YANMAR

M9961-H13021

SERVICE MANUAL

MARINE DIESEL ENGINE

6CXM-GTE/GTE2

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MODEL 6CXM-GTE/GTE2

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Revision history list				Page No.	1
Document name	SERVICE MANUAL FOR YANMAR MARINE DIESEL ENGINE				
Product name	6CXM-GTE/GTE2				
Revision No.	Revision date	Reason for revision	Revision outline	Revised item (page)	Revised by
Rev.1	November, 05	To add more details of fuel injection pump	3.11 Fuel Oil System was increased.	From page 3-29 to page 3-43-24	Marine Business Development Dept.

FOREWORD

This service manual outlines procedures for servicing and maintaining Yanmar 6CXM-GTE/GTE2 engines to obtain maximum life and performance. It explains about the structure, performance, 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.

4. Prepare the servicing tools, measuring devices, containers, etc.

CONTENTS

For Safe Operation

1 Warning Symbols

- Most accidents are caused by negligence of basic safety rules and precautions.
  For accident prevention, it is important to avoid such causes before development to accidents.
  Please read this manual carefully before starting repair or maintenance to fully understand safety precautions and appropriate inspection and maintenance procedures.
  Attempting a repair or maintenance job without sufficient knowledge may cause an unexpected accident.

- It is impossible to cover every possible danger in repair or maintenance in the manual.
  Sufficient consideration for safety is required in addition to the matters marked ⚠CAUTION.
  Especially for safety precautions in a repair or maintenance job not described in this manual, receive instructions from a knowledgeable leader.

- Warning Symbols used in this manual and their meanings are as follows:

⚠ DANGER	**DANGER-indicates an imminently hazardous situation which, if not avoided, WILL result in death or serious injury.**
⚠ WARNING	**WARNING-indicates a potentially hazardous situation which, if not avoided, COULD result in death or serious injury.**
⚠ CAUTION	**CAUTION-indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.**

- Any matter marked [NOTICE] in this manual is especially important in servicing. If not observed, the product performance and quality may not be guaranteed.

California Proposition 65 Warning

Diesel engine exhaust and some of its constitutions are known to the State of California to cause cancer, birth defects, and other reproductive harm.

California Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.
Wash hand after handling

2 Precautions for Safe Servicing

(1) Service Shop (Place)

⚠ WARNING

● Place allowing sufficient ventilation
Jobs such as engine running, part welding and polishing the paint with sandpaper should be done in a well-ventilated place.
[Otherwise]
Very dangerous for human body due to the possibility of poisonous gas or dust inhalation.

⚠ CAUTION

● Sufficiently wide and flat place
The floor space of the service shop for inspection and maintenance shall be sufficiently wide and flat without any hole.
[Otherwise]
An accident such as a violent fall may be caused.

⚠ CAUTION

● Clean, orderly arranged place
No dust, mud, oil or parts shall left on the floor surface.
[Otherwise]
An unexpected accident may be caused.

⚠ CAUTION

● Bright, safely illuminated place
The working place should be illuminated sufficiently and safely.
For a job in a dark position involving difficulty in observation, use a portable safety lamp. The bulb shall be covered with a wire cage.
[Otherwise]
The bulb may be broken accidentally to cause ignition of leaking oil.

⚠ CAUTION

● Place equipped with a fire extinguisher
Keep a fast aid kit and fire extinguisher close at hand in preparation for an emergency of fire.

(2) Working Wear

⚠ CAUTION

● Wears for safe operation
Wear a helmet, working clothes, safety shoes and other safety protectors matching each job. Especially, wear well-fitting working clothes.
[Otherwise]
A serious accident such as trapping by a machine may arise.

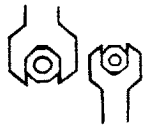
(3) Tools to Be Used

⚠ WARNING

● Appropriate holding and lifting
Never operate when the engine is supported with blocks or wooden pieces or only with a jack. To lift and hold the engine, always use a crane with a sufficient allowance in limit load or a rigid jack.

[Otherwise]
A serious accident may arise.

⚠ WARNING



● Use of appropriate tools
Use tools matching the jobs to be done. Use a correctly sized tool for loosening or tightening a machine part.

[Otherwise]
A serious injury or engine damage may arise.

(4) Use of Genuine Parts, Oil and Grease

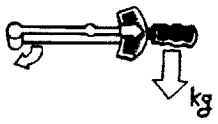
⚠ CAUTION

● Always use genuine parts.

[Otherwise]
Shortening of engine life or an unexpected accident may arise.

(5) Bolt and Nut Tightening Torques

⚠ WARNING



● Always tighten to the specified torque if designated in the manual.

[Otherwise]
Loosening or falling may cause parts damage or an injury.

(6) Handling Of Product

⚠WARNING

● Pay attention to hot portions.
Do not touch the engine during running or immediately after it is stopped.
[Otherwise]
Scalding may be caused by a high temperature.

⚠WARNING

● Pay attention to the rotating part.
Never bring clothes or a tool close to the rotating part during engine running.
[Otherwise]
Injury may be caused by entrapping.

⚠WARNING

● Harness short-circuit
Disconnect the battery negative (–) terminal before starting the service job.
[Otherwise]
Shorting of a harness may occur to start a fire.

⚠WARNING

● Battery charging
Since flammable gas is generated during battery charging, keep any fire source away.
[Otherwise]
Explosion may arise.

⚠WARNING

● Battery electrolyte
Since the electrolyte is diluted sulfuric acid, do not let it be splashed onto clothes or skin.
[Otherwise]
The clothes or skin may be burnt.

(7) Waste Disposal

⚠ CAUTION

Observe the following instructions with regard to waste disposal.
Negligence of each instruction will cause environmental pollution.

- Waste fluids such as engine oil and cooling water shall be discharged into a container without spillage onto the ground.
- Do not let waste fluids be discharged into the sewerage, a river or the sea.
- Harmful wastes such as oil, fuel, coolants, solvents, filter elements and battery shall be disposed according to the relevant laws and regulations. Ask a qualified disposal company for example.

(8) Safety Label Check

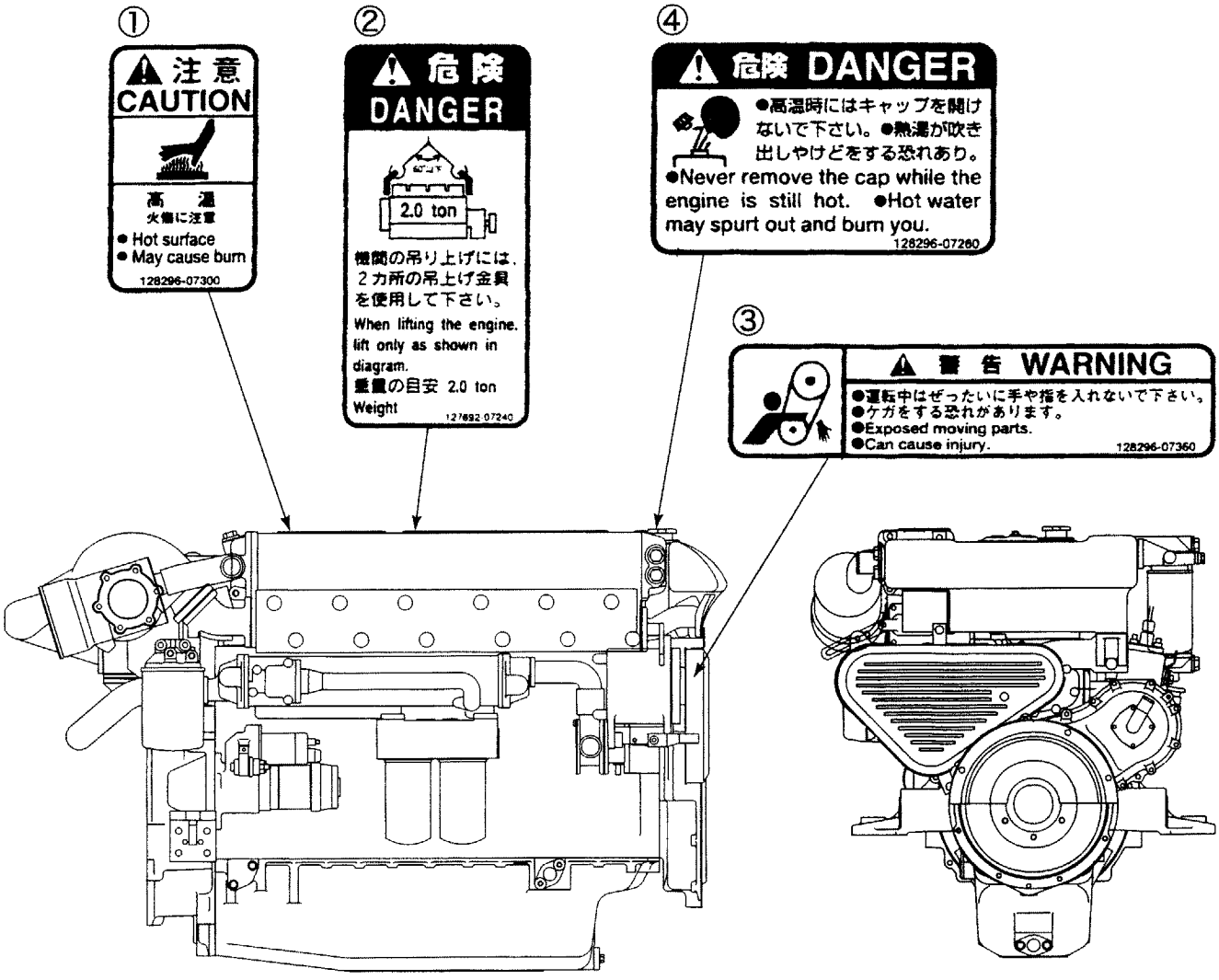
⚠ CAUTION

● Pay attention to the product safety label.
A safety label (caution plate) is affixed on the product for calling special attention to safety.
If it is missing or illegible, always affix a new one.

Location for Product Safety Labels

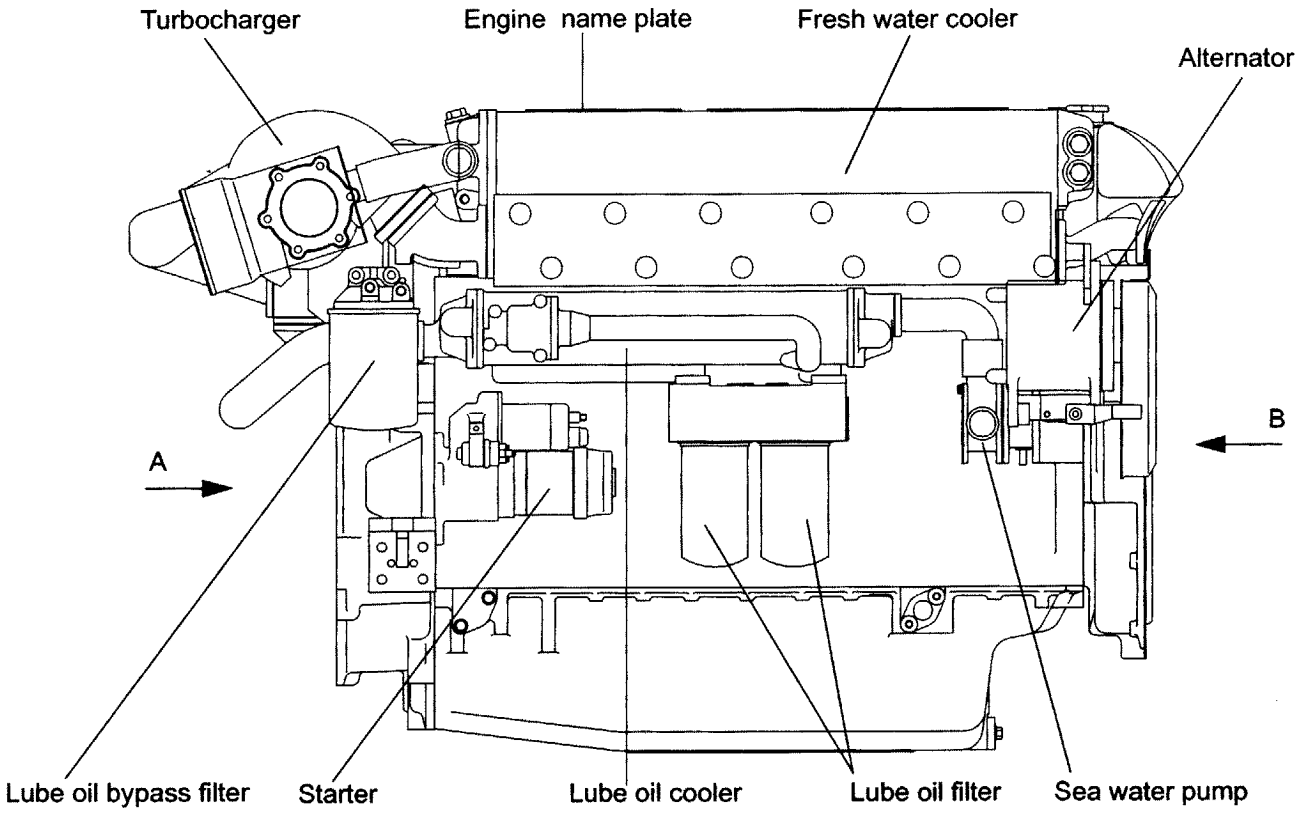
To insure safe operation, product safety labels have been attached. Their location is shown in the diagram below. Keep the labels from becoming dirty or torn and replace them if they are lost or damaged. Also replace labels when parts are replaced, ordering them in the same way as for the parts.

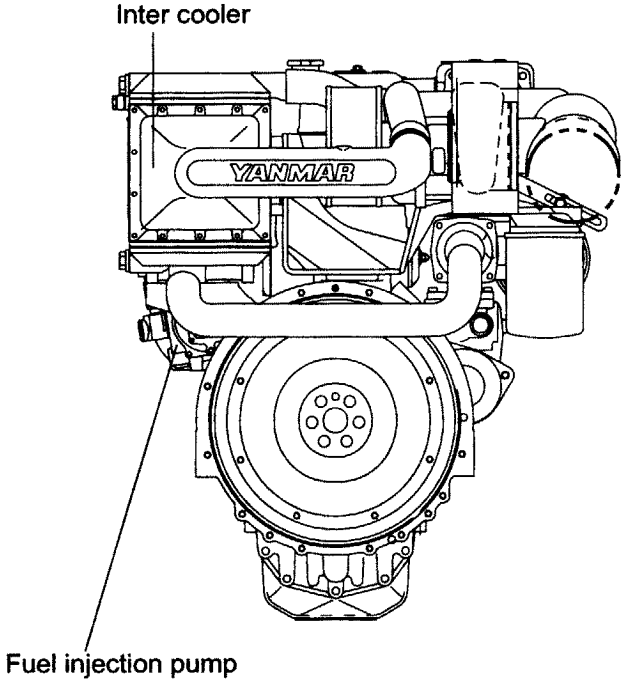
Product Safety Labels, Parts Code Numbers	
①	128296-07300
②	127692-07240
③	128296-07360
④	128296-07260



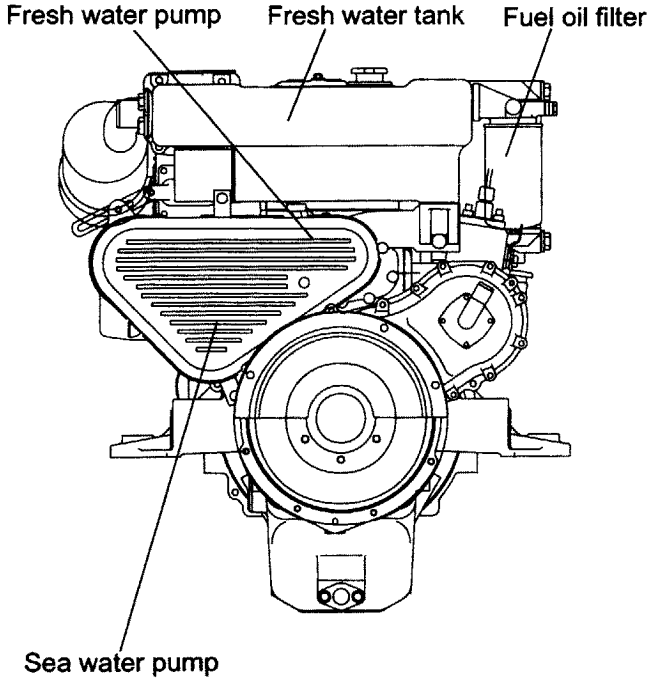
1 General

1.1 Exterior Views





See from A



See from B

1.2 Specifications

ENGINE MODEL			UNIT	6CXM-GTE	6CXM-GTE2
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 × 130	
Displacement			ℓ	7.413	
Continuous rating	Continuous power/Crankshaft speed		kW(PS)/rpm	305(415)/2750	324(440)/2800
	Brake mean effective pressure		MPa(kgf/cm^2)	1.797(18.32)	1.871(19.08)
	Piston speed		m/s	11.92	12.13
Max.rating	Fuel stop power/ Crankshaft speed	ISO3046-1	kW(PS)/rpm	*342(465)/2850	*357(485)/2900
		ISO8665		**332(451)/2850	**346(470)/2900
	Brake mean effective pressure		MPa(kgf/cm^2)	*1.943(19.81)	*1.991(20.31)
	Piston speed		m/s	12.35	12.57
High idle/Low idle			rpm	3200 ± 25/750 ± 25	3250 ± 25/750 ± 25
Starting system			———	Electric starting	
Firing order			———	1—4—2—6—3—5	
Direction of rotation (viewed from stem)	Crankshaft		———	Counter-clockwise	
Lub.oil capacity	Max.		ℓ	22	
	Min.		ℓ	14	
Fuel system	Fuel injection pump		———	In-line type	
	Injection timing (FID)		———	b.T.D.C 13° ± 1	
	Type of injection nozzle		———	Hole type (Φ0.29×155°)	Hole type (Φ0.30×155°)
	Injection pressure		MPa(kgf/cm^2)	23.5±0.5 (240±5)	
	Applicable fuel		———	Diesel oil (Cetan value ≥45)	
	Fuel filter		———	Paper element	
Engine lub.oil system	Lubrication		———	Forced lubrication by gear pump	
	Lub.oil discharge volume		ℓ/h	7100 (at crank shaft speed 2750 rpm)	
	Lub.oil pressure		MPa(kgf/cm^2)	0.49(5.0) (at 2750 rpm)	
	Lub.oil filter		———	Suction side:Perforated steel plate Discharge side:Paper element	

Fuel condition:

* : Fuel temperature 25°C at the fuel injection pump inlet.
Fuel density at 15°C : 0.832

** : Fuel temperature 40°C at the fuel injection pump inlet (ISO8665)
Fuel density at 15°C : 0.832

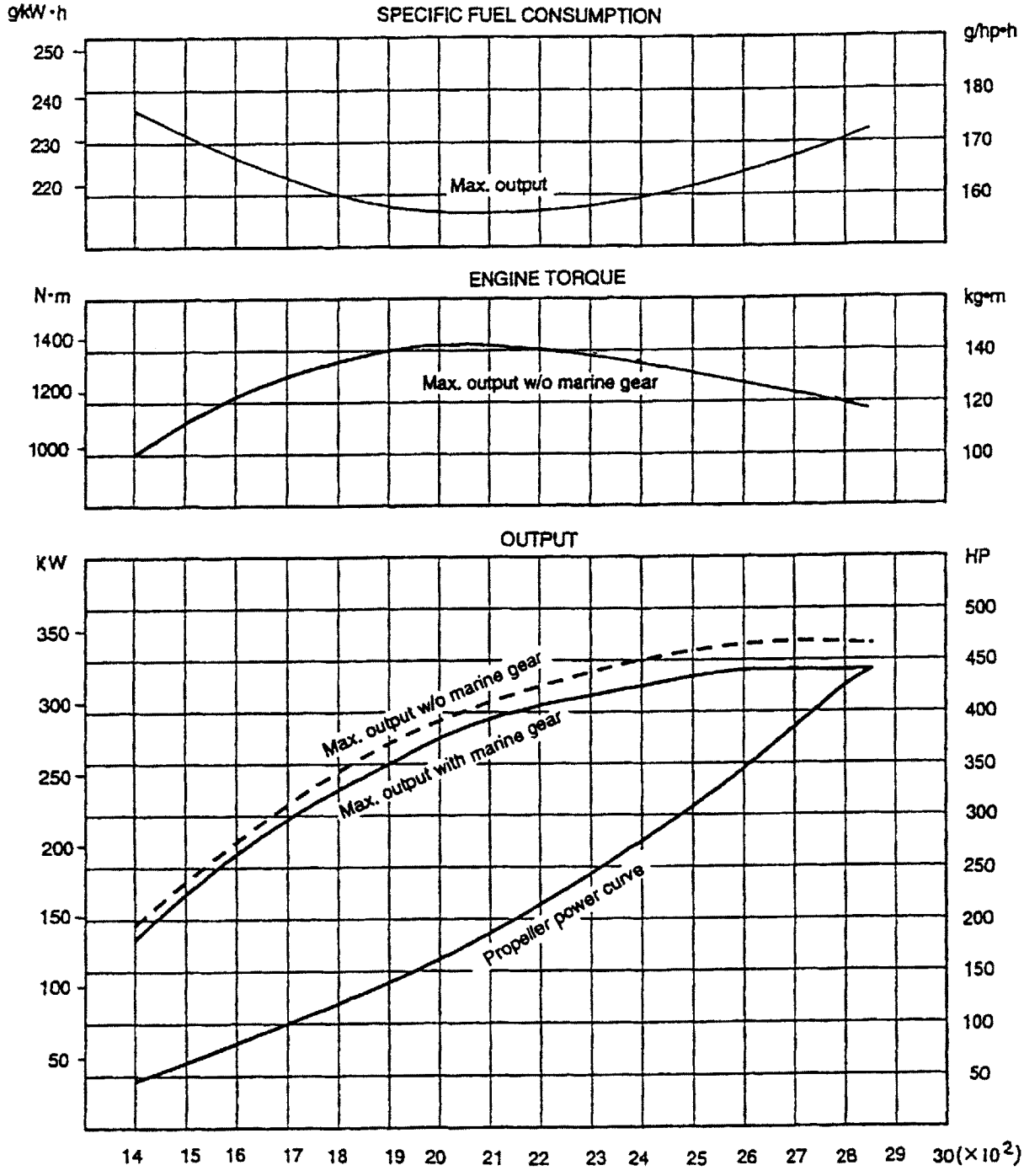
ENGINE MODEL		UNIT	6CXM-GTE	6CXM-GTE2
Cooling water system	Sea water pump	———	Rubber impeller type:gear driving type	
	Fresh water pump	———	Centrifugal type:V-belt driving type	
	Cooling method	———	Constant high temperature fresh water cooling	
	Pump discharge volume	ℓ/h	Sea water: ≥10300 (at crank shaft speed 2750 rpm) Fresh water: ≥22700 (at crank shaft speed 2750 rpm)	
	Fresh water capacity inside engine	ℓ	35	
	Fresh water capacity in subtank	ℓ	1.5	
Turbocharger	Type	———	HX50(Holset make)	
	Cooling	———	Air cooled	
	Lubrication	———	Forced lubrication using engine system lube oil	
Air cooler	Type	———	Fin tube type	
	Cooling method	———	Sea water cooling	
Engine dimension: Overall length×overall width×overall hight		mm	1190×805×905	
Piston removing height (from installation floor)		mm	800 (from back plate of isolationg rubber)	
Engine dry mass		kg	840	840

Note
- Max.rating: Continuous operation hours at fuel stop power are less than 0.5 hours.
- Engine lube oil:
  API classification . . . CD
  SAE viscosity 15W40
- Fuel oil: The diesel fuel oil [ISO 8217 DMA, BS 2869 A1 or A2 (Cetane No. 45 min.)]

1.3 Performance Curve

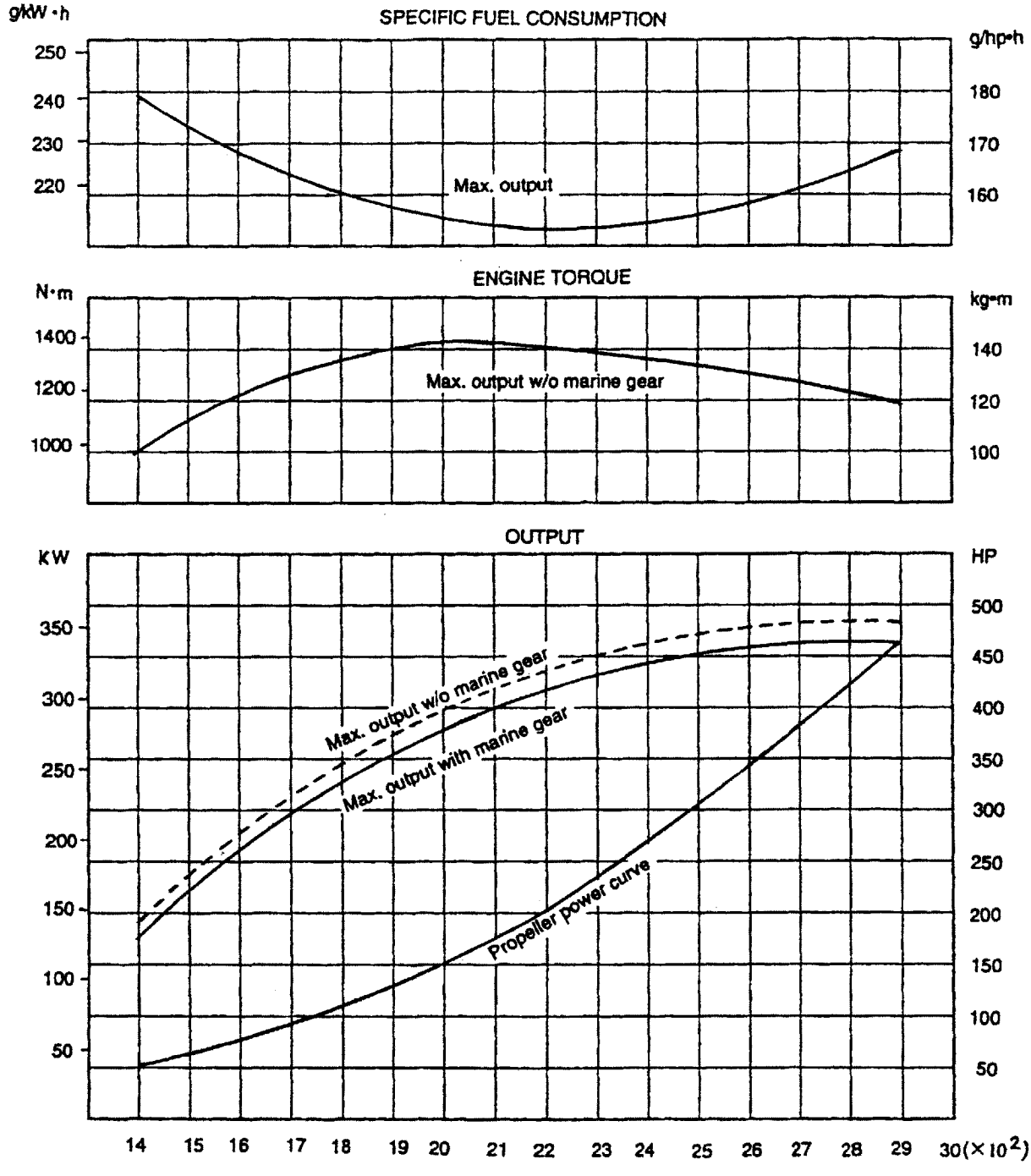
1.3.1 6CX-GTE Performance Curve

Note
- This data is measured at crankshaft and show the average performance as tested at our laboratory.
- Conditions for engine performance. Density of fuel: 832kg/m^3 at 15°C,
  Temperature of fuel: 25°C at FO punp inlet,
  Standard atmospheric condition: ISO 3046/1, 1hp ≒ 0.7355kW



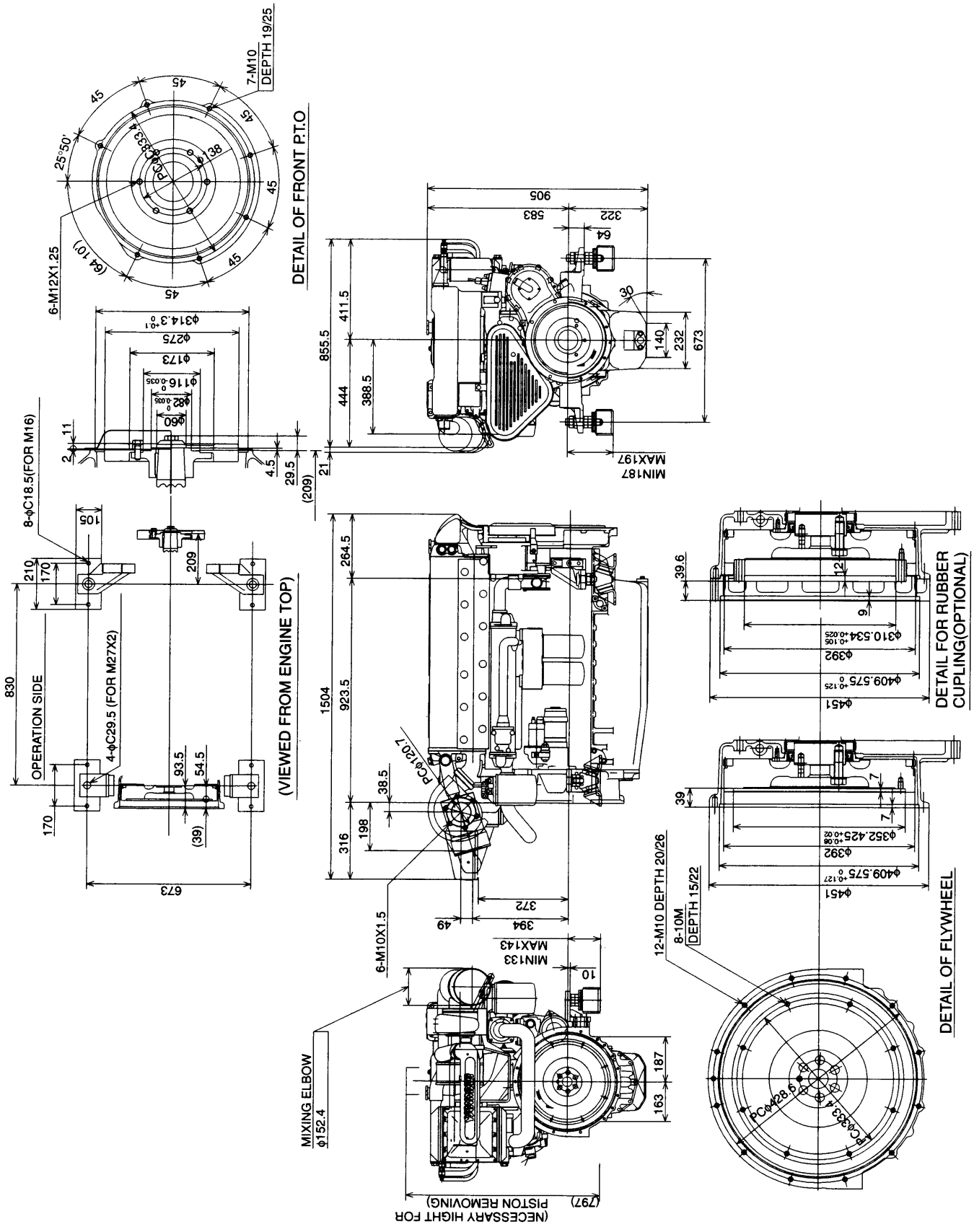
1.3.2 6CX-GTE2 Performance Curve

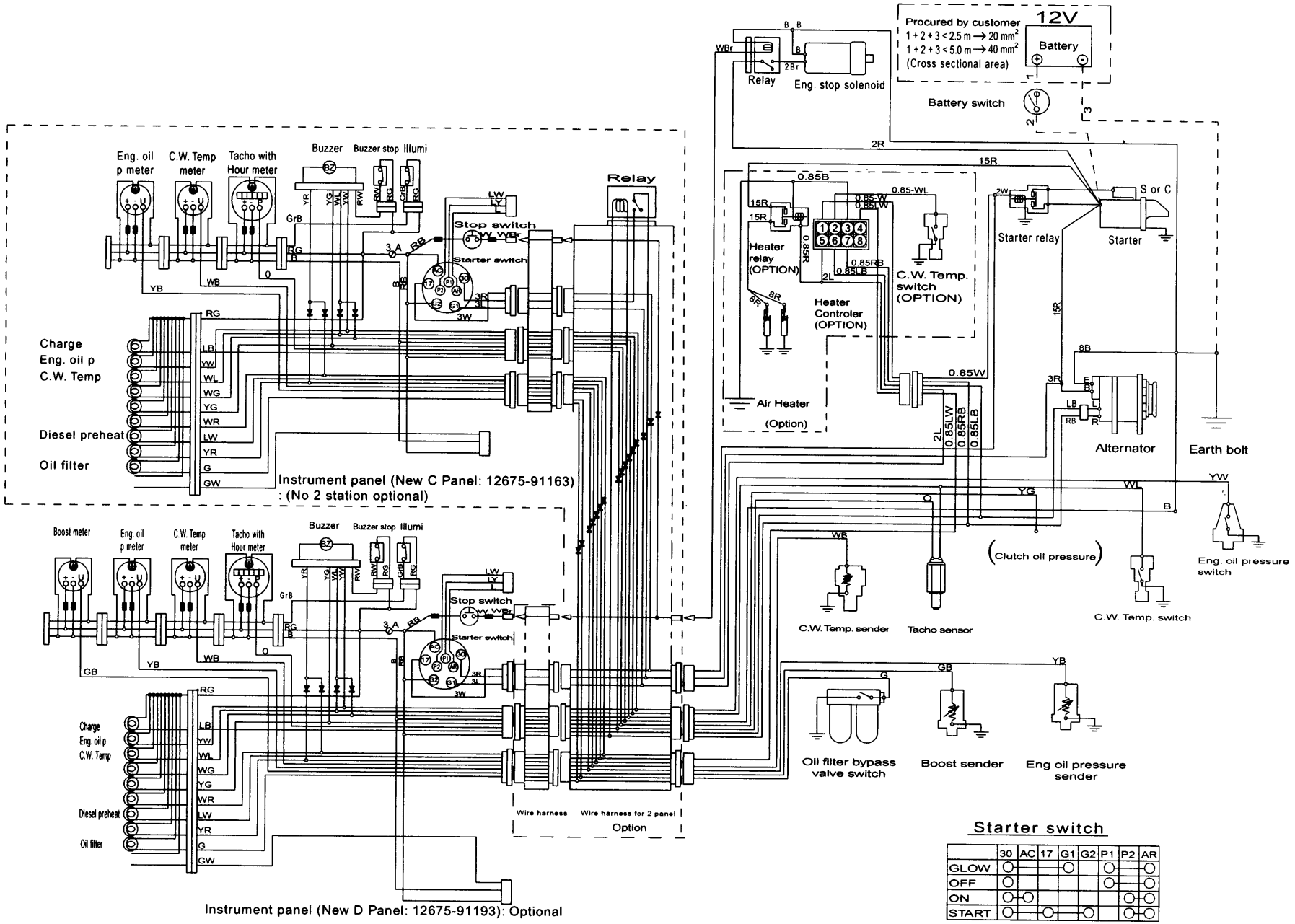
Note
- This data is measured at crankshaft and show the average performance as tested at our laboratory.
- Conditions for engine performance. Density of fuel: 832kg/m^3 at 15°C,
  Temperature of fuel: 25°C at FO punp inlet,
  Standard atmospheric condition: ISO 3046/1, 1hp ≒ 0.7355kW



1.4 Dimensions

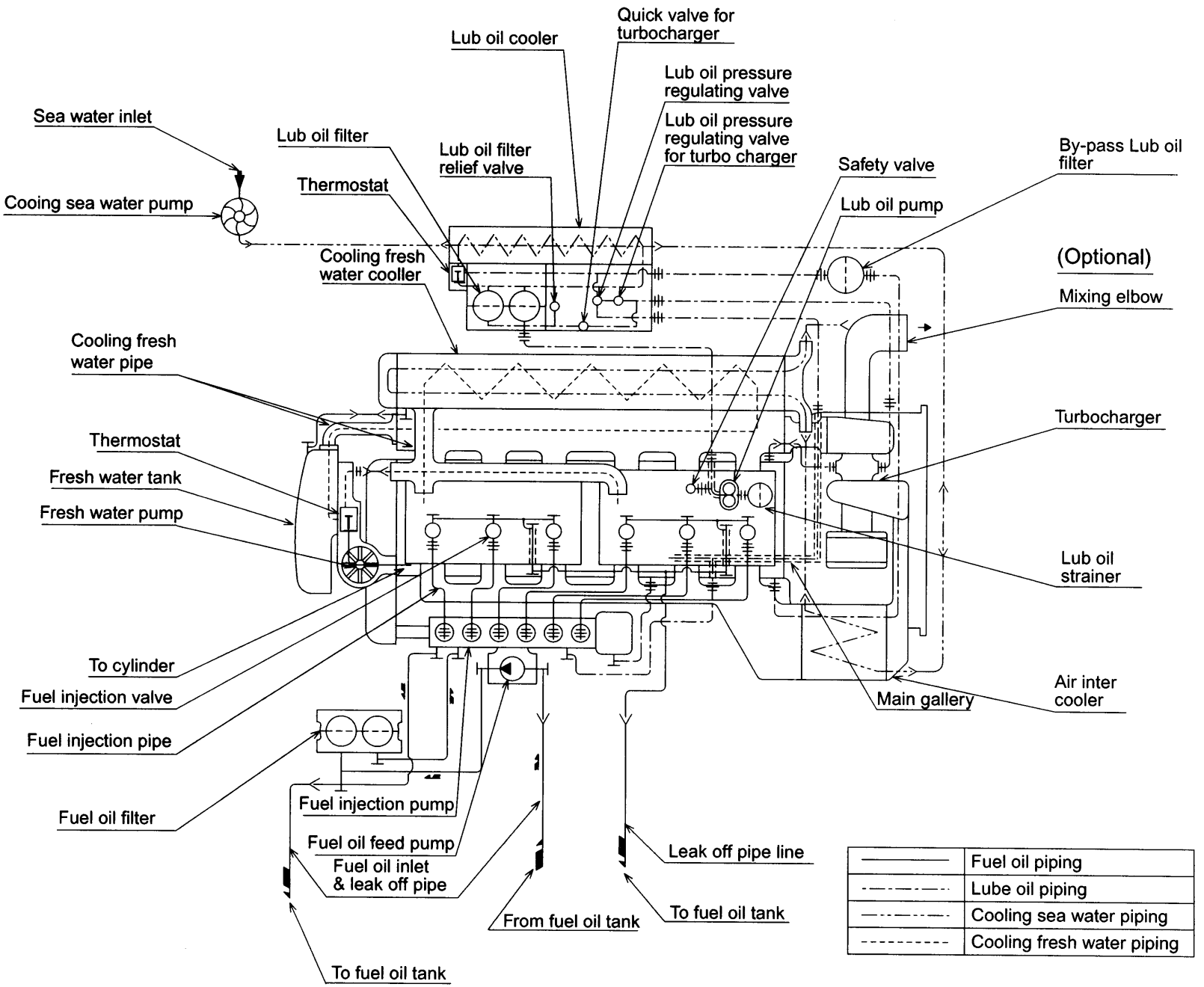
6CXM-GTE/GTE2





Starter switch

	30	AC	17	G1	G2	P1	P2	AR
GLOW	○			○		○		○
OFF	○					○		○
ON	○	○					○	○
START	○			○	○		○	○


Lub oil cooler
Quick valve for turbocharger
Lub oil pressure regulating valve
Lub oil pressure regulating valve for turbo charger
Sea water inlet
Lub oil filter
Lub oil filter relief valve
Thermostat
Safety valve
By-pass Lub oil filter
Cooing sea water pump
Lub oil pump
Cooling fresh water cooler
(Optional)
Mixing elbow
Cooling fresh water pipe
Turbocharger
Thermostat
Fresh water tank
Fresh water pump
Lub oil strainer
To cylinder
Fuel injection valve
Fuel injection pipe
Air inter cooler
Main gallery
Fuel oil filter
Fuel injection pump
Fuel oil feed pump
Fuel oil inlet & leak off pipe
Leak off pipe line
From fuel oil tank
To fuel oil tank
To fuel oil tank
Fuel oil piping
Lube oil piping
Cooling sea water piping
Cooling fresh water piping

2 Disassembly and Reassembly

2.1 Preparations before Disassembly and Reassembly

2.1.1 Disassembly

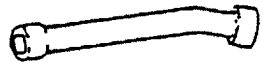
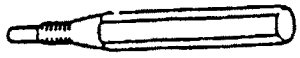
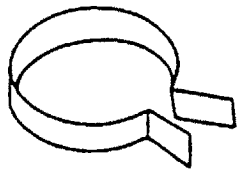
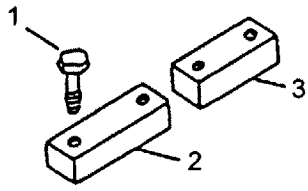
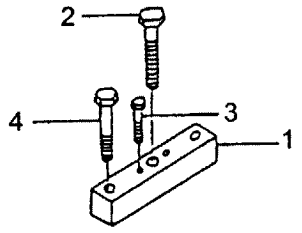
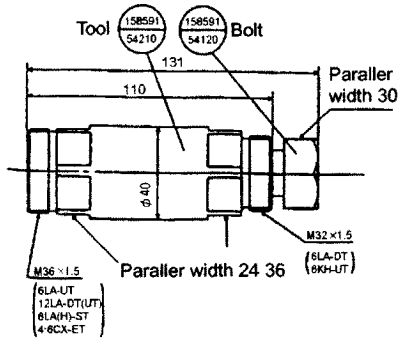
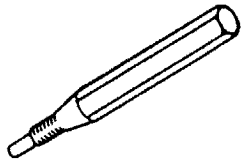
(1) Prepare the disassembly tools, measuring devices and record forms.
(2) Prepare the cleaning machine and cleaning cans.
(3) Prepare a place for putting parts and parts containers.
(4) Extract cooling water and lube oil.
(5) Put the disassembled parts in order.
(6) Return bolts and nuts to their original 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.

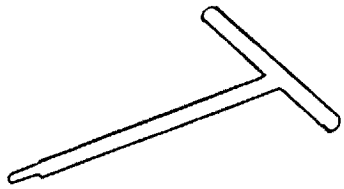
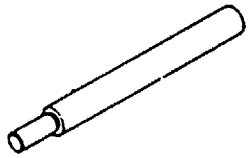
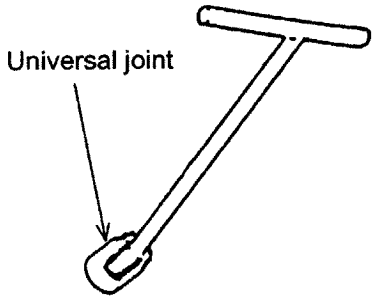
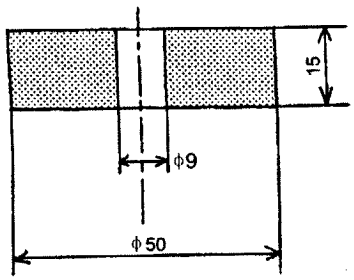
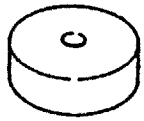
2.1.2 Reassembly

(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 alluminum 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 Tools and Agent

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 potitioning tool	1. Bolt (4pcs) 127610-92700 2. Spacers A 127610-92680 3. Spacers B 127610-92690	
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)	

Name of tool	Code No.	Shape
Protector puller	127695-92910	
Stem seal insertion tool	——	
Valve guide puller	——	
Exhaust manifold puller	——	
Fuel valve puller tool 127616-92500		

Measuring Device

Name	Quantity	Code No.	Using
Cap tester	RCT-2A	955000-055000	For testing the radiater and the cap.

Other Service Materials for Reference

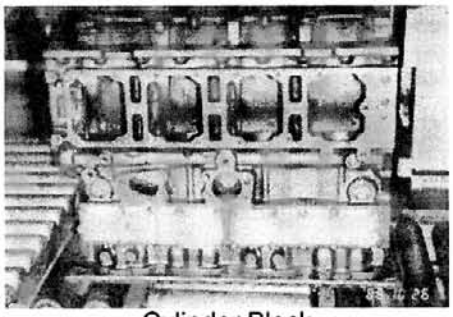
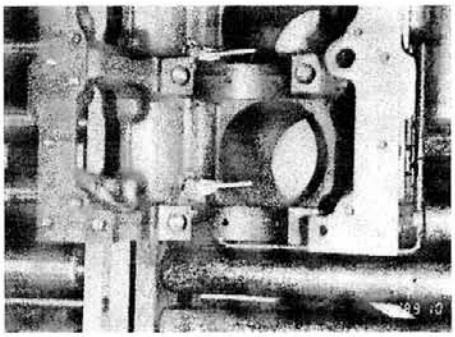
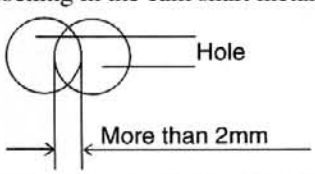
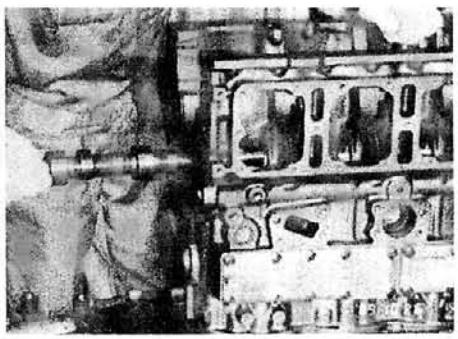
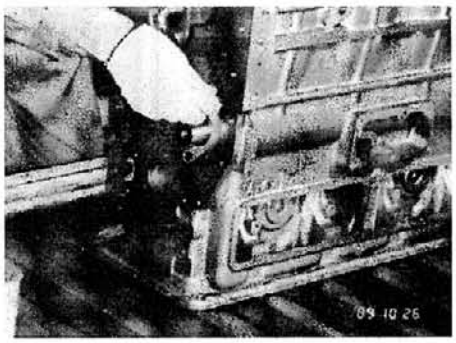
Items		Usual Contens	Features and application
Liquid gasket	Three Bond No.1 TB1101	200 g (1 kg also available)	Non-drying liquid gasket; solventless type, easy to remove, superior in seawater resistance, applicabel to various mating surfaces.
	Three Bond No.2 TB1102	200 g (1 kg also available)	Non-drying liquid gasket; easy to apply, superior in water resistance and oil resistance, especially superior in gasoline resistance.
	Three Bond No.3 TB1103	150 g	Drying film, low viscosity and forming of thin film, appropriate for mating surface of precision parts.
	Three Bond No.4 TB1104	200 g (1 kg also available)	Semi-drying viscoelastic material, applicable to non-flat surface having many indentations and protrusions, superior in heat resistance, water resistance, and oil resistance.
	Three Bond No.10 TB1211	100 g	Solventless type silicone-base sealant, applicable to high temperature areas. (-50°C to 250)
	Three Bond TB1212	100 g	Silicon-base, non-fluid type, thick application possible.
Adhesive	Loctite TB1401	200 g	Prevention of loose bolts, gas leakege, and corrosion. Torque required to loosen bolt: 10 to 20 % larger than tightening troque.
	Loctite SUPER TB1330B	50 g	Excellent adhesive strength locks bolt semipermanently.
Seal Tape		5 m round tape	Sealing material for threaded parts of various pipes. Ambient temperature range: -150°C to 200°C
EP lubricant (molybdenum disulfate)	Brand name (LOWCOL PASTE)	50 g	For assembly of engine cylinders, pistons, matels, shafts, ets. Spray type facilitates application work.
	Brand name (PASTE SPRAY)	330 g	
	Brand name (MOLYPASTE)	50 g	Prevention of seizure of threaded parts at high temperature. Applicable to intake and exhaust valves. (stem, guide, face)

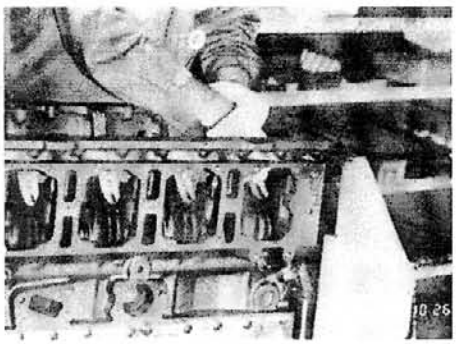
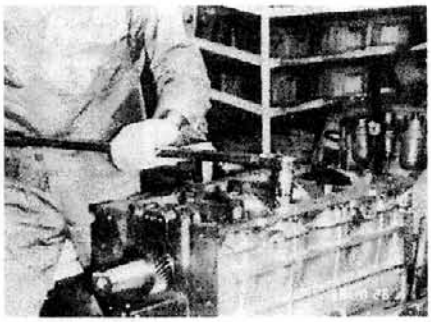
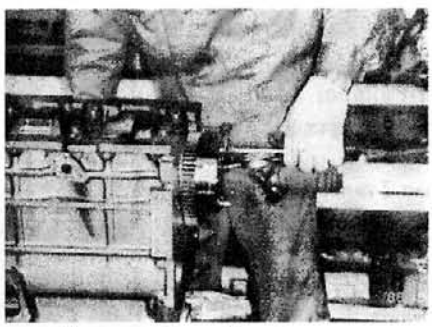
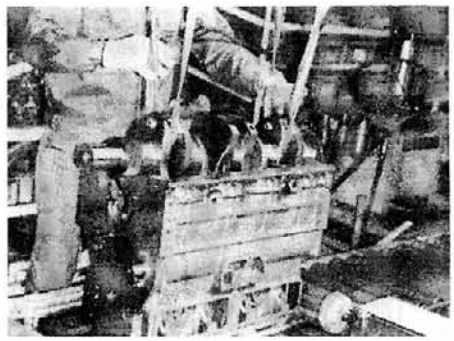
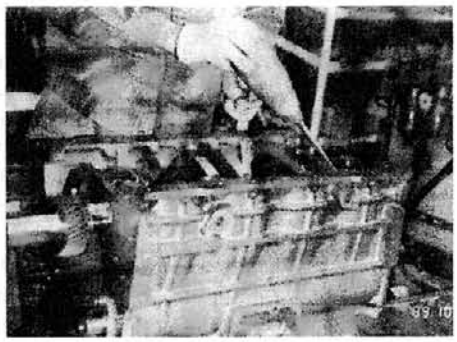
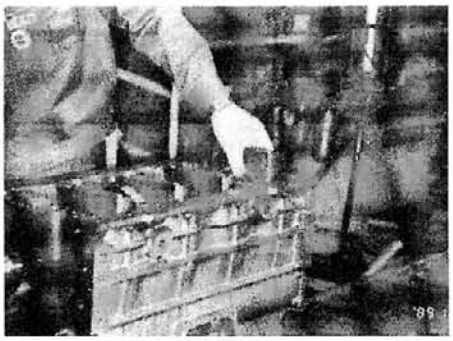
Caution

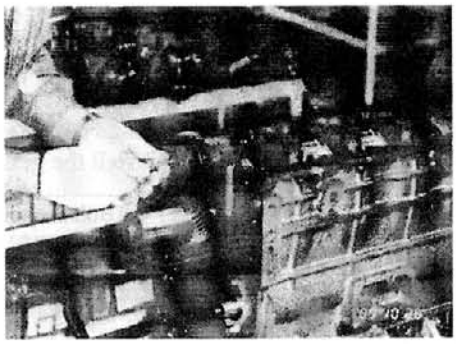
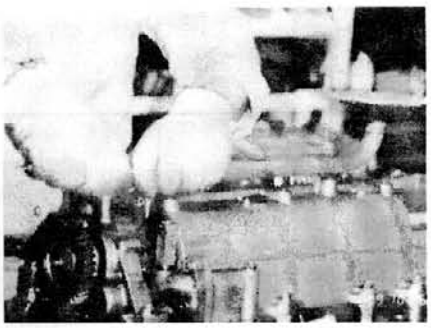
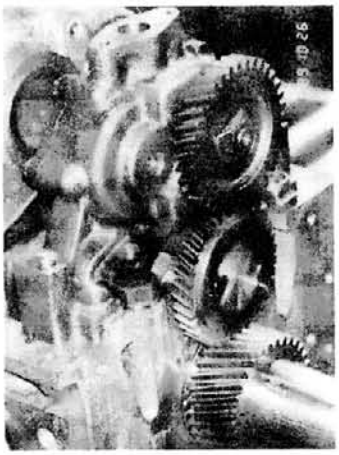
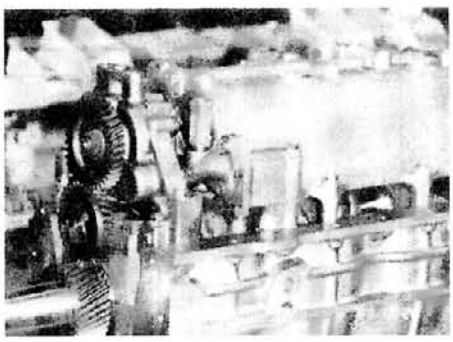
It is recommended that the liquid gasket of Three Bond TB1212 should be used for service work. Before providing service, observe the cautions below:

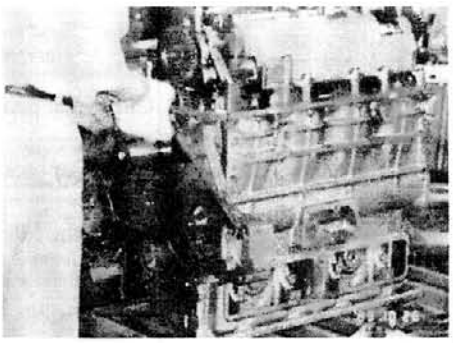
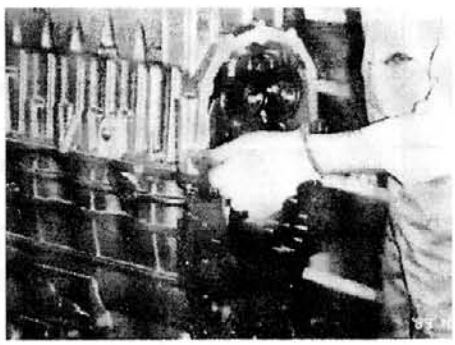
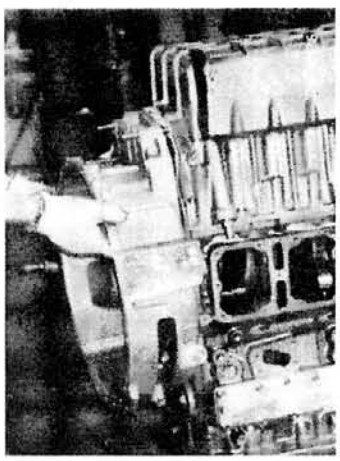
- Bulid up each gasket equally.
- For a bolt hole, apply liquid gasket to the inside surface of the hole.
- Conventionally, Three Bond TB1104 (gray) or Three Bond TB1102 (yellow) is used for paper packings though the use of only these bonds is not effective.
- If conventional packings are used, do not use a liquid packing.

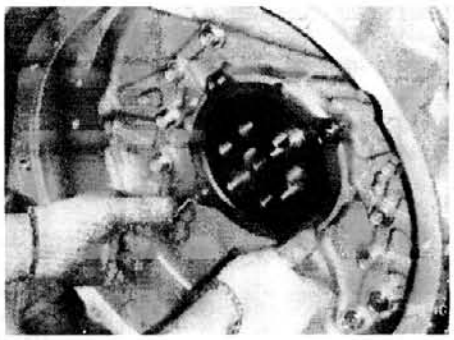
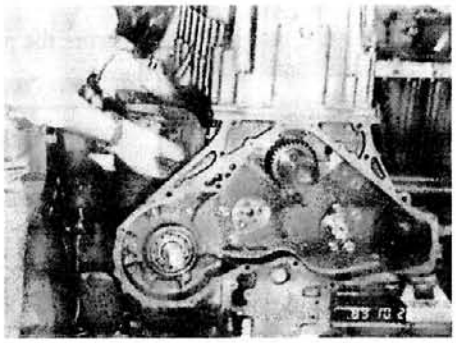
2.3 Reassembly Procedures

No.	Item	Procedure	Tool & Caution	Illustration
1	Cylinder Block	Clean the bearing holes comletely. Reverse the cylinder block before reassembly. T-plug 1/8 tightening torque: 4.9 N·m (0.5 kgf·m)	5	 Cylinder Block
2	Piston Cooling Nozzle	Install the nozzle correctly according to the positioning pin. Take care not to over-tighten the nozzle. Tightening torque: 19.6 N·m (2.0 kgf·m) 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.	17	 Piston Cooling Nozzle
3	Cam Shaft	Apply lube oil to the cam chaft journal. Insert the cam shaft. Install the thrust plate. Tightening torque: 25.5 N·m ($2.6^{\pm 0.2}$ kgf·m) Measure the side clearance. Side clearance: 0.10 - 0.25 mm Installation of cam shaft metal. Replace the cam shaft metal as follows: 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 2 mm 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.)  	12	 Cam Shaft  Installtion of the thrust metal

<table>
<tr><th>No.</th><th>Item</th><th>Procedure</th><th>Tool & Caution</th><th>Illustration</th></tr>
<tr><td>4</td><td>Cooling Water Passage Cover</td><td>Install the cooling water passage cover.</td><td>12</td><td> 
Fitting the upper bearing</td></tr>
<tr><td>5</td><td>Crankshaft and Main Bearing</td><td>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 the bolt to the specified tightening torque.
Turn manually to check that it turns lightly.
Measure the side clearance.
<table><tr><td>Cap bolt tightening torque</td><td>275±9.8 N·m ($28^{\pm 1.0}$ kgf·m)</td></tr><tr><td>Side clearance</td><td>0.155 - 0.296 mm</td></tr><tr><td>Crankshaft bearing oil clearance</td><td>0.04 - 0.108 mm</td></tr></table> 
Fitting the cap bolt
 
Measure the side clearance</td><td> 
 
24</td><td> 
Fitting the crank shaft
 
Apply lube oil
 
Fitting the bearing cap</td></tr>
</table>

No.	Item	Procedure	Tool & Caution	Illustration
6	Idle Gear (Lube Oil Pump)	Check the gear side clearance. Gear side clearance: 0.066 - 0.114 mm Check the gear backlash. Gear backlash: 0.08 - 0.16 mm Install the idle gear to the cap. Tightening torque: 14.7 - 19.6 N·m (1.5 - 2.0 kgf·m)		 Fitting the idle gear
7	Lube oil Pump	Install the lube oil assembly. Install the suction and discharge pipes. (Bolt head width 12) Tightening torque: 24.5±2 N·m ($2.5^{\pm 0.2}$ kgf·m) Check the gear backlash (to the crankshaft). Backlash for crank gear: 0.12 - 0.22 mm  Fitting to the suction pipe		 Fitting to the lube oil pump  Fitting to the Safety valve and dischanger pipe

No.	Item	Procedure	Tool & Caution	Illustration
8	Gear Case	Install the bolt for fixing the fuel pump and the stud bolt for fixing the seawater pump to the gaer case in advance. Match up the mounting surfaces of the oil pan. Align the positioning pin to the block and install the gear case. (Bolt head width 12) Tightening torque: 25.5±2 N·m ($2.6^{\pm 0.2}$ kgf·m) Cut off the protruding packing.	12	 Fitting the gear case
9	Oil pan	Bring the gear case level so that the packing will not break. (Use the fitting tool.) (Bolt head width 12) Tightening torque: 25.5±2 N·m ($2.6^{\pm 0.2}$ kgf·m) After tightening, cut off the packing protruding on the wheel housing side. **Note:** Apply THREEBOND to both side of the packing at the three-face joint of the gear case and flywheel side. Match up the installation faces of the wheel housing. Step of the joint face at the flywheel housing side: 0.1 mm	12	 Fit the oil pan useing the tool
10	Flywheel Housing	Assemble the flywheel housing according to the positioning parallel pin. Deviation at the oil seal insertion area: 0.2 mm Face deviation from the crankshaft center: 0.3 mm Flywheel housing tightening torque: 49 ± 5 N·m ($5^{\pm 0.5}$ kgf·m) Install the lube oil piping (flywheel housing-oil filter).		 Assemble the Fly wheel housing

No.	Item	Procedure	Tool & Caution	Illustration
11	Oil Seal Case	Press-fit the seal into the oil seal case (with the press-fitting tool). **Note:** Apply lube oil to the lip of the oil seal before press-fitting. Install the oil seal case assembly to the flywheel housing.	△ 12	 Assemble the oil seal case
12	Engin Foot	Install the engine foot.		 Install the engine foot
13	Reverse the cylinder block	Reverse the cylinder block.		
14	Tappet and Tappet Case cover	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.) Tappet hole oil clearance: 0.04 - 0.082 mm Install the tappet case cover after inserting all tappets. (Bolt head width 12) Tightening torque: 11.8 - 16.7 N·m (1.2 - 1.7 kgf·m)	12	 Tappet

<table>
<tr><th>No.</th><th>Item</th><th>Procedure</th><th>Tool & Caution</th><th>Illustration</th></tr>
<tr><td>15</td><td>Cylinder Sleeve</td><td>Clean the sleeve fitting area of the cylinder block completely.
Clean the outside circumference of the cylinder sleeve completely and insert it manualy into the cylinder block.

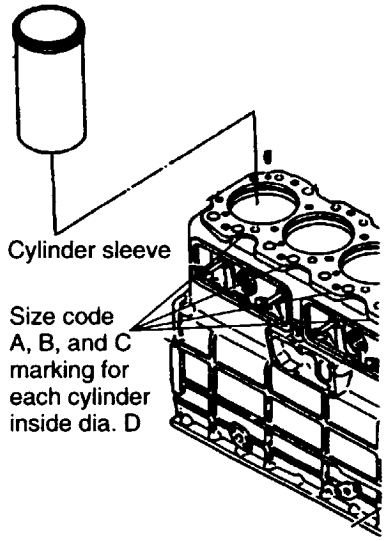
Note: Before inserting the cylinder sleeve, check the size code for each cylinder inside dia. D.
· Size code is for the cylinder sleeve.
· Make a combination of A, B, and C (see 3.4.3).
Do not place on the cylinder head face after inserting the cylinder sleeve.
Be sure to assemble the cylinder sleeve manually.
· Do not use a hammer.

Measure the protrusion of the cylinder sleeve.

Protrution: 0.03 - 0.09 mm

Measure the distortion of the cylinder sleeve.

Cylindricality: ≦ 0.03 mm

(The mark at the cylinder block side is punched on the head joint face of the operation side.)</td><td></td><td> 
</td></tr>
<tr><td>16</td><td>Idle Gear</td><td>Install the idle gear shaft. Direct the shaft's oil hole upwards.

Tightening torque: $49^{\pm 5}_{(5.0^{\pm 0.5}\ \text{kgf}\cdot\text{m})}$ N·m

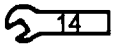
Install the idle gear.

Gear side clearance: 0.15 - 0.35 mm

Install the cam gear shaft.

Gear backlash: 0.08 - 0.16 mm
Gear side clearance: 0.10 - 0.25 mm

Use the puller tool to remove the cam gear. Install the fuel pump drive gear.

Tightening torque: 196 ± 9.8 N·m ($20^{\pm 1.0}$ kgf·m)</td><td> 
 
14
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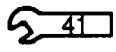
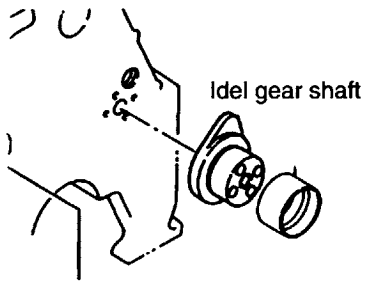
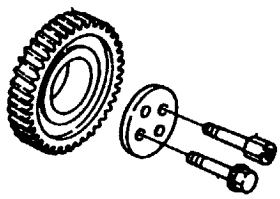
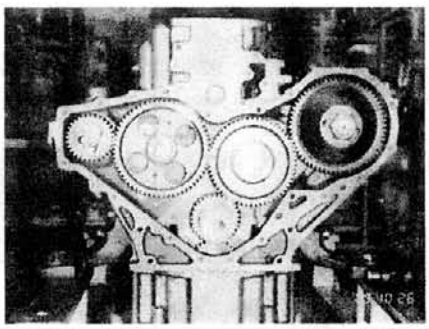
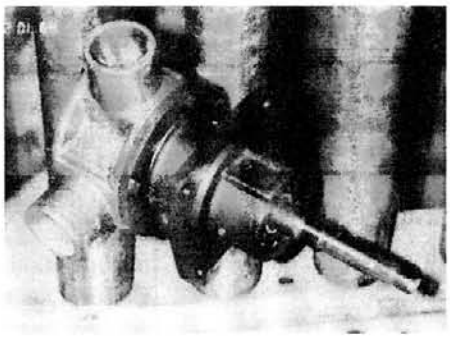
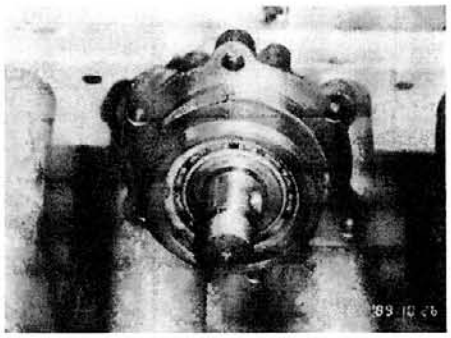
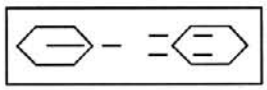
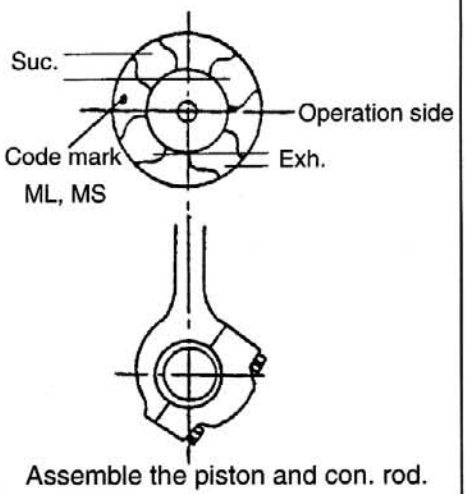
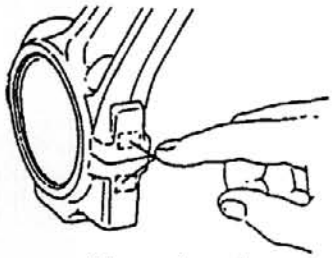
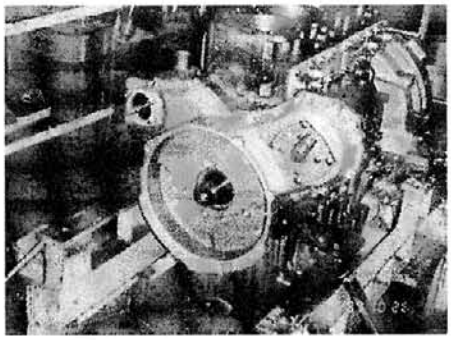
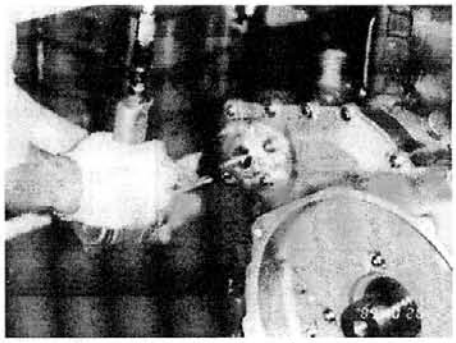
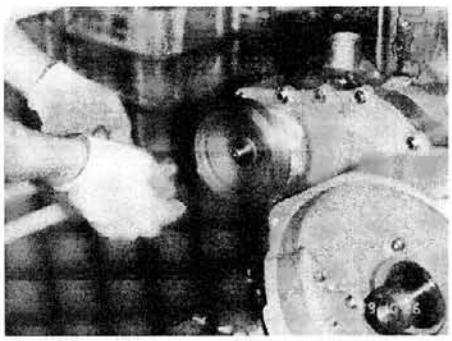
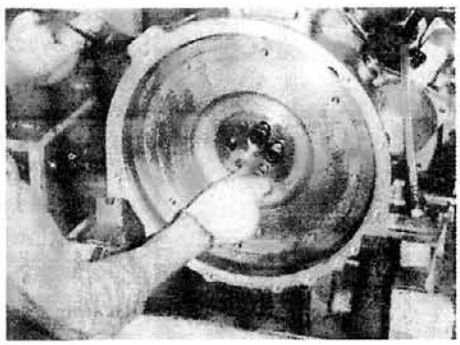
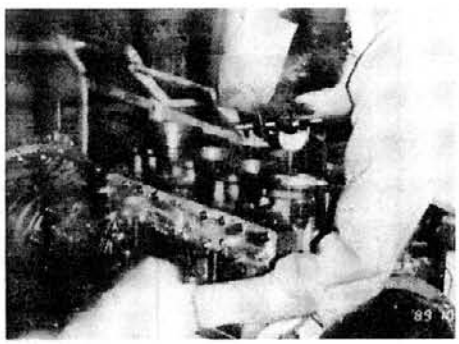
 
41</td><td> 

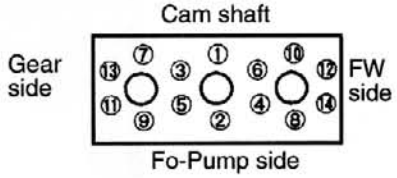
 
Idle gear</td></tr>
</table>

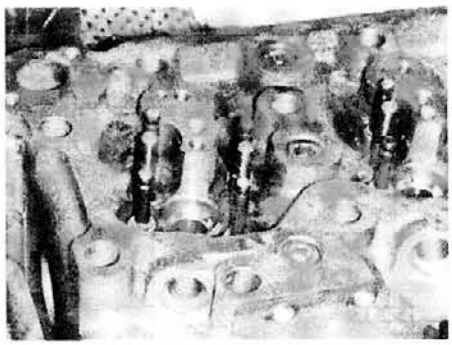
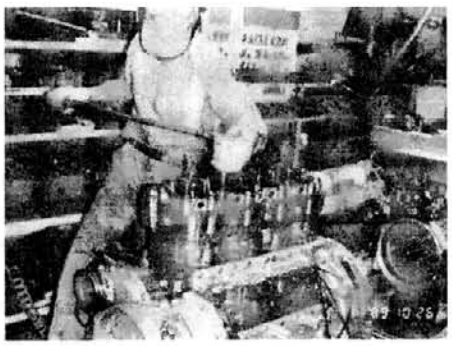
No.	Item	Procedure	Tool & Caution	Illustration
17	Sea water Pump	Install the sea water pump to the gear case, directing the oil receiving port upwards. Install the drive gear and tighten the nut to the specified tightening torque. Drive gear fixing nut tightening torque: 142 ± 4.9 N·m ($14.5^{\pm 0.5}$ kgf·m) Install the fuel pump driving bearing case assembly to the gear case. Gear backlash: 0.08 - 0.16 mm  Match up the alignment marks of gear at the same time.	12 • 30	 Sea water pump  Fuel pump driving bearing case

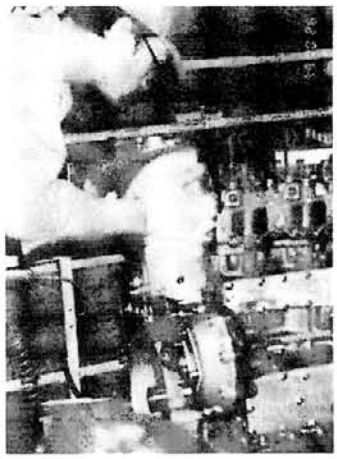
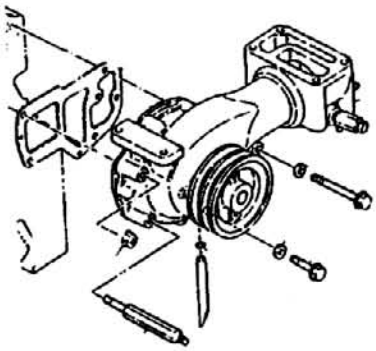
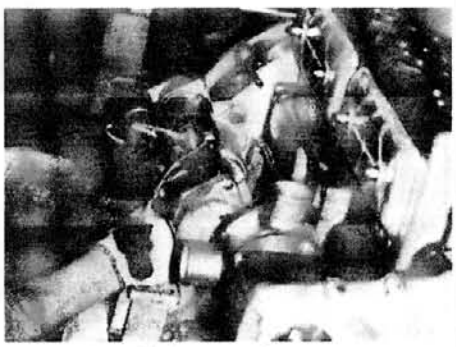
<table>
<tr><th>No.</th><th>Item</th><th>Procedure</th><th>Tool & Caution</th><th>Illustration</th></tr>
<tr><td>18</td><td>Piston and Connecting Rod</td><td>Assemble the connecting rod to the piston. The size code, ML or MS, is provided on the piston head. Match up the code with the correctly code of 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.
<table><tr><td>Tightening torque</td><td>226±5 N·m
(23$^{\pm 0.5}$ kgf·m)</td></tr></table>
Measure the side clearance after tightening the bolts.
<table><tr><td>Rod large end side clearance</td><td>0.15 - 0.35 mm</td></tr></table>
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.)
  </td><td>  </td><td> 

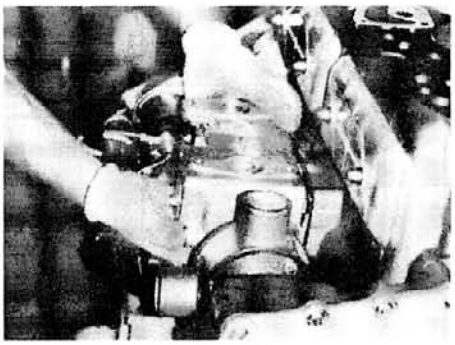
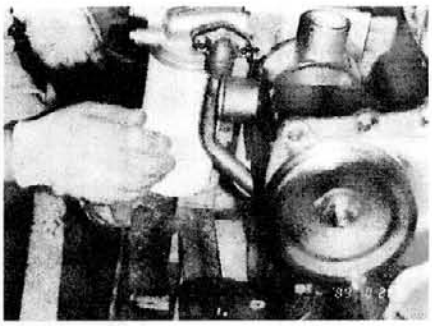
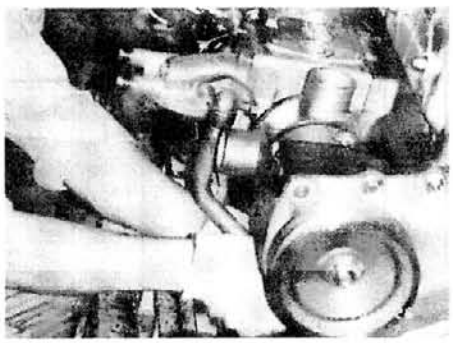
Assemble the piston and con. rod.
 
Aligment mark
 
Fitting the side cover
 
Fitting the gear case cover</td></tr>
<tr><td>19</td><td>Gear Case Cover</td><td>Install the oil seal to the gear case.
<table><tr><td>Note:</td><td>Apply lube oil to the exterior and lip of the oil seal before press-fitting it.</td></tr></table>
Install the gear case cover.
<table><tr><td>Note:</td><td>The positioning pin (spring pin) is provided at the joint face of the gear case and cylinder block.</td></tr></table>
Measure the face deviation of the front drive installation.
<table><tr><td>Face deviation</td><td>Less than 0.05 mm for crank center</td></tr></table></td><td></td><td></td></tr>
</table>

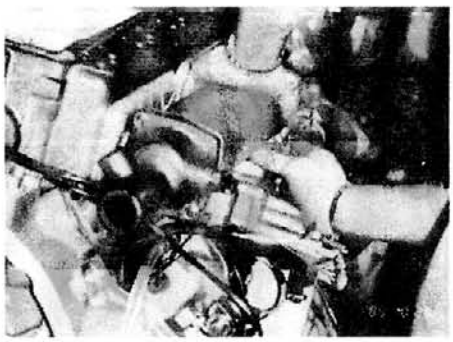
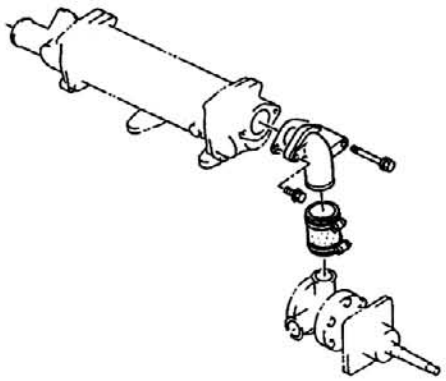
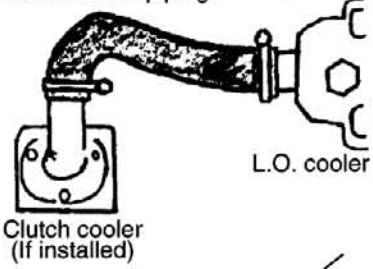
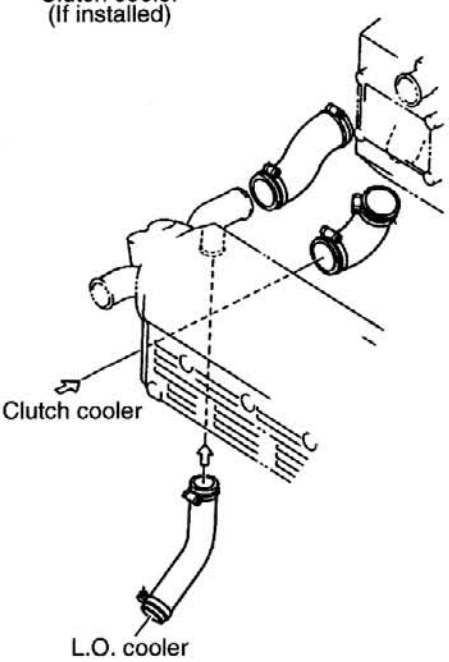
No.	Item	Procedure	Tool & Caution	Illustration
20	Bearing Case	Install the sea water pump drive bearing case. Install the V-pulley. Bend the washer after tightening the nut. Install the breather.		 Assemble the bearing case  Install the V-pulley
21	Flywheel	Install the flywheel. (Align the positioning parallel pin holes.) Tighten the bolts to the specified tightening torque. (Apply engine oil to the thread and seat) Tightening torque: 284 ± 10 N·m ($29^{\pm 1}$ kgf·m) Measure and check the flywheel face deviation and centering location deviation. Face deviation: Less than 0.13 mm 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.		 Assemble the flywheel  Check the No.1 cyl. top.

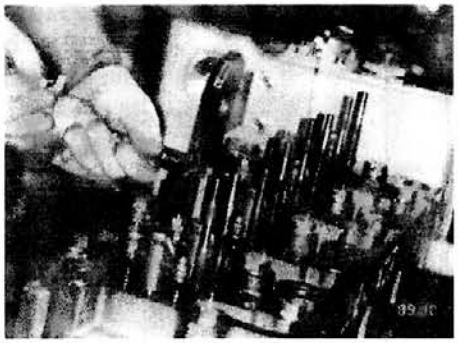
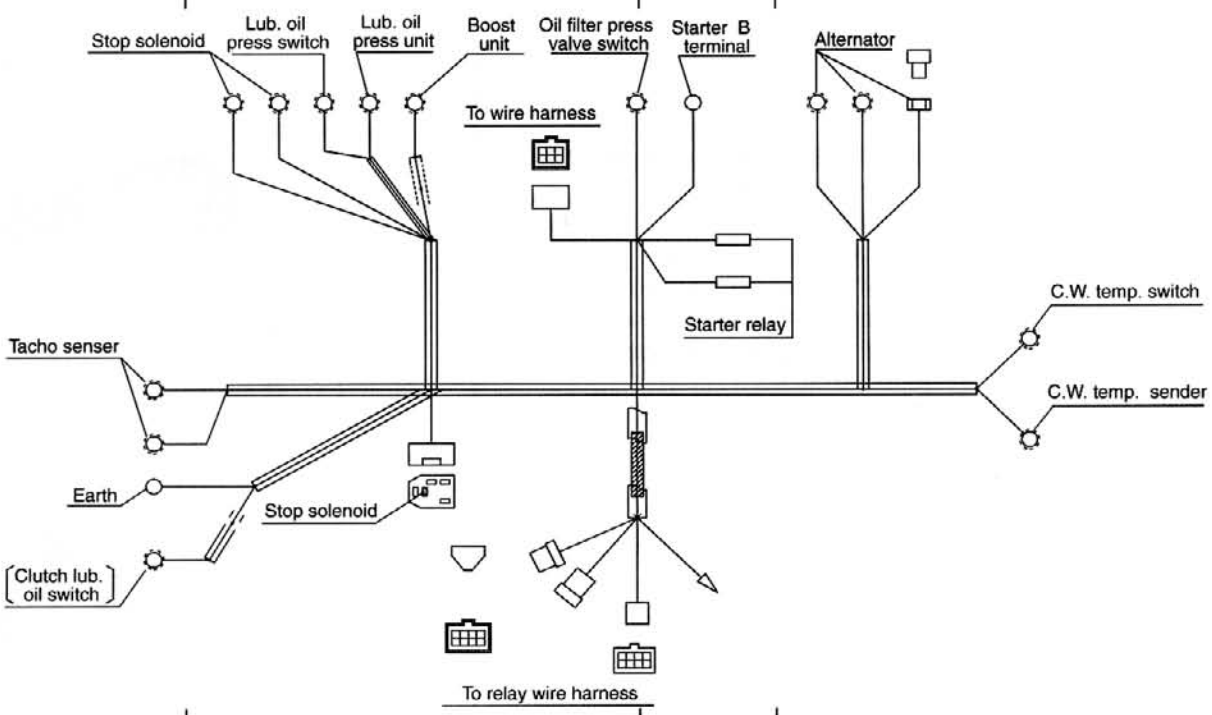
<table>
<tr><th>No.</th><th>Item</th><th>Procedure</th><th>Tool & Caution</th><th>Illustration</th></tr>
<tr><td>22</td><td></td><td>Install the injection timing adjustment and turning window covers.
1) Adjust the injection timing with the governor control level at its max. position (pump rack's max. scale).
2) After adjusting the fuel timing, punch an injection alignment mark aligned with the punched scale on the flange side mounting of the fuel pump.
3) Install the turning window cover.
<table><tr><td>Tightening torque</td><td>49±4.9 N·m
(5$^{\pm 0.5}$ kgf·m)</td></tr></table>
<table><tr><td>Injection timing</td><td>13 ± 1°</td></tr></table></td><td>14
•
24</td><td> 
Indication plate</td></tr>
<tr><td>23</td><td>Breather</td><td>Install the breather.</td><td></td><td></td></tr>
<tr><td>24</td><td>Cylinder Head</td><td>Valve sink: Intake 0.2 mm, Exhaust 0.2 mm.
Install the head gasket according to the positioning pin.
Lift the cylinder head level and install it according to the positioning pins (spring pins) (4 pcs.).
Apply lube oil to the threads and seat of the head bolts and tighten them 3 times to the specified tightening torque in the proper tightening order.
<table><tr><td>Tightening torque</td><td>245±4.9 N·m
(25$^{\pm 0.5}$ kgf·m)</td></tr></table>
(Procedures for the head bolts.)
Measure the top clearance.
<table><tr><td>Top clearance</td><td>0.95$^{\pm 0.09}$ mm</td></tr></table>
(Head gasket tightening torque and tightening order)
 

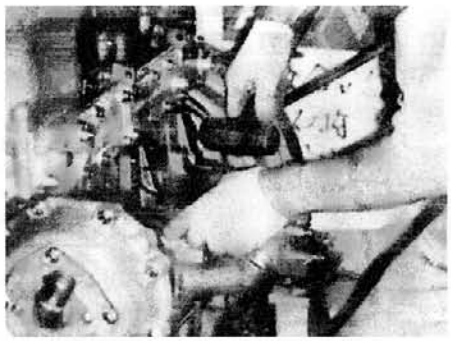
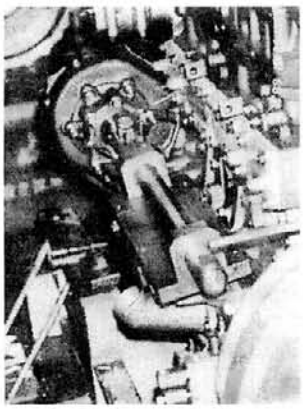
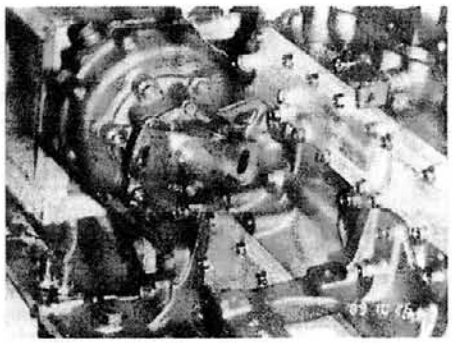
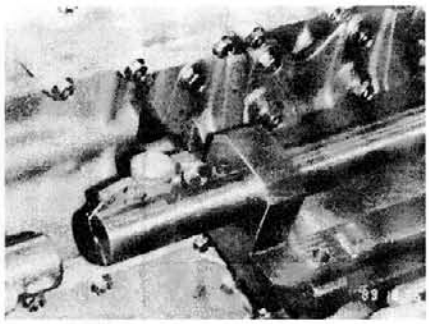
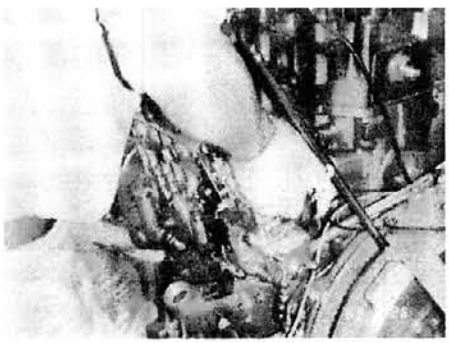
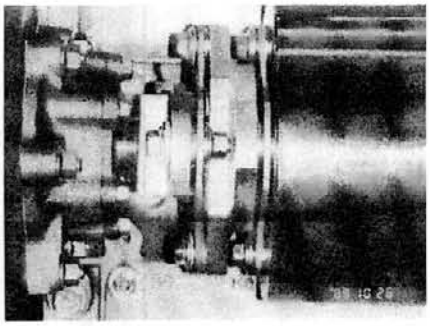
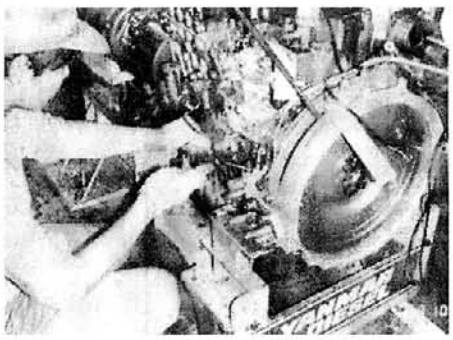
Install the fuel return pipe joint.</td><td>△
22</td><td> 
Cylinder head
 
Tightening of the cyl. head</td></tr>
</table>

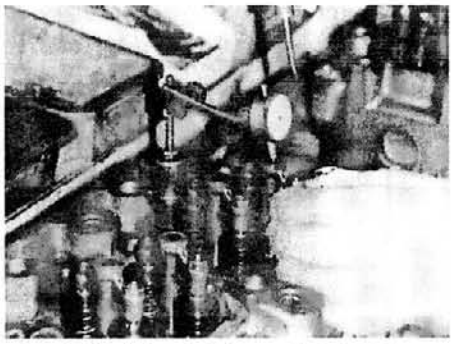
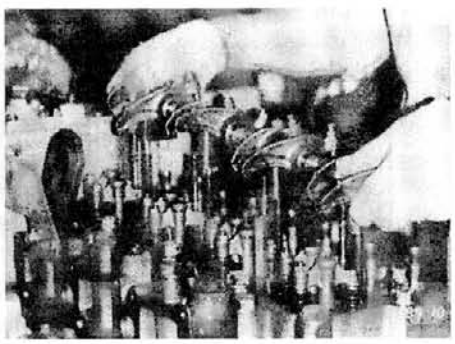
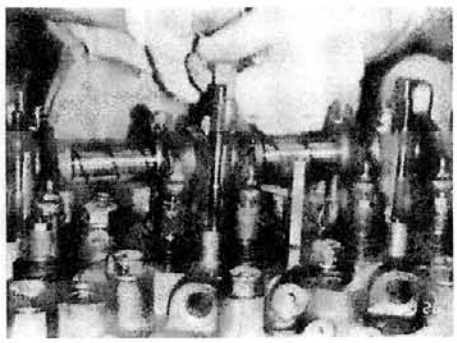
No.	Item	Procedure	Tool & Caution	Illustration
25	Fresh water Tank	Install the fresh water tank to the freshwater pump. Tightening torque: 25.5 ± 2 N·m ($2.6^{\pm 0.2}$ kgf·m) Install the stay of the fresh water tank.	12	 Install the freshwater tank
26	Fresh water Pump	Install the fresh water pump assembly to the cylinder block. Install the thermostat to the fresh water pump body. Thermostat valve opening temperature: 71°C. Full-open lift test temperature: 85°C.	△ 12	 Freshwater pump
27	Starting Motor	Install the starting motor to the flywheel housing. Tightening torque: 88 ± 4.9 N·m ($9^{\pm 0.5}$ kgf·m)	17	 Install the starting motor

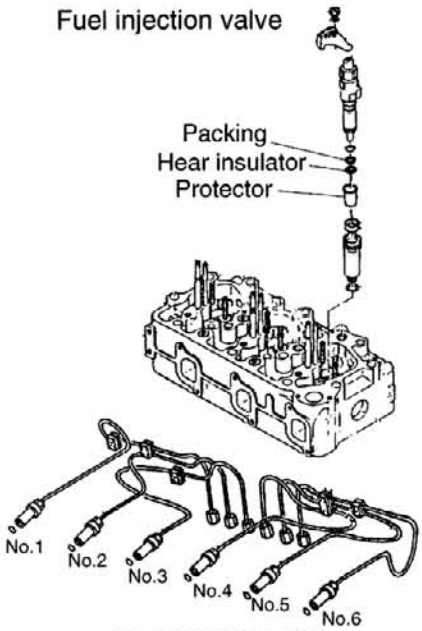
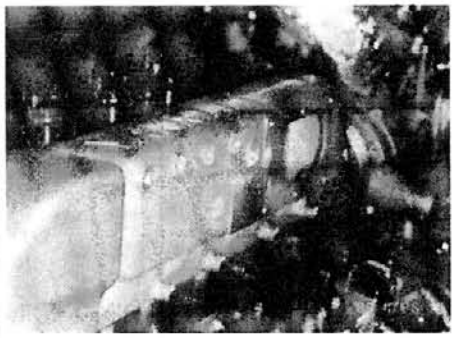
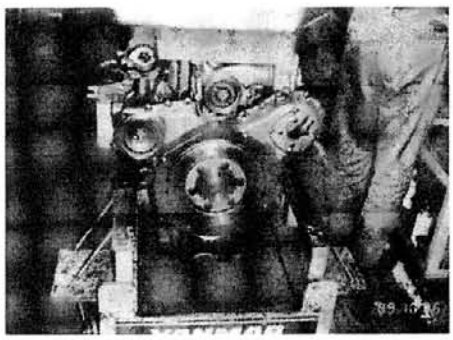
No.	Item	Procedure	Tool & Caution	Illustration
28	Lube Oil Pipe and Lube Oil Filter	Install the lube oil filter mount to the cylinder block.		 Install the lube oil filter mount
		Install the lube oil piping (Lube oil filter-flywheel housing). Install the lube oil piping (Lube oil filter-cylinder block). Install the filter.		 (Lube oil filter-flyweel housing)
		 (Install the filter)		 (Lube oil filter-cylinder block)

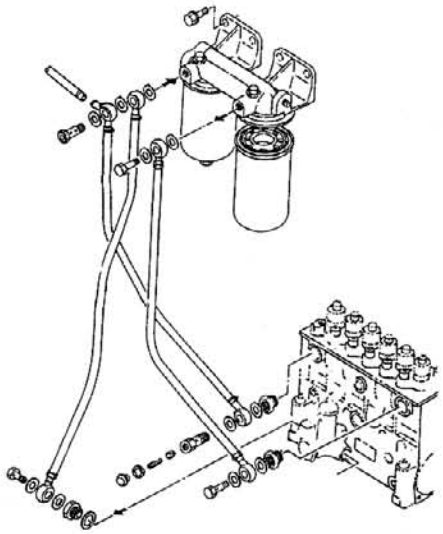
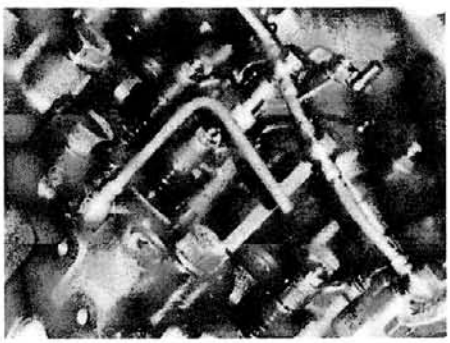
No.	Item	Procedure	Tool & Caution	Illustration
29	Lube oil Cooler	Install the oil cooler assembly to the oil cooler mount. (Install the elbow of the lube oil pipe filter and union lube oil pipe to the filter in advance.)	12	 (Install the oil cooler assembly)
30	Cooling Water Pipe	Install the cooling water piping (sea water pump-lube oil cooler). Install the cooling water piping (LO cooler-Marine gear cooler). Install the cooling water piping (Marine gear cooler-intercooler). Install the cooling water piping (intercooler-fresh water cooler). Install the cooling water piping (lube oil cooler-fresh water cooler).		 Do not bend the piping.  

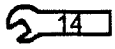
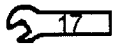
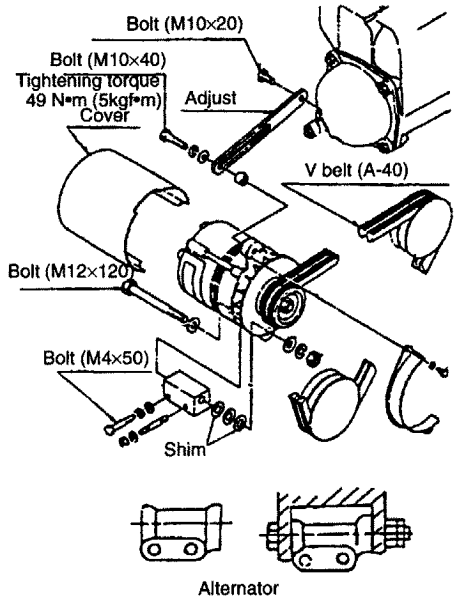
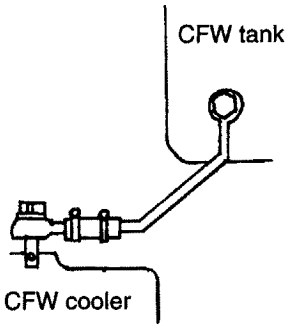
No.	Item	Procedure	Tool & Caution	Illustration
31	Engine Lift Fixture	Install the engine lift fixture.		 Install the engine lift fixture
32	Wire Harness	Install the wire harness (engine side): **Note:** • Beware of the heated area of the exhaust and bend pipes as well as the moving parts when wiring. • Refer to the electrical wiring diagram and ensure correct terminal connections.	 12	

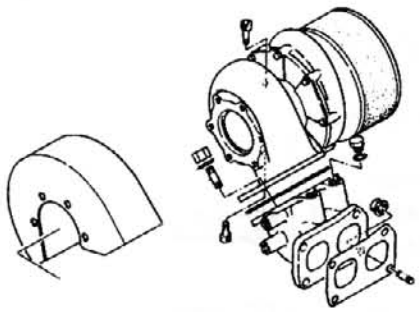
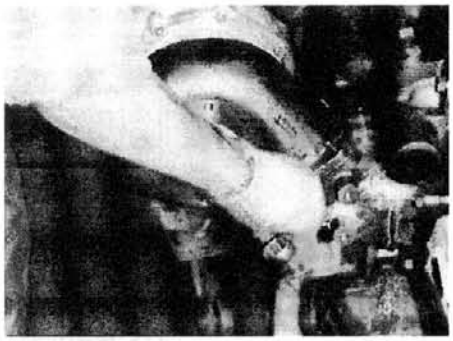
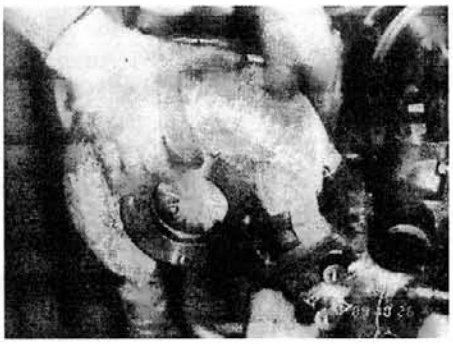
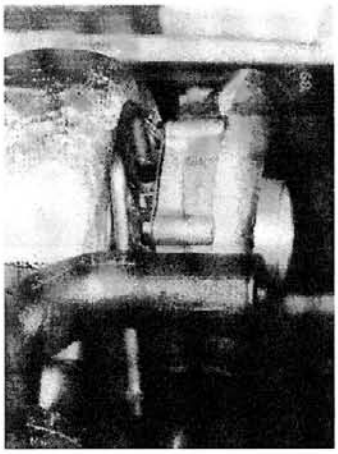
No.	Item	Procedure	Tool & Caution	Illustration
33	Fuel Pump	Install the fuel pump mount to the cylinder block. (Axial deviation TIR within 0.3; deviation angle within 30 degrees) (TIR: Total Indicator Reading) Insatll the fuel injection pump. Install the lube oil piping (cylinder block-fuel pump). **Caution:** Do not overtighten the block or it may crack. Union tightening torque: 4.9 - 9.8 N·m (0.5 - 1 kgf·m)		 Fuel pump mount
		 Tool for centering	12 17	 Assemble the flexible coupling
		 Measure the center		 Assemble the fuel pump
		 Timer and flexible coupling		 Install the lube oil pipe

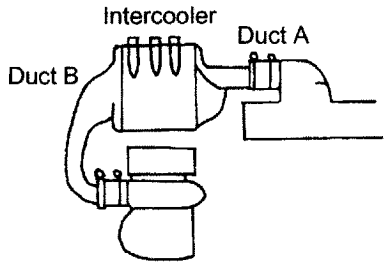
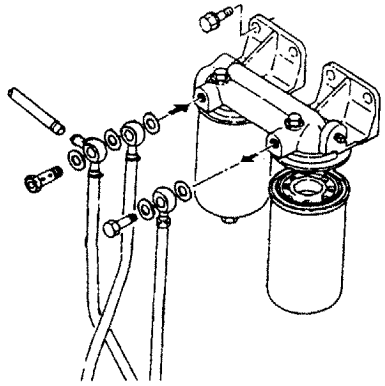
No.	Item	Procedure	Tool & Caution	Illustration
34	Intake/Exhaust Rocker Arm (Assembly)	Install the valve bridge. **Note:** · The installation range of the rocker arm shaft mount is 180 degrees. If the mount is installed in reverse, the valve head position will be varied. (See fig. at the right.) · Check the performance of the intakel exhaust valve. Adjust the valve bridge adjust bolt, and tighten the set nut. Fit the push rod to the dent in the tappet. Adjust the valve clearance. Valve clearance: Intake 0.25 mm, Exhaust 0.4 mm Tightening torque: 19.6 N·m (2.0 kgf·m) Install the intake/exhaust rocker arm (assembly). Rocker arm a'ssy Tightening torque: M8 bolt 25.5 ± 4.9 N·m (2.6 ±0.5 kgf·m); M10 bolt 39.2 ± 4.9 N·m (4 ±0.5 kgf·m)	14 17 12 14	 Adjust the bridge valve head  Assemble the push rod  Assemble the rocker arm a'ssy  Adjust the valve clearance

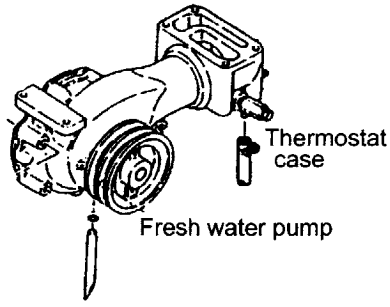
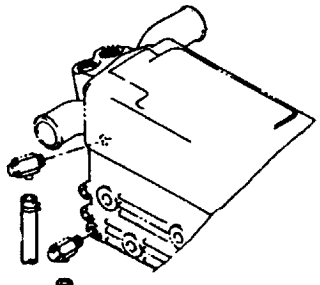
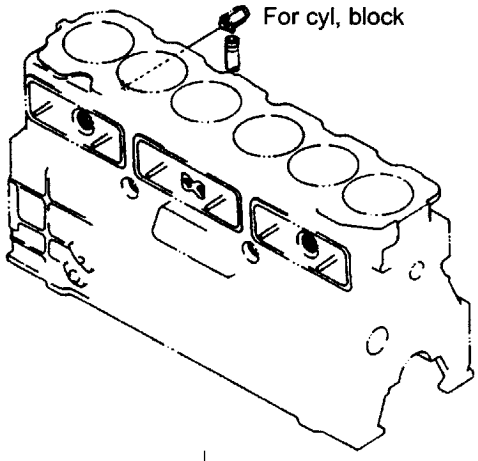
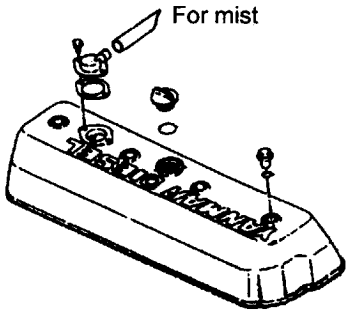
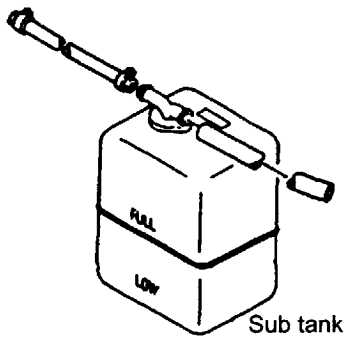
No.	Item	Procedure	Tool & Caution	Illustration
35	Fuel Injection Valve and Pipe	Put in the protector and adiabatic material and install the fuel injection valve to the cylinder head. Fuel valve retainer tightening torque: 31.4 ± 2 N·m ($3.2^{\pm 0.2}$ kgf·m) **Note:** · Provisionally tighten the fuel injection pipe joint unit it contacts with the fuel valve seat to a tightening torque of 2.5 - 3.0 kgf·m. Then, the fuel injection valve and the fuel injection pipe joint. · Apply molybdenum disulfide to both the outside and the inside circumferences of the protector before inserting it. Install the fuel injection pipe. Tightening torque: 34 N·m (3.5 kgf·m) Install the fuel return pipe. Install the rocker arm cover.	12 • 19	 Fuel injection pipe
36	Exhaust mainfold	Install the exhaust manifold.		 Install the exhaust manifold.
37	Viscous damper	Insatll the viscous damper.		 Viscous damper

No.	Item	Procedure	Tool & Caution	Illustration
38	Cooling Water Pipe (Fresh Water)	Install the piping between the exhaust manifold and the fresh water tank. Insatll the piping between the head and the fresh water cooler.	12	
39	Fuel Piping	Install the piping between the feed pump and the filter. Install the piping between the filter and the injection pump. Install the feed pump inlet piping.	12	
40	Fuel return piping	Install the fuel return piping.		 Fuel return piping

No.	Item	Procedure	Tool & Caution	Illustration
42	Alternator	Install the alternator. Install the alternator mount to the gear case. Tightening torque: 78.5 - 88.3 N·m (8 - 9 kgf·m) (Adjust the clearance between the alternator and the mount to 0.05 - 0.15 mm by the adjust shims and tighten.) Adjustment procedures 1) Install one end of the adjuster to the fresh water cooler side. 2) Install the other end of the adjuster to the alternator tentatively. 3) Adjust the pully with the shims. 4) Install the V-belts (2 pcs.) and adjust the tension with the adjuster. Flection distance: 10 mm	  	
43	Fresh water air venting pipe	Install the fresh water air venting pipe.		

No.	Item	Procedure	Tool & Caution	Illustration
44	Exhaust manifold, Exhaust bend and Turbocharger	Install the turbocharger mount to the exhaust manifold. Install the turbocharger. (Installing the turbochager body) Install the turbocharger cover. (Installing the insulator) Install the lube oil pipe to the turbocharger. (Inlet pipe, outlet pipe) Install the exhaust bend. 		 Install the turbocharger  Install the turbocharger cover  Install the lube oil pipe

No.	Item	Procedure	Tool & Caution	Illustration
45	Intercooler and Intake Connecting Pipe	Install the intercooler. Insatll the intake connecting pipe. (Ducts A, B) (Duct A, Duct B)	12 • 14	
46	V-belt cover	Install the V-belt cover.	12	
47	Fuel filter	Install the fuel filter assembly. 	12 • 17	

No.	Item	Procedure	Tool & Caution	Illustration
48	Drain Pipe	Draining the cyl. block (install the vinyl pipe). Fresh water pump (install the vinyl pipe). Sea water pump (install the vinyl pipe). Sub tank (install the vinyl pipe). Thermostat case.		    

3 Inspection and Servicing of Major Engine Parts

Preparations

(1) Clean all parts completely to remove dust, carbon, oil, scale, etc.
(2) Blow compressed air through oil holes to remove dust and check that there's no packing in the oil holes.
(3) Remove carbon from the cylinder head, intake/ exhaust valve, etc. Take care not to damage these parts when removing the carbon.
(4) Put in order the parts that have a definite combination.

Standard for Replacing (Repairing) Parts

Measure each part and check it according to the respective inspection procedures. If the part is defective or exceeds the wear limit, replace it. Also replace any part which is expected to exceed the wear limit by the next inspection even if it is within the wear limit now.

3.1 Cylinder Head

The 3-cylinder integrated type cylinder head has outstanding durability and high rigidity.
The unique Yanmar intake port and intake valve in the cylinder head give superb combustion performance.

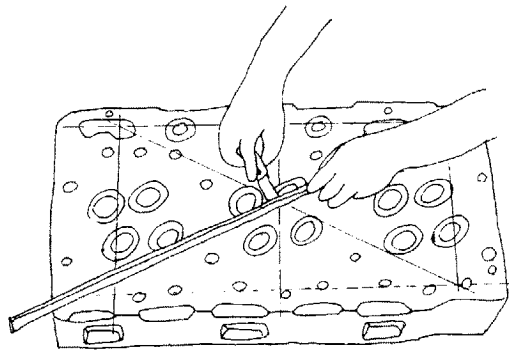
3.1.1 Inspection of Cylinder Head

(1) Distortion of Combustion Surface
Distortion causes head gasket breakage and compression leakage. Check and repair as follows:
1) Clean the cylinder head face.
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 the thickness gauge.

(mm)

	Standard dimension	Allowable limit
Distortion of cylinder head	0.05	0.15

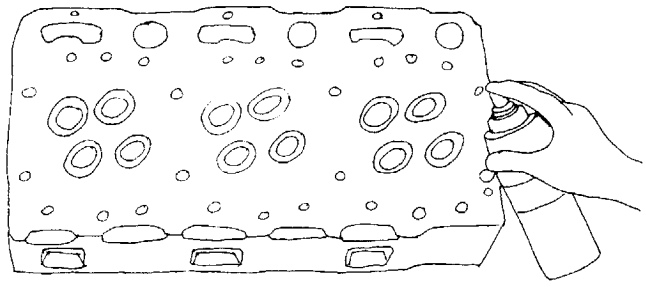
- When the clearance deviates from the allowable limit, either repair or replace the part.



Measure the combustion side

(2) Color Check of Combustion Surface

- Remove the fuel valve and intake/exhaust valves.
- Clean the combustion surface and check for the discoloration and distortion.
- Check for any cracks with the dyeing flaw detection agent(color check).



(Color check)

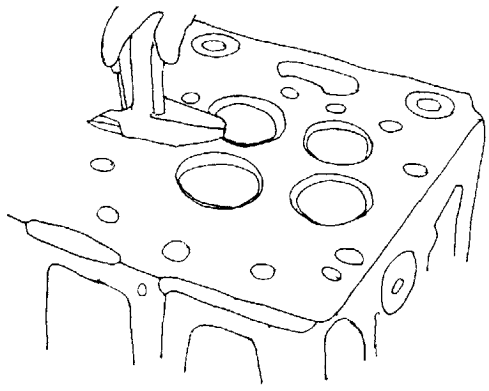
(3) Intake/Exhaust Valve Seat

- Stellite is welded to the valve seat to boost wear-resistant characteristics. Check the seat surface. If the width is too large, or the surface is too coarse, repair.

Seat deg.	Intake	120°
	Exhaust	90°

(mm)

Seat width	Intake	1.73
	Exhaust	2.12

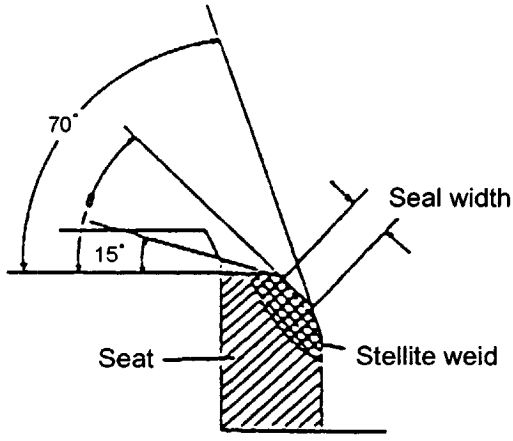


(Seat width measurement)

Valve Seat Repair Procedures:

- Repair the surface roughness of the seat with the seat grinder. Seat repair angle, Stellite weld, Seat width measurement
  Intake side grinder . . . . .Angle 30 degrees
  Exhaust side grinder . . . .Angle 45 degrees
- The valve seat width is extended after use.Grind the seat surface with the 70-degree grinder, and finish the seat surface to the standard dimension with the 15-degree grinder.

	θ
Intake	30°
Exhaust	45°

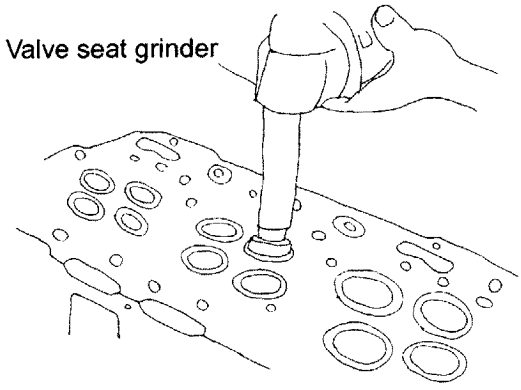


(Seat repair angle)

Note: Before repairing the seat surface be sure to check the clearance between the valve and valve guide. If the clearance exceeds the limit, replace the valve or valve guide first.

- Knead the valve compound with oil, and lap the valve with the compound.
- Lap the valve with only oil for finishing.

Note: After the valve seat repair is completed, clean the valve and cylinder head completely with gas oil to remove valve compound and grinding powder.



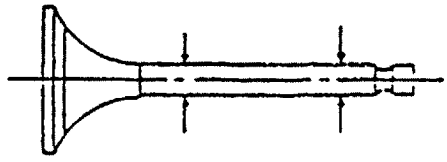
Lapping valve seat

3.1.2 Intake/Exhaust Valve and Valve Guide

(1) Measure the clearance between the intake/exhaust valve stem and valve guide. If the clearance exceeds the limit, replace the valve and valve guide.

(mm)

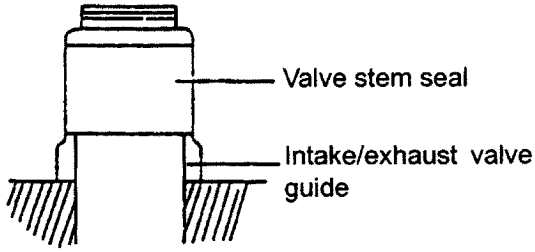
		Standard dimension		Standard clearance	Max. allowable clearance	Limit
		dia.	Dimensional tolerance			
Intake	Stem out-side dia.	ϕ8	-0.035 -0.047	0.035 - 0.062	0.2	7.9
	Valve guide inside dia.		0 +0.015			8.1
Exhaust	Stem out-side dia.	ϕ8	-0.040 -0.052	0.040 - 0.067	0.2	7.9
	Valve guide inside dia.		0 +0.015			8.1



Measring point

Note: The valve stem seal is assembled to the intake/ exhaust valve guide. If this is removed once, this can't be reused. In such cases, replace the part.

(2) The intake and exhaust valves have a similar shape. Do not mistake the one for the other:
- Intake valve has "S" mark, while the exhaust valve has "E" mark.
- Inside of the intake port is cut for the intake valve.

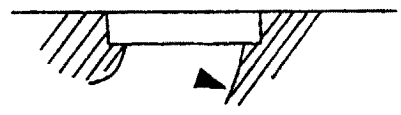


(Stem seal)

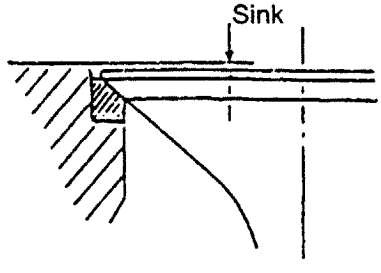
(3) Valve Sink
After a long use and valve lapping several times, the valve sinks and the combustion performance drops. Measure the valve sink, and replace the valve and seat if the sink is excessive.

(mm)

Valve sink	Standard dimension	Allowable limit
Intake	0.2 ± 0.1	0.9
Exhaust	0.2 ± 0.1	0.9



Cut point for intake point

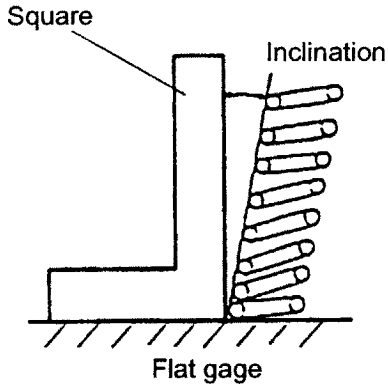


(Valve sink)

3.1.3 Valve Spring

(1) Inspection of Valve Spring

- Check for any flaws or corrosion in the spring.
- Measure the free length of the spring.
- Measure the side inclination of the spring using square.
- Measure the spring force if the tester is available.



(mm)

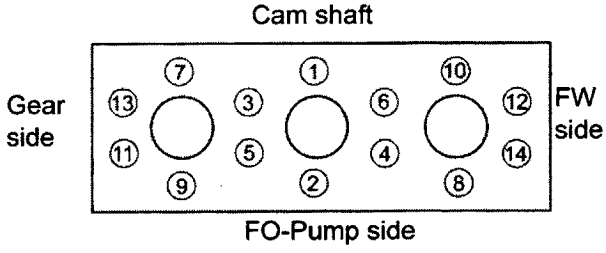
	Standard dimension	Allowable limit
Inclination	———	1.3
Free length	45	———
Spring force (at 1mm compression)	17.9 N (1.83 kgf)	———

3.1.4 Installation of Cylinder Head

Tighten the head bolts to the specified tightening torque acoording to the tightening order. Take care not to distort the cylinder head.

Tightening Procedures:

- Apply lube oil to the threads and seat face of the bolts.
- Tighten the bolts 3 times in the tightening order.



Cylinder head bolt tightening order

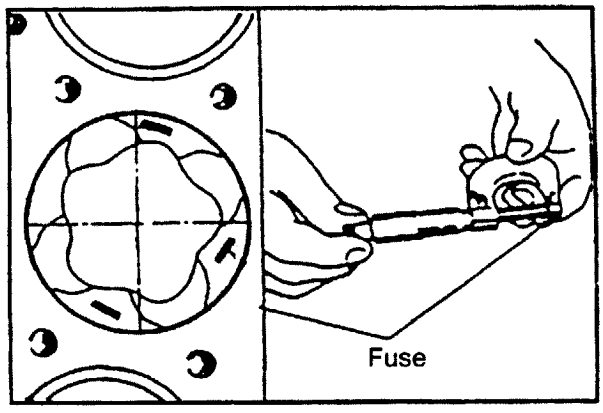
N·m (kgf·m)

	1st time	2nd time	3rd time
Tightening torque	118 ± 2.5 (12 ± 0.25)	177 ± 4.9 (18 ± 0.5)	245 ± 4.9 (25 ± 0.5)

3.1.5 Measurement of Top Clearance

(1) Measureing Procedures

- Place 3 pcs. of quality fuse (ϕ1.5,10mm length) on the piston head.
- Install the head gasket and cylinder head and tighten the bolts to the specified tightening torque.
- Turn the crank (in the operational direction) to depress the fuse.
- Take out the fuse, measure the depression and obtain the average value of the three fuses.



(How to place the Fuse)

(mm)

Top clearance	0.95 ± 0.09

Caution

The thickness of the standard head gasket is 1.5mm. The following gasket is also available for adjustment use.

Thickness	Part code	ID mark
1.4 mm	127695-01340	14
1.5 mm	127695-01350	15
1.6 mm	127695-01360	16

3.1.6 Intake/Exhaust Valve and Valve Arm Mount

(1) Inspection of Valve Arm and Mount

- Blow compressed air through the oil hole.
- Repair or replace the damaged or worn part. Measuring the valve arm bush valve arm shaft clearance

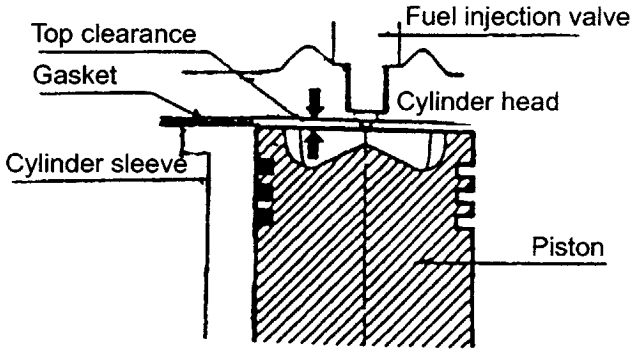
(mm)

	Standard dimension	Allowable limit
Shaft outside dia.	19.967 - 19.980	19.90
Bush inside dia.	20.0 - 20.021	20.083
Oil clearance	0.020 - 0.054	0.15

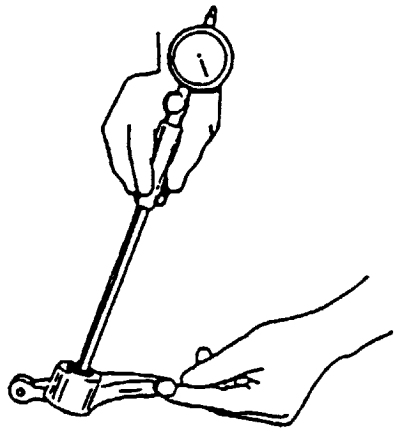
3.1.7 Adjustment of Intake/Exhaust Valve Clearance

Check the clearance every 300 hours operation and on disassembly and reassembly, and adjust when necessary.

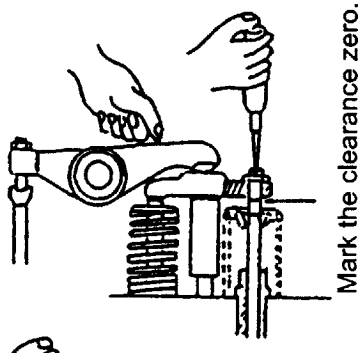
a) Adjust while the engine is cool.
b) Move the piston to the top dead center of the combustion stroke.
c) Loosen the valve arm adjust screw and nut, and the adjust screw and the nut at the bridge side.
d) Press down the valve arm lightly and turn the adjust screw of the valve head (at bridge side). Tighten it until there is no clearance with the valve head. (Fig.A)
e) Lock the adjust screw when the valve head clearance is zero.
f) Adjust the clearance between the valve arm and bridge to the specified value, and lock the adjust screw. (Fig.B)
g) When the timing gear is disassembled, be sure to check the opening and closing angles for both the intake and exhaust valves. (To check the opening and closing angles, turn the flywheel and read the scale on the flywheel according to the movement of the push rods.)



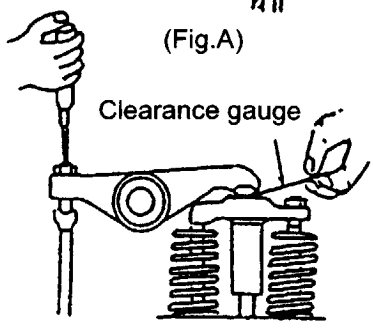
(Top clearance)



(Measuring the valve arm bush)



(Fig.A)



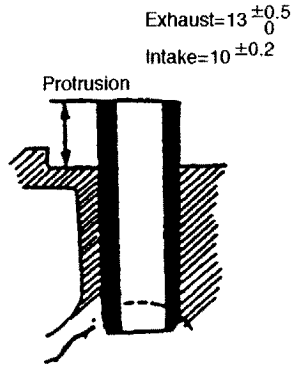
(Fig.B)

(mm)

Valve head clearance	Intake	$0.25^{\pm 003}$
	Exhaust	$0.4^{\pm 003}$

(2) When the timing gear is disassembled, be sure to check the opening and closing angles for both the intake and exhaust valve. (To check the opening and closeing angles, turn the flywheel and read the scale on the flywheel according to the movement of the push rods.)

Intake	Open	before T.D.C	50° ± 5
	Close	after B.D.C	44° ± 5
Exhaust	Open	after B.D.C	55° ± 5
	Close	before T.D.C	47° ± 5



(Valve guide protrusion)

3.2 Piston and Piston Pin

The piston employs a aluminum alloy casting with low thermal expansion and superior cooling efficiency. The oval piston shape offers smooth movement in the cylinder liner, and the toroidal shaped combustion chamber on the piston crown offers superb stating and combustion performance. The piston ring configuration consists of 3 compression rings and 1 oil ring. The top ring groove is specially processed to boost its wear-resistant characteristics. Each cylinder has a cooling nozzle to cool the inside of the piston. The piston and liner are fitted selectively.

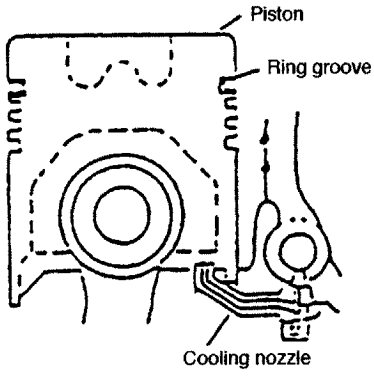
3.2.1 Piston

(1) Piston

- Remove the carbon on the piston head and combustion surface. (Do not damage the piston while removing the carbon.) Check for flaws and cracks on the combustion surface.(Conduct color checks if necessary.)

(2) Cooling Section

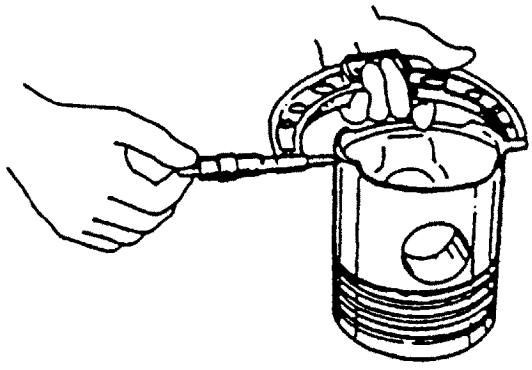
- Remove the lube oil sludge from the inside of the cooling section and clean.



(Piston shape)

(3) Piston Outside Dia. and Ring Grooves

- Repair or replace if the piston outside circumference and ring grooves are damaged or worn.
- Measure the piston dia. at about 28mm from the bottom at a right angle to the piston pin.



(Measuring piston)

(mm)

	Standard dimension	Allowable limit
Piston skirt outside dia.	$109.925^{\pm 0.015}$ (at 28mm from piston bottom)	109.75

(mm)

Cylinder Sleeve Bore			Piston dia	
Demensional torelance	Code		Code	Demensional torelance
110+0.020≤ D≤ 110+0.030	L	(O)	L	$109.925^{+0.015}_{+0.005}$
110+0.010≤ D<110+0.020	M		ML	$109.925^{+0.005\ \text{under}}_{0}$
		(O)	MS	$109.925^{0\ \text{under}}_{-0.005}$
110+0≤ D<110+0.010	S		S	$109.925^{-0.005\ \text{under}}_{-0.015}$

Piston outside dia. ID mark: (O) is only application with the use of the service part. (Do not use the part for regular dis- and re-assembly.)

Clearance :0.080 ~ 0.100
Identical code fitting

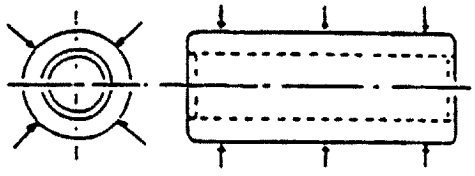
3.2.2 Piston Pin

(1) Fitting of Piston and Piston Pin
Apply lube oil to the piston pin hole and insert the pin into the hole slowly.

Fitting of piston and piston pin

(mm)

Piston pin outside dia.	$46^{-0.003}_{-0.012}$
Piston pin hole inside dia.	$46^{+0.011}_{+0}$
Piston pin hole clearance	0.003 - 0.023

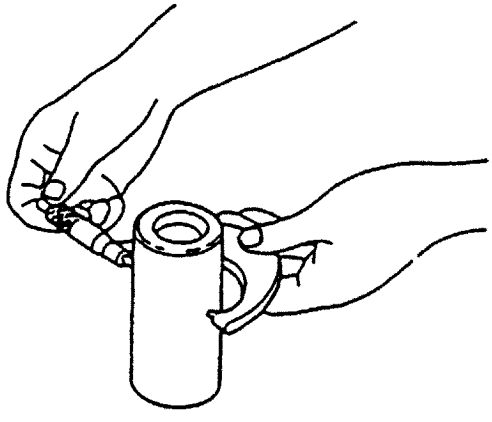


(Measuring piston pin position)

(2) Measurement of Piston Pin Outside Dia.
Measure the outside dia. Replace if worn beyond the limit or if there is excessive step wear.

(mm)

	Standard dimension	Allowable limit
Piston pin outside dia.	45.988 - 45.977	45.95



(Measuring piston pin)

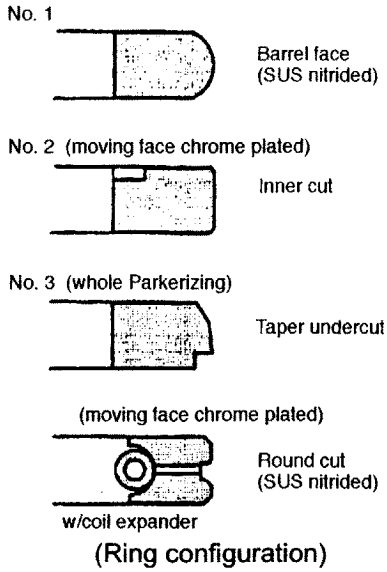
3.2.3 Piston Ring

(1) Measurement of Piston Ring

Measure the width and thickness of the rings as well as the clearance when the rings are inserted into the ring grooves. Replace the ring if it is worn beyound the limit.

(mm)

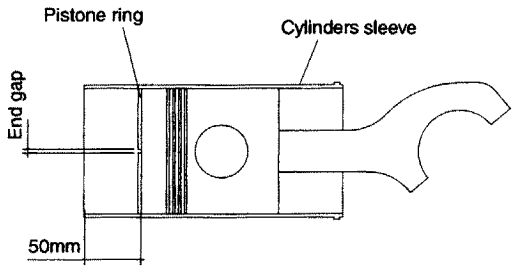
Ring width and ring groove width		Sfandard dimension	Standard clearance	Allowable max. clearance
No.1 ring	Ring width	2.5 $^{-0.01}_{-0.025}$	0.105 - 0.130	0.2
	Ring groove width	2.5 $^{+0.105}_{+0.95}$		
No.2 ring	Ring width	2.0 $^{-0.01}_{-0.025}$	0.075 - 0.105	0.2
	Ring groove widht	2.0 $^{+0.080}_{+0.065}$		
No3. ring	Ring width	2.0 $^{-0.01}_{-0.025}$	0.050 - 0.080	0.15
	Ring groove width	2.0 $^{+0.055}_{+0.040}$		
Oil ring	Ring width	4.0 $^{-0.01}_{-0.025}$	0.030 - 0.060	0.15
	Ring groove width	4.0 $^{+0.035}_{+0.020}$		



(Ring configuration)

(2) Measurement of Ring's End Gap

Insert the piston ring into the cylinder sleeve (use spare part) as shown in the illustration and fit the ring closely to the piston head to measure the end gap clearance of the ring with the thickness gauge. Measure the clearance at about 50mm from the bottom of the cylinder sleeve.

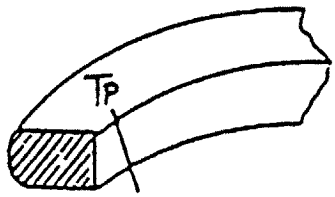


(mm)

End gap clearance	Standard dimension	Allowable limit
Piston ring	0.25 - 0.40	1.5
Oil ring	0.25 - 0.45	1.6

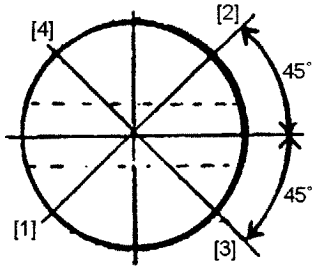
(3) Replacement of Piston Rings

- Clean the piston groove completely before replacing the ring. Fit the new ring with the ring fitting/ detaching tool. (Do not expand the end gap too much.)
- Fit the ring with the maker's punched mark side up (towards the combustion surface).
  (Note that there is no maker's punched mark on the oil ring.)
- Check that the ring moves lightly after fitting.



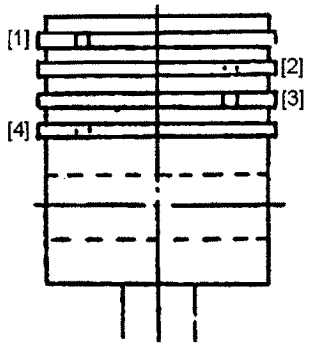
Fit the ring with the maker's punch mark side up.

Cautions for Piston Insertion



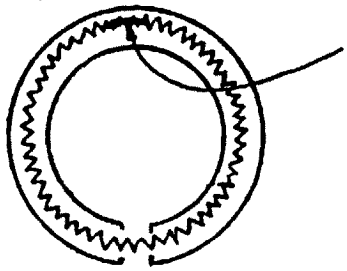
(1) Apply lube oil to the piston ring and the entire area of ring groove, and rotate the ring.

(2) Distribute the ring end gaps equally along the piston.(See illustration at the left)



(3) When distributing the ring end gap positions, place the end gap of the top (No.1) ring at the intake side.(Avoid the exhaust side in order to prevent the gas entry.)

Fitting the coil expander for the oil ring:



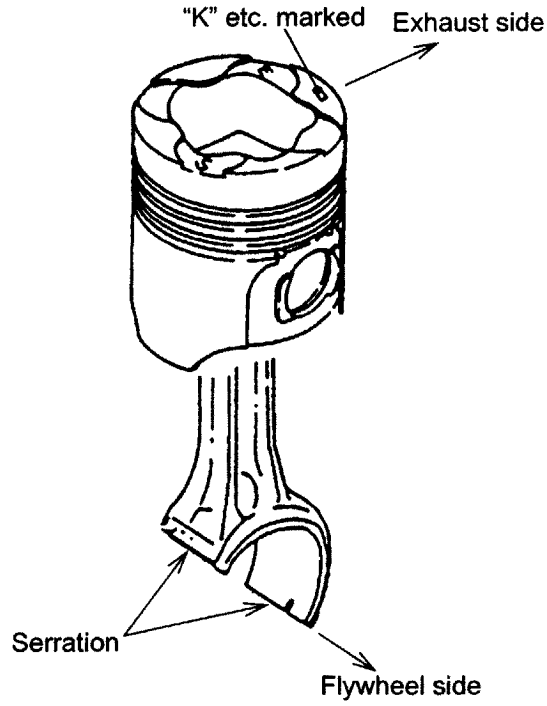
(1) Place the coil joint at the opposite side of the ring end gap.

(4) Piston and Con.Rod Assembly

- Assemble so that the marked ("K", size mark, and piston mass) side on the piston top comes to the exhaust side as shown the right.
- Insert the piston and con. rod assembly into the cyliner liner with the rod's punched mark directed to the suction side. (operation side)

Caution

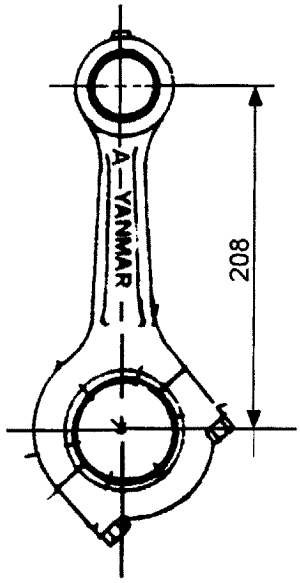
If the piston is assembled in reverse, the valve interferes with the piston head during operation.



(Piston and Con.Rod assembly)

3.3 Connecting Rod

The connecting rod is made of high strength carbon steel forged iron. The large end is cut slant and fitted with aluminum metal,while the small end employs a double layered copper alloy coil bush.



(Connecting rod length)

3.3.1 Inspection of Connecting Rod

(1) Inspection of Serration
Conduct a color check for the serrated area of the large end (refer to Page 43) to check for any cracks.

(2) Side Clearance after Assembly
Check the side clearance when the con. rod is assembled to the respective crank pin. Also check for any flaws on the thrust surface of both ends.

(mm)

	Standard dimension	Allowable limit
Side gap	0.15 - 0.35	0.4

3.3.2 Crank Pin Metal

(1) Inspection of Crank Pin Metal
- Check for flaking, fusion, seizure and other damage to the friction surface. If defective, replace the metal.
- Measure the oil clearance of the crank pin with the thickness gauge.

(mm)

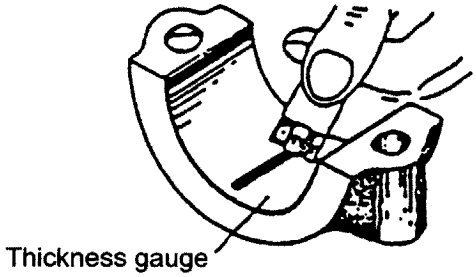
Standard dimension	Allowable limit
0.04 - 0.105	0.13

Measurement by Thickness Gauge:

1) Insert the thickness gauge into the large end cap in the crankshaft direction.
2) Tighten the cap to the specified tightening torque.
3) Remove the cap and measure the depressed gauge width using the measuring paper.

Cap tightening torque	226 ± 4.9 N·m (23 ± 0.5 kgf·m)

Apply lube oil to the thread and seat of the rod bolt, and tighten the rod bolt to the specified torque.



(Measurement by Thickeness Gauge)

(2) Cautions for Replacing Crank Pin Metal

- Clean both the bearing face and rear face of the metal completely.
- The metal should be fitted closely to the con. rod and cap.
- When assembling the con. rod, match up the large end nos., apply lube oil to the bolt seat face and tighten the bolts evenly.

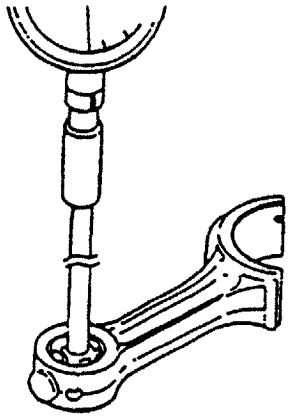
Crank pin metal

	Part code
Standard	127695-23300

3.3.3 Piston Pin Metal

(1) Inspection of Piston Pin Metal

- Replace the metal if it is discolored, worn or damaged.



(Measuring Piston Pin Metal)

(mm)

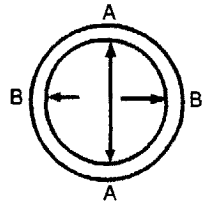
	Standard dimension	Allowable limit
Piston pin metal inner dia.	$46^{+0.040}_{+0.025}$	46.1
Oil clearance	0.028 - 0.052	0.07

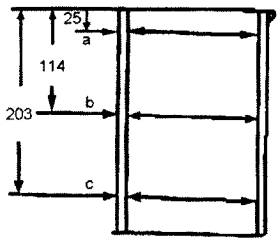
3.4 Cylinder Sleeve

The dry sleeve employing a new material has improved wear-resistant characteristics and higher strength.

3.4.1 Measurement of Sleeve

Measure the inside dia. of each cylinder with the cylinder gauge. If worn beyond the limit, replace the sleeve.





Measure A, B, and a, b, c

(mm)

		Standard dimension	Allowable limit
Cylinder sleeve inside dia.	L	ϕ 110 $^{+0.03}_{+0.03}$	0.15
	M	ϕ 110 $^{+0.02}_{+0.01}$	
	S	ϕ 110 $^{+0.01}_{0}$	
Cylinder sleeve roundness		< 0.015	0.08
Cylinder sleeve cylindricity		< 0.02	0.08

3.4.2 Insertion of Sleeve

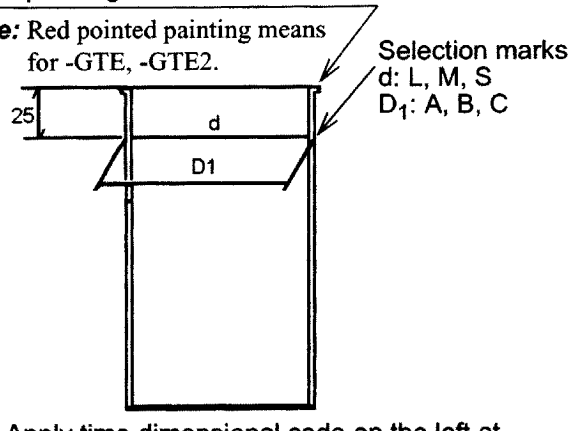
Cylinder sleeve outside dia.	Outside dia. and inside dia. selection marks specified on the cylinder sleeve outside (fig. right)
Cylinder block inner dia.	ID mark, A, B, or C marked on the upper portion of each cylinder (at opearation side)

(mm)

Cylinder block inside dia.		Combination	Sleeve outside dia.	
Dimensional tolerance	Code	Clearance 5μ - 20μ	Code	Dimensional tolerance
114.020 ≤ φD ≤ 114.030	A	⟷	A	114.000 ≤ φD$_1$ < 114.010
114.010 ≤ φD < 114.020	B	⟷	B	113.990 ≤ φD$_1$ < 114.000
114.000 ≤ φD < 114.010	C	⟷	C	113.980 ≤ φD$_1$ ≤ 113.990

Color painting: blue, white and yellow corresponding with L, M and S

Note: Red pointed painting means for -GTE, -GTE2.



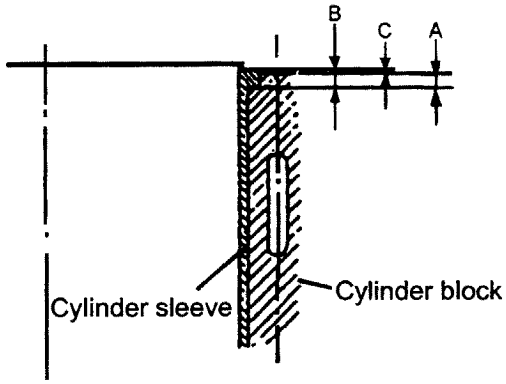
Apply time dimensional code on the left at the D_1 position.

3.4.3 Measurement of Protrusion

Measure the protrusion of the cylinder sleeve flange form the block surface and check that the following distance is ensured:

(mm)

Cylinder block flange hole depth: A	$5\ ^{0}_{-0.040}$
Cylinder sleeve flange thickness: B	$5\ ^{+0.050}_{+0.030}$
Cylinder sleeve protrusion: C	0.03 - 0.09



Types of gasket packing for top clearance adjustment

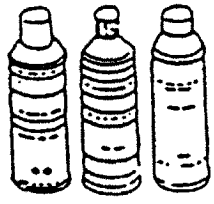
Thickness when tightened	Yanmar code	ID punched mark	Note
$1.4\ ^{\pm 0.07}$	127695-01340	14	Thin (-0.1)
$1.5\ ^{\pm 0.07}$	127695-01350	15	Standard
$1.6\ ^{\pm 0.07}$	127695-01360	16	Thick (+0.1)

3.5 Cylinder Block

The weight of the cylinder block is reduced by its thin structure, while the ribs are rationally distributed internally and a wave structure is employed for the side wall. This structure boosts the rigidity by far and is instrumental in preventing engine noise form spreading.

3.5.1 Inspection for Cracks

If the engine has experienced some abnormal accidents such as freezing, falls, etc., check the engine visually. If there may be cracks, inspect the part by color check. If the damage can't be repaired, replace the part.



(Dyeing Flaw Detection agent)

3.5.2 Cleaning of Oil Holes

Clean each oil hole and ensure its continuity.

- Take care not to remove the blind plugs.
  Dyeing Flaw Detection Agent (Color Check) The aerosol type device, sprays the liquid by preesing the button at the top to detect cracks in metals that are hard to find.

3.5.3 Inspection Procedures

- Clean the part to be inspected with cleaning agent.
- Spray the penetration liquid (red) for 5-10 min. (depending on the material) and wait for a while until the liquid penetrates inside.
- Clean and remove the red penetration liquid on the surface quickly.
- Spray the developing liquid (White) thinly and evenly.
- If there are cracks inside, the red penetration liquid oozes out on the surface.
  (Refer to the operation manual of the manufacturer before use.)

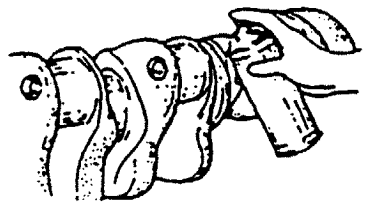
3.6 Crankshaft and Main Bearing

The crankshaft, made of precision forged SCM440, has high durability with the use of aluminum metal for the crank pin and journals. The dynamic imbalance is improved to reduce vibrations. This further enhances the durability. The front and rear seal sections, with the optimum finish to the oil seal and the use of special seals, are durable against seal wear highly effective in preventing oil leakage.

3.6.1 Inspection of Crankshaft

(1) Color Check of Shaft

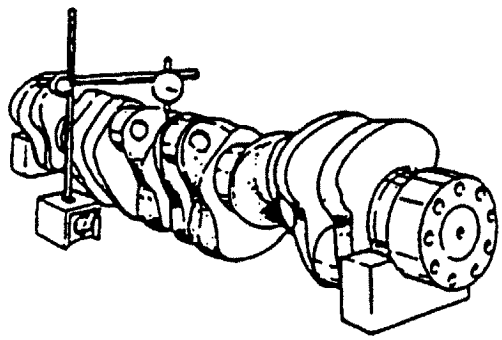
- Check the shaft by cleaning the crankshaft, color check or by magnetic flaw detector. If there are cracks in the shaft or it is excessively damaged, replace the shaft. If the damege is insignificant, repair by grinding.



(Color check of crankshaft)

(2) Circle runout of Crankshaft

- Hold both ends of the crankshaft journal with V-blocks. Turn the shaft and measure the deviation of the center journal with the dial gauge to check the circle runout. If the distortion is excessive, replace the shaft.



(Measure the circle runout)

(mm)

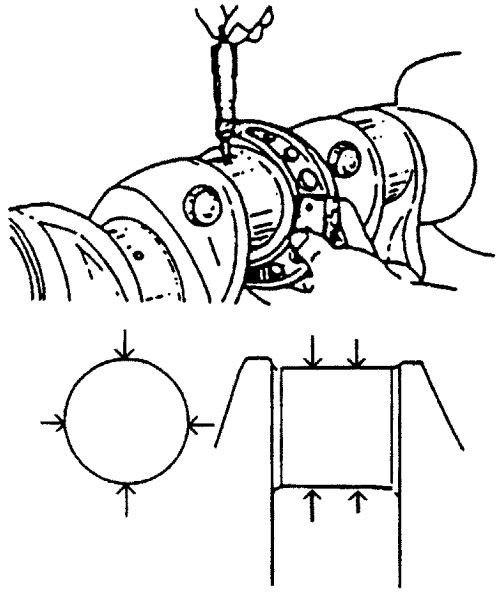
	Standard dimension	Allowable limit
Circle runout (TIR)	0.030 max.	0.07

(3) Outside Dia. and Cylindricity of Pin and Journal

- Check the pin and journal outside dia. of the crankshaft for biased wear (cylindricity, taper degree). When the wear is within the tolerance, re-grind and adjust within the limit of the outside dia. When the outside dia. falls below the limit, replace.

(mm)

		Standard dimension	Allowable limit
Cankshaft pin	Shaft outside dia.	71.94 - 71.96	71.87
	Cylindricity	0.015	0.05
	Oil clearance	0.04 - 0.0105	0.13
Cankshaft journal	Shaft outside dia.	85.94 - 85.96	85.87
	Cylindricity	0.015	0.05
	Oil clearance	0.040 - 0.108	0.13

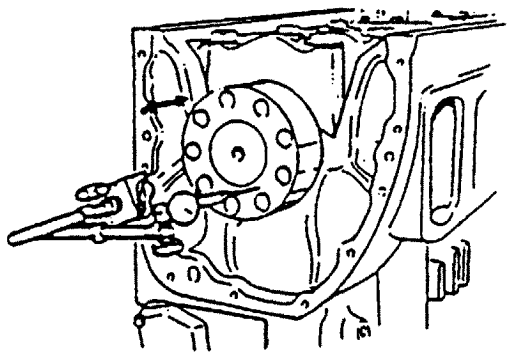


(Measuring Position of Outside dia. and Cylindricity for Crankshaft Pin and Journal)

Note: When the crankshaft is re-ground, use the under-sized main bearing and adjust the oil clearance to the specified value.

3.6.2 Side Clearance of Crankshaft

- Move the crankshaft to one end, place the dial gauge to the crankshaft end face and measure the thrust clearance, or measure the clearance between the standard bearing thrust section and the crankshaft thrust face directly with the thickness gauge. If the clearance exceeds the limit, replace the bearing with the over-sized bearing.



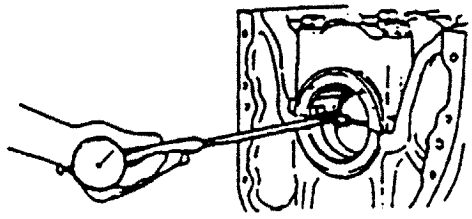
(Measure the crank shaft side clearance)

(mm)

	Standard dimension	Allowable limit
Side clearance	0.155 - 0.296	0.33

3.6.3 Inspection of Main Bearing

- Check for flaking, fusion, seizure and other damage on the contact surface. Replace if the bearing is defective.
- Measure the bearing inside dia., crankshaft outside dia. and oil clearance. If the clearance exceeds the limit, replace the bearing with a proper under-sized bearing.



(Measure the inner dia. of main bearing)

Note: Note the following points when installing the metal cap to cylinder block.

- The upper and lower metals are not identical.
- Align the oil hole positions.
- Assemble the metal cap with its F mark directed to the flywheel side.
  Apply lube oil to the thread and seat of the bearing cap bolt.
  Tighten to the specified tightening torque.

Main metal tightening torque	275 ± 9.8 N·m (28 ± 1 kgf·m)

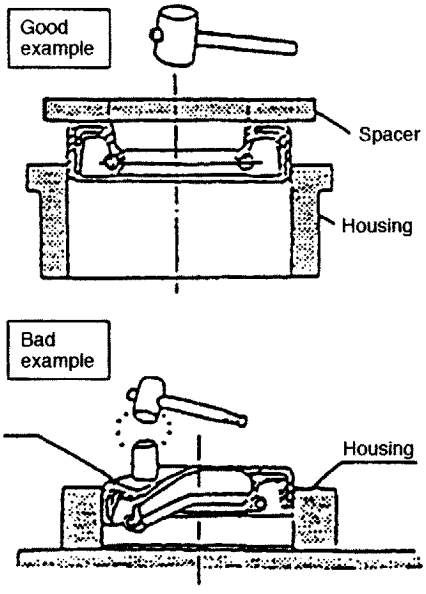
3.6.4 Crankshaft Oil Seal

- The crankshaft is equipped with oil seals at both ends to prevent lube oil leakage. At the flywheel side in particular, the spiral seal is used to prevent oil leakage due to the pumping movement during operation.
  In the case of the oil seal of this type, the viscous pumping movement is lost if grease is applied to the lip. Be sure to apply engine oil to the lip before re-assembly.

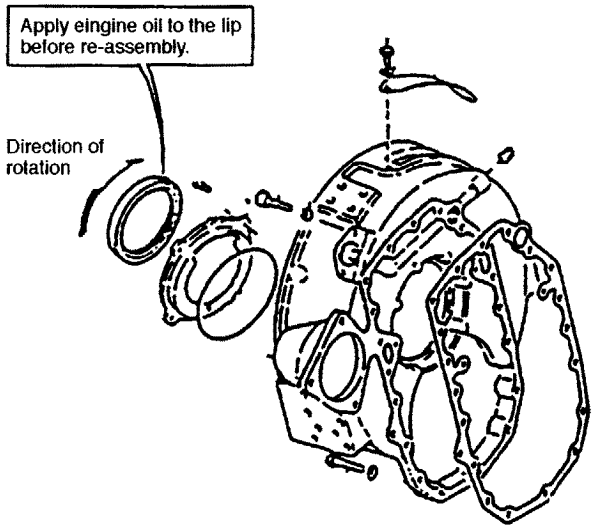
Oil seal

	Name	Part code No.
Flywheel side	105·135·11	123672-01781
Gear case side	TC58·80·12	124450-01800

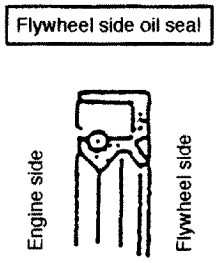
When replacing the oil seal, check for any flaws on the oil seal housing, apply engine oil to the outside dia. and lip of the new oil seal and press fit the seal.



(Fitting of oil seal)



(Oil seal case and flywheel housing)



(Flywheel side oil seal)

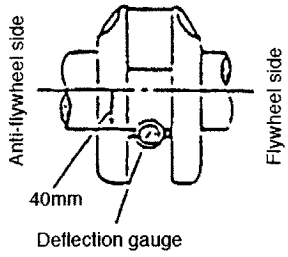
3.6.5 Measurement of Crankshaft Deflection

- For the direct coupling of the engine, be sure to check the crankshaft deflection by the deflection gauge and adjust the deflection with in the limit.

Deflection

(mm)

	Allowable limit
Deflection	0.0125
Deflection after Direct Coupling	0.0250

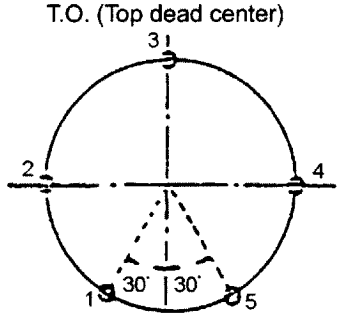


(Deflection gauge fittng position)

Measurement Procedures:

- Fit the deflection gauge to the crankshaft at a position between the crank arms of the No.1 cylinder, free from interference of rod rotations (40mm from the middle of the journal). Turn the engine in its operational direction with 1 shown in the figure at the right as the starting point and read the gauge at 1, 2, 3, 4, and 5 positions shown in the figure.
- The balance between the max. and min values measured is the deflection value.

Deflection gauge Yanmar part No.95540-000150



(Deflection gauge measuring position)

3.7 Camshaft and Valve Gear

The camshaft, equipped with the intake and exhaust valve cams, is made of normalized material. The cams and journals are surface hardened and machined. The polynomial cam with shockless curve reduces cyclical shocks given to the valve seat, resulting in the enhanced durability of the valve seat.

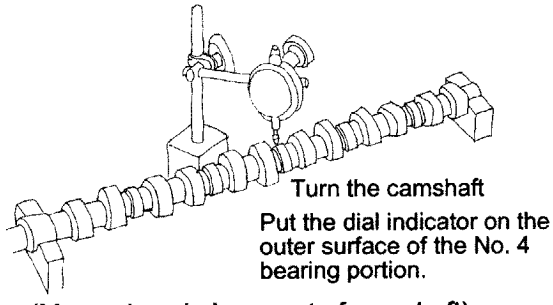
3.7.1 Camshaft and Bearing

- Check for circle runout, journal damage, wear, etc. of the camshaft. When distortion, damage or wear is excessive, repair or replace.

Camshaft Distortion

(mm)

Max. circle runout (TIR)	0.07



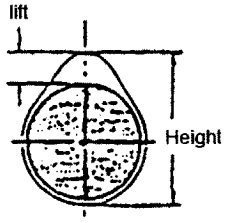
(Measuring circle runout of camshaft)

- Measure the height of the cam of the camshaft. If it is worn exceeded the limit, replace.

Cam height dimension

(mm)

	Standard dimension	Allowable limit
Intake/exhaust valve cam height	44.16 - 44.24	43.5



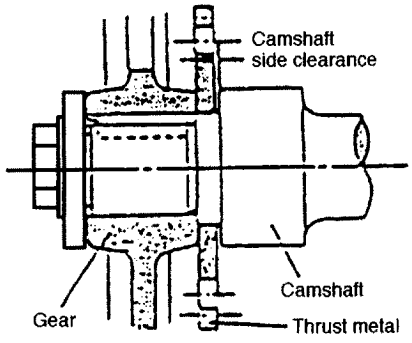
(Measure the cam height)

Check the camshaft journal dia. and journal for flaws, wear, etc. If the damage or wear is excessive, replace.

Dimension of cam shaft journal and cam shaft bearing

(mm)

	Standard dimension	Allowable limit
Camshaft journal dia.	51.95 - 51.975	51.8
Camshaft bearing inside dia.	52.02 - 52.09	52.15
Oil clearance	0.045 - 0.140	0.2



(Camshaft side clearance)

- Measure the side clearance of thrust metal. If clearance exceeds the limit, replace the thrust metal.

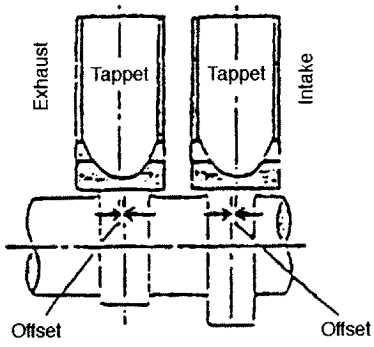
Measure the clearance after tightening the bolt to the specified tightening torque (88±10 N•m (9±1 kgf•m) with lube oil)

(mm)

	Standard dimension	Allowable limit
Side clearance	0.10 - 0.25	0.35
Thickness of thrust plate	6.95 - 7.00	6.8

3.7.2 Tappets

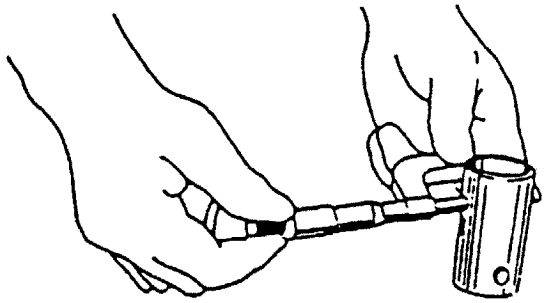
- The tappet, as shown in the fig. at the right, is rotated during engine operation to prevent biased wear. Check the tappet's contact condition. If there is biased wear or uneven rotation, replace the tappet and repair the cam.



(Camshaft and tappet)

Note:
- Before disassembling the cam shaft and tappet, remember the cylinder nos. and distinguish between intake and exhaust.
- When the sliding surface of the tappet to the cam shaft is damaged, check the cam shaft,too.

- Check the outside dia. of the tappet for wear and damage. Replace the tappet if it is defective.



Tappets and Tappet Guides

(mm)

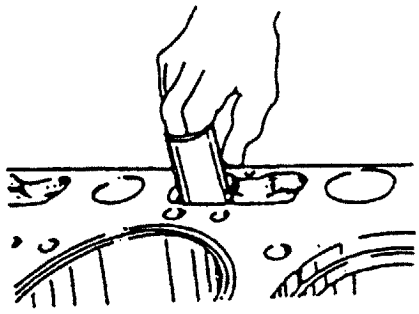
	Standard dimension	Allowable limit
Tappet outside dia.	26.939 - 26.96	26.90
Cylinder block bore	27.00 - 27.012	27.05
Oil clearance	0.04 - 0.082	0.12

3.7.3 Push Rod

- Replace the push rod if the bending exceeds the limit.

(mm)

	Standard dimension	Allowable limit
Bend of push rod	0.03	0.1
Length of push rod	289.5 - 290.5	———


(Insertion of tappet)

3.8 Timing Gear

The helical gear is used for the timing gear.
The gear teeth are hardened and polished for higher durability and noise.

3.8.1 Inspection of Gears

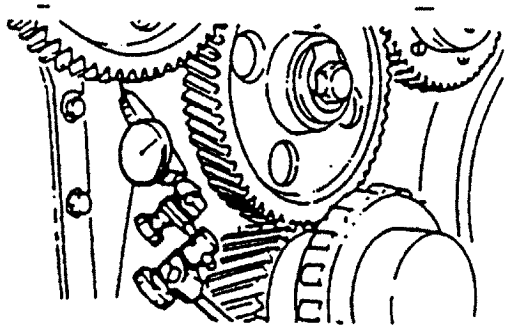
- Inspect the gear face and tooth flank. If there is flaw or wear, replace the gear.
- Measure the backlash of each gear. If the backlash exceeds the limit, replace the working gears as a set.

Backlash

(mm)

	Standard dimension	Allowable limit
Backlash of each gear	0.08 - 0.16	0.3

Note: Improper backlash not only causes noise, wear, scoring, etc. but also engine malfunction due to improper valve or fuel injection timing.



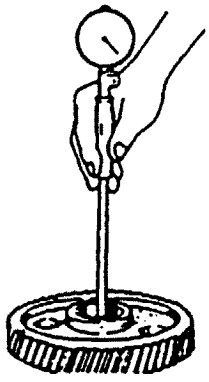
(Measure of backlash)

Replace the bush inside dia. and the mount of the idle gear.

Bush and shaft outside dia. of idle gear.

(mm)

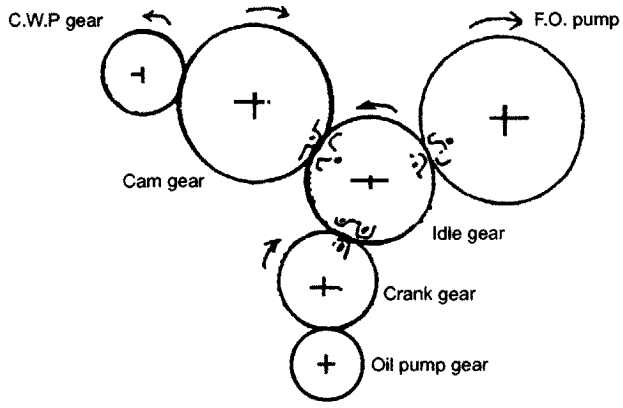
		Standard dimension	Allowable limit
Idle gear	Shaft outside dia.	50.95 - 50.975	50.9
	Bush inside dia.	51.00 - 51.025	51.05
	Oil clearance	0.025 - 0.075	0.12



(Measuring idle gear bush inside dia.)

3.8.2 Timing Mark

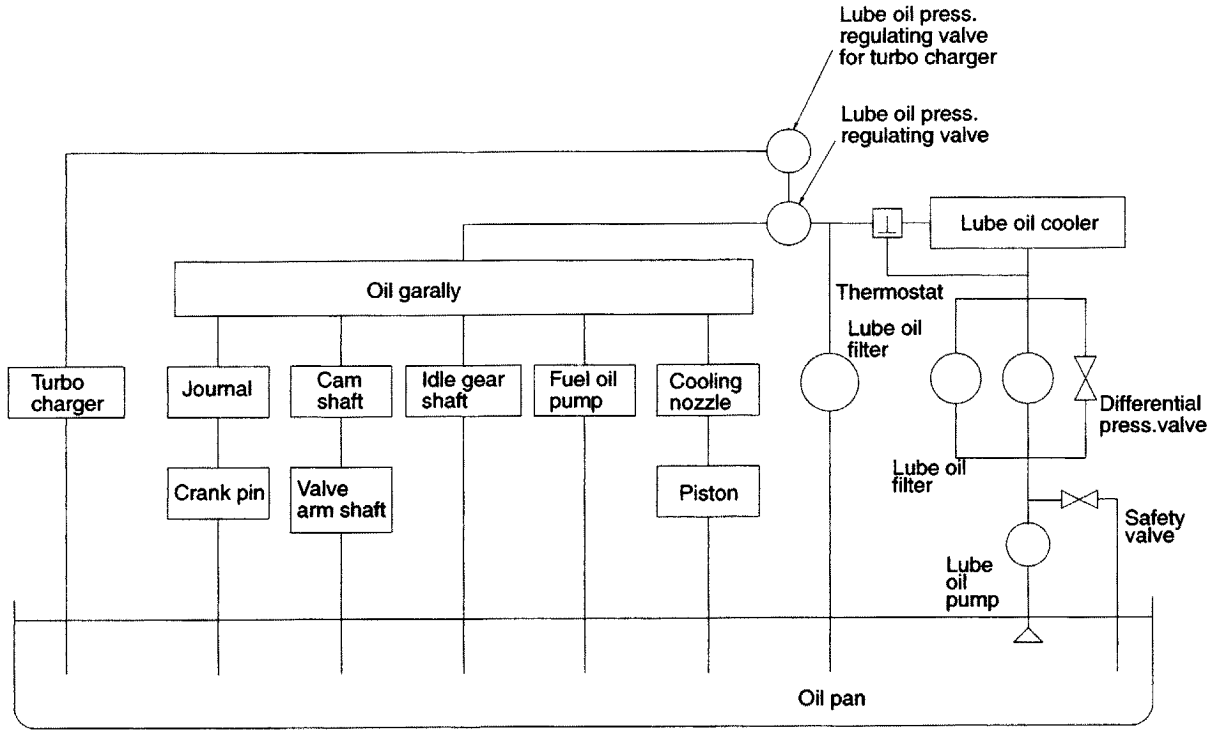
- The timing mark "0" is punched on the side face of each gear--timing gear & cam shaft drive gear, fuel injection pump drive gear, & oil pump drive gear. Check and align the marks on reassembly.



3.9 Lube Oil System

Engine parts are lubricated by the forced lubrication system using the gear pump as shown in the lubrication diagram. The hydraulic switch of the system monitors the lube oil condition and warns of any abnormal condition by sounding the alarm bell and turning on the oil lamp when the lube oil pressure falls below 0.05MPa (0.5kgf/cm^2).

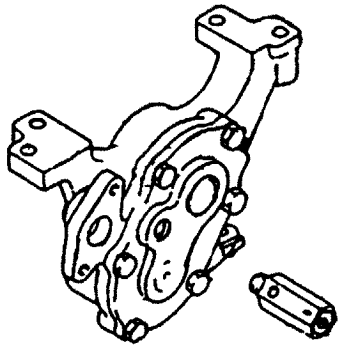
3.9.1 Lube Oil Diagram



3.9.2 Inspection of Parts

(1) Lube Oil Pump

The gear pump usually has no wear. However, when it seizes for to some reason, when the oil pressure can't be raised satisfactorily in spite of the adjustment by the pressure adjust valve, or when the drive shaft (gear) does not turn smoothly, replace the pump as an assembly. Do not disassemble the pump whenever possible. When the reassembly is improper, the pump will seize. If dis- and re-assembly of the pump are unavoidable, follow the service standard below.

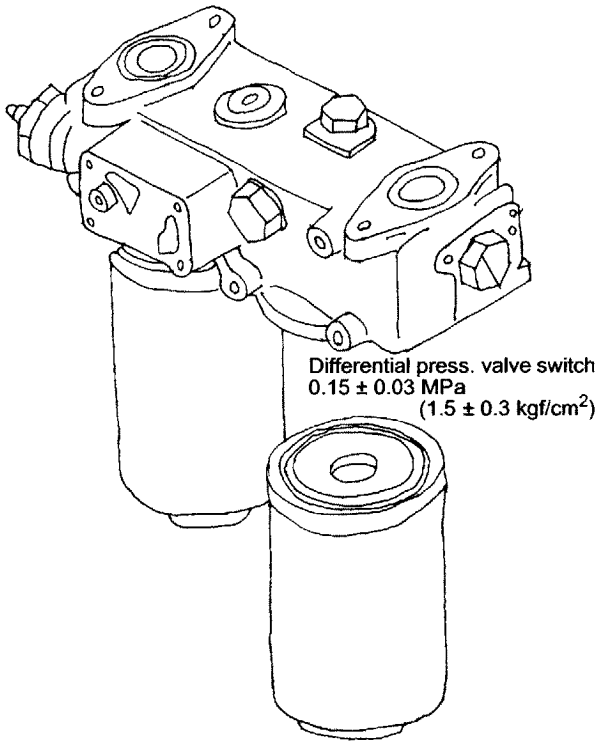


Lube oil pump

(mm)

		Clearance	Object
Gear	Radial	0.08 - 0.14	Outer case
	Axial	0.025 - 0.075	Side wall
Bearing	Radial	0.015 - 0.058	Shaft

(2) Lube oil filter
The oil filter uses high performance filtration paper. The lube oil enters into the filter from the outside circumference and goes out from the middle of the filter. The oil filter is equipped with an escape valve to prevent lube oil shortage on the filter element from clogging. If the element clogs during operation, the warning lamp on the instrument panel flickers.



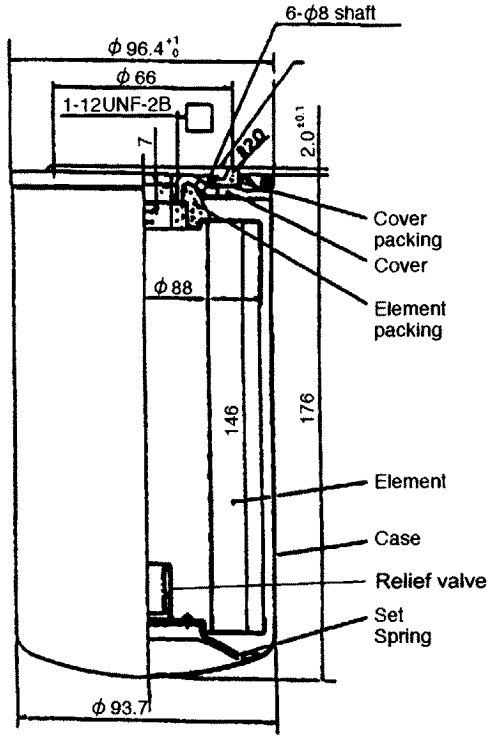
Replacement of Filter Element:

Replace of filter element	50 hrs. after installation and every 250 hrs. opeartion thereafter
Part code of filter element	127695-35150

Note:
- Use the accessory standard tool to fit and remove the filter element.
- Spare filter elements are provided.
- When replacing the element, check the used element for any trapped foreign matter.
- When fitting the element, confirm that the rubber packing is not disaligned.

Oil Cooler

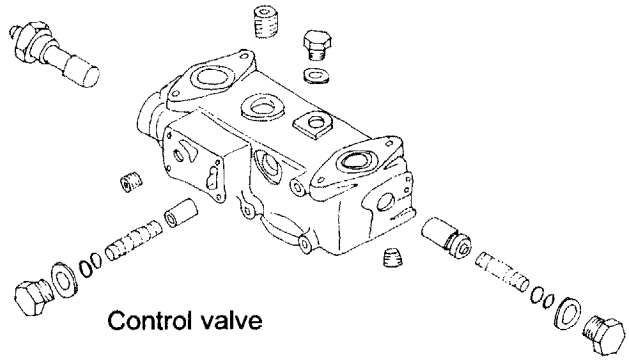
The multi-tubular type oil cooler cools lube oil flowing on the exterior of the tubes with seawater circulating inside the tubes. The oil cooler prevens the lube oil temperature from being raised and thus extends the service life of the lube oil.
When the cooler is disassembled, check the interior of the cooler cover and tubes carefully and remove scale and rust.



(Element)

Relief valve opening pressure:
0.177 ± 0.02 MPa (1.8 ± 0.2 kgf/cm²)
Filteration area: 4500cm²
Filteration performance:: 20μ

(3) Lube Oil Pressure Control Valve
The pressure of the pressure control valve is set at the level at which lube oil is press-fed to each lube oil system constantly at a definite pressure. When the pressure gauge on the instrument panel shows a pressure lower than the standard pressure, excessive oil clearance due to wear of bearings of lube oil systems or the decline of the pressure control valve spring are possible. In such cases, re-set the pressure at the specified level. If the pressure does rise but only sporadically (stick slip), malfunctioning of the pressure control valve is possible. Check and adjust the valve.


Control valve

Note:
- When the lube oil pressure is lower than the standard pressure, first check that there is no oil leakage from the parts. Then re-set the pressure of the pressure control valve while reading the pressure gauge.
- Increase or decrease the number of the pressure adjust plates to adjust the pressure.

Pressure adjust plate code	123672-34350

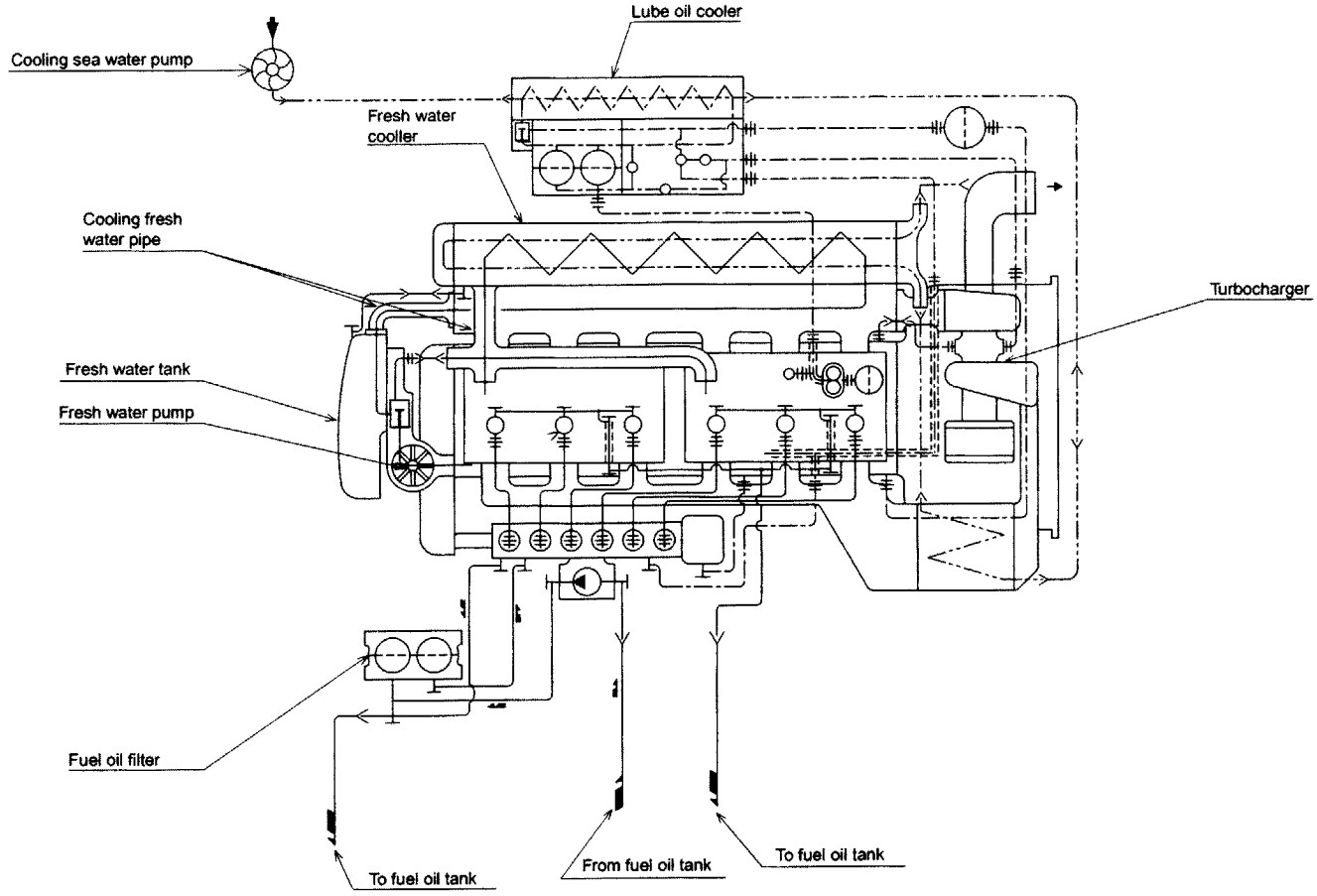
Standard lube oil pressure	0.44 - 0.55 MPa (4.5 - 5.5 kgf/cm^2)

(4) Lube Oil Pressure Control Valve for Turbine
The pressure control valve to adjust the lube oil pressure of the turbine is installed on the oil filter mount.
Adjust the pressure using the shims to 19.6 - 24.5N (2-2.5 kgf) at rated revolutions.
Do not raise the lube oil pressure too high.
This will increase the lube oil consumption.

3.10 Cooling Water System

The constant high temperature fresh water cooling system is employed to cool the cylinder and cylinder head (with circulating seawater to cool the fresh water). In this system, the cooling water temperature is kept constant irrespective of the engine load. This way, clearance between the piston and liner can be kept small and there is less thermal distortion of the liner. Combined with the appropriate ring configuration, the lube oil consumption is small and there is no fear of 'oil up'.

3.10.1 Cooling Water System Diagram



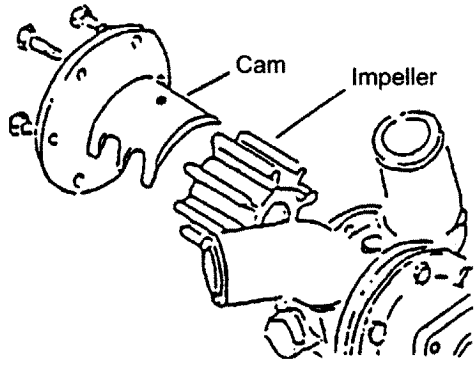
3.10.2 Seawater Cooling System

(1) Seawater Pump

If the cooling water discharge volume becomes small, or water leaks from the drain pipe or the joint surface, check the pump.

1) Rubber Impeller

- Remove the side cover and pull out the impeller. If the impeller or the body is damaged, replace the part.



(Check the rubber impeller)

Part code

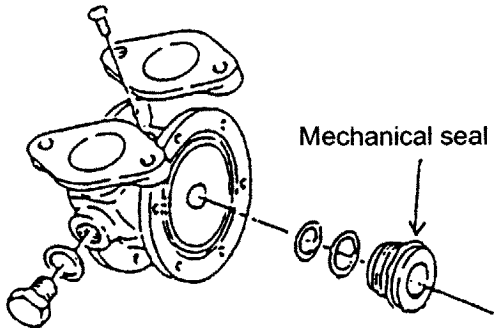
Sea water pump CMP	127695-42010
Rubber impeller	128620-42200

2) Wear Plate
- Remove the wear plate to check. If step-wear is noted on the side face, reverse the wear plate to re-use it.

3) Pump Housing
- If the wear or damage of the housing interior or impeller's moving face is excessive, replace.

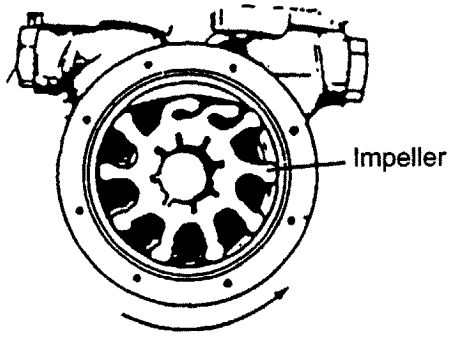
4) Mechanical Seal
- If water leakage from the drain pipe increases, replace the mechanical seal.

Part code No.	128620-42060



(Mechanical seal)

5) Reassembly of Seawater Pump
- Before assembly, apply oil to the shaft spline, both ends of impeller and impeller exterior surface and grease to the seal lip and bearing.
- Ensure the correct impreller blade direction when assembling the impeller to the body. (Impeller installation direction)
- Replace the O-ring on the joint surface.
- Apply seal agent (equivalent to THREEBOND No.4) to the whole area of the packing surface.



(Ensure the correct impeller blade direction)

(2) Anti-Corrosion Zinc
The anti-corrosion zinc is installed to the seawater cooling system to prevent corrosion.
Check the zinc on a periodic basis. Replace every 250 hrs. or when more than half is corroded.

Anti-corrosion zinc fitting positions	
Lube oil cooler	1 each for inlet and outlet
Fresh water cooler	2 each for inlet and outlet
Air cooler	6 pcs

Caution

To check the zinc, remove corrosion with a wire brush.

3.10.3 Fresh Water Cooling System

Water leakage must be checked carefully because of the circulating water system. If consumption of fresh water in the sub-tank increases, check the joints for water leakage.

(1) Fresh Water Pump

The centrifugal pump is used for the fresh water pump. If water leaks from the drain pipe, disassemble the pump to check and maintain.

1) Mechanical Seal

When the water leakage from the drain pipe is large, replace the mechanical seal. Remove the button body, remove the impeller and remove and replace the mechanical seal.

Fresh water pump mechanical seal:

Part code No.	124250-42350

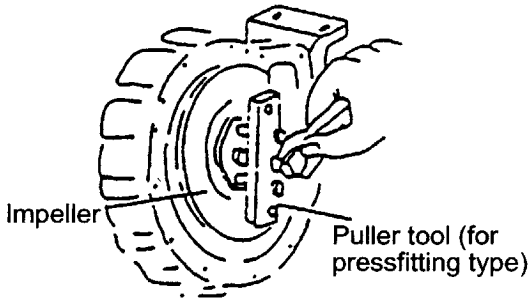
(2) Fresh Water Cooler

Seawater passing inside the tube cools the temperature of fresh water flowing on the exterior of the tube. The thermostat in the fresh water circuit keeps the fresh water temperature at a proper level constantly.

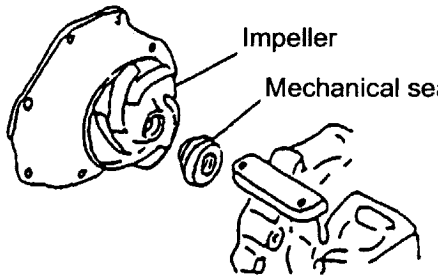
Should fresh water be lacking, the water level alarm device installed at the upper part of the fresh water tank senses the condition and gives the alarm by buzzer and lamp. Fresh water cools exhaust gas passage.

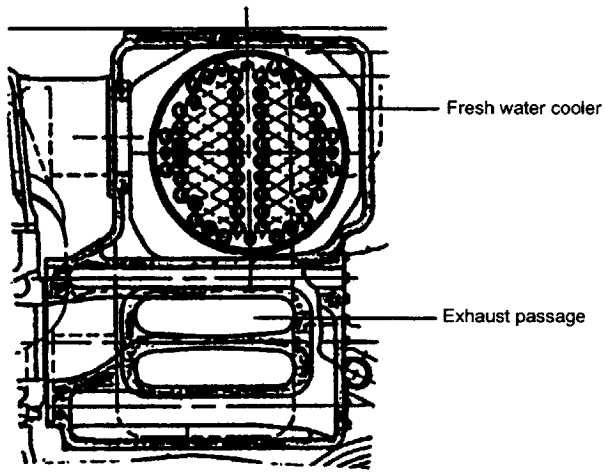
1) Inspection of Fresh Water Cooler

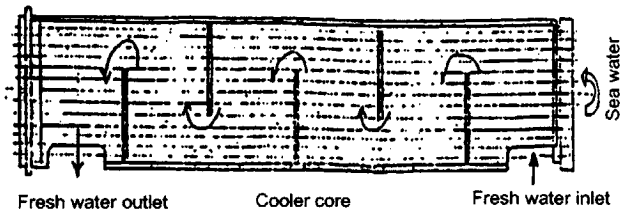
- Scale and rust inside the tube lowers the cooling efficiency. Disassemble to check and remove the contamination using scale removing agent.
- Scale and rust also develop outside the tube, resulting in the drop of cooling efficiency. Be sure to apply LLC.
- If freezing is expected in winter, pour in LLC. Refer to the instructions accompanying the LLC for the proper mixing ratio.



(Removing impeller of fresh water pump)



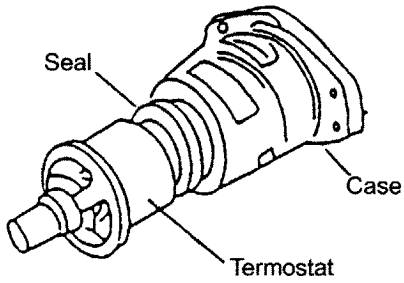




Fresh water = Outside the tube 1400 ℓ/h
Sea water = Inside the tube 10300 ℓ/h
Heat exchange area: 1.8m^2

(3) Pressurizing Cap

- When dust deposits on the pressurizing cap, it can't be closed completely and water q'ty will decrease. Check the cap and remove dust and scale.
- It is dangerous to remove the cap during operation or soon after stopping the engine.
  Hot steam may spurt out. If the cap must still be removed, lossen the cap slowly covering it with cloth.



(Thermostat)

(4) Thermostat

- The thermostat keeps the temperature of the cooling water (fresh water) at a constant level in the constant hight temperature cooling system.
- The thermostat is installed to the outlet of the fresh water tank.

Inspection of Thermostat

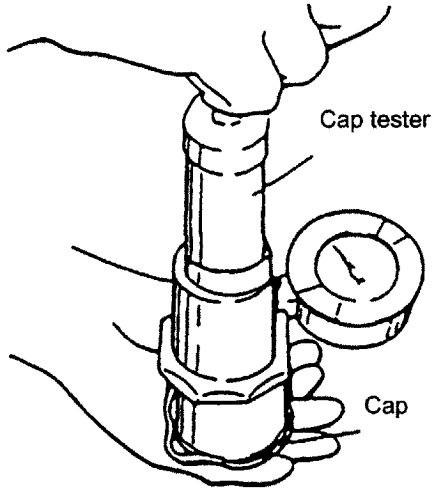
- Put the thermostat in a container of water.
  Heat the water and measure the temperature by thermometer. The valve should start to open at the specified valve opening temperature and is fully opened at the valve fully open temperature. If the timing deviates excessively or the thermostat is damaged, replace.

Thermostat	
Thermostat valve open temp.	71°C ± 2
Full-open temp.	85°C
Valve lift	11 mm
Code No.	145640-48410

Replacement interval:

(5) Water Leakage Check of the Fresh Water System

1) Inspection of pressure Cap of Fresh Water Tank
   - Fit the accessory adapter to the cap tester.
   - Operate the pump to pressurize. The cap is normal when the gauge is within the normal pressure range [0.088 ± 0.15 MPa (0.9 ± 0.15 kgf/cm^2)] for 6 seconds. If the pressure can't be raised or drops soon after being raised, degeneration, cracks or breakage of the packing or the decline of the spring is possible. In this case, replace the cap as an assembly.

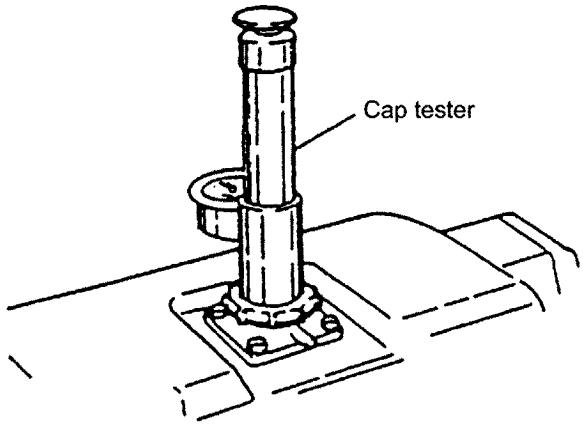


Note: If dust or scale deposits on the seal, the gauge may indicate an abnormal valve. Wash the seal and re-test.

2) Inspection of the Fresh Water System.
Inspect while the engine is still warm.

- Supply water to the specified water level.
- Install the cap tester unit to the fresh water tank (no adapter needed)
- Operate the pump, set the pressure at 0.088 ± 0.015 MPa (0.9 ± 0.15 kgf/cm^2) and check the water leakage.

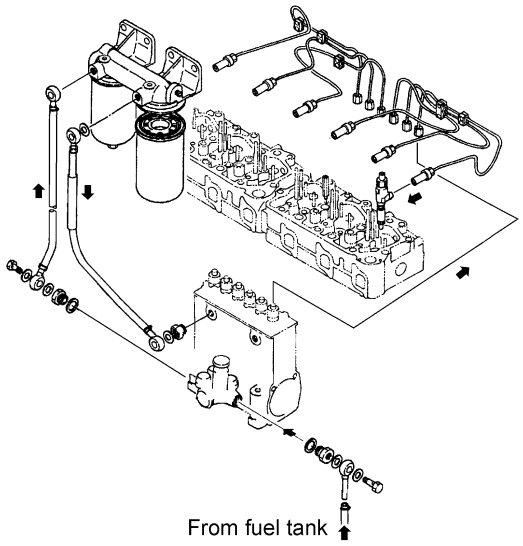
Note: Do not pressurize the system too high. This may damage the packing of the cooling system joint faces or hose.
Inspection Positions (under pressurized condition)
Hose joints and cooling water pump packings
When the gauge pressure drops and the leakage position can't be detected, leakage from inside the cylinder head or gasket is possible (Leakage inspection of fresh water system by cap tester)

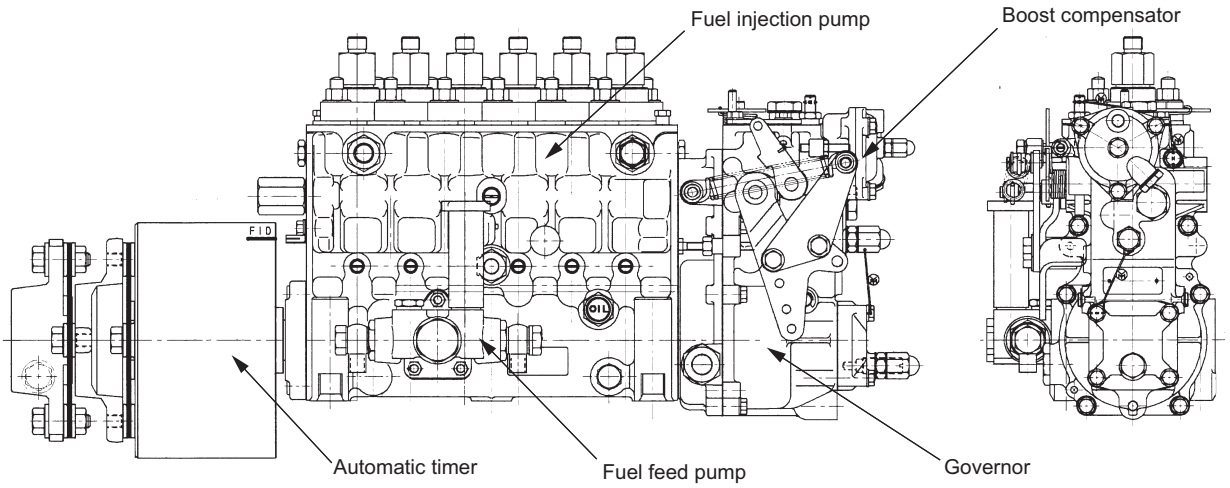


(Leakage inspection of fresh water system by cap tester)

3.11 Fuel Oil System

The engine revolutions are transmitted to the camshaft by the driving gear of the fuel pump via the timer.
The feed pump activated by the camshaft rotations sucks fuel oil from the fuel tank and feeds it to the fuel filter at the pressure of about 0.33 MPa (3.4 kgf/cm^2).
The filtered fuel oil is sent to the oil sump in the pump housing and is pressurized by the plunger. The fuel oil then flows through the injection pipe and nozzle holder and is injected from the nozzle to each cylinder.



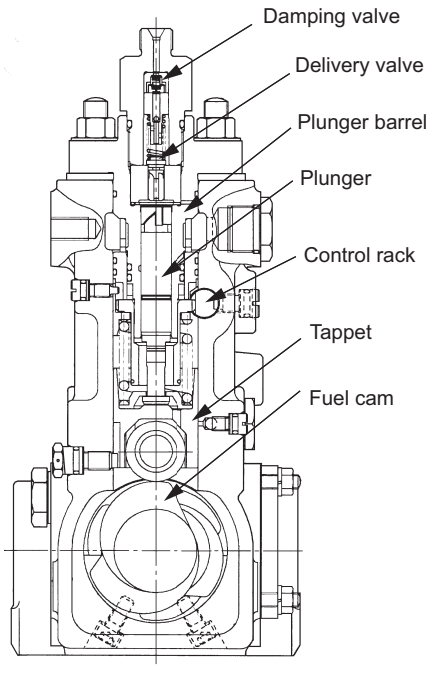


3.11.1 Fuel Injection Pump

The Yanmar YPES-PS fuel injection pump is an integrated type and the engine revolutions are transmitted to the camshaft of the pump through the driving gear and advance timer.

(1) Specifications

	Unit	6CXM-GTE/ 6CXM-GTE2
Plunger dia.	mm	13
Plunger pre-stroke	mm	3.5
Delivery valve suck-back q'ty	mm^3/st	70
Delivery valve dia.	mm	7
Cam lift	mm	12
Thrust clearance	mm	0.01 - 0.05
Plunger spring free length	mm	54
Plunger spring constant	N(kgf)/mm	36.7 (3.74)
Delivery valve spring free length	mm	21
Delivery valve spring constant	N(kgf)/mm	9.26 (0.944)



(YPES-PS type)

(2) Feature

The fuel injection pump supplies pressurized fuel to the injection nozzles through the action of the plunger.

The plunger reciprocates in the plunger barrel with a fixed stroke and is lapped for a precise fit.

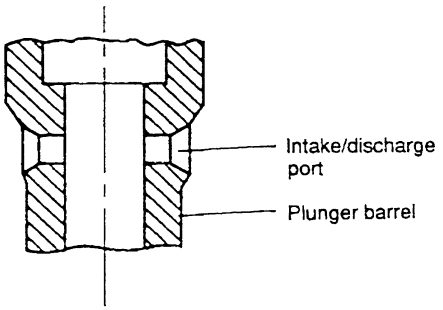
A lead groove is helically cut in the plunger, and this leads to a connecting groove which rises to the top of the plunger.

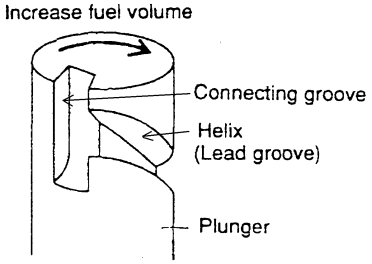
The integrate plunger barrel, the plunger barrel and the flange case for the delivery valve holder, equips a port for intake and discharge.

The injection volume of individual cylinders can therefore be adjusted by rotating the plunger.

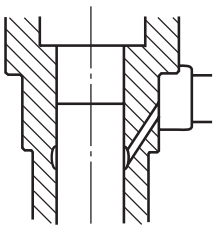
The fuel comes through this port into the plunger chamber is pressurized by the plunger, opens the delivery valve, flows to the fuel injection nozzle through the fuel injection pipe and is injected into the combustion chamber. Fuel injection ends when the pressurized fuel has been discharged.

This happens when the lead groove lines up with the port, (as the plunger rises and the pressure in the fuel injection pipe drops).





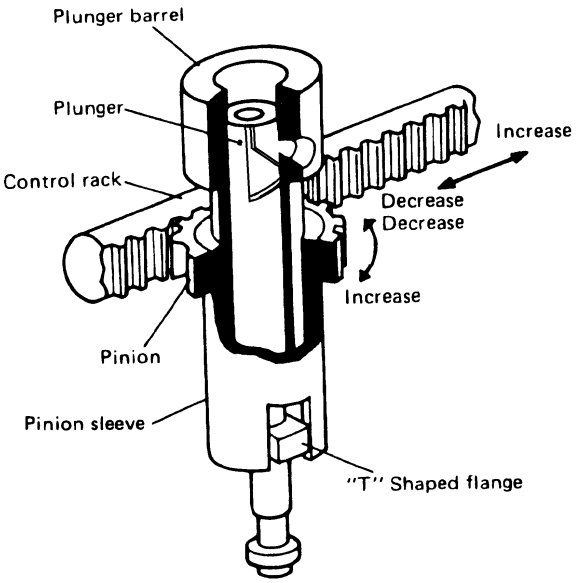
A fuel leak return hole is provided in the plunger barrel. This returns fuel which leaks through the gap between the plunger and the barrel to the fuel drain sump through the drain pipe, preventing dilution of the lubricant in the cam chamber.



(3) Injection volume control

The fuel control mechanism is shown in following fig.

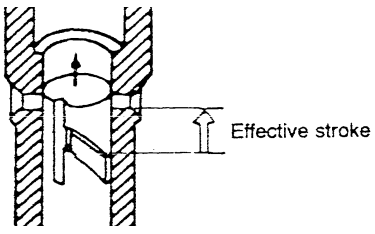
The T-shaped flange at the bottom of the plunger is fixed in the grooves of the pinion sleeve, and the pinion is engaged to the control rack. The plunger rotates at the same time as the control rack is moved, adjusting the effective stroke and controlling the injection quantity.



1) Full injection volume position

When the rack is set at maximum setting, maximum volume of fuel is discharged. Injection occurs when the top of the plunger lines up with the intake port in the barrel. At this time, the lead groove which is positioned at the widest stroke part, lines up with the discharge port, prolonging the injection time and increasing the volume of fuel injected.

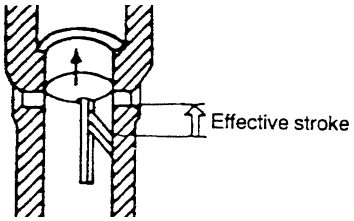
This setting is normally used for starting and max. output operation.



2) Half injection volume position

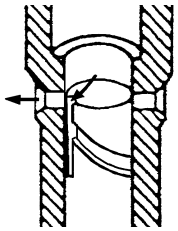
Discharge ends earlier as the rack is moved towards zero from the maximum setting.

The fuel injection volume is decreased accordingly.



3) No fuel injection

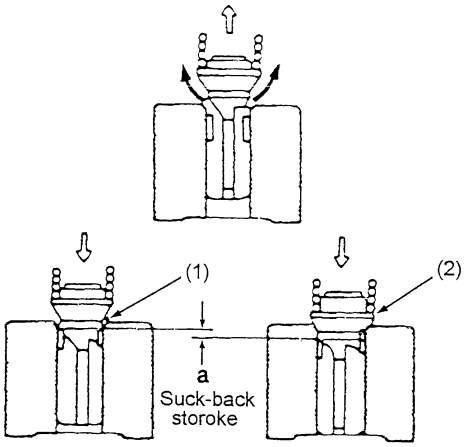
With the rack set near zero, the intake/discharge port in the barrel is always open, so no fuel is pressurized (even though the plunger continues to reciprocate).



(4) Delivery valve

The delivery valve at the top of the plunger prevents fuel in the fuel injection pipe from flowing back to the plunger chamber and sucks up fuel from the nozzle valve to prevent after-drip.

When 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 the same time, the suck-back collar (1) blocks off the fuel injection pipe and the delivery chamber, and the valve continues descending until the seat (2) comes in contact with the barrel.

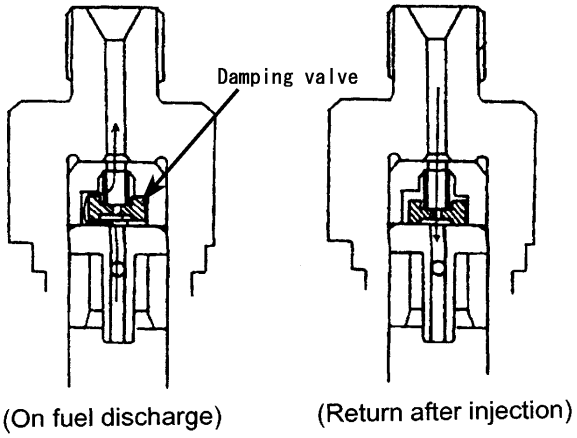
The fuel oil pressure in the fuel injection pipe decreases proportionately with the lowering of the valve (due to increased volume).

This accelerates the nozzle to the nozzle valve, and sucks up fuel from the nozzle to prevent dripping.

The result is a longer nozzle life and improved combustion efficiency.

(5) Injection wave damping valve

The injection wave damping valve is fitted inside the delivery valve holder. This valve prevents the cylindrical pressure from being raised again by the injection reaction and thus prevents secondary injection and cavitation.



3.11.2 Governor

(1) Feature

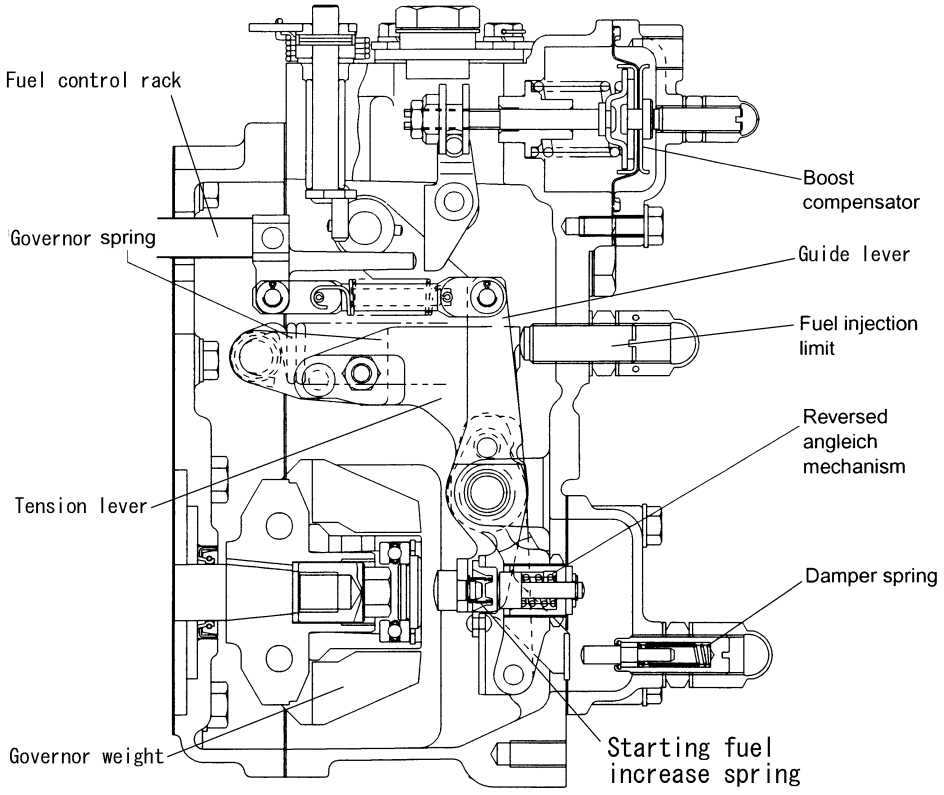
The two-point weight centrifugal type all speed control governor is directly coupled with the fuel pump. The governor weight assembly, driven by the pump shaft end, controls the control rack of the fuel pump to adjust the fuel injection quantity.

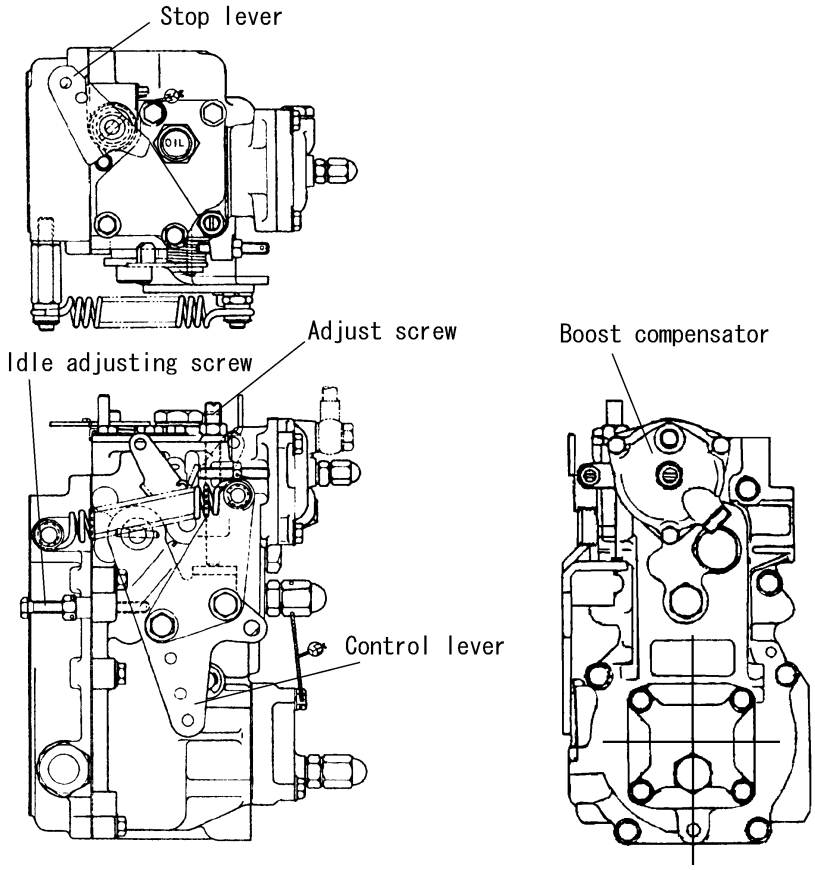
1) Condition during engine start
   When the control lever is pulled to the starting position, the governor weights are closed by the force of the governor spring, and the linkage connected to the shifter moves the control rack to the maximum injection position.

2) Conditioning during idling
   As the engine starts and the control lever is returned to the idle position, the spring retainer returns and the governor spring force is reduced.
   The governor weights are opened by the centrifugal force and push the control rack to reduce the fuel. The weight force is balanced with the spring force to maintain the idling speed.

3) Condition during maximum speed
   When the engine reaches its maximum speed, the weight force is balanced with the governor spring force and the rack is kept at the appropriate injection position. If the engine load is reduced, the engine speed increases and the governor weights open. The rack is then moved to reduce the engine speed, to return it to the specified maximum. The maximum fuel quantity is limited by the fuel injection limit screw. Do not try to adjust the injection limit screw except when necessary since it is sealed.
   When the stop lever is turned to the stop position, the control rack is moved to the stop position,
   regardless of the governor spring force, and stops the engine.

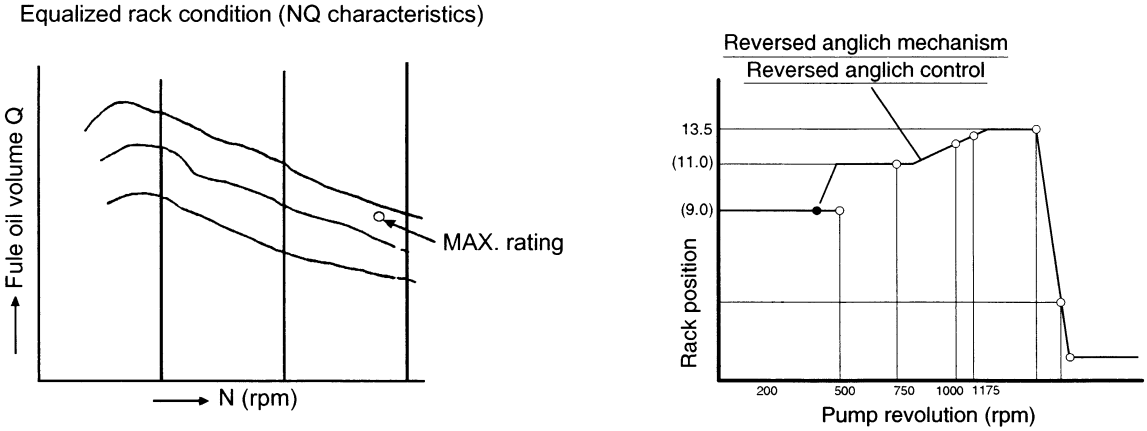
4) Damper spring
   To prevent engine stoppage on sharp engine speed reduction, damper spring is equipped.





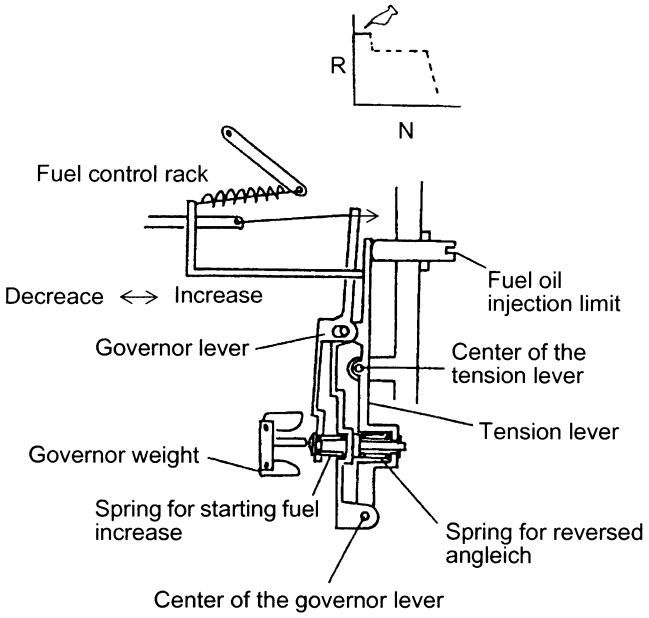
(2) Reversed angleich mechanism

The CXM model employs the high pressure fuel injection pump to match with its high output structure.
When using the high pressure pump, however, the injection volume at the equalized rack condition tends to decrease according to the rise of engine speed. Accordingly, a larger capacity pump is used.
The use of a large capacity pump, however, gives over-torque and adverse exhaust color due to excessive fuel injection during medium speed high load operation. To prevent this and to control fuel injection volume at the medium high load operation to the proper level, the reversed angleich mechanism is used for the governor.



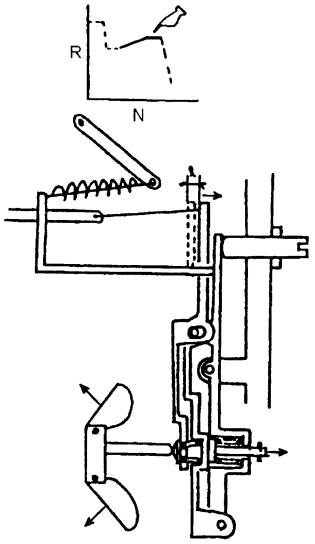
1) Before starting

The starting fuel increase spring let the governor lever move to the "fuel increase" side to raise the starting performance.



2) After starting

The starting fuel increase spring is compressed by the thrust force of the governor to stop the starting fuel increase.

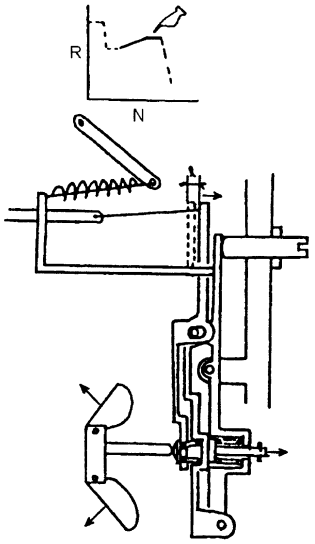


3) Max. speed

Thrust force of the governor increases according to the rise of revolutions and the fuel is increased until the reversed angleich spring is completely compressed.

(This is the max. injection position.)

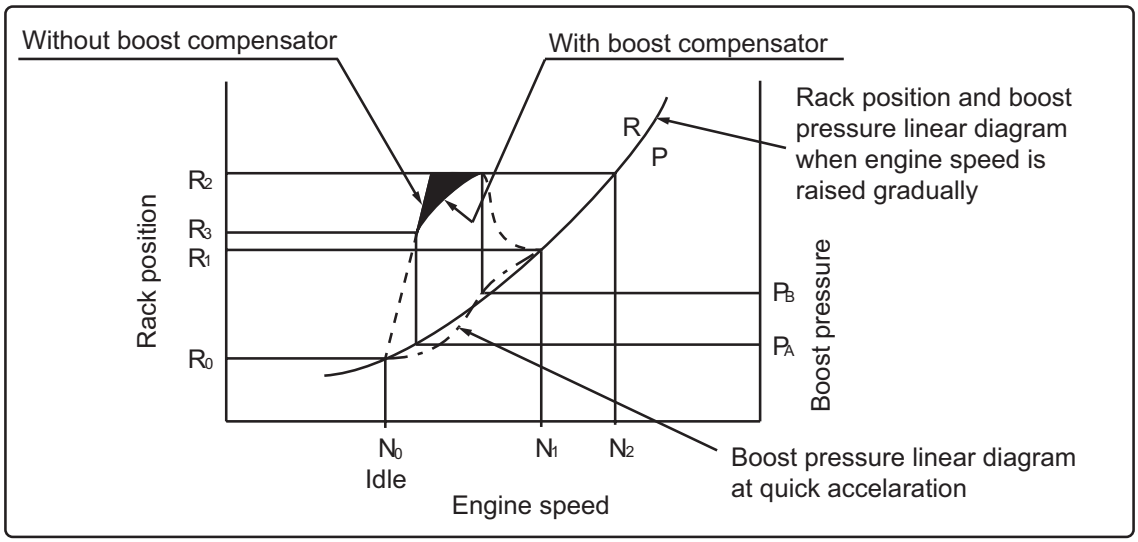
To explain the function more concretely, during the medium to high load operation, even if the tension lever contacts the fuel limiter and the rack is at the max. position, the reversed angleich spring overcomes the thrust force of the governor since the revolution is below the max. speed and caused the governor level to move to the fuel decrease side by the distance of the control q'ty (ℓ). This is the reversed angleich mechanism, which limits the fuel injection q'ty during medium to high load operation for preventing "over-torque" and adverse exhaust color.



3.11.3 Boost Compensator

The boost compensator, installed to the injection pump of the turbocharged engine models, limits the movement of the fuel control rack with the boost pressure detection equipment. It optimizes fuel injection and combustion according to the air volume inside the cylinder for complete combustion and higher output.

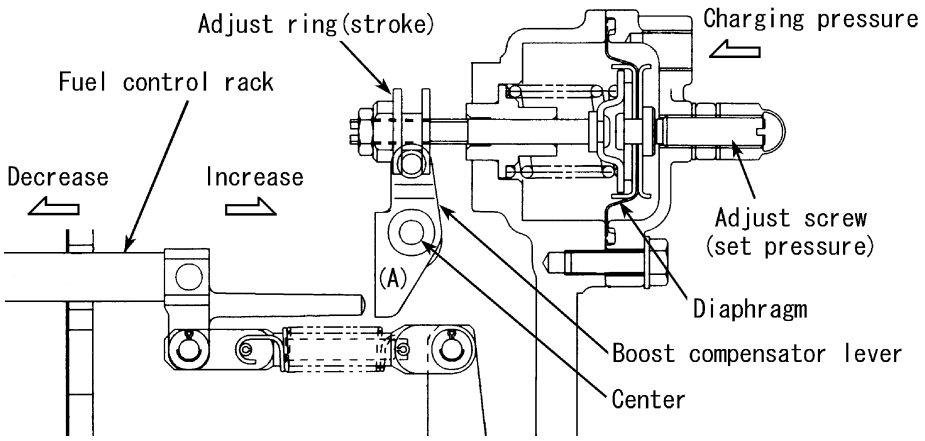
(1) Performance



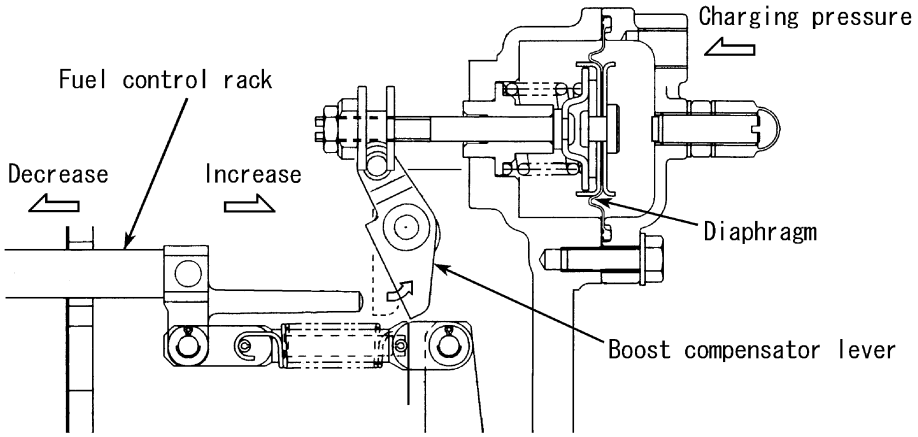
1) The solid line shows the rack's moving distance and the boost pressure when the engine speed is raised gradually.
2) When the regulator handle is raised quickly from the idling position (N0) to the (N1) position, the rack moves from R0 to R2 to attain the engine speed (N1), and injects a large quantity of fuel. The supply of air, however, is inadequate due to the follow-up delay of the turbocharger (i.e. insufficient boost pressure), and the exhaust turns black.
3) The boost compensator limits the advancing of the rack and keeps it at R3 position. The rack starts to move at pressure of PA and reaches to R2 position when pressure rises up to PB or more.
4) In engines with the boost compensator, injection quantity in the range of rack positions R2 - R3 (shadowed area) is limited and thus black exhaust is controlled.

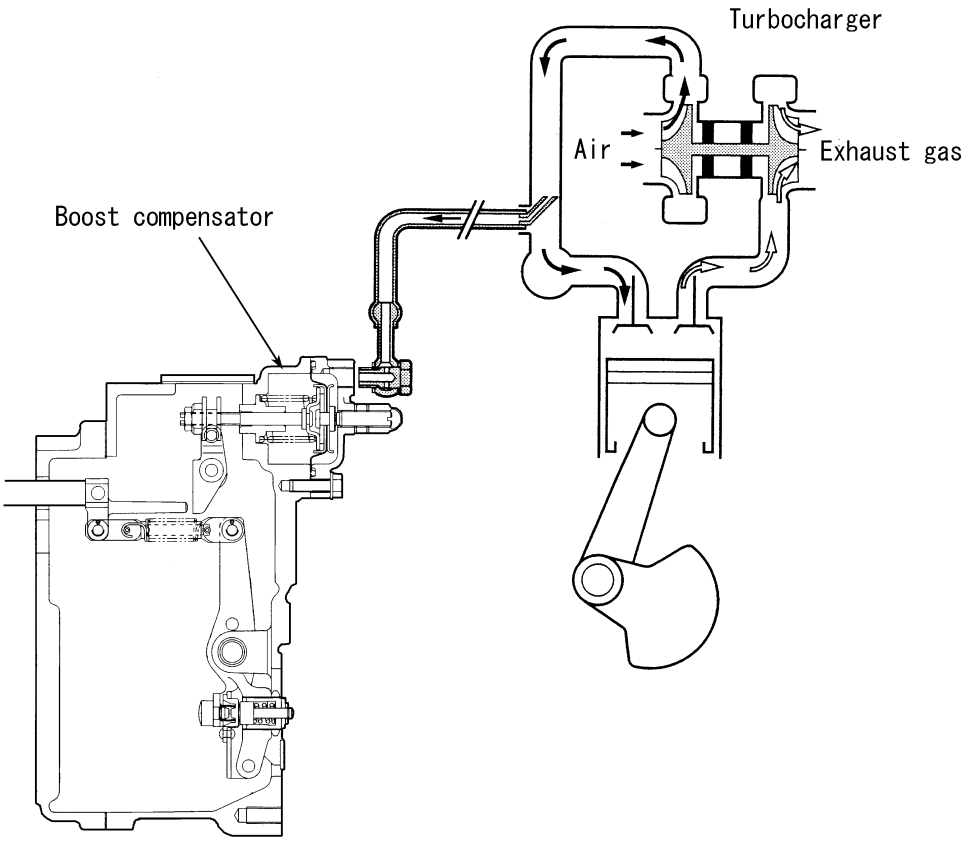
(2) Equipment

When the regulator handle is operated quickly for acceleration, the control rack moves to the fuel increase side and touches the boost compensator lever (A) to limit the rack's stroke. This position is the point where about 70% of the max. injection quantity is obtained. (Fine adjustment is possible by the adjust screw.)



When the turbocharger catches up the engine speed and the boost pressure is raised, the diaphragm is pressed by the charging pressure, causing the boost compensator's lever to move to turn the control rack to the fuel increase side: max. injection quantity is obtained.

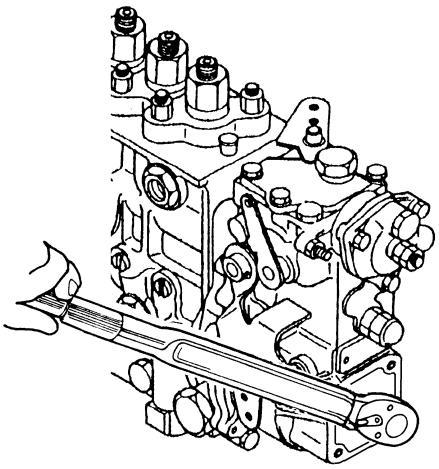




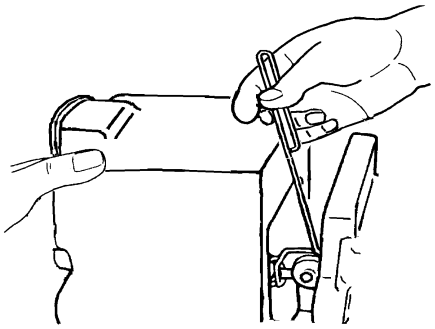
3.11.4 Disassembly of Governor

The fixing wire and seal are attached to the governor to limit engine speed and output for protecting the engine.
Do not disassemble and adjust the limit unless it is unavoidable. Faulty adjustment of the governor will lead to engine failure.

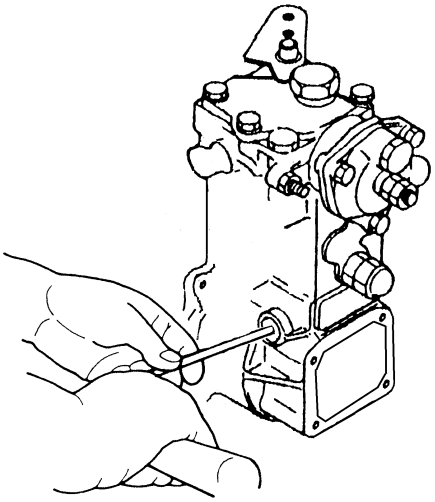
1) Remove the governor case cover.
2) Remove the reverse angleich mechanism.



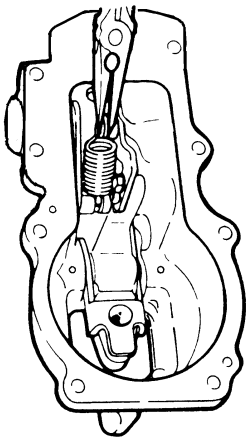
3) Remove the governor case bolt. Remove the governor case (parallel pin) from the spacer of the fuel pump side while lightly tapping the governor case with a wooden hammer.
   Make a gap between the governor case and spacer by moving only the moving parts of the governor cover.
4) Remove the connecting spring by inserting needle nosed pliers between the governor case and spacer.



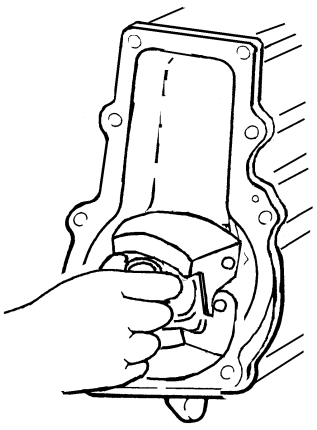
5) Slide the governor case and pull out the link pin of the fuel control rack.
6) Remove the snap-rings on both ends of the governor lever shaft.
7) Put a rod (10 mm (0.3937 in.) or less diameter) on one end of the governor lever shaft, and tap it until the O-ring comes out from other side of the governor case.
8) After removing the o-ring, lightly tap another end of the shaft, and remove the governor lever shaft. Then remove the governor shaft assembly and washer.



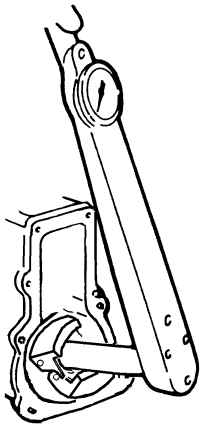
9) Unhook the governor spring from the tension lever and control lever shaft.



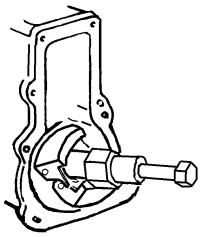
10) Pull out the governor sleeve at the end of the fuel camshaft by hand.



11) Remove the governor weight nut and washer with a box spanner, fixing the fuel camshaft by the hole of the fuel pump coupling or holding the coupling with a vice. Screw the governor weight nut back in two or three times.



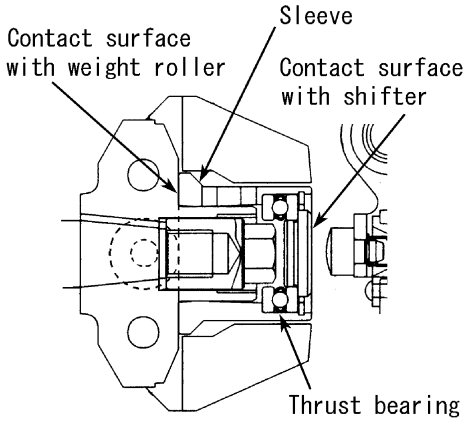
12) Remove the governor weight assembly from the fuel camshaft. Use the governor pulling tools.

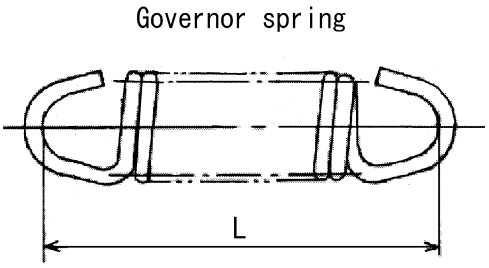


3.11.5 Inspection of governor

Inspect the following points when disassemble the governor.

	Check item	Allowance	Repair
1	Wear & excessive clearance of governor weight pin & pin hole	Within the standard clearance of 0.2mm and should move smoothly.	Replace the governor weight cmp.
2	Contact surface of governor sleeve with weight roller.	No excessive wear.	Replace the sleeve.
3	Thrust bearing	No seizure, discoloration, or breakage	Replace the thrust bearing.
4	Free length, fall of governor spring	Free length: Within 68 mm (Standard 65 - 65.5 mm)	Replace the governor spring.
5	Wear, distortion of lever shafts	No excessive clearance and distortion	Replace the shaft.
6	Oil leakage to outside	No oil oozing out and leakage	Replace the packing, O-ring.



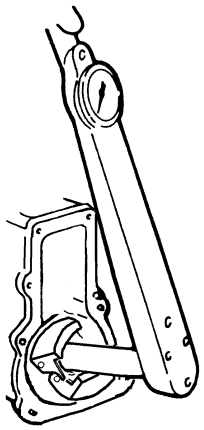


3.11.6 Reassembly of governor

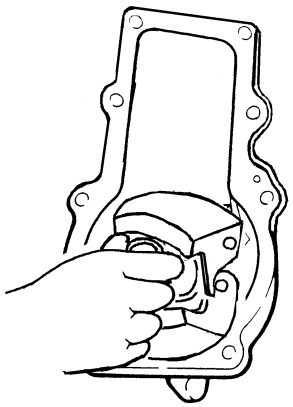
Inspect all parts after disassembly and replace any parts as necessary. Before starting reassembly, clean both the new parts and parts to be reused, and put them in order.
Be sure to readjust the unit after reassembly to obtain the specified performance.

1) Insert the governor weight assembly to the taper portion at the end of the fuel camshaft.
   Fix it by the hole of the fuel pump coupling or by holding the coupling with a vise.
   Mount the conical spring washer, and tighten the governor weight nut.

Governor weight tightening torque	59 - 69 N-m (6 - 7 kgf-m)



2) Open the governor weight and insert the sleeve in the end of the fuel camshaft.



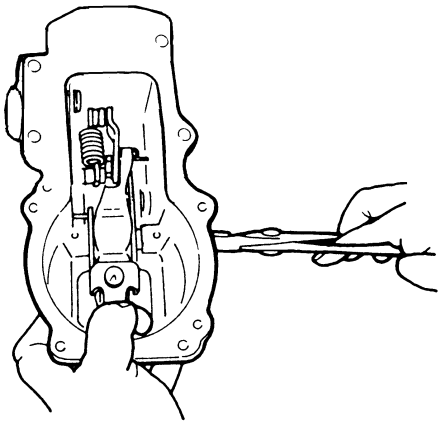
Note: Make sure that the sleeve moves smoothly after insertion.

3) 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.

4) Mount the governor link to the governor lever assembly.

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.

5) Put the governor lever shaft assembly in the governor case, insert the governor lever shaft until the O-ring groove come out from the opposite side of the governor case, and fit the O-ring.

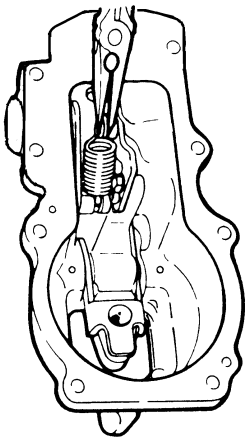


Note:
1. Fit the O-ring to the side you tapped it in from.
2. Coat the O-ring with the silicon oil for protection during insertion.
3. Don't forget to place washers on both sides of the governor lever.

6) After mounting the O-ring, tap the governor lever in the opposite direction, and mount the E-shaped stop rings on the grooves at both ends.

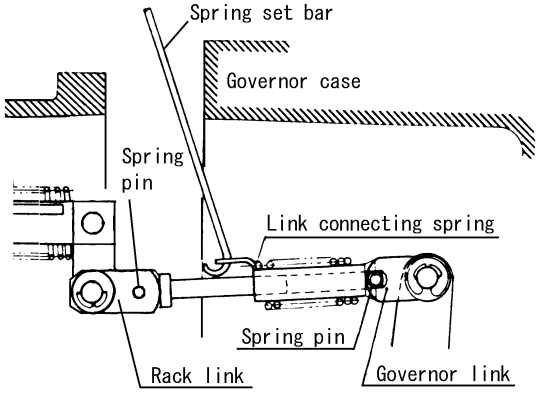
Note: After mounting the governor lever assembly, make sure that it moves smoothly.

7) Hook the governor spring on the pin of the governor lever and control lever.



8) Insert the rack link in the governor link, hook the link connecting spring on the spring pin of the governor link side with the spring set bar, and connect the governor link with the rack link.

9) Fit the link connecting spring to the spring pin at the rack link with the spring set bar by pushing the rack link into the governor link.



10) Mount the governor case to the fuel pump unit, lightly tapping it with a wooden hammer, and tighten the bolts.

11) Mount the governor case cover.

12) Insert the control lever to 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.

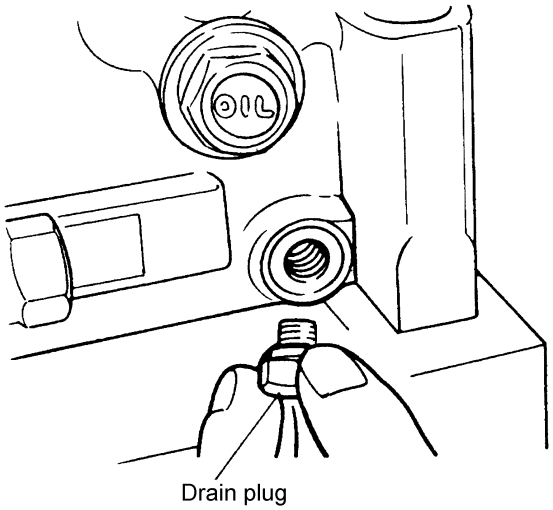
3.11.7 Disassembly of fuel injection pump

When disassembling the fuel injection 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 together and put them back in the same cylinder).

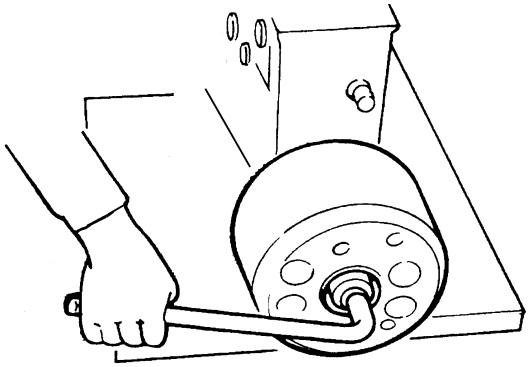
(1) Preparation

1) Wash off the dirt and grease on the outside of the pump with cleaning oil (kerosene or diesel oil) before disassembly.
2) Perform the work in a clean area.
3) Take off the drain plugs and drain the lubrication oil.

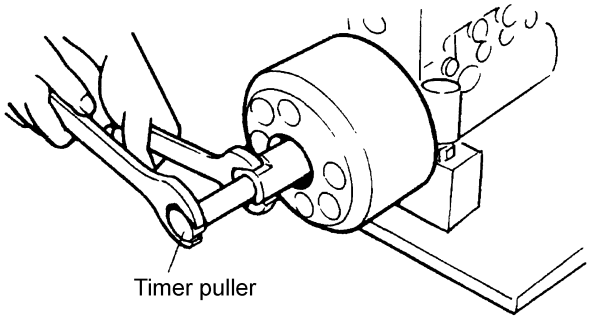


(2) Disassembly

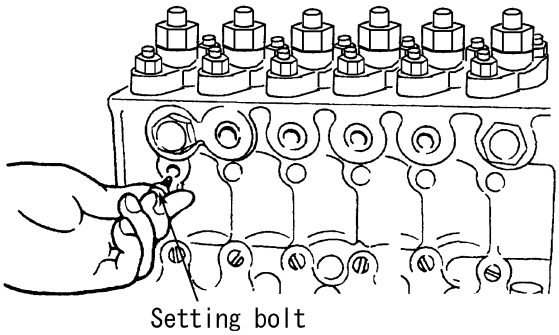
1) Fix the outside of the automatic timer and remove the nut.



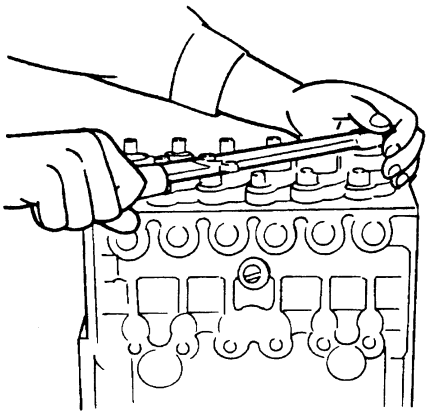
2) Screw the puller into the nut hole.
Remove the automatic timer by screwing in the puller bolt.



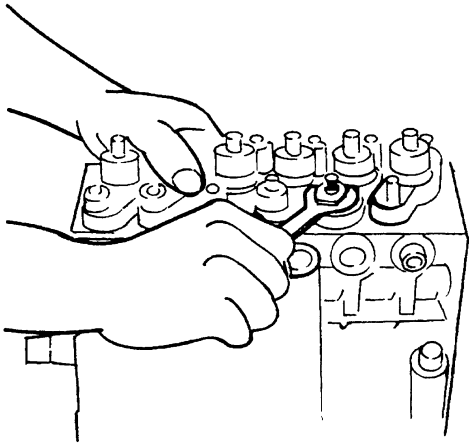
3) Remove the spring shoe setting screws of all cylinder.



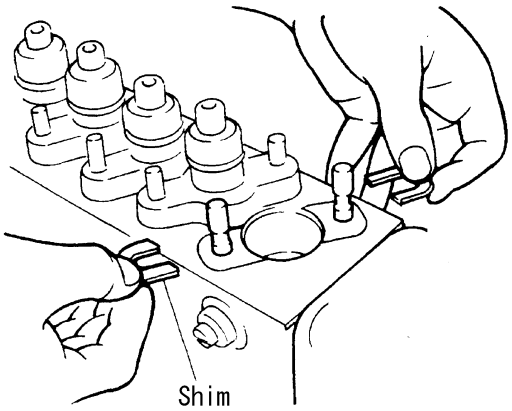
4) Loosen the delivery valve holders until they can be turned by fingers.



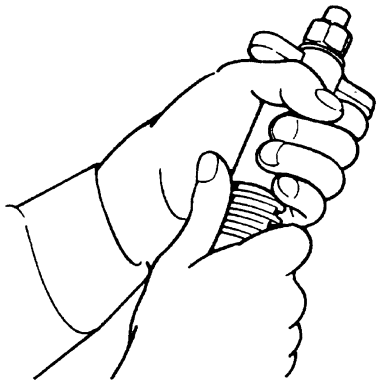
5) Remove the plunger barrel tightening nuts.



6) Remove the plunger barrel assembly.
   Insert two drivers under the barrel flange. (Be careful not to damage the surface of the pump housing.)
   Lift up the barrel by prying the driver. Pull out the barrel by turning it to and fro.
7) Remove and mark the shims to recall the original assembly.

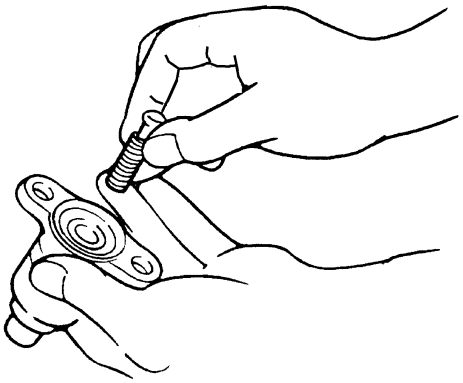


8) Remove the plunger and plunger barrel together with the plunger spring and lower spring retainer.

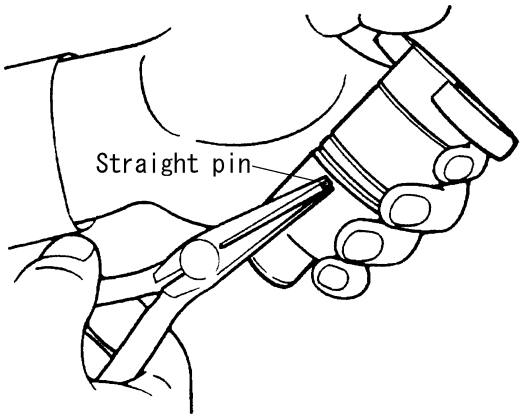


9) Remove the delivery valve holder, delivery valve, valve spring, valve stopper and O-ring from the plunger barrel.

Note: Mark each part to recall the original assembly.

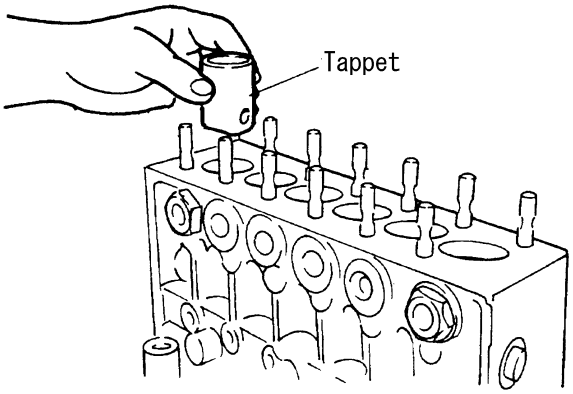


10) Remove the straight pins securing the spring shoe to the barrel support, then remove the pinion.

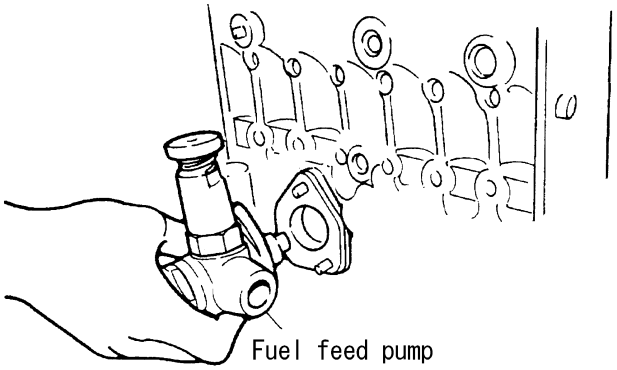


11) Remove the rack setting screw and the control rack.

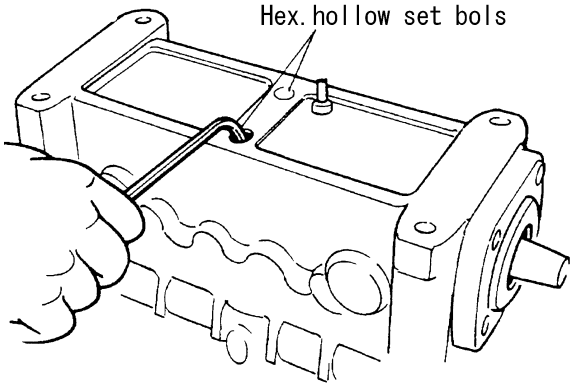
12) Remove the tappets.



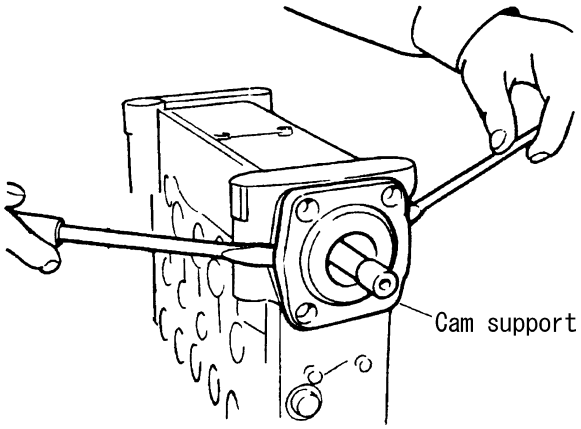
13) Remove the fuel feed pump.



14) Put the pump body upside down and remove the hex-hollow set bolts that secure the middle bearing.

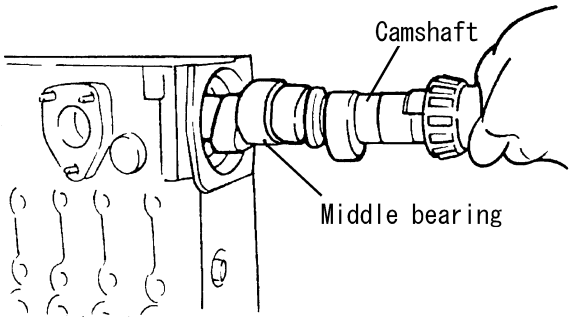


15) Remove the cam support and the shims by prying open the slots in the support with screw drivers.



16) Remove the camshaft together with the middle bearing from the drive side.

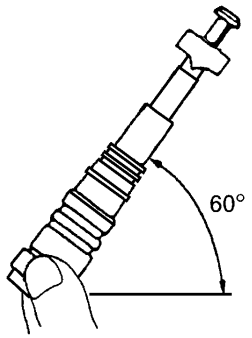
Note: Be careful not to damage the governor case oil seal when removing the camshaft.



3.11.8 Inspection of fuel injection pump

(1) Inspection of plunger

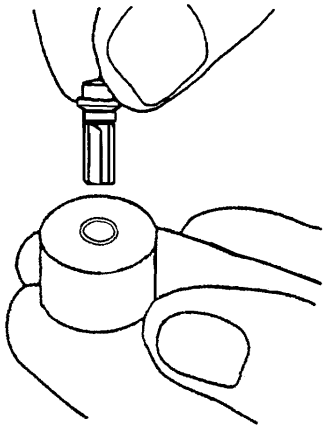
1) Thoroughly wash the plungers, and replace the plungers that have scratches on the plunger lead or are discolored.
2) The plunger is in good condition if it slides down smoothly when it is tilted at about 60° .
   Turn the plunger and try this test several times. If the plunger slides down too quickly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



(2) Inspection of delivery valve

1) Clean the delivery valve well before inspection.
   Replace as a set if the collar or seat of the delivery valve is scratched, scored, scuffed, worn etc.
2) The valve is good if it returns smoothly when released after being pushed down with your finger. (While the hole at the bottom of the delivery guide seat is covered.) Replace it if necessary. Likewise, the valve should completely close by its own weight when you take your finger off the hole at 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 housing

1) Inspect the sliding surface against the tappet guide for extreme wear. Scratches on the sliding surface against the roller pin are not a problem.
2) If there are burrs or discoloration, repair or replace the body 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 cam surface, deformation of key grooves and screw on both ends. Replace it if necessary.
2) Replace the bearings if the outer race surface are flaked or worn.

Note: Replace the fuel camshaft and bearings together.

(5) Inspection of tappet

1) Inspect the surface of the tappet, roller and roller pin for wear or damage. Replace it if necessary.
2) Measure the clearance between the roller and pin. Replace them if the clearance exceeds 0.2mm.

(6) Inspection of rack and pinion

Inspect the rack and pinion for wear and burrs on tooth surface. Replace them if necessary.

(7) Inspection of plunger spring and delivery valve spring

Inspect the spring for scratches, cracks, breakage, uneven wear and rust. Replace it if necessary.

(8) Inspection of setting screws

Inspect all setting screws and bolts for wear or damage. Replace it if necessary.

(9) Inspection of oil seal

Inspect the oil seal lips for wear or damage. Replace it if necessary.

3.11.9 Reassembly of fuel injection pump

(1) Preparation

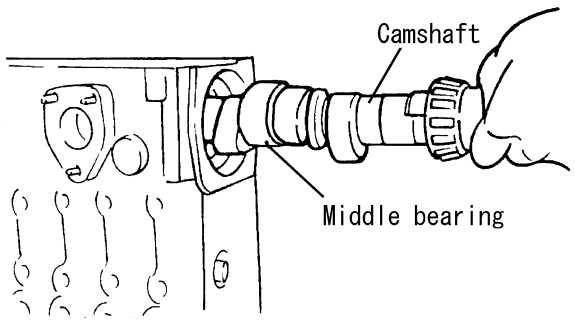
1) After inspection, arrange and clean all parts.
2) Prepare the parts for replacement before starting assembly.

Note:	Always replace gaskets, packing and O-rings with new ones.

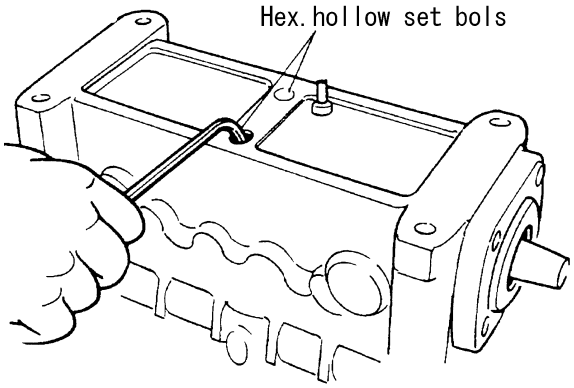
(2) Assembly

1) Install the governor case to the pump housing.
2) Fit the bearings to both ends of the camshaft. Place the pump housing upside down and insert the camshaft in the housing together with the middle bearing.

Note:	Apply grease to the middle bearing to prevent it from falling out before installation. Coat the camshaft and oil seal with clean lube oil to prevent damage to the lip of the oil seal.



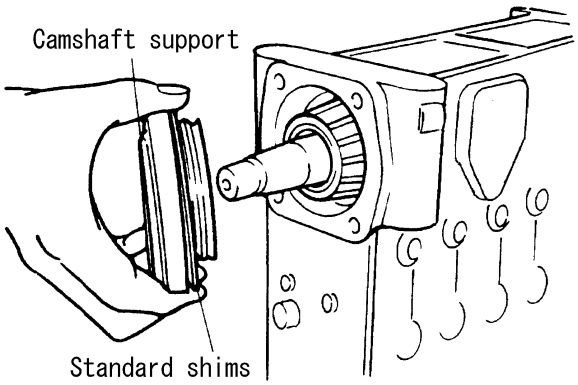
3) Provisionally tighten the middle bearing with hex. hollow set bolt.



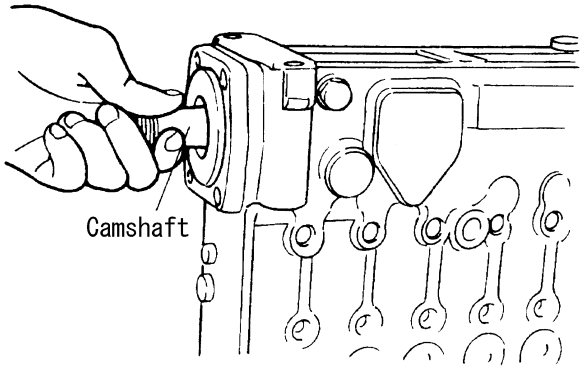
4) Provisionally install the camshaft support.
Sure to use the standard thickness shim.

Standard thrust clearance of camshaft	0.01 ～ 0.05mm

Note:	Do not install the O-ring at this stage. Coat the camshaft and oil seal with clean lube oil to protect the oil seal from damage. Take care that the shims do not stick in the O-ring grooves.



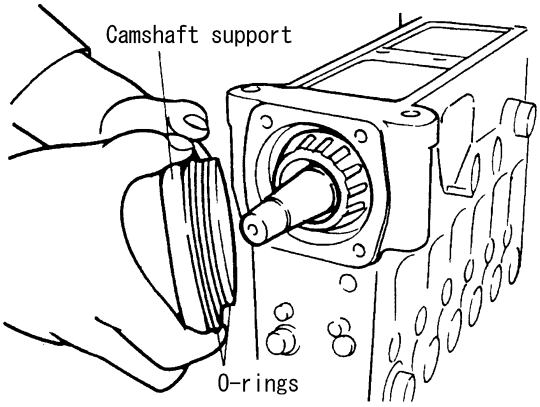
5) Tighten the camshaft support with four screws.
6) Tap both ends of the camshaft with a mallet to seat the bearings.
Turn the camshaft by hand and feel its rotating resistance (preload). If it is too heavy, adjust it by adding shims. Remove the shim if it is too light.



7) After adjusting the preload, remove the camshaft support and install new O-ring in the groove in the support.

8) Apply clean lube oil to the O-rings, pump housing bore and the camshaft support.

Note: Be careful not to damage the O-rings.

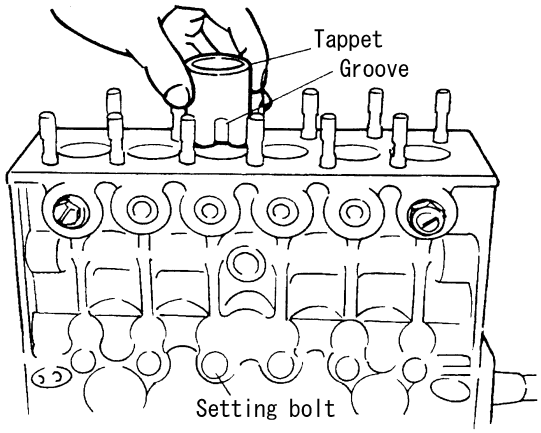


9) Securely tighten the hollow set bolts of the middle bearing.

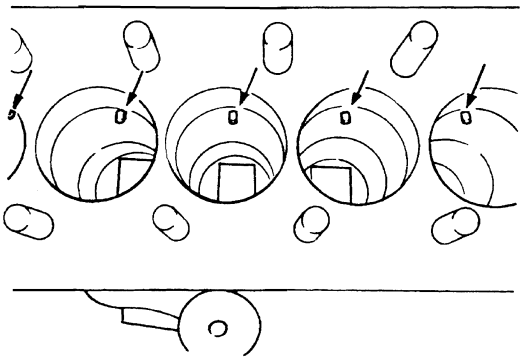
Note: Recheck the bearing preload after tightening the hollow set bolts, and readjust the preload if necessary.

10) Screw in the tappet setting bolts.

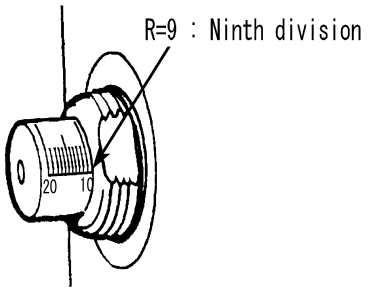
11) Align the groove in the tappet with the setting bolt and insert the tappet.



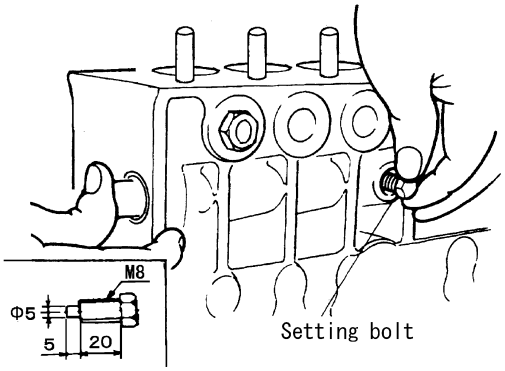
12) Screw in the spring shoe setting bolts.



13) Insert the rack in the pump housing and align its ninth division of the scale with the end surface of the pump housing thread.

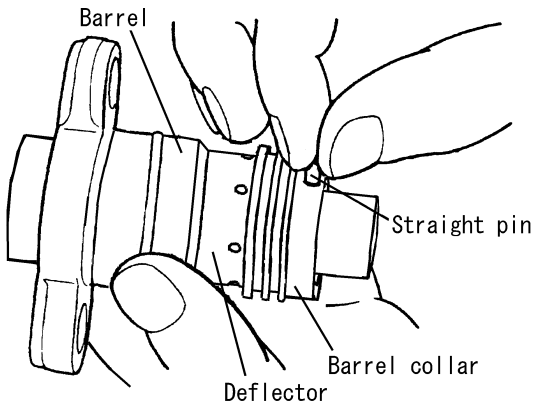


14) Lock the rack position with a special setting bolts as shown below.

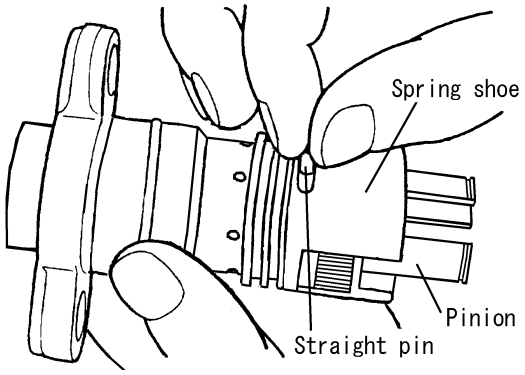


15) Install new O-ring in the plunger barrel.

16) Insert the plunger barrel in the deflector and barrel collar. Align the hole in the barrel with the hole in the collar, then set the straight pin in the holes of the barrel and collar to fix them.



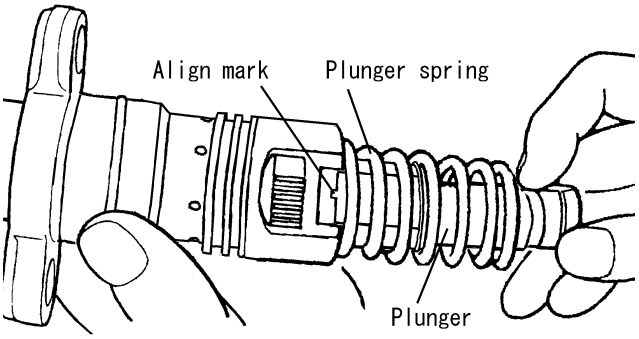
17) Insert the pinion in the spring shoe and install the spring shoe on the barrel collar. Secure the spring shoe with the straight pins.



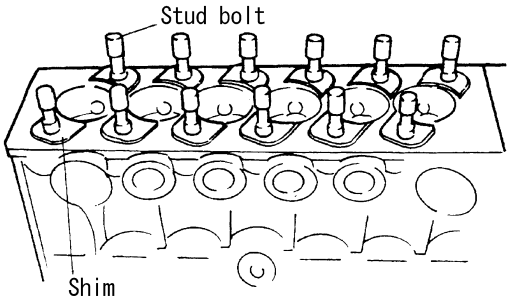
18) Insert the clip ring into the groove in the pinion.

19) Install the plunger spring.

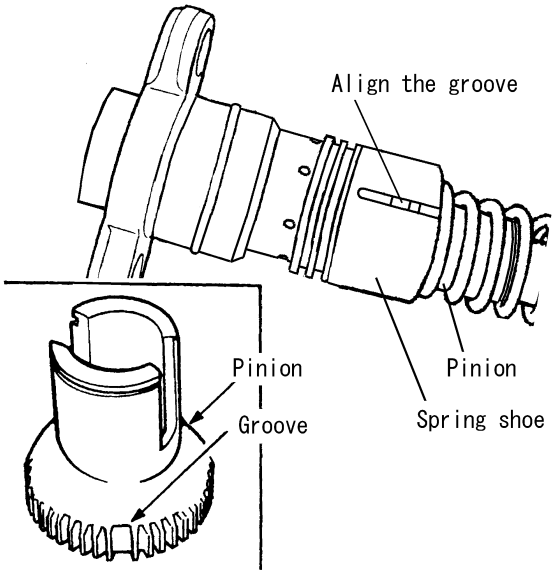
20) Hook the neck of the plunger to the spring retainer, align the plunger flange with the slots in the pinion and push the plunger until it is locked by the clip ring on the pinion.



21) Place a shim around each stud bolt.

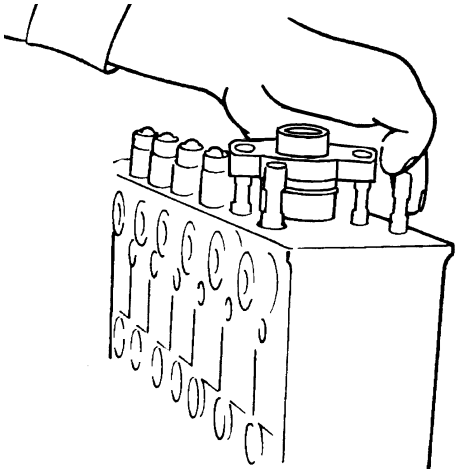


22) Align the grooves in the pinion and spring shoe.

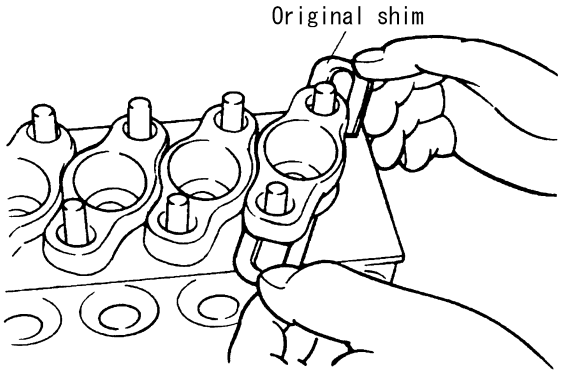


23) Align the groove of the spring shoe with the setting bolt and carefully insert the plunger barrel assembly in the pump housing bore.

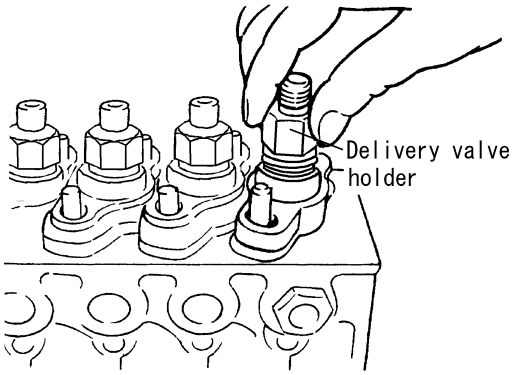
Note: Apply clean lube oil to the O-rings and pump housing bore in order not to damage the O-ring.
Do not try to drive in the barrel.
Before inserting the plunger barrel assembly, turn the camshaft and set the cam to the position that the tappet comes to the lowest position.



24) Install the original shims as marked during disassembly between the barrel and pump housing.

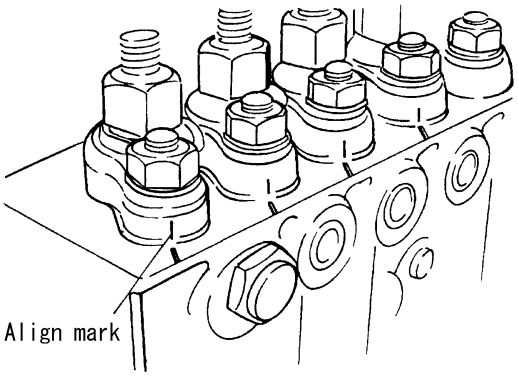


25) Install the delivery valve seat, valve, spring, stopper and O-ring, then finger tighten the delivery valve holder.



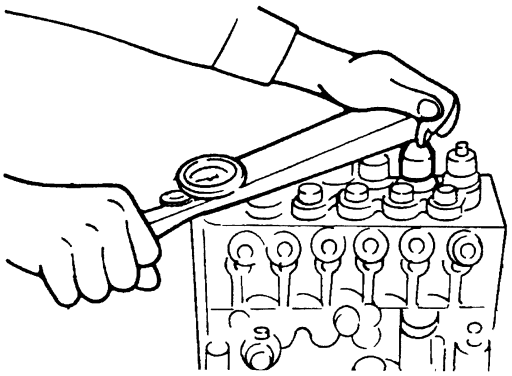
26) Align the marks on the barrel support and the pump housing, then tighten the nuts to the specified torque.

Torque	39 ～ 49 N・m (4 ～ 5 kgf・m)

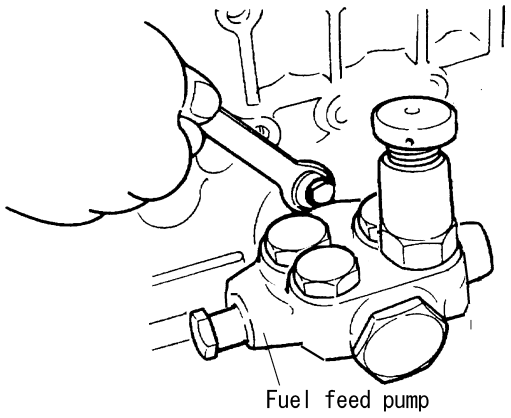


27) Tighten the delivery valve holders to the specified torque.

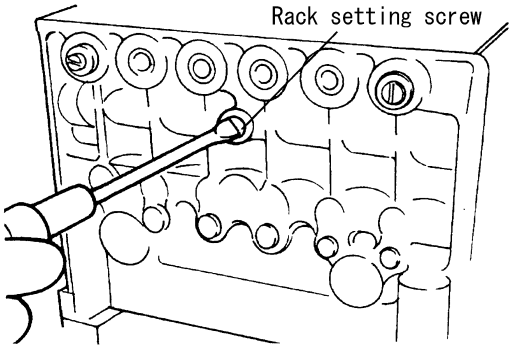
Torque	98 ～ 118 N・m (10 ～ 12 kgf・m)



28) Install the fuel feed pump to the pump housing.



29) Remove the rack set bolt and install the rack setting screw securely.



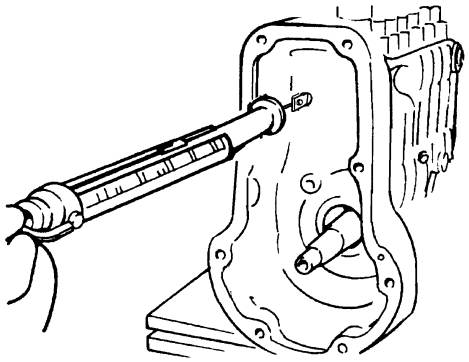
30) Hook a spring scale to the control rack and measure the sliding force.

Sliding force	1472 (150 gf) max.

Excessive sliding force may be caused by the followings.

- Large resistance at the sliding section of the plunger assembly.
- Excessive tightening of the delivery valve holder (distortion of the plunger barrel)
- Damage or particles at the tooth of the control rack or pinion.
- Damage at the outer periphery of the control rack.
- Damage at the control rack hole in the pump housing.

In each case, disassemble and repair.



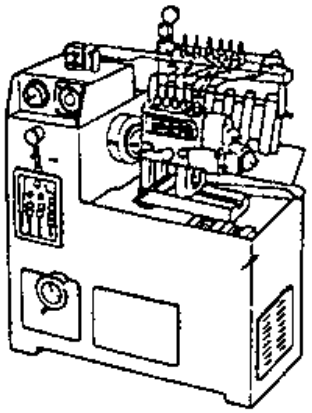
31) Assemble the governor.

32) Fill the pump and governor with clean lube oil.

Oil capacity	pump	250 cc
	governor	300 cc

3.11.10 Adjustment of fuel injection pump

Adjust the fuel injection pump after completing reassembly. The pump itself must be readjusted with a special pump tester when you have replaced major parts such as the plunger assembly, tappet assembly, fuel camshaft, etc.



(1) Preparation

Prepare for adjustment as follows.

1) Adjusting nozzle assembly and data sheet of injection start pressure.

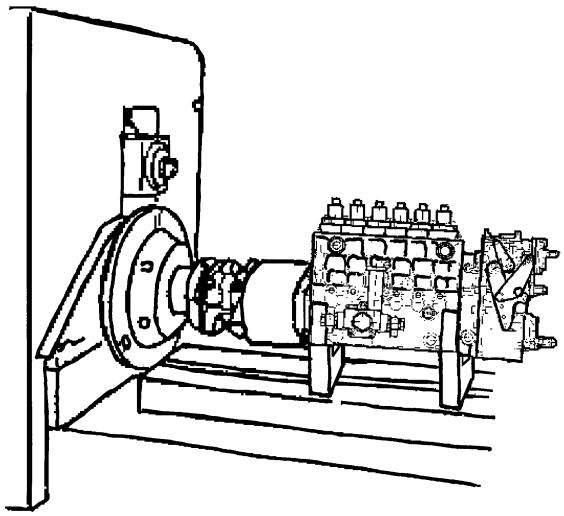
Adjusting nozzle type	See (7) Injection adjustment standard
Injection start pressure	

2) Adjusting injection pipe.

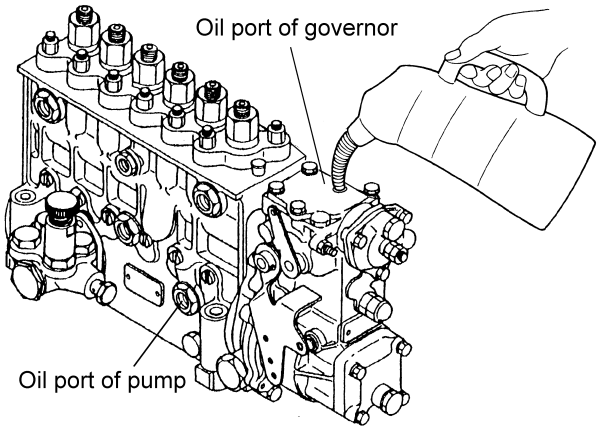
mm (in)

Inner dia. / outer dia. x length	ϕ 6.35/1.8 × 600mm
Minimum bending radius	25 (0.98)

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

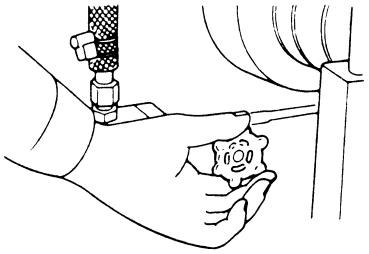


4) Fill the pump and governor with clean lube oil.
   oil capacity : pump 250 cc
   governor 300 cc



5) Connect the fuel oil pipes and operate the pump tester to purge the air in the line.

6) Set the oil feed pressure from the pump tester to the injection pump at the pressure specified in the separate service data sheet.

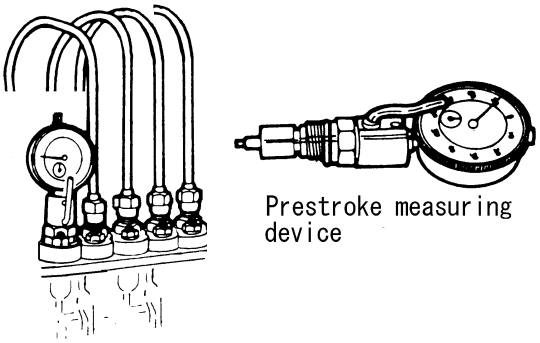


(2) Adjustment of pre-stroke

1) Remove the delivery valve holder of No.6 cylinder. Remove the delivery valve spring and delivery valve.

2) Screw the pre-stroke measuring device in the screw hole on the top of the barrel.

3) Set the control rack to the full load position.
   Find the bottom dead center of the plunger while rotating the pump by hand, and set the dial indicator to zero.



4) Slowly rotate the pump in the normal rotation direction by hand, and measure the plunger lift until fuel flow from the overflow pipe on the measuring device stops.
   Pre-stroke : See separate service data
5) If the measured pre-stroke is not standard, adjust by changing the shim thickness between the flange of the plunger barrel and pump housing.
6) Repeat the above procedure to adjust the pre-stroke of each cylinder.
7) After adjustment is completed, insert the delivery valve, delivery valve holder and spring.
   Tighten the delivery valve holder.

Delivery valve holder tightening torque	98 ～ 118 N・m (10 ～ 12 kgf・m)

(3) Adjustment of injection timing

After adjusting the pre-stroke for all cylinders, check and adjust the injection timing.

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

Cylinder No.	Count from drive coupling side
Direction of rotation	View from drive coupling side

2) Set the tester needle on the flywheel scale in a position where it is easy to read, and check the injection timing several times according to the injection order.

Injection order	1-4-2-6-3-5
Injection interval	60°
Allowable deviation	± 30'

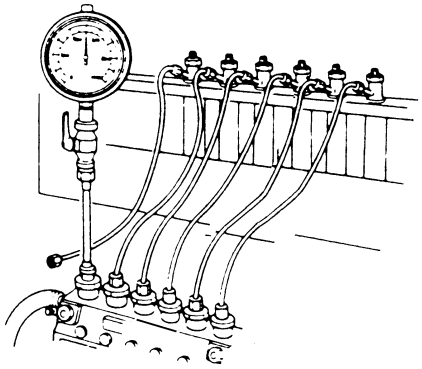
3) Readjust the pre-stroke of cylinders that are not within the allowable deviation (increase of the adjusting shim thickness makes the injection timing later, and decrease makes it earlier).
   The change in injection timing by the adjusting shims is as follows.

Adjusting thickness of shim	Change of injection timing	
	Cam angle	Crank angle
0.1 mm (0.0039 in.)	0.35°	0.7°

Thickness of shims	Standard	3.0 mm (0.118 in)
	Applicable	2.5 ～ 3.5 mm (0.984 ～ 1.378 in) (t = 0.1 mm step)

(4) Plunger pressure test

1) Mount the pressure gauge to the delivery valve holder of the cylinder to be tested.



Max. pressure gauge reading	98.1 MPa (1000 kgf/cm²)
Connecting screw dimensions	M14 × 1.5

2) Set the governor control lever in the stop position, operate the injection pump at about 200 rpm, and make sure that the pressure gauge reading is 49 MPa (500 kgf/cm²) or more. All the time lightly move the control rack towards fuel increase side.
   Replace the plunger if the pressure does not reach this value.
3) Check to see that oil is not leaking from the delivery valve holder or fuel injection piping, and there is no extreme drop in pressure.

(5) Delivery valve pressure test

1) Connect a pressure gauge to the delivery valve holder. (Refer to plunger pressure test.)Drive the pump at 200 rpm and, moving the control rack, apply a pressure of 12 MPa (120 kgf/cm²).
2) Set the control rack to the 0 mm position and measure the time required for the pressure to drop from 10 MPa (100 kgf/cm²) to 9 MPa (90 kgf/cm²).

Pressure drop limit	20 seconds minimum

   If the pressure drops faster than this, wash the delivery valve, and retest. Replace the delivery valve if the pressure drop is not remedied.

(6) Measurement and adjustment of injection volume

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

1) Measurement of injection volume.

a) Set the pump rpm, rack position and measuring stroke to the specified value and measure.

Pump rpm	See separate service data
Pump rotation direction	View from drive side
Rack indicator scale	See separate service data

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

Measuring stroke	See Standard Adjustment Value Table.
Specified injection volume at standard rack position	
Non-uniformity of cylinders	

2) Adjustment of injection volume

a) Loosen the two nuts on the plunger barrel flange, and turn the plunger barrel to the right or left.

b) Measure the injection volume of each cylinder. Repeat this process until the injection volume of every cylinder is within the specified limit.

c) After completing the measurements, retighten the nuts of plunger barrel flange.

Tightening torque	39 ～ 49 N・m (4.0 ～ 5.0 kgf・m)

d) If match mark is not aligned, make a new match mark.

(7) Injection adjustment standard (on engine)

Adjustment procedures

1) Set the initial rack position of the boost compensator at R=9.0 mm.
(air pressure in the boost air pipe is 0 MPa (0 kgf/cm^2). Fuel limiter released, regulator at FULL position)

2) Check the limit rack position of the boost compensator. R>15 [The pressure in the boost compensator piping line increased : 0 → 0.2 MPa (0 → 2 kgf/cm^2)]

3) Make the following adjustment and air leakage check of the boost compensator piping under the air pressure of 0.2 MPa (2 kgf/cm^2).

a) Adjustment of rated injection q'ty ①

b) Check of injection q'ty at idling condition. 2

c) Setting of reversed "Angleich" reduced injection q'ty. 3

d) Check of injection q'ty at reversed "Angleich" range. △4, ▽5

e) Check of rev. speed to start reversed "Angleich". △4

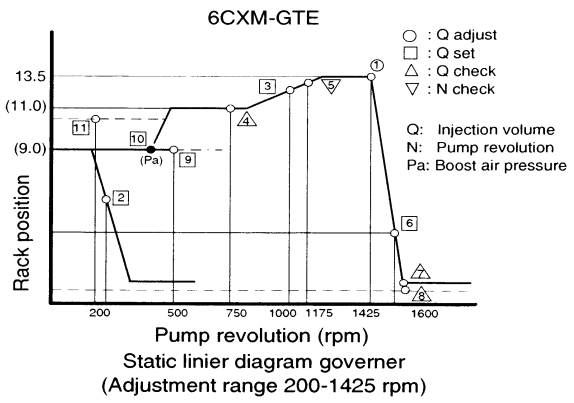
f) Setting of high idle injection q'ty. 6

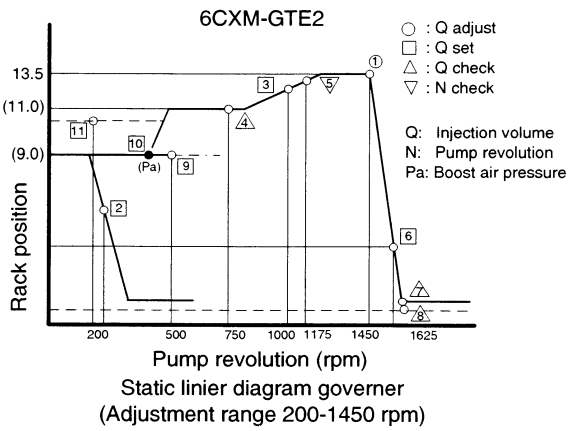
g) Check of regulation

h) Check of injection stop. △7

i) Check of injection stop when the stop lever is operated. △8

j) Check and set the injection q'ty at start. 11



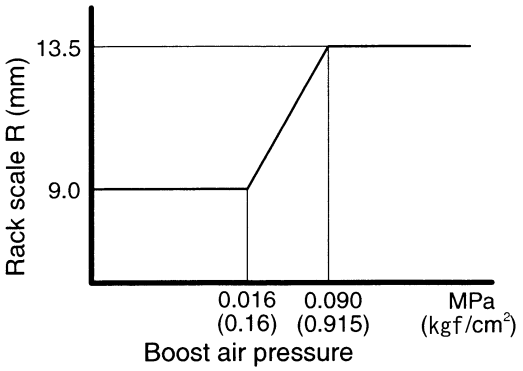


Standard Adjustment Value

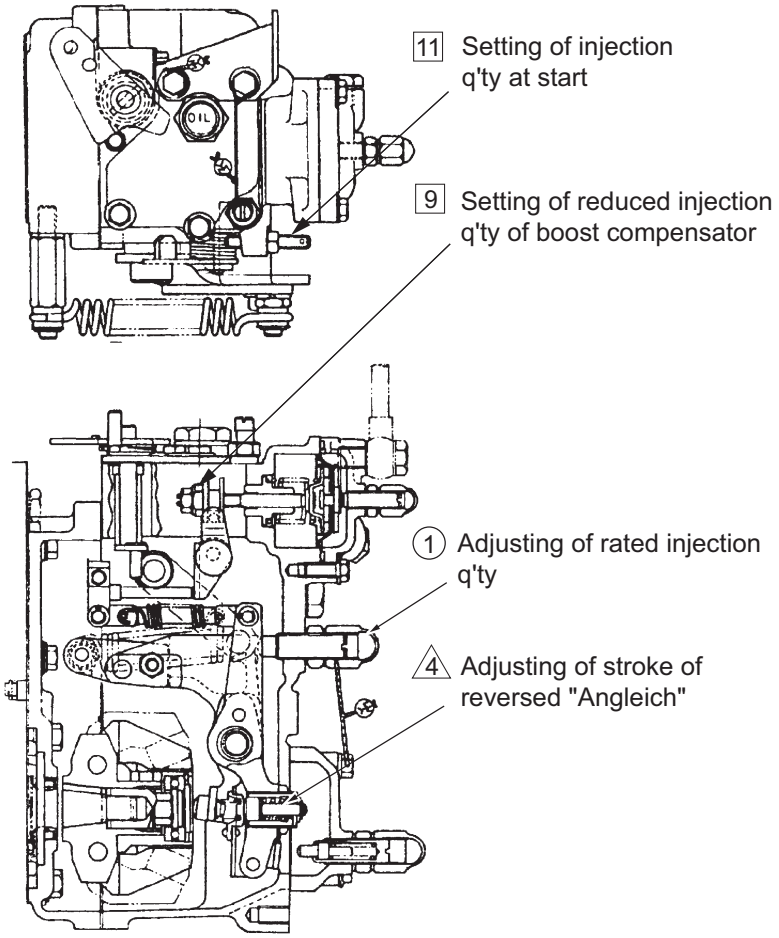
Adjustment Point	Rack scale	Pump speed (rpm)		Average injection q'ty (mm^3/st)		Not uniform %	Note	
		6CXM-GTE	6CXM-GTE2	6CXM-GTE	6CXM-GTE2		6CXM-GTE	6CXM-GTE2
①	13.5	1425	1450	197 ± 3	195 ± 3	± 3	at 2850rpm	at 2900rpm
2	(5)	350		10 ～ 20		± 15	—	
3	(11.7)	1000		194 ± 5	199 ± 5	—	Reversed angleich	
4	(11.0)	750		(191)	(196)	—	—	
5	(12.4)	1175		(198)	measure	—	—	
6	(4)	1600	1625	10 ～ 20		—	High idle	
9	(9)	500		110 ± 5		—	—	
11	(10)	200		190 ± 10		—	Start	

Test condition			Engine spec		
	6CXM-GTE	6CXM-GTE2			
Nozzle holder ass'y	D27672-53100	D27672-53200	Model	6CXM-GTE	6CXM-GTE2
Nozzle	155S296CZ	155S306CAZ	—	—	
Nozzle holder	PS-SLi		High idle	3200 ± 25rpm	3250 ± 25rpm
Nozzle opening pressure	23.5 ± 0.5MPa (240 ± 5kgf/cm^2)		Low idle	750 ± 25rpm	
Transfer pump pressure	0.05MPa (0.5kgf/cm^2)		—	—	
FO injection pipe	ϕ6.35/1.8 × 600mm		—	—	
Fuel oil	Diesel oil (JIS No2 equivalent)		—	—	
Temp of fuel oil	42 ± 2 ℃		—	—	

4) Make the air pressure in the boost compensator piping to 0 MPa(0 kfg/cm^2).
   a) Set the reduced injection q'ty of the boost compensator. 9
   b) Raise the air pressure of the boost compensator gradually from 0 MPa (0 kgf/cm^2) in order to check the operation start pressure. 10 , ①
      Make the air pressure of the boost compensator piping to 0 MPa (0 kgf/cm^2).
   c) Check and set the increased injection q'ty at starting. 11



(8) Adjusting points



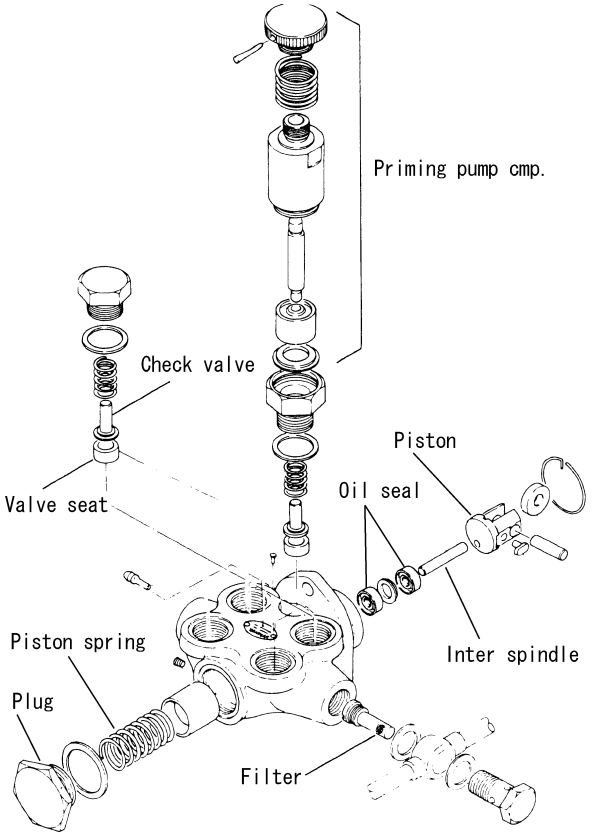
3.11.11 Fuel feed pump

(1) Feature

Fuel feed pump is double action piston type with four check valves. It is installed on the side of the injection pump and driven by a cam.

The feed pump sucks up fuel from the fuel tank and sends it to the fuel injection pump through a fuel filter. It also automatically adjusts the fuel delivery pressure.

Two oil seals are used on the push rod to prevent lube oil from mixing with the fuel from entering the cam chamber.



(2) Double action piston and automatic pressure control mechanism

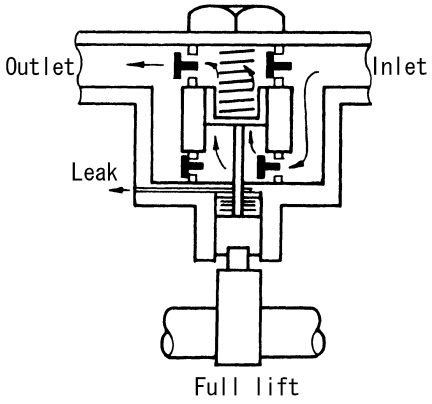
When the piston moves upward, the pressure in the upper chamber rises and the pressure in the lower chamber becomes negative. As to the check valve in the upper chamber, right vale is closed and left valve is opened. Thus, the fuel is delivered to the outlet.

As the pressure in the lower chamber is negative, left valve in the lower chamber is closed and right valve is opened, and then fuel flows into the lower chamber.

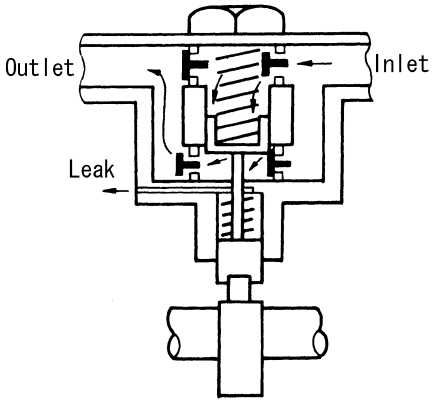
When piston moves downward, the pressure in the lower chamber rises and left check valves are opened and right valves are closed, and then fuel in the lower chamber is delivered to the outlet.

When the delivery pressure of the fuel pump rises up to the extent that the pressure at the back of the piston overcomes the piston spring force, the movement of the piston is hindered.

Thus, the fuel flow is automatically stopped, and the fuel pressure is maintained within a fixed range.



Full lift



Fully down

3.11.12 Disassembly of fuel feed pump

1) Remove the piston spring stopper plug and pull out the piston spring.
2) Remove the piston.
3) Push the tappet from the opposite side of the plug and remove the snap ring.
4) Remove the tappet and inter spindle.
5) Loosen the screw at the bottom of the priming pump and remove the priming pump assembly.
6) Remove the inlet and outlet check valve springs and check valves.

3.11.13 Inspection after disassembly

1) Block the inlet port of the priming pump with your finger and push in the piston. If the piston returns by the spring force, the piston does not have enough negative pressure. Always replace the priming pump as a set.
2) Check the piston spring for cuts, cracks, uneven wear and rust.
3) If the piston, inter spindle, or tappet assembly is extremely worn, replace the part.
4) Check the contact surface of the valve and valve seat for defects.
5) When there is play between a valve seat and feed pump body, the whole fuel pump body must be replaced.
6) Clean the filter screen in cleaning solvent and check it for damage or clogging. Replace it if damaged.

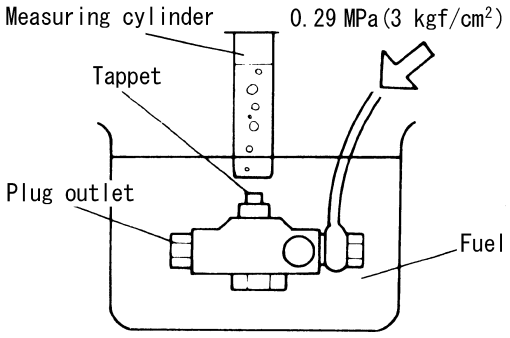
Note:	Play in the valve seat hinders the opening and closing of the valve, causing insufficient fuel supply and abnormal wear of the tappets and camshaft.

3.11.14 Assembly of fuel feed pump

Assemble in the reverse order of disassembly.

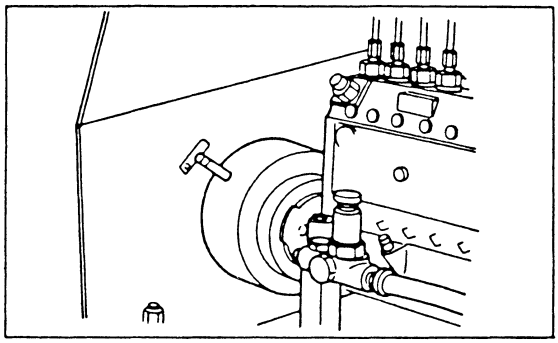
3.11.15 Inspection after assembly

1) 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.
2) Leakage from inter spindle seals
   Plug the outlet, apply compressed air at 0.29 MPa through the outer port, place the feed pump in a fuel tank and inspect for leakage from the inter spindle seals. If there are air bubbles, replace the oil seals, inter spindle or the feed pump body.



3.11.16 Test of fuel feed pump

1) Setting of the pump
   Set the fuel feed pump on the injection pump, and operate the assembled unit on the pump tester.
   Fuel piping should be provided directly from the tank, not through the delivery pump of the tester.

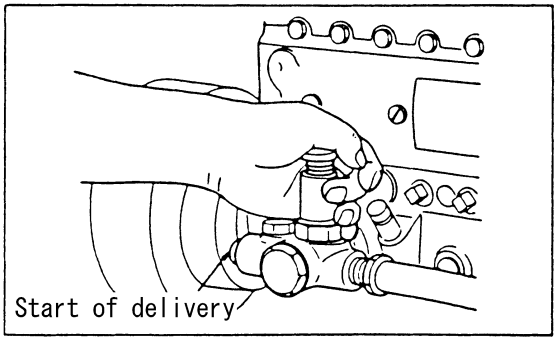


2) Suction test for the priming pump

Loosen the handle of the priming pump, and push the handle at 60 - 100 strokes/minute.

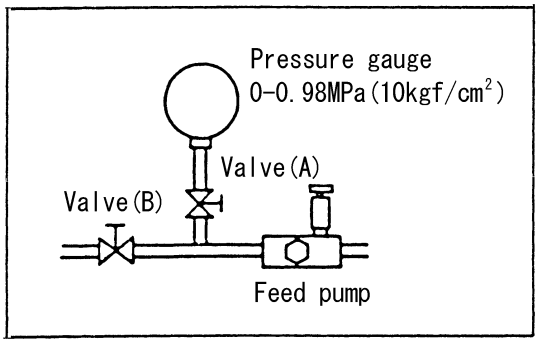
If fuel comes out of the delivery side of the feed pump after about 25 strokes, the priming pump is normal. If it takes longer, replace the priming pump as a set.

Suction head	1 m	Within 25 strokes
Suction pipe dia.	ϕ 13	



3) Delivery pressure test

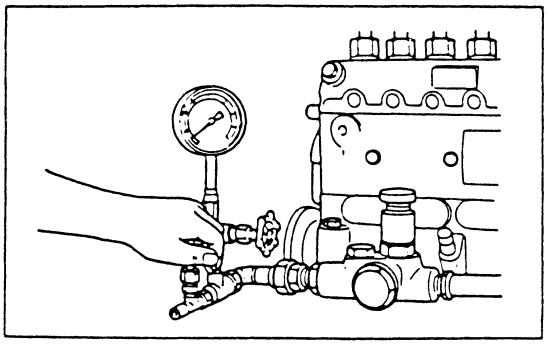
The special equipment is necessary to perform delivery pressure and delivery volume test.



Equipment for feed pump test

Operate the injection pump at the specified rpm, and read the pressure gauge indicator when valve B is tightened completely. Tighten the valve A so that the pressure gauge indicator does not move when the pressure is applied.

Note: Do not run the equipment for more than 5 minutes since the fuel injection pump may be damaged if operated in non-injection condition.



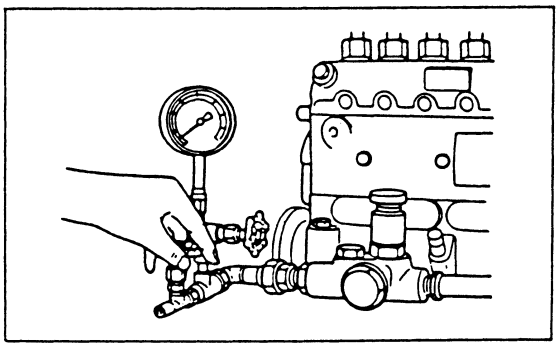
Max. delivery pressure test

Delivery pressure	0.40 ～ 0.55MPa (4.1 ～ 5.6 kgf/cm²)
Pump rpm	600

Replace the piston spring if it is defective.

4) Delivery volume test

Operate the fuel injection pump at the specified rpm, open valve B until the pressure gauge indicator shows 0.098 MPa (1kgf/cm²), and measure the delivery rate for one minute.



Delivery test

Delivery volume	> 4.8 ℓ/min
Back pressure	0.098 MPa (1 kgf/cm²)
Pump rpm	1000

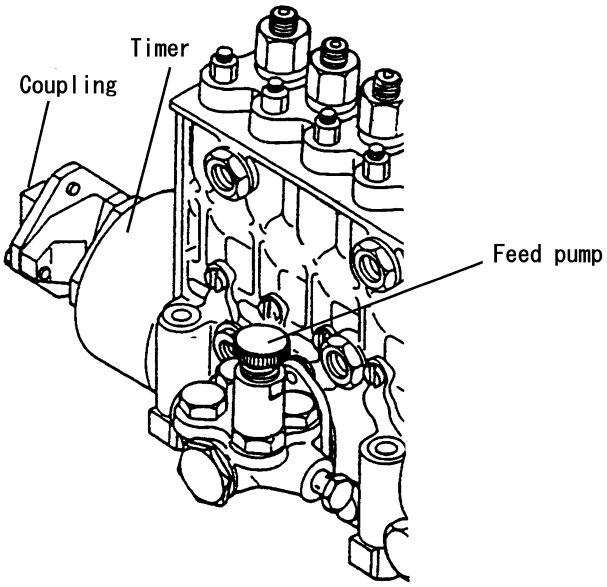
3.11.17 Automatic timer

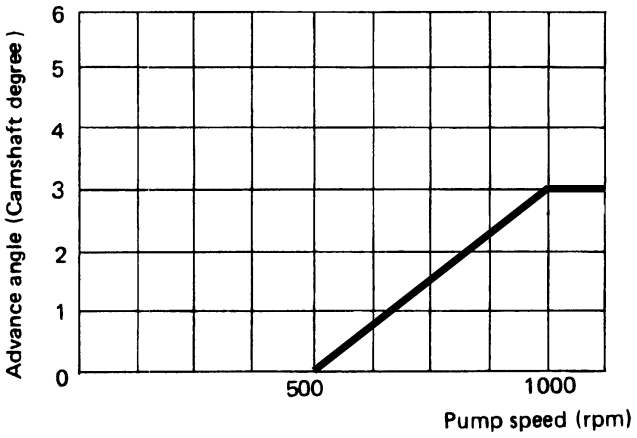
(1) Feature

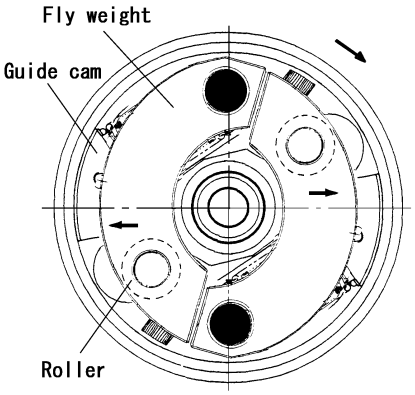
The automatic timer controls the fuel injection timing automatically through the centrifugal force of its rotation.

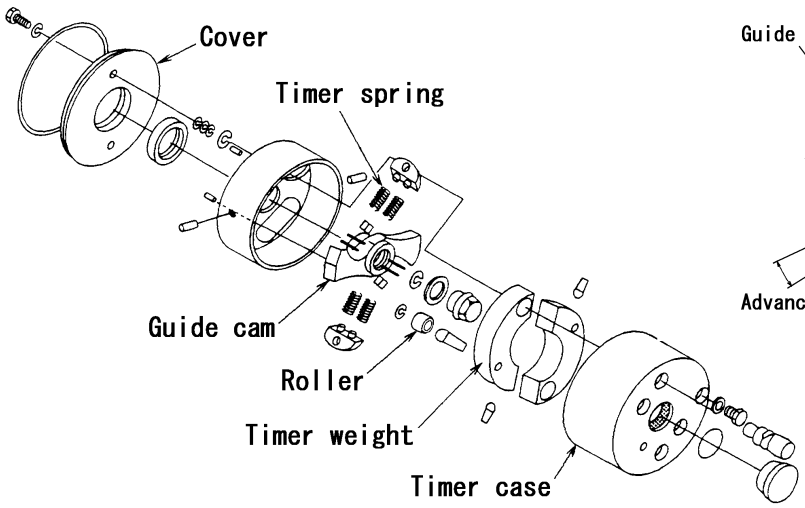
The automatic timer adjusts the advancing angle automatically as follows: - When the speed is increased, the fly weight expands outward from the fly weight holder under centrifugal force.

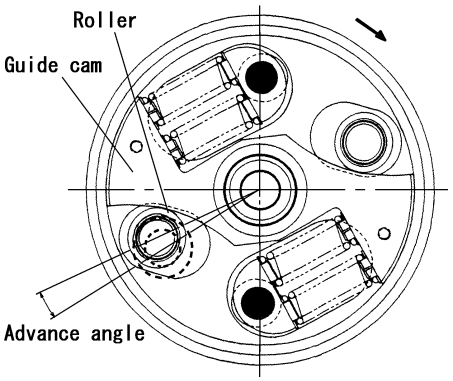
The roller installed on the fly weight moves outward along the guide cam while compressing the timer spring. Because the guide cam is connected directly to the camshaft, the camshaft rotates only as far as the timer spring has been compressed, and injection timing is advanced.





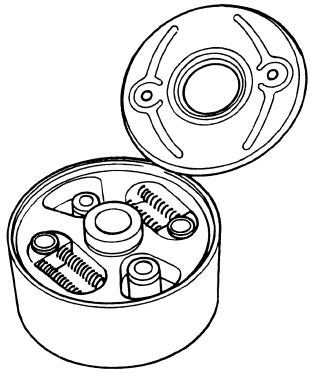






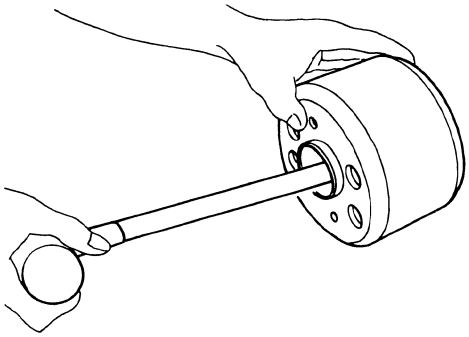
(2) Disassembly

1) Remove the attaching bolts of the timer case cover to remove the cover.



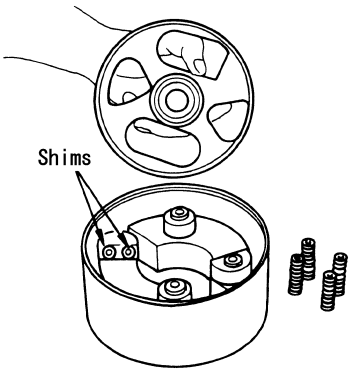
2) Remove the guide cam retainer from the timer case by pushing it with a wooden bar through the timer case hole.

Note: Take care when removing the retainer or the spring will pop out.



3) Remove the springs, weights and spring shoes from the timer case.

Note: Make the timer spring adjusting shims to recall the original assembly.

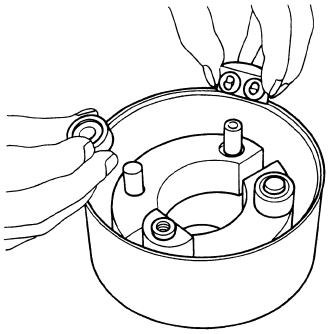


(3) Inspection

1) Check the guide cam surface for wear or damage and replace the timer if necessary.
2) Check the roller and bush for wear and cracks.
3) Check the spring for rust, flaws and degeneration.

(4) Assembly

1) Clean all parts in cleaning solvent.
2) Install the weights and rollers in the timer case.



3) Install the spacers and timer case cover and tighten the cover with two bolts.

Note: Use new oil seals and O-rings.

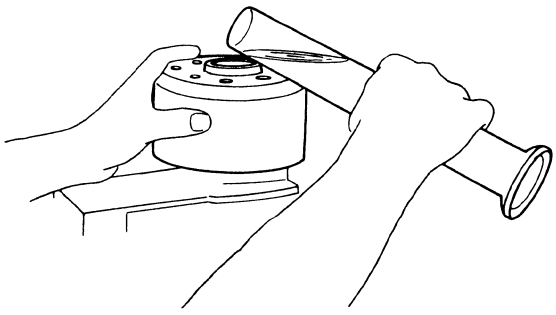
(5) Installation

1) Install the timer on the camshaft of the injection pump by aligning the key groove with the key.
2) Tighten the timer with the cap nut through the spring washer and packing.

Torque	167 ～ 196 N・m (17 ～ 20 kgf・m)

3) Fill the tier with lube oil.

Oil capacity	450 cc



3.11.18 Fuel injection nozzle

(1) Feature

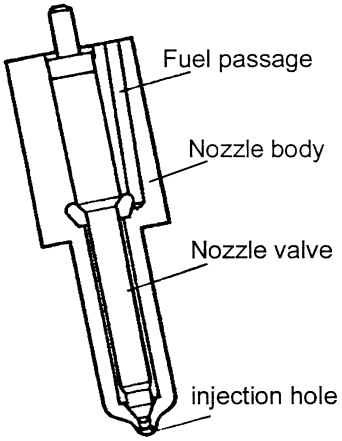
The semi-long type hole-nozzle is used with the direct injection combustion chamber.

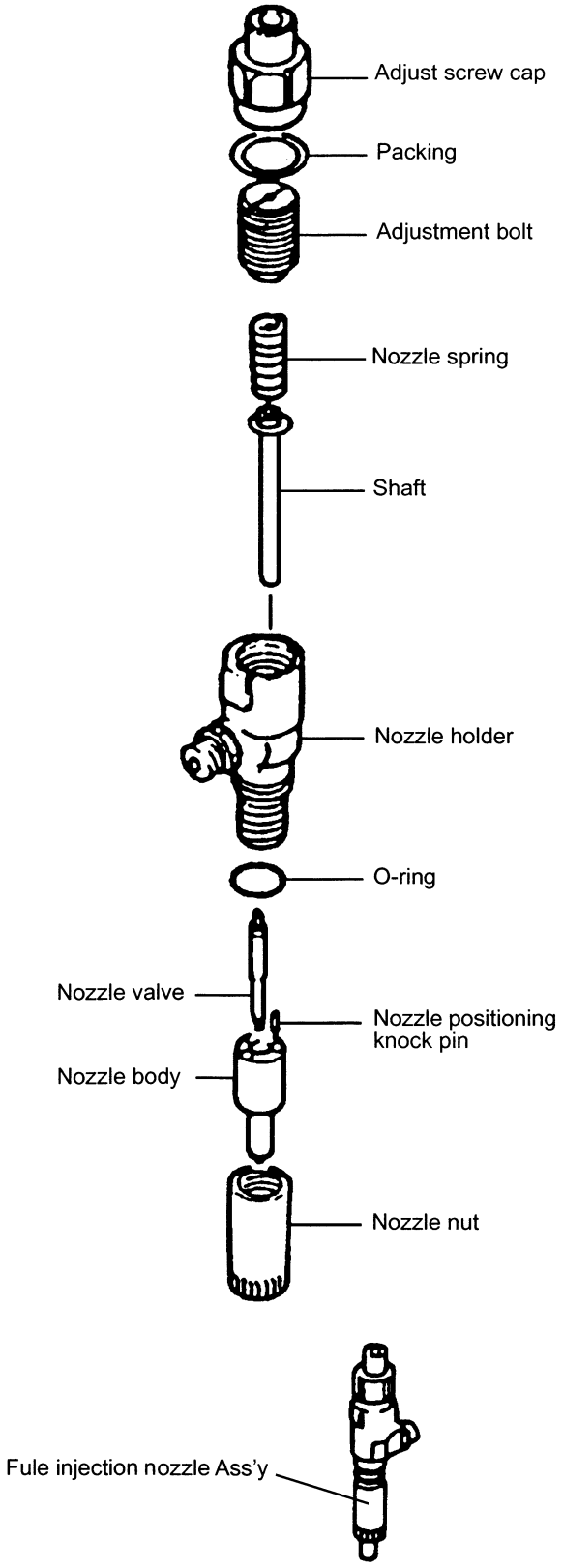
Fuel from the injection pump enters through the oil port in the nozzle holder, and enters the nozzle body reservoir. When oil reaches the specified pressure, it pushes up the nozzle valve held by the nozzle spring, and is injected through the small hole on the tip of the nozzle body.

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 adjustment bolt.



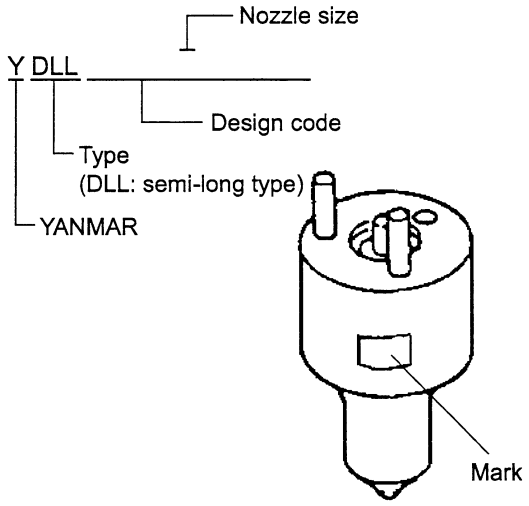


(2) Nozzle specifications

Engine model	6CXM-GTE	6CXM-GTE2
Type	Semi-long type hole-nozzle	
Nozzle No.	YDLL155S296CZ	YDLL155S306CAZ
Yanmar part No.	127672-53000	127694-53050
Valve seat	Single cone	
Operating pressure	23.5 ± 0.49 MPa (240 ± 5kgf/cm^2)	
No. of injection holes × injection hole dia	6-0.29	6-0.30
Injection angle	155°	
Valve lift	0.25 mm	0.30 mm

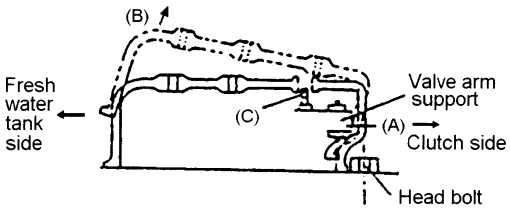
(3) Nozzle body identification number

The type of nozzle can be identified by the number on the outside of the nozzle body.

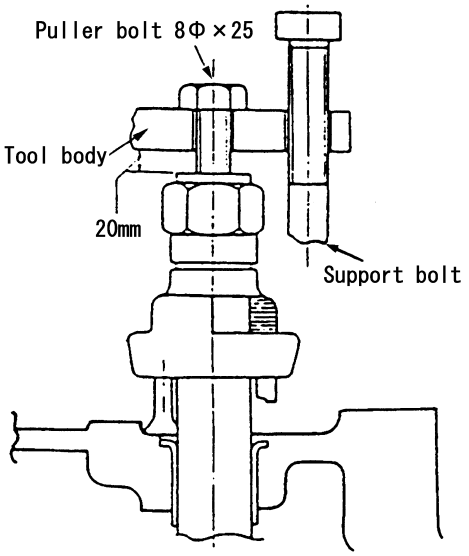


(4) Disassembly of fuel injection nozzle

1) Remove the bonnet fixing bolts.
2) Lift the valve slowly until it contacts the valve arm mount (A) as shown in the illustration.

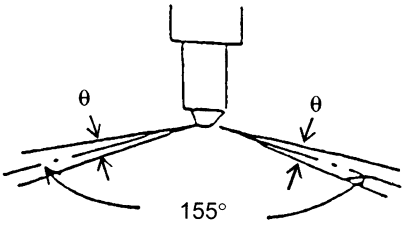


3) Lift the (B) side with (A) as the fulcrum.
4) After removing the stud bolt fixing the bonnet (C) from the installation hall, move the valve a little to the reduction reversing gear side and remove the valve completely.
5) Remove the fuel injection pipe, fuel return pipe and fuel injection valve fixing nut.
6) Fit the fuel injection valve puller tool.
(Place the foot of the support bolt on the plane making an right angle to the fuel injection valve.)
7) Adjust the foot length so that the puller tool body makes a right angle to the fuel injection valve and a distance of about 20 mm is ensured for the injection valve.
8) Apply lube oil to the puller bolt and screw it to the return oil joint bolt hole of the upper injection valve body to remove the injection valve body.



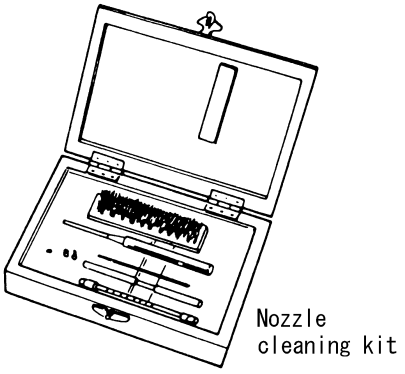
(5) Check and cleaning of fuel injection nozzle

1) Check the carbon flower deposit around the injection hole.
2) Check spray condition with nozzle tester operating the lever 2-3 times per second.

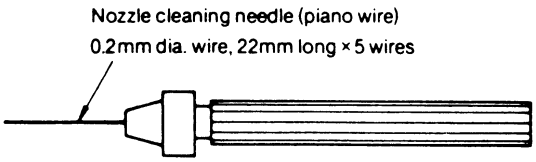


- No sharp angle deviation
- Uniform atomized fuel
- No dipping after stopping

3) Wash the nozzle in clean diesel oil with the nozzle cleaning kit.

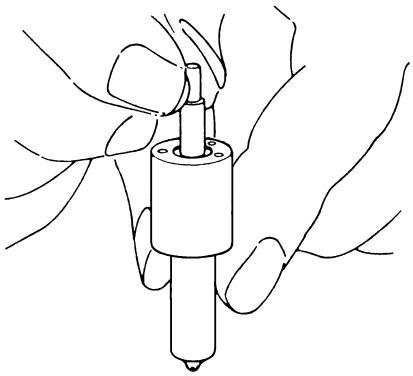


a) Clean off the carbon on the outside of the of the nozzle body with a brass brush.
b) Clean the nozzle seat with cleaning spray.
c) Clean off the carbon on the tip of the nozzle with a piece of wood.
d) Clean the nozzle hole with a nozzle cleaning needle.



(6) Inspection of fuel injection nozzle

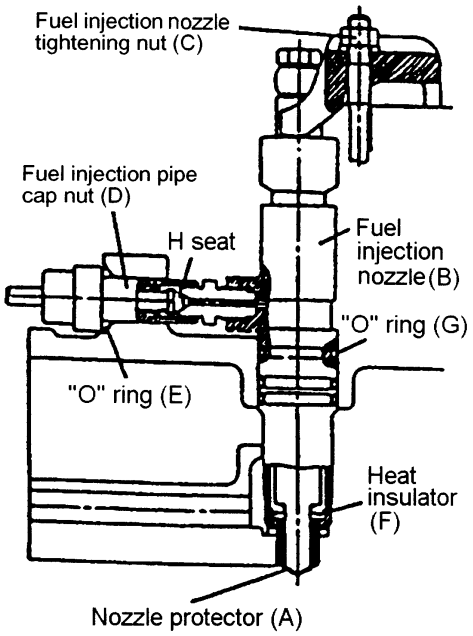
1) Inspect the nozzle for abnormal scratches or wear and replace it if the sliding surface or seat is scratched or abnormally worn.
2) Make sure that the nozzle slides down by itself when the nozzle is pulled out about half way from the body and released.
Rotate the nozzle a little, and try again.
Replace the nozzle as a set if there are some places where it does not slide smoothly.



(7) Reassembly of fuel injection nozzle

1) Install the fuel injection nozzle (B).
2) Install the fuel injection pipe joint to the fuel injection nozzle (B), (together with the rubber packing (E).

Pipe joint tightening torque	24.5 N・m (2.5 kgf・m)



3) Tighten the nozzle tightening nut (C).

Tightening torque	31.4 N・m (3.2 kgf・m)

4) Tighten the fuel injection pipe cap nut (D).

Tightening torque	34.3 N・m (3.5 kgf・m)

Caution:

* If the nozzle tightening nut (C) is tightened first, fuel oil may leak into the lube oil.
* If the cap nut (D) is tightened first to the final torque, gas may leak from the packing at the nozzle end.

3.11.19 Fuel filter

(1) Feature

The fuel filter is installed between the fuel feed pump and fuel injection pump.

Fuel is filtered as it passes through the filter element and the dirt/foreign matter and water from the fuel tank are removed.

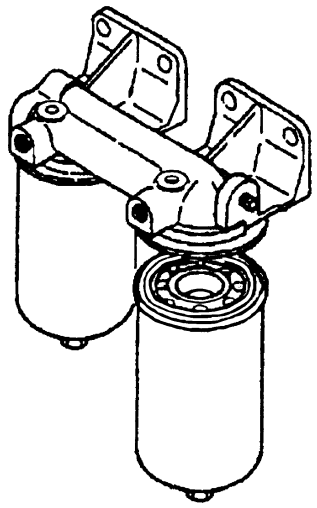
(2) Replacement of filter element

Replace the element every 250 hours of use.

Replace the element even before the provided time if the filter interior is contaminated or damaged.

If there is water or sediment inside the filter, wash it in clean oil and remove dust and rust completely.

Draining of filter	Every 50 hours of use
Filter element	Every 250 hours of use
Part No. of element	127695-55630



3.11.20 Troubleshooting of fuel oil system

(1) Before removing fuel injection pump

It is necessary to find out the cause of the trouble before replacing the defective parts.

The cause of the trouble may not necessarily be in the pump itself, but may be in the engine or the fuel oil system.

If the pump is removed prematurely, the 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

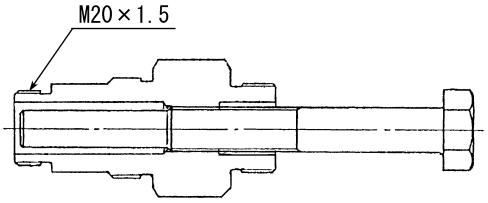
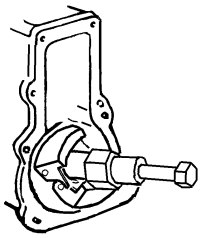
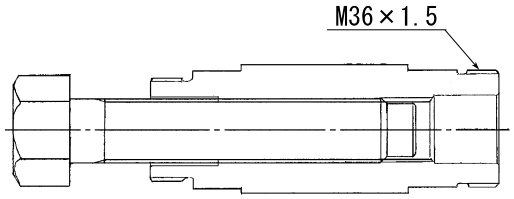
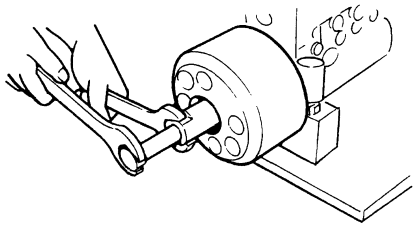
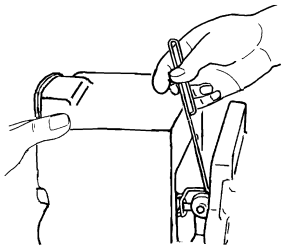
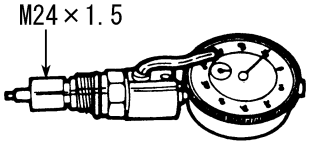
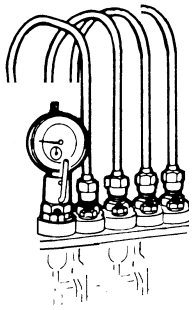
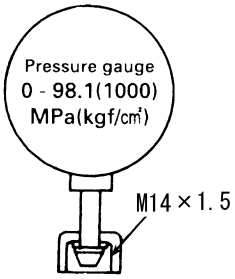
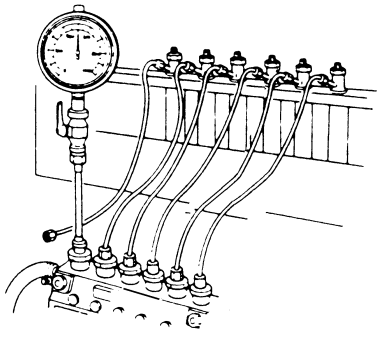
- Check for breaks or oil leaks through out the fuel system, from the fuel tank to the nozzle.
- Check the injection timings for all cylinders.
  Are they correctly adjusted?
  Are they too early or too late?
- Check the nozzle spray.
- Check the fuel delivery. Is it in good condition?
  Loosen the fuel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

(2) Major faults and troubleshooting

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

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

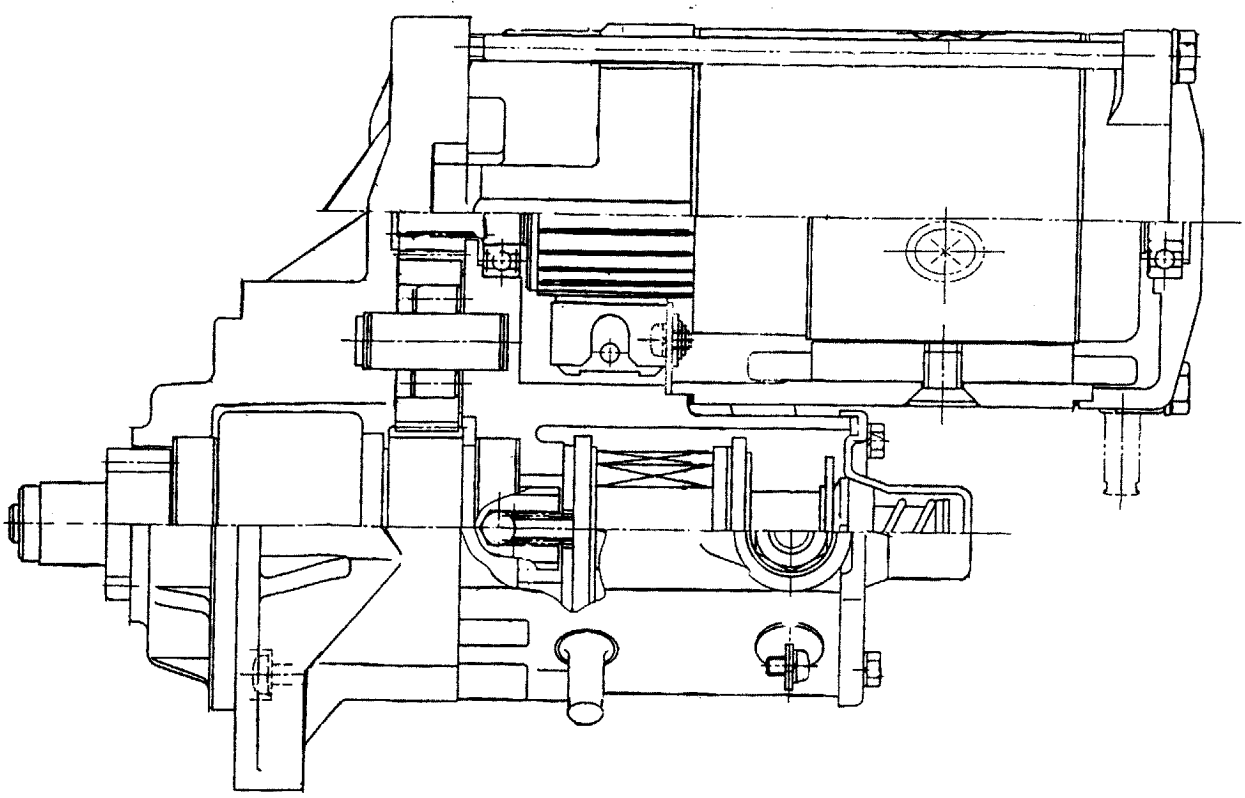
3.11.21 Tools

Name of tool	Shape	Apprication
Governor weight support extractor 721820-92580		
Timer extractor 158591-54200		
Spring set bar 121978-51610		
Prestroke measuring device 155900-51350		
Pressure gauge 155900-51500		

3.12 Electrical Equipment

3.12.1 Starting Motor

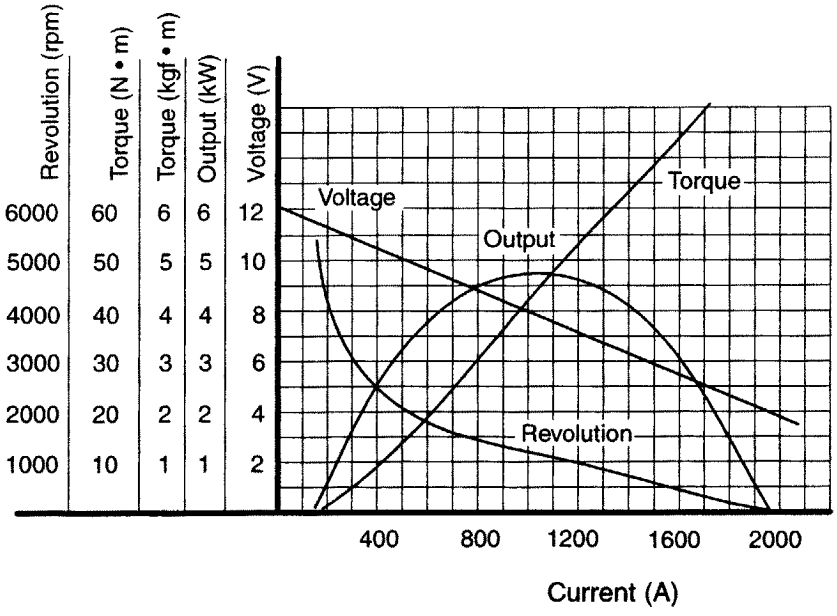
(1) Out view



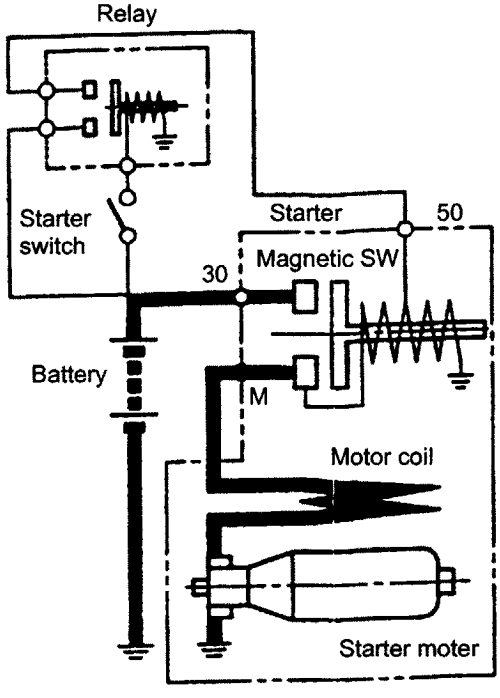
(2) Specifications

Part No		127675-77011
Nominal output		4.8 kW
Circuit voltage		12 V
Rating		30 sec
Direction of rotation		Clockwise (viewed from pinion)
Circuit system		Body earth
Type of clutch		Roller clutch
Pinion	No. of teeth	11
	Module	3
	Pressure angle	14.5 deg.
Mass		10.5 kg

(3) Performance curve



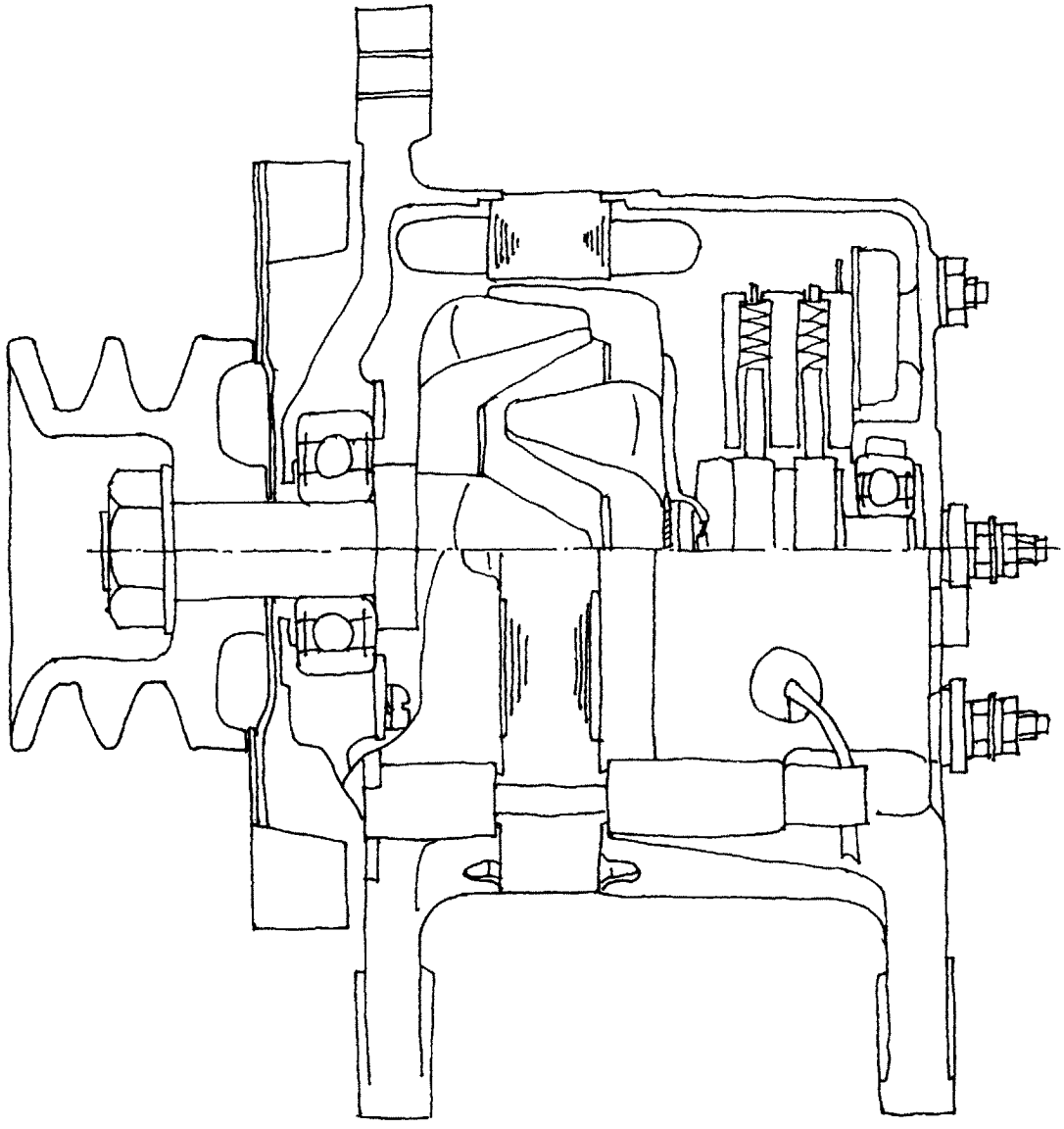
(4) Connecting diagram



3.12.2 Alternator

The alternator houses a fully-transistorized regulator. With the simple regulator wiring, there is no fear of interference to the wireless, fish finder, etc. unlike with the contact point type regulator.

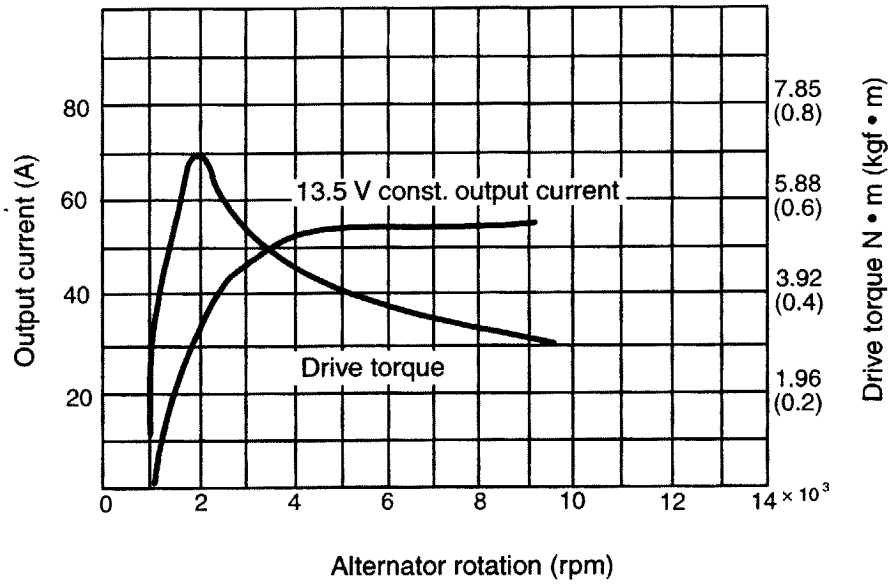
(1) Out view



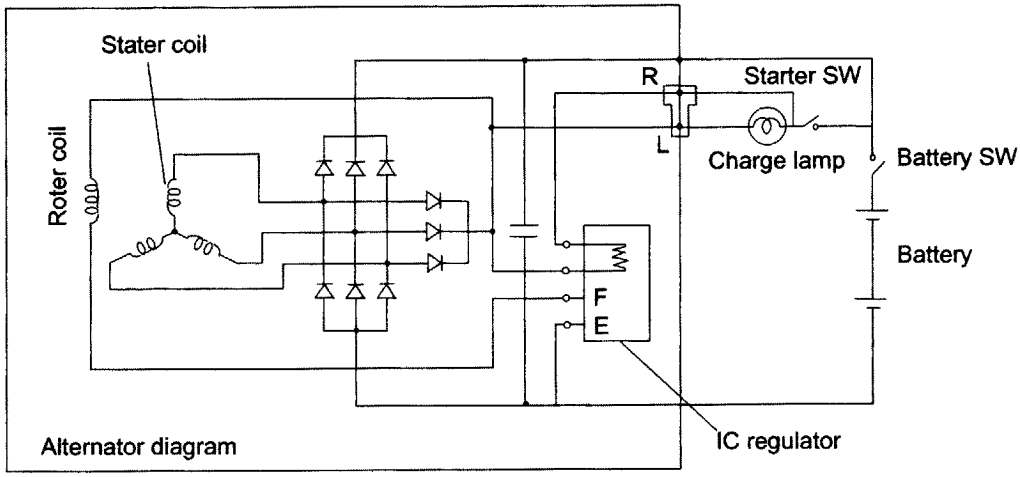
(2) Specifications

Part No	———	127675-77200
Battery voltage	V	12
Nominal output	V-A	12-55
Allowable rotation	rpm	1000-9000
No. of pole	———	12
Built-in regulator	———	IC regurator
Control voltage	V	14.5 ± 0.3

(3) Preformance curve

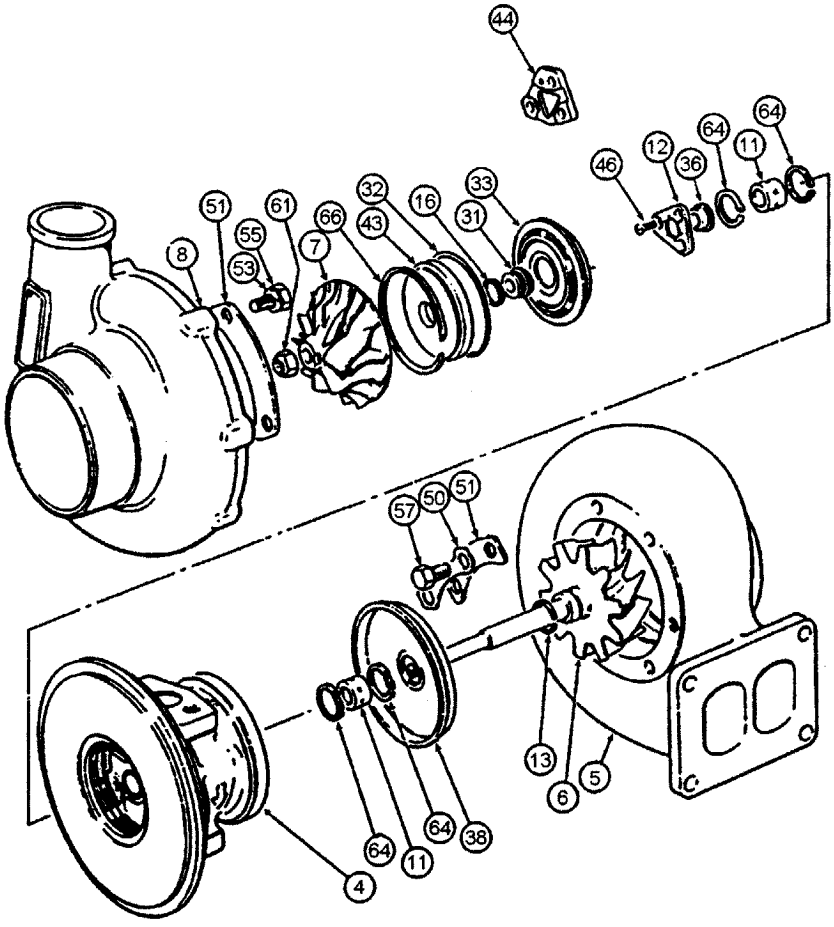


(4) Connecting diagram



3.13 Turbocharger

3.13.1 Name of Parts



No	Name
4	Bearing housing
5	Turbine housing
6	Shaft and Wheel
7	Compressor Wheel
8	Compressor cover
11	Bearing
12	Thrust Bearing
13	Piston Ring
16	Piston Ring
31	Oil slinger
32	O ring
33	Oil Deflector
36	Thrust Collar
38	Heat Shield
43	Insert
44	Spacer Plate
46	Bolt
50	Lock Plate
51	Crank Plate
53	Washer
55	Bolt
57	Bolt
61	Lock Nut
64	Circle Lip
66	Ring

3.13.2 Service Standard

(mm)

No	Name	Standard dimension
1	Shaft dia. at bearing	12.192 - 12.200
2	Thickness of thrust collar	1.40 - 1.45
3	Thickness of thrust bearing	3.487 - 3.512
4	Inside dia. of bearing case	19.050 - 19.063
5	Groove width of oil slinger	1.638 - 1.664
6	Bearing outside dia.	18.951 - 18.964
7	Bearing inside dia.	12.222 - 12.230
8	End play of roter shaft	0.10 - 0.15
9	Radial play of rotor shaft	0.31 - 0.050

3.13.3 Tightening Torque

N·m (kgf·m)

Location of Bolt	Binding Torque
Thrust Bearing	45.1 (4.6)
Compressor Wheel	181.4 (18.5)
Turbine Housing	203 (20.7)
Compressor Housing	85.3 (8.7)

4 Periodic Inspection

○: Check ◎: Replace ●: Adjust

Check item		Daily	every 50hrs.	every 250hrs.	every 500hrs.	1 year or every 1000hrs.	2 year or every 2000hrs.
Fuel Oil System	Check oil level in the tank and resupply	○					
	Drain the tank		○				
	Drain the fuel filter and oil/ water separator		○				
	Replace element of fuel filter			◎ or 1year			
Engine lube oil system	Check lube oil quantity	○					
	Replace lube oil filter element		◎ 1st time	◎ or 1year			
	Clean lube oil cooler						●
	Replace lube oil		◎ 1st time	◎			
Cooling Water (Seawater) System	Check cooling water discharge	○					
	Check and replace anticorrosion zinc			◎			
	Check and replace seawater impeller					●	
	Clean the seawater system						●
Cooling Water (Freshwater) System	Check q'ty and resupply fresh water	○					
	Replace fresh water					◎	
	Clean the fresh water system						●
Fuel Injection Pump and Injection valve	Check and adjust injection timing						●
	Check and adjust injection pressure and fuel spray condition			● 1st time		●	
Cylinder Head	Adjust valve clearance of intake/exhaust valve		● 1st time			●	
	Lap intake/exhaust valve						●
Turbocharger	Clean pre-filter and blower			○			
	Check air and gas leakage from joints	○					
Air cooler	Check and replace anticorrosion zinc			○			
Piping	Check and replace fuel oil pipe, cooling water pipe	○					●
Electrical Equipment	Check electrical equipment	○					
	Check battery liquid		○				
	Adjust V-belt tension of alternator				○		

5 Service Standard

5.1 Service Values

(mm)

Names of parts	Item			Nominal(standard) size/ Tolerance		Standard clearance when assembled	Allowable max. clearance (repair limit)	Part service limit (to the standard size)
Cylinder sleeve	Cyl. sleeve inside dia.		L	φ110	+0.030 or less +0.020 or more	—	—	+0.15
			M		less than +0.020 +0.010 or more			
			S		less than +0.010 0			
	Cyl. sleeve projection			—		0.03 - 0.09	—	—
	Sink of sleeve			—		—	—	—
	Roundness of sleeve			—		0.015 or less	—	0.08
	Cylindricality of sleeve			—		0.020 or less	—	0.08
Piston Pin	Piston Outside Dia.		L	φ109.925	+0.015 or less +0.005 or more	—	—	109.75
			ML		less than +0.005 0 or more			
			MS		less than 0 -0.005 or more			
			S		less than -0.005 -0.015 or more			
	Clearance between piston and cyl. sleeve	(Matching I.D.marks)		—		0.080 - 0.100		—
				—				—
	Piston pin hole dia.			φ46		0 - 0.022	—	—
	Dia. of piston pin							49.95
Piston Rings	Clearance between piston ring and ring groove	No.1	Ring width	2.5	- 0.01 - 0.025	0105 - 0130	0.20	-0.1
			Groove width		+0.105 +0.95			+0.15
		No.2	Ring width	2.0	-0.01 -0.025	0.075 - 0.105	0.15	-0.1
			Groove width		+0.080 +0.065			+0.15
		No.3	Ring width	2.0	-0.01 -0.025	0.050 - 0.080	0.15	-0.1
			Groove width		+0.055 +0.040			+0.15
		Oil ring	Ring width	4.0	-0.01 -0.025	0.030 - 0.060	0.15	-0.1
			Groove width		+0.035 +0.020			+0.15
	Ring thickness	No.1 Piston ring		3.95		—	—	—
		No.2 Piston ring		4.6				—
		Oil ring		2.8 (Ring body) 4.4 (with Coil expander)				—
	End gaps	Piston ring		—		0.250 - 0.40	1.5	—
		Oil ring		—		0.250 - 0.450	1.5	—
Cylinder Head	Distortion of cyl. head installation face			within 0.05		—	—	0.15
	Sink of intake/exhaust valve		intake	—		$0.2^{\pm 0.1}$	—	0.9
			exhaust	—		$0.2^{\pm 0.1}$	—	0.9
	Seat width of intake/exhaust valve		intake	1.73		—	—	—
			exhaust	2.12		—	—	—
	Valve guide and cyl. head interference			—		0.018 - 0.045	—	—

(mm)

Names of parts	Item		Nominal(standard) size/Tolerance		Standard clearance when assembled	Allowable max. clearance (repair limit)	Part service limit (to the standard size)
Intake/ Exhaust Valve	Intake Valve	Stem outside dia.	ϕ8.0	-0.035 -0.047	0.035 - 0.062	0.2	7.9
		Valve guide inside dia		0 +0.015			8.1
	Exhaust Valve	Stem outside dia.	ϕ8.0	-0.040 -0.052	0.040 - 0.067	0.2	7.9
		Stem outside dia.		0 +0.015			8.1
	Clearance between valve stem and valve guide	Intake	2.0		—	—	—
		Exhaust	1.5				—
Connecting Rod	Crank pin outside dia.		ϕ72	-0.040 -0.0760	0.040 - 0.105	0.13	71.87
	Crank pin metal inside dia.			0 +0.045			72.13
	Piston pin outside dia.		ϕ46	-0.003 -0.012	0.028 - 0.052	0.07	45.95
	Piston pin metal inside dia.			+0.04 +0.025			46.1
	Twist and bend		—		Less than 0.02/100 mm	—	—
Crankshaft	Crank journal outside dia.		ϕ86	-0.04 -0.06	0.040 - 0.108	0.13	85.87
	Crank main bearing metal inside dia.			0 +0.048			86.13
	Crankshaft side clearance		—		0.155 - 0.296	0.33	—
	Deflection		—		0.0125	—	—
	Circle runout (TIR)		—		<0.03		—
Cam Shaft	Cam shaft outside dia.		ϕ52	-0.025 -0.050	0.045 - 0.140	0.2	51.8
	Cam shaft bearing inside dia.			+0.02 +0.09			52.15
	Cam shaft side clearance		—		0.10 - 0.25	0.25	—
	Cam height	Intake	44.16 - 44.24		—	—	43.5
		Exhaust					
Valve	Valve spring	Spring force N (kgf/mm)	17.9 (1.83)		—	—	—
		Free length	45		—	—	49
		Inclination	—		—	—	1.3
	Intake/exhaust rocker arm outside dia.		ϕ20	-0.02 -0.033	0.020 - 0.054	0.15	19.90
	Dia. of the rocker arm bearing			0 +0.021			20.083
	Circle runout (TIR)		less than 0.03		—	—	0.1
	Length of push rod		$290^{\pm 0.5}$		—	—	—
	Tappet	Outside dia.	ϕ20	-0.04 -0.061	0.04 – 0.082	0.12	26.90
		Cylinder hole		+0.021 0			27.05
Timing Gear	Idle gear	Shat outside dia.	ϕ51	-0.025 -0.05	0.025 - 0.075	0.15	50.9
		Bush inside dia.	ϕ51	0 +0.025			51.05

5.2 Adjustment Values

Item		Unit	Service Standard
Intake/exhaust valve top Clearance (cold engine)		mm	Intake=0.25 Exhaust=0.40
Injection timing (FID)	b. TDC	degree	$13^{\pm1}$
Fuel injection pressure		MPa (kgf/cm^2)	$23.5^{\pm0.5}$ ($240^{\pm5}$)
Top clearance		mm	$0.95^{\pm0.09}$

5.3 Check Values

Item			Unit	Check Value
Intake valve	Open	b TDC	degree	50
	Close	a BDC	degree	44
Exhaust valve	Open	b BDC	degree	55
	Close	a TDC	degree	47
Pressure	Engine Lube Oil		MPa (kgf/cm^2)	$0.49^{\pm0.05}$ ($5^{\pm0.5}$)
	Turbo Lube Oil		MPa (kgf/cm^2)	Common engine
Thermostat	Valve opening temp.		°C	$71^{\pm2}$
	Full-open temp.		°C	85
	Valve lift		mm	11
Temperature	Cooling water engine outlet temp.		°C	
	Lube oil cooler inlet temp.		°C	less than 85
Fresh Water Capacity			ℓ	Engine=35 Subtank=1.5
Lube Oil Capacity			ℓ	Max=22 Effect=8
Warning	Charge lamp		———	more than 450 rpm : Lamp OFF
	'Lube oil filter clogged' lamp		———	Different pressure of the IN/OUT port more than 0.12 - 0.18 MPa (1.2 - 1.8kgf/cm^2): Lamp ON
	Water temp. rise warning		———	more than $95^{\pm2}$ °C: Lamp ON
	Eng. LO pressure drop warning		———	less than 0.05 MPa (0.5 kgf/cm^2): Lamp ON

6 Tightening Torque of Major Bolts and Nuts

	Bolt head width	Tightening torque (N·m(kgf·m))	Bolt	Note
Cylinder head installation bolts (main bolts)	22	245 $^{\pm 5}$ (25 $^{\pm 0.5}$)	M15 × 1.5	with LO
Connectiong rod tightening bolts	22	226 $^{\pm 5}$ (23 $^{\pm 0.5}$)	M16 × 1.5	with LO
Flywheel tightening bolts	27	284 $^{\pm 10}$ (29 $^{\pm 1}$)	M18 × 1.5	with LO
Main bearing installation bolts	27	275 $^{\pm 10}$ (28 $^{\pm 1}$)	M18 × 1.5	with LO
Cam shaft drive gear tightening bolt	17	88 $^{\pm 10}$ (9 $^{\pm 1}$)	M12 × 1.75	with LO
Idle gear tightening nuts	14	49 $^{\pm 5}$ (5.0 $^{\pm 0.5}$)	M10 × 1.5	———
Seawater pump drive gear tightening nuts	30	142 $^{\pm 5}$ (14.5 $^{\pm 0.5}$)	M20 × 1.5	with LO
Crankshaft front coupling installation bolts	24	230 $^{\pm 5}$ (23.5 $^{\pm 0.5}$)	M16 × 1.5	with LO
Piston cooling nozzle installation bolts	17	19.6 (2.0)	M10 × 1.25	———
Rocker arm mount tightening nuts	12	25.5 $^{\pm 2}$ (2.6 $^{\pm 0.2}$)	M8 × 1.25	with LO
Rocker arm mount tightening bolts	14	39 $^{\pm 5}$ (4 ±0.5)	M10 × 1.25	with LO
Fuel injection valve retainer tightening nuts	12	31.4 $^{\pm 2}$ (3.2 $^{\pm 0.2}$)	M8 × 1.25	with LO
Fuel pump drive gear installation nuts	41	196 $^{\pm 10}$ (20 $^{\pm 1.0}$)	M27 × 2.0	———
Damper installation bolts	19	62.8 $^{\pm 5}$ (6.4 $^{\pm 0.5}$)	M12 × 1.25	with LO
Seawater pump V-pulley nuts	19	49 $^{\pm 5}$ (5 $^{\pm 0.5}$)	M14 × 1.5	———
Fuel injection pipe cap nut	19	34.3 (3.5)	———	———
Nozzle sleeve	———	88.2 $^{\pm 5}$ (9 $^{\pm 0.5}$)	———	———

Note For bolts and nuts marked "with LO" - Apply engine oil to the thread and seat.

List of Tightening Torque for Standard Bolts

Tighten the bolts other than the major bolts according to this list.
Apply 80% torque of the values listed below when tightening to aluminum parts.
Tighten bolts with "4" mark to 60% tightening torgue.

Bolt (7T*)	Tightening torque(N·m(kgf·m))	Bolt head width
M6 × 1	10.8 $^{\pm 1}$ (1.1 $^{\pm 0.1}$)	10
M8 × 1.25	24.5 $^{\pm 2.5}$ (2.6 $^{\pm 0.25}$)	12
M10 × 1.5	49 $^{\pm 5}$ (5.0 $^{\pm 0.5}$)	14
M12 × 1.75	88.3 $^{\pm 10}$ (9.0 $^{\pm 1.0}$)	17
M14 × 1.5	137 $^{\pm 15}$ (14.0 $^{\pm 1.5}$)	19
M16 × 1.5	226 $^{\pm 20}$ (23.0 $^{\pm 2.0}$)	24

* JIS strength classification: 7T

Taper pulgu and Pipe joint bolt

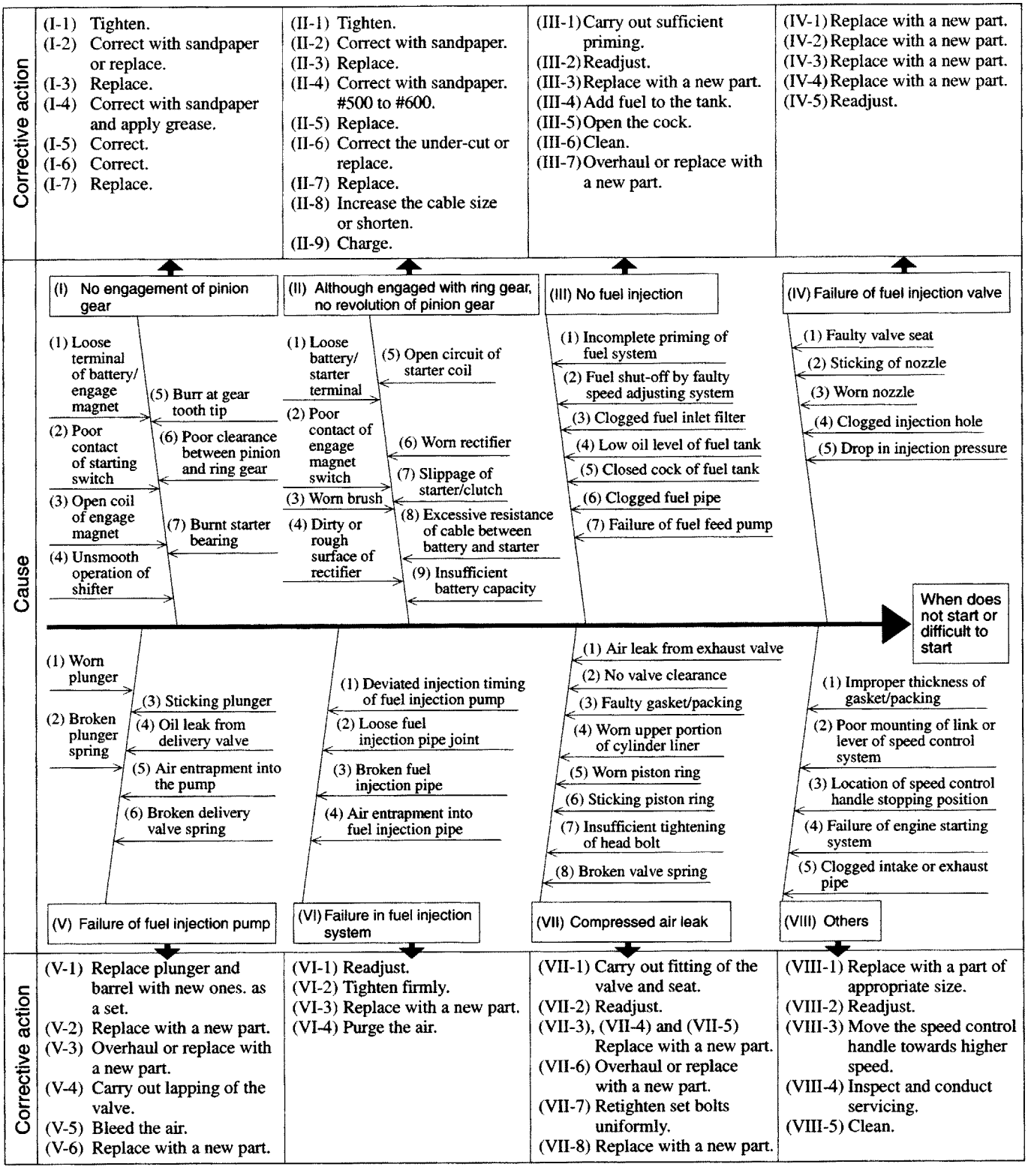
	Thread dia.	Tightening torque (N•m(kgf•m))
Taper plug	1/8	9.8 (1.0)
	1/4	19.6 (2.0)
	3/8	29.4 (3.0)
	1/2	58.8 (6.0)

	Thread dia.	Tightening torque (N•m(kgf•m))
Pipe joint bolt	M8	14.7 $^{\pm 2.0}$ (1.5 $^{\pm 0.2}$)
	M12	29.4 $^{\pm 4.9}$ (3.0 $^{\pm 0.5}$)
	M14	44.1 $^{\pm 4.9}$ (4.5 $^{\pm 0.5}$)
	M16	53.9 $^{\pm 4.9}$ (5.5 $^{\pm 0.5}$)

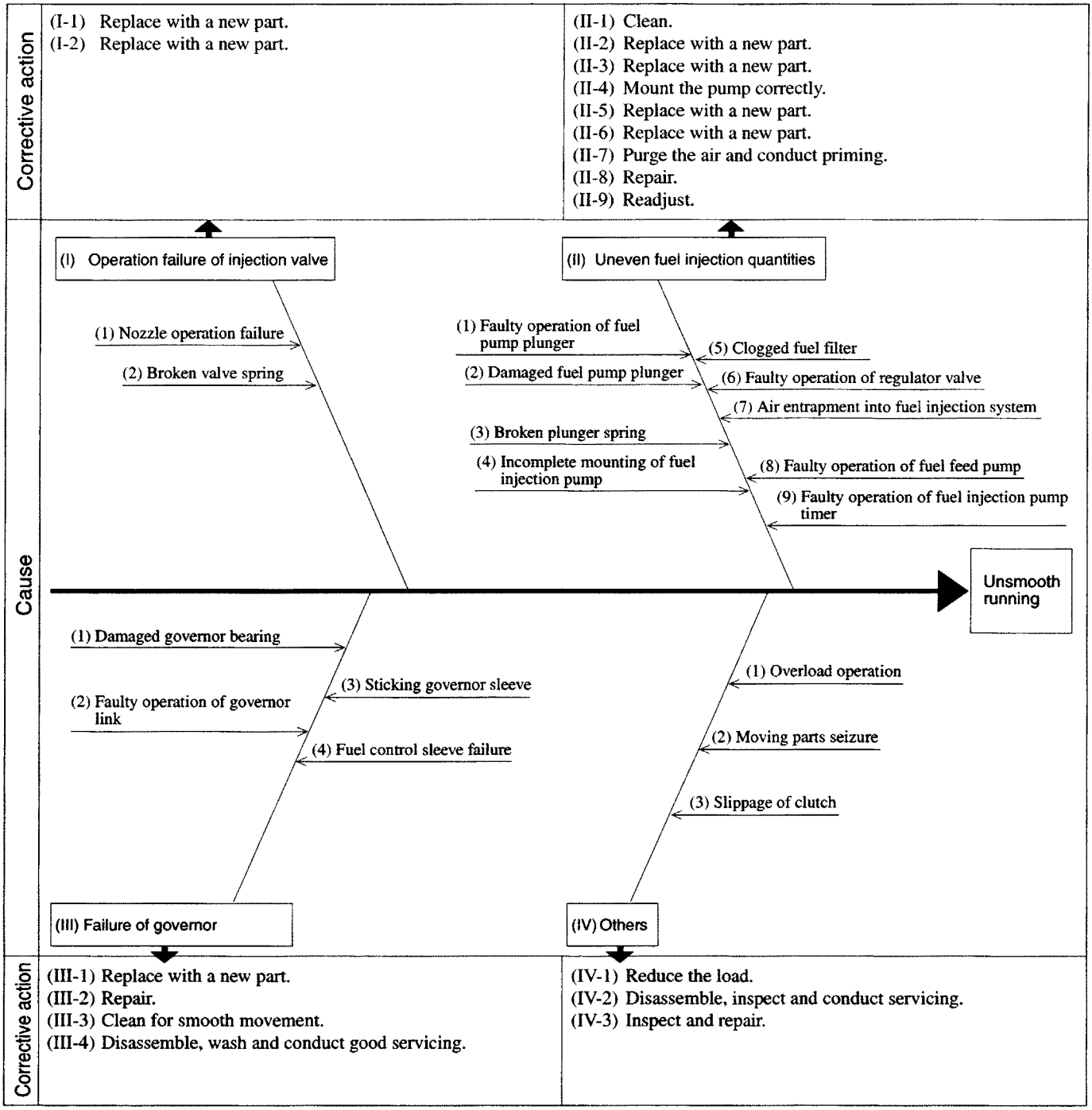
7 Troubleshooting

Note Since fuel injection pump disassembly and adjustment requires special knowledge and equipment, please contact the DENSO service shop for the job.

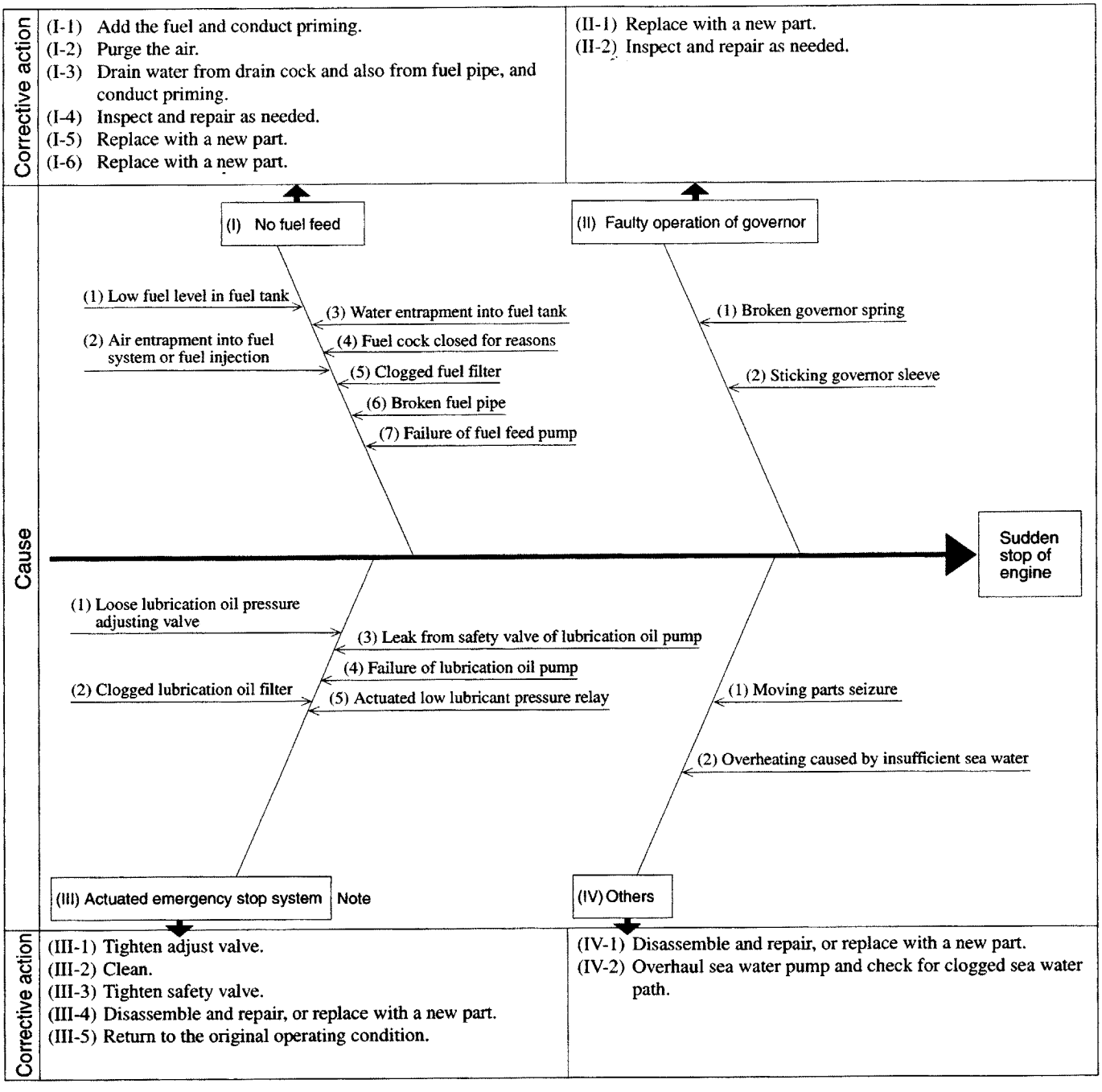
7.1 Does not Start or Difficult to Start



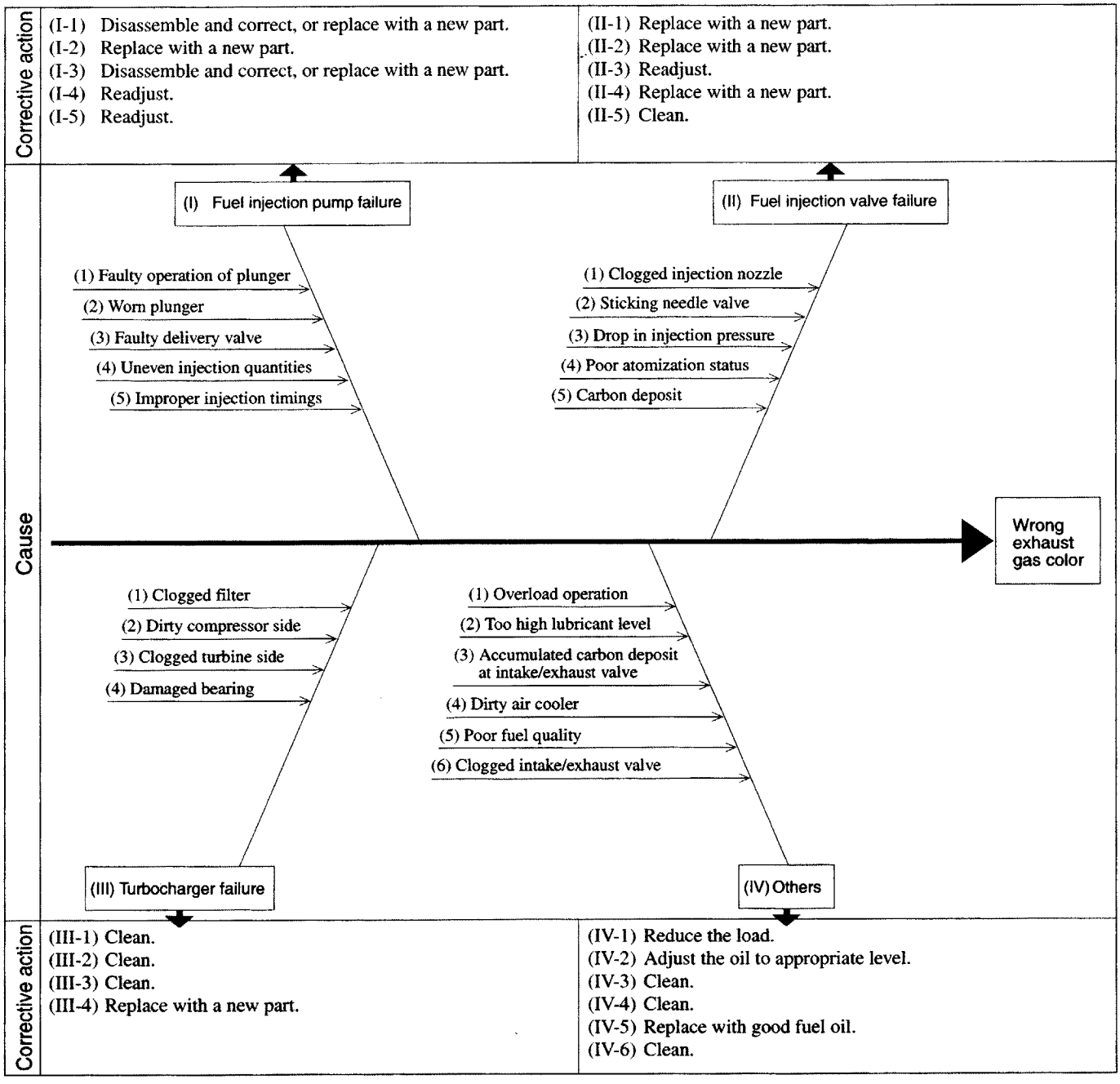
7.2 Unsmooth Running



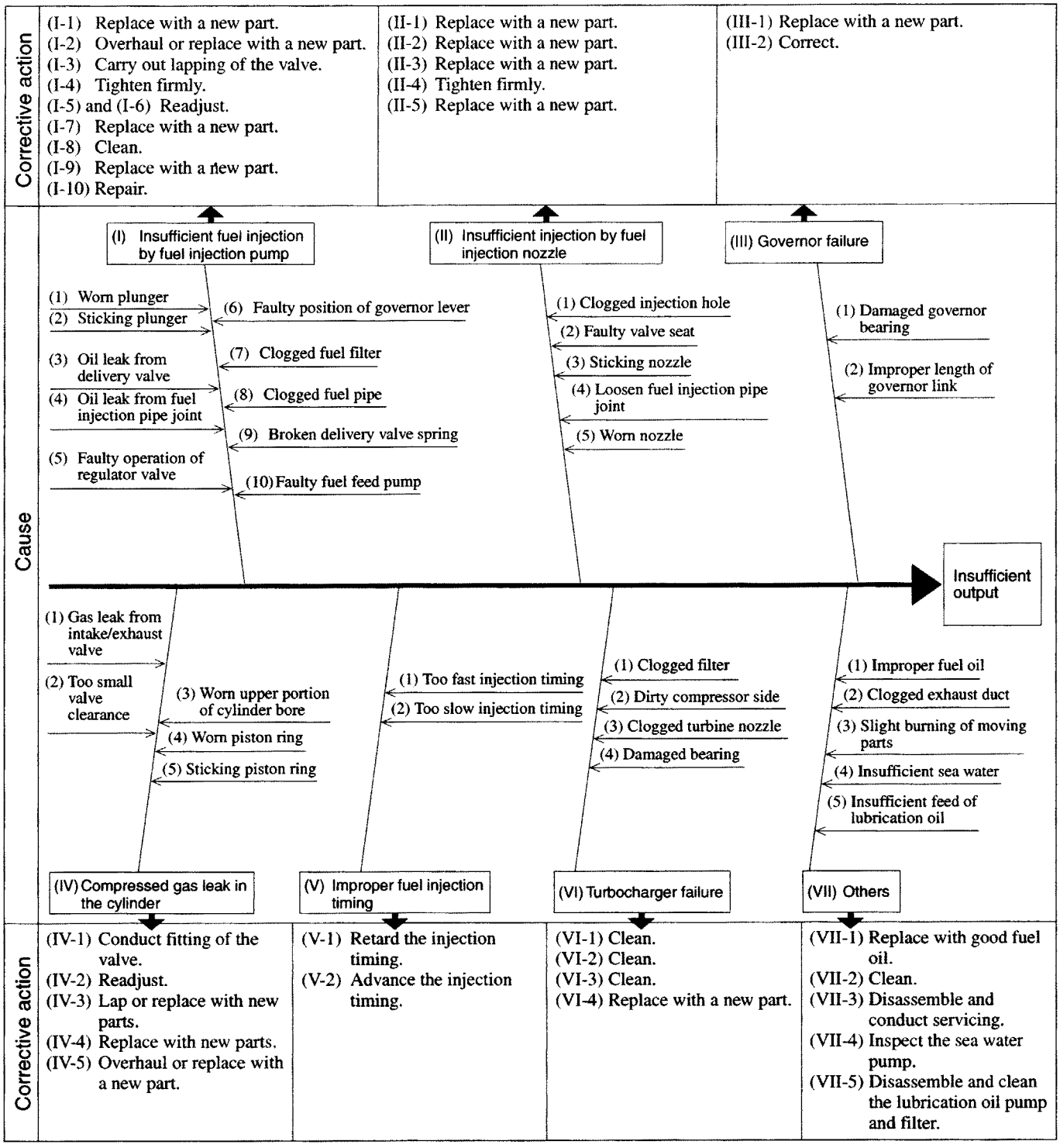
7.3 Sudden Engine Stop



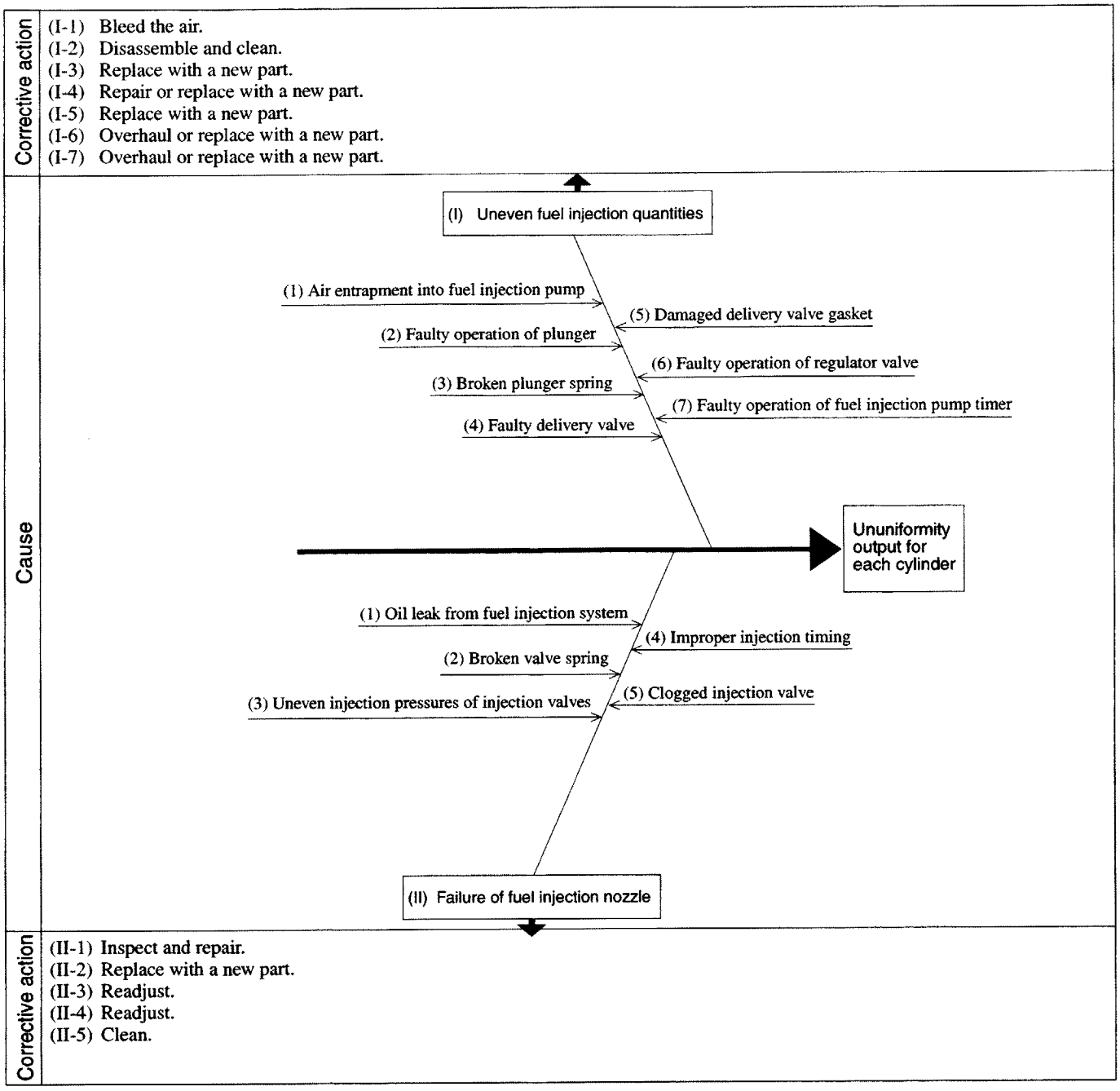
7.4 Poor Exhaust Gas Color



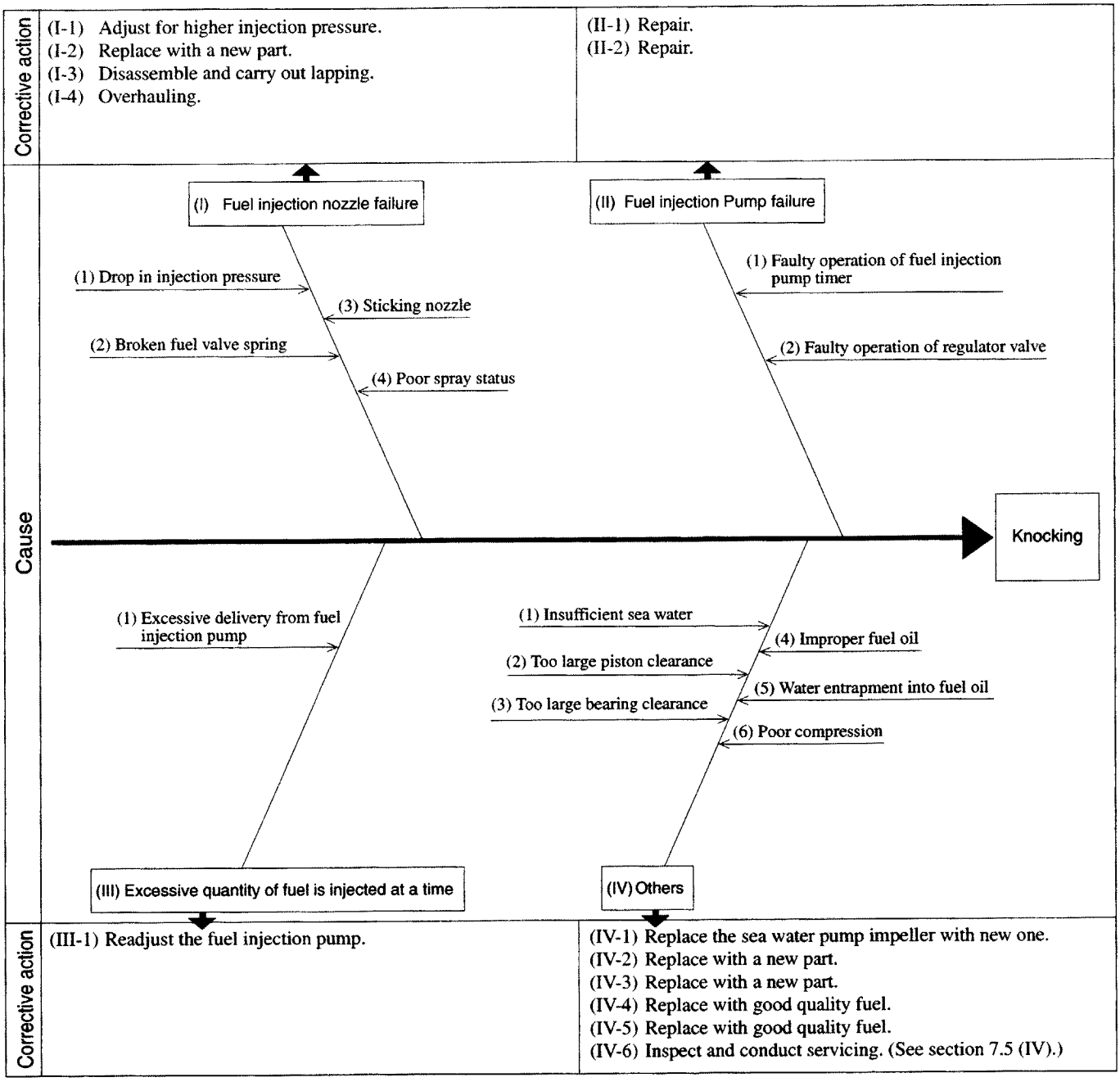
7.5 Insufficient Output



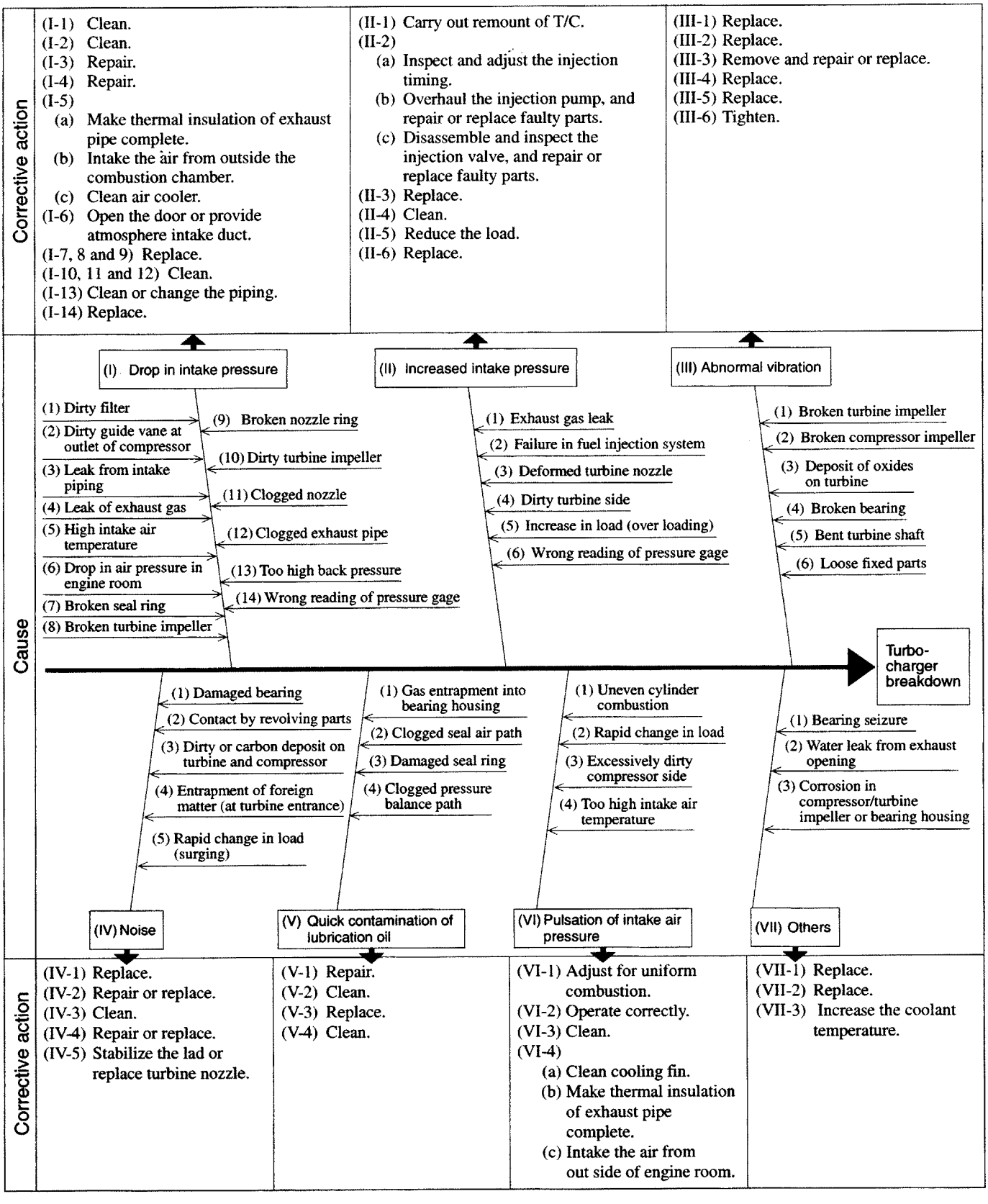
7.6 Ununiformity Output for Each Cylinder



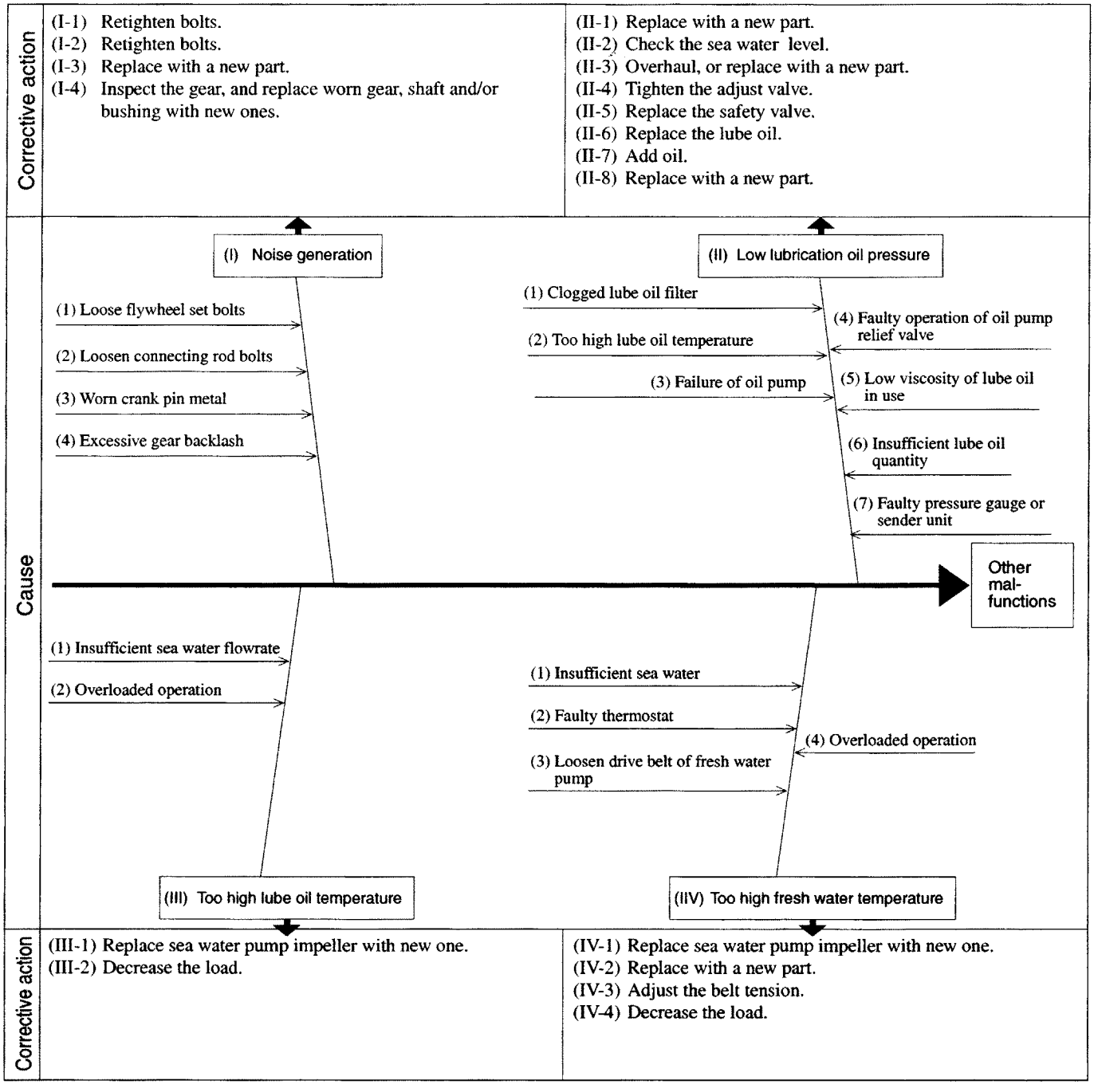
7.7 Knocking


Corrective action
(I-1) Adjust for higher injection pressure.
(I-2) Replace with a new part.
(I-3) Disassemble and carry out lapping.
(I-4) Overhauling.
(II-1) Repair.
(II-2) Repair.
Cause
(I) Fuel injection nozzle failure
(II) Fuel injection Pump failure
(1) Drop in injection pressure
(3) Sticking nozzle
(2) Broken fuel valve spring
(4) Poor spray status
(1) Faulty operation of fuel injection pump timer
(2) Faulty operation of regulator valve
Knocking
(1) Excessive delivery from fuel injection pump
(1) Insufficient sea water
(4) Improper fuel oil
(2) Too large piston clearance
(5) Water entrapment into fuel oil
(3) Too large bearing clearance
(6) Poor compression
(III) Excessive quantity of fuel is injected at a time
(IV) Others
Corrective action
(III-1) Readjust the fuel injection pump.
(IV-1) Replace the sea water pump impeller with new one.
(IV-2) Replace with a new part.
(IV-3) Replace with a new part.
(IV-4) Replace with good quality fuel.
(IV-5) Replace with good quality fuel.
(IV-6) Inspect and conduct servicing. (See section 7.5 (IV).)

7.8 Trouble Related to Turbocharger



7.9 Other Malfunctions



YANMAR CO.,LTD.

1-32, CHAYAMACHI, KITA-KU, OSAKA 530-0013 JAPAN TEL.(06)6376-6211 TELEX63436 YANMARJ FAX.(06)6372-2455

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