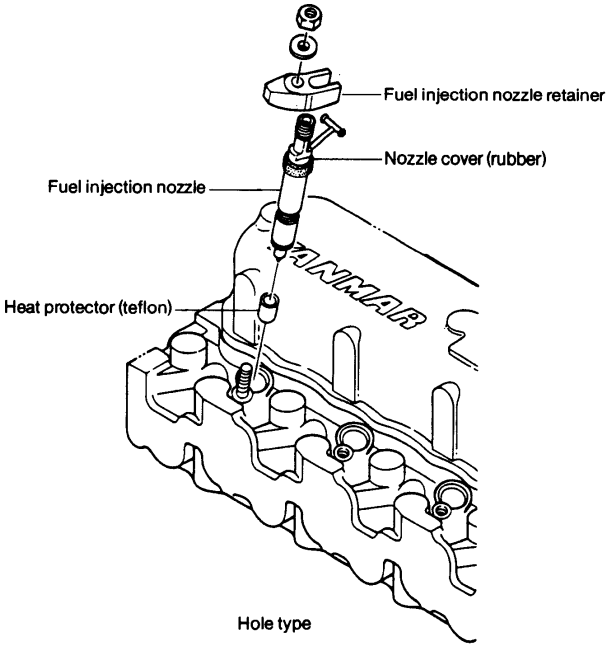
Sample



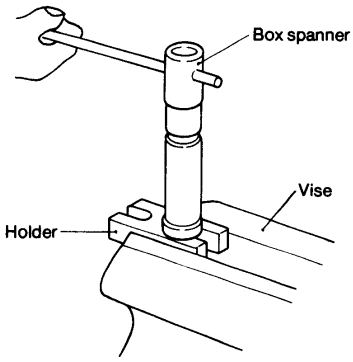
7-3 Fuel injection nozzle disassembly

NOTE: 1. Disassemble fuel injection nozzle in a clean area as for fuel injection pump.
2. When disassembling more than one fuel injection nozzle, keep the parts for each injection nozzle separate for each cylinder (i.e. the nozzle for cylinder 1 must be remounted in cylinder 1).

(1) When removing the injection nozzle from the cylinder head, remove the high pressure fuel pipe, fuel leakage pipe, etc., the injection nozzle retainer nut, and then the fuel injection nozzle.



(2) Put the nozzle in a vise
NOTE: Use the special nozzle holder for the hole type injection nozzle so that the high pressure mounting threads are not damaged.
(3) Remove the nozzle nut



NOTE: Use a special box spanner for the hole type (the thickness of the two nozzle nuts is 15mm (0.5906in.)).

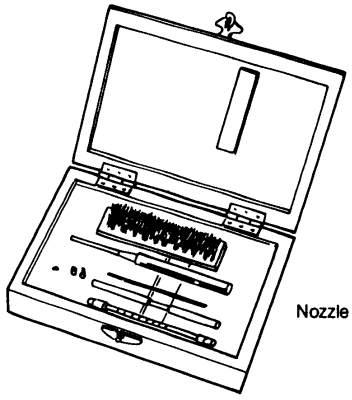
(4) Remove the inner parts

NOTE: Be careful not to loosen the spring seat, adjusting shims or other small parts.

7-4 Fuel injection nozzle inspection

7-4. 1 Washing

(1) Make sure to use new diesel oil to wash the fuel injection nozzle parts.
(2) Wash the nozzle in clean diesel oil with the nozzle cleaning kit.



1) Diesel Kiki nozzle cleaning kit:
Type NP-8486B No. 5789-001
2) Anzen Jidosha Co., Ltd. nozzle cleaning kit:
Type NCK-001

(3) Clean off the carbon on the outside of the nozzle body with a brass brush.

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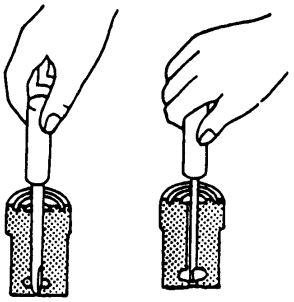
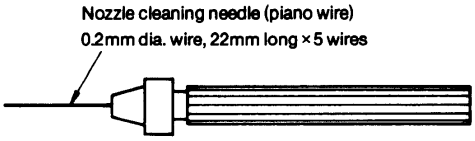
(4) Clean the nozzle seat with cleaning spray.



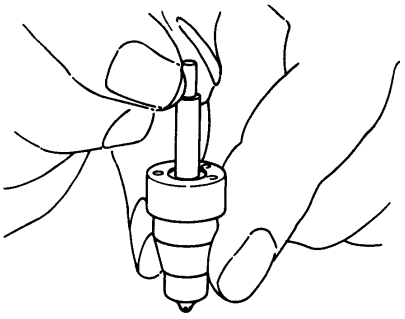
(5) Clean off the carbon on the tip of nozzle with a piece of wood.
(6) Clean hole type nozzles with a nozzle cleaning needle.



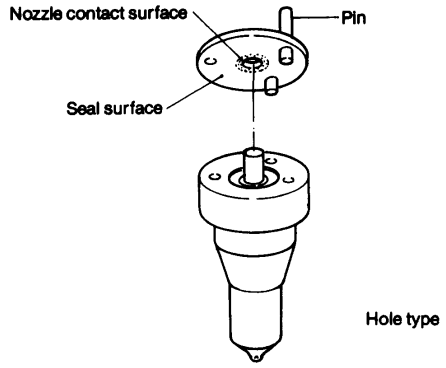
Part code no.	28210-000010

7-4. 2 Nozzle inspection

(1) Inspect for scratches/wear
Inspect oil seals for abnormal scratches or wear and replace nozzle if the nozzle sliding surface or seat are scratched or abnormally worn.
(2) Check nozzle sliding
Wash the nozzle and nozzle body in clean diesel oil, and make sure that when the nozzle is pulled out about half way from the body, it slides down by itself when released.
Rotate the nozzle a little; replace nozzle/nozzle body as a set if there are some places where it does not slide smoothly.



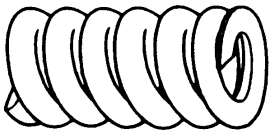
(3) Inspecting stop plate (inter-piece)
Check for scratches/wear in seals on both ends, check for abnormal wear on the surface where it comes in contact with the nozzle; replace if stop plate is excessively worn.



mm (in.)

Nozzle contact surface wear limit	0.1 (0.0039)

(4) Inspecting nozzle spring
Replace the nozzle spring if it is extremely bent, or the surface is scratched or rusted.



(5) Nozzle holder
Check oil seal surface for scratches/wear; replace if wear is excessive.

7-5 Fuel injection nozzle reassembly

The fuel injection nozzle is reassembled in the opposite order to disassembly.
(1) Insert the adjusting shims, nozzle spring and nozzle spring seat in the nozzle holder, mount the stop plate with the pin, insert the nozzle body/nozzle set and tighten the nut.
(2) Use the special holder when tightening the nut for the hole type nozzle as in disassembly.

Nozzle nut tightening torque — kg-m (ft-lb)

Hole type nozzle	4 ~ 4.5 (28.9 ~ 32.5)

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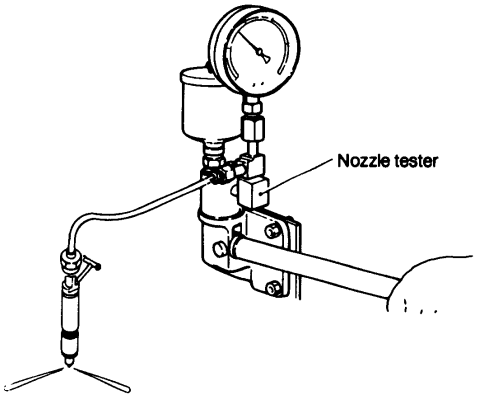
7-6 Adjusting fuel injection nozzle

7-6. 1 Adjusting opening pressure

Mount the fuel injection nozzle on the nozzle tester and use the handle to measure injection starting pressure. If it is not at specified pressure, use the adjusting shims to increase/decrease pressure (both hole and pintle types).



Injection starting pressure

kg/cm² (lb/in.²)

Injection starting pressure	195 ~ 205 (2773 ~ 2915)

7-6. 2 Injection test

After adjusting the nozzle to the specified starting pressure, check the fuel spray condition and seat oil tightness.

(1) Check seat oil tightness

After two or three injections, gradually increase the pressure up to 20 kg/cm² (284 lb/in.²) before reading the starting pressure, maintain the pressure for 5 seconds, and make sure that no oil is dripping from the tip of the nozzle.

Test the injection with a nozzle tester; retighten and test again if there is excessive oil leakage from the overflow coupling.

Replace the nozzle as a set if oil leakage is still excessive.

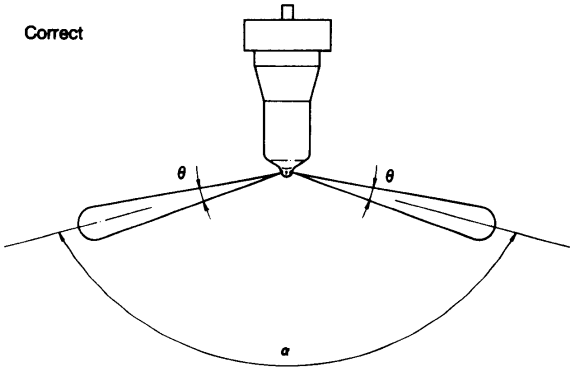
(2) Injection spray condition

Operate the nozzle tester lever once to twice a second and check for abnormal injection.

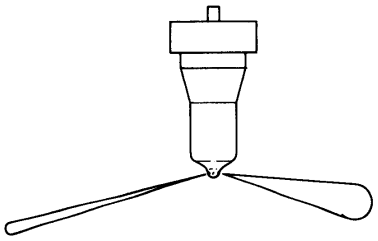
1) Hole type nozzles

Replace hole type nozzles that do not satisfy the following conditions:

- Proper spray angle (θ)
- Correct injection angle (α)
- Complete atomization of fuel
- Prompt starting/stopping of injection



Spray from each nozzle hole is uniform



- Excessive difference in spray angle (θ)
- Excessive difference in injection angle (α)
- Incomplete atomization
- Sluggish starting/stopping of injection

8. Troubleshooting

1. Troubleshooting of fuel injection pump

Complete repair means not only replacing defective parts, but finding and eliminating the cause of the trouble as well. The cause of the trouble may not necessarily be in the pump itself, but may be in the engine or the fuel system. If the pump is removed prematurely, the true cause of the trouble may never be known. Before removing the pump from the engine, at least go through the basic check points given here.

Basic check points

- Check for breaks or oil leaks throughout the fuel system, from the fuel tank to the nozzle.
- Check the injection timings for all cylinders. Are they correctly adjusted? Are they too fast or too slow?
- Check the nozzle spray.
- Check the fuel delivery. Is it in good condition? Loosen the fuel pipe connection at the injection pump inlet, and test operate the fuel feed pump.

2. Major faults and troubleshooting

Fault		Cause	Remedy
1. Engine won't start.	Fuel not delivered to injection pump.	(1) No fuel in the fuel tank.	Resupply
		(2) Fuel tank cock is closed.	Open
		(3) Fuel pipe system is clogged.	Clean
		(4) Fuel filter element is clogged.	Disassemble and clean, or replace element
		(5) Air is sucked into the fuel due to defective connections in the piping from the fuel tank to the fuel pump.	Repair
		(6) Defective valve contact of feed pump	Repair or replace.
		(7) Piston spring of feed pump is broken.	Replace
		(8) Inter-spindle or tappets of feed pump are stuck.	Repair or replace
	Fuel delivered to injection pump.	(1) Defective connection of control lever and accel. rod of injection pump.	Repair or adjust
		(2) Plunger is worn out or stuck.	Repair or replace
		(3) Delivery valve is stuck.	Repair or replace
		(4) Control rack doesn't move.	Repair or replace
		(5) Injection pump coupling is damaged, or the key is broken.	Replace
	Nozzle doesn't work.	(1) Nozzle valve doesn't open or close normally.	Repair or replace
		(2) Nozzle seat is defective.	Repair or replace
		(3) Case nut is loose.	Inspect and tighten
		(4) Injection nozzle starting pressure is too low.	Adjust
		(5) Nozzle spring is broken.	Replace
		(6) Fuel oil filter is clogged.	Repair or replace
		(7) Excessive oil leaks from the nozzle sliding area.	Replace the nozzle assembly
	Injection timing is defective.	(1) Injection timing is retarded due to failure of the coupling.	Adjust
		(2) Camshaft is excessively worn.	Replace camshaft
		(3) Roller guide incorrectly adjusted or excessively worn.	Adjust or replace
		(4) Plunger is excessively worn.	Replace plunger assembly
2. Engine starts, but immediately stops.		(1) Fuel pipe is clogged.	Clean
		(2) Fuel filter is clogged.	Disassemble and clean, or replace the element.
		(3) Improper air-tightness of the fuel pipe connection, or pipe is broken and air is being sucked in.	Replace packing; repair pipe
		(4) Insufficient fuel delivery from the feed pump.	Repair or replace

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Fault		Cause	Remedy
3. Engine's output is insufficient.	Defective injection timing, and other failures.	(1) Knocking sounds caused by improper (too fast) injection timing.	Inspect and adjust
		(2) Engine overheats or emits large amount of smoke due to improper (too slow) injection timing.	Inspect and adjust
		(3) Insufficient fuel delivery from feed pump.	Repair or replace
	Nozzle movements is defective	(1) Case nut loose.	Inspect and retighten
		(2) Defective injection nozzle performance.	Repair or replace nozzle
		(3) Nozzle spring is broken.	Replace
		(4) Excessive oil leaks from nozzle.	Replace nozzle assembly
	Injection pump is defective.	(1) Max. delivery limit bolt is screwed in too far.	Adjust
		(2) Plunger is worn.	Replace
		(3) Injection amount is not uniform.	Adjust
		(4) Injection timings are not even.	Adjust
		(5) The 1st and 2nd levers of the governor and the control rack of the injection pump are improperly lined up.	Repair
		(6) Delivery stopper is loose.	Inspect and retighten
		(7) Delivery packing is defective.	Replace packing
		(8) Delivery valve seat is defective.	Repair or replace
		(9) Delivery spring is broken.	Replace
4. Idling is rough.		(1) Movement of control rack is defective.	
		1) Stiff plunger movement or sticking.	Repair or replace
		2) Rack and pinion fitting is defective.	Repair
		3) Movement of governor is improper.	Repair
		4) Delivery stopper is too tight.	Inspect and adjust
		(2) Uneven injection volume.	Adjust
		(3) Injection timing is defective.	Adjust
		(4) Plunger is worn and fuel injection adjustment is difficult.	Replace
		(5) Governor spring is too weak.	Replace
		(6) Feed pump can't feed oil at low speeds.	Repair or replace
		(7) Fuel supply is insufficient at low speeds due to clogging of fuel filter.	Disassemble and clean, or replace element
5. Engine runs at high speeds, but cuts out at low speeds.		(1) The wire or rod of the accel. is caught.	Inspect and repair
		(2) Control rack is caught and can't be moved.	Inspect and repair
6. Engine doesn't reach max. rpm.		(1) Governor spring is broken or excessively worn.	Replace
		(2) Injection performance of nozzle is poor.	Repair or replace
7. Loud knocking.		(1) Injection timing is too fast or too slow.	Adjust
		(2) Injection from nozzle is improper. Fuel drips after each injection.	Adjust
		(3) Injection nozzle starting pressure is too high.	Adjust
		(4) Uneven injection.	Adjust
		(5) Engine overheats, or insufficient compression.	Repair
8. Engine exhausts too much smoke.	When exhaust smoke is black:	(1) Injection timing is too fast.	Adjust
		(2) Air volume intake is insufficient.	Inspect and repair
		(3) The amount of injection is uneven.	Adjust
		(4) Injection from nozzle is improper.	Repair or replace
	When exhaust smoke is white:	(1) Injection timing is too slow.	Adjust
		(2) Water is mixed in fuel.	Inspect fuel system, and clean
		(3) Shortage of lube oil in the engine.	Repair
		(4) Engine is over-cooled.	Inspect

9. Fuel Injection Pump Service Data

July 18 '85

Adjustment	Item \ Engine model		4JHE		4JH-TE		4JH-HTE		4JH-DTE	
	Assemble cord	Part No.	729470 – 51300		729472 – 51300		729474 – 51300		729473 – 51300	
		I.D. mark	B300		B303		B306		B364	
	Adjustment specs.		Engine specs.	Calibration specs.	Engine specs.	Caribration specs.	Engine specs.	Calibration specs.	Engine specs.	Calibration specs.
4-1-(1)	Nozzle type I.D.mark		150P244JO/*155P244J1/**155P244J2	DN-12SD12	150P284JO/**140P255J2	DN-12SD12	145P265J1/**140P255J2	DN-12SD12	140P255J2	DN-12SD12
	Injection starting pressure kg/cm² (lb/in²)		195 ~ 205 (2,773 ~ 2,915)	165 ~ 175 (2,346 ~ 2,489)	195 ~ 205 (2,773 ~ 2,915)	165 ~ 175 (2,346 ~ 2,489)	195 ~ 205 (2,773 ~ 2,915)	165 ~ 175 (2,346 ~ 2,489)	195 ~ 205 (2,773 ~ 2,915)	165 ~ 175 (2,346 ~ 2,489)
4-1-(2)	Fuel injection pipe OD φ /ID φ x L mm (in)		φ6 / φ1.8 x 400 (0.2362/0.078 x 15.748)	φ6 / φ2 x 600 (0.2362/0.0787 x 23.622)	φ6 / φ1.8 x 400 (0.2362/0.0708 x 15.748)	φ6 / φ2 x 600 (0.2362/0.0787 x 23.622)	φ6 / φ2 x 400 (0.2362/0.0787 x 15.748)	φ6 / φ2 x 600 (0.2362/0.0787 x 23.622)	φ6 / φ2 x 400 (0.2362/0.0787 x 15.748)	φ6 / φ2 x 600 (0.2362/0.0787 x 23.622)
4-2	Top clearance /Prestroke mm (in)		0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)		0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)		0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)		0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)	
4-7-1	Rated load	Pump rpm: N1 rpm	1,800		1,800		1,800		1,800	
		Rack position: R1 mm(in.)	7 (0.2756)		7 (0.2756)		7 (0.2756)		7 (0.2756)	
		Measuring stroke St	1,000		1,000		1,000		1,000	
		Injection volume cc	25	26.5 **27.5	31	32 **34	33	34 **36.5	40	47
		Nonuniformity %	±3		±3		±3		±3	
4-7-2	No load	Pump rpm: N2 rpm	1,950		1,950		1,950		1,950	
		Rack position: R2 mm(in.)								
4-7-3	Idling	Pump rpm: N3 rpm	325		325		325		325	
		Measuring stroke St	1,000		1,000		1,000		1,000	
		Injection volume cc	7 ~ 8	8 ~ 9	9 ~ 10	10 ~ 11	9 ~ 10	10 ~ 11	9 ~ 10	10 ~ 11
		Nonuniformity %	± 10		± 10		± 10		± 10	
4-7-4	Starting	Pump rpm: N4 rpm	200		200		200		200	
		Rack position mm(in.)	11.5 ~ 12.5 (0.4527 ~ 0.4921)		11.5 ~ 12.5 (0.4527 ~ 0.4921)		11.5 ~ 12.5 (0.4527 ~ 0.4921)		11.5 ~ 12.5 (0.4527 ~ 0.4921)	
		Measuring stroke St	1,000		1,000		1,000		1,000	
		Injection volume cc	60~70	55~65, **65~75	60~70	55~65, ** 65~75	60~70	55~65, ** 65~75	60~70	65~75

*NOTE 1 : * Applicable engine number : # 00575 and after (Engine model 4JHE)*
*NOTE 2 : ** Applicable engine model and engine number : 4JH-TE # 11001 and after*
4JH-HTE # 21001 and after
4JHE # 01001 and after

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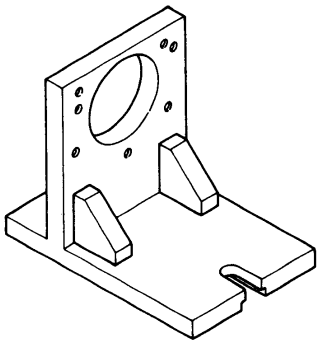
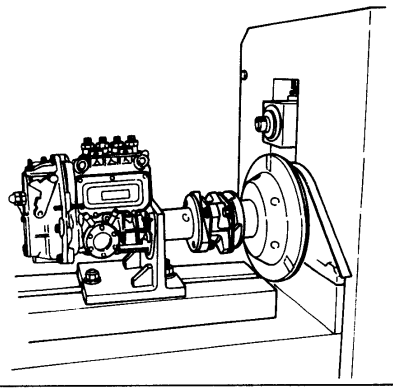
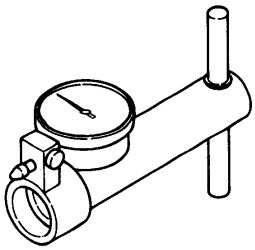
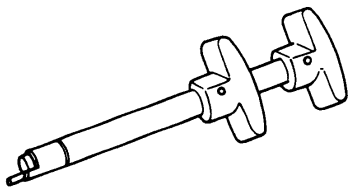
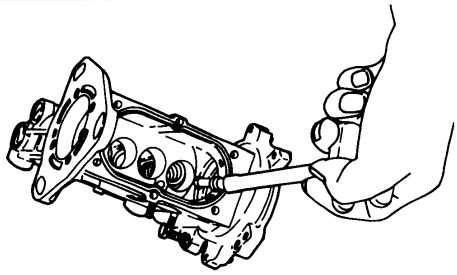
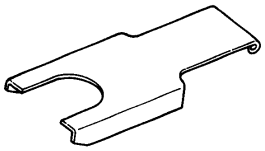
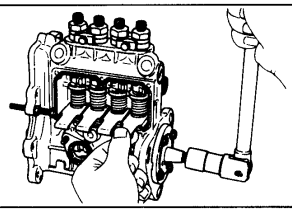
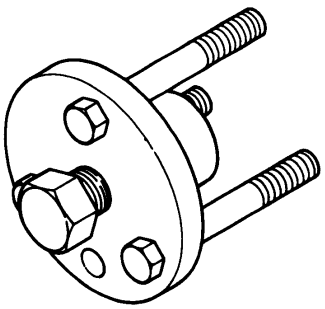
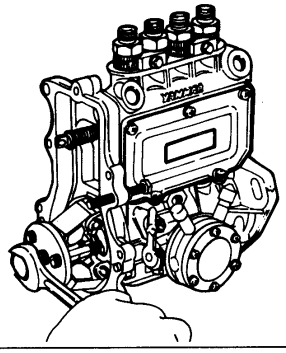
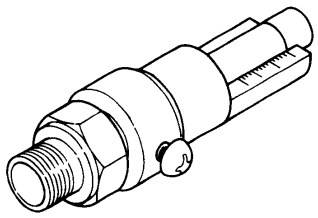
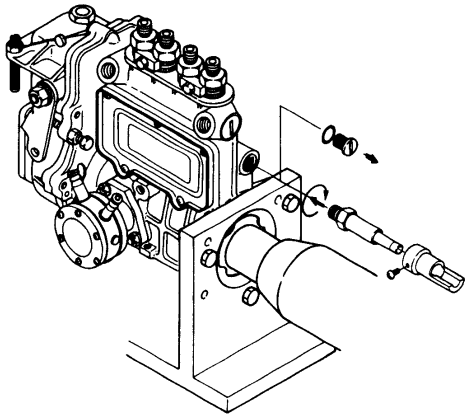
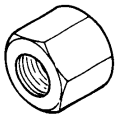
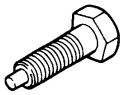
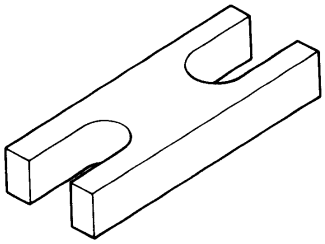
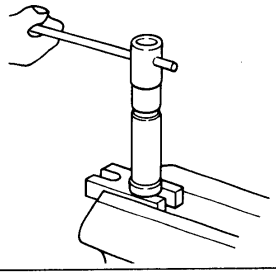
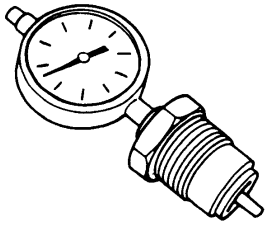
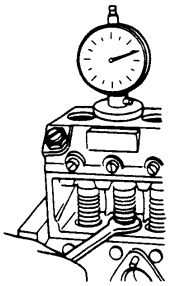
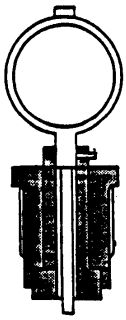
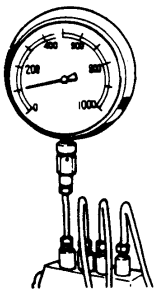
10. Tools

Name of tool	Shape and size	Application
Pump mounting scale for Yanmar tester 158090-51010 for Bosch (tester) 158090-51020		
Measuring device (cam backlash) 158090-51050		
Plunger insert 158090-51100		
Tappet holder 158090-51200		
Weight extractor 158090-51400		

Name of tool	Shape and size	Application
Rack indicator 158090-51500		
Rack lock screw 158090-51010		
Dummy nut 158090-51520		
Nozzle plate 158090-51700		
Plunger gauge 121820-92540		
Top clearance gauge 158090-51300		
Timer extraction tool		

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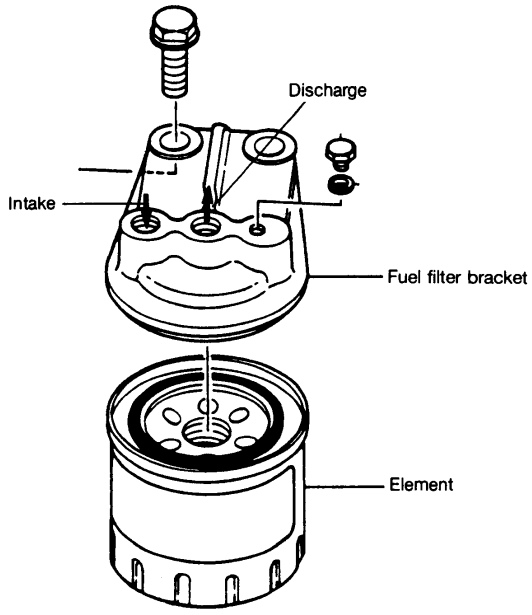
11. Fuel Filter

The fuel filter is installed between the fuel feed pump and fuel injection pump, and removes dirt/foreign matter from the fuel pumped from the fuel tank.
The fuel filter element must be changed periodically. The fuel pumped by the fuel feed pump goes around the element, is fed through the pores in the filter and discharged from the center of the cover. Dirt and foreign matter in the fuel is deposited in the element.



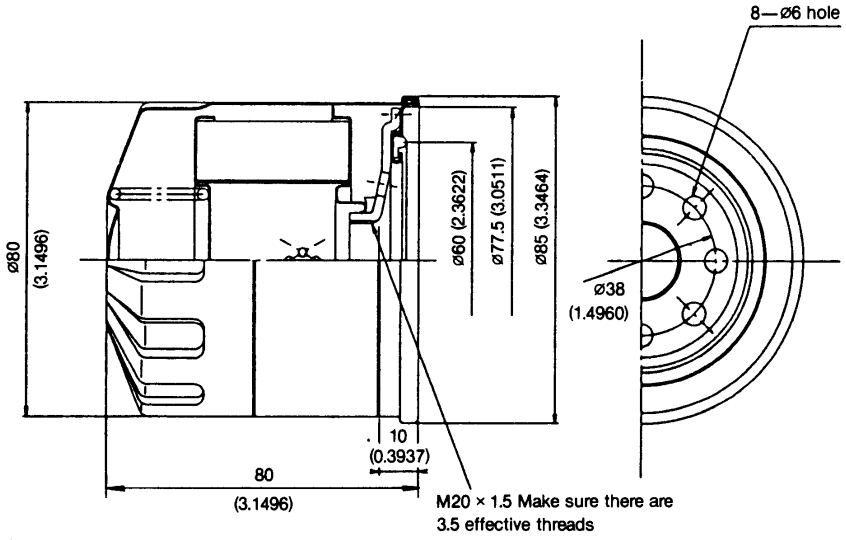
11-1 Fuel filter specifications

Filtering method	filter paper
Filtering area	840cm² (130.20in.²)
Maximum flow	0.25 ℓ/min (15.25 in.³/min)
Pressure loss	100mm (3.9370in.) Hg or less
Max. dia. of unfiltered particle	5μ

11-2 Fuel filter inspection

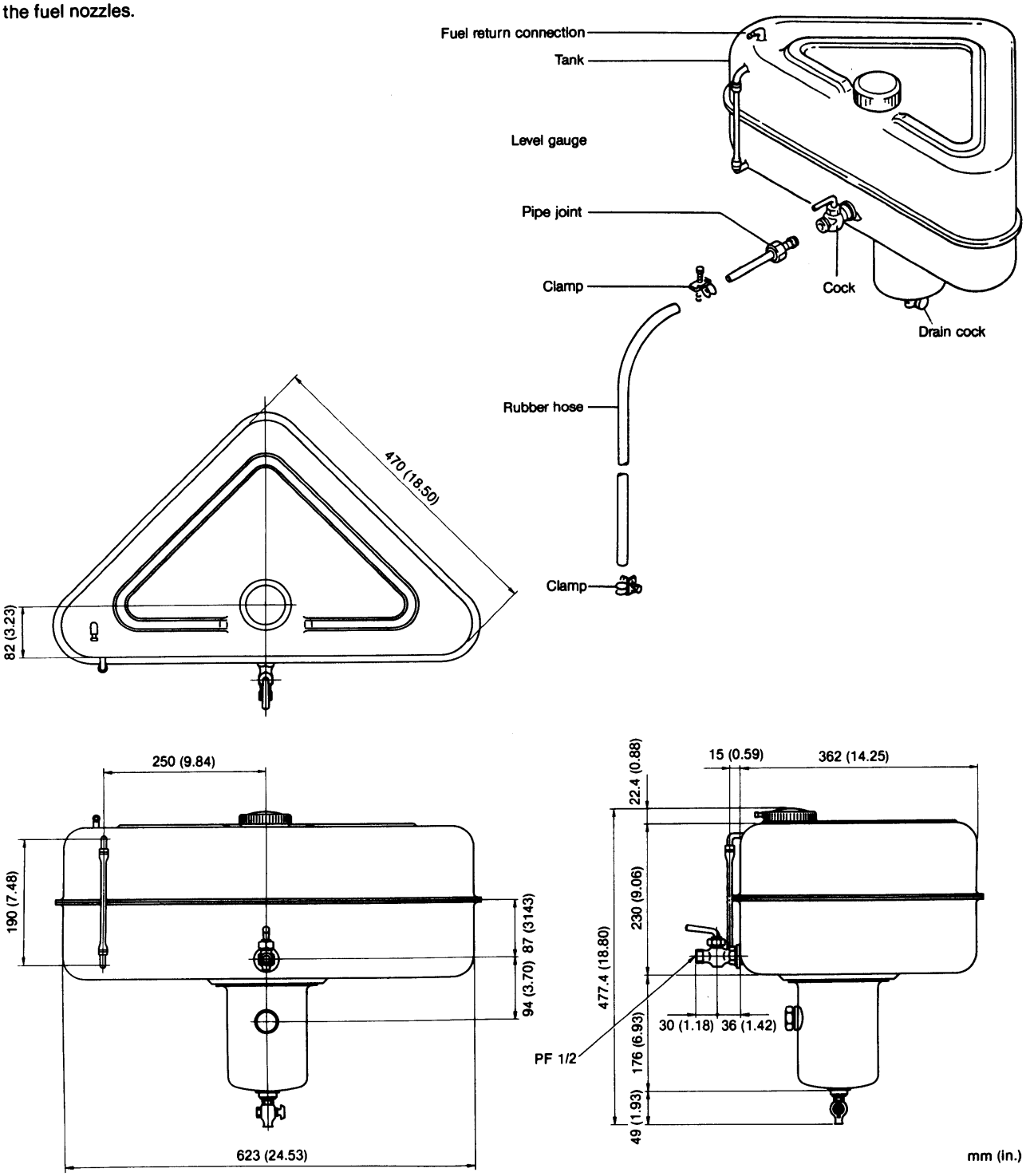
The fuel strainer must be cleaned occasionally. If there is water or foreign matter in the strainer bowl, disassemble the strainer and wash with clean fuel oil to completely remove foreign matter. Replace the element every 300 hours of operation.
Replace the filter prior to this if the filter is very dirty, deformed or damaged.

Element changes	every 300 hours
Element part code number	129470-55700



12. Fuel Tank

A triangular 30 liter fuel tank with a 2000mm (78.7402in.) rubber fuel hose to fit all models is available as an option. A fuel return connection is provided on top of the tank to which a rubber hose can be connected to return fuel from the fuel nozzles.



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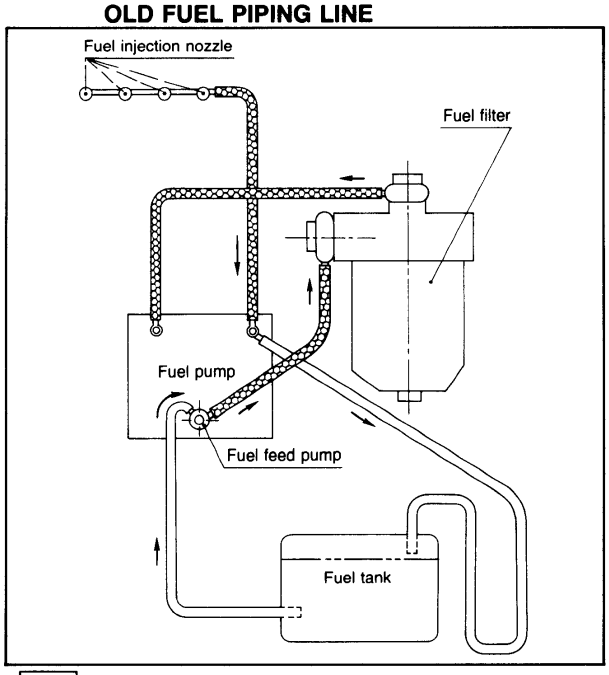
13. Design Change of Fuel Piping Line

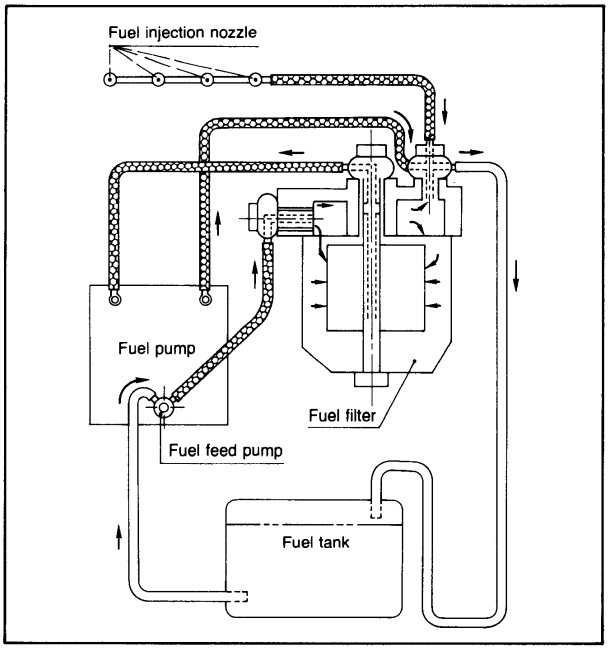
To facility easy servicing, following design modifications will be made on the marine diesel engine model 4JH-series. Through the change of fuel piping line, air-bleeding will be done more easily.

13-1 Modification of fuel piping line.

OLD FUEL PIPING LINE



NEW FUEL PIPING LINE



13-2 Applicable engine models and serial numbers.

Engine Model	Serial Number	Plant Production
4JH(B)E	#01179 and thereafter	From Dec., 1985
4JH-T(B)E	#11201 and thereafter	
4JH-HT(B)E	#21226 and thereafter	
4JH-DT(B)E	#30312 and thereafter	

NOTE: Air-bleeding of the following engines with the modified fuel piping require the equivalent procedure as in the engine with the former fuel piping.

Engine Model	Serial Number
4JH(B)E	#01109 – 01178
4JH-T(B)E	#11143 – 11200
4JH-HT(B)E	#21180 – 21225
4JH-DT(B)E	#30256 – 30311

CHAPTER 4

INTAKE AND EXHAUST SYSTEM

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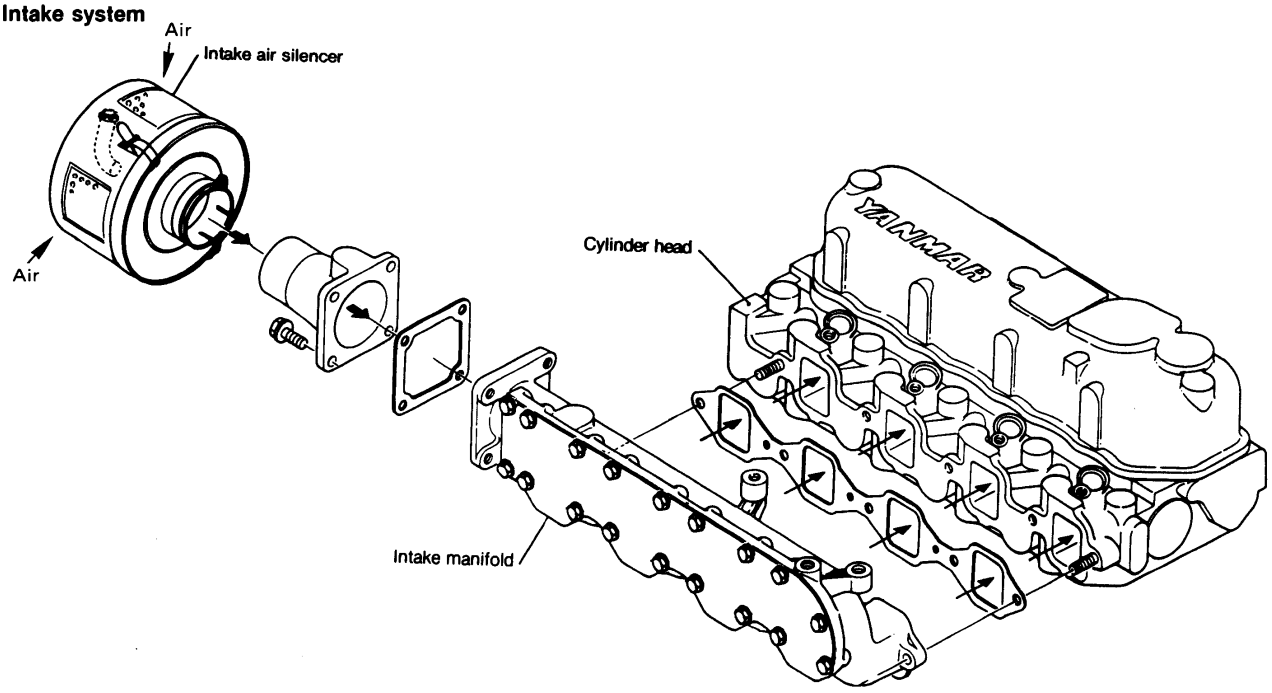
1. Intake and Exhaust System

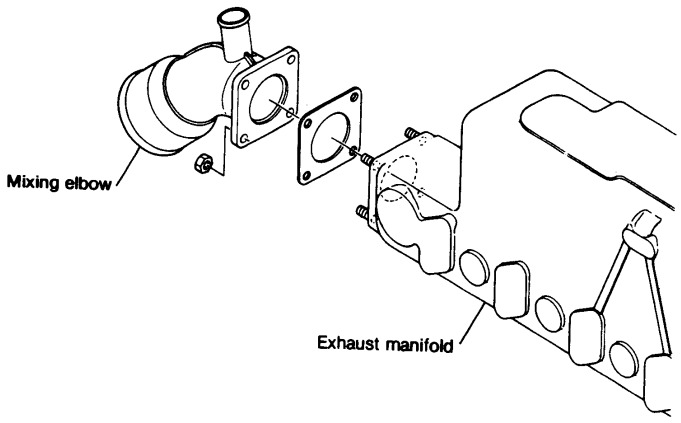
1-1 4JHE engine

Air enters in the intake silencer mounted at the end of the intake manifold, is fed to the intake manifold and then on to each cylinder.
Exhaust gas goes into the exhaust manifold (in the fresh water tank) mounted on the cylinder head discharge. After cooling it enters the mixing elbow which is directly connected with the exhaust manifold, and is discharged from the ship along with waste cooling water.

Intake system



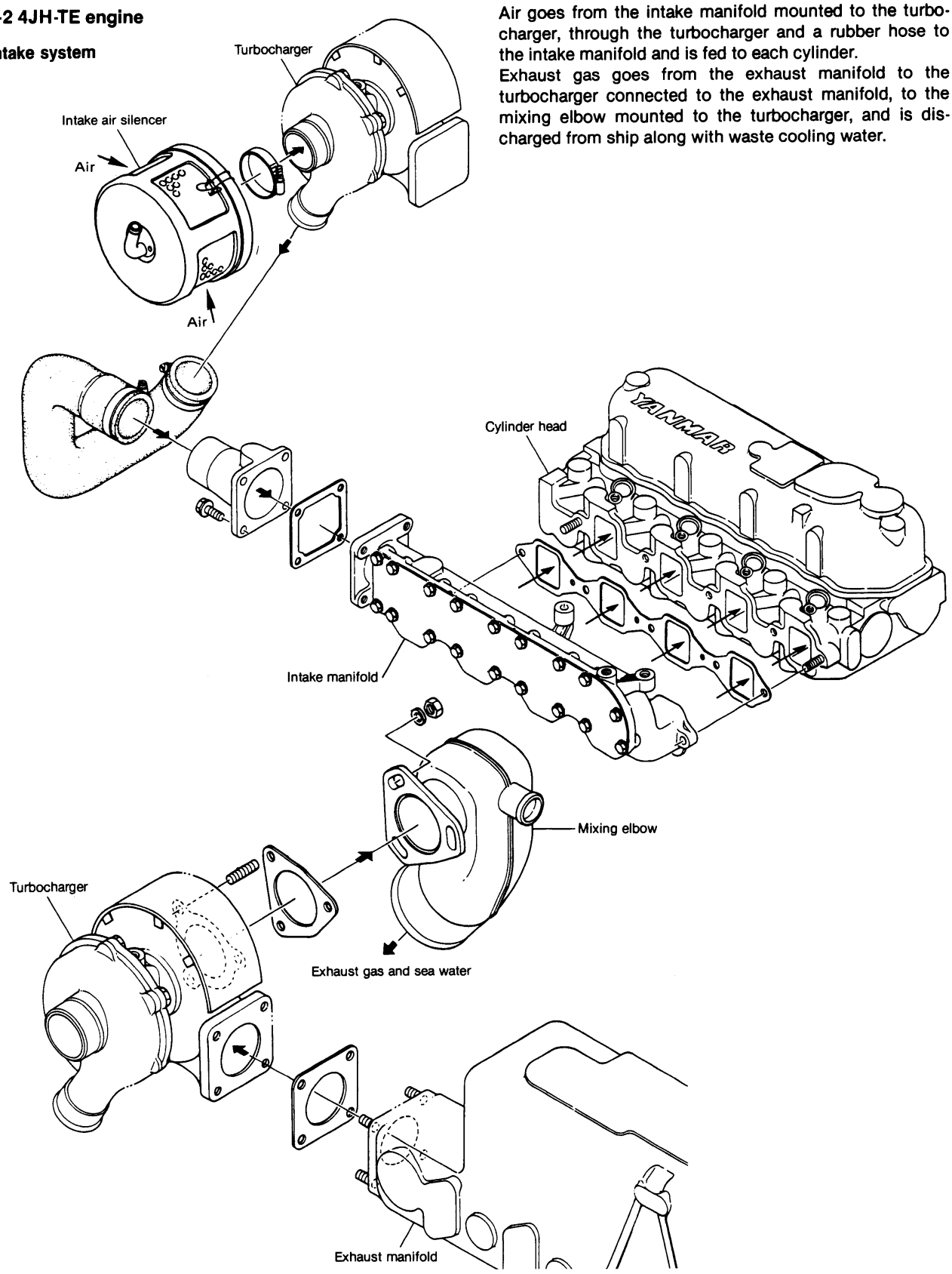
Exhaust system



1-2 4JH-TE engine

Intake system

Air goes from the intake manifold mounted to the turbocharger, through the turbocharger and a rubber hose to the intake manifold and is fed to each cylinder.
Exhaust gas goes from the exhaust manifold to the turbocharger connected to the exhaust manifold, to the mixing elbow mounted to the turbocharger, and is discharged from ship along with waste cooling water.



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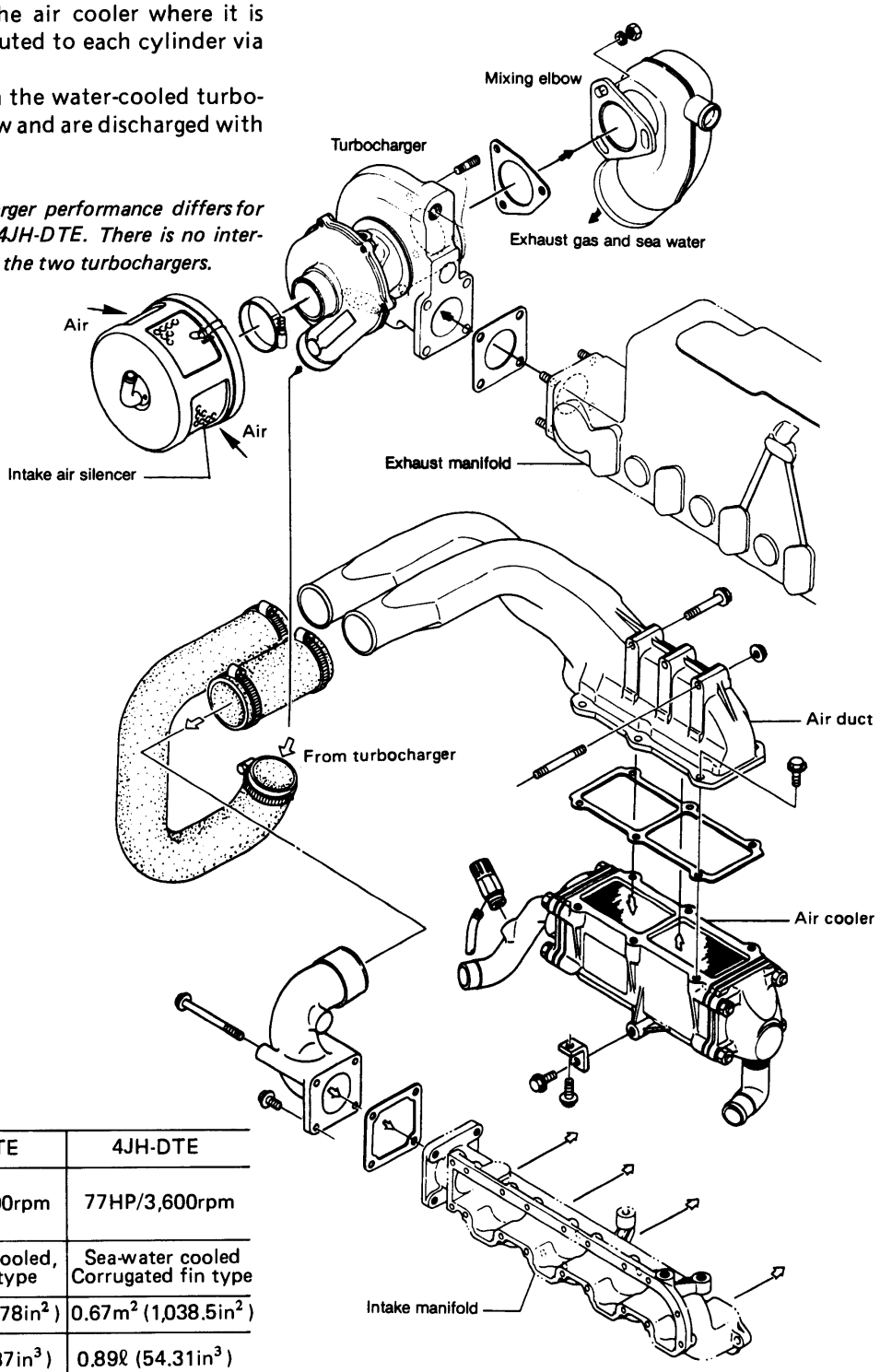
Air Cooler for Models 4JH-HTE and 4JH-DTE

Air introduced from the intake air silencer passes through the air duct to the air cooler where it is cooled, and is then distributed to each cylinder via the intake manifold.
Exhaust gases pass through the water-cooled turbocharger to the mixing elbow and are discharged with the sea water.

NOTE: Water-cooled turbocharger performance differs for models 4JH-HTE and 4JH-DTE. There is no interchangeability between the two turbochargers.



Air Cooler Specifications

Engine model	4JH-HTE	4JH-DTE
Output Din6270B Rating	66HP/3,600rpm	77HP/3,600rpm
Type	Sea-water cooled, Plate fin type	Sea-water cooled Corrugated fin type
Radiation area	0.76m^2 (1,178in^2)	0.67m^2 (1,038.5in^2)
Sea-water capacity	0.85ℓ (51.87in^3)	0.89ℓ (54.31in^3)

NOTE: ⇨ Charging Air
➡ Exhaust gas and Sea-water

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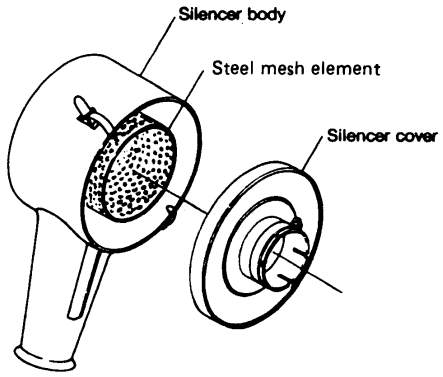
2. Intake Silencer

2-1 Construction

The intake silencer has a steel plate element with holes to reduce noise.
The silencer is provided with a mist breather pipe joint from which mist is taken in.

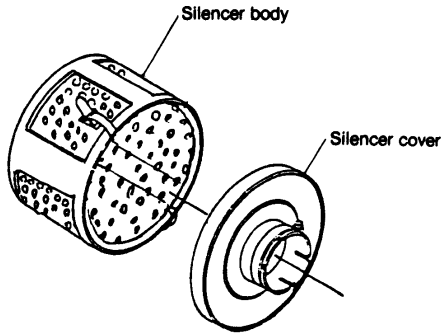
Old type (Part No. 129495-12500)



2-2 Intake silencer inspection

(1) Sometimes disassemble the silencer and clean the inside. If welds are cracked or corroded, repair or replace as necessary.
(2) Inspect the mist pipe joint, remove any dirt and thoroughly clean.

New type (Part No. 129470-12300)



			4JHE	4JH-TE	4JH-HTE	4JH-DTE
Rating air discharge volume		m^3/min (ft^3/min)	2.5 (88.27)	3.7 (130.64)	4.7 (165.96)	5.6 (197.74)
Ventilation resistance	Old type	mmAq (in.Aq)	120 (4.72)	150 (5.90)	–	–
	New type	mmAq (in.Aq)	35 (1.38)	70 (2.76)	100 (3.94)	125 (4.92)

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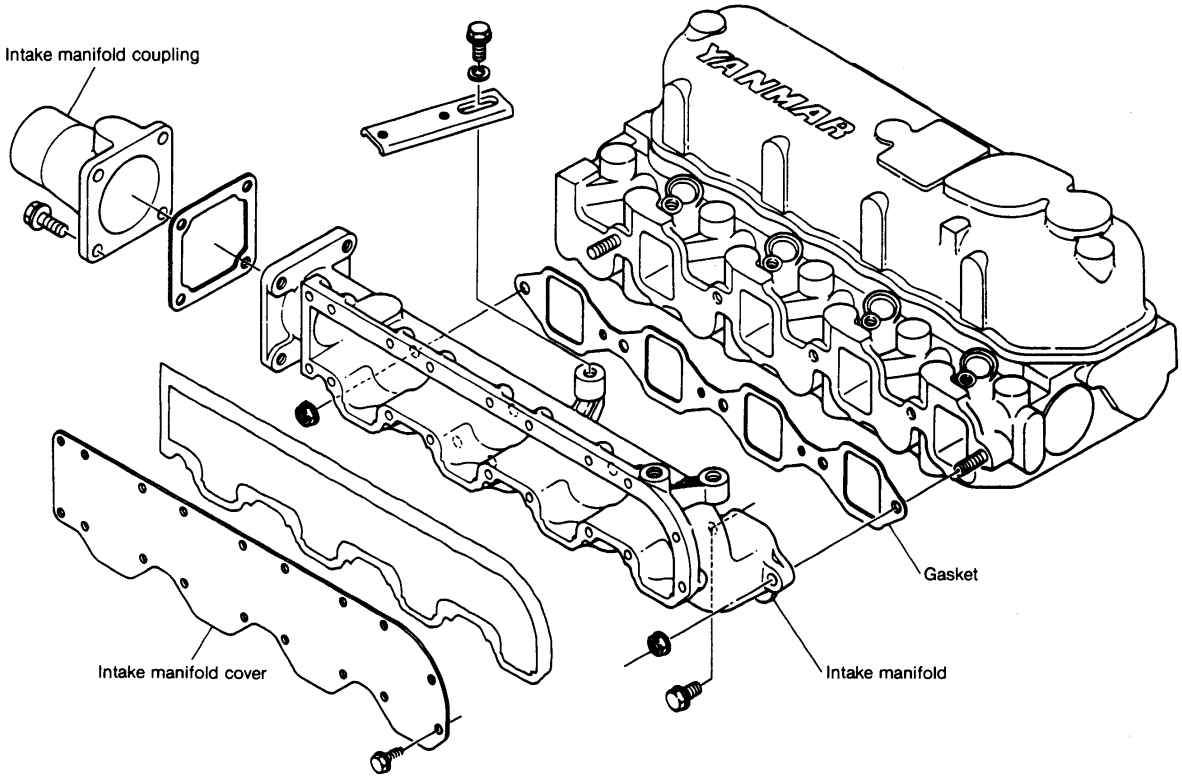
3. Intake Manifold

3-1 Construction

The intake manifold consists of the manifold and the cover, but the cover should not be disassembled without a special reason as it is coated with adhesive and bolted.
If it is disassembled, recoat with adhesive and tighten to specified torque. (It can only be disassembled three times).

3-2 Inspection

(1) Make sure that air flows through smoothly and clean out any dirt. Replace if it is excessively corroded, cracked or otherwise damaged.
(2) Inspect the gasket packings and replace if damaged.
(3) On models equipped with an air heater between the manifold and coupling, inspect the nickel-chrome wires for breakage, damaged contacts, etc.,



Intake manifold cover set bolts tightening torque	0.7 kg-m (5.06 ft-lb)

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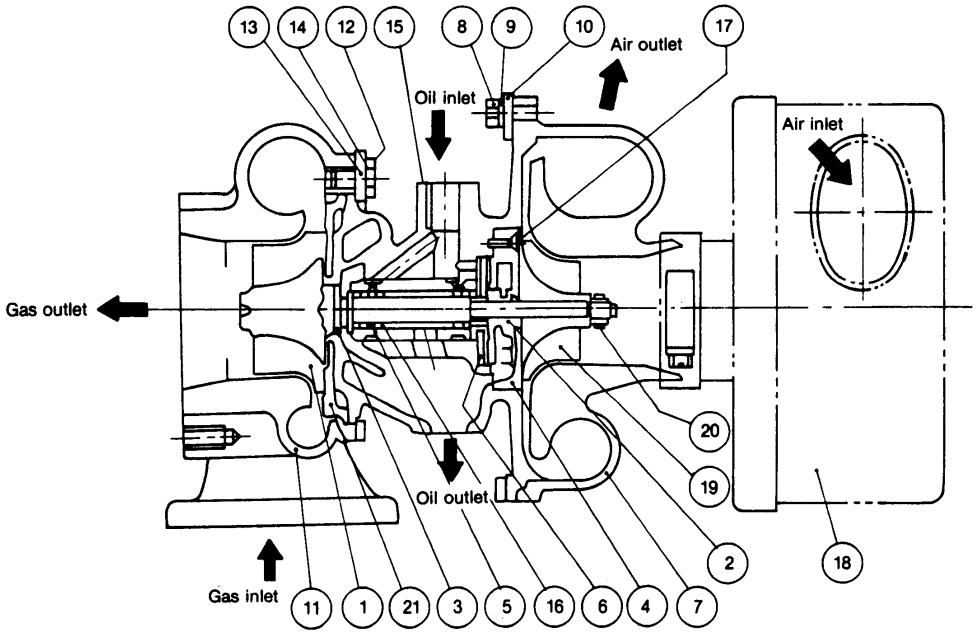
4. Turbocharger

4-1 Specifications

Turbocharger maker	ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIAL CO.,LTD. (I H I)			
Turbine type	Radial flow			
Blower type	Centrifugal			
Bearing type	Full floating			
Lubrication method	Outer lubrication			
Cooling method	Air cooled		Water cooled	
Continuous rated rpm	140,000		160,000	170,000
Max. gas inlet temp. (continuous allowable)	700°C			
Dry weight, approx.	4.2kg (9.26 lb.)			
Turbocharger model	MY20	*MY29	MY31	MY34
Applicable engine model	4JH-TE		4JH-HTE	4JH-DTE

*NOTE: *MY29 is equipped on models 4JH-TE producted at Yanmar plants since Nov., 21.1984*

4-2 Construction



1. Turbine shaft
2. Oil thrower
3. Turbine side seal ring
4. Seal plate
5. Floating bearing
6. Thrust bearing
7. Blower wheel chamber
8. M5 hexagonal bolt
9. M5 lock washer
10. Blower side top plate
11. Turbine wheel chamber
12. M6 hexagonal bolt
13. Turbine side locking plate
14. Lock washer
15. Bearing chamber
16. Stop ring
17. Screw M3
18. Intake silencer
19. Blower wheel fixing nut
20. Blower wheel
21. Heat insulating board

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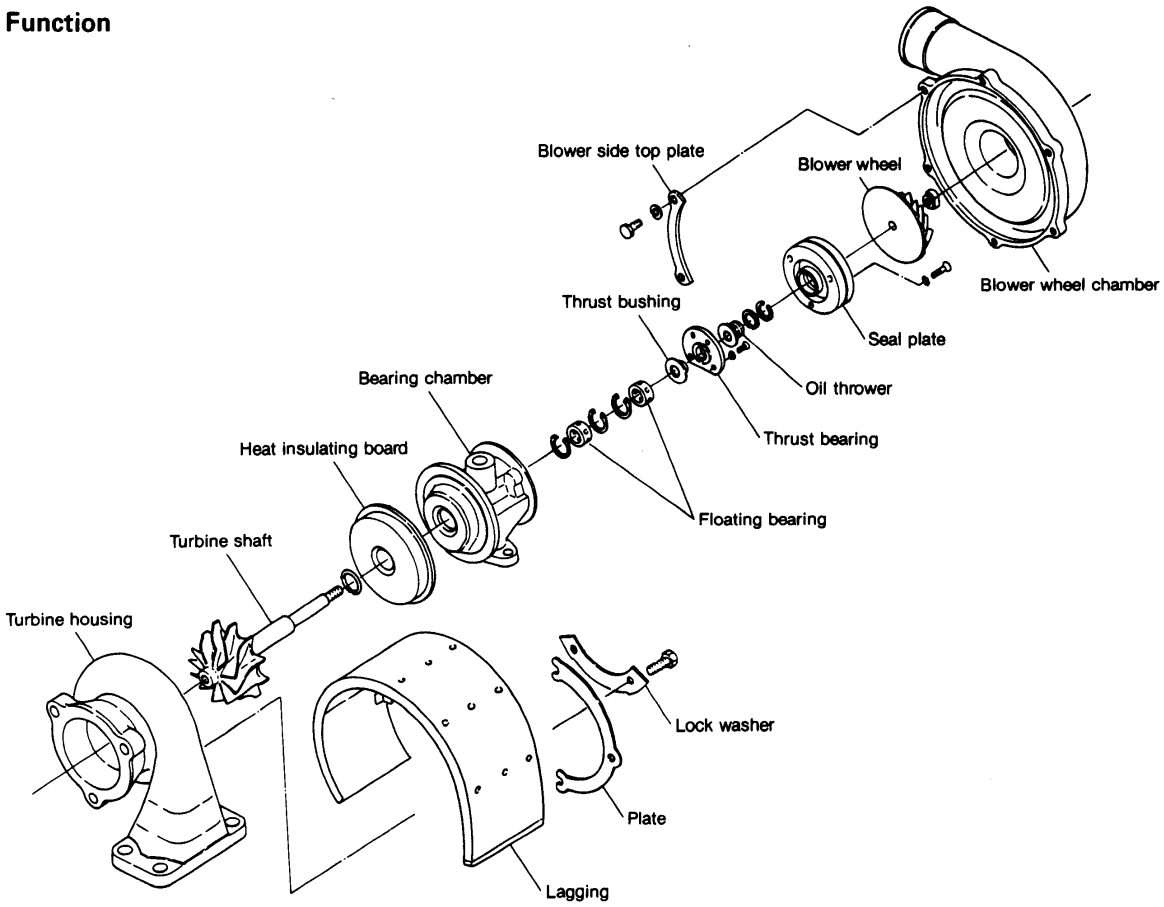
4-3 Function



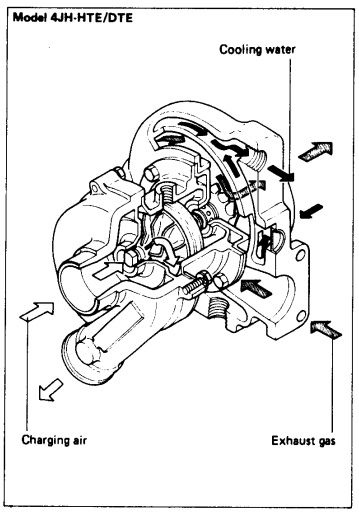
(1) Turbine
Exhaust air from the engine is accelerated by the nozzle of the turbine chamber and is blown onto the turbine (blade) to drive the turbine shaft.
This mechanism is called the turbine, and is provided with a seal ring(s) and heat shield to prevent the gas from adversely affecting the bearings.

(2) Blower
The turbine shaft drives the blower blade mounted on the shaft. This sucks in and compresses the air and feeds it to the supply pipe.
This mechanism is called the blower.

(3) Bearings
1) Thrust bushings
The thrust bushings prevent the turbine shaft from rotating due to the constant centrifugal force.
2) Radial bushings
Floating type radial bushings are used. When compared with the normal fixed type, this kind of bushing provides for an inner/outer double oil film, and as the bushings rotate with the shaft, the bushing surface sliding speed is less than the turbine shaft rotating speed. This in turn facilitates increased dynamic stability.

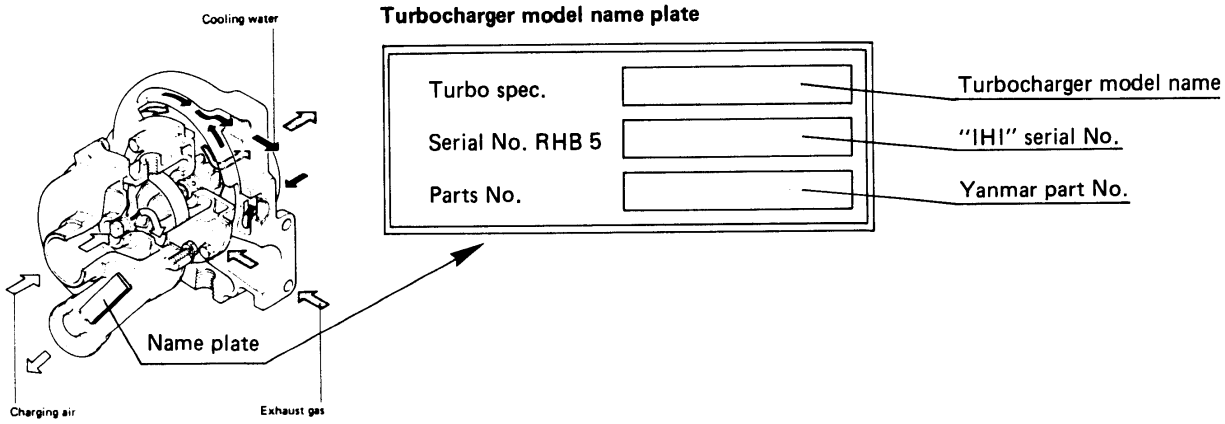
(4) Blower side seal mechanism
A double-walled sealing plate is provided at the back of the blower blade to prevent air or oil leakage.

(5) Water-cooled type
Turbocharger with fresh water cooling piping in the turbine housing. Used for models 4JH-HTE and 4JH-DTE.



4-4 Interchangeability of turbochargers

The IHI-make turbocharger used for the 4JH serieses differ according to the engine model. Care should therefore be taken to assemble only components for the turbocharger used in your engine when replacing parts. The use of incorrect turbocharger components will detract from the performance of the engine. Turbocharger models can be distinguished by their name plates.



Engine model	Turbocharger model (spec.)	Yanmar parts No.	Note.
4JH - TE	MY20	129492 - 18000	Design changed from MY29
	MY29	129497 - 18000	Yanmar production start Nov., 21. 1984
4JH - HTE	MY31	129474 - 18000	
4JH - HTE	MY34	129473 - 18000	

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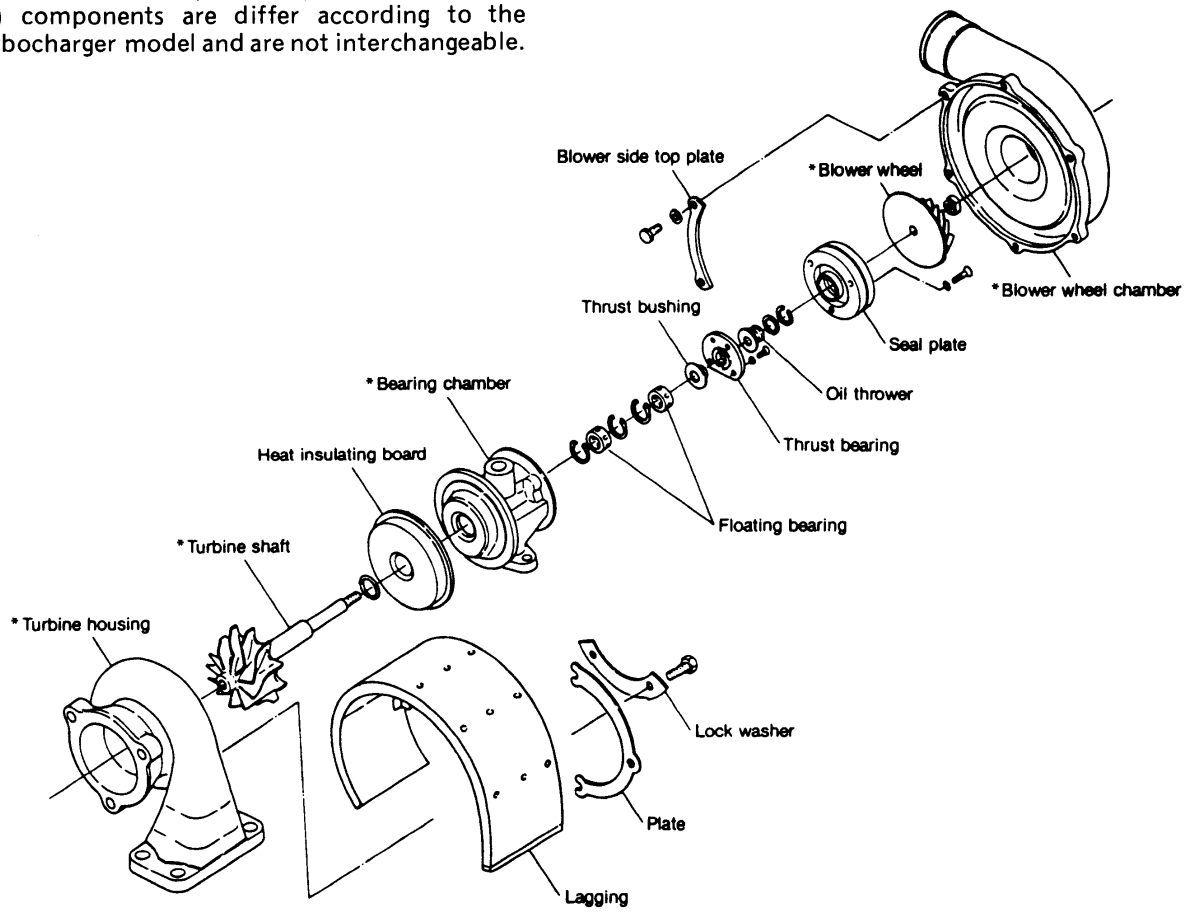
4-5 Interchangeability of turbocharger components

The inspection procedures and adjustment standard are identical for all turbocharger models. Please note, however, that the asterisked (*) components are differ according to the turbocharger model and are not interchangeable.



Part name	Part No.	Turbocharger model	Engine model
Turbine houaing	X-N138892	MY20	4JH-TE
	X-N138872	MY29	
	X-N139452	MY31	4JH-HTE
	X-N139402	MY34	4JH-DTE
Bearing chamber	X-N133422	MY20	4JH-TE
	X-N133432	MY29, MY31	4JH-TE, 4JH-HTE
	X-N133442	MY34	4JH-DTE
Turbine shaft	X-N131502	MY20, MY29, MY34	4JH-TE, 4JH-DTE
	X-N131572	MY31	4JH-HTE
Blower sheel	X-N136504	MY20, MY29, MY31	4JH-TE, 4JH-HTE
	X-N136606	MY34	4JH-DTE
Blower wheel chamber	X-N134072	MY20, MY29, MY31,	4JH-TE, 4JH-HTE
	X-N134092	MY34	4JH-DTE

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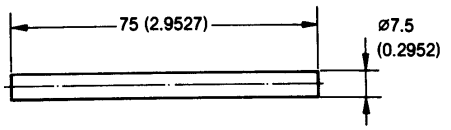
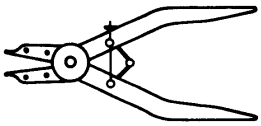
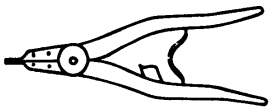
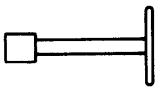
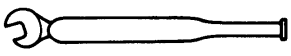
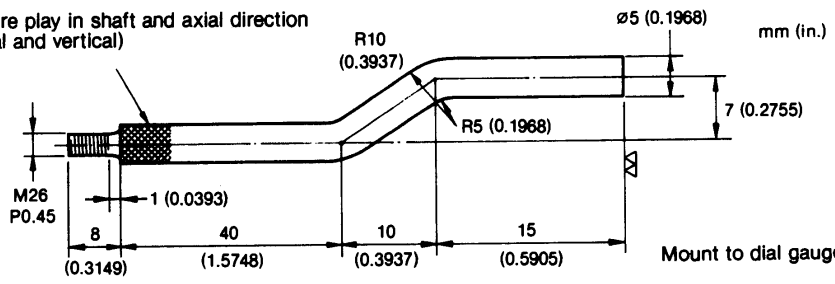
4-6 Disassembly, assembly

4-6.1 Preparations for disassembly

The following special tools are required for disassembly of the turbocharger, in addition to the standard tools.

Name of tool	Use	Illustration
Bar	To remove thrust metal and thrust bushings	mm (in.)  Material: Copper or brass
Pliers	To remove floating bushing stop ring	
Pliers	To remove seal ring	
Torque driver (Phillips) 5 ~ 50kg/cm² (71.11 ~ 711.16 lb/in.²)	To mount thrust metal and seal plate (+)	 Standard Model
Box wrench	To tighten turbine shaft 10mm (0.3937in.) × 12 square	 Box only may be used
Torque wrench	For following bolts M6: 10mm (0.3937in.) 110kg/cm² (1564.56 lb/in.²) M5: 8mm (0.3149in.) 45 kg/cm² (64.005 lb/in.²) M5: 8mm (0.3149in.) 20 kg/cm² (284.46 lb/in²)	
Gauge wire	To measure play in shaft and axial direction (horizontal and vertical)	mm (in.)  Mount to dial gauge

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4-6.2 Inspection prior to disassembly

(1) Make sure that the turbine and blower blades are not in contact and that the rotor rotates smoothly.
(2) Measuring rotor play.

mm (in.)

	Standard	Wear limit
Rotor play in direction of shaft	0.03 ~ 0.06 (0.0011 ~ 0.0023)	0.09 (0.0035)
Rotor play in axial direction	0.08 ~ 0.13 (0.0031 ~ 0.0051)	0.17 (0.0066)

4-6.3 Disassembly

Make match marks before disassembling the turbocharger to show how the super charger is mounted on the engine. This determines the angle at which the turbine chamber, bearing chamber and blower chamber are mounted.
(1) Removing blower chamber
1) Remove the M5 mounting bolts, spring washers and blower side retaining plate.
2) Remove the blower chamber.

NOTE: 1. The blower chamber and bearing chamber mounting surfaces are coated with a liquid gasket.
2. Be careful not to scratch the blower blade when disassembling the blower chamber.

(2) Removing blower blade
1) Fit a box wrench (10mm (0.3937in.)) to the end of the turbine side of the turbine shaft and remove the shaft end nut.

NOTE: The box end nut has left handed threads.

2) Remove the blower blade.

(3) Removing turbine chamber, lagging.
1) Remove the turbine chamber mounting bolts and the turbine side retaining plate for lagging.
2) Remove the lagging and turbine chamber.
(4) Pulling the turbine shaft
1) Lightly hold the heat shield by the hand and pull out the turbine shaft.

NOTE: If the turbine shaft is hard to pull out, lightly tap the blower side end of the shaft with a wood mallet.

2) Remove the heat shield.

NOTE: If the heat shield is hard to remove, tap it lightly with a caulking chisel.

(5) Removing the seal plate
1) Loosen the M3 flat seal plate mounting screws with a plus screwdriver and remove them along with double grip (tooth) washers.
2) Remove the seal plate.

NOTE: The seal plate and bearing chamber mounting surfaces are coated with a liquid gasket.

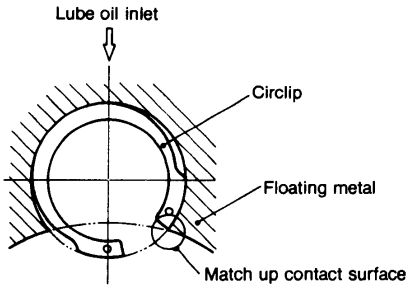
3) Remove the oil ring seal from the seal plate.
(6) Removing the thrust metal and thrust bushing.
1) Loosen the M3 flat seal plate mounting screws with a plus screwdriver and remove them along with the double grip washers.
2) Use a copper rod to remove the thrust metal and thrust bushing.
(7) Removing the floating metal (bushing)
1) Remove the round R stop ring from the bearing chamber with stop ring pliers.
2) Remove the floating metal from the bearing chamber.
(8) Removing seal ring
1) Remove the turbine side seal ring from the turbine shaft.
2) Remove the large and small blower side seal rings from the oil seal.

4-6.4 Preparations for reassembly

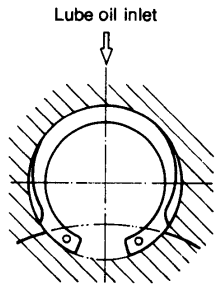
(1) When the turbocharger is reassembled, special tools, liquid gasket (Three Bond No.1207S or Three Bond No.1215) and burning preventative agent are needed in addition to the standard tools.
(2) Always replace the following with new parts when reassembling the turbocharger:

Turbine side seal rings
Blower side seal rings (large)
Blower side seal rings (small)
M3 flat screws
Bent washers
Double grip washers

Near the turbine



All other cases



Looking from turbine side

4-6.5 Reassembly

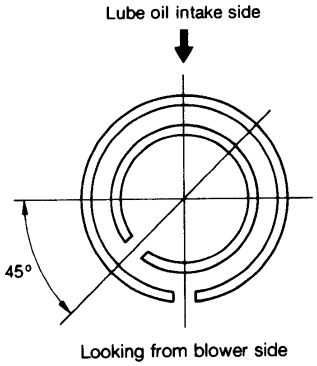
(1) Reassembly of floating metal
1) Mount the inside round R stop ring in the bearing chamber with stop ring pliers.
2) Fit the floating metal in the bearing chamber.
3) Mount the outside round R stop ring in the bearing chamber.

NOTE: 1. The round R stop ring opening should be mounted as shown in the illustration. The round part of the stop ring should be mounted on the metal.
2. When mounting, coat the floating metal with engine oil.

(2) Reassembly of the turbine shaft
1) Insert the seal ring in the turbine shaft.
2) Mount the heat shield on the turbine side bearing chamber.
3) Coat the journal of the turbine shaft with engine oil and insert from the turbine side of the bearing chamber.

NOTE: Take adequate care not to scratch the floating metal with the turbine shaft.
The seal ring opening should face the oil intake and be inserted aligned with the turbine shaft center.

(3) Reassembly of the thrust metal
1) Insert the thrust bushing in the turbine shaft.
2) Coat the thrust metal with engine oil and mount it in the bearing chamber.
3) Put the double grip washers on the thrust metal mounting M3 flat screws and tighten with the torque driver.



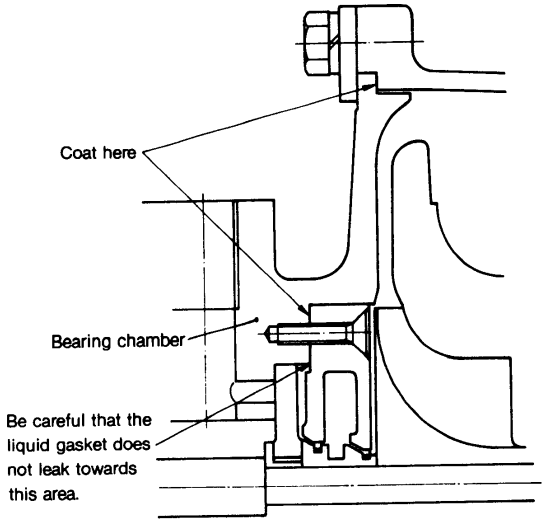
kg-cm (ft-lb)

Tightening torque	12 ~ 14 (0.86 ~ 1.01)

(4) Mounting seal plate
1) Insert the seal ring in the oil drain.
2) Insert the seal plate in the oil drain.

NOTE: The seal ring opening should face the direction indicated in the upper right illustration.

3) Coat the blower side seal plate mounting surface of the bearing chamber (20) with the liquid gasket (Three Bond No.1207S or Three Bond No.1215).



mm (in.)

Coating thickness	0.1 ~ 0.2 (0.0039 ~ 0.0078)

NOTE: See the illustration for where to coat it.

4) Mount the sealing plate on the bearing chamber.
5) Put the double grip washers on the sealing plate mounting M3 flat screws and tighten with the torque driver.

kg-cm (ft-lb)

Tightening torque	12 ~ 14 (0.86 ~ 1.01)

(5) Mounting blower blade
1) Put the blower blade on the turbine shaft.
2) Tighten the turbine side shaft end nut of the turbine shaft with a box wrench (10mm (0.3937in.)).

NOTE: The shaft end nut has a left handed thread.

kg-cm (ft-lb)

Tightening torque	18 ~ 22 (1.30 ~ 1.59)

(6) Mounting turbine chamber
1) Mount the turbine chamber, aligned with the match marks made before disassembly.

NOTE: When replacing parts, mount after checking the oil intake/discharge and exhaust gas intake positions.

2) Lugging
Put on the turbine side retainer plate for lugging and the bent washer, and tighten with the M6 hex bolt.
Make sure to bend the washer after tightening the M6 hex bolt.

kg-cm (ft-lb)

Tightening torque	105 ~ 115 (7.59 ~ 8.31)

(7) Mounting blower chamber
1) Coat the blower side flange surface of the seal plate with the liquid gasket (Three Bond No.1207S or Three Bond No.1215).

NOTE: Refer to page (21) for where to coat.

mm (in.)

Coating thickness	0.1 ~ 0.2 (0.0039 ~ 0.0078)

2) Align the match marks made before disassembly and mount the seal plate in the blower chamber.

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NOTE: When replacing parts, mount only after checking oil intake/discharge and air discharge positions.

3) Replace on the blower side retaining plate and spring washer and tighten with the M5 hex bolt.

kg-cm (ft-lb)

Tightening torque	40 ~ 50 (2.89 ~ 3.61)

(8) Measuring rotor play
See item 3-2 on inspection procedure—the measuring procedure is the same.
Rotor play above the standard is usually due to improper assembly or use of the wrong part—reassemble.

mm (in.)

	Standard
Rotor play in direction of shaft	0.03 ~ 0.06 (0.0011 ~ 0.0023)
Rotor play in axial direction	0.08 ~ 0.13 (0.0031 ~ 0.0051)

4-6.6 Disassembly/reassembly precautions

Observe the following during and after mounting the turbocharger on the engine.
Be especially careful to prevent the entrance of foreign matter into the turbocharger.
(1) Precautions on mounting the turbocharger.

Lube oil system

1) Run new engine oil through the oil intake holes before mounting on the engine, turn the turbine shaft by hand and lubricate the journal metal (bushings) and thrust metal.
2) Wash the engine oil intake pipe and oil discharge pipe, check for damage and make sure it is not clogged up with dirt or other foreign matter.
3) Make sure that there is no oil leakage from the oil pipes and joints after assembly.

Intake system

1) Make sure that there is no dirt or other foreign matter in the air intake system.
2) Make sure that there is no air leakage from the air supply duct/air cleaner connections.

Exhaust system

1) Make sure that there is no dirt or other foreign matter in the exhaust gas system.
2) Make sure not to mix up the special heat resistant bolts and nuts with the regular bolts when mounting the parts. Coat the bolts, nuts, etc. with burning preventive agent.
(Heat resistant hex bolts are used for the turbine chamber.)
3) Make sure that there is no gas leakage from exhaust piping/connections.

4-7 Inspection and maintenance

4-7.1 Washing

(1) Inspection prior to washing
Make a visual inspection of disassembled parts before washing to check for burning, wear, foreign, matter and carbon build-up. Make an especially thorough inspection in case of breakdowns as a step towards determining the cause of the breakdown.

Major items

Inspection	Location
Carbon build-up	1) Turbine shaft turbine side seal ring and back of blade. 2) Around the heat shield mounting of the bearing chamber and the inside wall of the bearing chamber.
Lubrication (wear, burning, discoloration)	1) Turbine shaft journal, thrust bushing, oil drain. 2) Floating metal and thrust metal. 3) Around the inner bearing race of the bearing chamber.
Oil leakage	1) Inside wall of the turbine chamber. 2) Outer circumference of the bearing chamber and around the heat shield mounting. 3) Turbine side seal ring of the turbine shaft and the back of the blade. 4) Inside wall of the blower chamber. 5) Back of the blower blade. 6) Back of the seal plate and portion where the seal ring is inserted.

(2) Washing procedure
Keep the following in mind when washing the parts.

Item	Tools/Cleaning Agent	Procedure
(1) Turbine shaft	1. Tools (1) Bucket (500 × 500) (2) Heat source steam or gas burner (3) Brush 2. Cleaning agent Standard carbon removing agent	(1) Boil the turbine shaft in the washing bucket. Do not hit the blade to remove the carbon. (2) Soak in the cleaning agent until the carbon and other materials adhering to the surface become soft. (3) Use a plastic scrubber or hard hair brush to remove the softened foreign matter. (4) Be very careful not to scratch the turbine shaft bearing surface or the seal ring grooves. (5) Any foreign matter will unbalance the turbine shaft, so be sure to clean it well. Do not use a wire brush.
(2) Turbine chamber	1. Tools same as for turbine shaft 2. Cleaning agent same as for turbine shaft	(1) Boil the turbine chamber in the washing bucket. (2) Soak in the cleaning agent until all the material adhering to the surface becomes soft. (3) Use a plastic scrubber or hard hair brush to remove the foreign matter.
(3) Blower blade, blower chamber	1. Tools (1) Bucket (500 × 500) (2) Brush 2. Cleaning agent	(1) Soak in the cleaning agent until the foreign matter adhering to the surface becomes soft. (2) Use a plastic scrubber or hard hair brush to remove the softened foreign matter. Do not use a wire brush.
(4) Other parts	(1) Wash all other parts with diesel oil. (2) Clean all lube oil lines with compressed air. (3) Be careful not to scratch parts or allow them to rust.	

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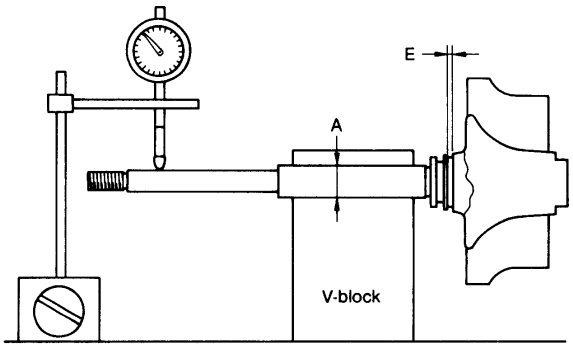
4-7.2 Inspection procedure

(1) Blower chamber
Inspect for scratches caused by contact with the blower blade, scratches in the mounting surface, any galling or cracks.
Replace if necessary.

(2) Turbine chamber
Inspect for scratches caused by contact with the turbine blade, flaking due to oxidation of the skin, and deformation due to heat or cracks.
Replace if necessary.

(3) Blower blade
Inspect for scratches caused by contact, and for breakage, corrosion or deformation.
Replace if necessary.

(4) Turbine shaft
1) Inspect the portion around the turbine blade for scratches, breakage, discoloration or deformation, and inspect the shaft for bending, discoloration of journal, abnormal wear, seal ring groove scratches or wear.
Replace if necessary.
2) Measure the outer diameter of turbine shaft journal (A) and seal ring groove width (E), and replace if beyond the wear limit.



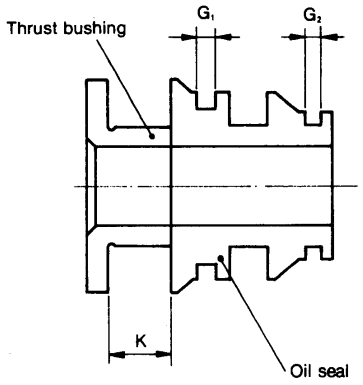
mm (in.)

		Wear limit
Journal outer dia.	A	7.98 (0.3141)
Seal ring groove width	B	1.29 (0.0507)

3) Measure turbine shaft undulation and replace if it exceeds 0.011mm (0.0004in.).

(5) Head shield
Inspect for scratches due to contact, deformation due to heat, and corrosion.
Replace if necessary.

(6) Thrust bushing, oil seal and thrust metal. Inspect for wear, scratches, discoloration, etc., and replace if necessary, even if they remain within the wear limit.



1) Thrust bush
Measure the thrust bush groove clearance (K), and replace if it exceeds the wear limit.

mm (in.)

		Wear limit
Thrust bush groove clearance	K	4.07 (0.1602)

2) Oil ring
Measure the seal ring groove width (G_1), (G_2) and replace if it exceeds the wear limit.

mm (in.)

		Wear limit
Seal ring groove width	G_1	1.31 (0.0515)
	G_2	1.11 (0.0437)

3) Thrust metal
Measure the thrust metal width (J), and replace if it exceeds the wear limit.

mm (in.)

		Wear limit
Thrust metal width	J	3.98 (0.1566)

(7) Floating metal
1) Inspect for abnormal wear, discoloration, scratches, etc., and replace if necessary.
2) Measure the inner diameter (C) and outer diameter (D) of the metal, and replace if either exceeds the wear limit.

mm (in.)

		Wear limit
Floating metal outer dia.	C	12.31 (0.4846)
Floating metal inner dia.	D	8.04 (0.3165)

(8) Bearing chamber
1) Inspect for flaking due to oxidation of the skin, galling and scratches, and replace if necessary.
2) Inspect the round R stop ring for breakage or cracks and replace if necessary.
3) Measure the (B) and (F) dimensions of the bearing chamber as shown in the illustration on the right, and replace if either exceeds the wear limit.

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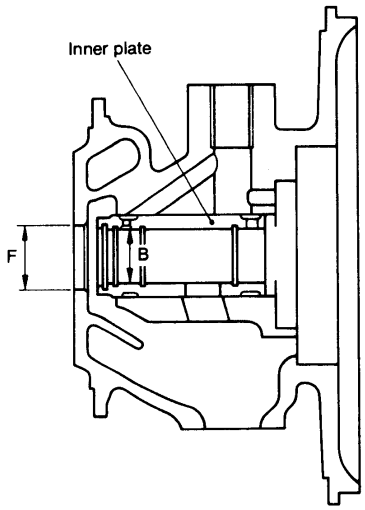
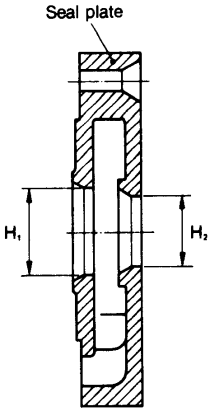


mm (in.)

		Wear limit
Bearing chamber inner dia.	B	12.42 (0.4889)
Turbine side seal ring area inner dia.	F	15.05 (0.5925)

(9) Seal plate

1) Inspect for scratches due to contact, scratches in mounting surface, galling and cracks and replace if necessary.
2) Measure the blower side seal ring area (H_1, H_2) and replace if either exceeds the wear limit.



mm (in.)

		Wear limit
Blower side seal ring area inner dia.	H_1	12.45 (0.4901)
	H_2	10.05 (0.3956)

(10) Seal ring

Inspect for wear or deformation and replace if necessary.

(11) Inspect retaining plates, bolts and spring washers for deformation and replace if necessary. Always replace the M3 flat screw bend washer and grip washer.

4-7.3 Periodic inspection

(1) Periodically inspect the overall condition of supercharger and the amount of dirt build-up. Inspect at the intervals specified in the following chart.

Item	Interval		
	3 months or 1500 hours	6 months or 3000 hours	12 months or 6000 hours
Rotation of rotor	○		
Rotor play		○	
Disassembly, cleaning and inspection of entire unit			○
Cleaning and inspection of air filter	Every 300 hours		

(2) Inspection Procedure

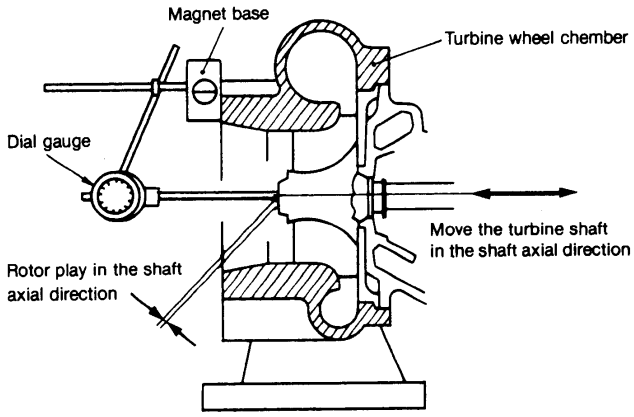
1) Rotation of rotor

The rotation of the rotor is checked by listening for any abnormal noise when it is rotating. Use a listening bar, placing the tip of the bar firmly against the turbocharger and gradually increasing engine rpm. If a loud noise is emitted every 2 or 3 seconds, rotation is abnormal. The turbocharger should be replaced or repaired as something may be wrong with the metal or rotor.

2) Rotor play

Remove the turbocharger from the engine and check the play in the shaft axial and radial directions as shown below.

3) Rotor play in the shaft axial direction.



mm (in.)

	Standard	Wear limit
Rotor play in shaft axial direction	0.03 ~ 0.06 (0.0018 ~ 0.0023)	0.09 (0.0035)

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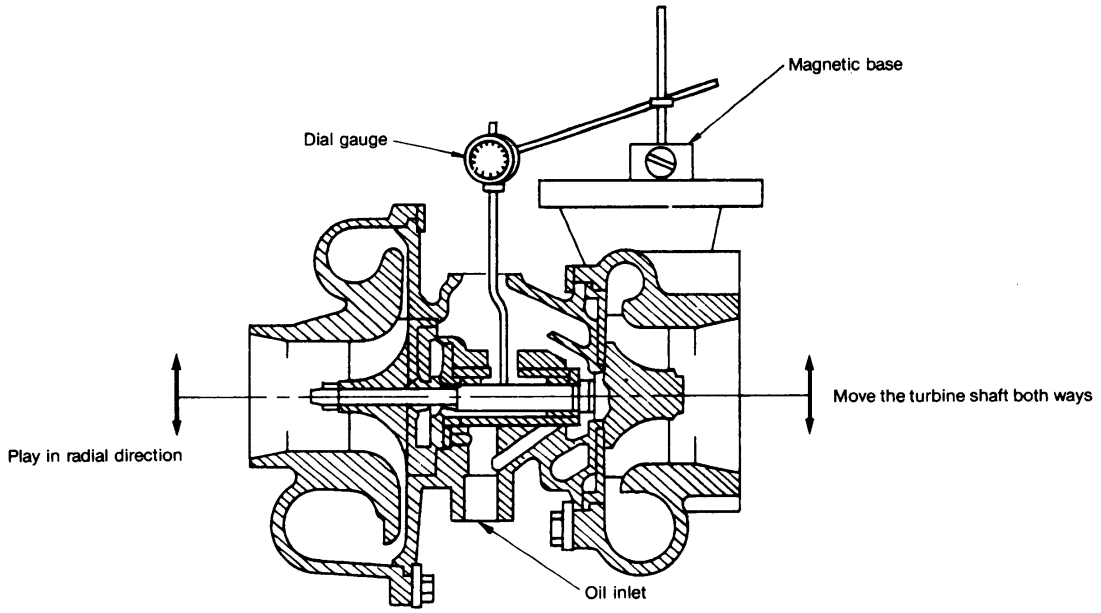
4) Rotor play in shaft radial direction.



mm (in.)

	Standard	Wear limit
Rotor play in the shaft radial direction	0.08 ~ 0.13 (0.0031 ~ 0.0051)	0.17 (0.0066)

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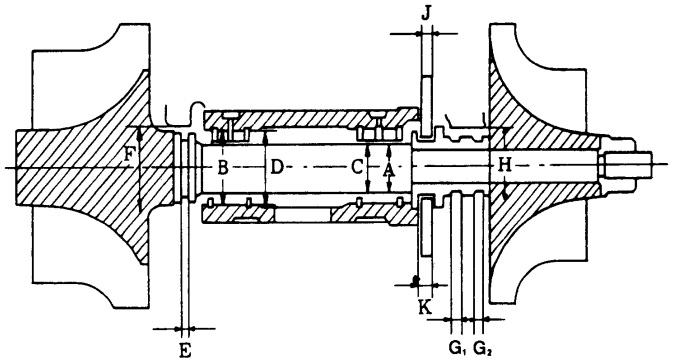

mm (in.)

	Items to check	Standard	Wear limit
Turbine shaft	Turbine shaft journal outer dia. (A)	7.99 ~ 8.00 (0.3145 ~ 0.3149)	7.980 (0.3141)
	Turbine side seal ring groove width (E)	1.25 ~ 1.28 (0.0492 ~ 0.0503)	1.210 (0.0476)
	Blower side seal ring groove width (G_1)	1.22 ~ 1.23 (0.0480 ~ 0.0484)	1.310 (0.0515)
	Blower side seal ring groove width (G_2)	1.02 ~ 1.03 (0.0401 ~ 0.0405)	1.110 (0.0437)
	Turbine shaft play	0.01 (0.0003)	0.011 (0.0004)
Bearing	Floating bearing inner dia. (C)	8.01 ~ 8.03 (0.3153 ~ 0.3161)	8.040 (0.3165)
	Floating bearing inner dia. (D)	12.32 ~ 12.33 (0.4850 ~ 0.4854)	12.310 (0.4846)
	Bearing set ring inner dia. (B)	12.40 ~ 12.41 (0.4881 ~ 0.4885)	12.420 (0.4889)
Thrust bearing	Thrust bearing width (J)	3.99 ~ 4.01 (0.1570 ~ 0.1578)	3.980 (0.1566)
	Thrust bushing groove dimension (K)	4.04 ~ 4.05 (0.1590 ~ 0.1594)	4.070 (0.1602)
Seal ring fixing area	Turbine side (bearing wheel chamber) (F)	15.00 ~ 15.02 (0.5905 ~ 0.5913)	15.050 (0.5925)
	Blower side (seal plate) (H_1)	12.40 ~ 12.42 (0.4881 ~ 0.4889)	12.450 (0.4901)
	Blower side (seal plate) (H_2)	10.00 ~ 10.02 (0.3937 ~ 0.3944)	10.050 (0.3956)
Play of rotor in shaft axial direction		0.03 ~ 0.06 (0.0011 ~ 0.0023)	0.090 (0.0035)
Play of rotor in radial direction		0.08 ~ 0.13 (0.0031 ~ 0.0051)	0.170 (0.0066)

Tightening torque

	Screw dia. mm	Tightening torque kg-cm (ft-lb)
Turbine chamber set bolt	M6	105 ~ 115 (7.59 ~ 8.31)
Blower chamber set bolt	M5	40 ~ 45 (2.89 ~ 3.25)
Thrust metal set screw	M3	12 ~ 14 (0.86 ~ 1.01)
Seal plate set screw	M3	12 ~ 14 (0.86 ~ 1.01)
Blower blade nut	left hand screw M5	18 ~ 22 (1.30 ~ 1.59)

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4-8 Troubleshooting

The engine will not produce the required output if the turbocharger breaks down. If the engine output drops, first check the engine to see if anything is wrong, and then check the turbocharger according to the following procedure if there is nothing wrong with the engine.

4-8.1 Excessive smoke

(1) Insufficient air intake

Cause	Remedy
1) Air cleaner is clogged up.	• Replace or wash the element.
2) Air intake is closed.	• Open to proper position.
3) Leakage from air intake system connections.	• Inspect and repair

(2) Turbocharger does not rotate

Cause	Remedy
1) Build-up of foreign matter in oil on seals inhibiting turbine shaft rotation.	• Disassemble and clean turbocharger and change engine oil.
2) Burned metal • Insufficient oil or clogging up of supply pipe. • Oil temperature too high. Rotating parts are out of balance. • Insufficient warming up or sharp stopping.	• Disassemble turbocharger and repair. • Inspect engine oil supply system, repair any parts as necessary and change the engine oil. • Wash or replace rotating parts. • Read operation manual and operate engine accordingly.
3) Turbine or blower blade knocking something or broken. • Excessive rpm • Excessive exhaust gas temperature rise. • Entrance of foreign matter. • Worn metal (bushings) • Improper reassembly	• Inspect engine parts and adjust. • Disassemble and thoroughly remove any foreign matter, inspect the air cleaner, and engine parts, and repair as necessary. • Disassemble turbocharger and repair. • Reassemble

(3) Excessive exhaust gas drag (resistance)

Cause	Remedy
1) Insufficient turbocharger rpm due to leakage of exhaust gas before entry into turbocharger.	• Inspect fittings and repair.
2) Insufficient turbocharger rpm due to deformation of exhaust system piping.	• Repair

4-8.2 White exhaust smoke

Cause	Remedy
1) Oil leaking on blower side or turbine side due to clogging or deformation of return piping.	• Repair or replace pipe.
2) Seal ring excessively worn or broken due to excessive metal wear.	• Disassemble turbocharger and repair.

4-8.3 Excessive oil consumption

Cause	Remedy
1) Seal ring excessively worn or broken due to excessive metal wear.	• Disassemble turbocharger and repair.

4-8.4 Decrease in (engine) output

Cause	Remedy
1) Gas leakage from exhaust gas system. 2) Air leakage from blower side discharge.	• Inspect parts and repair.
3) Air cleaner element clogged up.	• Clean or replace element.
4) Turbocharger dirty or damaged.	• Disassemble turbocharger and repair, or replace.

4-8.5 Poor (slow) turbocharger responsiveness (starting)

Cause	Remedy
1) Carbon build-up on turbine side (blade seal) inhibiting turbine shaft rotation.	• Disassemble and wash turbocharger and replace engine oil.
2) Incomplete combustion.	• Inspect engine fuel system and improve combustion efficiency.

4-8.6 Abnormal noise or vibration

(1) Abnormal noise

Cause	Remedy
1) Blower discharge air flows back (surges) when the gas line area is considerably reduced due to closing of the turbine chamber nozzle or during acceleration.	• Disassemble and clean turbocharger.
2) Rotating parts knocking something.	• Disassemble turbocharger and repair or replace.

(2) Vibration

Cause	Remedy
1) Fittings connecting turbocharger and exhaust gas piping/oil pipe have become loose.	• Inspect fittings and retighten/repair as necessary.
2) Rotating parts making contact with surrounding parts because of metal failure, or turbine blade or blower blade damaged due to entrance of foreign matter.	• Disassemble turbocharger and repair or replace. Thoroughly remove any foreign matter.
3) Rotating parts out of balance.	• Repair or replace rotating parts.

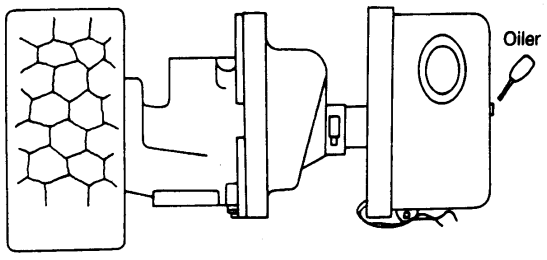
4-9 Turbocharger blower washing procedure

4-9.1 General

(1) Use "Blower Wash" and clean water to wash the blower.
(2) Make it a general practice to wash the turbocharger blower when the air supply pressure has decreased by about 10 percent. The frequency of this will differ greatly depending on working conditions, but about once a week is generally sufficient.
(3) This prodecure cannot be used for cleaning the entire turbocharger. It must be periodically disassembled and cleaned.
(4) Only remove the inlet cap when washing the blower—it must not be removed under any other circumstances.

4-9.2 Procedure

(1) Run the engine at normal load (3/4 ~ 4/4 load) and apply Blower Wash for 4 ~ 5 seconds with a 20cc standard oiler.
(2) 3 ~ 5 minutes after application of the Blower Wash the dirt will be loosened up. Slowly put in 20cc of water (over about 4 ~ 10 seconds).
(3) Use a vinyl container to feed in the cleaning agent or water. If too much cleaning agent or water enters suddenly there might be a breakdown or breakage of the blower blade. Be sure to feed in the cleaning agent or water at the correct speed.
(4) If there is no change in the air supply pressure or exhaust gas temperature after washing, repeat the washing after about 10 minutes.
No change after washing the blower 3 ~ 4 times indicates that either the blower is extremely dirty or something else is out of order. Disassemble and clean the washer, and take any other action as necessary.
(5) Run the engine under load to dry for at least 15 minutes after feeding in the agent or water.



Clean the blower: Every 150 hours

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5. Mixing Elbow

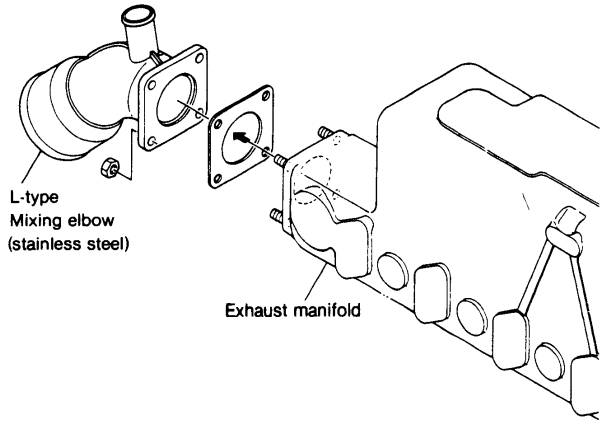
5-1 Construction

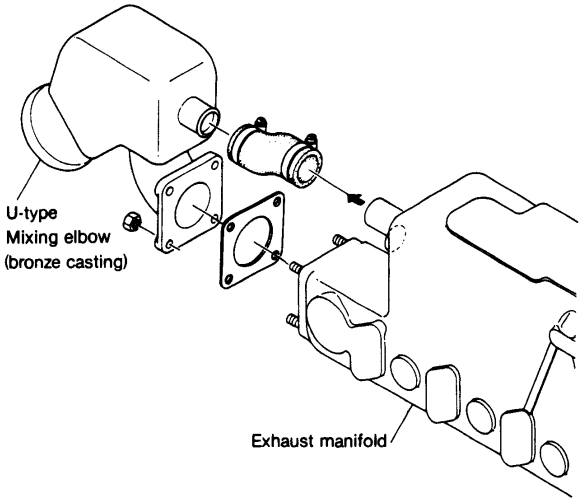
Threre are two types of mixing elbows for the 4JHE engine: the L and U types. Both types are bolted to the exhaust mainfold.
There are also L and U types for the 4JH-TE, 4JH-HTE and 4JH-DTE engines.
Both are mounted on the turbocharger discharge.

5-2 Mixing elbow inspection

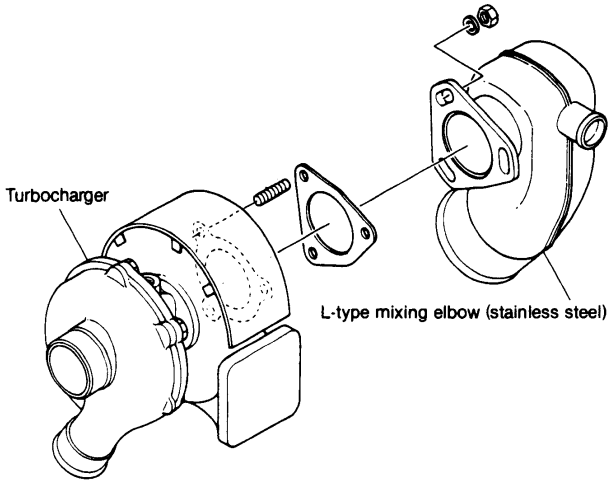
(1) Clean dirt and scale out of the air and cooling water lines.
(2) Repair cracks or damage to welds, or replace.
(3) Inspect the gasket packing and replace as necessary.

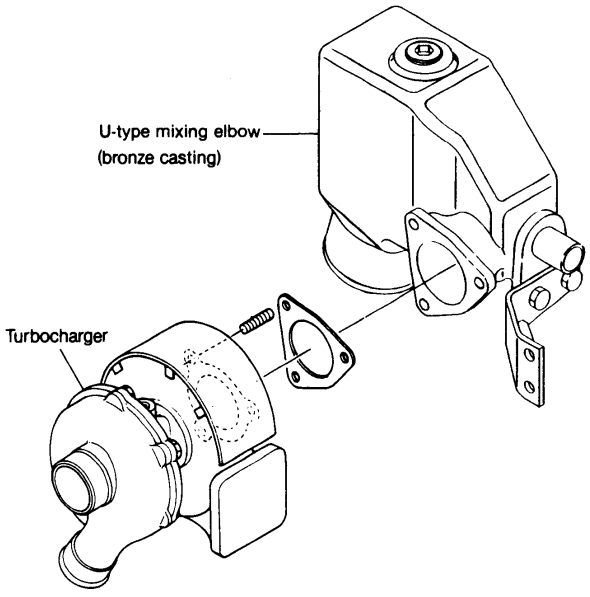
For model 4JHE





For models 4JH-TE, 4JH-HTE and 4JH-DTE





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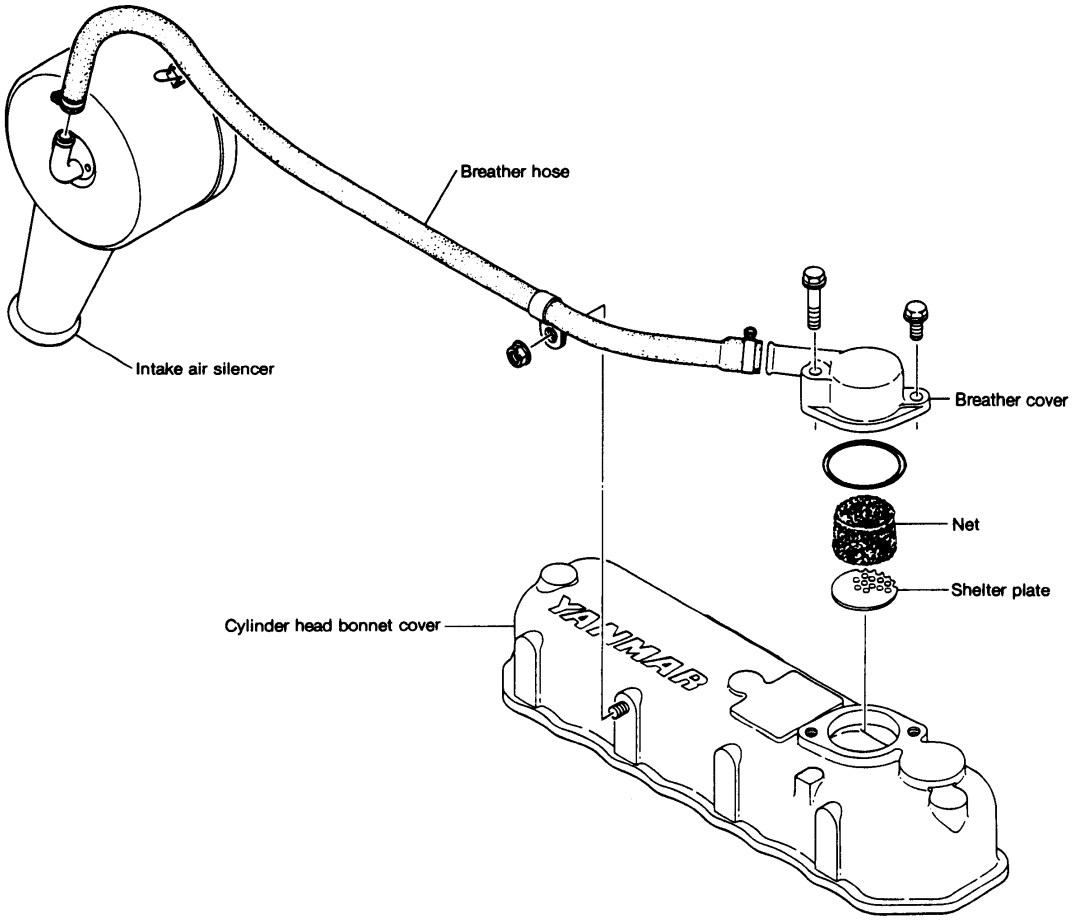
6. Breather

6-1 Construction

The mist in the crank chamber goes past the tappets in the cylinder block to the valve arm chamber, through the breather in the bonnet (head) cover, into the intake silencer through the mist (removal) pipe, and is sucked in together with the intake air.

6-2 Breather inspection

(1) Remove the breather cover and clean the wire element.
(2) Check to see whether the breather pipe is clogged up, and clean if necessary. Replace the pipe if damaged or cracked.
(3) Inspect the O-ring(s) and replace as necessary.



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CHAPTER 5

LUBRICATION SYSTEM

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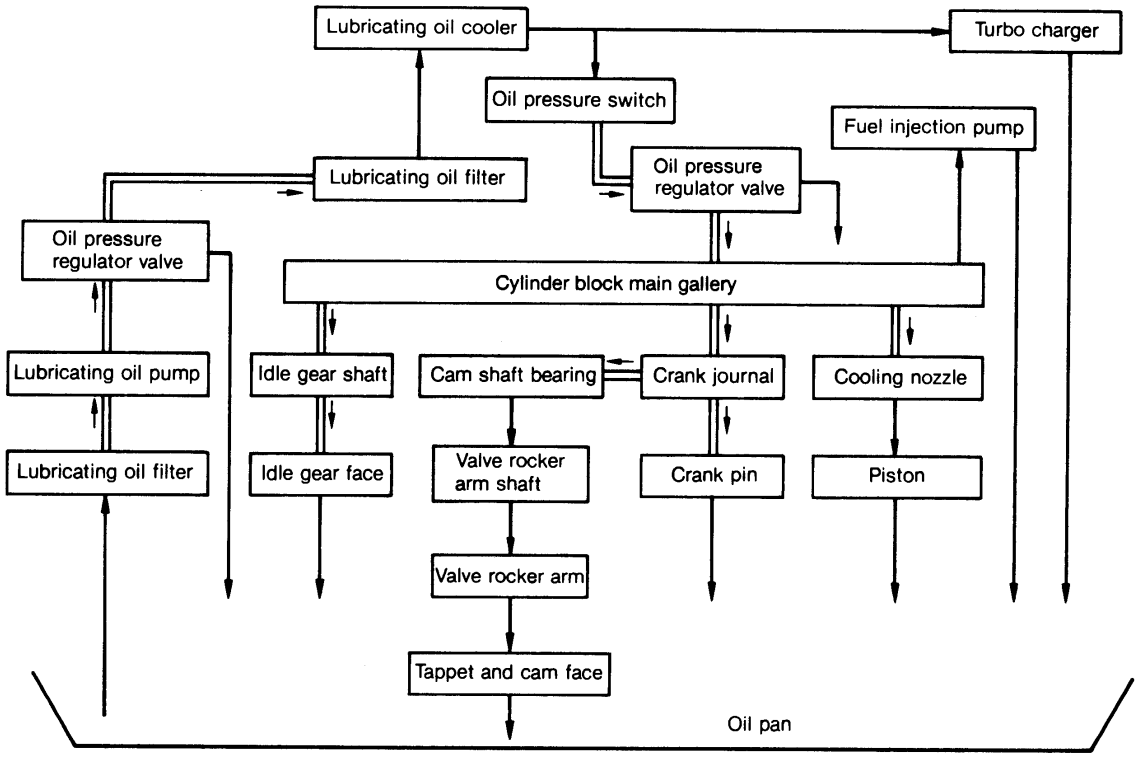
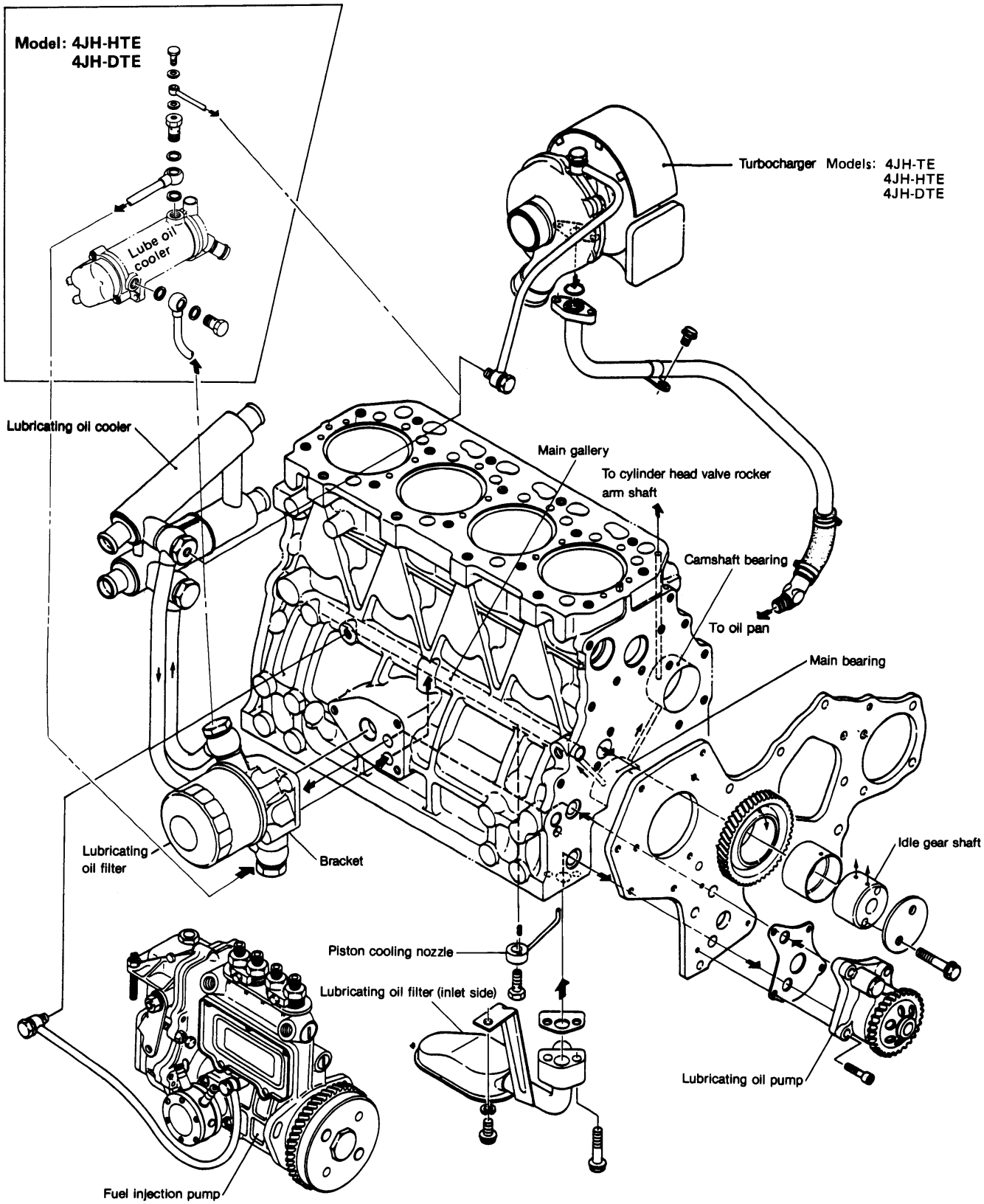
1. Lubrication System

The lube oil in the oil pan is pumped up through the intake filter and intake piping by the lube oil pump, through the holes in the cylinder body and on to the discharge filter.
The lube oil which flows from the holes in the cylinder body through the bracket to the oil element is filtered and sent to the oil cooler. It returns from the oil cooler to the bracket, the pressure is regulated, and it is fed back to main gallery in cylinder body.
The lube oil which flows in the main gallery goes to the crankshaft journal, lubricates the crank pin from the crankshaft journal, and a portion of the oil is fed to the camshaft bearings.
Oil is sent from the gear case camshaft bearings through the holes in the cylinder body and cylinder head to the valve arm shaft to lubricate the valve arm and valves.
Oil is also sent from the main gallery to the piston cooling nozzle to cool the piston surface, and is sent through the intermediate gear bearing (oil) holes to lubricate the intermediate gear bearings and respective gears.
Lube oil for the fuel injection pump is sent by pipe from the main gallery to the fuel injection pump.
Part of the lube oil is sent from the oil cooler discharge to the supercharger in engines fitted with one, and is then piped back from the supercharger to the oil pan.





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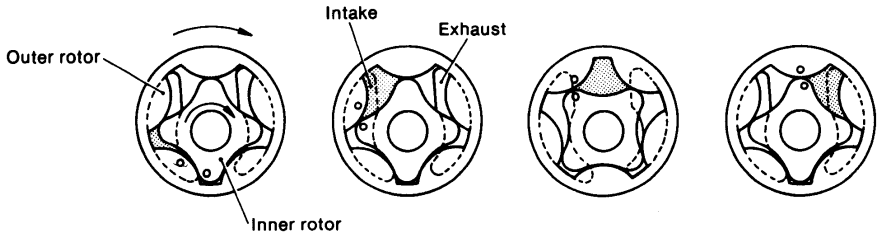
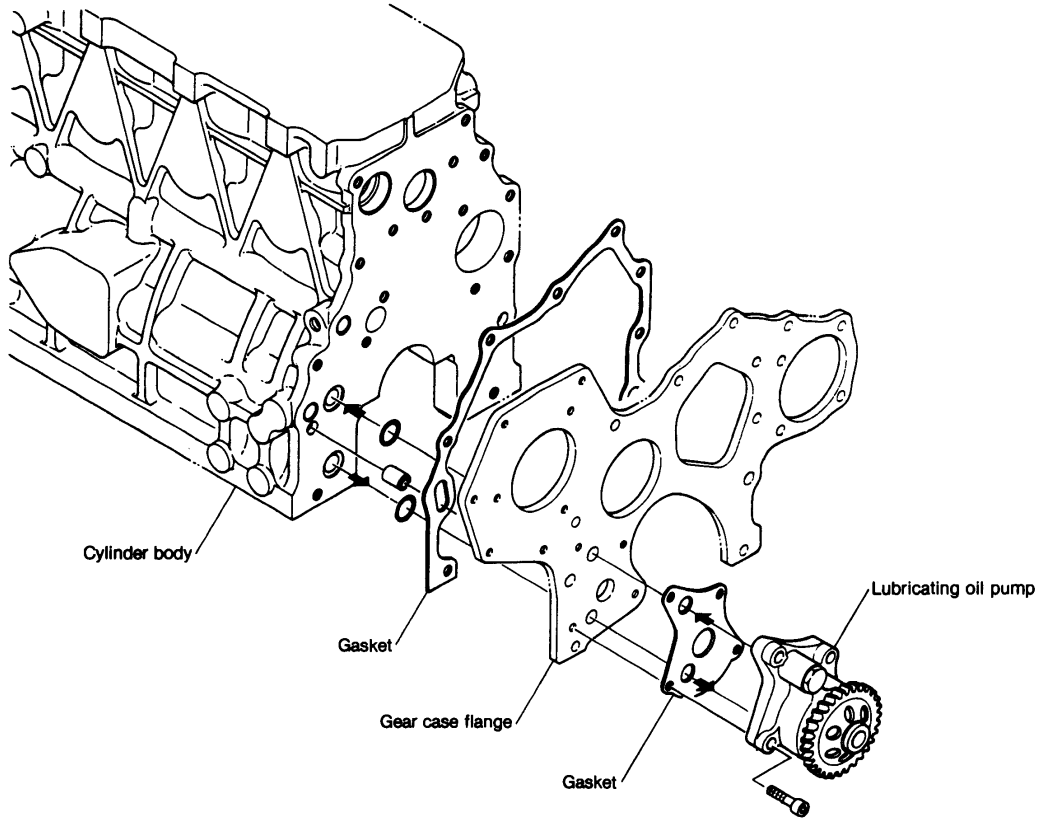
2. Lube Oil Pump

2-1 Lube oil pump construction

The trochoid type lube oil pump is mounted on the gear case side engine plate, and the rotor shaft gear is driven by the crankshaft gear.
The lube oil flows from the intake filter mounted on the bottom of the cylinder body through the holes in the cylinder body and engine plate, and out from the holes in the engine plate and cylinder body to the discharge filter.
The lube oil pump is fitted with a pressure regulating valve which maintains the discharge pressure at 3kg/cm².





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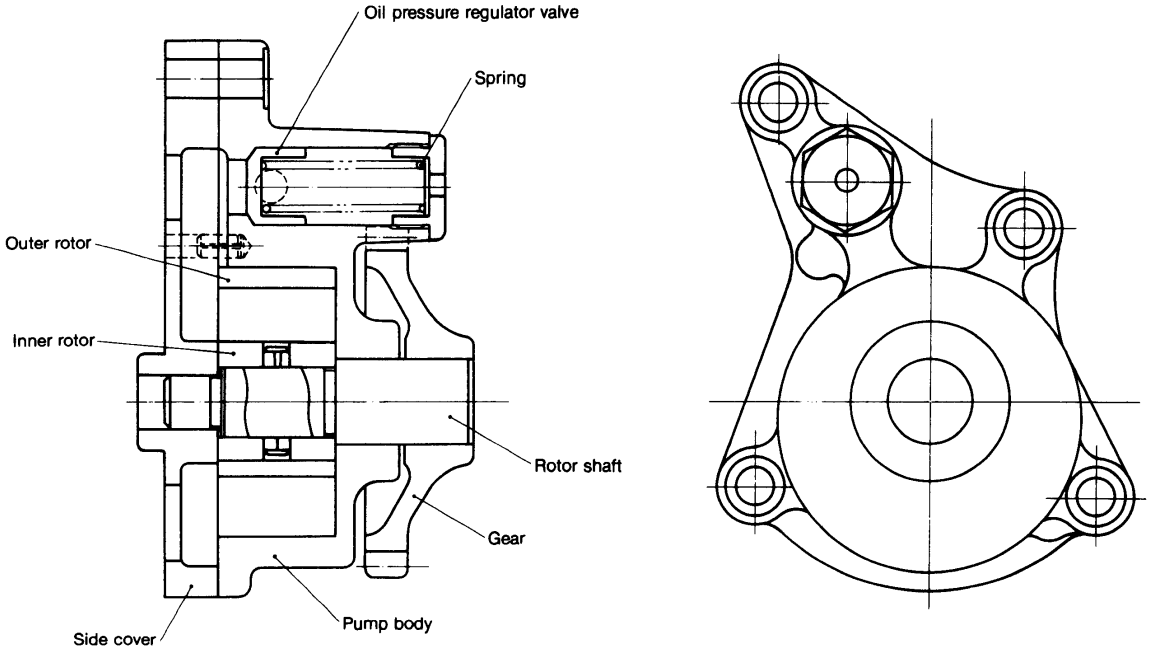

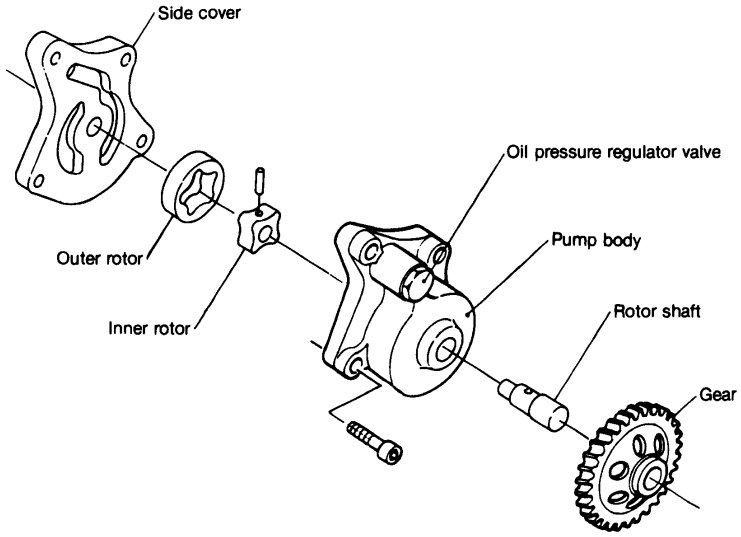

2-2 Specifications of lube oil pump

Engine speed	3600 rpm
Gear ratio (crank gear/pump gear)	28/29
Pump speed	3477 rpm
Discharge volume	36 ℓ/min (2196 in.³/min)
Discharge pressure	3 kg/cm² (42.66 lb/in.²)

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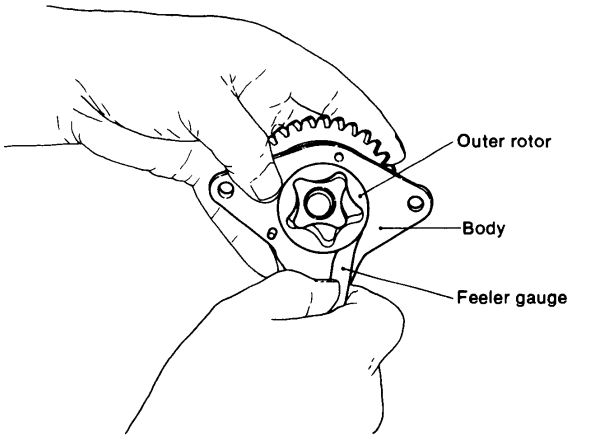
2-3 Lube oil pump disassembly

(1) Remove the lube oil pump assembly from the engine plate.
(2) The lube oil pump cover may be disassembled, but do not disassemble the rotor, rotor shaft or drive gear. The oil pressure regulating valve plug is coated with adhesive and screwed in, so it cannot be disassembled. These parts cannot be reused after disassembly. Replace if necessary as an assembly.

2-4 Lube oil pump inspection

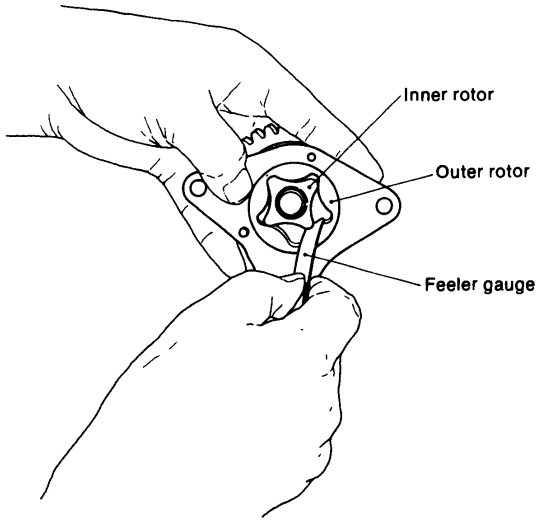
(1) Clearance between outer rotor and pump body
Insert a feeler gauge between the outer rotor and pump body to measure the clearance, and replace if it exceeds the limit.

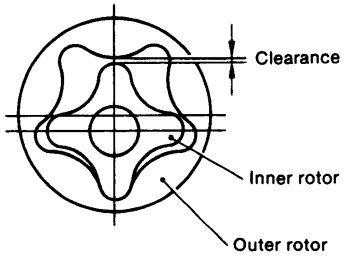


mm (in.)

	Standard	Wear limit
Outer rotor and pump body clearance	0.100 ~ 0.170 (0.0039 ~ 0.0066)	0.25 (0.0098)

(2) Clearance between outer rotor and inner rotor
To measure clearance, insert a feeler gauge between the top of the inner rotor tooth and the top of the outer rotor tooth, and replace if it exceeds the limit.

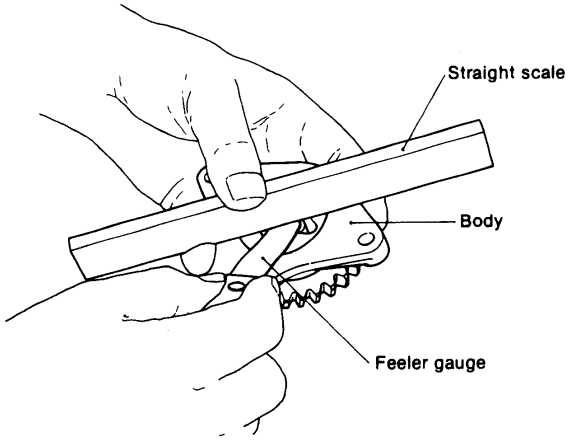




mm (in.)

	Standard	Wear limit
Outer rotor and inner rotor clearance	0.050 ~ 0.105 (0.0019 ~ 0.0041)	0.15 (0.0059)

(3) Clearance between pump body and inner rotor side of outer rotor
Place a straight-edge against the end of the pump body and insert a feeler gauge between the straight-edge and the rotor to measure side clearance. Replace the assembly if the clearance exceeds the limit.



mm (in.)

	Standard	Wear limit
Pump body and inner rotor, outer rotor clearance	0.03 ~ 0.09 (0.0011 ~ 0.0035)	0.13 (0.0051)

(4) Clearance between rotor shaft and side cover
Measure the rotor shaft outer diameter and the side cover hole diameter, and replace the entire assembly if the clearance exceeds the limit.

mm (in.)

	Standard	Wear limit
Rotor shaft and body clearance	0.013 ~ 0.043 (0.0005 ~ 0.0016)	0.2 (0.0078)

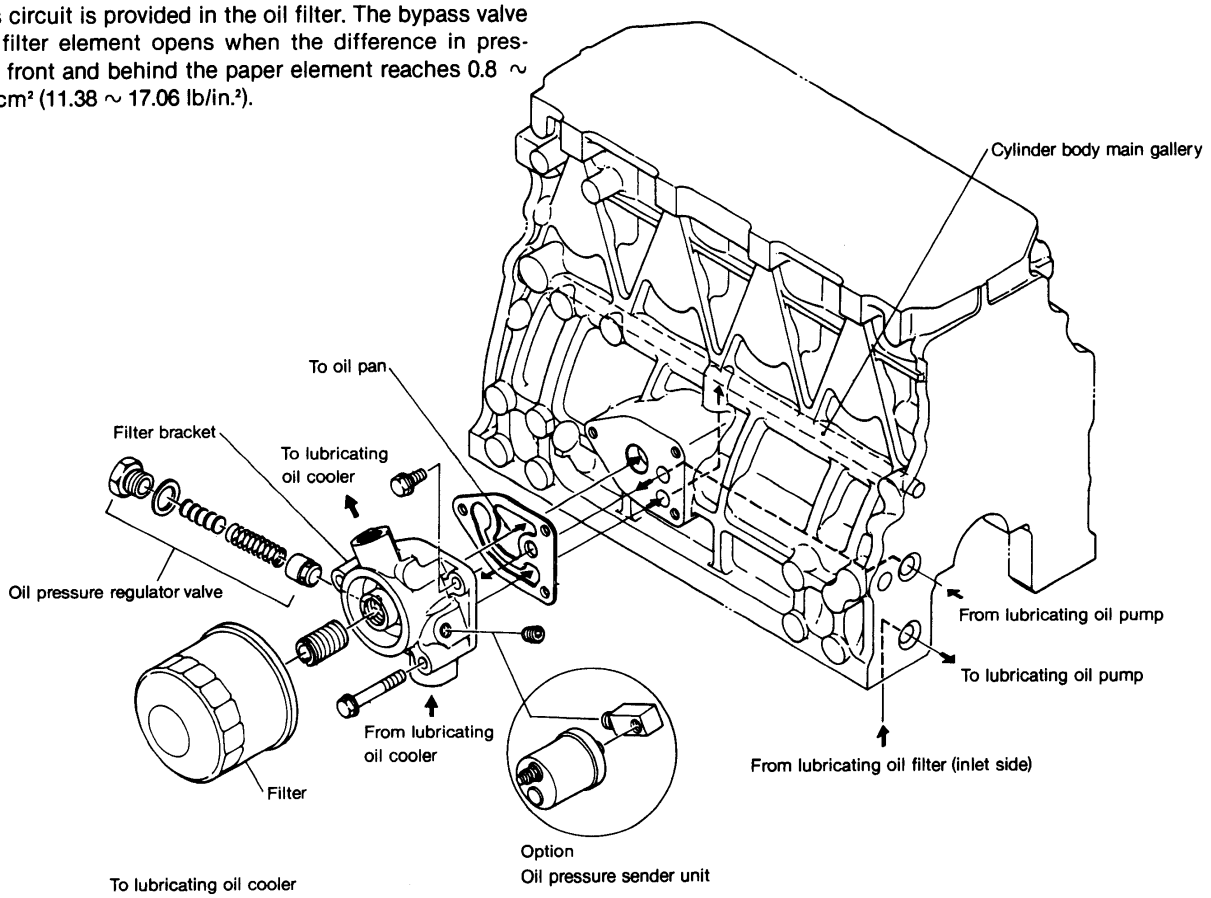
(5) Check for looseness of driver gear/rotor shaft fitting, and replace the entire assembly if loose or wobbly.
(6) Push the oil pressure regulating valve piston from the oil hole side, and replace the assembly if the piston does not return due to spring breakage, etc.
(7) Make sure that the rotor shaft rotates smoothly and easily when the drive gear is rotated.

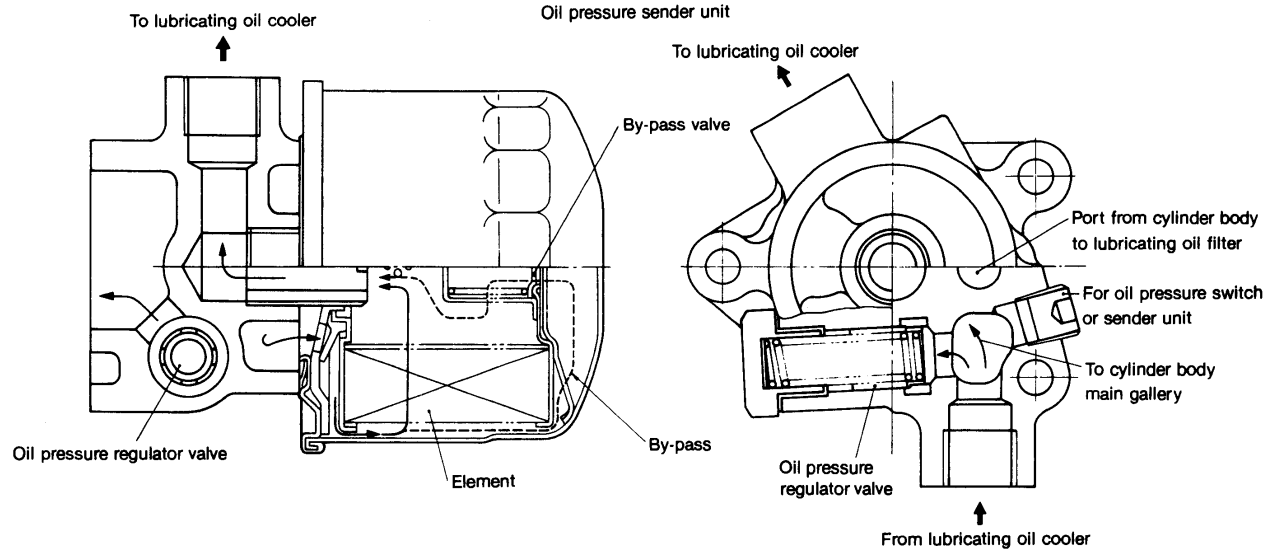
Turning torque	less than 1.5 kg-cm (0.108 ft-lb)

3. Lube Oil Filter

3-1 Lube oil filter construction

The lube oil filter is a full-flow paper element type, mounted to the side of the cylinder body with the filter bracket. It is an easy to remove cartridge type filter.
To prevent seizure in the event of the filter clogging up, a bypass circuit is provided in the oil filter. The bypass valve in the filter element opens when the difference in pressure in front and behind the paper element reaches 0.8 ~ 1.2 kg/cm² (11.38 ~ 17.06 lb/in.²).





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Type	Full flow, paper element
Filtration area	0.10m² (155 in.²)
Discharge volume	30 ℓ/min (1830 in.³/min)
Pressure loss	0.3 ∼ 0.5 kg/cm² (4.26 ∼ 7.11 lb/in.²)
By-pass valve regulating pressure	0.8 ∼ 1.2 kg/cm² (11.37 ∼ 17.06 lb/in.²)

3-2 Lube oil filter replacement

(1) Period

The paper element will get clogged up with dirt after long hours of usage, and eventually unfiltered oil will be fed to the engine through the bypass circuit. Replace the filter according to the following standard, as the dirt in unfiltered oil will of course have a detrimental affect on the engine.

Oil filter replacement period	Every 300 hours of engine operation

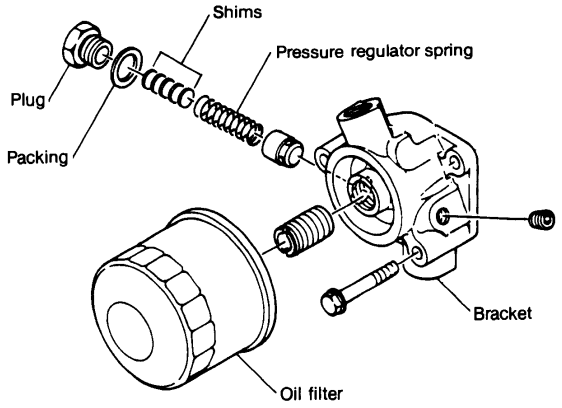
(2) Replacement

1) Remove the lube oil filter with the special tool.
2) Clean the filter mounting surface on the filter bracket and mounting screws.
3) Coat the filter rubber packing with lube oil.
4) Screw in the filter until the rubber packing comes in contact with the bracket mounting surface, and then 2 ∼ 3 turns more.
5) Run the engine after mounting the filter, and make sure that there is no oil leakage.

4. Oil Pressure Control Valve

4-1 Oil pressure control valve construction

The oil pressure control valve built into the oil filter bracket controls the oil pressure from the time the lube oil leaves the filter and is cooled in the lube oil cooler until just before it enters the cylinder body main gallery.
When the pressure of lube oil entering the cylinder body main gallery exceeds the setting, the control valve piston opens the bypass hole and lube oil flows back into the oil pan.



Regulating pressure	3.5 ~ 4.5 kg/cm² (49.78 ~ 64.00 lb/in.²)

4-2 Oil pressure control valve replacement

The control valve has been adjusted and assembled at the factory, so it should not be disassembled without good reason.
If the oil pressure control valve is disassembled due to spring trouble, etc., mount a pressure gauge on the oil pressure sender unit mounting washer, and adjust the pressure with adjustment shims until it is at the specified value.

Shim thickness	Shim part No.
0.2mm (0.0078 in.)	121850-35210
0.5mm (0.0196 in.)	121850-35220
1.0mm (0.0393 in.)	121850-35230

4-3 Vibration preventing damper

The filter bracket hydraulic (oil pressure) sender unit mount is constructed so that a vibration preventing damper can be mounted on it.
The hydraulic sender unit is mounted on the damper.

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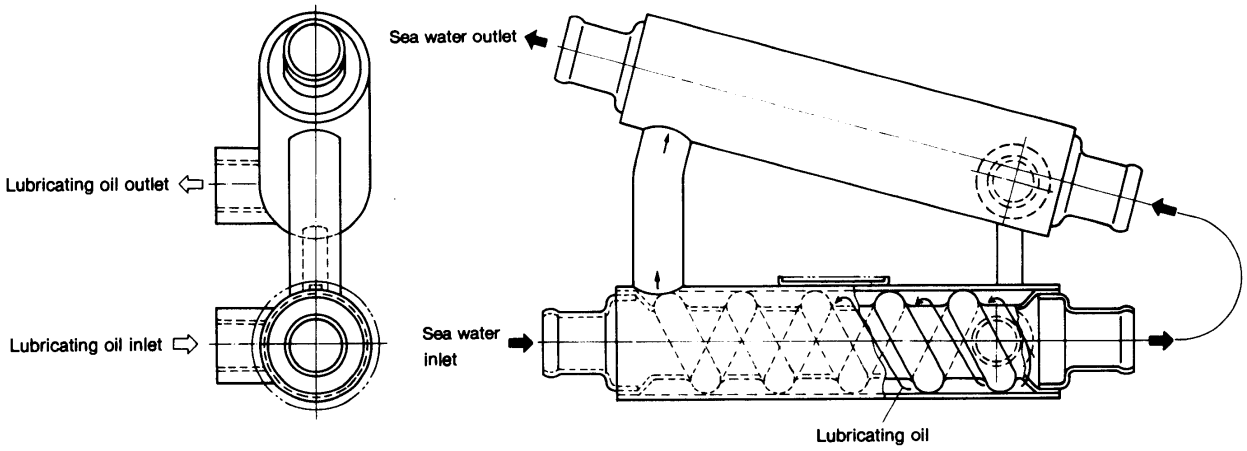
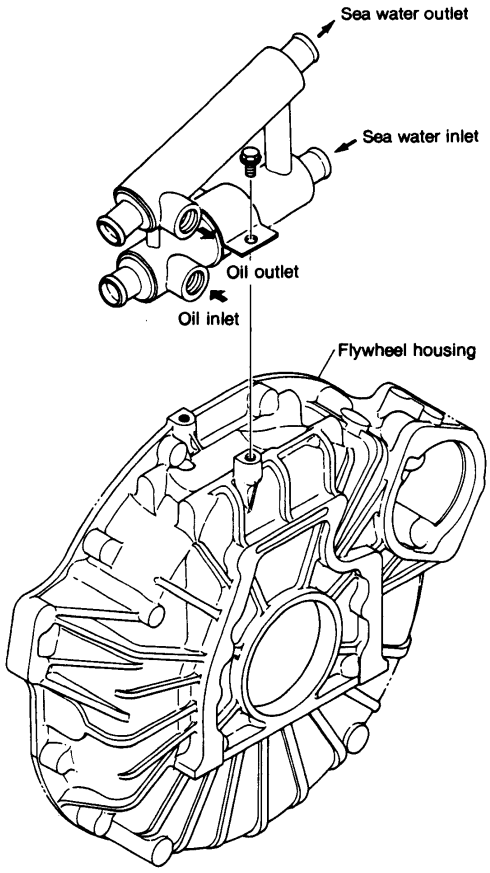
5. Lube Oil Cooler [Applicable Engine Model 4JHE & 4JH-TE]

5-1 Lube oil cooler construction

The spiral thread of the inner pipe is in contact with the inner surface of the outer pipe. This forms a spiral passageway.
The lube oil flows through this passageway and is cooled by the cooling water (sea water) flowing through the inner pipe.

There are two such pipes, connected side by side, designed so that the lube oil and sea water flow in the opposite directions.





Cooling area	0.0192m² (29.76 in.²)
Cooling water discharge volume	3773 ℓ/hr (230228 in.³/h)
Lubricating oil discharge volume	2160 ℓ/hr (131803 in.³/h)
Lubricating oil temperature at 40°C room air	Model 4JHE: 110°C or below Model 4JH-TE: 115°C or below

5-2 Inspecting the lube oil cooler

(1) Clean the inside of the sea water pipes with a wire brush to prevent the build-up of scale.
(2) If the rubber hose connection or welds are corroded, repair or replace the cooler.
(3) Apply the following water pressures to the sea water and lube oil lines to check for any leakage. Repair or replace the cooler if there are any leaks.

	Test pressure
Lubricating oil circuit	8 kg/cm² (113.78 lb/in.²)
Sea water circuit	4 kg/cm² (56.89 lb/in.²)

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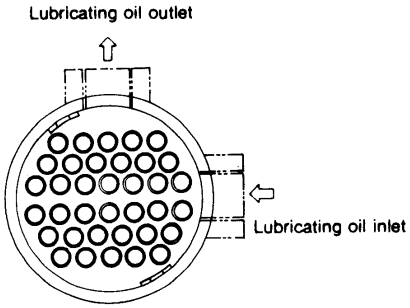
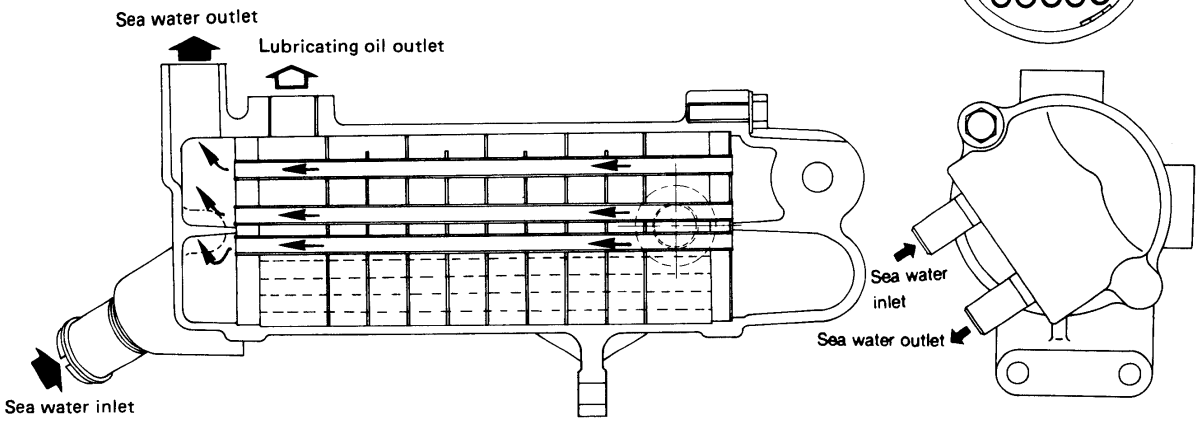
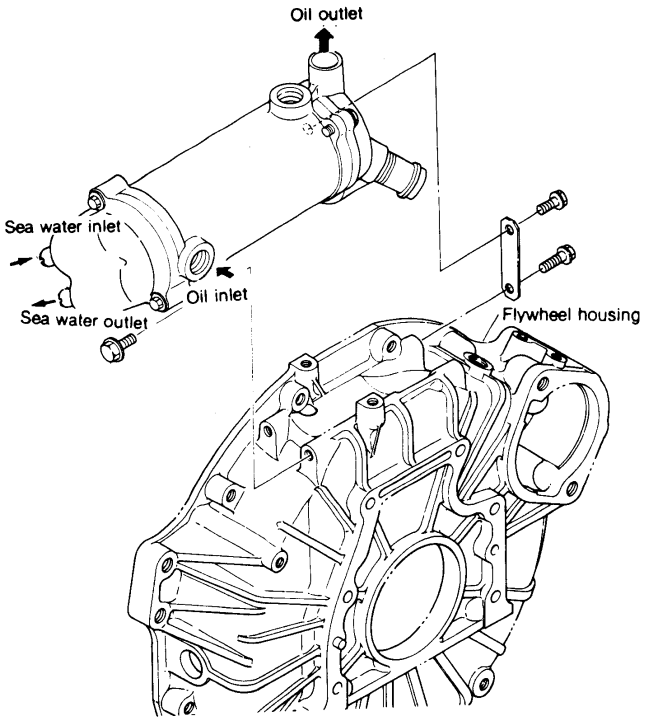
Lube Oil Cooler [Applicable Engine Model 4JH-HTE & 4JH-DTE]

5-1 Lube oil cooler construction

The lube oil cooler is comprised of 36 cooling pipes and 9 internal baffle plates.
The lube oil flows through this passageway and is cooled by the cooling water (sea water) flowing through the inner pipe.







Cooling area	0.165m² (255.75 in.²)
Cooling water discharge volume	3500ℓ/hr (213570 in³/h)
Lubricating oil discharge volume	2160 ℓ/hr (131803 in.³/h)
Lubricating oil temperature at 40°C room temperature	100°C or below

5-2 Inspecting the lube oil cooler

(1) Clean the inside of the sea water pipes with a wire brush to prevent the build-up of scale.
(2) If the rubber hose connection or welds are corroded, repair or replace the cooler.
(3) Apply the following water pressures to the sea water and lube oil lines to check for any leakage. Repair or replace the cooler if there are any leaks.

	Test pressure
Lubricating oil circuit	15kg/cm² (213.30 lb/in.²)
Sea water circuit	4 kg/cm² (56.89 lb/in.²)

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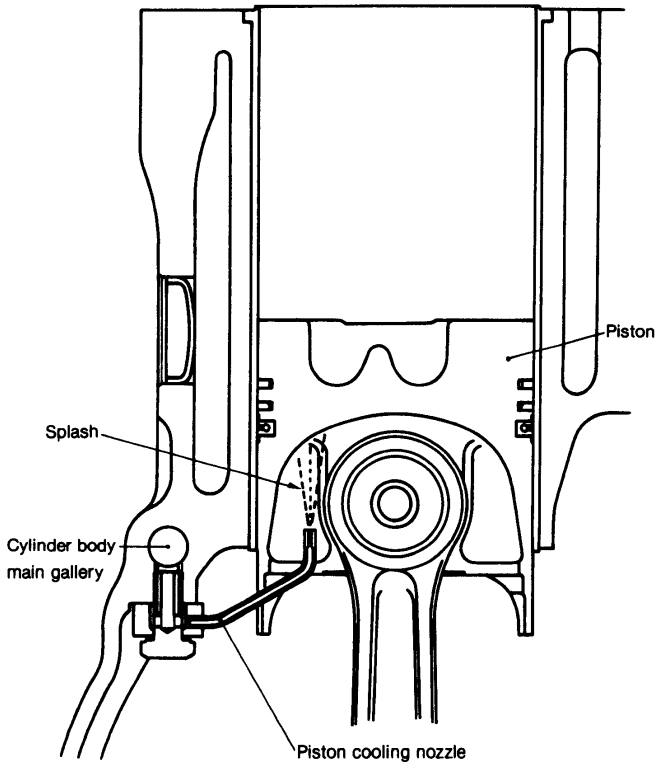
6. Piston Cooling Nozzle

6-1 Piston cooling nozzle construction

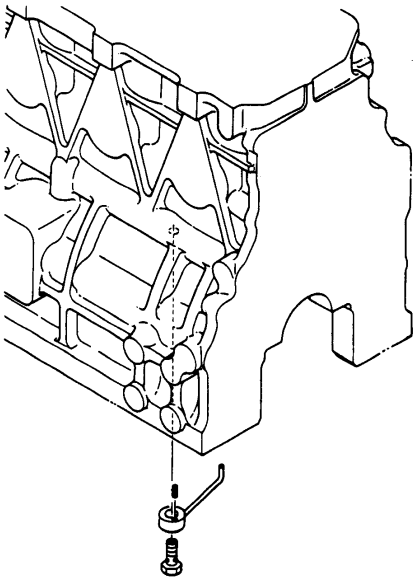
A nozzle made from steel piping is mounted on the lower part of cylinder body main gallery. Lube oil from the main gallery is sprayed out in a jet from the steel tip (ø1.77mm (0.0697in.)) of this pipe.
This jet spray cools the piston surface when the piston goes down.



Oil injection volume	1.3 ℓ/min. (79.32 in.³/min)
Oil injection pressure	3.5 kg/cm² (49.78 lb/in.²)

6-2 Inspection of piston cooling nozzle

(1) Check the nozzle tip hole to see if it is clogged up with dirt or other foreign matter, and clean.
(2) Inspect the pipe mounting to see if it is or may become loose or come off due to vibration, etc., and replace if necessary.



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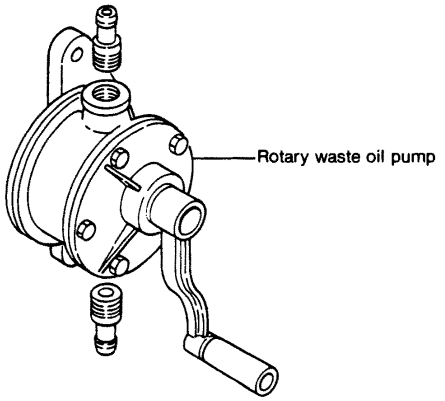
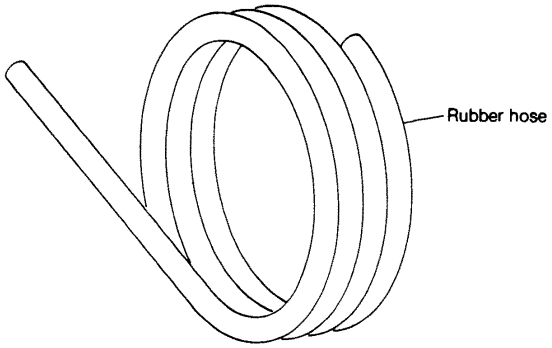
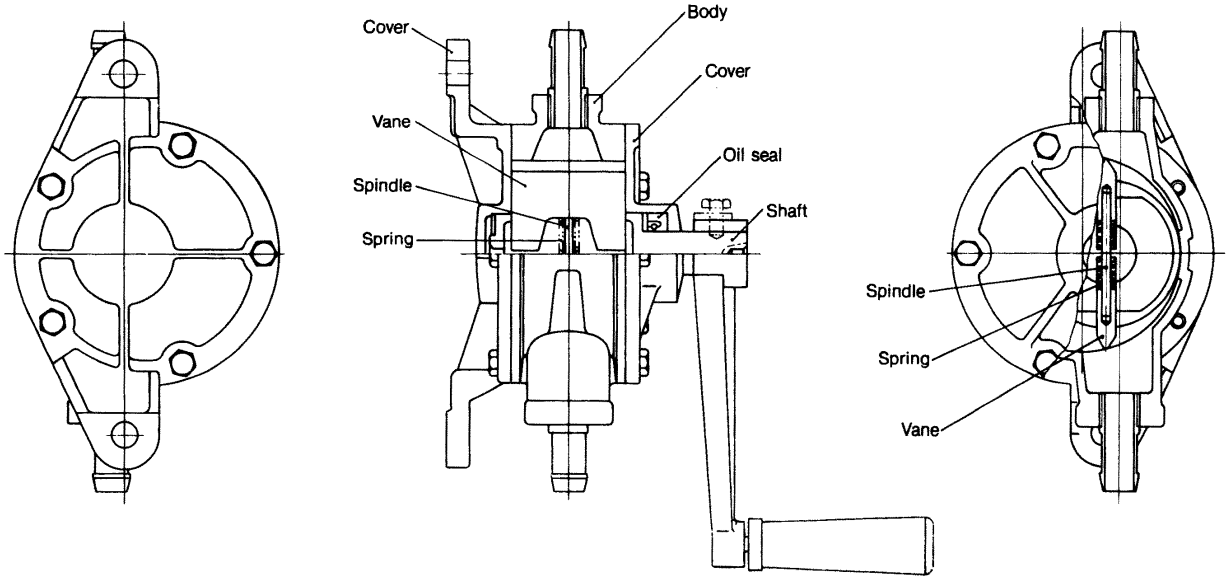
7. Rotary Waste Oil Pump (Optional)

A rotary waste oil pump to pump out waste oil during oil changing is available as an option.
This is a vane type pump. Turning the handle rotates the vanes and pumps out lube oil.





7-1 Construction



Rotary waste oil pump

Delivery capacity of one stroke	0.13ℓ (7.93 in.³)
Delivery pressure	1.5 kg/cm² (21.33 lb/in.²) or below
Suction head	less than 1m (39.37 in.)
Part No.	43600-002311

Rubber hose

Inner dia. × length	ø12 × 1000mm (0.4724 × 39.37 in.)
Part No. of rubber hose	43720-001220

7-2 Inspecting the waste oil pump

(1) Disassemble the waste oil pump and check for spring breakage or vane damage when there is an extreme drop in discharge volume, and replace if necessary.
(2) Replace the oil seal if there is excessive oil leakage from the handle shaft.
(3) Replace the impeller if there is an excessive gap between the impeller and the covers on both sides of casing. This will cause a drop in discharge volume.
(4) The hose coupling is coated with adhesive and screwed in. It therefore cannot be disassembled.

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CHAPTER 6

COOLING WATER SYSTEM

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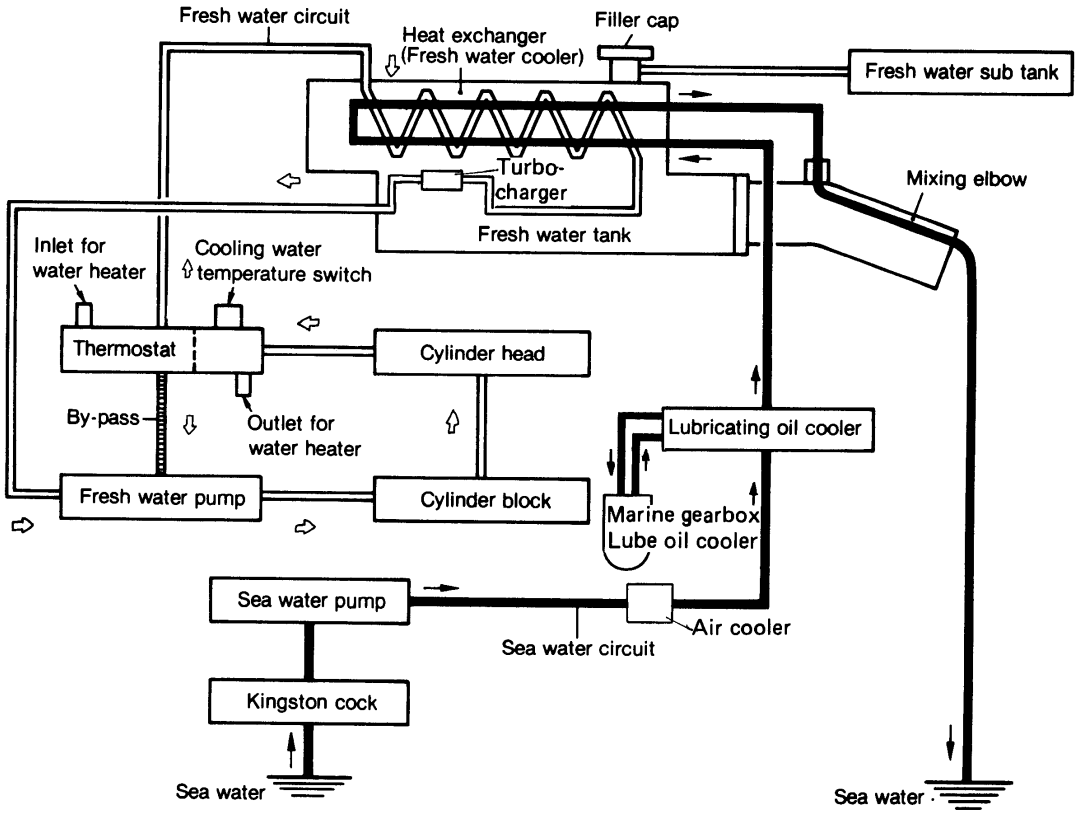
1. Cooling Water System

The cooling water system is of the indirect sea water cooled, fresh water circulation type. The cylinders, cylinder heads, turbocharger (only 4JH-HTE & 4JH-DTE) and exhaust manifold are cooled with fresh water, and the lube oil cooler air cooler (only 4JH-HTE & 4JH-DTE) and fresh water cooler (heat exchanger) use sea water.
Sea water pumped in from the sea by the sea water pump cools the lube oil in the lube oil cooler and then goes to the heat exchanger, where it cools the fresh water. Then it is sent to the mixing elbow and is discharged from the ship with the exhaust gas.
Fresh water is pumped by the fresh water pump from the fresh water tank to the cylinder jacket to cool the cylinders, turbocharger and then the cylinder head. The fresh water pump body also serves as a discharge passageway (line) at the cylinder head outlet, and is fitted with a thermostat.
The thermostat is closed when the fresh water temperature is low, immediately after the engine is started and during low load operation, etc. Then the fresh water flows to the fresh water pump inlet, and is circulated inside the engine without passing through the heat exchanger.
When the temperature of the fresh water rises, the thermostat opens, fresh water flows to the heat exchanger, and it is then cooled by the sea water in the tubes as it flows through the cooling pipe. The temperature of the fresh water is thus kept within a constant range by the thermostat.



NOTE: Air cooler, marine gear box, lube oil cooler, and water-cooled turbocharger are only for models 4JH-HTE and 4JH-DTE.

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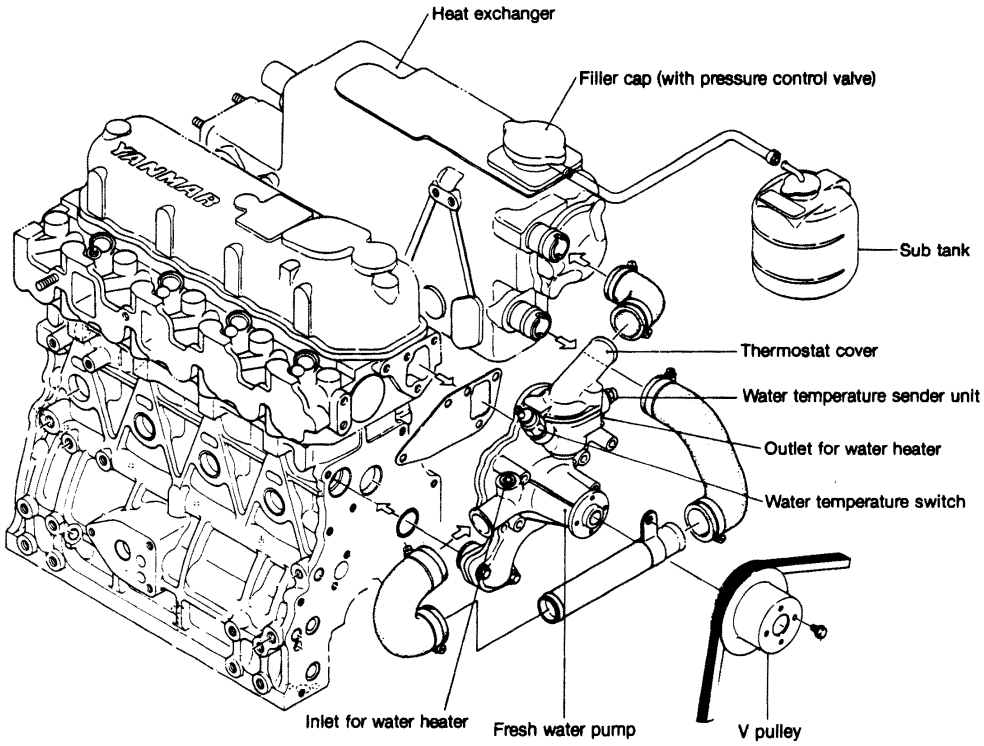
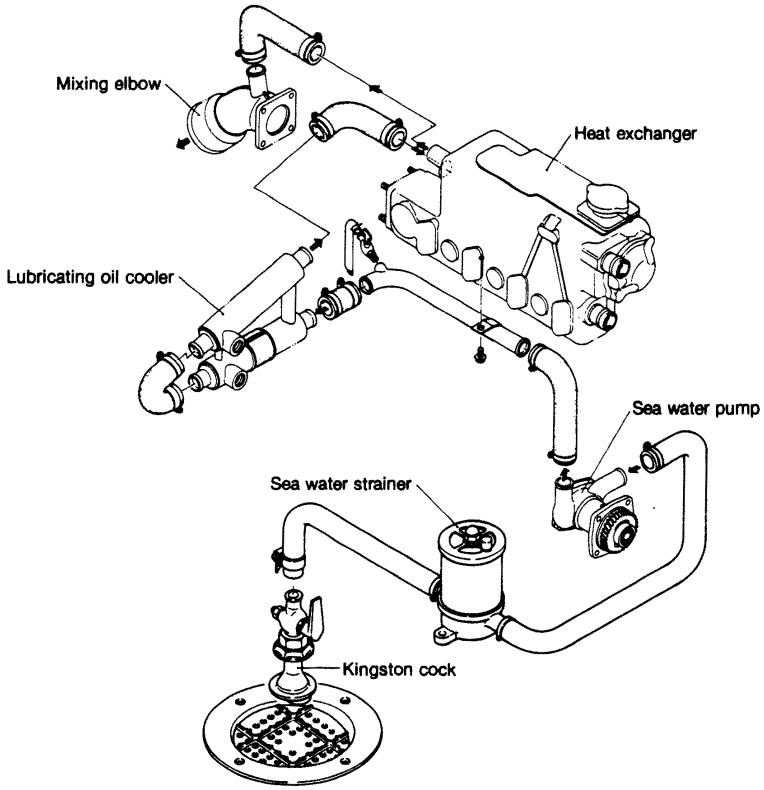
Fresh water line [ENGINE MODEL: 4JHE & 4JH-TE]



Sea water line [ENGINE MODEL: 4JHE & 4JH-TE]



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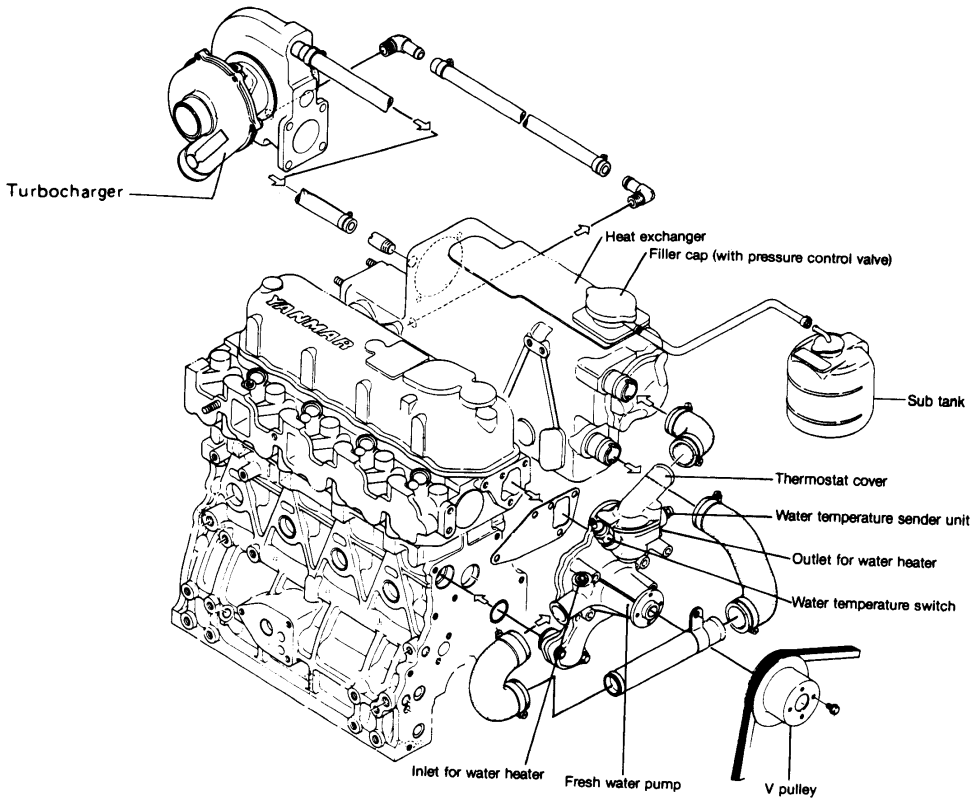
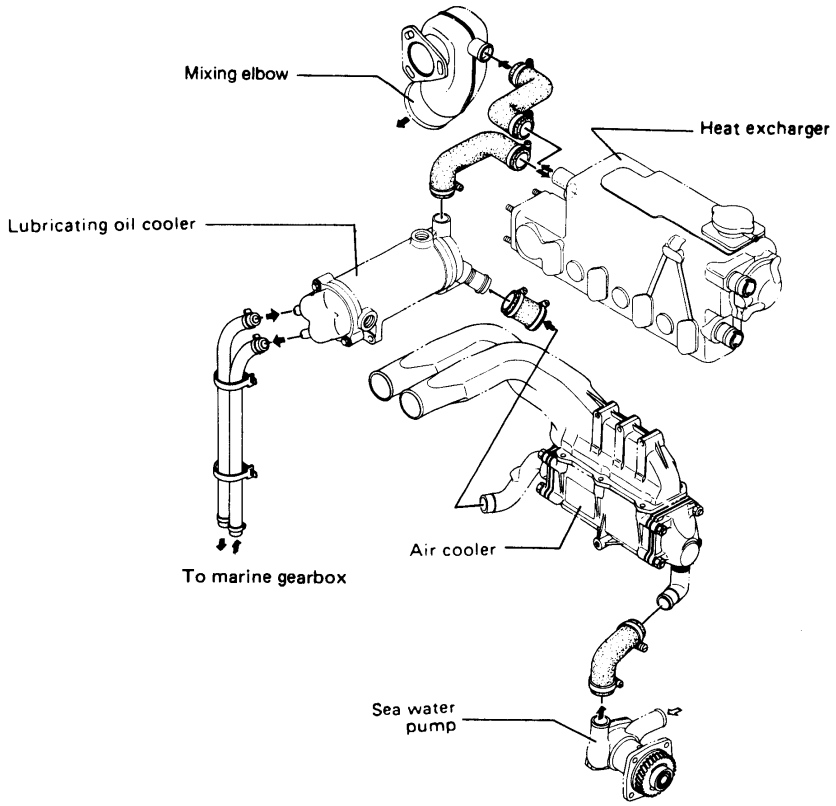
Fresh water line [ENGINE MODEL: 4JH-HTE & 4JH-DTE]



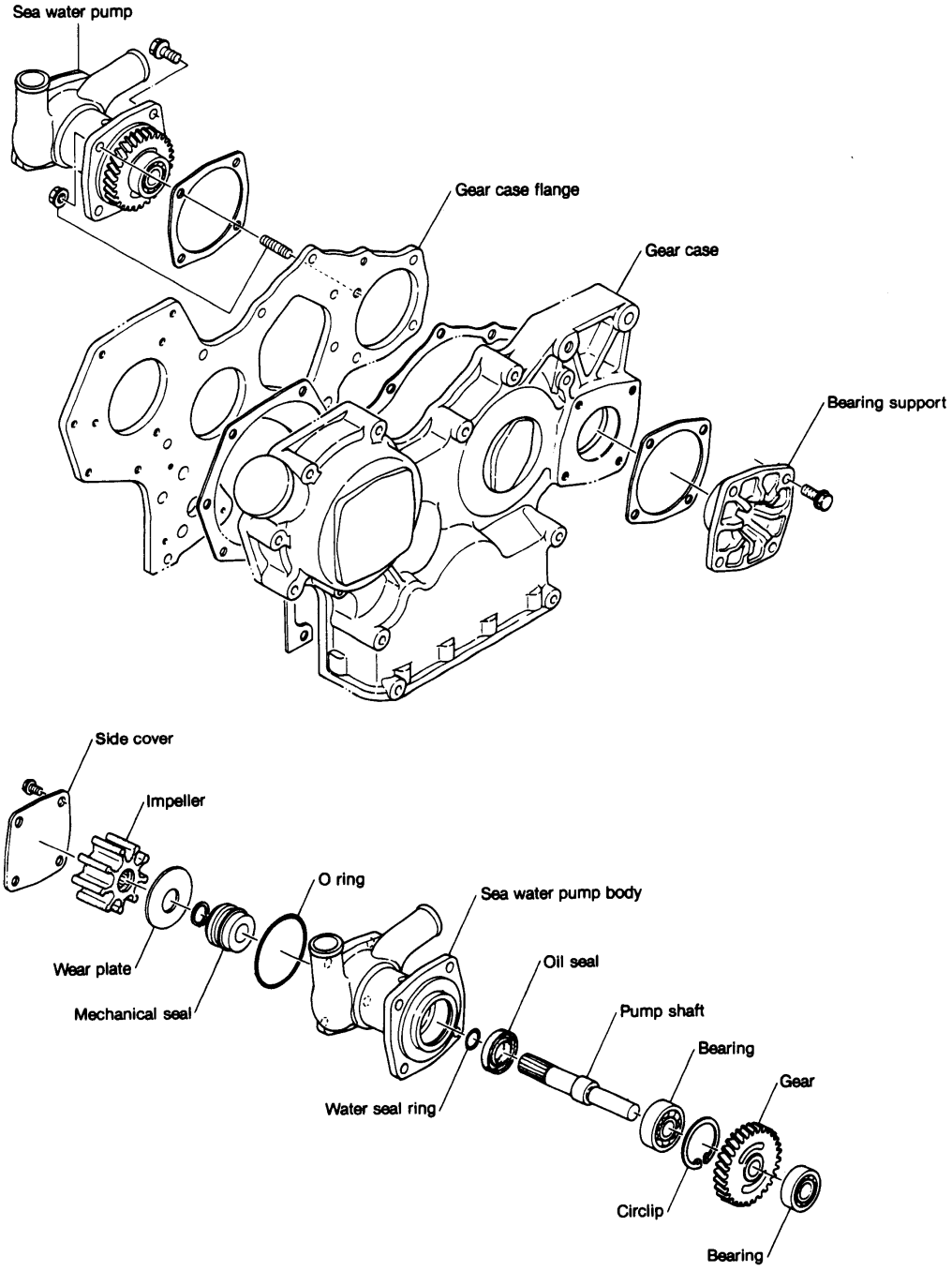
Sea water line [ENGINE MODEL: 4JH-HTE & 4JH-DTE]



2. Sea Water Pump

2-1 Sea water pump construction and functioning

The sea water pump has a rubber impeller. The sea water pump is mounted to the gear case, and the drive gear on the end of the sea water pump shaft meshes with the camshaft gear to drive the pump.



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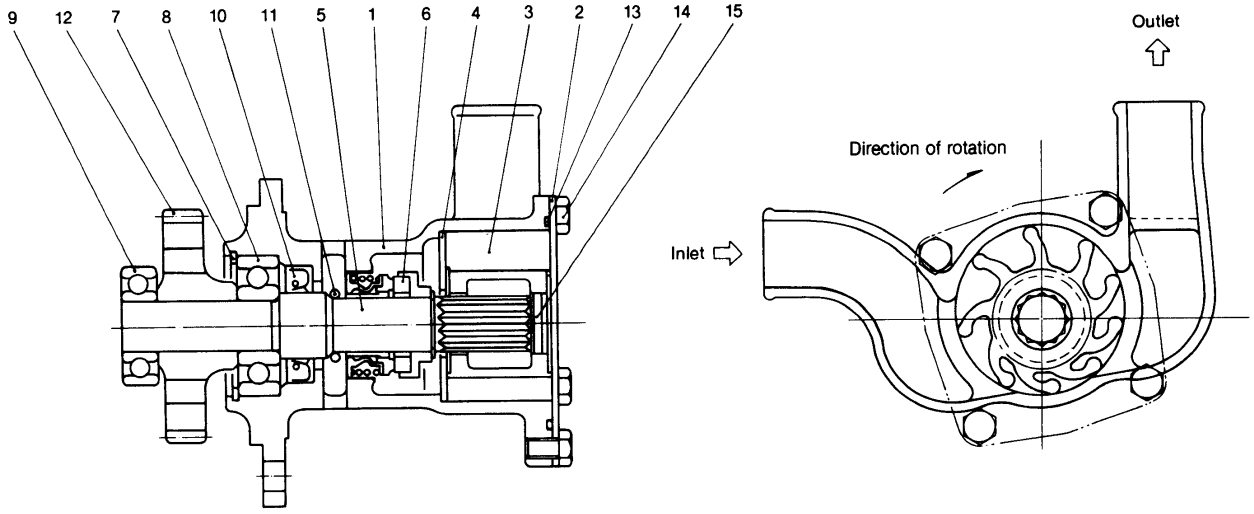

1. Sea water pump body
2. Side cover
3. Impeller (C-type)
4. Wear plate
5. Pump shaft
6. Mechanical seal
7. Circlip
8. Bearing
9. Bearing
10. Oil seal
11. Water seal ring
12. Gear
13. O ring
14. Hexagonal bolt
15. Impeller blind cover

2-2 Specifications of sea water pump

Engine speed (max.)	3600 rpm
Gear ratio (crank gear/pump gear)	28/31
Pump speed	3252 rpm
Suction head	0.5m (1.66 ft)
Total head	9.5m (31.16 ft)
Delivery capacity	3250 ℓ/h (198315 in.³/h)

2-3 Sea water pump disassembly

(1) Remove the rubber hose from the sea water pump outlet and then the sea water pump assembly from the gear case.
(2) Remove the sea water pump cover and take out the O-ring, impeller and wear plate.
(3) Remove the mechanical seal side stop ring.
(4) Insert pliers from the drive gear long hole and remove the stop ring that holds the bearings.
(5) Lightly tap the pump shaft from the impeller side and remove the pump shaft, bearings, and drive gear as a set.
(6) Remove the oil seal and mechanical seal if necessary.

2-4 Sea water pump inspection

(1) Inspect the rubber impeller, checking for splitting around the outside, damage or cracks, and replace if necessary.

mm (in.)

	Standard	Clearance at assembly	Maximum allowable clearance	Wear limit
Impeller width	31.6 ~ 31.8 (1.2440 ~ 1.2519)	0 ~ 0.3 (0 ~ 0.0118)	0.8 (0.0314)	31.3 (1.2322)
Wear plate thickness	2 (0.0787)			1.8 (0.0708)
Housing width	33.8 ~ 33.9 (1.3307 ~ 1.3346)			—
Side plate thickness	2 (0.0787)			1.8 (0.0708)

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(3) Inspect the mechanical seal and replace if the spring is damaged, or the seal is corroded. Also replace the mechanical seal if there is considerable water leakage during operation.

Cooling water leakage	less than 3 cc/h (0.18 in.³/h)

Parts No. of oil seal	129795-42670

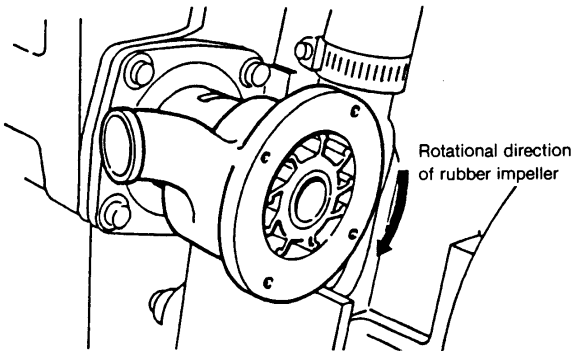
(4) Make sure the ball bearings rotate smoothly. Replace if there is excessive play.

2-5 Sea water pump reassembly

(1) When replacing the mechanical seal, coat the No.1101 oil seal and pressure fit. Coat the sliding surface with a good quality silicon oil, taking sufficient care not to cause any scratches.
(2) When replacing the oil seal, coat with grease and insert.
(3) Mount the pump shaft, ball bearing and gear assembly to the pump unit and fit the bearing stop ring. Be sure not to forget the water O-ring when doing this.

NOTE: Coat the shaft with grease.

(4) After inserting the mechanical seal stop ring, mount the wear plate and impeller.



NOTE: 1. When inserting the impeller in the pump, make sure that the impeller lies in the proper direction.
2. Coat the inside of pump body impeller housing with grease.

(5) Mount the O-ring side cover.

NOTE: Replace the O-ring.

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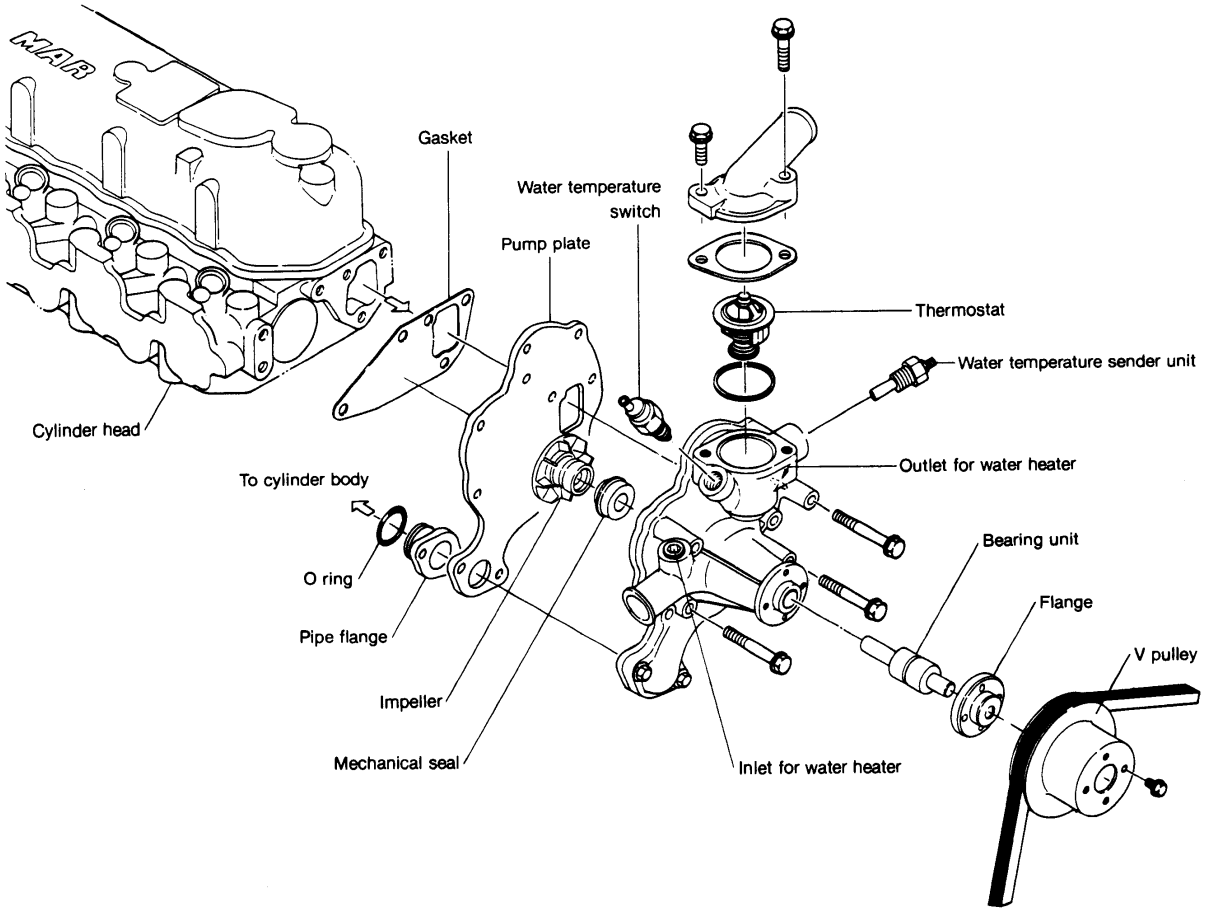
3. Fresh Water Pump

3-1 Fresh water pump construction

The fresh water pump is of the centrifugal (volute) type, and circulates water from the fresh water tank to the cylinders and cylinder head.
The fresh water pump consists of the pump body, impeller, pump shaft, bearing unit and mechanical seal. The V pulley on the end of the pump shaft is driven by a V belt from the crankshaft.
The bearing unit assembled in the pump shaft uses grease lubricated ball bearings and cannot be disassembled.
The totally enclosed mechanical seal spring presses the impeller seal mounted on the impeller side away from the pump body side. This prevents water from leaking along the pump shaft.
As the impeller and pulley flanges are press fit assembled, they cannot be disassembled.



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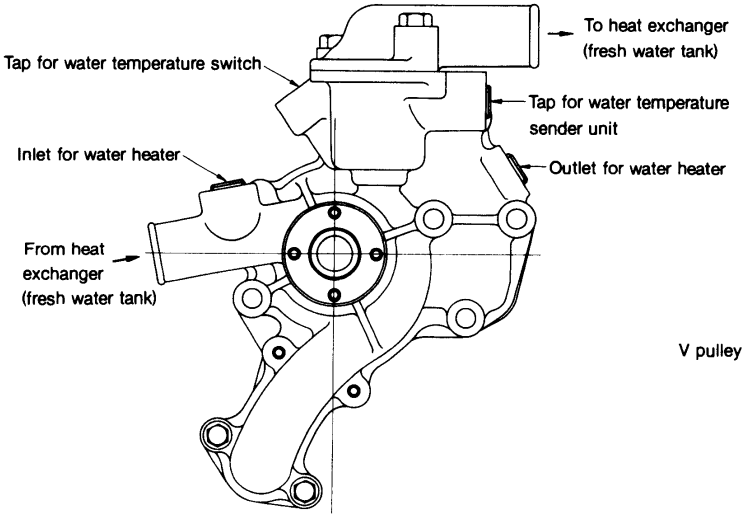

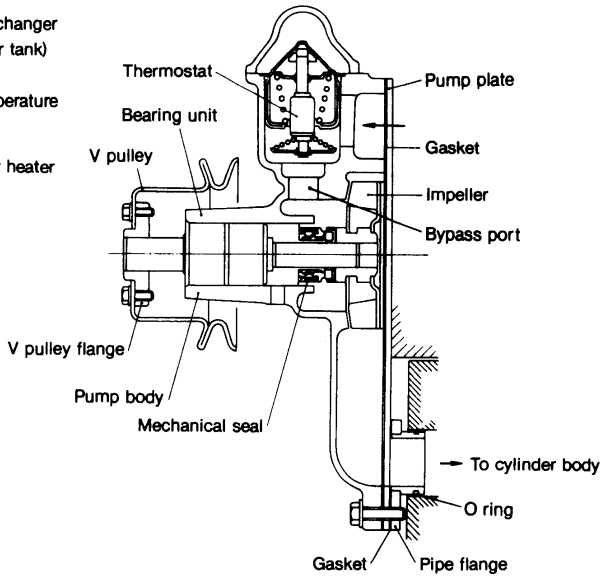

3-2 Specifications of fresh water pump

Crank shaft speed (max.)	3600 rpm
Pulley ratio (crank shaft/pump shaft)	ø134/ø120
Pump shaft speed	4020 rpm
Delivery capacity	86.6 ℓ/min (5284 in.³/min)
Total head	4m (13.12 ft)

3-3 Fresh water pump disassembly

(1) Do not disassemble the fresh water pump. It is difficult to disassemble and, once disassembled, even more difficult to reassemble. Replace the pump as an assembly in the event of trouble.
(2) When removing the fresh water pipe as an assembly from the cylinder and cylinder head, replace the cylinder intake pipe O-ring.
(3) When the fresh water pump body and cylinder intake flange and/or fresh water pump and pump plate are disassembled, retighten to the specified torque.

Tightening torque for pump setting bolts	70 ~ 110 kg-cm (5.06 ~ 7.94 ft-lb)

3-4 Fresh water pump inspection

(1) Bearing unit inspection
Rotate the impeller smoothly. If the rotation is not smooth or abnormal noise is heard due to excessive bearing play or contact with other parts, replace the pump as an assembly.
(2) Impeller inspection
Check the impeller blade, and replace if damaged or corroded, or if the impeller blade is worn due to contact with pump body.
(3) Check the holes in the cooling water and bypass lines, clean out any dirt or other foreign matter and repair as necessary.
(4) Replace the pump as an assembly if there is excessive water leakage due to mechanical seal or impeller seal wear or damage.
(5) Inspect the fresh water pump body and flange, clean off scale and rust, and replace if corroded.
(6) Measure the clearance between the impeller and the pump body, and the impeller and the plate.
Measure the clearance between the impeller and the pump body by pushing the impeller all the way towards the body, and inserting a thickness gauge diagonally between the impeller and the body.
Measure the clearance between the impeller and the plate (pump body bracket) by placing a straight-edge against the end of the pump body and inserting a thickness gauge between the impeller and the straight-edge.

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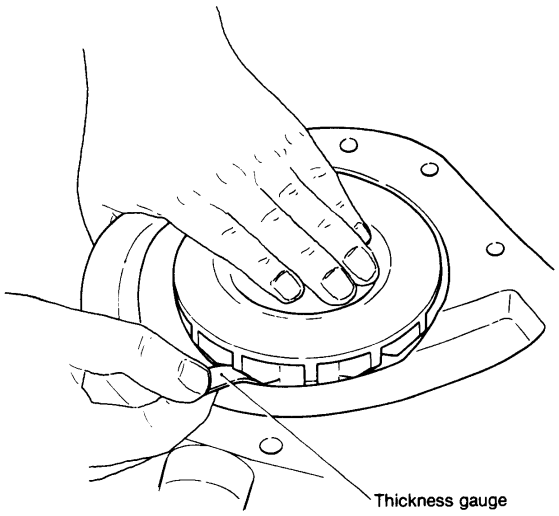
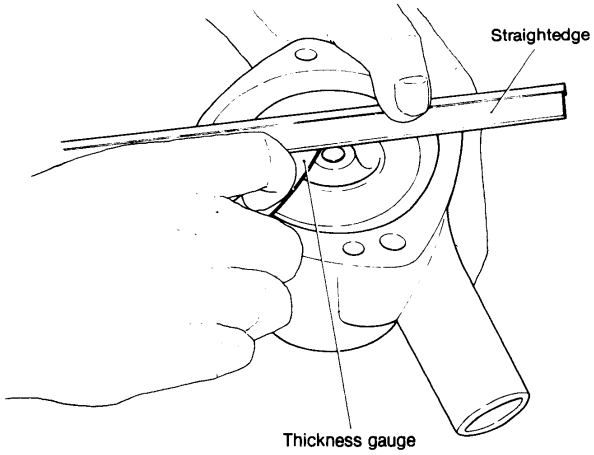
Measuring clearance between impeller and pump body.



Measuring clearance between impeller and pump body bracket.



mm (in.)

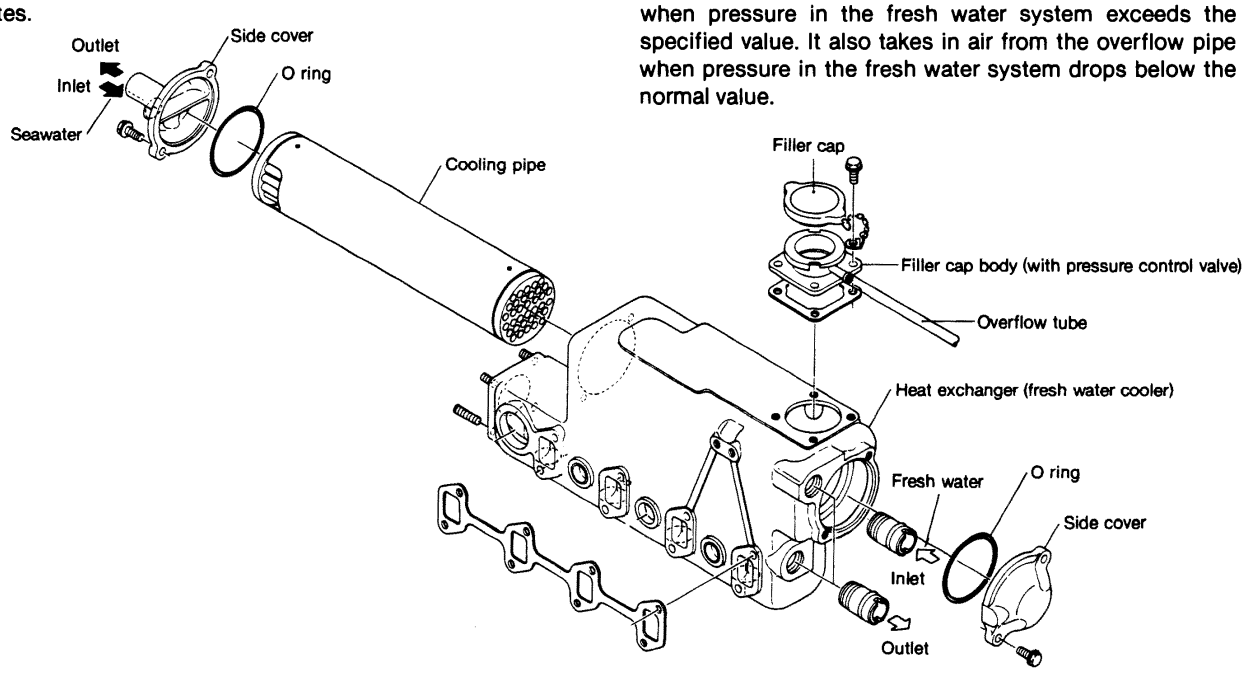
	Standard	Wear limit
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)	1.5 (0.0590)
Clearance between impeller and plate	1.5 (0.0590)	—

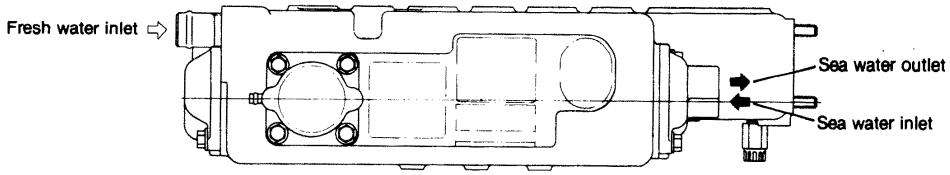
4. Heat Exchanger

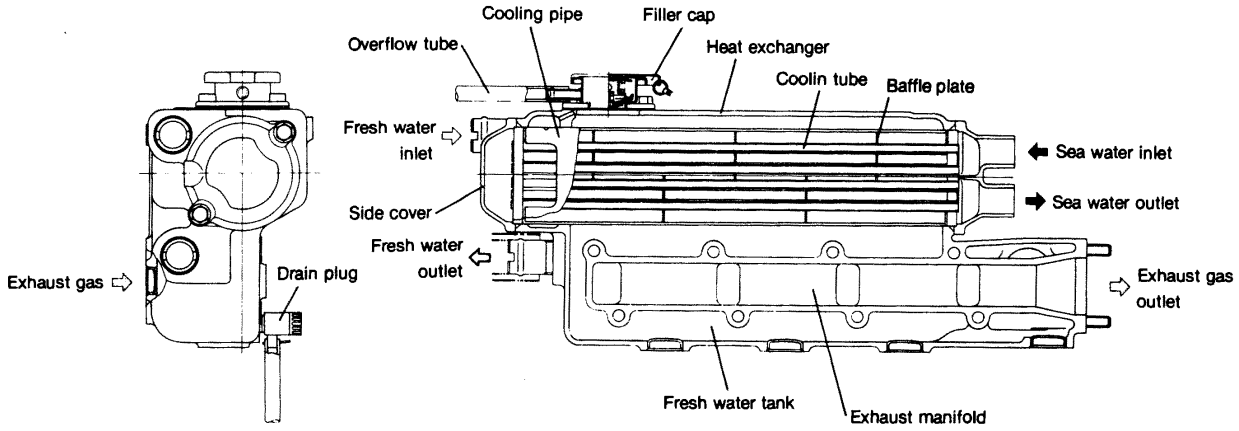
4-1 Heat exchanger construction

The heat exchanger cools the hot fresh water that has cooled the inside of the engine with sea water.
The inside of the heat exchanger cooling pipe consists of 36 small dia. tubes and baffle plates.
The sea water flows through the small dia. tubes and the fresh water flows through the maze formed by the baffle plates.

There is a resevoir at the bottom of the cooling pipe which serves as the fresh water tank. There is an exhaust water passageway (line) in the reservoir which forms a water cooled exhaust gas manifold.
The filler cap on top of the heat exchanger has a pressure valve, which lets off steam through the overflow pipe when pressure in the fresh water system exceeds the specified value. It also takes in air from the overflow pipe when pressure in the fresh water system drops below the normal value.







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4-2 Specifications of heat exchanger

Model of engine		4JHE	4JH-TE	4JH-HTE	4JH-DTE
Output (DIN6270 B rating)	HP/rpm	44/3600	55/3600	66/3600	77/3600
Pipe dia. x pieces	mm(in.)	ϕ6.4/ϕ8 (0.2519/0.3149) x 36			
Radiation area	m^2 ($in.^2$)	0.298 (461.9)			
Radiation area/HP	m^2/HP($in.^2$/HP)	0.00677(10.493)	0.00542(8.401)	0.00452(7.006)	0.00387(6.000)
Fresh water discharged volume	ℓ/hr ($in.^3$/hr)	5562 (339393)			
Sea water discharged volume	ℓ/hr ($in.^3$/hr)	3773 (230228)			3200(195264)
Fresh water flow speed in cooling pipe	m/s (ft/s)	1.74 (5.71)			1.54 (5.05)
Sea water flow speed in cooling tube	m/s (ft/s)	1.81 (5.94)			
Fresh water capacity	ℓ ($in.^3$)	6.5 (396.6)			

4-3 Disassembly and reassembly of the heat exchanger

(1) Remove the covers on both sides and take out the cooling pipe and O-ring(s).

NOTE: Replace the O-ring(s) when you have removed the cooling pipe.

(2) Remove the filler assembly.

4-4 Heat exchanger inspection

(1) Cooling pipe inspection

1) Inspect the inside of the tubes for rust or scale build-up from sea water, and clean with a wire brush if necessary.

NOTE: Disassemble and wash when the cooling water temperature reaches 85°C.

2) Check the joints at both ends of the tubes for looseness or damage, and repair if loose. Replace if damaged or corroded.
3) Check tubes and replace if leaking.
4) Clean any scale or rust off the outside of the tubes.

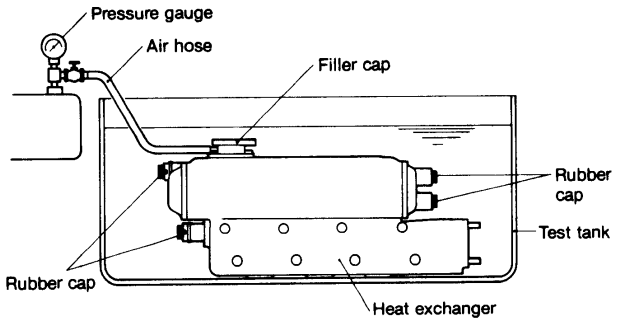
(2) Heat exchanger body inspection

1) Check heat exchanger body and side cover for dirt and corrosion. Replace if excessively corroded, or cracked.
2) Inspect sea water and fresh water inlets and outlets, retighten any joints as necessary and clean the insides of the pipes.
3) Check the exchaust gas intake flange and line, and replace if corroded or cracked.

(3) Heat exchanger body water leakage test

1) Compressed air/water tank test

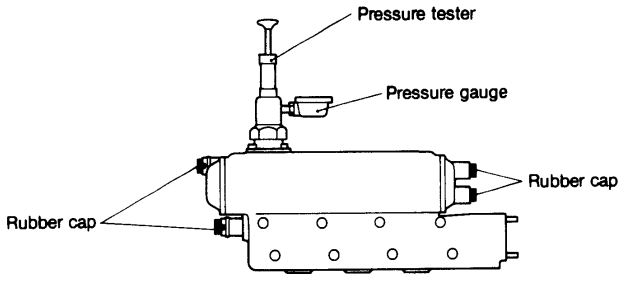
Fit rubber covers on the fresh water and sea water inlets and outlets. Place the heat exchanger in a water tank, feed in compressed air from the overflow pipe and check for any (water) leakage, (air bubbles).



Test pressure	2 kg/cm² (28.44 lb/in.²)

2) Use of the tester

Fit the fresh and sea water inlets and outlets with rubber covers and fill the fresh water tank with fresh water. Fit a pressure cap tester in place of the pressure cap, operate the pump for one minute and set the pressure at 1.5kg/cm² (21.33lb/in.²). If there are any leaks the pressure will not rise. If there are no leaks the pressure will not fall.



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5. Pressure Cap and Sub Tank

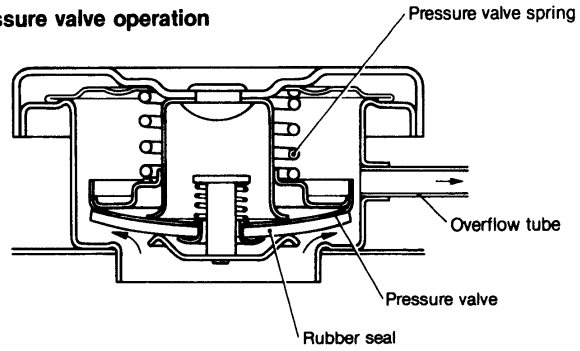
5-1 Pressure cap construction

The pressure cap mounted on the fresh water filler neck incorporates a pressure control valve. The cap is mounted on the filler neck cam by placing it on the rocking tab and rotating. The top seal of the cap seals the top of the filler neck, and the pressure valve seals the lock seat.

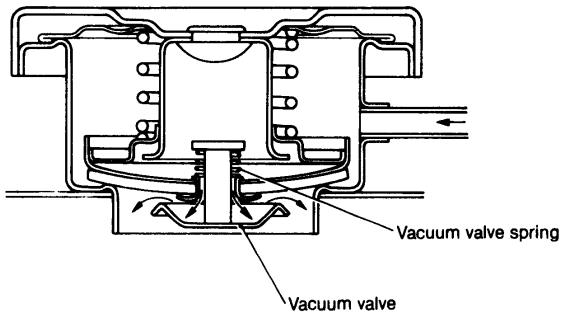
5-2 Pressure cap pressure control

The pressure valve and vacuum seal both seal the valve seat when the pressure in the fresh water system is within the specified value of 0.9kg/cm² (12.80lb/in.²). This seals the fresh water system.
When the pressure within the fresh water system exceeds the specified value, the pressure valve opens, and steam is discharged through the overflow pipe. When the fresh water is cooled and the pressure within the fresh water system drops below the normal value, atmospheric pressure opens the vacuum valve, and air is drawn in through the overflow pipe.

Pressure valve operation



Vacuum valve operation



The sub tank, (which will be described later), keeps the water level from dropping due to discharge of steam when the pressure valve opens.

Action of pressure control valve

Pressure valve	Open at 0.9 kg/cm²G (12.80 lb/in.²)
Vacuum valve	Open at 0.05 kg/cm²G (0.71 lb/in.²) or below

5-3 Pressure cap inspection

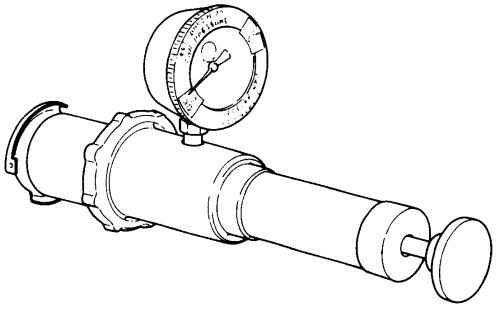
Precautions

Do not open the pressure cap while the engine is running or right after stopping because high temperature steam will be blown out. Remove the cap only after the water has had a chance to cool down.

(1) Remove scale and rust, check the seat and seat valve, etc. for scratches or wear, and the spring for corrosion or settling. Replace if necessary.

NOTE: Clean the pressure cap with fresh water as it will not close completely if it is dirty.

(2) Fit the adapter on the tester to the pressure cap. Pump until the pressure gauge is within the specified pressure range (0.75 ~ 1.05kg/cm² (10.67 ~ 14.91lb/in.²)) and note the gauge reading. The cap is normal if the pressure holds for six seconds. If the pressure does not rise, or drops immediately, inspect the cap and repair or replace as necessary.



Parts No. of cap tester	120445-44600

5-4 Function of the sub tank

The pressure valve opens to discharge steam when the steam pressure in the fresh water tank exceeds 0.9kg/cm² (12.80lb/in.²).
This consumes water. The sub tank maintains the water level by preventing this discharge of water.
The steam discharged into the sub tank condenses into water, and the water level in the sub tank rises.
When the pressure in the fresh water system drops below the normal value, the water in the sub tank is sucked back into the fresh water tank to raise the water back to its original level.
The sub tank facilitates long hours of operation without water replacement and eliminates the possibility of burns when the steam is ejected from the filler neck becase the pressure cap does not need to be removed.

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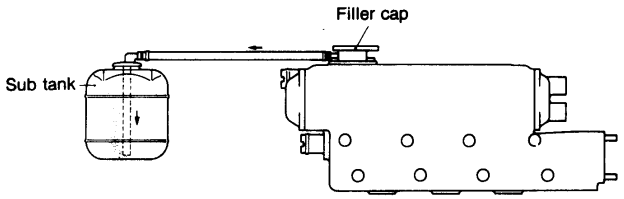
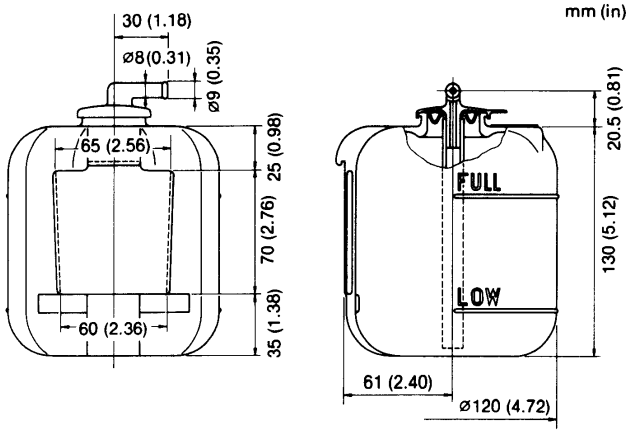




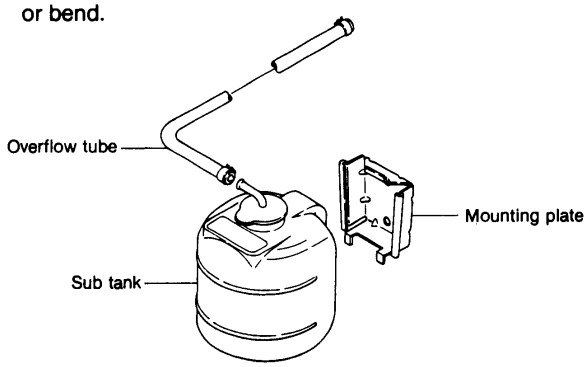
5-5 Specifications of sub tank

Subtank capacity	Overall capacity	1.25ℓ (76.27 in.³)
	Full-scale position	0.8ℓ (48.81 in.³)
	Low-scale position	0.2ℓ (12.20 in.³)
Part No. of subtank		120445-44530

5-6 Mounting the sub tank

(1) The sub tank is mounted at approximately the same height as the heat exchanger (fresh water tank). (allowable difference in height: 300mm (11.8110in.) or less)

(2) The overflow pipe should be less than 1000mm (39.3701in.) long, and mounted so that it does not sag or bend.



NOTE: Make sure that the overflow pipe of the sub tank is not submerged in bilge. If the overflow pipe is submerged in bilge, water in the bilge will be siphoned into the fresh water tank when the water is being cooled.

5-7 Precautions on usage of the sub tank

(1) Check the sub tank when the engine is cool and refill with fresh water as necessary to bring the water level between the low and full marks.

(2) Check the overflow pipe and replace if bent or cracked. Clean out the pipe if it is clogged up.

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6. Thermostat

6-1 Functioning of thermostat

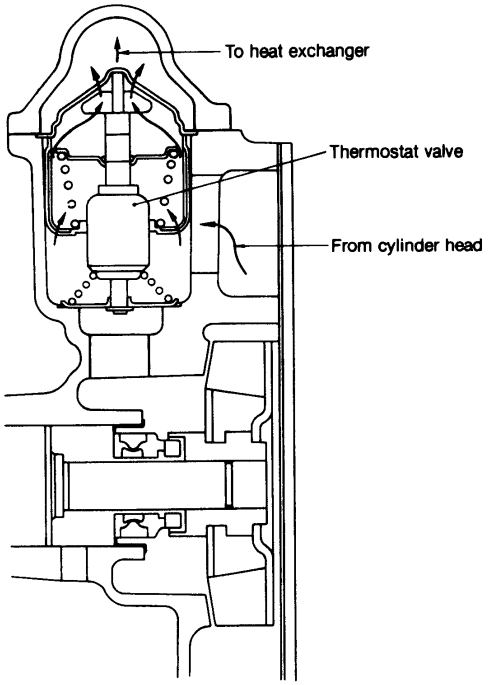
The thermostat opens and closes a valve according to changes in the temperature of the fresh water inside the engine, controlling the volume of water flowing to the heat exchanger from the cylinder head, and in turn maintaining the temperature of the fresh water in the engine at a constant level.

The thermostat is bottom bypass type. It is located in a position connected with the cylinder head outlet line at the top of the top of fresh water pump unit.

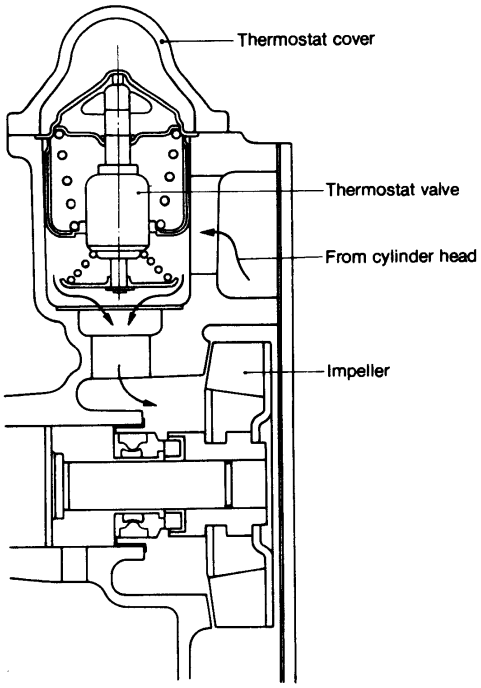
When the fresh water temperature is low (75.0 ~ 78.0°C or less), the thermostat is closed, and fresh water goes from the bypass line to the fresh water pump intake and circulates in the engine.

When the fresh water temperature exceeds the above temperature, the thermostat opens, and a portion of the water is sent to the heat exchanger and cooled by sea water, the other portion going from the bypass line to the fresh water pump intake.

The bypass line is closed off as the thermostat valve opens, and is completely closed when the fresh water temperature reaches 81.5°C (valve lifts 4mm (0.1575in.)), sending all of the water to the heat exchanger.



When valve is opened (by-pass passage is closed)



When valve is closed (by-pass passage is opened)

6-2 Thermostat construction

The thermostat used in this engine is of the wax pellet type, with a solid wax pellet located in a small chamber. When the temperature of the cooling water rises, the wax melts and increases in volume. This expansion and construction is used to open and close the valve.

6-3 Characteristics of thermostat

Opening temperature	75 ~ 78°C (167 ~ 174°F)
Full open temperature	90° (194°F)
Valve lift at full open	8mm (0.3149 in.)
By-pass valve lift	3.7mm (0.1456 in.)
By-pass valve close temperature	81.5°C (178°F)

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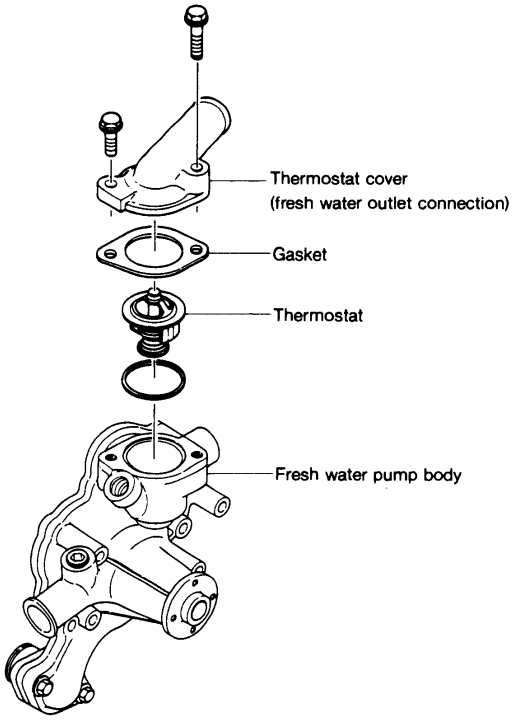
6-4 Thermostat inspection

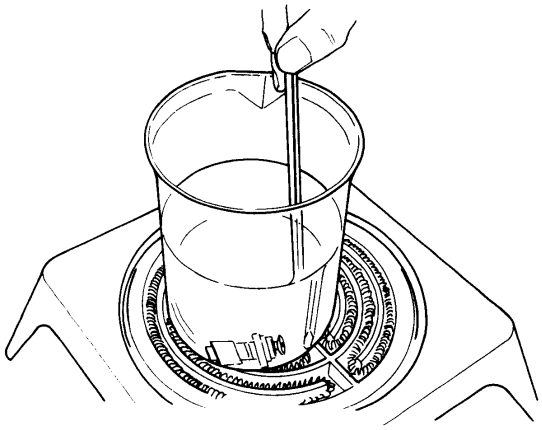
Remove the thermostat cover on top of the fresh water pump and take out the thermostat. Clean off scale and rust and inspect, and replace if the characteristics (performance) have changed, or if the spring is broken, deformed or corroded.



Part No. of thermostat	129470-49800

6-5 Testing the thermostat

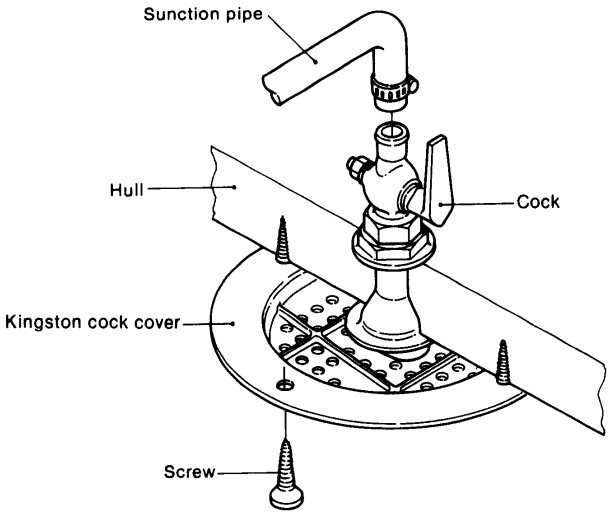
(1) Put the thermostat in a beaker with fresh water, and heat it on an electric stove. The thermostat is functioning normally if it starts to open between 75 ~ 78°C, and opens 8mm (0.3150in.) or more at 90°C. Replace the thermostat if it is not functioning normally.
(2) Normally, the thermostat should be inspected every 500 hours of operation, but, it should be inspected before this if the cooling temperature rises abnormally or white smoke is emitted for a long time after engine starting.
(3) Replace the thermostat every year or 2000 hours of operation (whichever comes first).

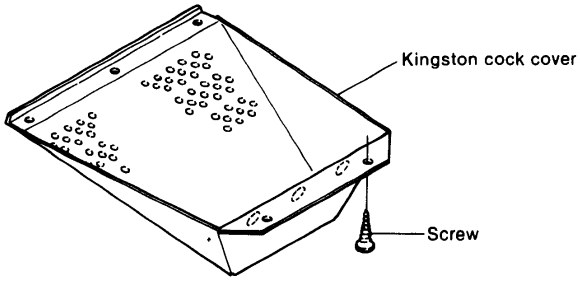


7. Kingston Cock (Optional)

7-1 Construction

The Kingston cock, installed on the bottom of the hull, controls the intake of cooling water into the boat. The Kingston cock serves to filter the water so that mud, sand, and other foreign matter in the water does not enter the water pump.
Numerous holes are drilled in the water side of the Kingston cock, and a scoop strainer is installed to prevent the sucking in of vinyl, etc.





7-2 Handling precautions

Caution the user to always close the Kingston cock after each day of use and to confirm that it is open before beginning operation.
If the Kingston cock is left open, water will flow in reverse and the vessel will sink if trouble occurs with the water pump.
On the other hand, if the engine is operated with the Kingston cock closed, cooling water will not be able to get in, resulting in engine and pump trouble.

7-3 Inspection

When the cooling water volume has dropped and the pump is normal, remove the vessel from the water and check for clogging of the Kingston cock.
If water leaks from the cock, disassemble the cock and inspect if for wear, and repair or replace it.

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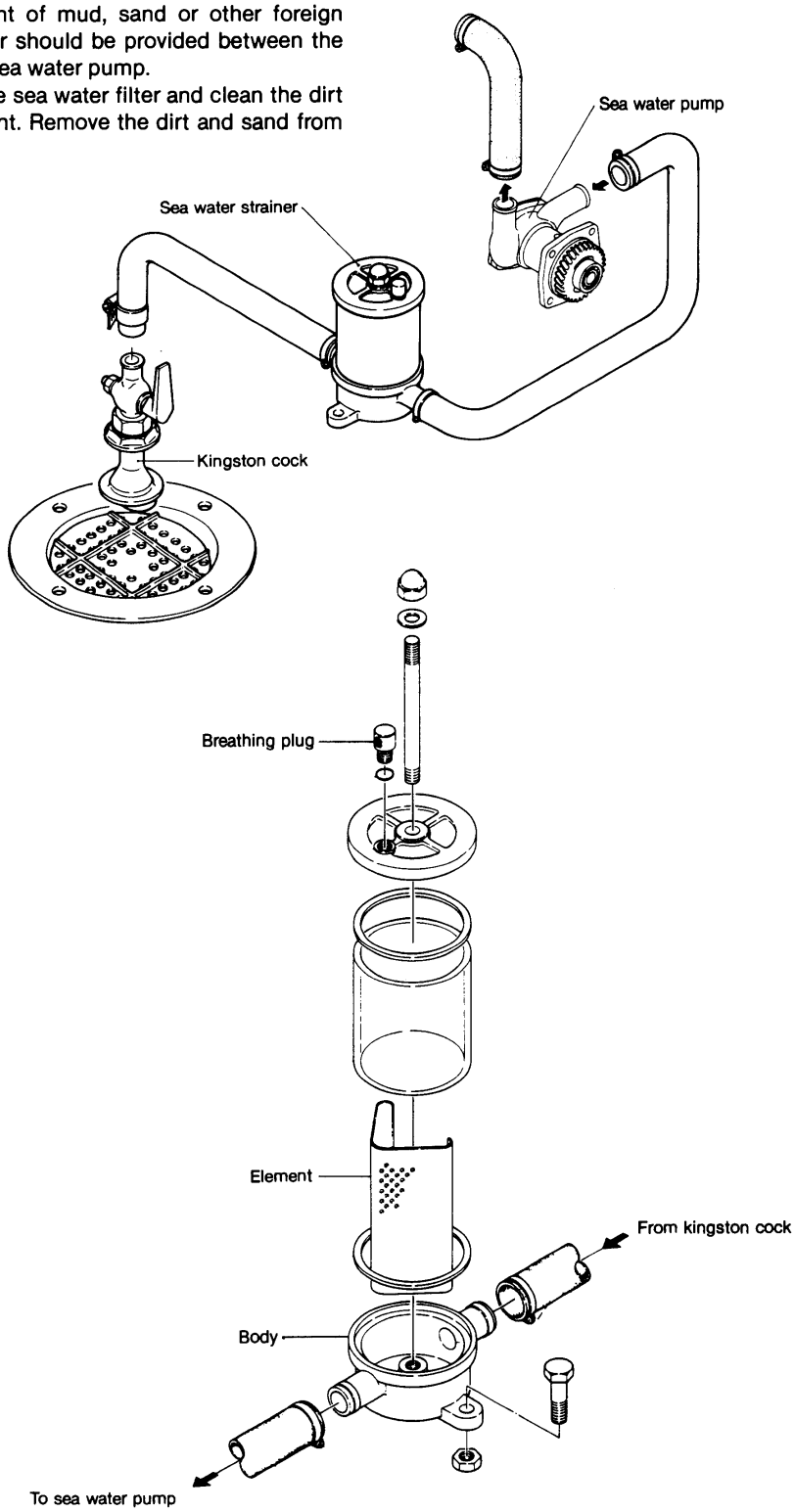
8. Sea Water Filter (Optional)

When operating the engine in areas where the sea water contains a large amount of mud, sand or other foreign matter, a sea water filter should be provided between the kingston cock and the sea water pump.
Occasionally inspect the sea water filter and clean the dirt and scale off the element. Remove the dirt and sand from the bottom of the filter.



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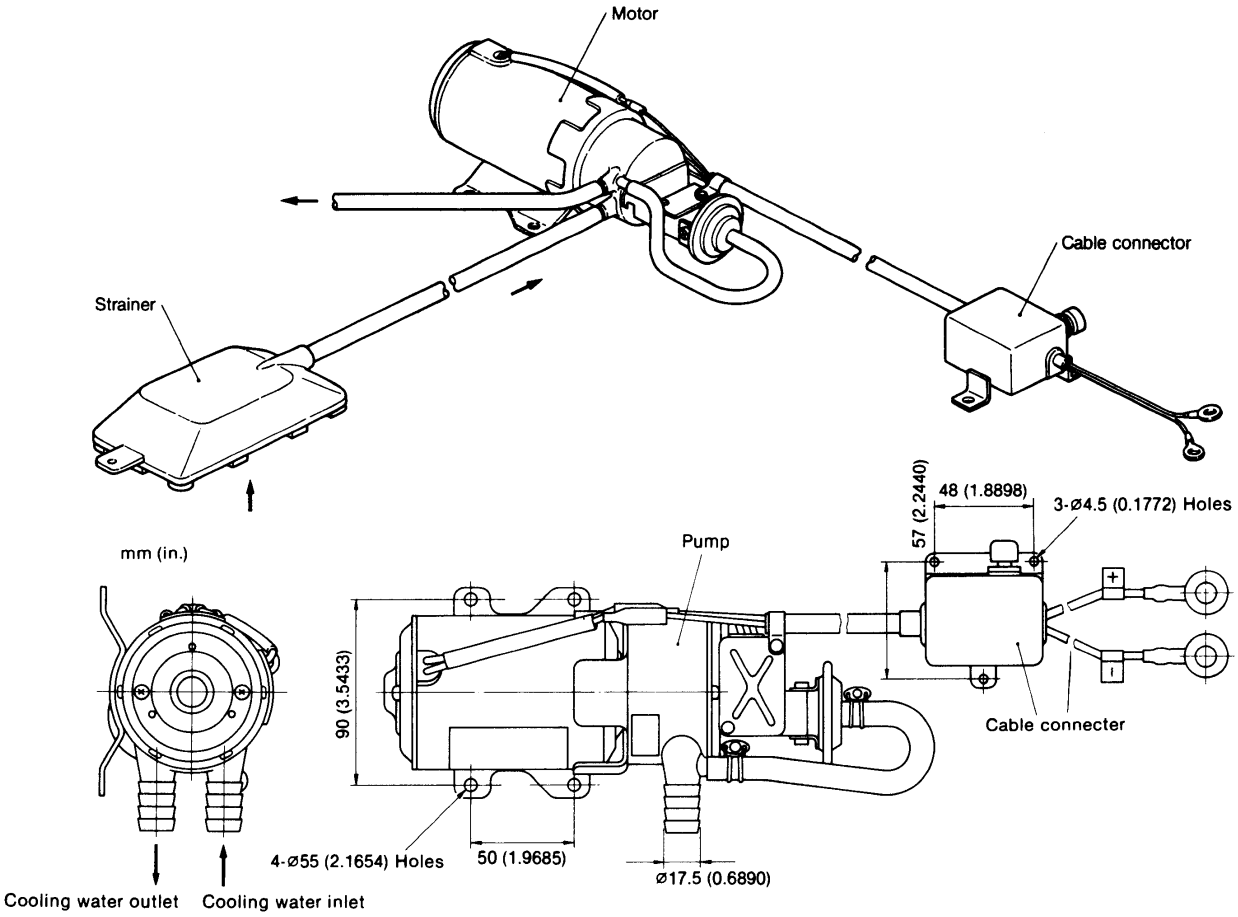
9. Bilge Pump and Bilge Strainer (Optional)



9-1 Bilge pump

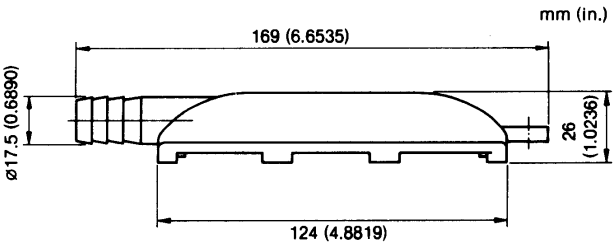
9-1.1 Specifications

Code No.	120345-46010 (with strainer)
Model No.	BP190-10
Rating	60 min.
Voltage	12V
Output	90W
Weight	3.0kg (6.6 lb)

9-1.2 Performance of pump (in pure water)

Suction performance	Voltage	11.5V
	Max. suction lift	1.2m (3.94 ft)
	Suction time	4 sec.
Pumping lift performance	Voltage	11.5V
	Current	8A
	Total lift	1m (3.28 ft)
	Lifting volume of water	17 ℓ/min

9-2 Bilge strainer



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