YANMAR
SERVICE MANUAL

INDUSTRIAL DIESEL ENGINE
MARINE DIESEL ENGINE

MODEL **HA(L)** series

[2-2.]Marine Engine

6HA(M)-E

a) Engine

Item			Unit	Specifications	
Model			—	6HAE(With marine gear)	6HAM-E(With marine gear)
Type			—	4-cycle,6-cycle water cooled diesel engine with turbocharger	
Combustion chamber type			—	Direct injection	
Turbocharging system			—	Exhaust gas turbocharger with intercooler	
Cylinder bore × Stroke			mm(in)	130×150(5.118×5.906)	
Displacement			ℓ (cu in)	11.946	
Continuous rating	Output		HP/rpm	165/2000	173/2000
	Net mean effective pressure		kg/cm²(psi)	6.22(88.45)	6.52(92.71)
	Mean piston speed		m(ft)/sec.	10.00(32.81)	
Practical maximum			—		
	Output		HP/rpm	200/2100	208/2100
	Net mean effective pressure		kg/cm²(psi)	7.18(102.10)	7.46(106.08)
	Mean piston speed		m(ft)/sec.	10.50(34.45)	
Starting method,capacity			kW	Electric,24V 6kW	
Maximum explosion pressure/Compression ratio			kg(psi)/cm²	85(1208.7)/15.6	
Piston top clearance/Valve clearance			mm(in)	1.2(0.047)	0.4(0.016)
Fuel system	Injection pump type		—	PEP Bosch in-line collective type(plunger dia.: ϕ	
	Injection timing(FID)		°BTDC	21	
	Injection valve type		—	Holes nozzle 4−ϕ0.36×150°	
	Injection pressure		kg/cm²(psi)	220(3128.4)	
	Applicable fuel oil		—	Diesel fuel oil	
	Fuel filter		—	Paper element	
	Firing order		—	1−4−2−6−3−5−1	
Lubricating system	Lubricating method		—	Forced lubrication with gear pump	
	Oil delivery capacity		ℓ /hr	7300min. (27630US gal,24100Imp gal)at 2000rpm	
	Oil pressure		kg/cm²(psi)		
	Oil filter		—	Paper element(double)	
	Applicable lubricating oil		—	API grade CD	
	Oil capacity	Total	ℓ	38	
		Effective	ℓ	20	
Cooling system	Cooling method		—	Constant-high-temperature fresh water cooling	
	Cooling water delivery volume		ℓ /hr	Sea water pump:12000min.,Fresh water pump:14000min.(at2000rpm)	
	Fresh water capacity		ℓ	45(170US gal,204Imp gal)	
Turbocharger	Type		—	———	
	Cooling method		—	———	
	Lubricating method		—	———	
	Lubricating oil pressure		kg/cm²(psi)	———	
Intercooler	Type,capacity		m²(ft²)	———	
	Cooling method		—	———	
Bilge pump	Type		—	Electric bilge pump	
	Delivery volume		ℓ /hr		

5. Accessories

[5-1.] Industrial Engine

○ : Standard ▲ : Optional

	Application	Generator				Industrial			
		4HAL	6HAL	6HAL-T	6HAL-HT	4HAL	6HAL	6HAL-T	6HAL-HT
Fuel system	F.O. tank 100ℓ (mounted on engine)	○	○	○	○	–	–	–	–
	F.O. tank 100 ~ 1000ℓ	▲	▲	▲	▲	▲	▲	▲	▲
	Water separator (Fixed on engine)	▲	▲	▲	▲	▲	▲	▲	▲
	F.O. filter paper element (additional, not fixed on engine)	▲	▲	▲	▲	▲	▲	▲	▲
	F.O. filter, paper element (fixed on engine)	○	○	○	○	○	○	○	○
	F.O. feed pump (mecanical) Fixed on fuel injection pump	○	○	○	○	○	○	○	○
Lubrication system	L.O. filter (paper element)	○	○	○	○	○	○	○	○
	L.O. cooler	○	○	○	○	○	○	○	○
	Sender unit (pressure)	○	○	○	○	○	○	○	○
	L.O. priming device (manual)	▲	▲	▲	▲	▲	▲	▲	▲
	L.O. rotary hand pump with rubber nose (supply & evercation)	▲	▲	▲	▲	▲	▲	▲	▲
Cooling system	Radiator & fan with safety net	○	○	○	○	○	○	○	○
	Water pump	○	○	○	○	○	○	○	○
	Thermostat for cooling water	○	○	○	○	○	○	○	○
	Heater for cooling water, single AC 200V 1KW	▲	▲	▲	▲	▲	▲	▲	▲
	Sender unit (temp)	○	○	○	○	○	○	○	○
Stating system	Stater motor 24V 5.2 kW	○	–	–	–	○	–	–	–
	Stater motor 24V 6 kW		○	○	○		○	○	○
	Alternator & regurator 24V 400W	○	○	○	○	○	○	○	○
Equipment	P.T.O. clutch SAE No. 1 (Anderton or Yanmar)	–	–	–	–	○	○	○	○
	Engine bed	–	–	–	–	○	○	○	○
	Engine bed with antivibration	○	○	○	○	–	–	–	–
	Bonnet	▲	▲	▲	▲	–	–	–	–
Control (Instrument panel)	Instrument panel	○	○	○	○	○	○	○	○
	Tachometer (mechanical)	○	○	○	○	○	○	○	○
	L.O. pressure gauge (electric)	○	○	○	○	○	○	○	○
	C.W. temperature gauge (electric)	○	○	○	○	○	○	○	○
	Charge lamp	○	○	○	○	○	○	○	○
	Starter switch	○	○	○	○	○	○	○	○
	Engine stop device with solenoids (electric)	▲	▲	▲	▲	▲	▲	▲	▲
Control	Engine stop device (manual)	○	○	○	○	○	○	○	○
	Safety stop device (Low L.O. pressure High C.W. temp.) Mecanical	▲	▲	▲	▲	▲	▲	▲	▲
	Safety stop device (Low L.O. pressure High C.W. temp.) Electric	▲	▲	▲	▲	▲	▲	▲	▲
	Over speed control device (electric)	▲	▲	▲	▲	▲	▲	▲	▲
	Battery switch	○	○	○	○	○	○	○	○
	Battery capacity: 4HAL 24V, 120 AH (12V, 120AHX 2)	▲	–	–	–	▲	–	–	–
	Battery capacity: 6HAL-(T) (HT) 24V, 150AM (12V, 150AHX 2)	–	▲	▲	▲	–	▲	▲	▲
	Wire with terminal for battery	▲	▲	▲	▲	▲	▲	▲	▲
	Exhaust gas temperature gauge	▲	▲	▲	▲	▲	▲	▲	▲
	Air pressure gauge for turbocharger	–	–	▲	▲	–	–	▲	▲

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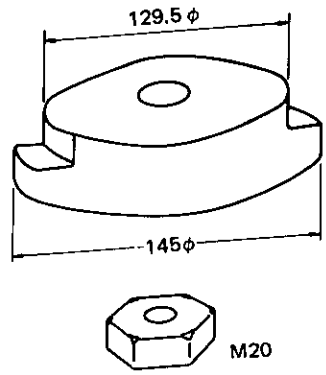
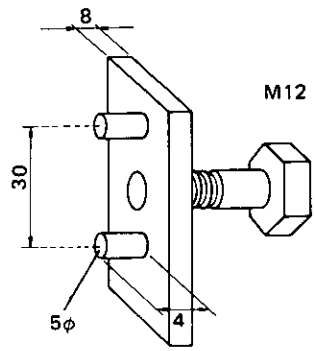
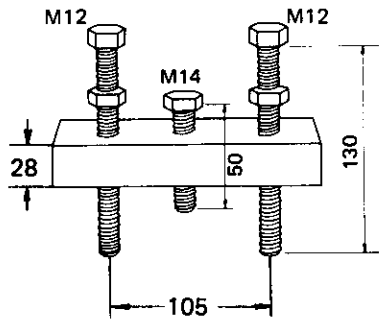
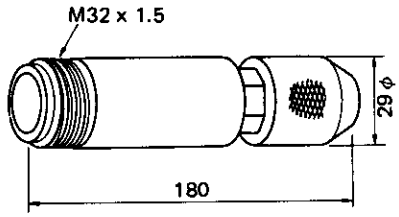
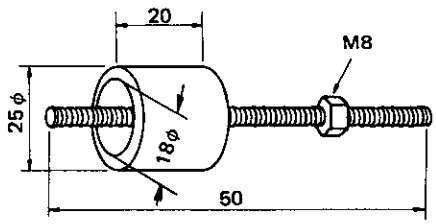
Name	Tool Number	Description	Remarks (page)
Cylinder liner puller	126650-92020		(4-12)
Cooling water pump impeller wrench	126650-92400		(6-5)
Cam gear puller	145610-92900 (Body) 126650-92650 (M12) 126650-92660 (M14)		(4-14)
Automatic timer puller	126630-92770		Marine engine only (7-11)
Flywheel straight pin puller	126650-92670 126650-92680 (M8)		(4-21)

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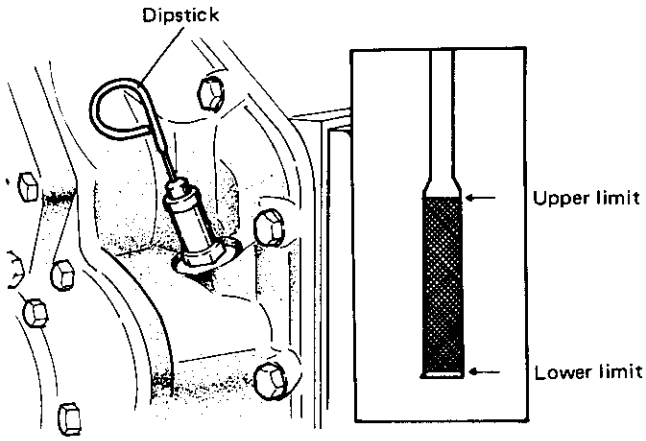
3. Remove the drain plug on the oil filter and drain oil from the filter.
4. Install the drain plug.
5. Pour in the prescribed amount of recommended oil (see page 1-16) through the oil filler opening.

Oil capacity – 4HAL: 19.5 ℓ (5⅛ U.S. gal, 4¼ Imp. gal)
6HAL-T: 29 ℓ (7⅝ U.S. gal, 6⅜ Imp. gal)

f.) Marine gear oil level check (marine engine)

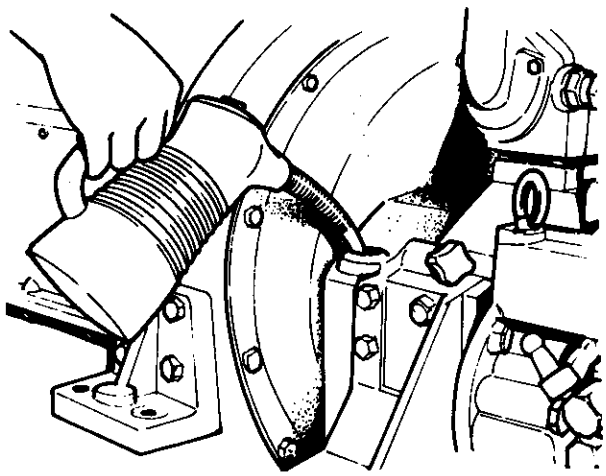
1. Inspect the oil level with an oil level gauge.

Fig. MI-14. Checking the oil level (typical)



2. If the oil level is lower than the lower limit or is nearing it, remove the filler cap and add the recommended engine oil (see page 1-16) up to the upper limit.

Fig. MI-15. Adding oil (typical)



g.) Marine gear oil change (marine engine)

1. Wait for 1-2 hours after stopping the engine and remove the oil filler cap.
2. Remove the dipstick, connect the vinyl hose of the rotary pump to the opening and drain the oil.
3. Pour in the prescribed amount of the recommended oil (see page 1-16) through the oil filler opening.

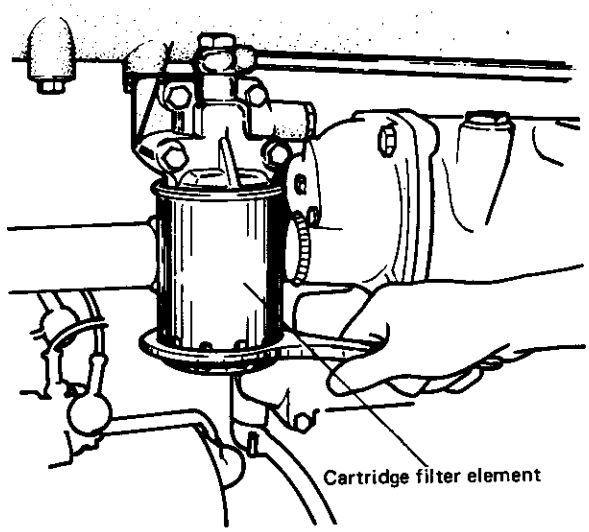
h.) Marine gear oil filter screen cleaning (marine engine)

1. Drain oil from the marine gear.
2. Remove the oil filter screen and clean it with cleaning solvent.
3. Inspect the screen and replace it if damaged.
4. Install the screen and pour in oil.

i.) Turbocharger oil filter element replacement (6HA(M)-HTE)

1. Remove the cartridge type filter element.
2. Install a new element.

Fig. MI-16. Replacing the turbocharger oil filter



Sec. 3. CYLINDER HEAD AND VALVE (CH)

Contents of this section

b.) Nozzle sleeve re-expanding

The nozzle sleeve expands in the cylinder head groove as shown in Fig. CH-27. If water leakage occurs, re-expand the sleeve following the steps for expanding the sleeve under "Nozzle sleeve replacement".

Note:

- *Re-expand the sleeve after completely removing the carbon deposit around the expanded area of the nozzle sleeve.*
- *The sleeve can be re-expanded only once. The amount to be installed (L measurement) of the mandrel is approximately 7 mm (0.28 in).*

c.) Nozzle sleeve replacement

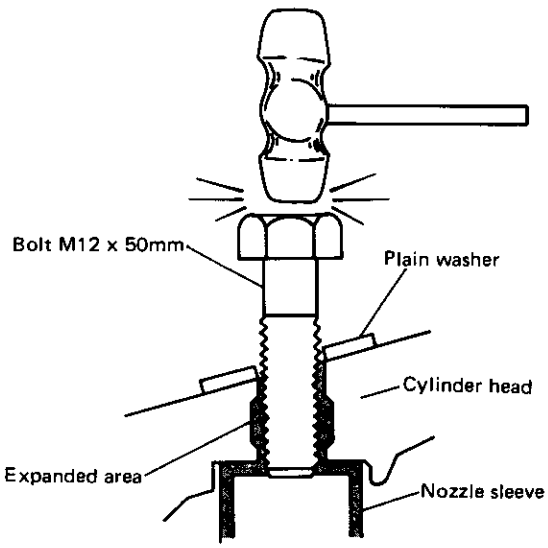
If water leakage is not prevented even after re-expanding the sleeve, replace the nozzle sleeve in the following order:

1. Tap a M12 thread in the expanded area of the sleeve from the combustion surface side.
2. Screw a 50 mm (2 in) M12 bolt through the plain washer into the thread.
3. Tap the bolt head with a hammer from the combustion surface side, and drive the nozzle sleeve out to the opposite side.

Note:

Take care not to damage the nozzle sleeve opening in the head.

Fig. CH-28. Removing the nozzle sleeve



4. Remove the fragments of the sleeve remaining in the expanding area of the cylinder head and the carbon on the seat surface.
5. Thoroughly clean the expanding area, seat surface and O-ring surface of the cylinder head.
6. Install a new O-ring on a new nozzle sleeve and insert the nozzle sleeve into the cylinder head.

Note:

Install the nozzle sleeve so that the combustion surface of the cylinder head and the end of the nozzle sleeve will be parallel (see Fig. CH-29).

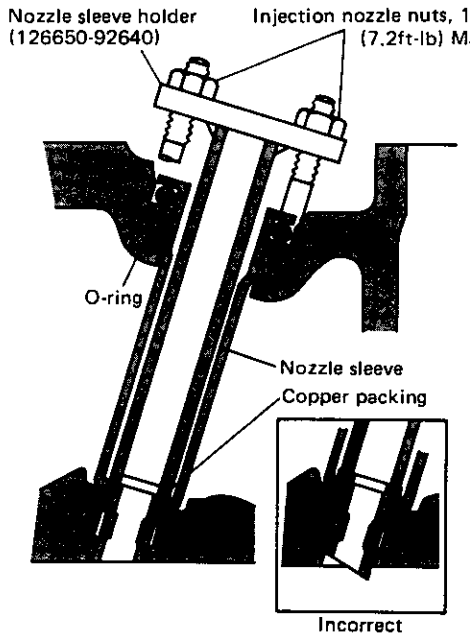
7. Install the copper packing for the injection valve into the nozzle sleeve. Secure the nozzle sleeve by using a nozzle sleeve holder (126650-92640) and injection nozzle attaching nuts.

Torque: 1 kg-m (7.2 ft/lb) or less

Caution:

Use only packing in good condition to prevent the packing surface in the nozzle sleeve from damage, which will cause gas leakage.

Fig. CH-29. Installing the nozzle sleeve holder



8. Place the cylinder head on the working bench with the intake manifold side down.
9. Coat the expander roller, the expanding area of the sleeve and the protective washer (M10 plain washer) at the combstion side with molybdenum disulfide grease.
10. Completely insert the expander roller into the nozzle sleeve through the plain washer.

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Note:

- *When replacing the piston, check the piston pin hole-to-piston pin clearance.*

Piston pin hole inside diameter (Standard):	48.0 – 48.016 mm (1.8898 – 1.89014 in)
Piston pin outside diameter (Standard):	47.989 – 48.0 mm (1.8893 – 1.8898 in)
Piston pin hole-to-pin clearance (Standard):	0 – 0.027 mm (0 – 0011 in)

- Select correct size of piston to obtain specified piston-to-cylinder liner clearance (see page 4-12).

Size Code	Piston O.D.
S	$130\ ^{-0.157\ mm}_{-0.147\ mm}$ $(5.1181\ ^{-0.0062\ in}_{-0.0057\ in})$
MS	$130\ ^{-0.147\ mm}_{-0.142\ mm}$ $(5.1181\ ^{-0.0057\ in}_{-0.0055\ in})$
ML	$130\ ^{-0.142\ mm}_{-0.137\ mm}$ $(5.1181\ ^{-0.0055\ in}_{-0.0053\ in})$
L	$130\ ^{-0.137\ mm}_{-0.127\ mm}$ $(5.1181\ ^{-0.0053\ in}_{-0.0050\ in})$

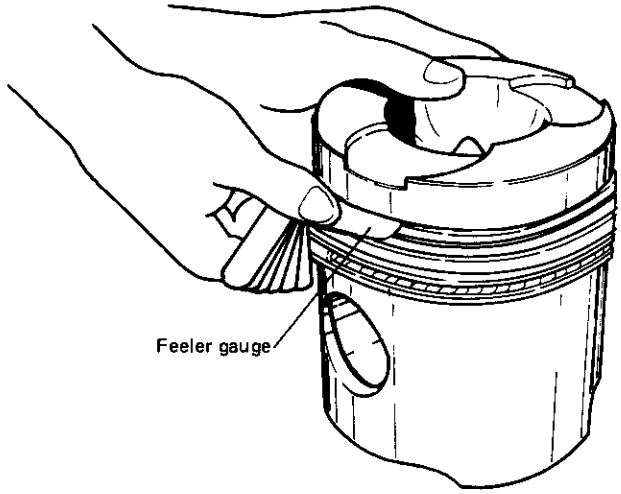
d.) Piston ring groove-to-piston ring clearance

Measure the piston ring-to-ring groove clearance. If it exceeds the service limit, replace the piston ring.

Ring-to-groove clearance

	Service limit
Top	0.15 mm (0.006 in)
2nd	0.15 mm (0.006 in)
3rd	0.15 mm (0.006 in)
Oil	0.15 mm (0.006 in)

Fig. EP-8. Measuring the piston ring-to-ring groove clearance

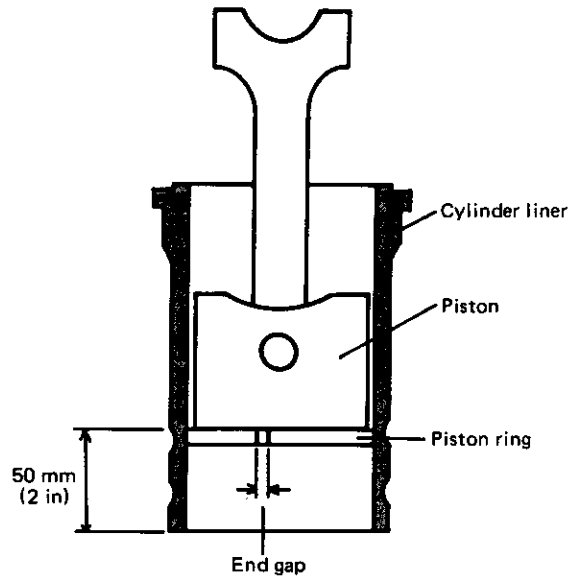


e.) Piston ring end gap

As shown in Fig. EP-9, Insert each piston ring into the liner with the top of the piston. Measure the end gap at 50 mm (2 in) from the bottom of the liner using a feeler gauge.

	Service limit
Top	1.5 mm (0.06 in)
2nd	1.5 mm (0.06 in)
3rd	1.5 mm (0.06 in)
Oil	1.5 mm (0.06 in)

Fig. EP-9. Measuring the piston ring end gap



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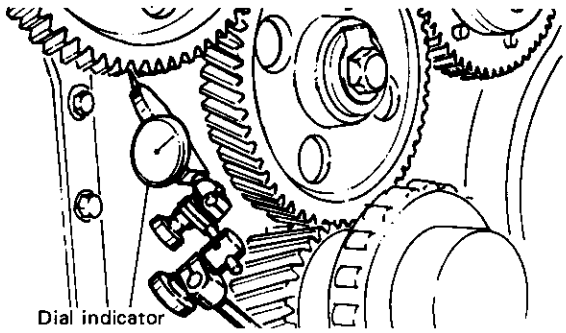
2. Inspect each gear for backlash. If it exceeds the service limit, replace the engaged gears as a set.
Standard: 0.12 – 0.20 mm (0.0047 – 0.0079 in)
Service limit: 0.35 mm (0.0138 in)

Fig. EP-40. Measuring the backlash



Caution:
Unsuitable backlash will cause abnormal noise, excessive wear or damage at the tooth. Moreover, the valve and fuel injection timings will be incorrect and the engine will not run smoothly.

Note:
- *When replacing the oil pump drive gear on the industrial engine, remove the oil pan.*
- *When crankshaft gear replacement is necessary, replace it with the crankshaft assembly.*

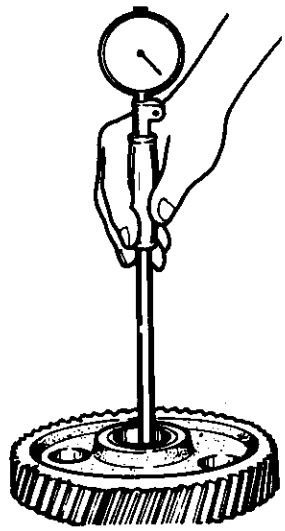
b.) Idle gear oil clearance

Measure the inside diameter of the idle gear bushing and the outside diameter of the base shaft, and calculate the oil clearance. If it exceeds the service limit, replace the idle gear or the base.

Timing idle gear:
- **Shaft O.D.:**
  Standard: 41.95 – 41.97 mm (1.6516 – 1.6524 in)
- **Bushing I.D.:**
  Standard: 42.00 – 42.025 mm (1.6535 – 1.6545 in)
- **Oil clearance:**
  Standard: 0.03 – 0.075 mm (0.0012 – 0.0030 in)
  Service limit: 0.15 mm (0.0059 in)

Oil pump idle gear:
- **Shaft O.D.:**
  Standard: 29.959 – 29.98 mm (1.1795 – 1.1803 in)
- **Bushing I.D.:**
  Standard: 30.00 – 30.021 mm (1.1811 – 1.1819 in)
- **Oil clearance:**
  Standard: 0.020 – 0.0062 mm (0.0008 – 0.0024 in)
  Service limit: 0.15 mm (0.0059 in)

Fig. EP-41. Measuring the idle gear I.D.



c.) Idle gear side clearance

Measure the idle gear side clearance. If it exceeds the service limit, replace the idle gear or base.

Idle gear:
Standard: 0.15 – 0.30 mm (0.0059 – 0.0118 in)
Service limit: 0.4 mm (0.016 in)

Oil pump idle gear:
Standard: 0.10 – 0.20 mm (0.0039 – 0.0079 in)
Service limit: 0.4 mm (0.016 in)

[4-4.] Installation

a.) Industrial engine

1. Coat the shaft on the oil pump idle gear base with engine oil. Install the idle gear on the shaft. Tighten the metal cap to torque 6 kg-m (43 ft-lb).

Note:
- *Do not forget to attach the straight pins.*
- *Securely bend the lock washer against the bolt head.*
- *Check the backlash and side clearance.*
  Backlash: 0.12 – 0.20 mm (0.0047 – 0.0079 in)
  Side clearance: 0.10 – 0.20 mm (0.0039 – 0.0079 in)

2. Install the timing idle gear base with its oil hole facing up.

Note:
Secure the bolts with new lock wires.

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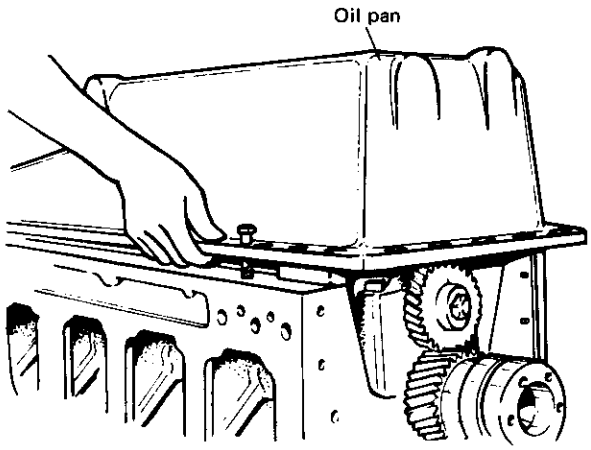
10. Use a new gasket and install the oil pan.

Note:
Tighten after aligning it to the matching surface of the cylinder block (Marine engine only).

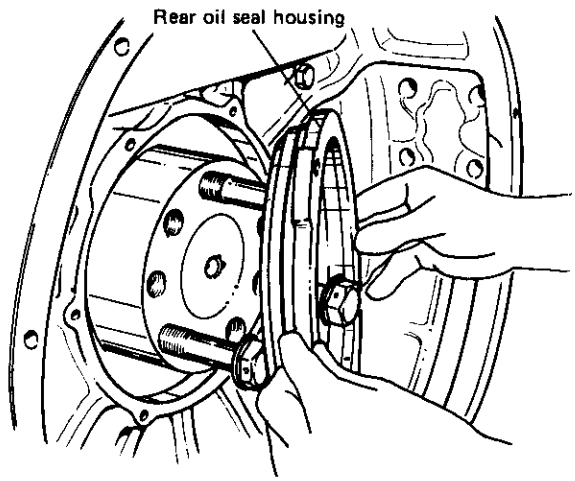
Fig. EP-76. Installing the oil pan



11. Turn the cylinder block to its upright position.
12. Install the rear oil seal housing assembly.

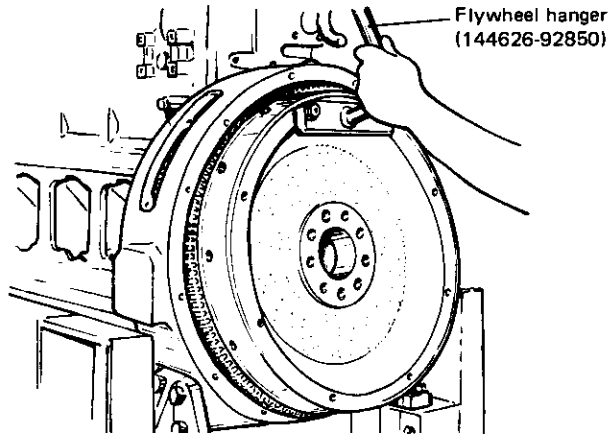
Note:
- *Place the engine oil supply cut-away upward inside the housing.*
- *Fill the oil seal lip gap and crankshaft with lithium grease. Do not use silicon grease.*
- *Be careful not to damage the seal lip.*

Fig. EP-77. Installing the rear oil seal housing assembly



13. Using the Flywheel Hanger (144626-92850), install the flywheel.

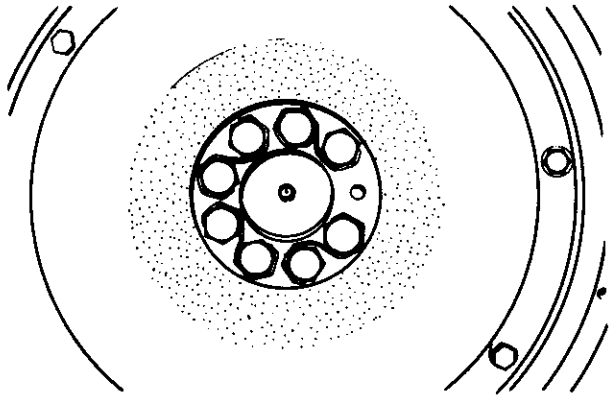
Fig. EP-78. Installing the flywheel



14. Coat the straight pin with engine oil and drive it in the crankshaft hole until it stops.
15. Torque the flywheel attaching bolts to 20 kg-m (145 ft-lb). Secure the bolts with a new lock wire.

Note:
Install the lock wire in the direction which will not loosen the bolts, as shown in Fig. EP-79.

Fig. EP-79. Installing the lock wire



16. Use a new gasket, align the knock hole with the knock pin and install the gear housing flange.

Note:
- *Cut off the projecting portion of the flange gasket.*
- *Coat the three faced matching corner with liquid sealant.*

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[4-4.] Installation

1. Install in the reverse order of removal.

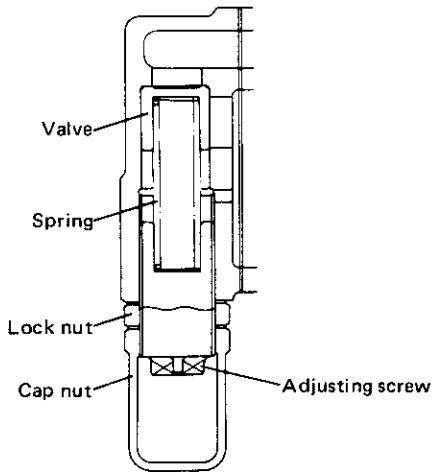
Note:
Apply new gaskets and O-rings. Coat the gasket surface with liquid sealant.
2. Pour in the prescribed amount of lubricating oil.
3. With the industrial engine, pour in cooling water (see page 6-6).
4. Inspect for water leakage and oil leakage.

5. Pressure Regulator Valve

[5-1.] Description

The pressure regulator valve regulates the oil pressure so that lubricating oil is sent to all parts of the lubricating oil circuit at the specified pressure. It is installed on the oil cooler on industrial engines and the lower left side of the cooling water passage chamber cover A on marine engines.

Fig. LS-11. Construction of the pressure regulator valve



[5-2.] Inspection

If the pressure indicated on the pressure gauge on the instrument panel is lower than the specified oil pressure during operation, clearance of lubricated bearings in the lubricating oil circuit may be too large due to wear of the shaft or bearing, or the spring of the pressure regulator valve may have deteriorated. In these cases, adjust the valve to the specified pressure. If the pressure increases but in stages (stick-slip) the pressure regulator may be faulty, inspect and repair it.

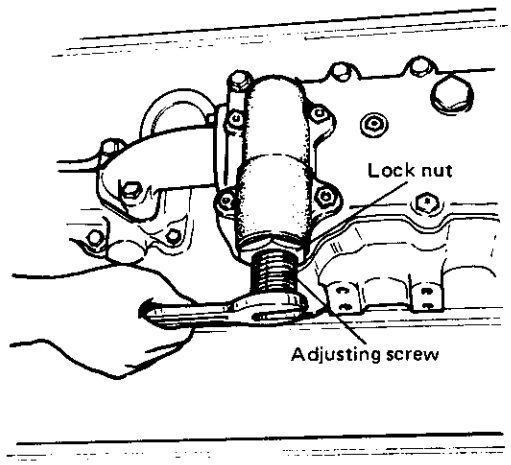
[5-3.] Adjustment

1. Make sure that there is no oil leakage in any part.
2. Remove the cap nut and loosen the lock nut.
3. Operate the engine at 1800 rpm, and set to the specified oil pressure by rotating the adjusting screw while looking at the pressure gauge.

Adjusting the oil pressure

	Industrial engine	Marine engine
Specified oil pressure (at 1800 rpm) kg/cm^2 (psi)	3.5 – 4.5 (50 – 64)	4 – 4.5 (57 – 64)

Fig. LS-12. Adjusting the oil pressure

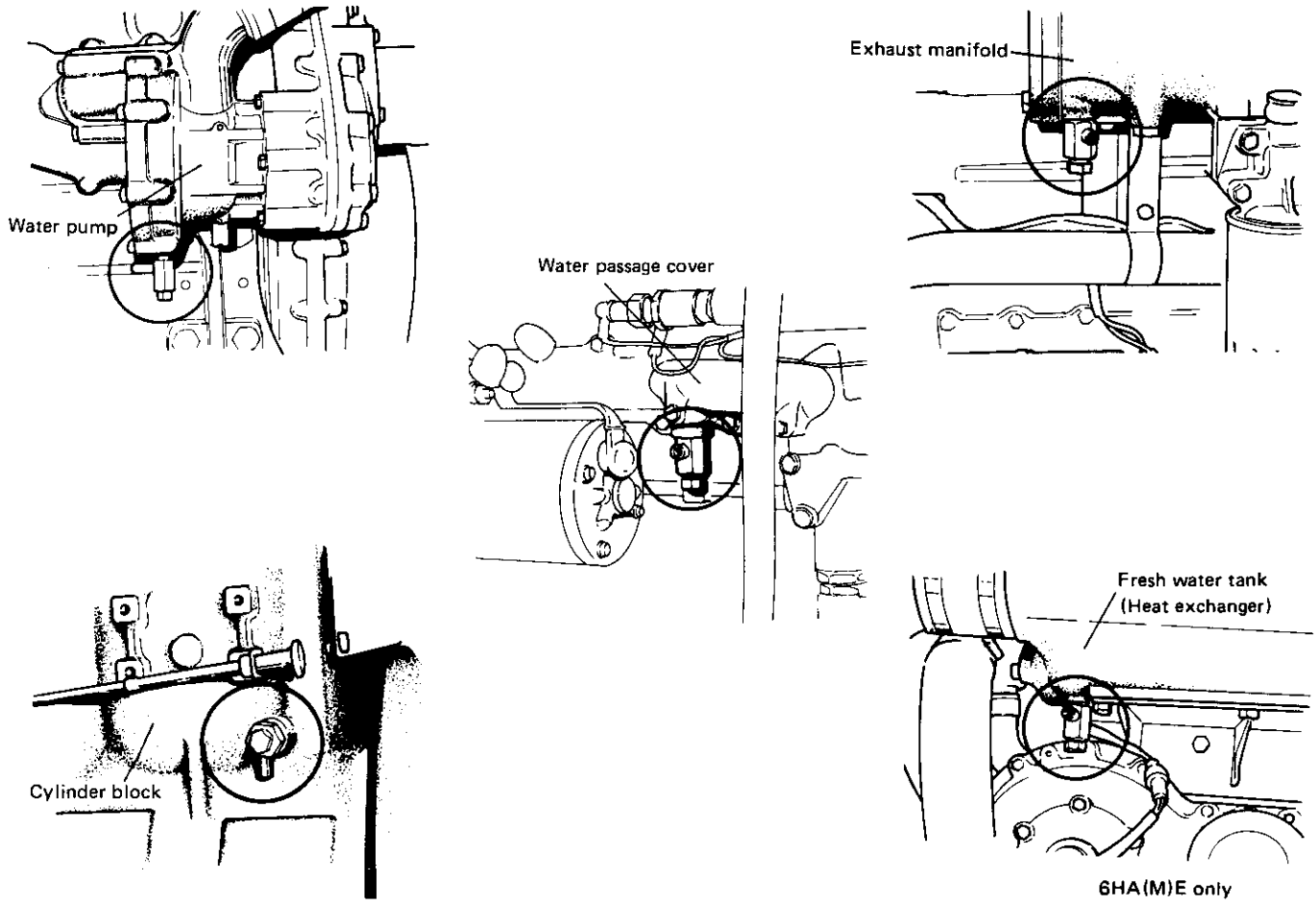


4. After adjusting, securely tighten the lock nut and install the cap nut.

[4-1.] Removal

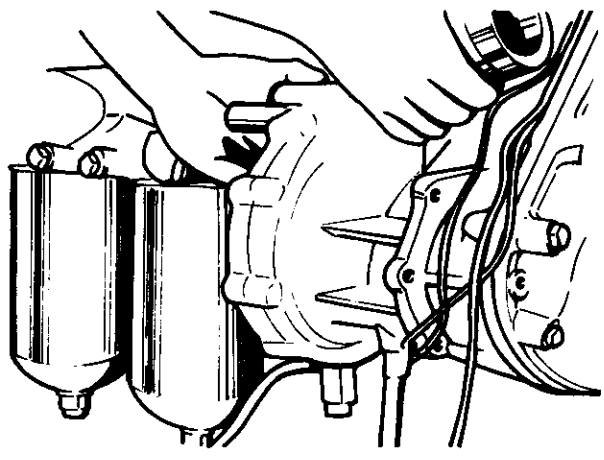
1. Loosen all drain plugs and drain the fresh water.

Fig. CS-14. Position of the drain plugs



2. Disconnect the fresh water pump from the cooling water connecting chamber cover A.
3. Loosen the connection of the water passage to the cooling water inlet.
4. Remove the fresh water pump together with the drive gear.

Fig. CS-15. Removing the fresh water pump



c.)Service data

Item			Service data					
Model			4HAL	6HAL	6HAL-HT	6HA(M)E	6HA(M)-HTE	6HA(M)-DTE
Pump model			PES-A		PES-P			
Control rack(control rod) sliding resistance gr(ib)		At pump stand still	150(0.33)Max.		130(0.29)Max.			
		600 rpm	100(0.22)Max.		50(0.11)Max.			
		1000 rpm	.....		70(0.15)Max.			
Pre-stroke		mm(in)	2.7(0.106)		3.3(0.130)		3.0(0.118)	
Injection interval			90°± 30′	60°± 30′				
Oil-tightness of delivery valve: 100→90kg-cm² (1422→1280 psi)descending time			Limit of use:5 sec Max.		.....			
injection volume	Rack(rod)position	mm(in)	12.7(0.500)		8.7(0.343)	9.0(0.354)	10.3(0.406)	
	Pump rotation speed	rpm	900			1050		
	Injection volume	cm³(cu-in)/min	109±2.2(6.65±0.13)		133.2±2.7 (8.13±0.16)	123±2.5 (7.51±0.15)	170±3.4 (10.37±0.21)	
	Inequality volume	%	±2					
	Rack(rod)position	mm(in)	7.5(0.295)		5.2(0.205)	5.6(0.220)	5.1(0.201)	
	Pump rotation speed	rpm	250			200		
	Injection volume	cm³(cu-in)/min	3.75±0.38(0.229±0.0023)			2.4±0.24 (0.146±0.015)	3.0±0.3 (0.183±0.018)	
	Inequality volume	%	±10					
Injection timing BTDC			26°	Reted rpm		23°	21°	17°
				1500	26°			
				1800	29°			
Feed pump	Lift capacity(at pump speed 1000 stroke/min.		Lifting height: 1 m (3.3 ft)within 40 sec.		Lifting height:0.6 m(2.0 ft)within 40 sec.			
	Delivery capacity(at pump speed 1000 stroke/min.with 1 kg/cm² pressure applied outlet side)		405 cm³(24.7 cu-in)min. within 15 sec.		530 cm³(32.3 cu-in)min. within 15 sec.			
	Air tightness		30 cm³(1.83 cu-in)/min. Max					

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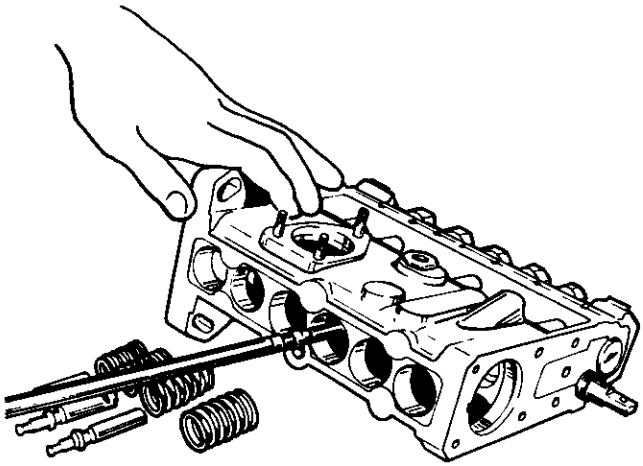
17. Insert a plunger contracting tool through the plug hole and remove the plungers. Remove the plunger springs from the screw plug holes.

⚠ Note:
- *Take care not to damage the plungers.*
- *Mark each plunger to insure original assembly.*
- *Immerse the plungers in clean fuel oil.*

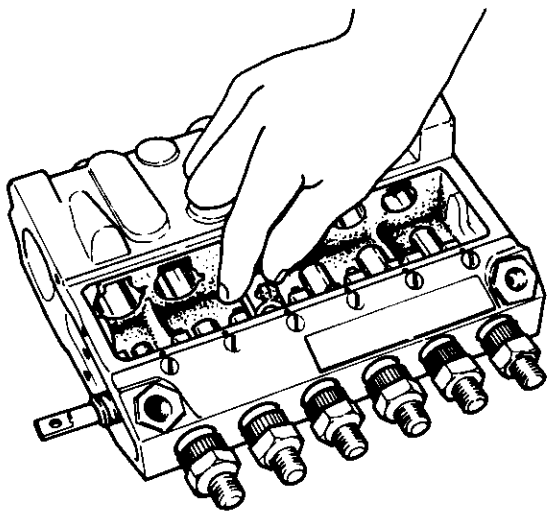
Fig. FS-32. Removing the plungers



18. Remove the upper spring seats and control sleeves together with the control pinion from the cover plate opening.

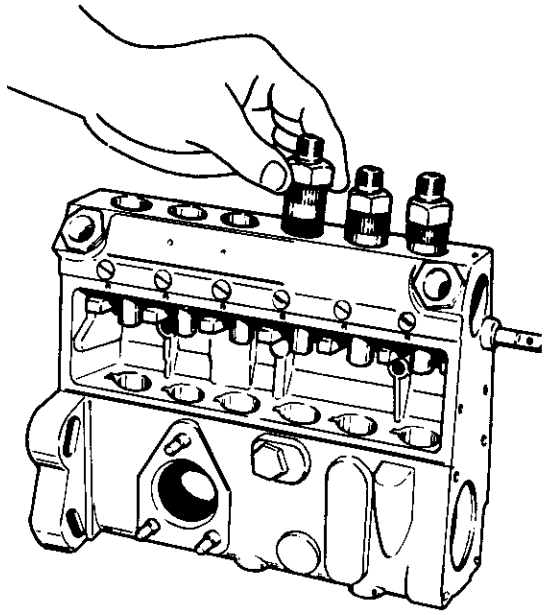
⚠ Note:
Mark each part to insure original assembly.

Fig. FS-33. Removing the control sleeve



19. Place the injection pump upright and remove the valve holder lock plate.
20. Loosen the delivery valve holders with a socket wrench and remove the delivery valve holders together with the delivery valve springs.

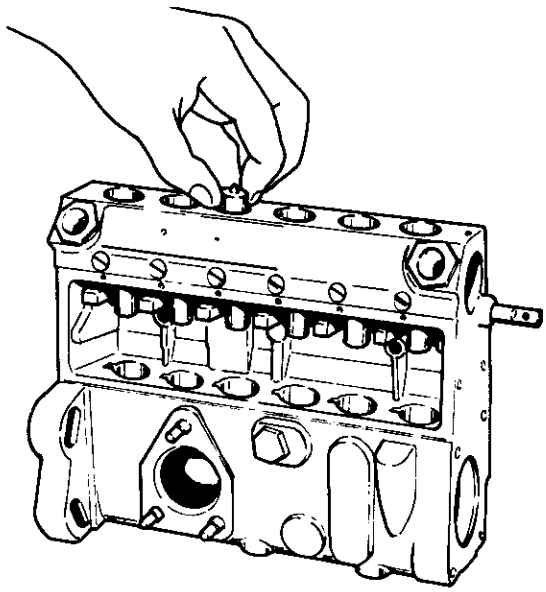
Fig. FS-34. Removing the delivery valve holders



21. Remove the delivery valves and delivery valve seats.

⚠ Note:
Always immerse the delivery valve assembly together with the plungers in clean fuel.

Fig. FS-35. Removing the delivery valve



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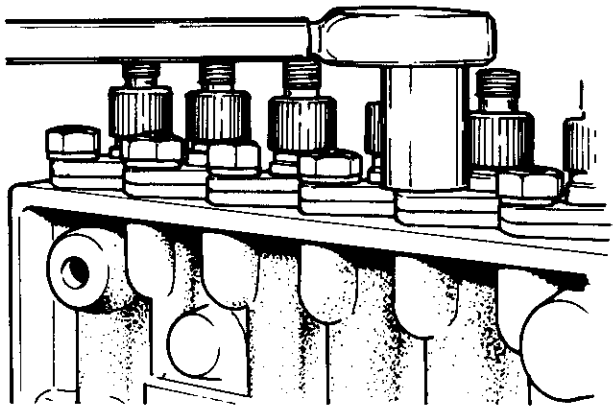
6. When tightening the flange sleeve nut, align the scribe lines on the flange sleeve and pump housing made during disassembly. Then equally tighten them alternately with a torque wrench.
   Torque: 4.3 kg-m (31 ft-lb)

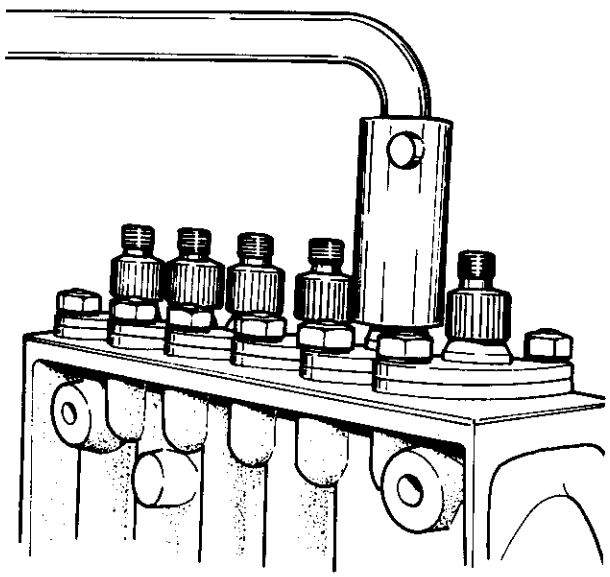
Fig. FS-68. Tightening the flange sleeve



7. Tighten the delivery valve holder to the specified torque with a torque wrench or a socket wrench.
   Torque: 12 → 0 → 12 → 0 → 11 kg-m
   (87 → 0 → 87 → 0 → 80 ft-lb)

⚠ Caution:
If the tightening torque is less than the specified torque, it will cause oil leakage or damage of the related parts. If it is too large, it will cause malfunction of the plunger or damage the related parts.

Fig. FS-69. Tightening the delivery valve holder

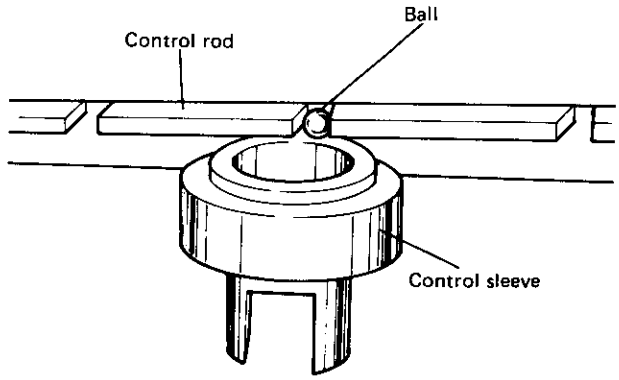


8. Insert the control rod from the driving side. After inserting it assemble in the order: bushing, pin and screw.
9. Assemble the control sleeve from the cam chamber side, and completely place the ball on the sleeve in the groove in the control rod.

⚠ Note:
Assembly is made easier if the groove in the control rod and the tappet guide groove in the pump housing are aligned.

⚠ Caution:
If the ball on the control sleeve is not in the control rod groove, the ball will be deflected when assembling related parts, causing improper sliding of the control rod after assembly is completed.

Fig. FS-70. Assembling the control rod and sleeve



10. After installing the control sleeve, assemble in the order: upper spring seat, plunger spring and plunger.

⚠ Note:
Install the plunger so that the mark on the flange is pointing to the front of the pump.

11. While compressing the tappet together with the plunger spring, insert the flange on the plunger into the guide groove in the control sleeve with a tappet mounting device.

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[4-4.] Inspection

a.) Air leak test

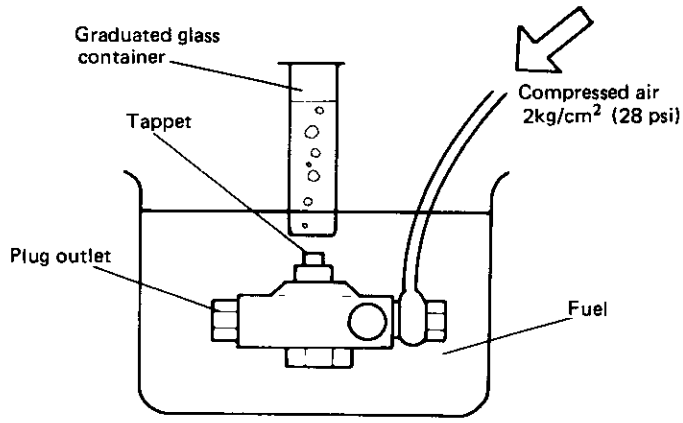
Inspect the air-tightness of each pipe and packing etc. Especially check the inlet side because air is likely to enter due to the negative pressure of the suction action during piston movement.

b.) Push rod seal leakage inspection

Plug the outlet, apply compressed air of 2 kg/cm² (28 psi) through the inlet port, place it in an fuel tank and inspect for leakage from the push rod seal. If there are air bubbles over 30 cm³ (1.83 cu-in) per minute, replace the oil seal, push rod or the feed pump housing.

Leakage volume (new part): 30 cm³ (1.83 cu-in)/min. max.

Fig. FS-90. Inspecting leakage from the push rod seal



[4-5.] Test

a.) Lift capacity test

Under the following condition, check the ability to suck up fuel by using the priming pump.

Lift capacity

	for model PES-A	for model PES-P
Pump speed	100 strokes/min.	60 – 100 strokes/min.
Pipe inside diameter x length	8 x 200 mm (0.315 x 7.9 in)	
Lifting height	1 m (3.3 ft)	0.6 m (2.0 ft)
Required time	within 40 sec.	

b.) Output capacity test (Model PES-A)

Run the pump at 1000 rpm and measure the output capacity while applying pressure of 1 kg/cm² to the outlet side of the pump.

	for model PES-A	for model PES-P
Output capacity	405 cm³ (24.7 cu-in) min.	530 cm³ (32.3 cu-in) min.
Required time	within 15 sec.	

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8. Intake & Exhaust System

1. Service Information

[1-1.] Tools and Materials

3/8" socket wrench
5/8" socket wrench
Pliers 49160-90100
Pliers 49160-90200
Pliers 49160-90300
Feeler gauge
Micrometer
Dial indicator
Blast equipment

[1-2.] Specifications

a.) Torque value

Item	Torque values	
	kg-m	ft-lb
Compressor lock nut	2.8	20
V-clamp lock nut	1.1	8

To tighten the bolts and nuts other than those mentioned above, follow the standard tightening torque (page 1-17).

b.) Service data

Item		Standard mm (in)
Turbocharger	Bearing housing inside diameter	22.27 (0.8768) Max.
	Shaft journal outside diameter	14.25 (0.5610) Min.
	Shaft runout	0.015 (0.0006) Max.
	Insert inside diameter (Piston ring end gap)	0.026 – 0.102 (0.0010 – 0.0040)
	Turbine wheel-to-turbine housing clearance (at assembly)	0.44 – 0.85 (0.0173 – 0.0335)
	Shaft end play (at assembly)	0.08 – 0.152 (0.0031 – 0.0060)

2. Intake System

[2-1.] Removal

a.) 4HAL and 6HAL

1. Remove the intake connecting rubber hose (air cleaner-to-intake manifold).
2. Remove the air cleaner bands and remove the air cleaner.
3. Remove the fuel injection pipes together with the stay.
4. Remove the intake manifold.

b.) 6HAL-T and 6HA(M)E

1. On 6HAL-T model, remove air duct C.
2. Remove the fuel injection pipes together with the stay.
3. Remove the intake manifold.

c.) 6HA(M)-HTE

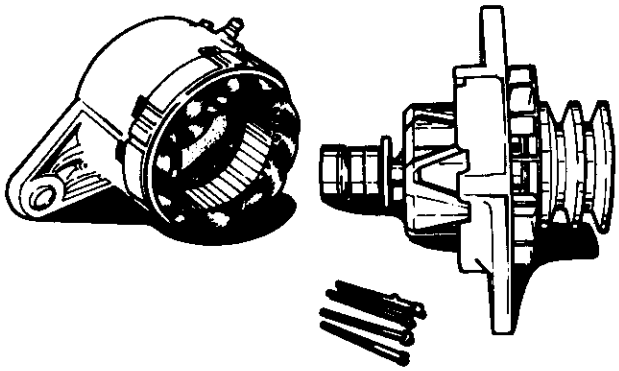
1. Close the kingston cock. Drain the sea water.
2. Remove the air duct B.
3. Remove the cooling water connecting pipes.
4. Remove the intercooler support and remove the intercooler.
5. Remove the injection pipe stay and remove the injection pipes.
6. Remove the intake manifold.

Sec. 9. ELECTRICAL SYSTEM (ES)

Contents of this section

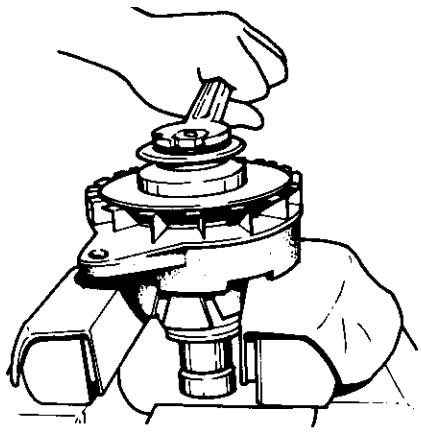
7. Remove the 3 through bolts securing the rear and front covers. When separating the rear and front, place the pulley downward and lift up the rear cover.
   Remove the stator and rear cover together.

Fig. ES-16. The front and rear when separated



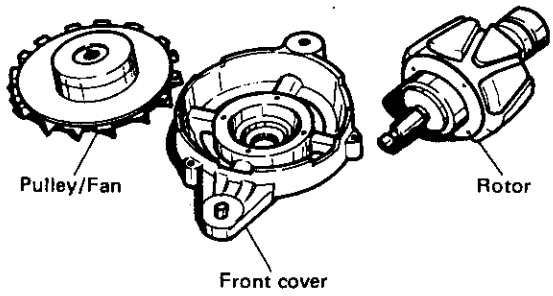
8. Hold the rotor with a vise on the copper plates and remove the pulley nut.

Fig. ES-17. Removing the pulley nut



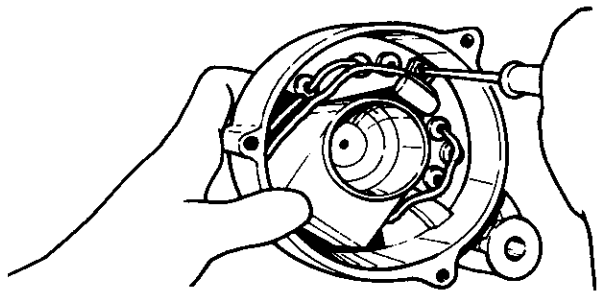
9. Remove the V-pulley/fan with a puller. Remove the semi-circular key.
10. Remove the bearing protector tightening bolts and separate the front cover and rotor.

Fig. ES-18. Separating the front cover and rotor



11. Remove the solder at the middle section of the lead wire coming from the stator coil and diode, and separate the stator coil from the rear cover.

Fig. ES-19. Separating the rear cover and stator



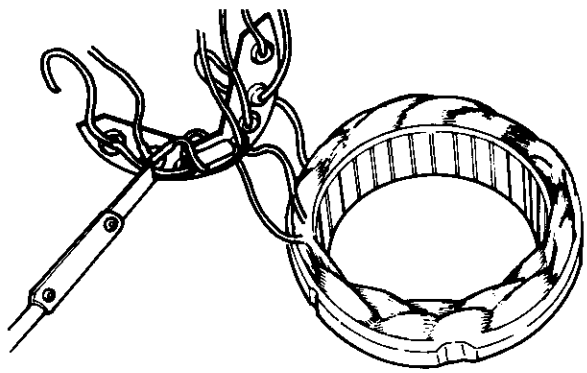
12. Remove the nuts at each terminal and then remove each bushing.

Note:
Mark the assembling order of bushings on each terminal to insure original assembly.

13. Remove the rear cover and diode holder attaching screw (also attaching the condenser holder).
14. Remove the diode holder from the rear cover.
15. Remove the solder of the lead cable and diode.

Note:
When melting the solder grip the diode side with long nosed pliers and be careful that heat is not transmitted directly to the diode.

Fig. ES-20. Removing the solder at the diode



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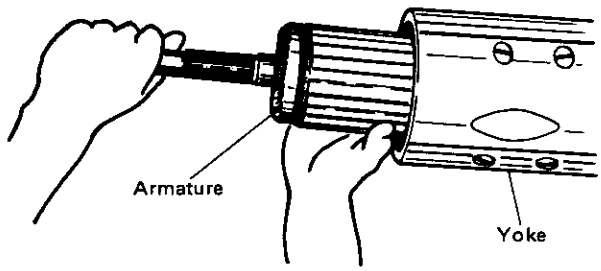
9. Remove the armature from the yoke.

Fig. ES-46. Removing the armature



10. Remove the rear bracket assembly.

Note:
Do not lose the shaft bearing thrust washer at the rear bracket interior.

[2-4.] Inspection

a.) Commutator

If the commutator surface is corroded or rough, repair with No. 500 – 600 sandpaper. If the roughness is extreme or if the surface runout is beyond the service limit, replace the commutator.

Commutator runout
Standard: 0.03 mm (0.0012) max.
Service limit: 0.2 mm (0.008 in)

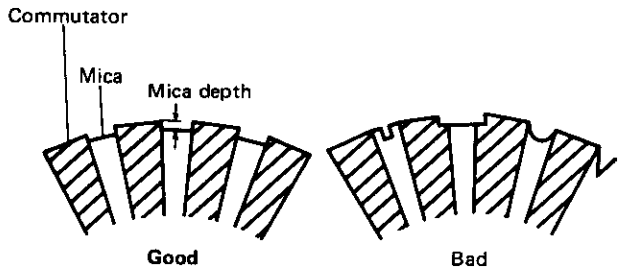
Commutator outside diameter
Standard: 53.5 mm (2.106 in)
Service limit: 50.5 mm (1.988 in)

b.) Commutator mica depth

Inspect the mica depth, and if it is shallow, repair it by scraping with a metal saw blade.

Mica depth
Standard: 0.5 – 0.8 mm (0.02 – 0.03 in)
Allowable: 0.2 mm (0.008 in)

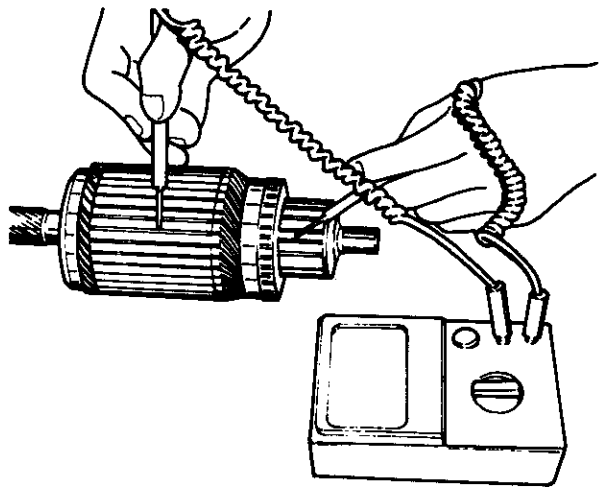
Fig. ES-47. Mica depth



c.) Armature coil insulation test

It is in good condition if there is no continuity between the commutator and shaft or armature coil. If there is continuity, there is a grounded circuit, so replace the armature.

Fig. ES-48. Armature insulation test



d.) Armature shaft and bearing inspection

Measure the outside diameter of the armature shaft and if it is heavily worn, replace it. Measure the inside diameter of the shaft bearing and if it is worn beyond the service limit, replace it.

Armature shaft outside diameter
[Front]
Standard: 18.927 – 18.960 mm (0.7451 – 0.7464 in)
[Center]
Standard: 22.427 – 22.460 mm (0.8829 – 0.8842 in)
[Rear]
Standard: 17.941 – 17.968 mm (0.7064 – 0.7074 in)
[Pinion]
Standard: 18.927 – 18.960 mm (0.7451 – 0.7464 in)

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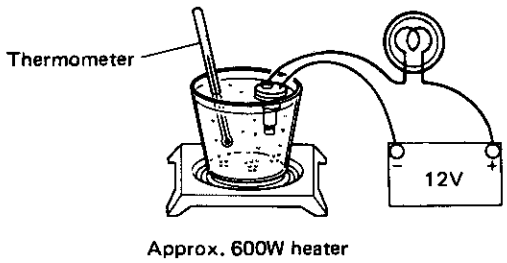
Fig. ES-82. Inspecting the thermo switch



2. Place the thermo switch in a container with anti-freezing solution or oil. Then while measuring the temperature, increase the temperature by 1°C (1.8°F) per minute until it reaches about 95°C (203°F).
   If the operating temperature of the switch differs greatly from the specified operating temperature, replace the switch.

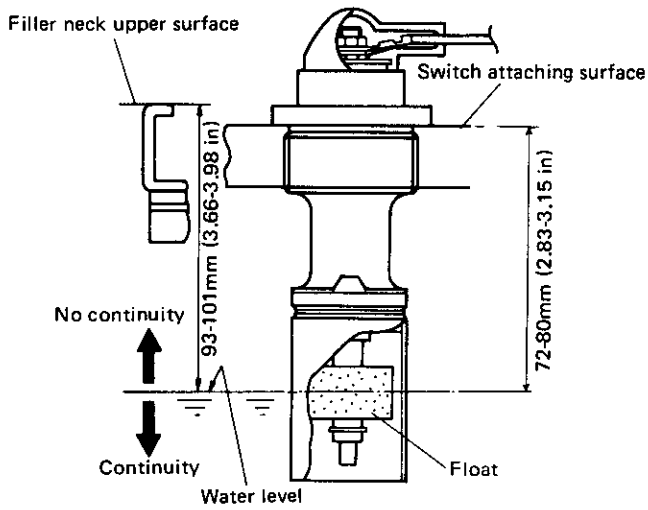
Operating temperature	ON	103 – 109°C (217 – 228°F)
	OFF	100 – 103°C (212 – 217°F)

b.) Water level switch

1. Connect the tester to the lead wire and ground with the water level switch attached to the fresh water tank (there is continuity in this condition).
2. Pour water into the fresh water tank and stop when the continuity is OFF. Then measure the water level from the filler upper surface or from the water level switch attaching surface. Replace the switch if the measured value differs greatly from the specified level.

Operating water level	From filler upper surface	93 – 101 mm (3.66 – 3.98 in)
	From switch attaching surface	72 – 80 mm (2.83 – 3.15 in)

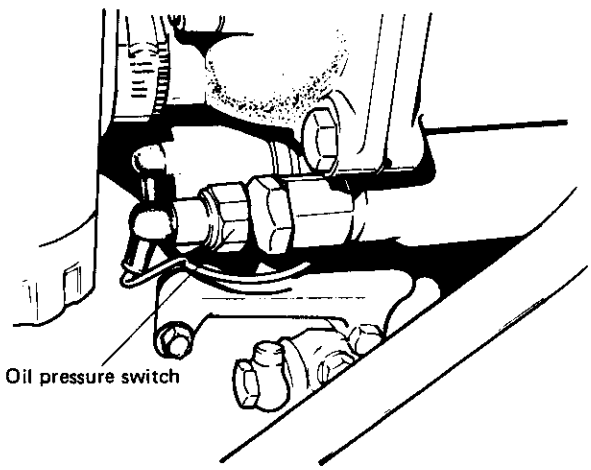
Fig. ES-83. Water level switch



c.) Oil pressure switch

Turn the buzzer switch and starter switch to "ON". The contact is good if the pilot lamp illuminates and the buzzer sounds for about 3 seconds and then goes off.

Fig. ES-84. Oil pressure switch



Inspect the lamp and pressure switch if the lamp does not illuminate when the starter and buzzer switches are turned ON.

Operating oil pressure: 0.8 – 1.2 kg/cm² (11 – 17 psi)

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11. Engine Installation

1. Industrial Engine

[1-1.] Output Correction

The indicated engine output is the output obtained under the following conditions:

Engine intake temperature: 5° – 30°C (41° – 86°F)
Atmospheric pressure: 760 mmHg (30 in Hg), altitude 150 m (492 ft)
Relative humidity: 65% or less

When operating the engine in an environment with conditions other than the standard condition, perform the output correction as shown below:

a.) Engine intake temperature correction

To 30°C: continous rated output
To 40°C: 96% of the continuous rated output
To 50°C: 92% of the continuous rated output

b.) Altitude correction

Correct 1% for every 100 m (328 ft) above sea level.

c.) Humidity correction

Table for revising the humidity is indicated below.

Note:

When revising the humidity, refer to the atmospheric temperature instead of the engine intake temperature.

Relative temperature and humidity correction (%)

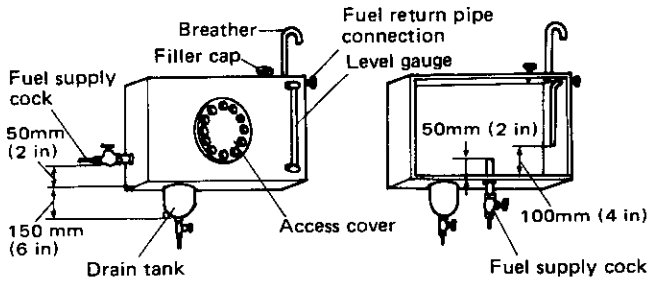
Atmospheric temperature		Relative humidity (%)									
°C	°F	10	20	30	40	50	60	70	80	90	100
30	86	.....	.....	.....	.....	0.1	0.6	1.2	1.7	2.2	2.7
32	90	.....	.....	.....	.....	0.4	1.0	1.1	2.1	2.7	3.3
34	93	.....	.....	.....	0.1	0.8	1.4	2.1	2.7	3.3	4.0
36	97	.....	.....	.....	0.4	1.2	1.9	2.6	3.3	4.0	4.7
38	100	.....	.....	.....	0.8	1.6	2.4	3.1	3.9	4.7	5.5
40	104	.....	.....	0.2	1.1	2.0	2.9	3.8	4.7	5.5	6.4
42	108	.....	.....	0.5	1.5	2.5	3.5	4.5	5.4	6.4	7.4
44	111	.....	.....	0.9	2.0	3.0	4.1	5.2	6.3	7.4	8.5
46	115	.....	.....	1.2	2.4	3.6	4.8	6.0	7.3	8.5	9.7
48	118	.....	0.3	1.6	2.9	4.3	5.6	7.0	8.3	9.6	11.0
50	122	.....	0.6	2.0	3.5	5.0	6.5	7.9	9.4	10.9	12.4
52	124	.....	0.9	2.5	4.1	5.8	7.4	9.0	10.6	12.3	13.9

4. Follow procedures 2 – 6 on the final centering of "When the Same Base is Used for the Engine and Equipment" (see page 11-9).

[1-12.] Fuel System

1. Since the fuel tank affects the combustion of the engine, wear of the fuel system parts, etc., use one which meets the following requirements:
- Provide a cover for interior inspection and cleaning, a drain cock, breather pipe, fuel filler opening and cap at the top of the tank, a fuel level gauge and a drain tank.
- The position of the fuel feed pipe opening must be 50 mm (2 in) above the bottom of the tank. Also attach a fuel cock.
- Install the fuel return pipe connecting opening.
- There should be no fuel leakage. Also, the interior should be treated with anti-rust agents.

Fig. EI-19. Representative example of the fuel tank



2. The feed pipe extracting opening of the fuel tank must not be 1 m (3.28 ft) lower than the fuel feed pump. Also, install the tank as close as possible to the engine.

Fig. EI-20. Fuel line connection

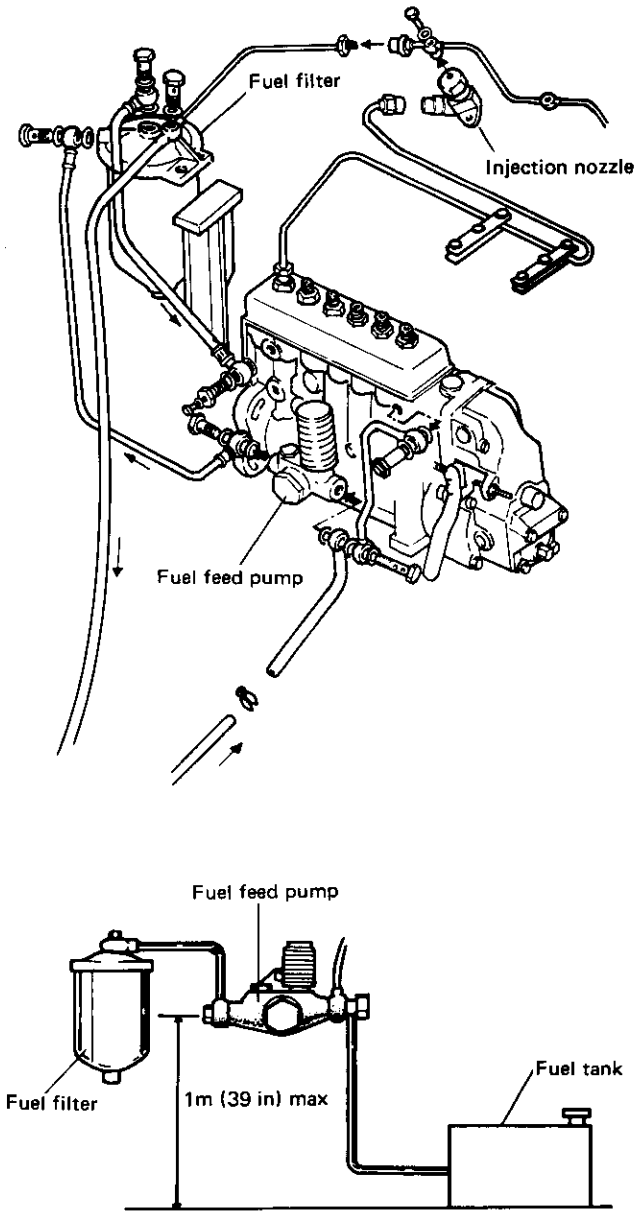
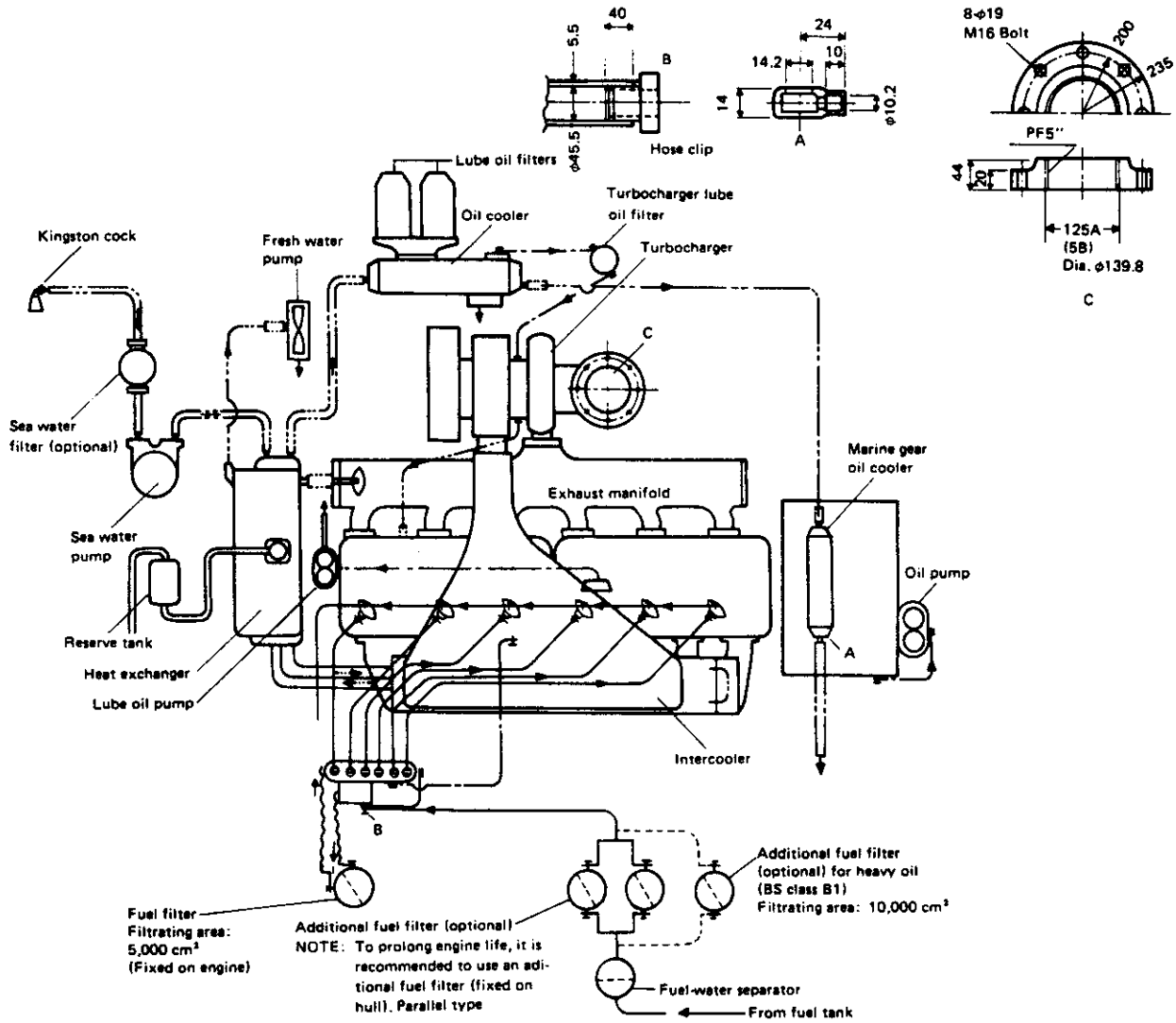


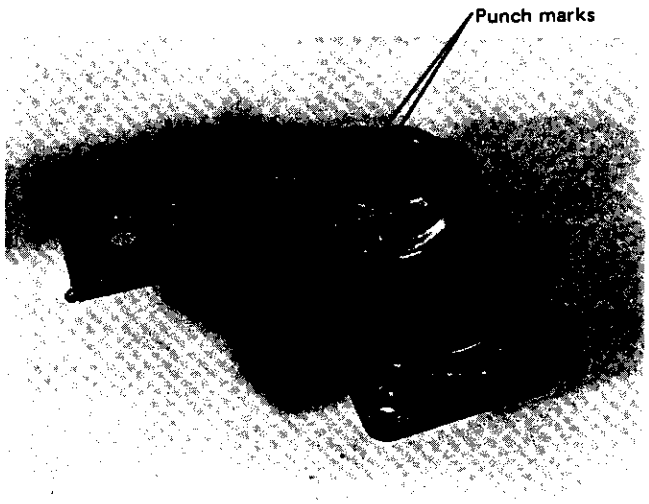
Fig. EI-45. Piping diagram (6HA(M)-HTE and 6HA(M)-DTE)



Sec. 13. MARINE GEAR (MG)

Contents of this section

Fig. MG-17. Aligning marks of the valve lever and stem



[2-4.] Inspection

1. Check the sliding surfaces of the pump gears, case, base and cover for wear, scratches or scoring.
2. Check the regulating valve pistons, orifice piston and selector valve stem for wear, scratches or scoring.
3. Check the valve springs for damage.
   Measure the clutch oil regulating valve spring free length.

MGN46B-1, MGN46BL-8, MGN47BL-8

Standard:	Inner:	44.0 mm (1.73 in)
	Outer:	70.0 mm (2.76 in)

MGN56B-8, MGN56BL-8, MGN57BL-8

Standard:	Inner:	45.5 mm (1.79 in)
	Outer:	61.0 mm (2.40 in)

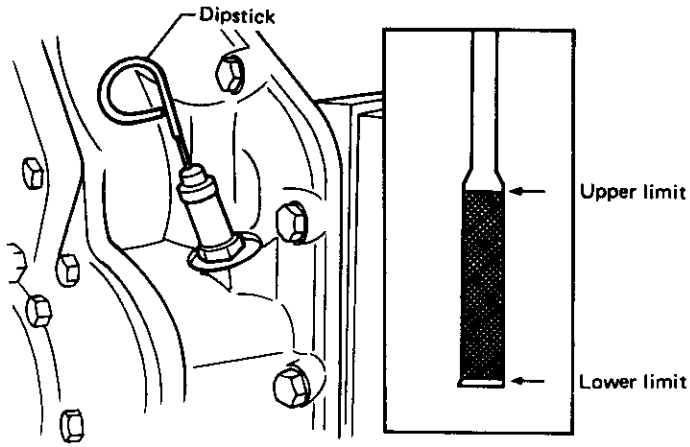
[2-5.] Assembly

Assemble the gear pump and selector valve in the reverse order of disassembly. Note the followings.
1. Clean all parts in cleaning solvent.
2. Blow out all passages of the selector valve body.
3. Coat all parts with clean engine oil.
4. When installing the selector valve lever on the stem, align the punch marks (Fig. MG-17).

[2-6.] Installation

1. Install the gear pump and selector valve on the end cover and tighten the bolts to 4.3 kg-m (31 lb-ft).
2. Install the oil pipes and joint bolts.
3. After installation, inspect the oil level with the dipstick. If the oil level is lower than the lower limit or is nearing it, remove the filler cap and add the recommended engine oil up to the upper limit. Run the engine for a few minites at idle and recheck the oil level.

Fig. MG-18. Checking the oil level

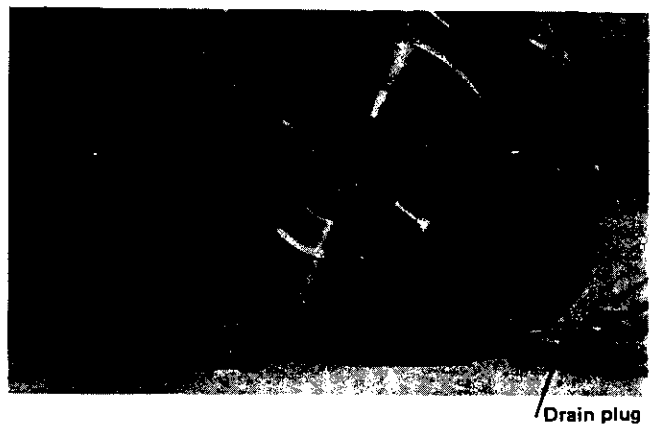


3. Input Shaft/Gear Shaft

[3-1.] Removal

1. Remove the drain plug and drain the oil thoroughly.
2. Remove the gear pump and selector valve (see page 13-8).
   Remove the oil strainer (see page 13-17).

Fig. MG-19. Drain plug



3. Remove the shims and oil pump drive block.

⚠ Note:
The drive block is installed on the rear end of the input shaft with the knock pin on MGN56B-8, MGN56BL-8 and MGN57BL-8 models.

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