

0000A05022-9206

SERVICE MANUAL

MARINE DIESEL ENGINE

6CX-ETYE

2000. 3. 10

FOREWORD

This service manual outlines procedures for servicing and maintaining Yanmar 6CX-ETYE engines to obtain maximum life and performance. It explains about the structure, performance, dis- and re-assembly procedures, important inspection points, servicing instructions and the wear limit of parts. For a full understanding of this manual, also refer to the Operation Manual and Parts Catalog. Besides reference use at your service shop, this manual can also be used as a text for your service engineers. You should understand the contents of this manual fully to offer accurate and efficient service to your customers.

For accurate and efficient work, the following preparations are necessary:

1. Check the service date of your customer

- ① When was the last service?
- ② How many months or hours has the engine been used since the last service?
- ③ What was the trouble and what parts were replaced in the last service?
- ④ What parts must be replaced in the present service?

2. Preparation of Parts

Check the inventory of parts that are necessary for servicing.

3. Preparation of Report Forms

Inspection and service check sheets, parts measurement record form, operation test record form.

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1. Specifications

1-1. Major Specification

(Without marine gear)

ENGINE MODEL		UNIT	6CX-ETYE				
Type			Vertical, water-cooling, 4-cycle diesel engine				
Combustion system			Direct injection				
Aspiration			Turbocharger with air cooler				
No. of cyl. - bore × Stroke		mm	6 - 110 × 125				
Displacement		ℓ	7.127				
Continuous rating	Output/Crankshaft speed	HP/rpm	320/2600				
	Brake mean effective pressure	kgf/cm ²	15.54				
	Piston speed	m/sec	10.83				
Max. rating	Specifications		Flywheel end				
	Output/Crankshaft speed	HP/rpm	350/2700				
	Brake mean effective pressure	kgf/cm ²	16.37				
	Piston speed	m/sec	11.25				
Non-load rotation speed (Max./Min)		rpm	3000 ± 25/450 ₃ ⁵ 9				
Starting system			Electric starting, 24V-4kW				
Firing order			1-4-2-6-3-5-1				
Direction of rotation (viewed from stem)	Crankshaft		Counter-clockwise				
	Propeller shaft		BI-rotation				
Lub. oil capacity	Max.	ℓ	33				
	Effect	ℓ	19				
Marine gear	Model		YX-71-1				
	Type		Hydraulic wet multi-disk type				
	Reduction ratio(forward)		2.07	2.58	2.91		
	Propeller shaft speed(at cont. rating)	rpm	1256	1008	893		
	Direction of rotation(propeller shaft)		Clockwise or counterclockwise viewed from stem				
	Dry weight	kg	212				
	Lubricating oil capacity	Max.	ℓ	6			
		Effective	ℓ	0.5			
Hydraulic oil pressure	kgf/cm ²	22 ± 5					
Fuel system	Fuel injection pump		In-line type				
	Injection timing		b.T.D.C 12 ± 1				
	Type of injection nozzle degree		Hole type 5 - φ 0.33 × 150°				
	Injection pressure	kgf/cm ²	240 ± 5				
	Applicable fuel		Diesel oil or light oil (Cetane value ≥ 45)				
	Fuel filter		Paper element				
Engine lub. oil system	Lubrication		Forced lubrication by geared pump				
	Lub. oil discharge volume	ℓ/hr./rpm	≥ 6720/2600				
	Lub. oil pressure	kgf/cm ²	5 ± 0.5				
	Lub. oil		API Service grade CD				
	Lub. oil filter		(Suction side)	Perforated steel plate		(Discharge side) Paper element	
Cooling water system	Sea water pump		Rubber impeller type, gear driving type				
	Freshwater pump		Center type, V-belt driving type				
	Cooling		Fresh water cooling				
	Pump discharge volume	ℓ/hr./rpm	Seawater : ≥ 9820/2600 Fresh water : ≥ 13000/2600				
	Fresh water capacity inside engine	ℓ	35				
	Fresh water capacity in sub-tank	ℓ	1.1				
Turbocharger	Type		Garret T51				
	Cooling		Air cooling				
	Lubrication		Common with engine				
Air cooler	Type and capacity		Fin tube type 6.5m ²				
	Cooling		Seawater cooling				
Engine dimension: Overall length × overall width × overall height		mm	1586 × 896 × 964				
Piston stroke height(from installation floor)			764				
Engine dry weight(inc. clutch)		kg	1050				

△ NOTE Max. rating: Continuous operation hours at max. below 0.5 hours.


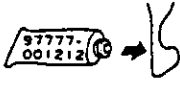





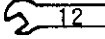
1-2. Marine Gear

Reduction and reversing gear	Model		YX-71-1		
	Type		Constant mesh gear with multiple disc clutch		
	Reduction ratio(Ahead/Astern)		2.07/2.07	2.58/2.58	2.91/2.91
	Propeller speed(Ahead)(at continuous rating)	rpm	1256/1256	1008/1008	—
Direction of rotation	Crankshaft		Counterclockwise viewed from stern		
	Propeller shaft		Changeable(Clockwise/conter-clockwise)		
Hydraulic oil pressure			22kg/cm ² ±0.5/2700rpm		
Lube oil pressure			2.5kg/cm ² ±0.5/2700rpm		
API Service grade			CD		
Dry weight		kg	212		

2. Disassembly and Reassembly

2-1. Preparations before Disassembly and Reassembly

2-1-1 Visual Mark List for Disassembly and Reassembly

Visual Mark		Visual Mark	
	See		※1 Apply liquid packing
	Caution		Safety
	Measure		Clean
	Oil supply		※2 Use torque wrench

※1 THREE BOND 3B-388-055

※2 The figure shows the widths across flat of the hexagonal part.

2-1-2 Disassembly

- (1) Prepare the disassembly tools, measuring devices and record forms.
- (2) Prepare the cleaning machine and cleaning cans.
- (3) Prepare a place for putting parts and parts containers.
- (4) Extract cooling water and lube oil.
- (5) Put the disassembled parts in order.
- (6) Return bolts and nuts to their original positions temporarily to avoid confusion with different bolt and nut types.
- (7) Locate the cause of trouble accurately before disassembly, and do not remove or disassemble unnecessary parts.

2-1-3 Reassembly

- (1) Clean and inspect the disassembled parts completely.
- (2) Apply clean engine oil to the sliding and rotational parts before installation.
- (3) Replace all gaskets and O-rings.
- (4) Apply liquid packing to the necessary parts to prevent water or oil leakage.
- (5) Check and ensure the correct oil and thrust clearance during reassembly.
- (6) Install the parts according to the alignment marks when they are provided. Take care of the combination of the parts with selective engagement.
- (7) Do not mix up bolts, nuts and washers. Tighten the major bolts and nuts to the specified tightening torque. Take special care when tightening aluminum alloy parts.
- (8) Apply engine oil to the threads and seat of the major bolts and tighten them to the specified tightening torque.

2-2. Disassembly and Reassembly Tools

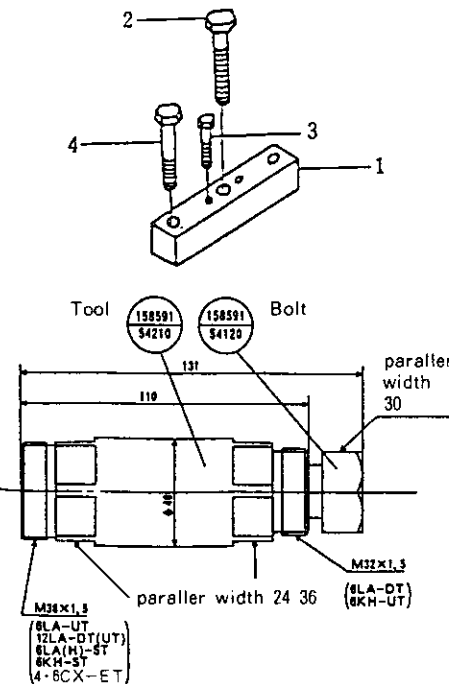
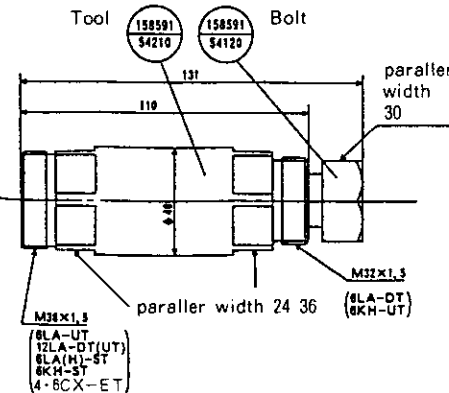
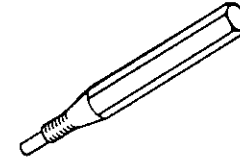
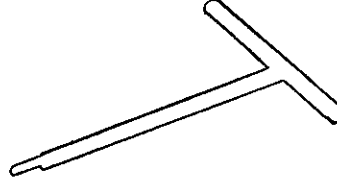
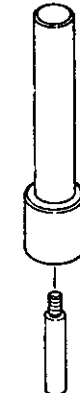
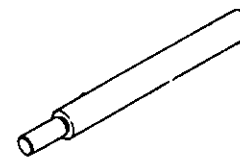
Standard tools

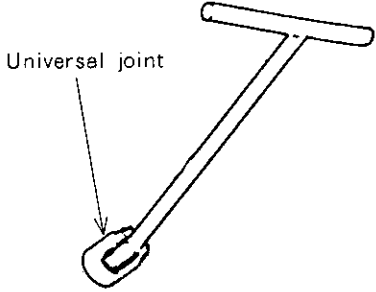
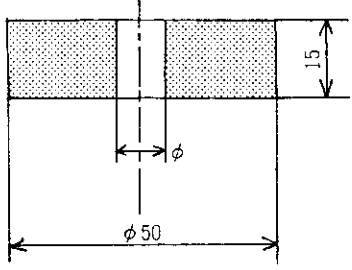

The following are the standard disassembly and reassembly tools:

Name of tool	Size	Shape
Double-headed wrench	8 × 10, 12 × 14, 13 × 17 19 × 22, 24 × 27	(for removing fuel valve)
Wrench	7, 26	
Monkey wrench	200	
Screw driver	⊕, ⊖ changeable	
Hexagon bar wrench	(for clutch emergency bolt)	
Double-head wrench	17 × 19	
Pliers		
Box wrench	19 × 12 (for cyl. head) 13 × 17 (for fuel oil pump)	
Extractor	(for fuel valve adiabatic packing) 127610-92910	
Extractor	(for removing fuel valve) 127616-92500	
Clearance gauge	(for adjusting intake/exhaust valve clearance)	
Hammar		
Filter wrench	(for removing filters) 127610-92750	(Filter wrench)
Oiler		
Turning handle		

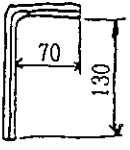
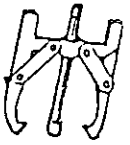
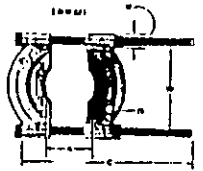
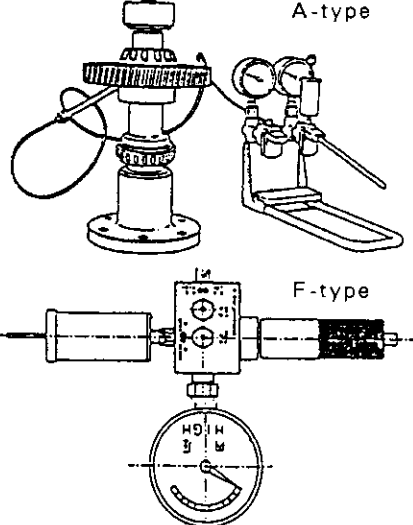
Tools (to be specially ordered)

Name of tool	Code No.	Shape
Socket (for rod bolt)	127610-92730	
Extractor for valve guide	127411-92160	
Extractor for fuel oil valve	127616-92500	
Piston insertion tool	122310-92140	
Piston rings fitting/removal tool	135410-92140	
Oil pan positioning tool	1. Bolt (4pcs) 127610-92700 2. Spacers A 127610-92680 3. Spacers B 127610-92690	

Name of tool	Code No	shape
Fresh water pump impeller (cam gear puller) (Press-fitting type)	1. Spacer 127610-92430 2. Bolt 124160-77511 3. Bolt (for impeller) × 2 26116-060302 4. Bolt (for cam gear) × 2 26116-080502	
Automatic timer tool (adiabatic material puller)	158591-54120 158591-54200	
Adiabatic material puller	127610-92910 (Standard)	
Protector puller	127695-92910	
Stem seal insertion tool		
Valve guide puller		

Name of tool	Code No.	shape
Exhaust manifold puller		 <p>Universal joint</p>
Fuel valve puller tool 127616-92500		

Special tools for clutch

No.	Name of tool	Note	shape
1	Emergency bolt span	For tightening the emergency bolt on clutch failure	
2	Gear puller		
3	Bearing separator	For removing bearing; used together with the gear puller	
4	Hydraulic fitting tool	For disassembly of output shaft joint Output shaft joint and large gear	 <p>A-type</p> <p>F-type</p>

Name	for using
Liquid packing (THREEBOND auxiliary packing):	<p>The silver grey semi-dry type viscoelastic liquid packing based on extreme heat-resisting synthetic rubber and synthetic resin. Apply the packing to the seal surface and join the part after several minutes when the packing has become semi-dry.</p> <p>The white liquid packing based on nylon resin. Brush the packing on the seal surface and join the part after several minutes when the packing has become semi-dry.</p> <p>Be sure to stir well before use.</p>

White paint	Coat the paint on the contact area with the cylinder body before inserting the cylinder liner to prevent rust and water leakage. (Use the oil type make-up paint.)
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Name	quantity	Code No.	Note
Scale removing agent	UNICON 1 case (4kg × 4)	974100-01460	The strong scaling agent removes scale quickly (1-10 hrs.).
	Counteragent (caustic soda) 1 case (2kg × 4)	974100-0200	Dissolve the agent in 10 parts of water or seawater (by weight ratio) and stir it well.
	PH test paper	974100-04200	Scale can be removed by just immersing the disassembled parts. To speed up the treatment, stir the solution. When the cleaning performance drops, neutralize the solution and throw it away.
Anti-rust agent	21	974100-04200	Mix the agent in ten parts of fresh water and stir the solution by operating the engine for about 5 minutes. The anti-rust performance lasts for about 6 months.
Yanmar Super Freeze			<p>Can be used both as anti-freeze in winter and coolant in summer. The performance lasts for 2 years.</p> <p>The Super Freeze can safely be mixed with anti-rust agent.</p>

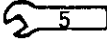
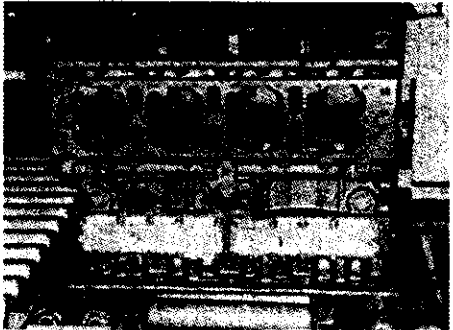

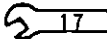
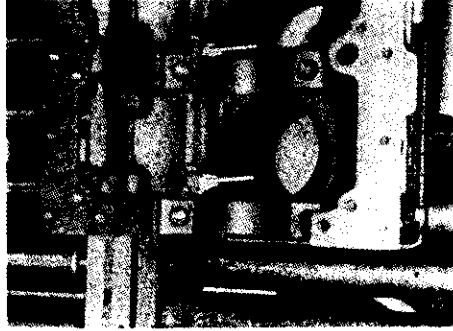
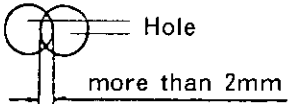

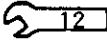
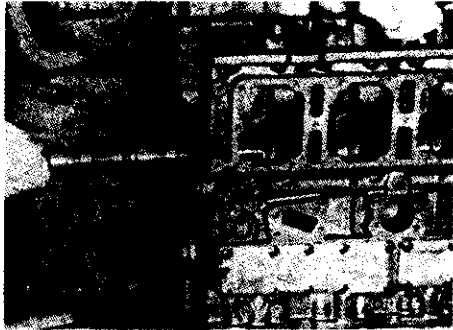
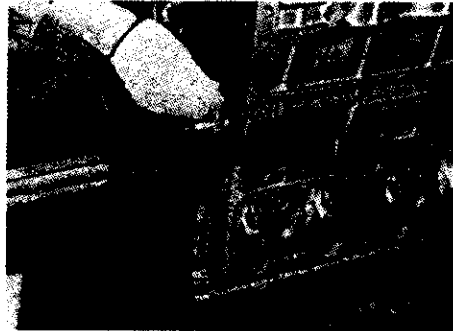
Temp.	-5°C	-10°C	-15°C	-20°C	-25°C	-30°C	-35°C	-40°C
Volume ratio	15%	25%	30%	35%	40%	45%	50%	55%

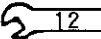


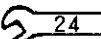



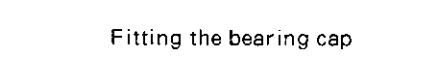


Name	quantity	Code No.	using
Metal Clean Y (cleaning agent)	1kg × 20	975600-02000	<p>Has strong performance to remove accumulated carbon.</p> <p>Can safely be heated to double the cleaning performance.</p> <p>Corrodes almost no metals, including iron. (Also has anti-rust effect.)</p> <p>To use, dissolve 1kg of the agent in 40 liters of water.</p> <p>When a cleaning machine is used, use 4-6% solution and heat in to 60-80°C.</p> <p>This will further raise the effect.</p>
Blower Clean (Special cleaning agent for turbocharger)	4 ℓ × 4	919200-10000	Special cleaning agent for turbocharger blower. Needs on water washing.
	18 ℓ × 1	919200-30000	
	1500cc × 6	919200-20000	


Measuring Device

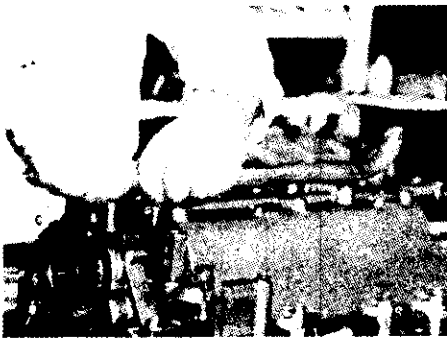
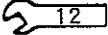
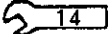

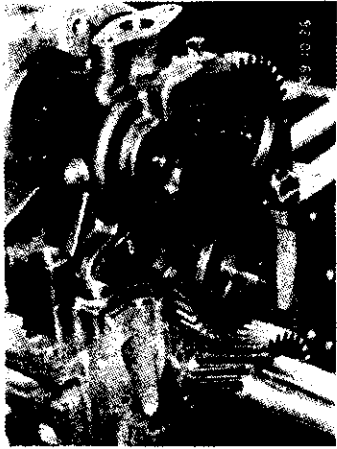
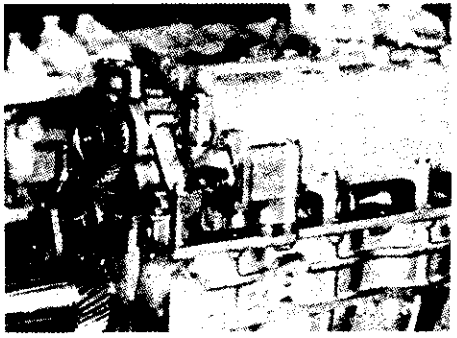
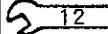
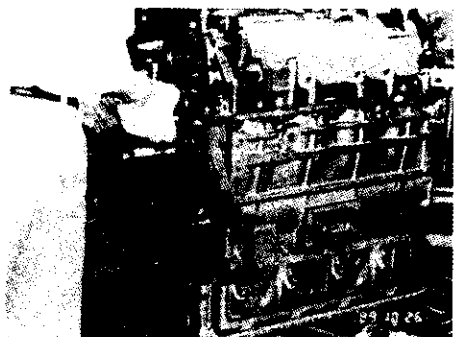
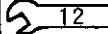



Name	quantity	Code No.	using
Cap tester	RCT-2A	955000-055000	For testing the radiator and the cap.

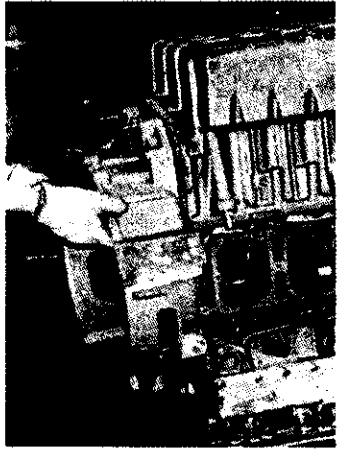

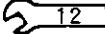
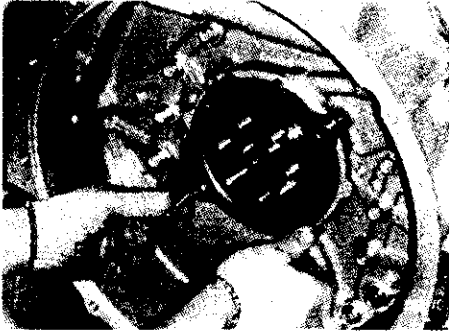
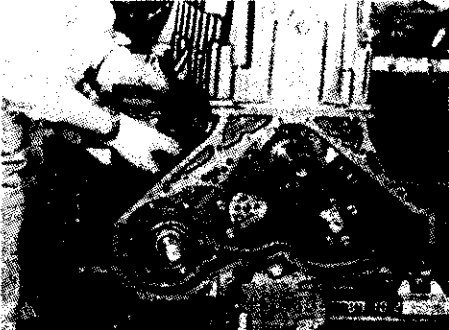
2-3. Reassembly Procedures


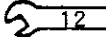
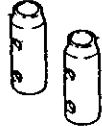
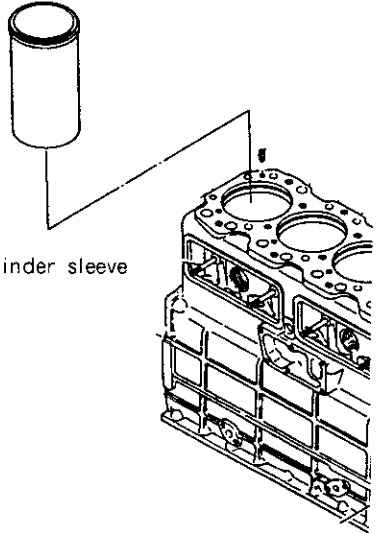
No.	Item	Procedure	Tool & Caution	Illustration				
1	Cylinder Block	<p>Clean the bearing holes completely. Reverse the cylinder block before reassembly.</p> <table border="1"> <tr> <td>T-plug 1/8 tightening torque</td> <td>0.5kgf - m</td> </tr> </table>	T-plug 1/8 tightening torque	0.5kgf - m		 <p>Cylinder Block</p>		
T-plug 1/8 tightening torque	0.5kgf - m							
2	Piston Cooling Nozzle	<p>Install the nozzle correctly according to the positioning pin. Take care not to over-tighten the nozzle.</p> <table border="1"> <tr> <td>Tightening torque</td> <td>2.0kgf-m</td> </tr> </table> <p>Check carefully that there are no chips or dust in the oil holes of the nozzle body, nozzle installation hole and check nozzle. Check that the nozzle body does not touch the cylinder block.</p>	Tightening torque	2.0kgf-m	 	 <p>Piston Cooling Nozzle</p>		
Tightening torque	2.0kgf-m							
3	Cam Shaft	<p>Apply lube oil to the cam shaft journal. Insert the cam shaft. Install the thrust plate.</p> <table border="1"> <tr> <td>Tightening torque</td> <td>2.6 ± 0.2 kgf-m</td> </tr> </table> <p>Measure the side clearance.</p> <table border="1"> <tr> <td>Side clearance</td> <td>0.10-0.25mm</td> </tr> </table> <p>Installation of cam shaft metal. Replace the cam shaft metal as follows:</p> <ol style="list-style-type: none"> 1. Apply lube oil to the outside circumference of the cam shaft metal and the inside bore of the block. 2. Align the oil hole so that the joint of the winding metal comes to the upper side. 3. Overlapping of not less than 2mm will suffice for the alignment of the oil holes of the block and cam shaft metal. (Check the alignment after knocking in the cam shaft metal.) <div>  </div>	Tightening torque	2.6 ± 0.2 kgf-m	Side clearance	0.10-0.25mm	 	 <p>Cam Shaft</p>  <p>Installation of the thrust metal</p>
Tightening torque	2.6 ± 0.2 kgf-m							
Side clearance	0.10-0.25mm							

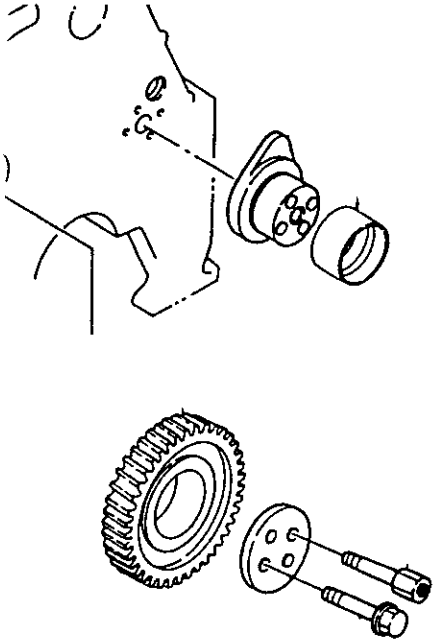
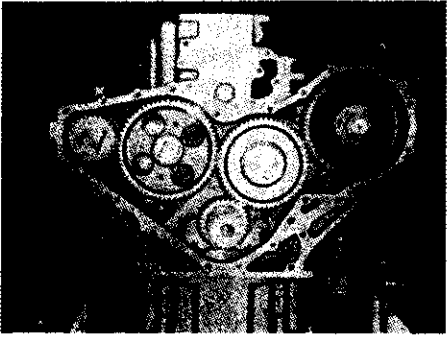
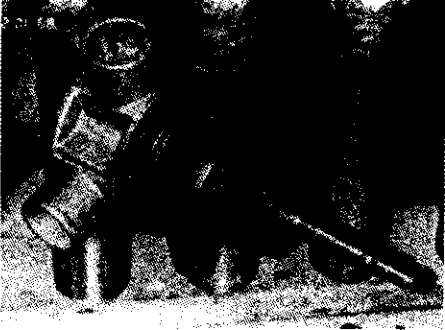

No.	Item	Procedure	Tool & Caution	Illustration						
4	Cooling Water Passage Cover	Install the cooling water passage cover.								
5	Crankshaft and Main Bearing	<p>The upper bearing (block side) has an oil groove; no oil groove in the lower bearing. The standard bearing is at the flywheel side (with flange). Apply lube oil to the crank and assemble. Confirm the alignment number on the bearing cap and block. Assemble with the F-mark at the flywheel side. Apply lube oil to the bolt threads and seat face and tighten the bolt to the specified tightening torque. Turn manually to check that it turns lightly. Measure the side clearance.</p> <table border="1"> <tr> <td>Cap bolt tightening torque</td> <td>28 ± 1.0 kgf-m</td> </tr> <tr> <td>Side clearance</td> <td>0.155–0.296mm</td> </tr> <tr> <td>Crankshaft bearing oil clearance</td> <td>0.04–0.108mm</td> </tr> </table>	Cap bolt tightening torque	28 ± 1.0 kgf-m	Side clearance	0.155–0.296mm	Crankshaft bearing oil clearance	0.04–0.108mm	 	 <p>Fitting the upper bearing</p>  <p>Fitting the crank shaft</p>  <p>Apply lube oil</p>  <p>Fitting the bearing cap</p>  <p>Fitting the cap bolt</p>  <p>Measure the side clearance</p>
Cap bolt tightening torque	28 ± 1.0 kgf-m									
Side clearance	0.155–0.296mm									
Crankshaft bearing oil clearance	0.04–0.108mm									



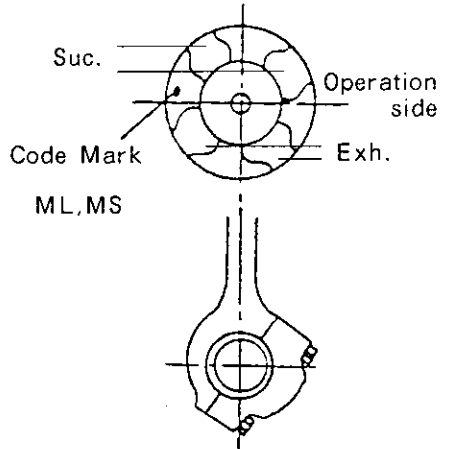
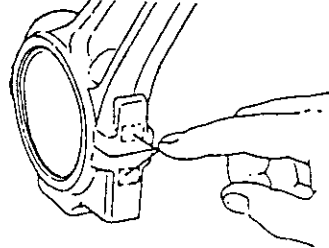



No.	Item	Procedure	Tool & Caution	Illustration						
6	Idle Gear (Lube Oil Pump)	<p>Check the gear side clearance.</p> <table border="1"> <tr> <td>Gear side clearance</td> <td>0.066–0.114mm</td> </tr> </table> <p>Check the gear backlash.</p> <table border="1"> <tr> <td>Gear backlash</td> <td>0.08–0.16mm</td> </tr> </table> <p>Install the idle gear to the cap.</p> <table border="1"> <tr> <td>Tightening torque</td> <td>1.5–2.0kgf-m</td> </tr> </table>	Gear side clearance	0.066–0.114mm	Gear backlash	0.08–0.16mm	Tightening torque	1.5–2.0kgf-m		 <p>Fitting the idle gear</p>
Gear side clearance	0.066–0.114mm									
Gear backlash	0.08–0.16mm									
Tightening torque	1.5–2.0kgf-m									


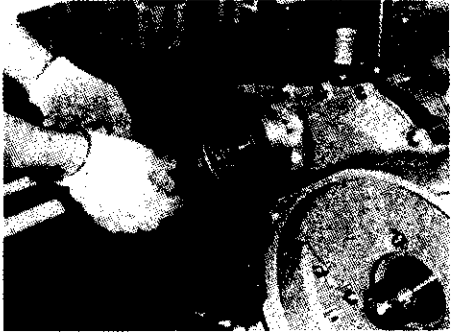
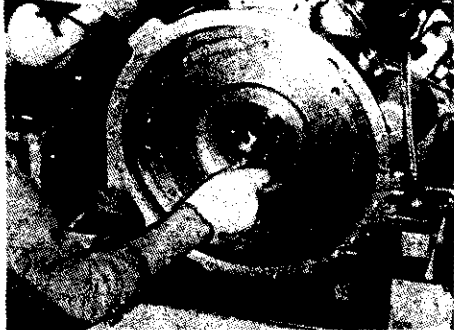

No.	Item	Procedure	Tool & Caution	Illustration						
7	Lube Oil Pump	<p>Install the lube oil assembly. Install the suction and discharge pipes.</p> <table border="1"> <tr> <td>(Bolt head width 12) Tightening torque</td> <td>2.5 ± 0.2 kgf-m</td> </tr> </table> <p>Check the gear backlash (to the crankshaft).</p> <table border="1"> <tr> <td>Backlash for crank gear</td> <td>0.12–0.22mm</td> </tr> </table>  <p>Fitting to the suction pipe</p>	(Bolt head width 12) Tightening torque	2.5 ± 0.2 kgf-m	Backlash for crank gear	0.12–0.22mm	  	 <p>Fitting to the lube oil pump</p>  <p>Fitting to the Safety valve and discharger pipe</p>		
(Bolt head width 12) Tightening torque	2.5 ± 0.2 kgf-m									
Backlash for crank gear	0.12–0.22mm									
8	Gear Case	<p>Install the bolt for fixing the fuel pump and the stud bolt for fixing the seawater pump to the gear case in advance. Match up the mounting surfaces of the oil pan. Align the positioning pin to the block and install the gear case.</p> <table border="1"> <tr> <td>(Bolt head width 12) Tightening torque</td> <td>2.6 ± 0.2 kgf-m</td> </tr> </table> <p>Cut off the protruding packing.</p>	(Bolt head width 12) Tightening torque	2.6 ± 0.2 kgf-m		 <p>Fitting the gear case</p>				
(Bolt head width 12) Tightening torque	2.6 ± 0.2 kgf-m									
9	Oil Pan	<p>Bring the gear case level so that the packing will not break. (Use the fitting tool.)</p> <table border="1"> <tr> <td>(Bolt head width 12) Tightening torque</td> <td>2.6 ± 0.2 kgf-m</td> </tr> </table> <p>After tightening, cut off the packing protruding on the wheel housing side.</p> <p><i>Note:</i></p> <table border="1"> <tr> <td colspan="2"><i>Apply THREEBOND to both sides of the packing at the three-face joint of the gear case and flywheel side. Match up the installation faces of the wheel housing.</i></td> </tr> </table> <table border="1"> <tr> <td>Step of the joint face at the flywheel housing side</td> <td>0.1mm</td> </tr> </table>	(Bolt head width 12) Tightening torque	2.6 ± 0.2 kgf-m	<i>Apply THREEBOND to both sides of the packing at the three-face joint of the gear case and flywheel side. Match up the installation faces of the wheel housing.</i>		Step of the joint face at the flywheel housing side	0.1mm	  	 <p>Fit the oil pan using the tool</p>
(Bolt head width 12) Tightening torque	2.6 ± 0.2 kgf-m									
<i>Apply THREEBOND to both sides of the packing at the three-face joint of the gear case and flywheel side. Match up the installation faces of the wheel housing.</i>										
Step of the joint face at the flywheel housing side	0.1mm									

No.	Item	Procedure	Tool & Caution	Illustration						
10	Flywheel Housing	<p>Assemble the flywheel housing according to the positioning parallel pin.</p> <table border="1"> <tr> <td>Deviation at the oil seal insertion area</td> <td>0.2mm</td> </tr> </table> <table border="1"> <tr> <td>Face deviation from the crankshaft center</td> <td>0.3mm</td> </tr> </table> <table border="1"> <tr> <td>Flywheel housing tightening torque</td> <td>5 ± 0.5 kgf-m</td> </tr> </table> <p>Install the lube oil piping (flywheel housing-oil filter).</p>	Deviation at the oil seal insertion area	0.2mm	Face deviation from the crankshaft center	0.3mm	Flywheel housing tightening torque	5 ± 0.5 kgf-m		 <p>Assemble the Fly wheel housing</p>
Deviation at the oil seal insertion area	0.2mm									
Face deviation from the crankshaft center	0.3mm									
Flywheel housing tightening torque	5 ± 0.5 kgf-m									
11	Oil Seal Case	<p>Press-fit the seal into the oil seal case (with the press-fitting tool).</p> <p><i>Note :</i></p> <table border="1"> <tr> <td><i>(Apply lube oil to the outside lip of the oil seal before press-fitting.)</i></td> </tr> </table> <p>Install the oil seal case assembly to the flywheel side with its oil escape hole vertical.</p>	<i>(Apply lube oil to the outside lip of the oil seal before press-fitting.)</i>	 	 <p>Assemble the oil seal case</p>					
<i>(Apply lube oil to the outside lip of the oil seal before press-fitting.)</i>										
12	Engine Foot	Install the engine foot.		 <p>Install the engine foot</p>						
13	Reverse the cylinder block	Reverse the cylinder block.								

No.	Item	Procedure	Tool & Caution	Illustration				
14	Tappets and Tappets Case cover	<p>Insert the tappets into the cylinder block hole. (Apply engine oil to the tappets. Move the tappets manually to check that they are inserted smoothly.)</p> <table border="1"> <tr> <td>Tappet hole oil clearance</td> <td>0.04–0.082mm</td> </tr> </table> <p>Install the tappet case cover after inserting all tappets.</p> <table border="1"> <tr> <td>(Bolt head width 12) Tightening Torque</td> <td>1.2–1.7kgf-m</td> </tr> </table>	Tappet hole oil clearance	0.04–0.082mm	(Bolt head width 12) Tightening Torque	1.2–1.7kgf-m	 	 <p>Tappet</p>
Tappet hole oil clearance	0.04–0.082mm							
(Bolt head width 12) Tightening Torque	1.2–1.7kgf-m							
15	Cylinder Sleeve	<p>Clean the sleeve fitting area of the cylinder block completely. Clean the outside circumference of the cylinder sleeve completely and insert it manually into the cylinder block.</p> <p><i>Note :</i></p> <div style="border: 1px solid black; padding: 5px;"> <p><i>Before inserting the cylinder sleeve, check the cylinder number and the insertion direction. (Size code is for the cylinder sleeve) (Identical code for the cylinder block and sleeve) (Make a combination of A, B, C and D.) (Direct the code side to the anti-operation side.) (Marked in black paint at the anti-operation side.) Do not place on the cylinder head face after inserting the cylinder sleeve. Be sure to assemble the cylinder sleeve manually. (Do not use a hammer.)</i></p> </div> <p>Measure the protrusion of the cylinder liner.</p> <table border="1"> <tr> <td>Liner protrusion</td> <td>0.03–0.09mm</td> </tr> </table> <p>Measure the distortion of the cylinder liner.</p> <table border="1"> <tr> <td>Cylindricity</td> <td>≤0.03mm</td> </tr> </table> <p>(The mark at the cylinder block side is punched on the head joint face of the operation side.)</p>	Liner protrusion	0.03–0.09mm	Cylindricity	≤0.03mm		 <p>Cylinder sleeve</p> <p>Size code is for the cylinder sleeve. Marked in black paint at the anti-operation side.</p> <div style="text-align: center;"> <p>「 B M 」</p> <p>↑ ↑</p> <p>Piston fitting code</p> <p>↑</p> <p>Cylinder block fitting code</p> </div>
Liner protrusion	0.03–0.09mm							
Cylindricity	≤0.03mm							

No.	Item	Procedure	Tool & Caution	Illustration										
16	Idle Gear	<p>Install the idle gear shaft. Direct the shaft's oil hole upwards.</p> <table border="1"> <tr> <td>Tightening torque</td> <td>2.6^{±0.3} kgf-m</td> </tr> </table> <p>Install the idle gear.</p> <table border="1"> <tr> <td>Gear side clearance</td> <td>0.15–0.35mm</td> </tr> </table> <p>Install the cam gear shaft.</p> <table border="1"> <tr> <td>Gear backlash</td> <td>0.08–0.16mm</td> </tr> <tr> <td>Gear side clearance</td> <td>0.10–0.25mm</td> </tr> </table> <p>Use the puller tool to remove the cam gear. Install the fuel pump drive gear.</p> <table border="1"> <tr> <td>Tightening torque</td> <td>20^{±1.0} kgf-m</td> </tr> </table>	Tightening torque	2.6 ^{±0.3} kgf-m	Gear side clearance	0.15–0.35mm	Gear backlash	0.08–0.16mm	Gear side clearance	0.10–0.25mm	Tightening torque	20 ^{±1.0} kgf-m	<p>?</p> <p>12</p> <p>•</p> <p>36</p>	 <p>Idle gear</p>
Tightening torque	2.6 ^{±0.3} kgf-m													
Gear side clearance	0.15–0.35mm													
Gear backlash	0.08–0.16mm													
Gear side clearance	0.10–0.25mm													
Tightening torque	20 ^{±1.0} kgf-m													
17	Sea water Pump	<p>Install the sea water pump to the gear case, directing the oil receiving port upwards. Install the drive gear and tighten the nut to the specified tightening torque.</p> <table border="1"> <tr> <td>Drive gear fixing nut tightening torque</td> <td>14.5^{±0.5} kgf-m</td> </tr> </table> <p>Install the fuel pump driving bearing case assembly to the gear case.</p> <table border="1"> <tr> <td>Gear backlash</td> <td>0.08–0.16mm</td> </tr> </table>  <p>Match up the alignment marks of gears at the same time.</p>	Drive gear fixing nut tightening torque	14.5 ^{±0.5} kgf-m	Gear backlash	0.08–0.16mm	<p>12</p> <p>•</p> <p>30</p>	 <p>Sea water pump</p>  <p>Fuel pump driving bearing case</p>						
Drive gear fixing nut tightening torque	14.5 ^{±0.5} kgf-m													
Gear backlash	0.08–0.16mm													

No.	Item	Procedure	Tool & Caution	Illustration				
18	Piston and Connecting Rod	<p>Assemble the connecting rod to the piston. The size code, ML or MS, is provided on the piston head. Match up the code with the correctly code of the cylinder sleeve. Distribute the end gaps of the piston rings evenly on the piston. Insert the piston into the cylinder liner, placing the con. rod alignment mark on the operation side. Apply lube oil. Confirm the alignment marks on the connecting rod and cap, and install the cap. Apply lube oil to the thread seat face and tighten the rod bolt to the specified tightening torque. Tighten the bolts by turns evenly 3 times to avoid uneven tightening.</p> <table border="1"> <tr> <td>Tightening torque</td> <td>23 ± 0.5 kgf-m</td> </tr> </table> <p>Measure the side clearance after tightening the bolts.</p> <table border="1"> <tr> <td>Rod large end side clearance</td> <td>0.15-0.35mm</td> </tr> </table> <p>Install the cylinder block side cover. (An alignment mark is provided on the rod bolt. This is because a torque wrench cannot be used in restricted engine room spaces.)</p> 	Tightening torque	23 ± 0.5 kgf-m	Rod large end side clearance	0.15-0.35mm		 <p>Assemble the piston and con.rod.</p>  <p>alignment mark</p>  <p>Fitting the side cover</p>  <p>Fitting the gear case cover</p>
Tightening torque	23 ± 0.5 kgf-m							
Rod large end side clearance	0.15-0.35mm							
19	Gear Case Cover	<p>Install the oil seal to the gear case.</p> <p><i>Note :</i></p> <table border="1"> <tr> <td><i>Apply lube oil to the exterior and lip of the oil seal before press-fitting it.</i></td> </tr> </table> <p>Install the gear case cover.</p> <p><i>Note :</i></p> <table border="1"> <tr> <td><i>The positioning pin (spring pin) is provided at the joint face of the gear case and cylinder block.</i></td> </tr> </table> <p>Measure the face deviation of the front drive installation.</p> <table border="1"> <tr> <td>Face deviation</td> <td>Less than 0.05mm for crank center</td> </tr> </table>	<i>Apply lube oil to the exterior and lip of the oil seal before press-fitting it.</i>	<i>The positioning pin (spring pin) is provided at the joint face of the gear case and cylinder block.</i>	Face deviation	Less than 0.05mm for crank center		 <p>Fitting the gear case cover</p>
<i>Apply lube oil to the exterior and lip of the oil seal before press-fitting it.</i>								
<i>The positioning pin (spring pin) is provided at the joint face of the gear case and cylinder block.</i>								
Face deviation	Less than 0.05mm for crank center							

No.	Item	Procedure	Tool & Caution	Illustration			
20	Bearing Case	Install the sea water pump drive bearing case. Install the V-pulley. Bend the washer after tightening the nut. Install the breather.		 <p>Assemble the bearing case</p>  <p>Install the V-pulley</p>			
21	Flywheel	Install the flywheel. (Align the positioning parallel pin holes.) Tighten the bolts to the specified tightening torque. <table border="1"> <tr> <td>Tightening torque</td> <td>29 ± 1 kgf-m</td> </tr> </table> Measure and check the flywheel face deviation and centering location deviation. <table border="1"> <tr> <td>Face deviation</td> <td>less than 0.13mm</td> </tr> </table> Follow the instructions below when replacing the top indication plate: 1) Bring the No.1 piston at the flywheel side to the top position. (Check using the dial gauge.) 2) Install aligning the top punched line of the flywheel to the piston top position. 3) The alignment error between the top mark of the indication plate and the top punched line of the flywheel should be within +30 min.	Tightening torque	29 ± 1 kgf-m	Face deviation	less than 0.13mm	 <p>Assemble the flywheel</p>  <p>Check the No1 cyl.top.</p>
Tightening torque	29 ± 1 kgf-m						
Face deviation	less than 0.13mm						