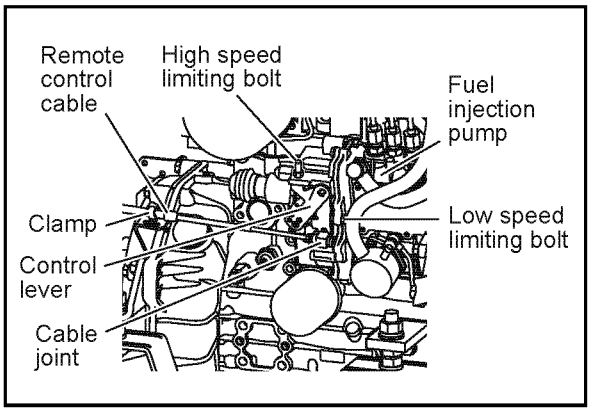
2.3 Adjusting the no-load maximum or minimum speed

1) After warming the engine up, gradually raise the speed and set it at the no-load maximum speed.
2) If the no-load maximum speed is out of the standard, adjust it by turning the high idle limiting bolt.
3) Then set the no-load minimum speed by adjusting the low idle limiting bolt.



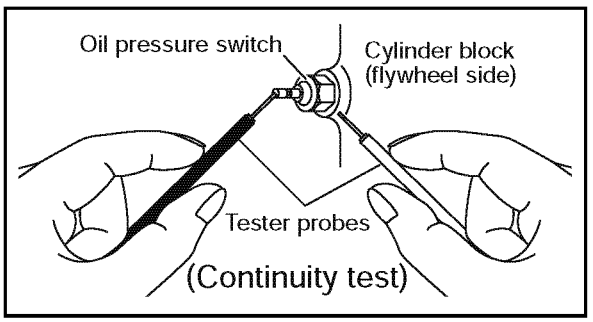
Standards (Unit : min^{-1})

No-load maximum	No-load minimum
3850±25	850±25

2.4 Sensor Inspection

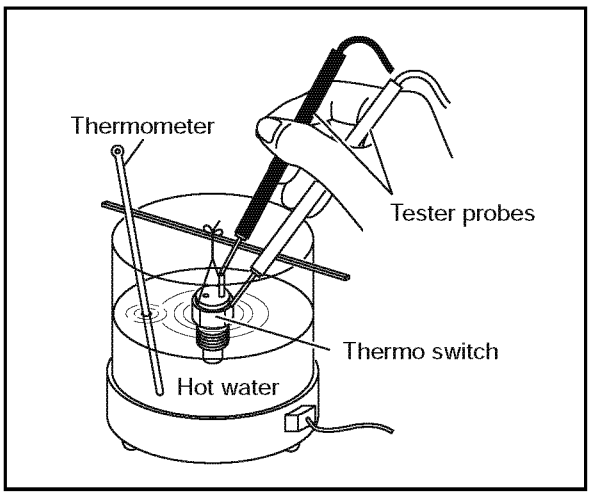
2.4.1 Oil pressure switch

Disconnect the connector from the oil pressure switch. Keep the voltameter probes in contact with the switch terminal and cylinder block while operating the engine. It is abnormal if circuit is closed.



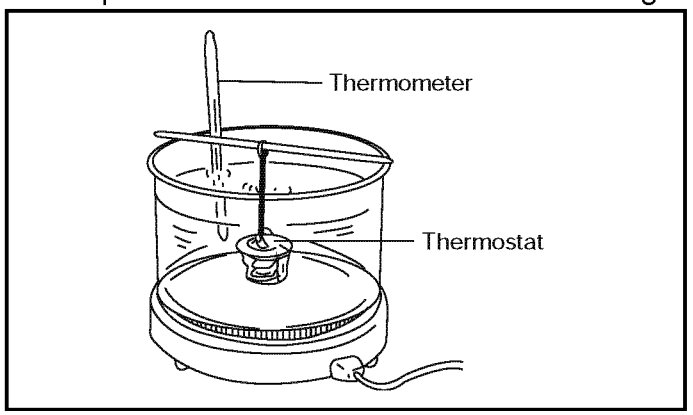
2.4.2 Thermo switch

Place the thermo switch in a container filled with antifreeze or oil. Heat it while measuring the fluid temperature. The switch is normal if the voltameter shows continuity when the fluid temperature is 93-97 deg C.



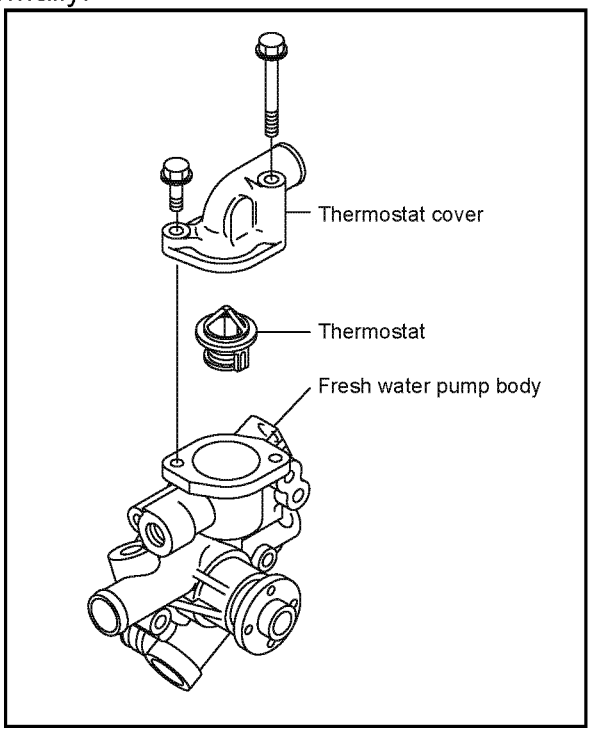
2.5 Thermostat inspection

(1) Put the thermostat in a beaker with fresh water, and heat it on an electric stove. The thermostat is functioning normally if it starts to open between 75-78 deg C, and opens until 8 mm or more at 90 deg C.
Replace the thermostat if it not functioning normally.



Valve opening Temperature (deg C)*	Full open lift (Temperature) (mm)
69.5-72.5	8 or more (85 deg C)

* Valve opening temperature is carved on the flange.



(2) Normally, the thermostat should be inspected every 500 hours or operation, but, it should be inspected before this if the cooling temperature rises abnormally or white smoke is emitted for a long time after engine starting.

(3) Replace the thermostat every year or 2000 hours of operation (whichever comes first).

2.6 Adjusting operation

Perform the adjusting operation for an engine as follows after the maintenance job:

2.6.1 Preliminary precautions

Before making a test run, make sure of the following points.

(1) Warm the engine up.

(2) Remove any precipitation from the F.O. filter. water separator, and F.O. tank.

(3) Use only lube oil recommended by Yanmar.

(4) Be sure to add Long Life Coolant Antifreeze (LLC) to cooling fresh water.

(5) Provide good ventilation in the engine room.

2.6.2 Adjusting operation procedure

1) Supply the fuel oil, lubricating oil and cooling water.

Note:
Check the levels of the lube oil and cooling water again after test running (for about 10 minutes) and add as required.

2) Start the engine, and carry out idling at a low speed (700 to 900 min^{-1}) for a few minutes.
3) Run in the engine for about five minutes at the rated speed (no-load). Check any water, fuel or lube oil leakage and existence of abnormal vibration or noise. Also check the oil pressure, cooling water temperature and exhaust gas color.
4) Adjust the no-load minimum and maximum speed. (Refer to 2.3.)
5) Perform loaded operation as required.

2.6.3 Check points and precautions during running

Step	Item	Instructions	Precautions
1	Checks before operation	1) Make sure that the sea cock is open. 2) Make sure there is enough lube oil and (fresh) cooling water. 3) Operate the remote control handle and check if the device connected to the engine works property.	3) Lamp should go off when engine is running.
2	No load operation; warm up operation	1) When the lube oil temperature is raised to allow the engine to start, the pilot lamp goes off. 2) When the engine is started, check the following: • There is no leakage of water, fuel and lube oil. • Exhaust gas does not leak when the engine is started. • here is no abnormal indication on the instrument panel. • There is no abnormality in cooling water discharge, engine vibration. or engine sound. 3) To warm up the engine, operate at low speed for about 5 minutes, then raise the speed to the rated speed and then to max. speed.	2) • Fit leaks if any. • Check the intake/ exhaust valves, fuel injection nozzle and cylinder head. 3) Do not raise the engine speed abruptly.
3	Cruising (load) operation	1) Do not operate the engine at full load yet, but raise the speed gradually for about 10 minutes until it reaches the rated speed. 2) Make sure that exhaust gas color and temperature are normal. 3) Check the instrument panel and see if the water temperature and oil pressure are normal.	
4	Stopping the engine	1) Before stopping the engine, operate it at 650-700 min^{-1} for about 5 minutes. 2) Raise engine speed to 1,800 min^{-1} jut before stopping the engine and idle the engine for about 3-4 seconds.	1) Stopping the engine suddenly during high speed operation increases the temperature of engine parts. 2) This procedure prevents carbon from being deposited on the valve seats, etc.
5	Checks after stop-ping the engine	1) Check again for water and oil leaks. 2) Make sure that no nuts and bolts are loose. 3) Close the sea cock and fuel cocks. 4) When the temperature is expected to fall below freezing, drain the seawater. 5) Turn off the battery switch.	1) Check the oil seal area. 2) Especially the engine installation bolts. 4) Drain from the seawater pump.

2.7 Long storage

Observe the following instructions when the engine is to be stored for a long period without operation:

1) Do not drain cooling water in the cold season or before the long storage.

[NOTICE]

Negligence of adding anti-freeze will cause the cooling water remaining inside the engine to be frozen and expanded to damage the engine parts.

2) Remove the mud, dust and oil deposit and clean the outside.
3) Perform the nearest periodic inspection before the storage.
4) Drain or fill the fuel oil fully to prevent condensation in the fuel tank.
5) Disconnect the battery cable from the battery negative (-) terminal.
6) Cover the silencer, air cleaner and electric parts with PVC (Poly Vinyl Chloride) cover to prevent water and dust from depositing or entrance.
7) Select a well-ventilated location without moisture and dust for storage.
8) Perform recharging once a month during storage to compensate for self-discharge.
9) When storing an engine for long time, run the engine periodically according to the following procedure because the rust occurrence inside the engine, the rack agglutination of the fuel pump, and so on are likely to occur. (In case that the engine is equipped with a boat.)
   a) Replace the lube oil and the filter before the engine running.
   b) Supply fuel if the fuel in the fuel tank was removed, and bleed the fuel system.
   c) Confirm that there is the coolant in the engine.
   d) Operate the engine at the low idling speed for about five minutes. (If it can be done, once a month)

3. Troubleshooting

3.1 Preparation before troubleshooting

If the signs of a trouble appear, it is important to lecture on the countermeasure and treatment before becoming a big accident not to shorten the engine life.

When the signs of a trouble appear in the engine or a trouble occurs, grasp the trouble conditions fully by the next point and find out the cause of sincerity according to the troubleshooting. Then repair the trouble, and prevent the recurrence of the trouble.

1) What's the occurrence phenomenon or the trouble situation?
   (e.g. Poor exhaust color)
2) Investigation of the past records of the engine
   Check a client control ledger, and examine the history of the engine.
- Investigate the engine model name and the engine number. (Mentioned in the engine label.)
  Examine the machine unit name and its number in the same way.
- When was the engine maintained last time?
- How much period and/or time has it been used after it was maintained last time?
- What kind of problem was there on the engine last time, and what kind of maintenance was dane?

3) Hear the occurrence phenomenon from the operator of the engine in detail.
   5W1H of the occurrence phenomenon : the investigation of when (when), where (where), who (who), what (what), why (why) and how (how)
- When did the trouble happen at what kind of time?
- Was there anything changed before the trouble?
- Did the trouble occur suddenly, or was there what or a sign?
- Was there any related phenomenon.
  (e.g. Poor exhaust color and starting failure at the same time)

4) After presuming a probable cause based on the above investigation, investigate a cause systematically by the next troubleshooting guide, and find out the cause of sincerity.

3.2 Quick reference chart for troubleshooting

It is important to thoroughly under stand each system and the function of all of the parts of terse systems. A careful study of the engine mechanism will make this possible. When problems arise, it is important to carefully observe and analyze the indications of trouble in order to save time in determining their cause. Begin by checking the most easily identifiable causes of difficulty. Where the cause of the difficulty is not readily apparent, make a thorough examination of the system from the very beginning, proceeding until the point of trouble can be determined. While experience is an important factor in pinpointing engine problems, careful study and understanding of the engine mechanism combined with good common sense will help you to rapidly become more expert at troubleshooting.

Chart 1

TROUBLE AND TROUBLESHOOTING

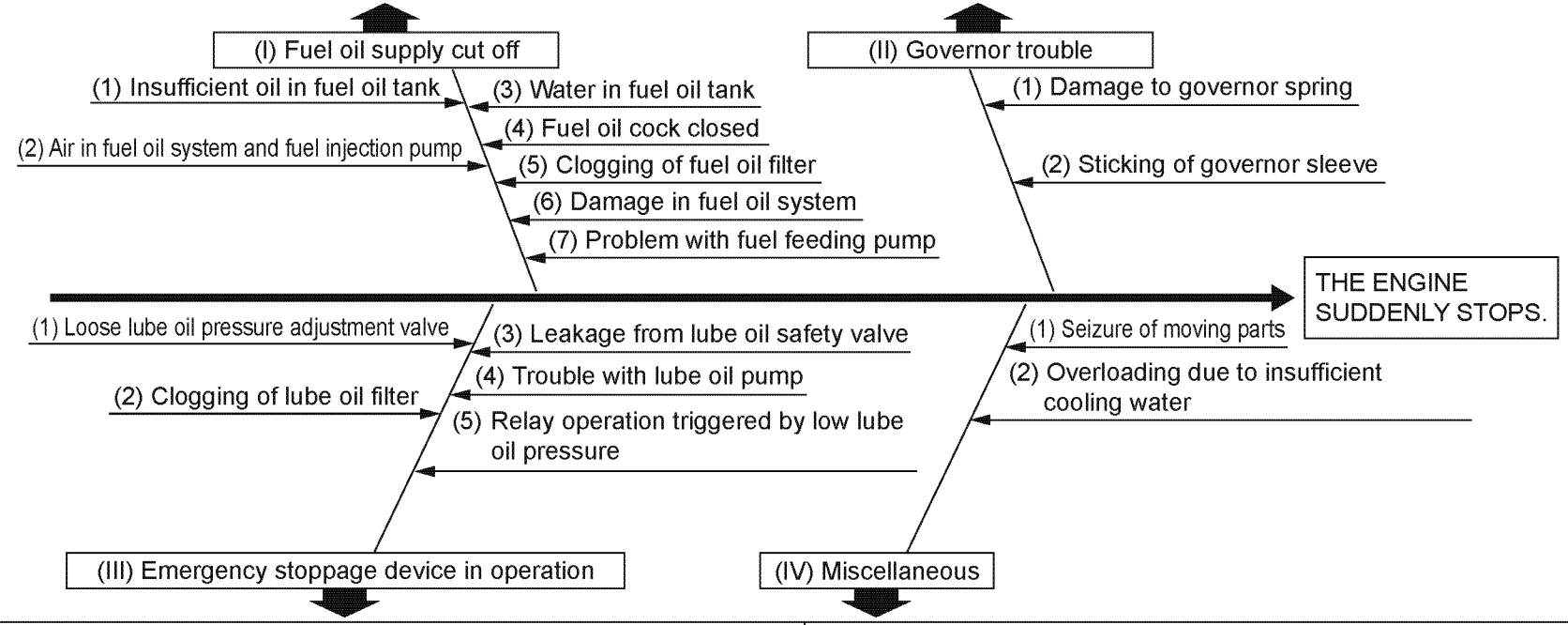
THE ENGINE SUDDENLY STOPS.

Countermeasure

(I-1) Add fuel oil and prime.
(I-2) Bleed air.
(I-3) Remove water from drain and fuel oil system and prime.
(I-4) Check and make necessary repairs.
(I-5) Clean.
(I-6) Replace.
(I-7) Check and make necessary repairs.

(II-1) Replace.
(II-2) Clean carefully to insure good working order.

Cause and Effect



Countermeasure

(III-1) Tighten adjustment valve.
(III-2) Clean.
(III-3) Tighten safety valve.
(III-4) Remove and repair or replace.
(III-5) Return to original condition.

(IV-1) Remove and repair or replace.
(IV-2) Disassemble and clean cooling water pump and check cooling water system.

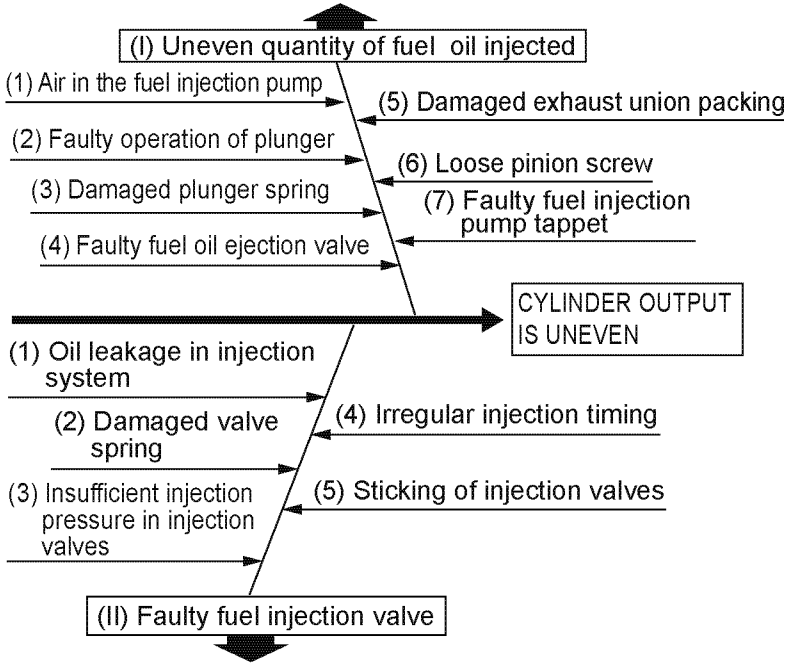
Chart 2

TROUBLE AND TROUBLESHOOTING — CYLINDER OUTPUT IS UNEVEN COUNTERMEASURE

Countermeasure

(I-1) Bleed air.
(I-2) Disassemble and clean.
(I-3) Replace.
(I-4) Repair or replace.
(I-5) Replace.
(I-6) Tighten firmly.
(I -7) Disassemble and clean and repair replace.

Cause and Effect



Countermeasure

(II-1) Check and repair.
(II-2) Replace.
(II-3) Adjust.
(II-4) Adjust.
(II-5) Clean.

Chart 3

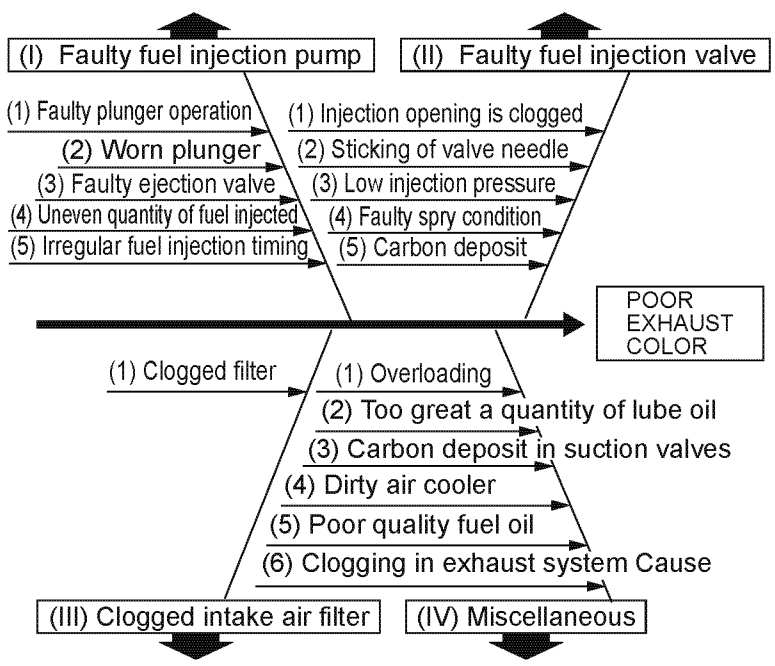
Trouble and Troubleshooting — POOR EXHAUST COLOR

Countermeasure

(I-1) Check, repair or replace.
(I-2) Replace.
(I-3) Check, repair or replace.
(I-4) Adjust.
(I-5) Adjust.

(II-1) Clean.
(II-2) Check, repair or replace.
(II-3) Adjust.
(II-4) Check, repair or replace.
(II-5) Clean.

Cause and Effect



Countermeasure

(III-1) Clean.

(IV-1) Reduce load.
(IV-2) Adjust quantity of oil.
(IV-3) Clean.
(IV-4) Clean.
(IV-5) Reduce. with new oil.
(IV-6) Clean.

Chart 4

TROUBLE AND TROUBLESHOOTING

TROUBLE WITH MARINE GEAR

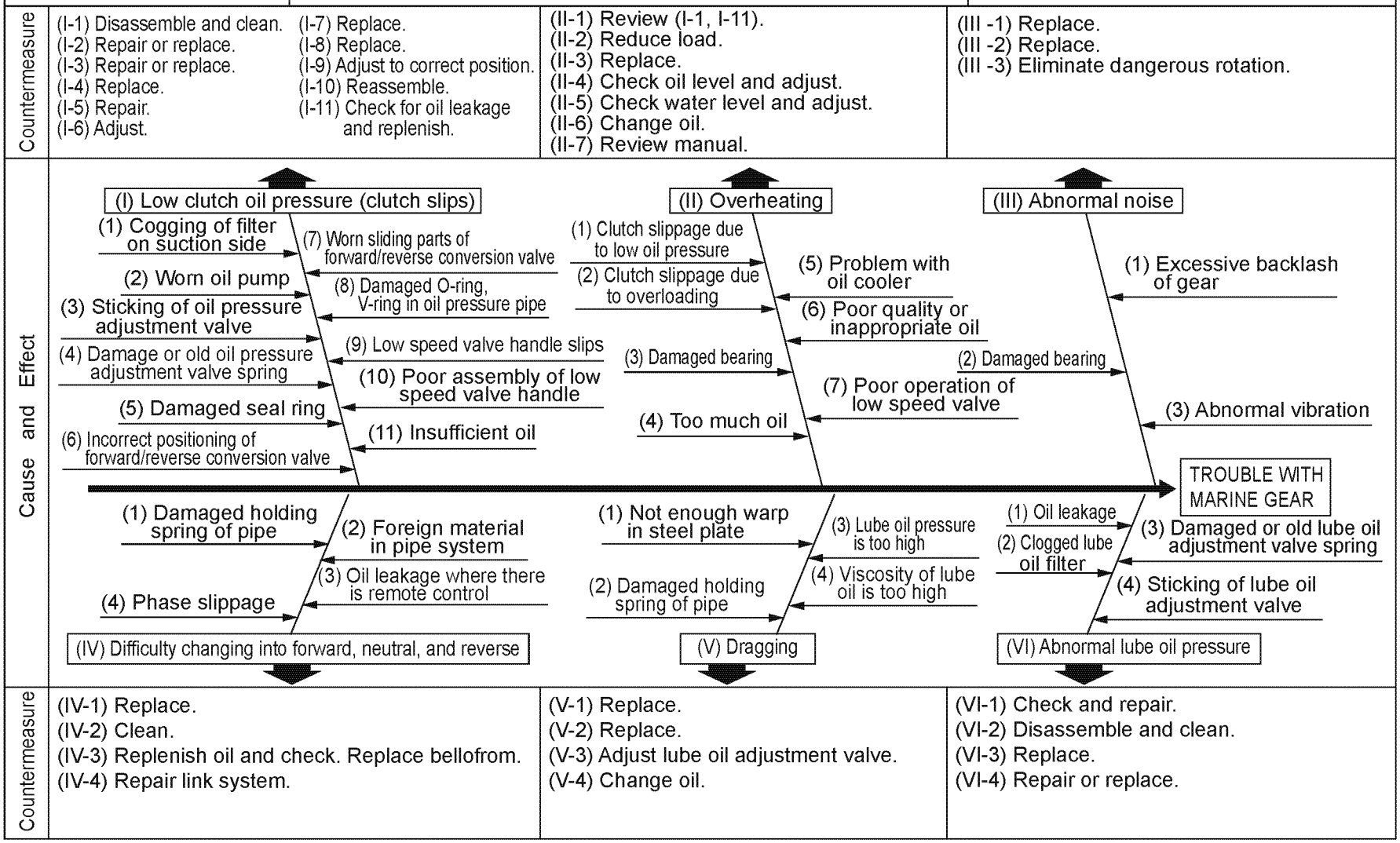


Chart 5

TROUBLE AND TROUBLESHOOTING

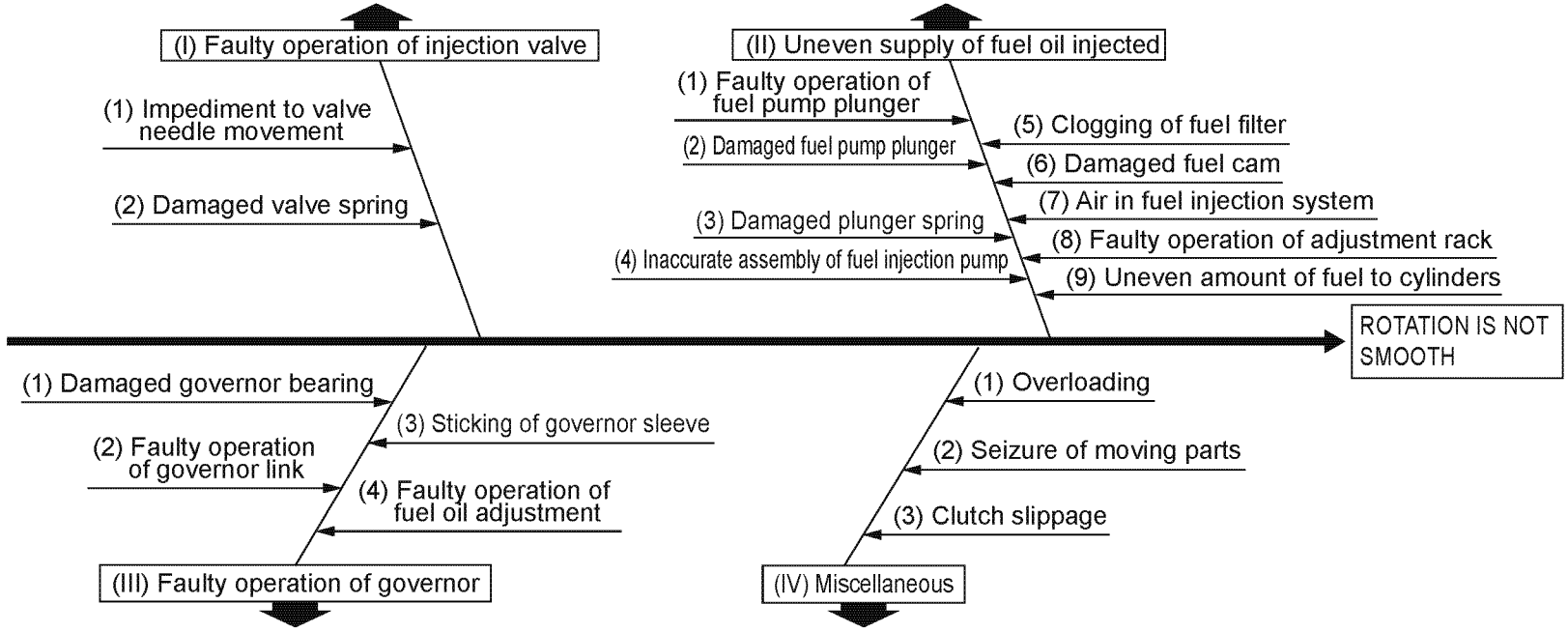
ROTATION IS NOT SMOOTH

Countermeasure

(I-1) Lap.
(I-2) Replace.

(II-1) Clean.
(II-2) Replace.
(II-3) Replace.
(II-4) Correctly install pump.
(II-5) Clean.
(II-6) Replace.
(II-7) Bleed air and prime.
(II-8) Adjust.
(II-9) Adjust.

Cause and Effect



Countermeasure

(III-1) Replace.
(III-2) Adjust.
(III-3) Clean.
(III-4) Disassemble, wash and repair.

(IV-1) Reduce load.
(IV-2) Disassemble, check and repair.
(IV-3) Check and adjust.

Chart 6

TROUBLE AND TROUBLESHOOTING

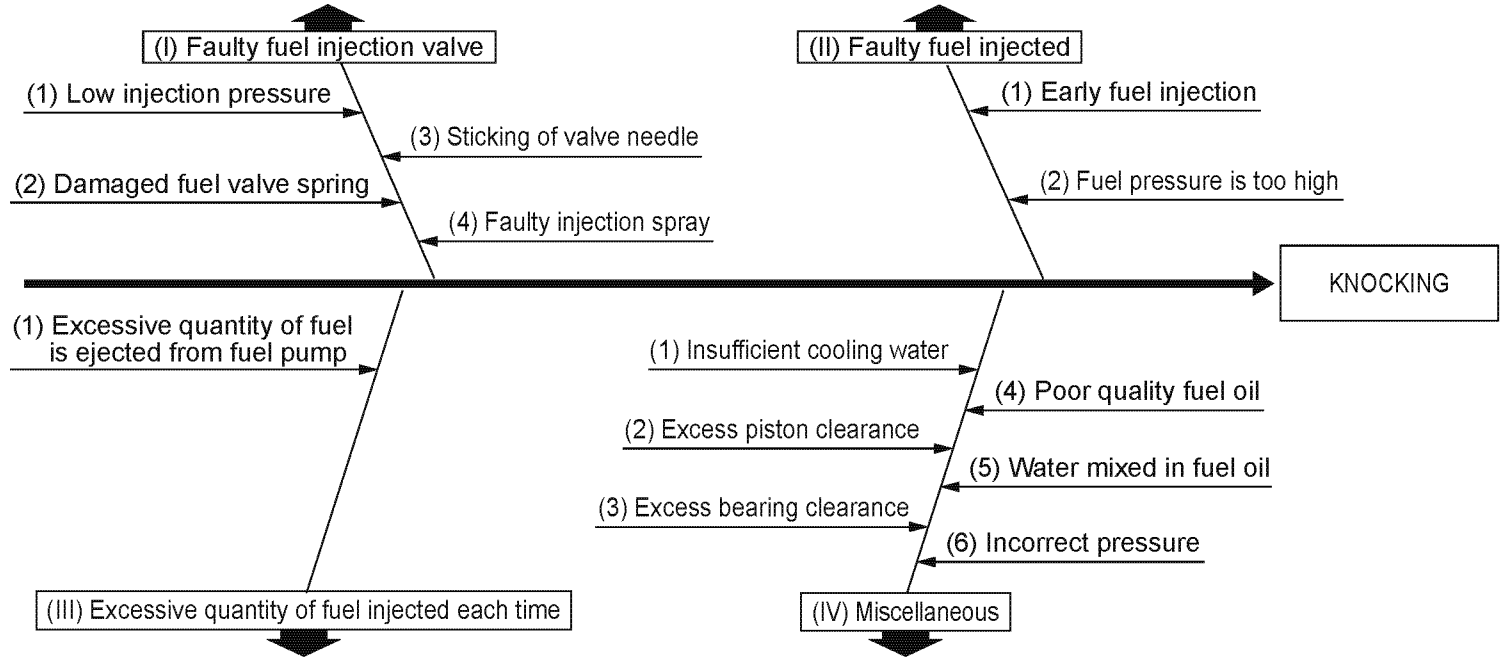
KNOCKING

Countermeasure

(I-1) Increase injection pressure.
(I-2) Replace.
(I-3) Disassemble and lap.
(I-4) Disassemble and repair.

(II-1) Delay injection timing.
(II-2) Adjust standard injection pressure.

Cause and Effect



Countermeasure

(III-1) Adjust pump adjustment rack.

(IV-1) Check cooling water pump and lap valves.
(IV-2) Replace.
(IV-3) Replace.
(IV-4) Replace with good fuel oil.
(IV-5) Replace with good fuel oil.
(IV-6) Check and repair.

Chart 7

TROUBLE AND TROUBLESHOOTING

TROUBLE WITH STARTING

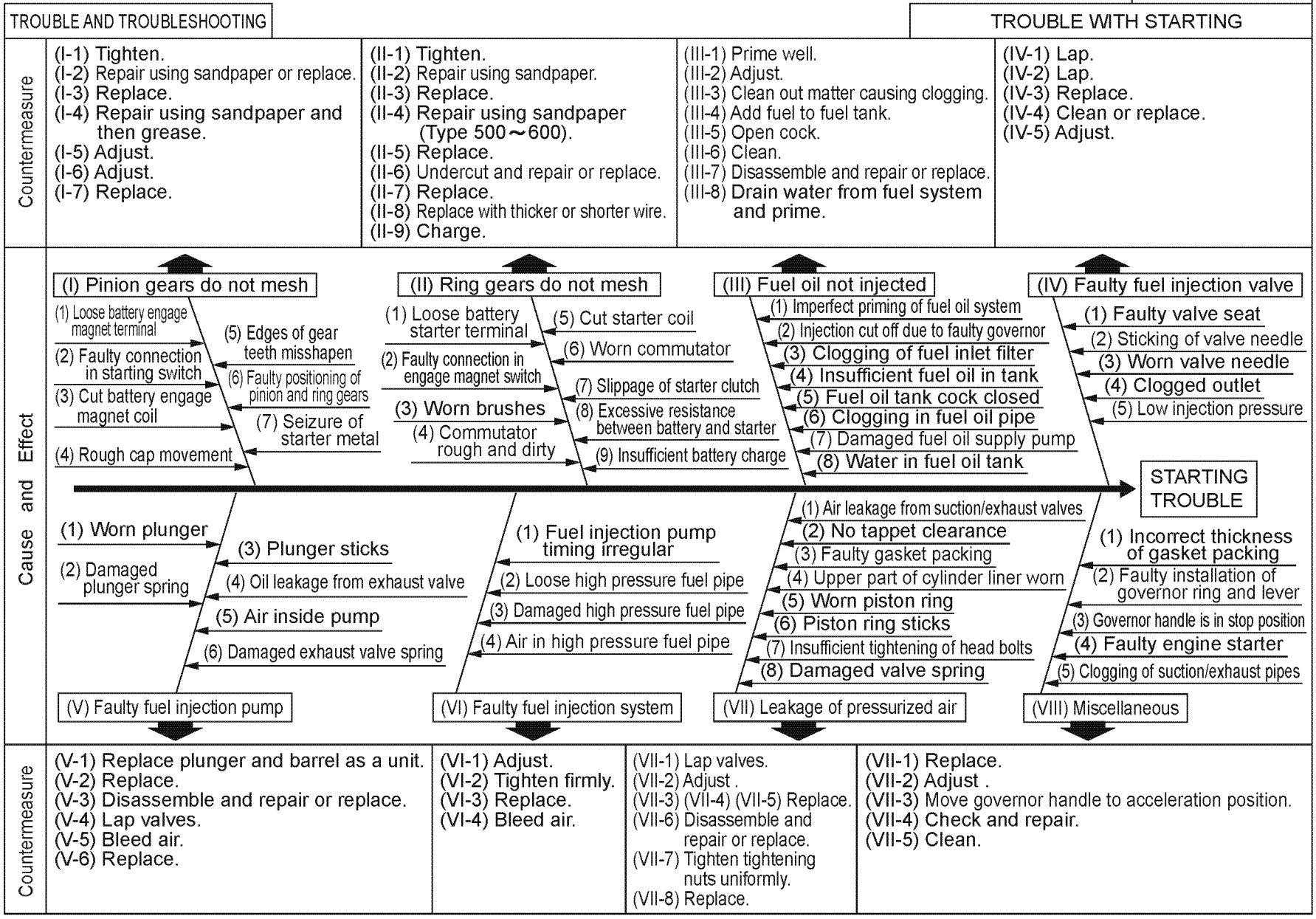


Chart 8

TROUBLE AND TROUBLESHOOTING

INSUFFICIENT POWER OUTPUT

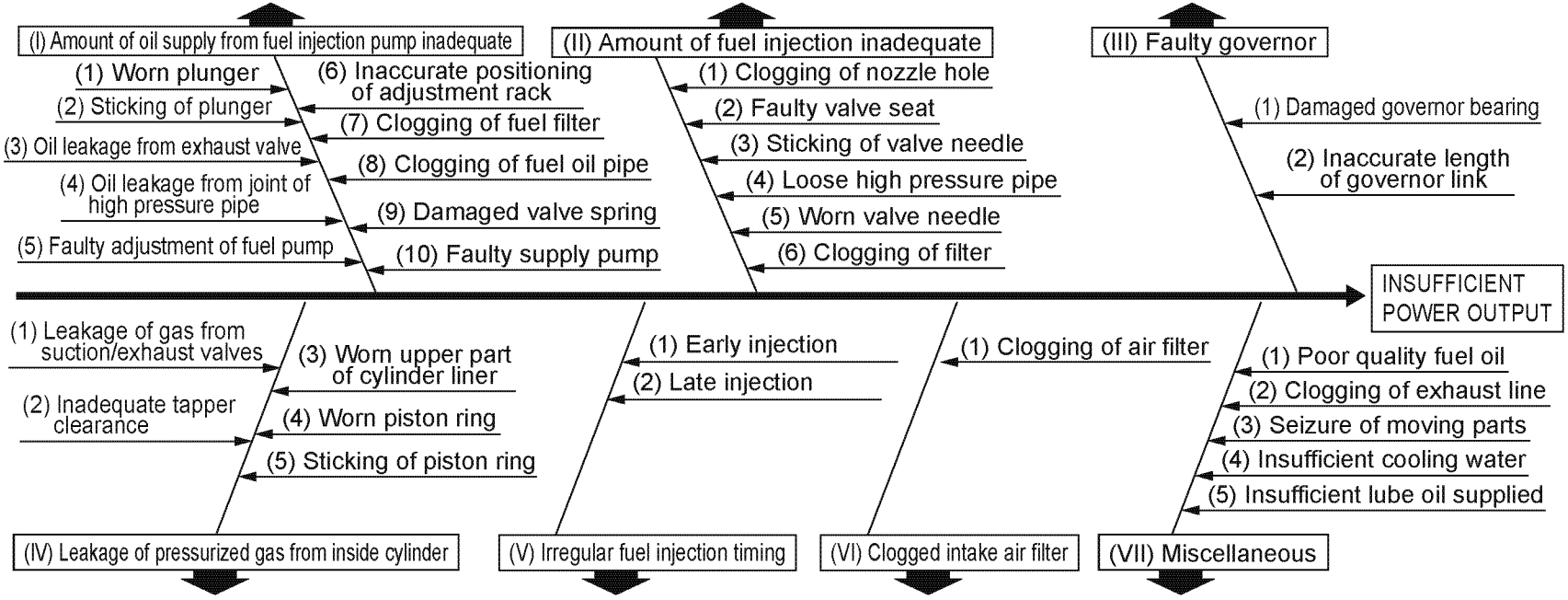
Countermeasure

(I-1) Replace.
(I-2) Disassemble and repair or replace.
(I-3) Lap valves.
(I-4) Tighten firmly.
(I-5) (I-6) Adjust.
(I-7) (I-8) Clean.
(I-9) Replace.
(I-10) Repair.

(II-1) Clean nozzle hole or replace.
(II-2) Lap or replace.
(II-3) Lap or replace.
(II-4) Tighten firmly.
(II-5) Replace.
(II-6) lean.

(III-1) Replace.
(III-2) Repair.

Cause and Effect



Countermeasure

(IV-1) Lap valves.
(IV-2) Adjust.
(IV-3) Replace.
(IV-4) Replace.
(IV-5) Disassemble and repair or replace.

(V-1) Adjust timing to delay injection.
(V-2) Adjust timing to speed injection.

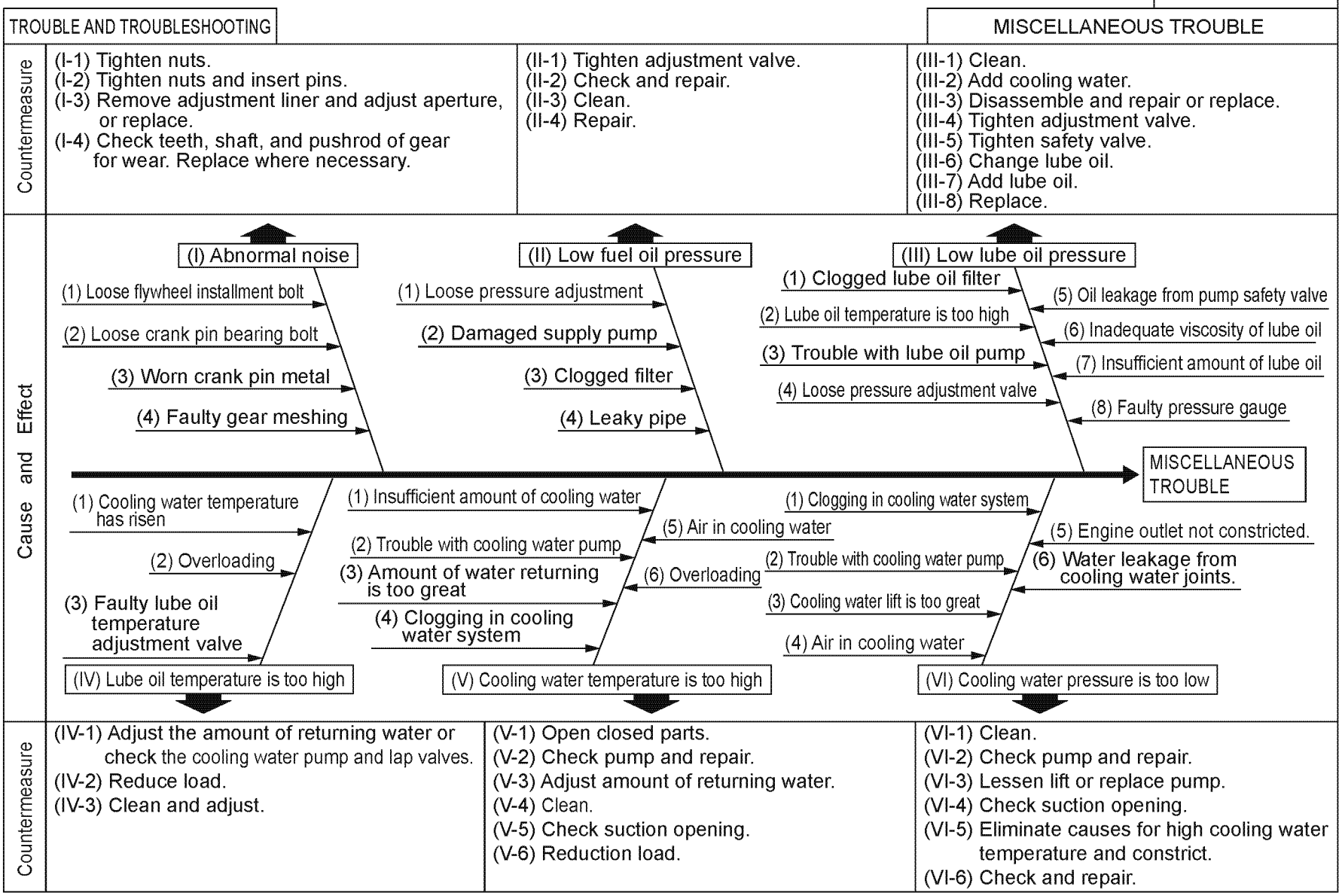
(VI-1) Clean.

(VII-1) Replace with good fuel oil.
(VII-2) Clean.
(VII-3) Disassemble, check and repair.
(VII-4) Lap cooling water pump suction/exhaust valves.
(VII-5) Disassemble and clean lube oil pump and filter.

Chart 9

TROUBLE AND TROUBLESHOOTING

MISCELLANEOUS TROUBLE



3.3 Troubleshooting (Concerning engine and fuel injection equipment)

Malfunctions	Causes	Remedies
The engine does not operate		
1. Fuel oil is not injected from the injection pump	1. There is no fuel oil in the fuel tank	Supply fuel and bleed the system
	2. The fuel line from the fuel tank is blocked	Clean or replace
	3. The fuel is clogged	Clean or replace
	4. There is air in the fuel filter or the pump chamber	Bleed the system
	5. The accelerator linkage is not properly connected	Repair
	6. The magnet valve wiring is broken or its armature is sticking	Repair or replace
	7. The feed pump blades are sticking, and therefore not operating	Repair or replace
	8. The drive gear or woodruff key is broken	Replace
2. Injection timing is incorrect	1. The drive gear or belt connections are incorrect	Repair
	2. The injection pump is incorrectly installed on the engine	Repair and adjust injection timing
	3. The roller holder assembly's roller or pin is worn excessively	Replace the assembly
	4. The plunger is worn excessively	Replace the distributor assembly
3. The nozzle does not operate	1. The nozzle or nozzle holder is functioning incorrectly	Inspect, then repair or replace
4. The engine operates but only for short time	1. The pipe(s) to the injection pump is blocked or the fuel filter is clogged	Clean or replace the pipe(s) or fuel filter
	2. The fuel oil contains air or water	Bleed of air or replace the fuel oil
	3. The feed pump's delivery quantity (or pressure) is insufficient	Repair or replace
5. The engine "knocks"	1. The injection timing is too advanced	Readjust the timing
	2. The nozzle or nozzle holder is functioning incorrectly	Inspect, then repair or replace

Malfunctions	Causes	Remedies
The engine exhaust contains smoke and the engine “knocks”	1. The injection timing is incorrect	Readjust the timing
	2. The nozzle or nozzle holder is functioning incorrectly	Inspect, then repair or replace
	3. The injection quantity is excessive	Readjust
The engine output is unstable	1. The fuel filter element is clogged and fuel oil delivery is poor	Clean or replace
	2. The amount of fuel or pressure delivered by the feed pump is too little	Inspect and repair
	3. The injection pump is sucking air	Inspect and repair
	4. The regulating valve is stuck in the open position	Replace
	5. The plunger is sticking and does not travel its full stroke	Replace the distributor assembly
	6. The plunger spring is broken	Replace
	7. The control sleeve is not sliding smoothly	Repair or replace
	8. The governor lever is not operating properly or is worn excessively	Repair or replace
	9. The delivery valve spring is broken	Replace
	10. The delivery valve is not sliding properly	Repair or replace
	11.The nozzle or the nozzle holder is not functioning properly	Inspect, and then repair or replace
	12.The injection timing is incorrect	Readjust
Insufficient output 1. The injection quantity is insufficient	1. The specified full-load injection quantity is not delivered	Readjust
	2. The control lever is not reaching the maximum speed position	Readjust
	3. The governor spring is weak and therefore the governed speed is too low	Replace
	4. The plunger is worn	Replace the distributor assembly
	5. The delivery valve seating portions are damaged	Replace
2. The injection timing is too advanced and the engine is “knocking”		Readjust
3. The injection timing is too retarded and the engine is overheating or the exhaust contains smoke		Readjust

Malfunctions	Causes	Remedies
4. The nozzle or the nozzle holder is not functioning properly		Inspect and then repair or replace
The engine cannot reach its maximum speed	1. The governor spring is too weak or is improperly adjusted	Readjust or replace
	2. The control lever is not reaching the maximum-speed position	Readjust
	3. The nozzle's injection operation is poor	Repair or replace
The engine's maximum speed is too high	1. The governor spring is too strong or is improperly adjust	Readjust or replace
	2. The governor flyweights or governor sleeve movement is not smooth	Repair or replace
Idling is unstable	1. The injection quantities are not uniform (the delivery valve is not operating properly)	Inspect or replace
	2. The governor's idling adjustment is improperly adjusted	Readjust
	3. The plunger is worn	Replace the distributor assembly
	4. The plunger spring is broken	Replace
	5. The rubber damper is worn.	Replace
	6. The governor lever shaft pin is worn excessively	Replace
	7. The feed pump blades are not operating properly	Repair or replace
	8. The regulating valve is stuck in the open position	Replace
	9. The fuel filter element is clogged and therefore fuel oil delivery is poor	Clean or replace
	10.The nozzle or the nozzle holder is not functioning properly	Inspect and then repair or replace

3.4 Troubleshooting by measuring compression pressure

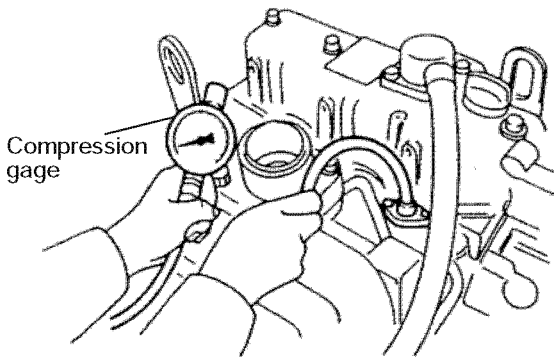
Compression pressure drop is one of major causes of increasing blowby gas (lubricating oil contamination or increased lubricating oil consumption as a resultant phenomenon) or starting failure. The compression pressure is affected by the following factors:

1) Degree of clearance between piston and cylinder
2) Degree of clearance at intake/exhaust valve seat
3) Gas leak from nozzle gasket or cylinder head gasket

In other words, the pressure drops due to increased parts wear and reduced durability resulting from long use of the engine.
A pressure drop may also be caused by scratched cylinder or piston by dust entrance from the dirty air cleaner element or worn or broken piston ring. Measure the compression pressure to diagnose presence of any abnormality in the engine.

(1) Compression pressure measurement method

1) After warming up the engine, remove the fuel injection pipe and valves from the cylinder to be measured.
2) Crank the engine before installing the compression gage adapter.
   a) Perform cranking with the stop handle at the stop position (no injection state).
   b) See 4.2.3(2) in Chapter 4 for the compression gage and compression gage adapter.
3) Install the compression gage and compression gage adapter at the cylinder to be measured.
   a) Never forget to install a gasket at the tip end of the adapter.
4) With the engine set to the same state as in 2)a), crank the engine by the starter motor until the compression gage reading is stabilized.



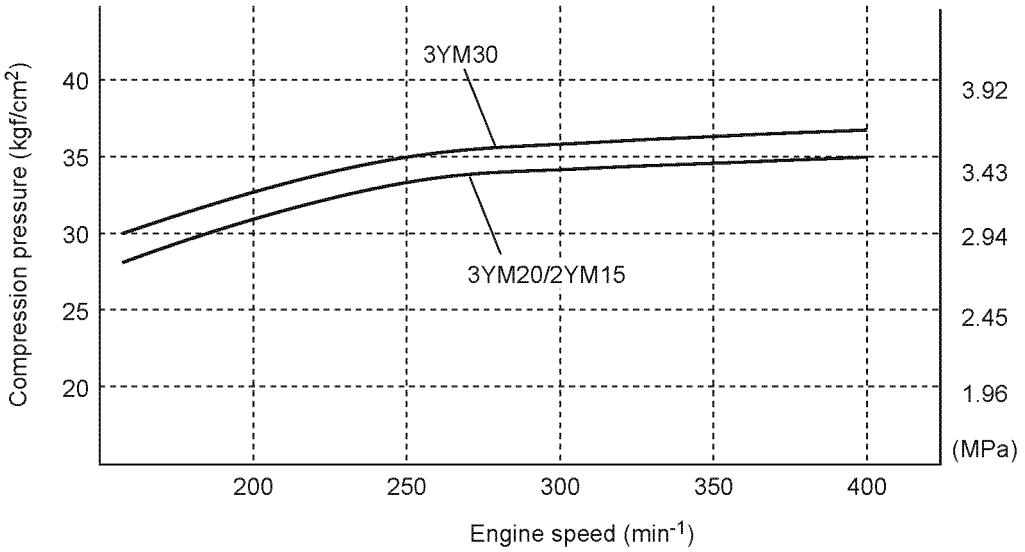
(Measurement of the compression pressure)

(2) Standard compression pressure

Engine compression pressure list (reference value)

Model	Compression pressure at 250 min^{-1} MPa (kgf/cm^2)		Deviation among cylinders MPa (kgf/cm^2)
	Standard	Limit	
3YM30	3.43 ± 0.1 (35 ± 1)	2.75 ± 0.1 (28 ± 1)	0.2 ± 0.3 (2 ± 3)
3YM20/2YM15	3.23 ± 0.1 (33 ± 1)	2.55 ± 0.1 (26 ± 1)	0.2 ± 0.3 (2 ± 3)

(3) Engine speed and compression pressure (for reference)



(4) Measured value and troubleshooting

When the measured compression pressure is below the limit value, inspect each part by referring to the table below.

No.	Item	Cause	Corrective action
1	• Air cleaner element	• Clogged element • Broken element • Defect at element seal portion	• Clean the element. • Replace the element.
2	• Valve clearance	• Excessive or no clearance	• Adjust the valve clearance. (See 2.2.2(5) in Chapter 2.)
3	• Valve timing	• Incorrect valve clearance	• Adjust the valve clearance. (See in Chapter2.)
4	• Cylinder head gasket	• Gas leak from gasket	• Replace the gasket. • Retighten the cylinder head bolts to the specified torque. (See 5.2.5 in Chapter 5.)
5	• Intake / exhaust vale • Valve seat	• Gas leak due to worn valve seat or foreign matter trapping • Sticking valve	• Lap the valve seat. (See 5.2.2 in Chapter 5.) • Replace the intake/exhaust valve.
6	• Piston • Piston ring • Cylinder	• Gas leak due to scratching or wear	• Perform honing and use an oversized part.

4. Disassembly and reassembly

4.1 Disassembly and reassembly precautions

(1) Disassembly

- Take sufficient time to accurately pin-point the cause of the trouble, and disassemble only those parts which are necessary.
- Be careful to keep all disassembled parts in order.
- Prepare disassembly tools.
- Prepare a cleaner and cleaning can.
- Clear an adequate area for parts and prepare a container(s)
- Drain cooling water (seawater, fresh water) and lube oil.
- Close the seacock

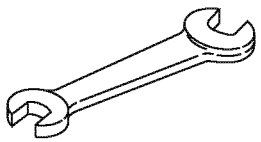
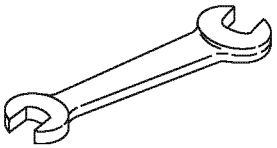
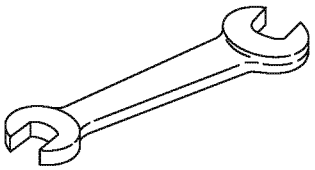
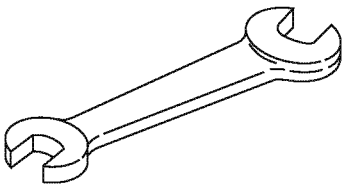
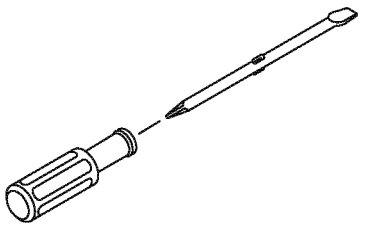
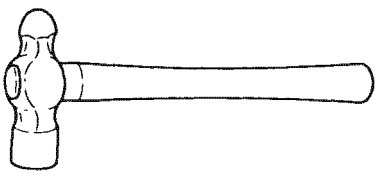
(2) Reassembly

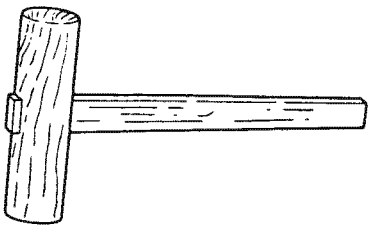
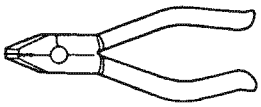
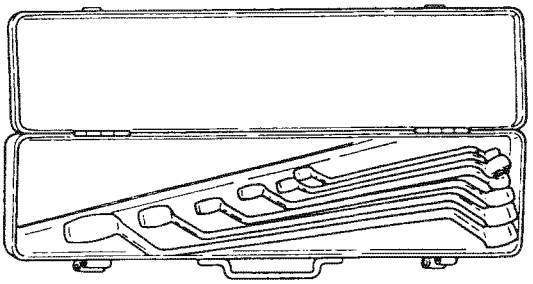
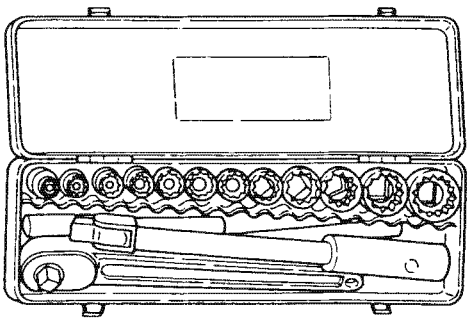
- Sufficiently clean and inspect all parts to be assembled.
- Coat sliding and rotating parts with new engine oil when assembling.
- Replace all gaskets and O-rings.
- Use a liquid packing agent as necessary to prevent oil/water leaks.
- Check the oil and thrust clearances. etc. of parts when assembling
- Make sure you use the correct bolt/nut/washer.
- Tighten main bolts/nuts to the specified torque. Be especially careful not to over tighten the aluminum alloy part mounting bolts.
- Align match marks (if any) when assembling. Make sure that the correct sets of parts are used for bearings, pistons, and other parts where required.

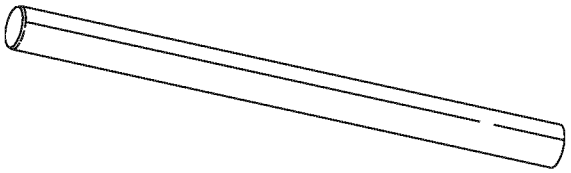
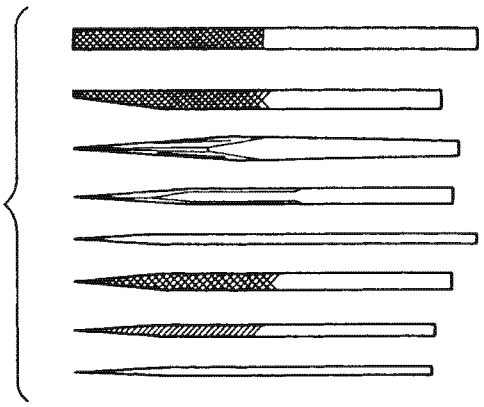
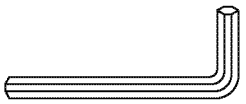
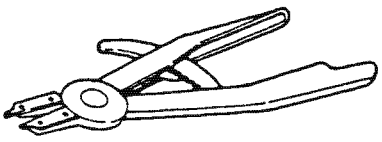
4.2 Disassembly and reassembly tools

The following tools are required when disassembling and reassembling the engine.
Please use them as instructed.

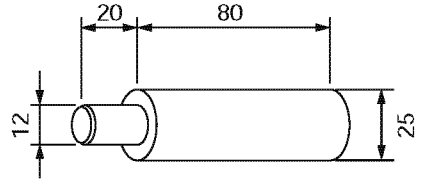
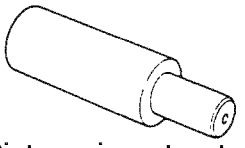
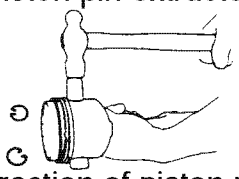
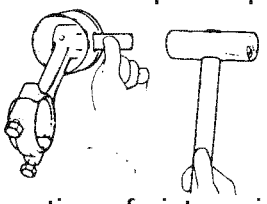
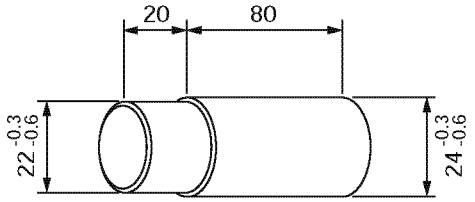
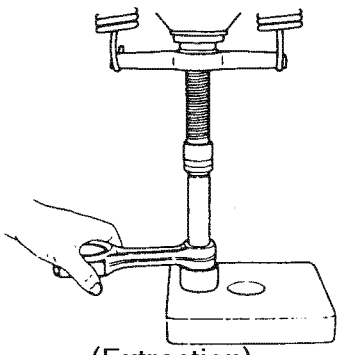
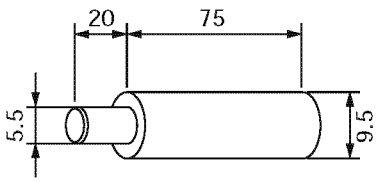
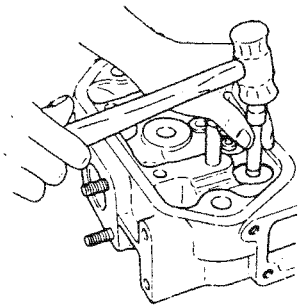
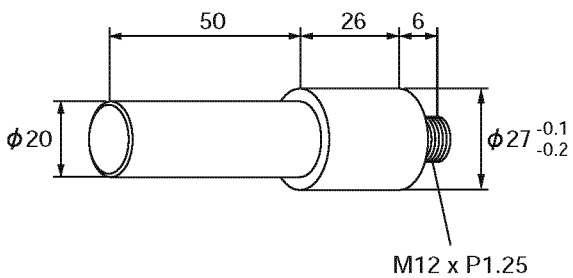
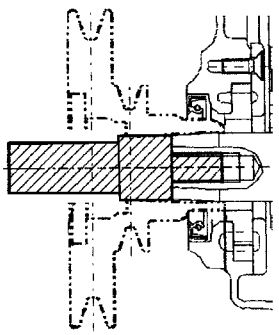
4.2.1 General hand tools

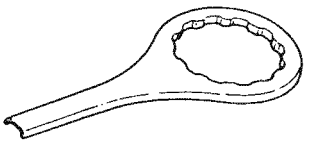
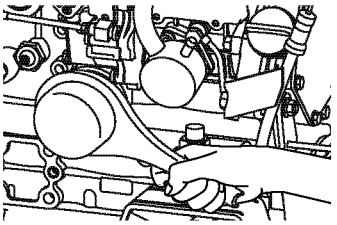
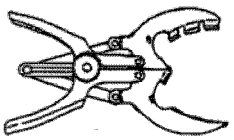
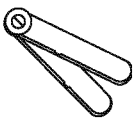
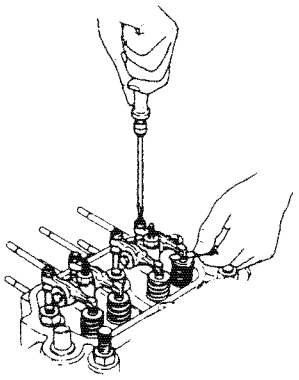
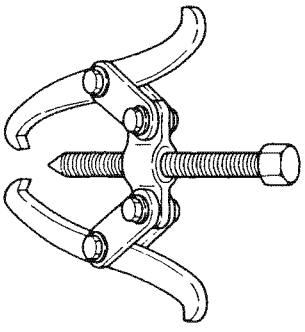
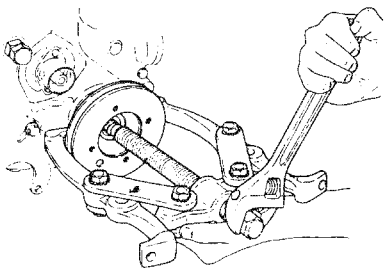
Name of tool	Illustration	Remarks
Wrench		Size : 10 x 13
Wrench		Size : 12 x 14
Wrench		Size : 17 x 19
Wrench		Size : 22 x 24
Screwdriver		
Steel hammer		Local supply

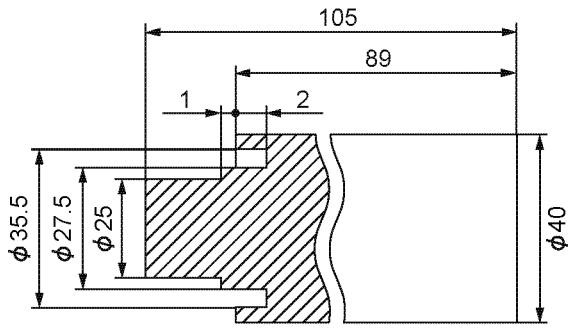
Name of tool	Illustration	Remarks
Copper hammer		Local supply
Mallet		Local supply
Nippers		Local supply
Pliers		Local supply
Offset wrench		Local supply 1 set
Box spanner		Local supply 1 set
Scraper		Local supply

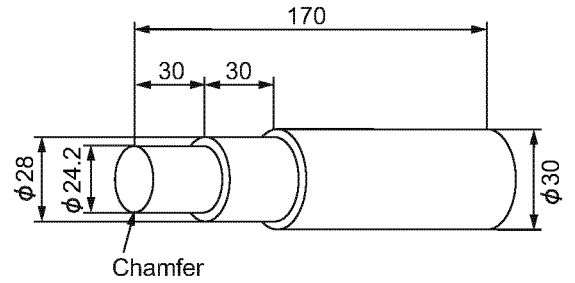
Name of tool	Illustration	Remarks
Lead rod		Local supply
File		Local supply 1 set
Rod spanner for hexagon socket head screws		Local supply Size : 6 mm 8 mm 10 mm
Stariing pliers Hole type Shaft type	 S - 0  H4 - H8 S = Hole type H = Shaft type	Local supply

4.2.2 Special hand tools

Name of tool	Illustration	Remarks
Piston pin insertion/ extraction tool		 (Piston pin extractor)  (Extraction of piston pin)  (Insertion of piston pin)
Connecting rod small end bushing insertion/extraction tool	 * Locally manufactured	 (Extraction)
Intake and exhaust valve insertion/ extraction tool	 * Locally manufactured	
Crankshaft pulley insertion tool		

Name of tool	Illustration	Remarks
Lube oil filter case remover		
Piston ring replacer (for removal / installation of piston ring)		
Valve lapping tool (Rubber cap type)		
Valve lapping powder	 Code No. 28210-000070	
Feeler gauge		
Pulley puller	 (Local supply)	 (Removing the coupling)

<table>
<tr><th>Name of tool</th><th>Illustration</th><th>Remarks</th></tr>
<tr><td>Press tool 1 for filler neck</td><td> 

(Tool 1)</td><td>-</td></tr>
<tr><td>Press tool 2 for filler neck copper tube</td><td> 

(Tool 2)</td><td>-</td></tr>
<tr><td>Stem seal insertion (for inserting stem seal)</td><td>mm
<table>
<tr><th>d1</th><th>d2</th><th>d3</th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>15.0</td><td>21</td><td>12</td><td>11.0</td><td>65</td><td>4 or more</td></tr>
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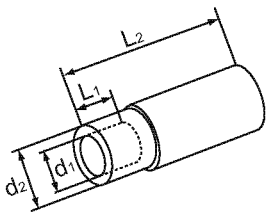
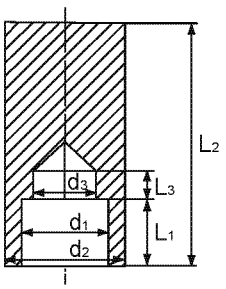
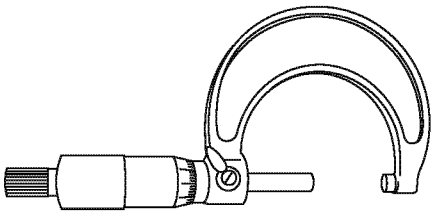
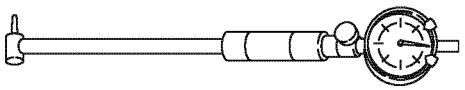
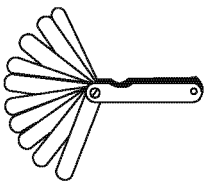
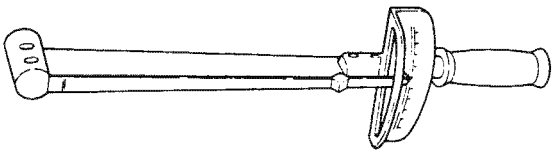
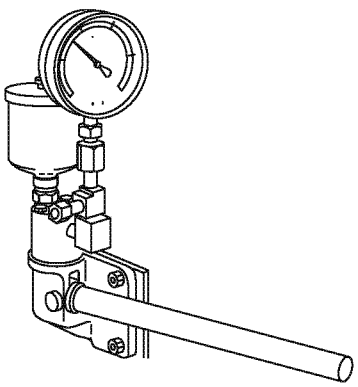


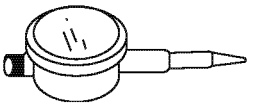
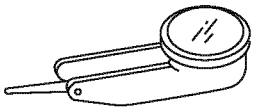
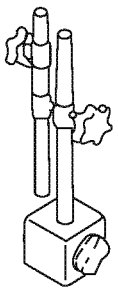
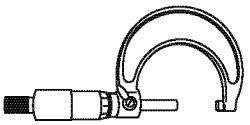
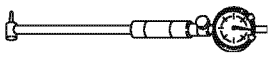
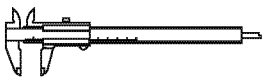
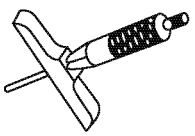
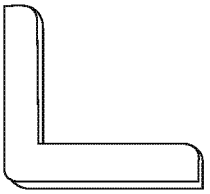

</td><td>-</td></tr>
</table>

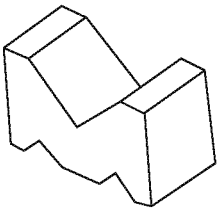
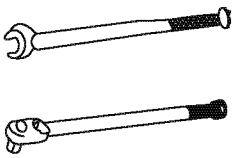
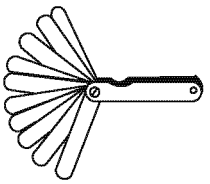
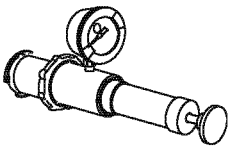
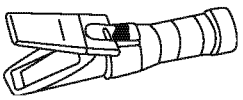
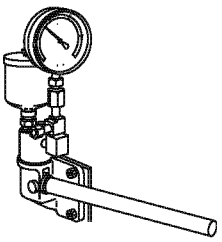
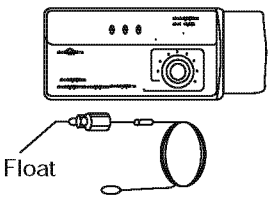
4.2.3 Measuring instruments

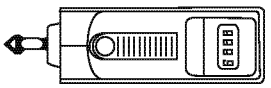
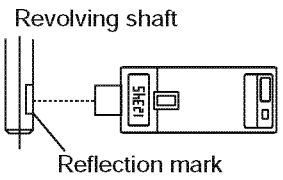
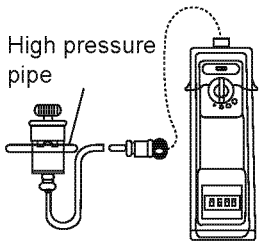
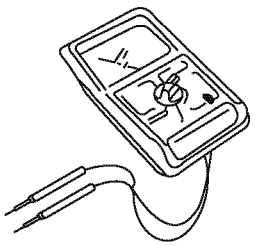
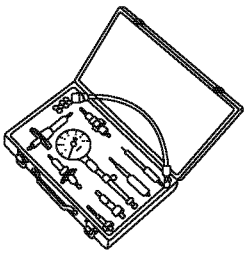
(1) Application of tools

Name of tool	Illustration	Remarks
Vernier calipers		0.05 mm 0-150 mm
Micrometer		0.01 mm 0-25 mm 25-50 mm 50-75 mm 75-100 mm 100-125 mm 125-150 mm
Cylinder gauge		0.01 mm 18-35 mm 35-60 mm 50-100 mm
Thickness gauge		0.05-2 mm
Torque wrench		128 N•m (0-13 kgf•m)
Nozzle tester		0-49 Mpa (0-500 kgf/cm^2)

(2) Use of tools

No.	Name of tool	Use	Illustration
1	Dial gauge	Measures shaft bending, distortions of levelness, and gaps.	
2	Test indicator	Measures narrow and deep places, which cannot be measured with dial gauge.	
3	Magnetic stand	Keeps the dial gauge firmly in position, thereby permitting it to be used at various angles.	
4	Micrometer	Measures the outer diameter of the crank shaft, piston, piston pin, etc.	
5	Cylinder gauge	Measure the inner diameter of the cylinder liner and rod metal.	
6	Vernier calipers	Measures various outer diameters, thicknesses, and widths.	
7	Depth micrometer	Measures sinking of valves.	
8	Square	Measures distortion in position of springs and perpendicularity of parts.	

No.	Name of tool	Use	Illustration
9	V Block	Measures shaft distortion.	
10	Torque wrench	Used to tighten bolts and nuts to standard torque.	
11	Thickness gauge	Measures the distance between the ring and ring groove, and between the shaft and shaft joint at time of assembling.	
12	Cap tester	Check for leakage in the fresh water system.	
13	Battery current tester	Checks density of antifreeze and charging condition of battery fluid.	
14	Nozzle tester	Checks the shape and pressure of spray emitted from the fuel injection valve at the time of injection.	
15	Digital thermostat	Measures temperature of various parts.	

No.	Name of tool		Use	Illustration
16	Rotation gauge	Contact type	Measures rotation speed by placing at the indentation hole of the revolving shaft.	
		Photoelectric type	Measures rotation speed by using a reflector seal which is placed on the exterior of the revolving shaft	
		High pressure fuel pipe clamp type	Measures rotation speed without reference to revolving shaft center or the exterior of the revolving shaft.	
17	Circuit tester		Measures the resistance, voltage, and continuity of the electric circuit.	
18	Compression gauge		Measures the pressure of the compression. Yanmar code No.: TOL-97190080	

4.2.4 Other material

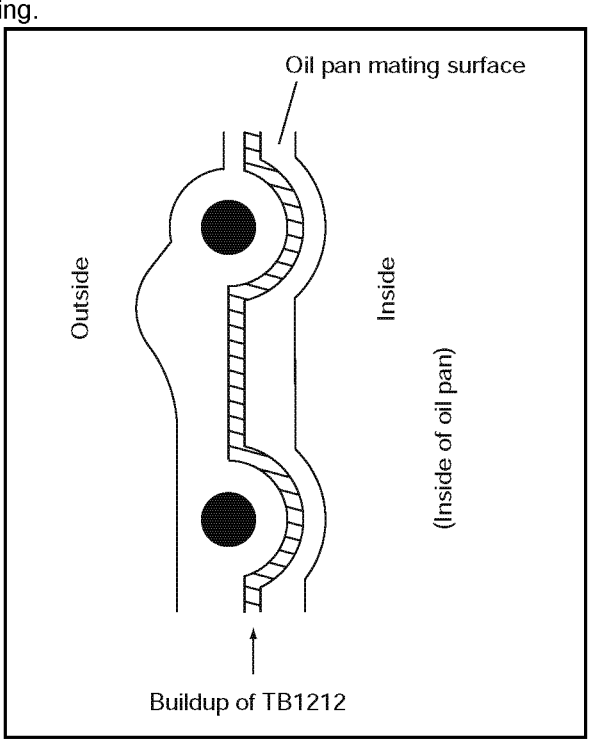
Items		Usual contents	Features and application
Liquid gasket	Three Bond No.1 TB1101	200g (1 kg also available)	Non-drying liquid gasket ; solvent less type, easy to remove, superior in seawater resistance, applicable to various mating surfaces.
	Three Bond No.2 TB1102	200g (1 kg also available)	Non-drying liquid gasket ; easy to apply, superior in water resistance and oil resistance, especially superior in gasoline resistance.
	Three Bond No.3 TB1103	150g	Drying film, low viscosity and forming of thin film, appropriate for mating surface of precision parts.
	Three Bond No.4 TB1104	200g (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	100g	Solvent-less type silicone-base sealant, applicable to high temperature areas. (-50°C to 250°C)
	Three Bond TB1212	100g	Silicone-base, non-fluid type, thick application possible.
Adhesive	Three Bond TB1401	200g	Prevention of loose bolts, gas leakage, and corrosion. Torque required to loosen bolt : 10 to 20% larger than tightening torque.
	Lock tight SUPER TB1324	50g	Excellent adhesive strength locks bolt semi-permanently.
Seal tape		5m round tape	Sealing material for threaded parts of various pipes. Ambient temperature range : -150°C to 200°C
O-ring kit		Ø 1.92-m dia.:1 Ø 2.42-m dia.:1 Ø 3.12-m dia.:1 Ø 3.52-m dia.:1 Ø 5.72-m dia.:1	O-ring of any size can be prepared, whenever required. (Including adhesive, release agent, cutter, and jig)
EP lubricant (molybdenum disulfate)	Brand name (LOWCOL PASTE)	50g	For assembly of engine cylinders, pistons, metals shafts, etc. Spray type facilitates application work.
	Brand name (PASTE SPRAY)	330g	
	Brand name (MOLYPASTE)	50g	Prevention of seizure of threaded parts at high temperature. Applicable to intake and exhaust valves. (stem, guide, face)

Items		Usual contents	Features and application
Scale solvent	Scale solvent	1 box (4 kg × 4 removers)	• The scale solvent removes scale in a short time. (1 to 10 hours) • Prepare water (seawater is possible) in an amount that is about 10 times the weight of the solvent. Mix the solvent with water. • Just dipping disassembled part into removes scale. To shorten removal time, stir remover mixture. • If cleaning performance drops, replace remover mixture with new remover mixture. • Neutralize used mixture, and then dispose of it. To judge cleaning performance of mixture, put pH test paper into mixture. If test paper turns red, remover mixture is still effective.
	Neutralizer (caustic soda)	1 box (2 kg × 4 neutralizers)	
	pH test paper		
Antirust			Add antirust to fresh water system. Then operate engine for approximately 5 minutes. Antirust will be effective for 6 months.
Anti freeze			Add anti freeze to fresh water system at the cold area to engine operate.
Cleaning agent			• The cleaning agent removes even carbon adhering to disassembled parts. • If a cleaning machine is used, prepare 4 to 6% mixture of 60° to 80° to ensure more effective cleaning.

[Notice]

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

1) Build up each gasket equally.
2) For a bolt hole, apply liquid gasket to the inside surface of the hole.
3) Conventionally, Three Bond TB1104 (gray) or Three Bond TB1102 (yellow) is used for paper packing though single use of one of these bounds is not effective.
4) If conventional packing is used, do not use liquid packing.



4.3 Disassembly and reassembly

4.3.1 Disassembly

• Preparation on a boat

For engines mounted in an engine room of a ship, remove the piping and wiring connecting them to the ship.

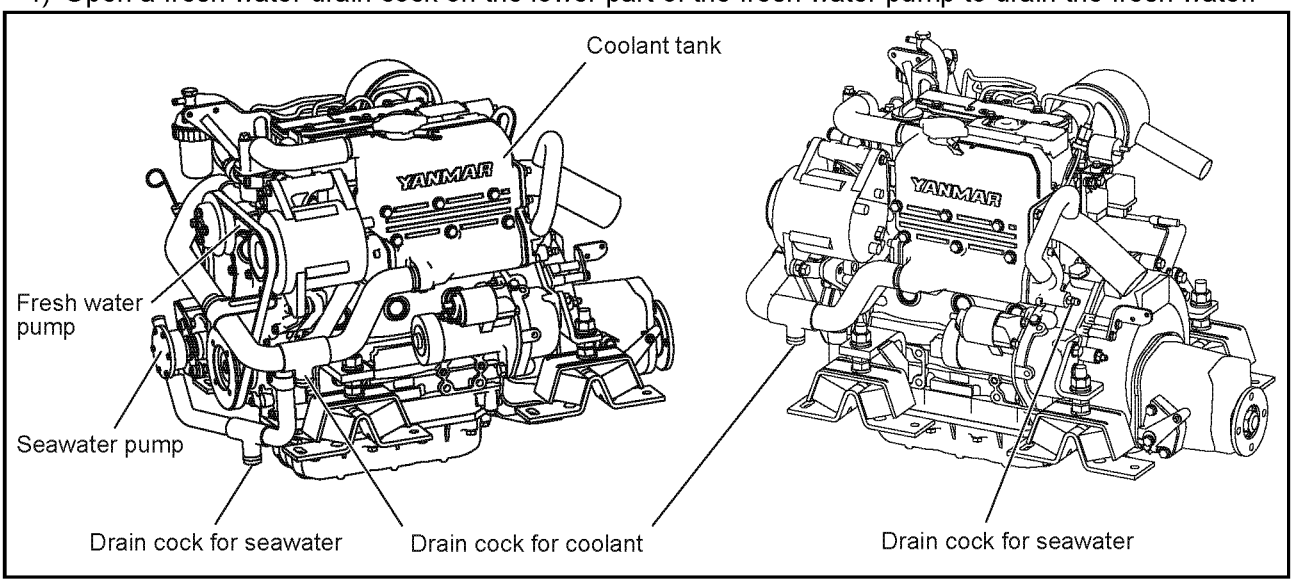
1) Remove the remote control cable (from engine and marine gearbox).
2) Unplug the extension cord for the instrument panel from the engine.
3) Remove the wiring between the starting motor and the battery.
4) Remove the exhaust rubber hose from the mixing elbow.
5) Remove the rubber hose connecting the coolant recovery tank to the filler cap.
6) Remove the seawater inlet hose for the seawater pump (after making sure the seacock is closed).
7) Remove the fuel oil inlet rubber hose from the fuel feed pump.
8) Remove the body fit (reamer) bolts and disassemble the propeller shaft coupling and thrust shaft coupling.
9) If a driven coupling is mounted to the front drive coupling, disassemble.
10) Remove the flexible mount nut, lift the engine, and remove it from the engine base. (Leave the flexible mount attached to the engine base.)

• Disassembling an engine in a workshop

(1) Drain cooling water

Refer to 2.2.5(6).

1) Open a seawater drain cock to drain the seawater.
2) Open a drain cock on the cylinder body to drain the fresh water from the cylinder head and cylinder body.
3) Open a fresh water drain cock on the lower part of the coolant tank to drain the fresh water.
4) Open a fresh water drain cock on the lower part of the fresh water pump to drain the fresh water.



(2) Drain lube oil

1) Remove the pipe coupling bolt, which holds the lube oil dipstick guide, and drain the lube oil from the engine.
2) Remove the drain plug on the lower part of the crank case control side, and drain the lube oil from the marine gearbox.

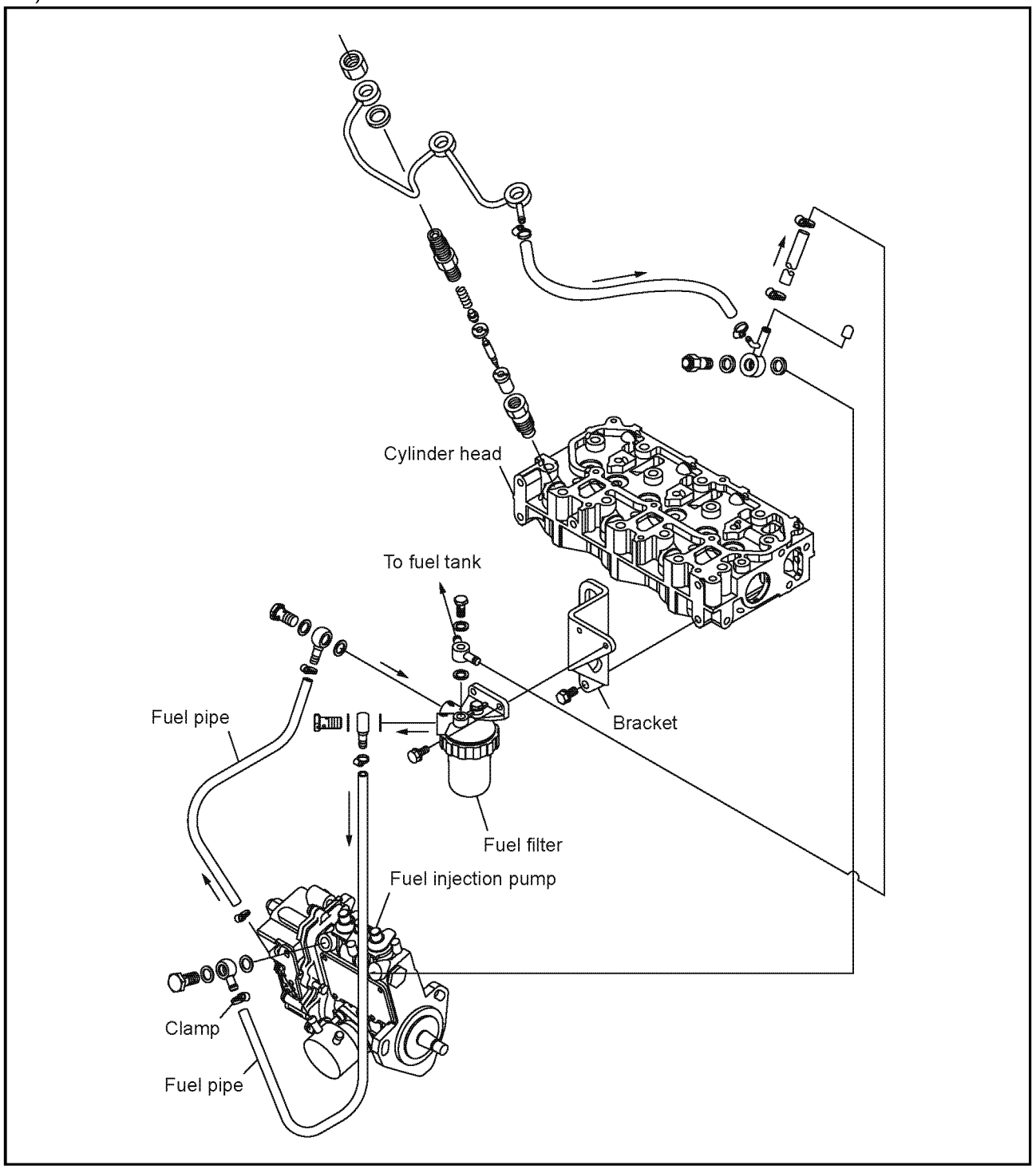
[NOTE:]
If a lube oil supply/discharge pump is used for the engine, the intake hose is placed in the dipstick guide, and for the clutch side (gearbox) it is placed in the oil hole on top of the case. (Refer to 2.2.2(2) & (3))

(3) Removing (electrical) wiring

Remove the wiring from the engine. (Refer to 2.2.4(9))

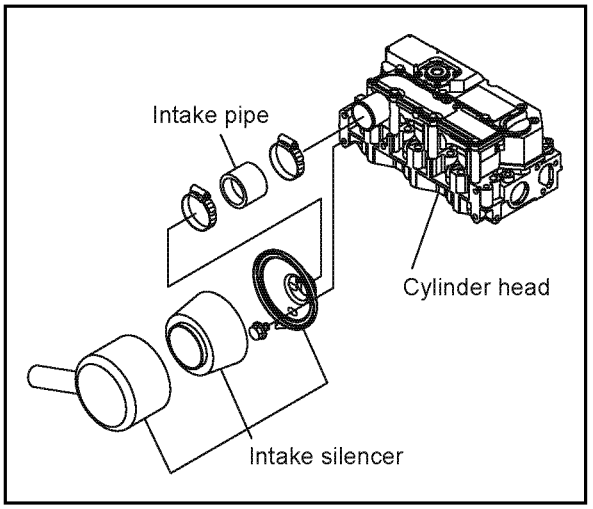
(4) Removing the fuel filter & fuel pipe

1) Remove the fuel pipes (fuel filter-fuel feed pump, fuel filter-fuel injection pump and fuel nozzle-fuel pump)
2) Remove the fuel filter.



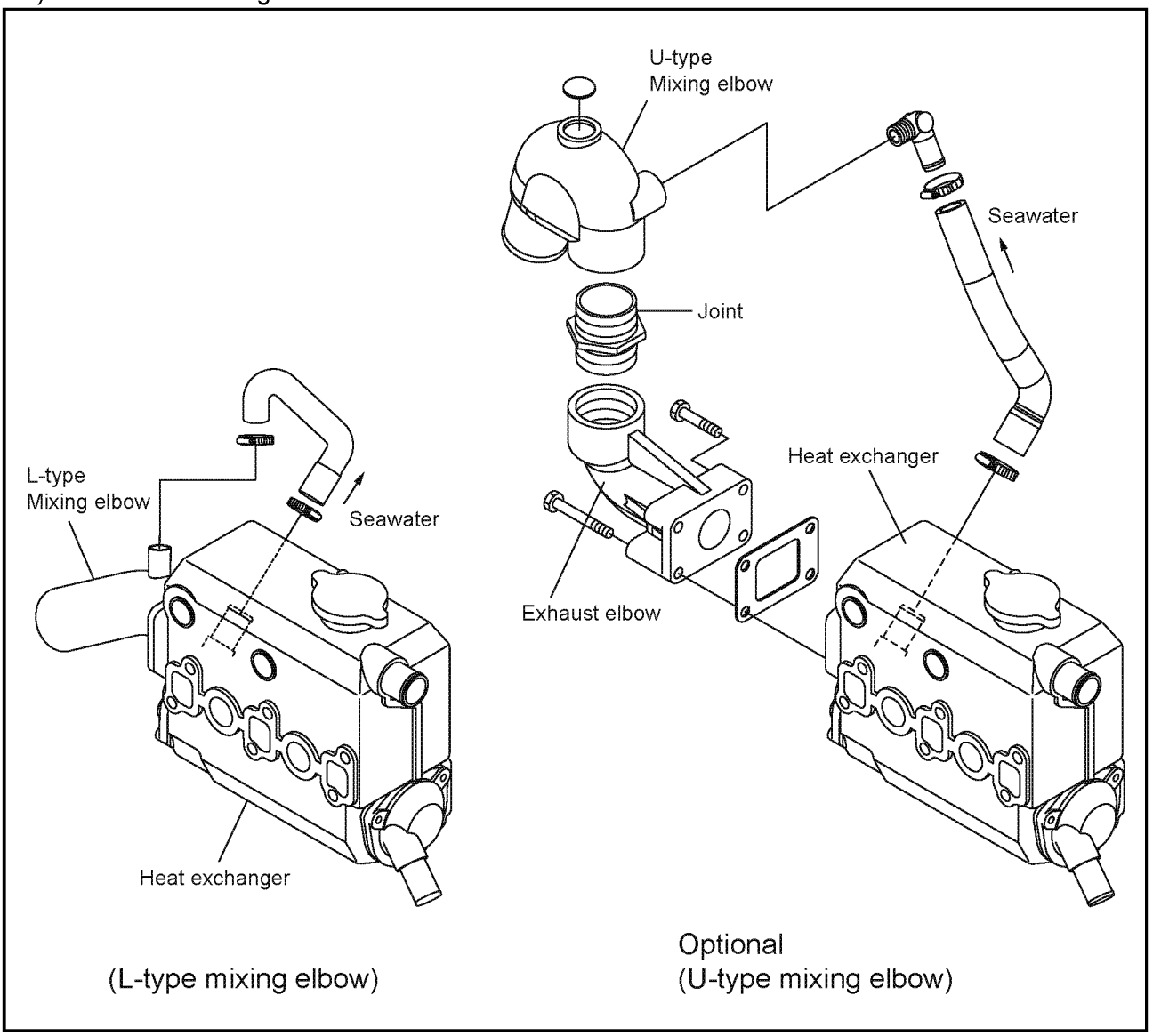
(5) Removing the intake silencer

1) Remove the air intake hose attached to the intake manifold.
2) Remove the intake silencer from cylinder head.



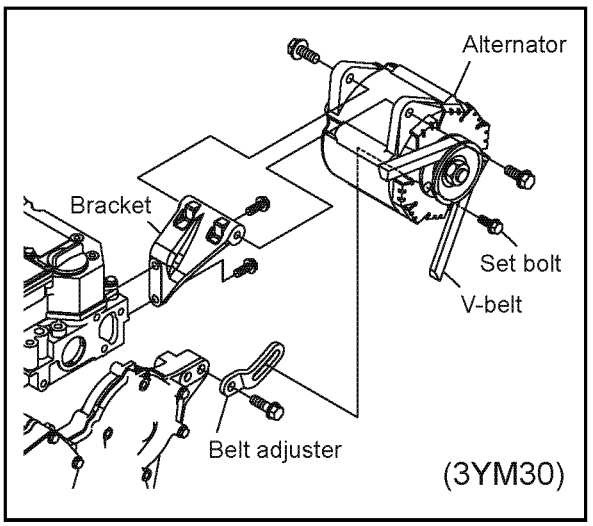
(6) Removing the mixing elbow

1) Remove the seawater rubber hose connecting to a heat exchanger- a mixing elbow.
2) Remove the mixing elbow from the exhaust manifold.



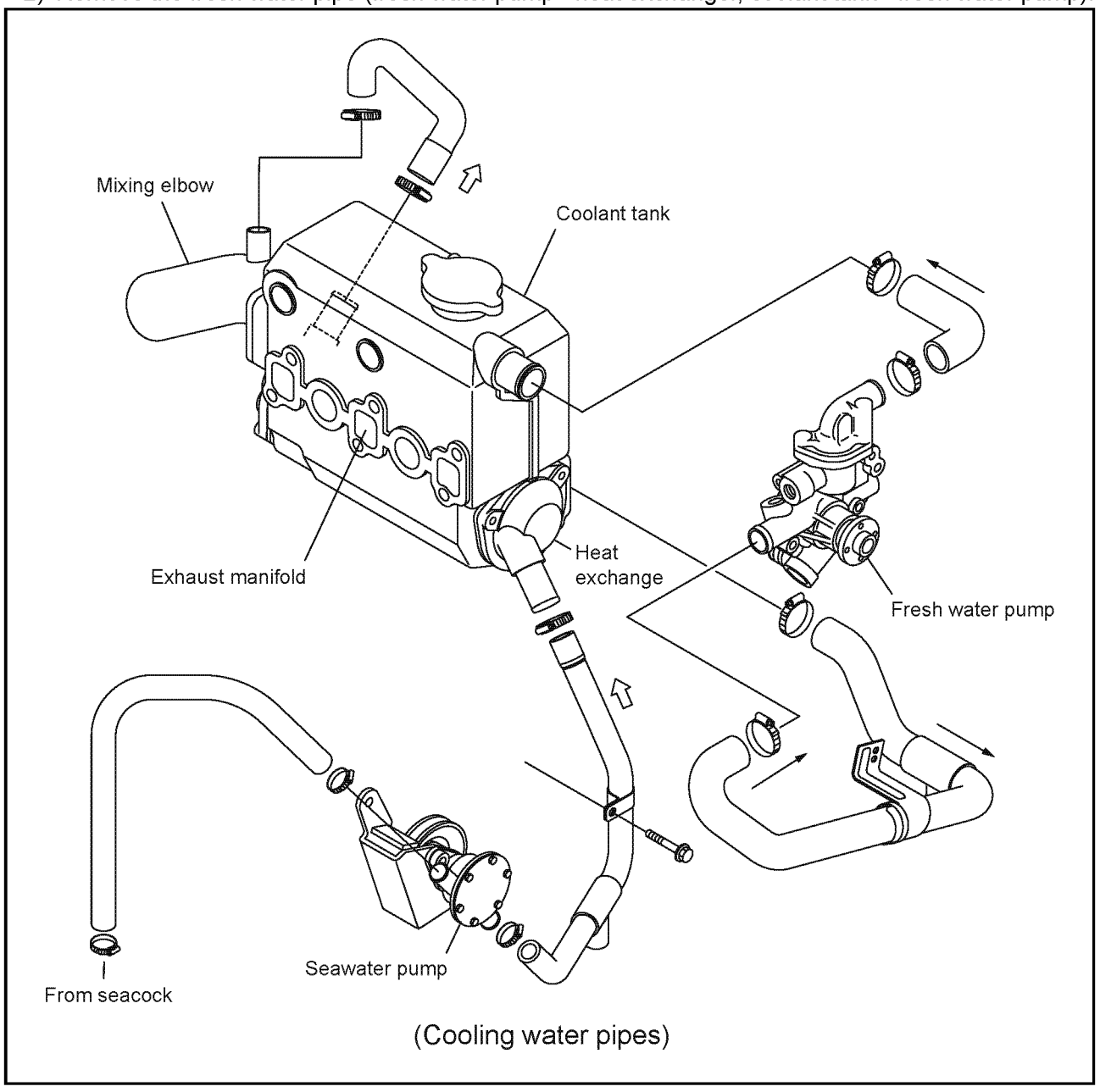
(7) Removing the alternator

1) Loosen the set bolt (belt adjuster bolt) and move the alternator downwards. Loosen the V-pulley set bolts for the cooling water pump and remove the V-belt.
2) Remove the belt adjuster from the gear case and remove the alternator from the cylinder head (with bracket).



(8) Removing the cooling water pipes (seawater/ fresh water)

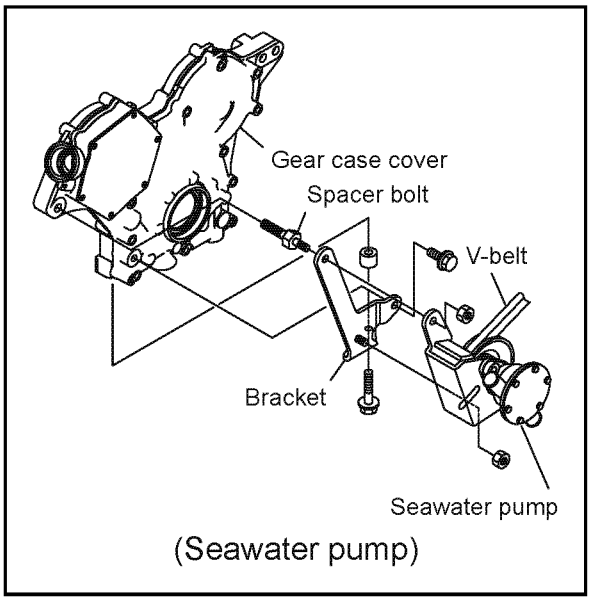
1) Remove the seawater pipe (seawater pump-heat exchanger).
2) Remove the fresh water pipe (fresh water pump - heat exchanger, coolant tank - fresh water pump).



(Cooling water pipes)

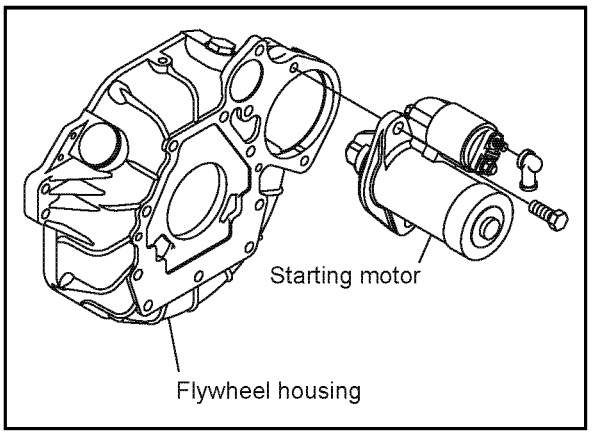
(9) Removing the heat exchanger (exhaust manifold, coolant tank unit)
Remove the heat exchanger and gasket packing from cylinder head.

(10)Removing the seawater pump
Loosen the nut on the spacer bolt and remove the seawater pump.

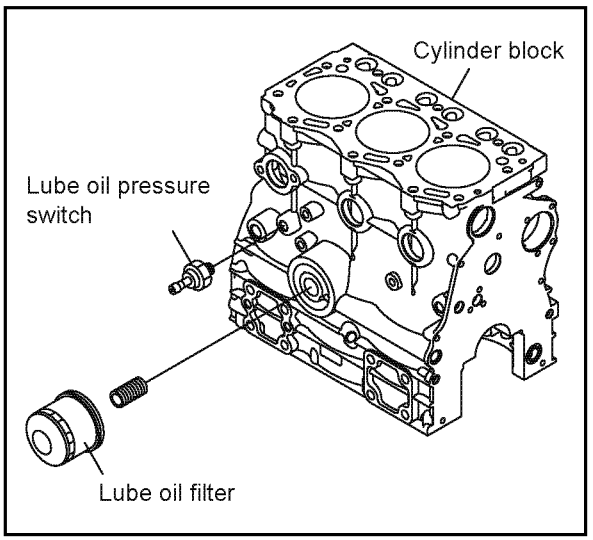


(Seawater pump)

(11)Removing the starting motor
Remove the starting motor from the flywheel housing.



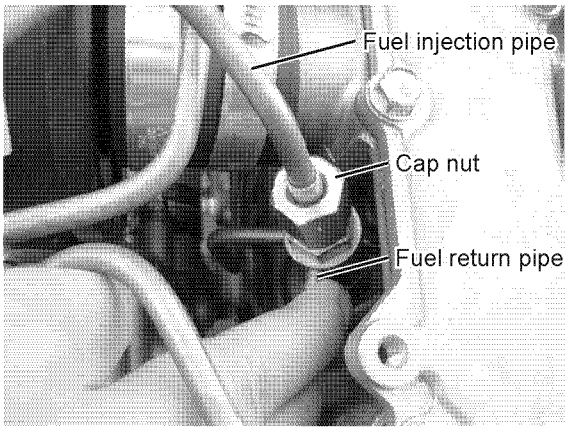
(12)Removing the lube oil filter
Remove the lube oil filter from the cylinder block.



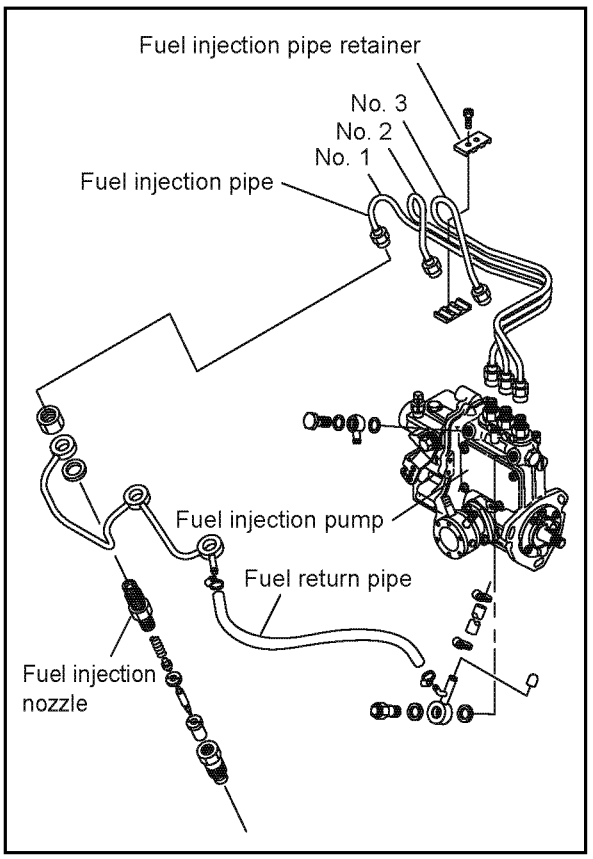
(13)Removing the fuel injection pipe

1) Remove the fuel injection pipe retainer.
2) Loosen the cap nuts on both ends of the fuel injection pipe and remove the fuel injection pipe.

Note:
When loosening the cap nut, loosen the nut with holding the return pipe by hand so that the fuel return pipe may not break.

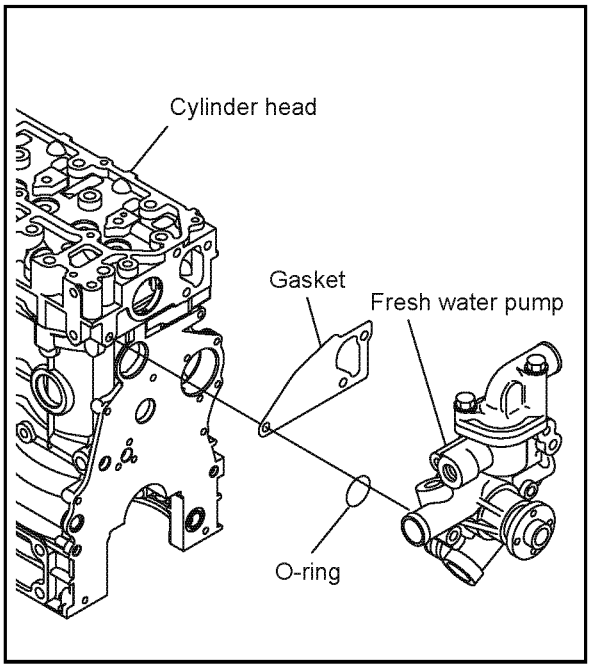


3) Remove the fuel return pipe (fuel nozzle-fuel pump)



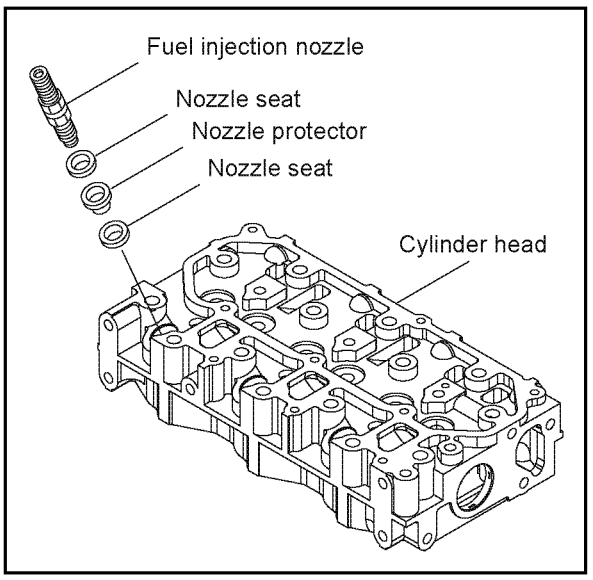
(14)Removing the fresh water pump

Remove the fresh water pump and gasket.



(15)Removing the fuel injection nozzles

Loosen the fuel nozzles and remove them from the cylinder head.



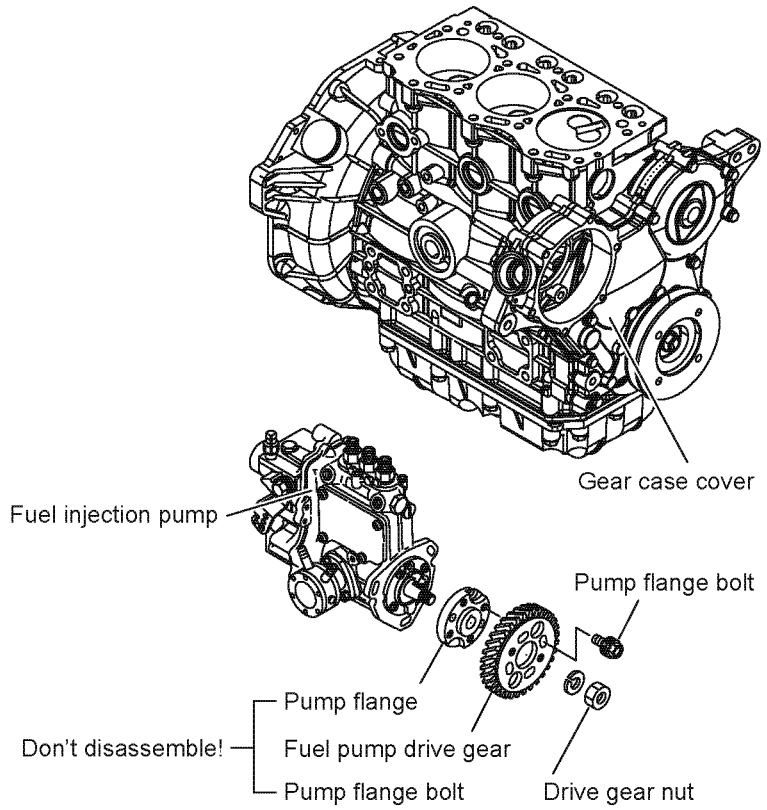
(16)Remove the fuel injection pump

1) Loosen the drive gear nut for fuel pump drive gear, and pull out the fuel pump drive gear /flange assembly with an extraction tool.

Note:

Don't disassemble the pump flange and the pump drive gear.

2) Loosen the three (3) nuts for the fuel pump and remove the fuel injection pump and O-ring from the gear case.

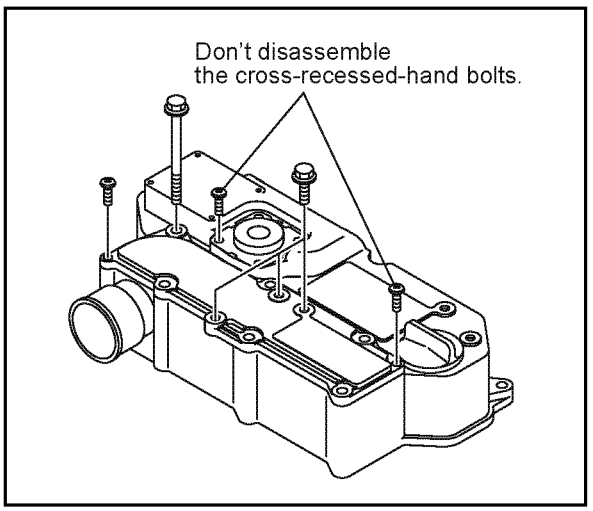


(17)Removing the rocker arm shaft assembly

1) Loosen the hexagon head bolts and remove the rocker arm cover.

Note:
Don't loosen the cross-recessed-head bolts on the rocker arm cover, when removing the rocker arm cover.

2) Remove the bolts(s) for the rocker arm shaft support, and remove the entire rocker arm shaft assembly.
3) Pull out the push rods.



(18)Removing the cylinder head

1) Loosen the cylinder head bolts with a torque wrench, and remove the cylinder head.
2) Remove the cylinder head gasket.

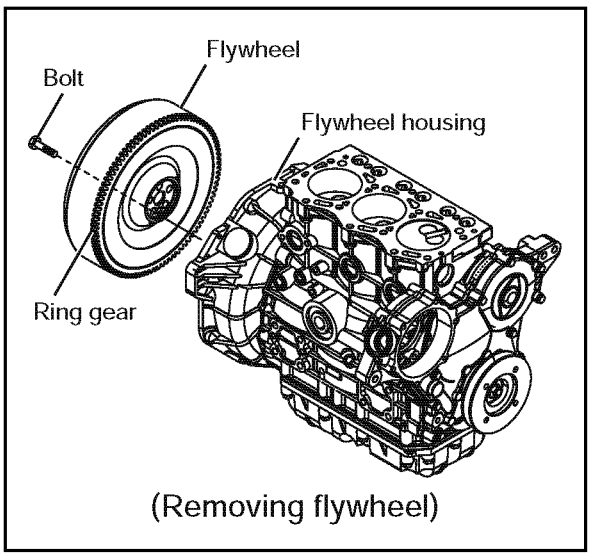
(19)Removing the marine gearbox

Loosen the bolts for the clutch case flange, and remove the gearbox assembly.

(20)Removing the flywheel

Loosen the flywheel bolts and remove the flywheel.

Note:
Be careful not to scratch the ring gear.



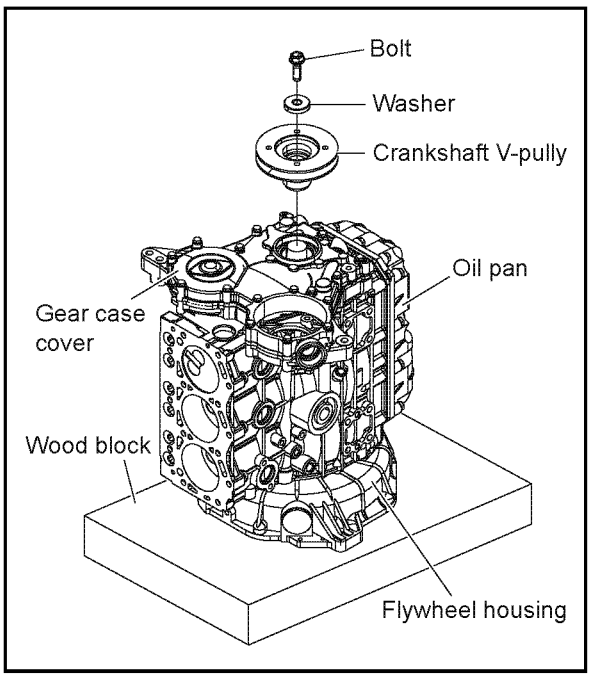
(Removing flywheel)

(21)Turning the engine over

1) Place a wood block of appropriate size on the floor, and stand up the engine on the flywheel housing.
2) Remove the engine mounting feet.

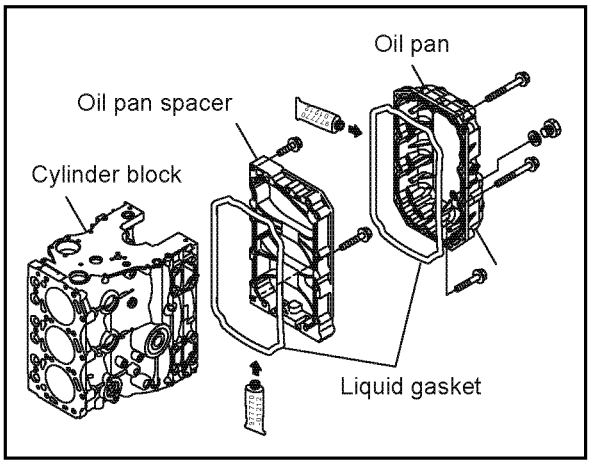
(22)Removing the crankshaft V-pulley

Loosen the bolt tightening the crankshaft V-pulley and remove the crankshaft V-pulley with a pulley puller.



(23) Removing the oil pan

Remove the oil pan and spacer.

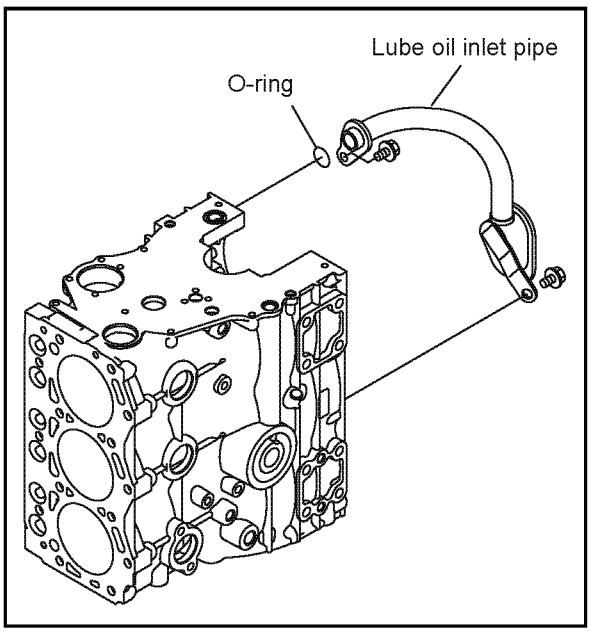


(24)Removing the lube oil inlet pipe

Remove the lube oil inlet pipe and O-ring.

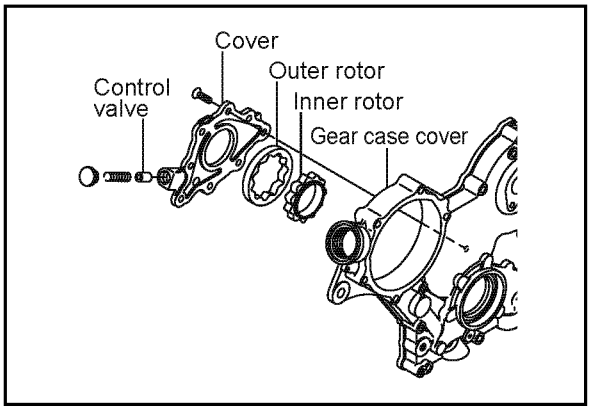
(25)Removing the gear case

Loosen the gear case cover bolts, and remove the gear case cover from the gear case.



(26)Removing the lube oil pump

Remove the lube oil pump from the gear case cover.



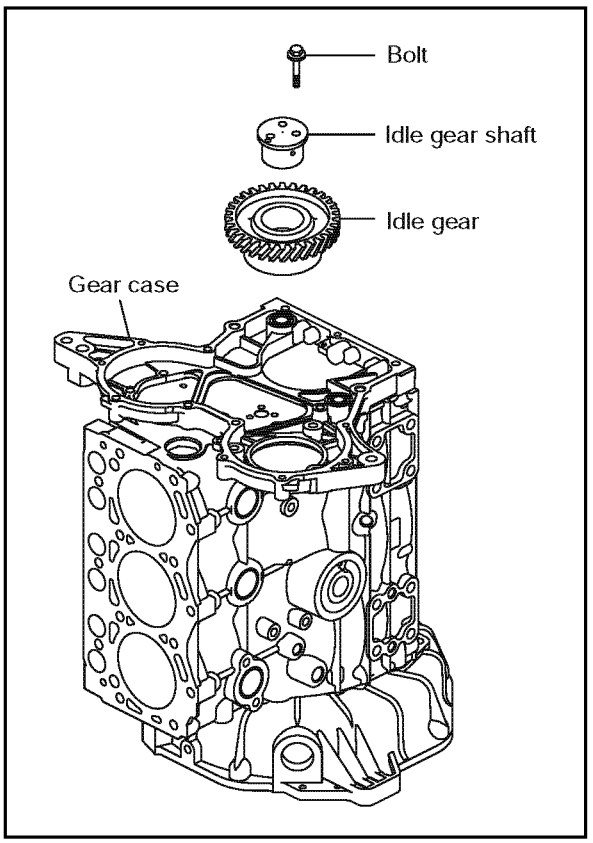
(27)Removing the idle gear

Loosen the three bolts holding the idle gear and pull out the idle gear and shaft.

(28) Removing the camshaft

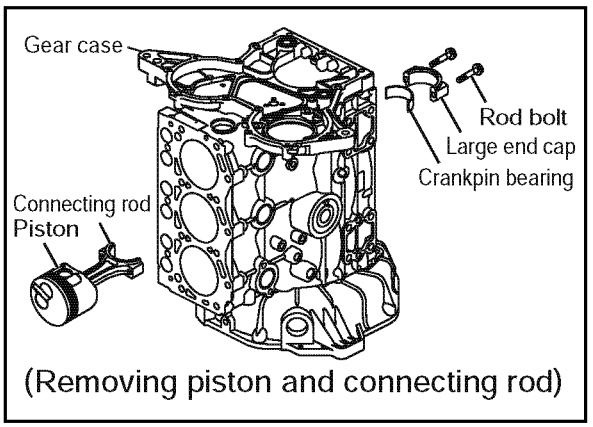
1) Push up tappet by turning a camshaft to remove it from the cylinder block easily.
2) Loosen the thrust metal bolts through the holes of the camshaft gear, and remove.
3) Pull out the camshaft gear and camshaft assembly from the cylinder block.

NOTE:
The camshaft gear and camshaft are shrunk fit. They must be heated to 180-200 °C to disassemble.



(29) Removing the pistons and connection rods

1) Loosen the rod bolts and remove the large end cap.
2) Push the connecting rod and pull out the piston & connecting rod assembly.



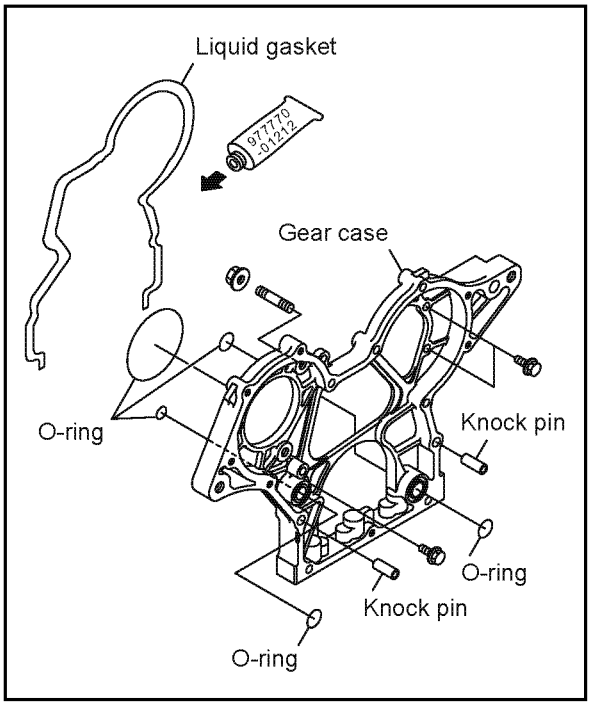
(Removing piston and connecting rod)

(30) Removing the gear case

1) Remove the gear case from the cylinder block.
2) Remove the O-rings from the lube oil passage.

NOTE

1) When mounting the gear case, match up the two knock pins for cylinder block.
2) Be sure to coat the O-rings for the cylinder block lube oil passage with grease when assembling, so that it does not get out of place.



(31)Loosening the main bearing bolts.

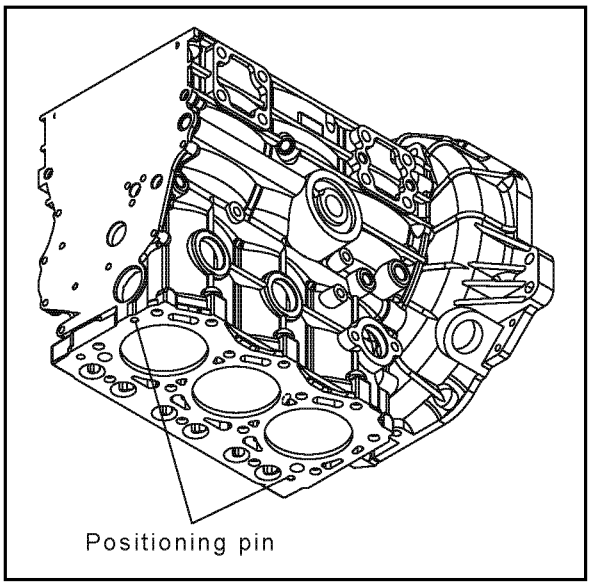
Loosen the main bearing bolts. Don't remove them.

(32)Turning the engine over

Turn the engine over, with the cylinder head mounting surface facing down.

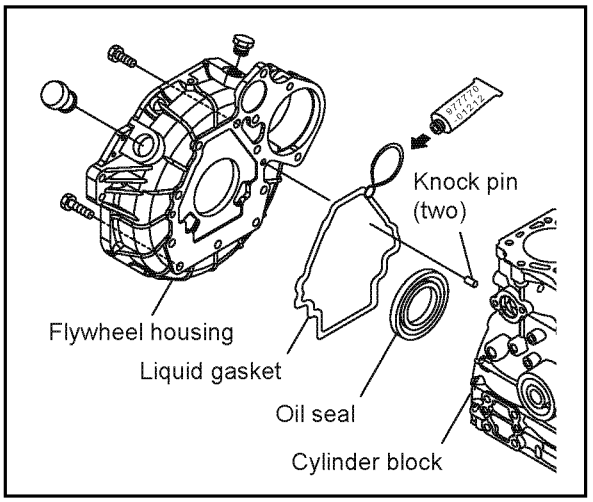
NOTE:

Make sure that the cylinder head positioning pins on the cylinder block do not come in contact with the wood block.



(33)Removing the flywheel housing

Remove the flywheel housing with the oil seal from the cylinder block.



(34)Removing the main bearing

1) Remove the main bearing bolts.
2) Remove the main bearing cap and lower main bearing metal.

NOTE:
The thrust metal (lower) is mounted to the base main bearing cap.

(35)Removing the crankshaft

1) Remove the crankshaft

NOTE:

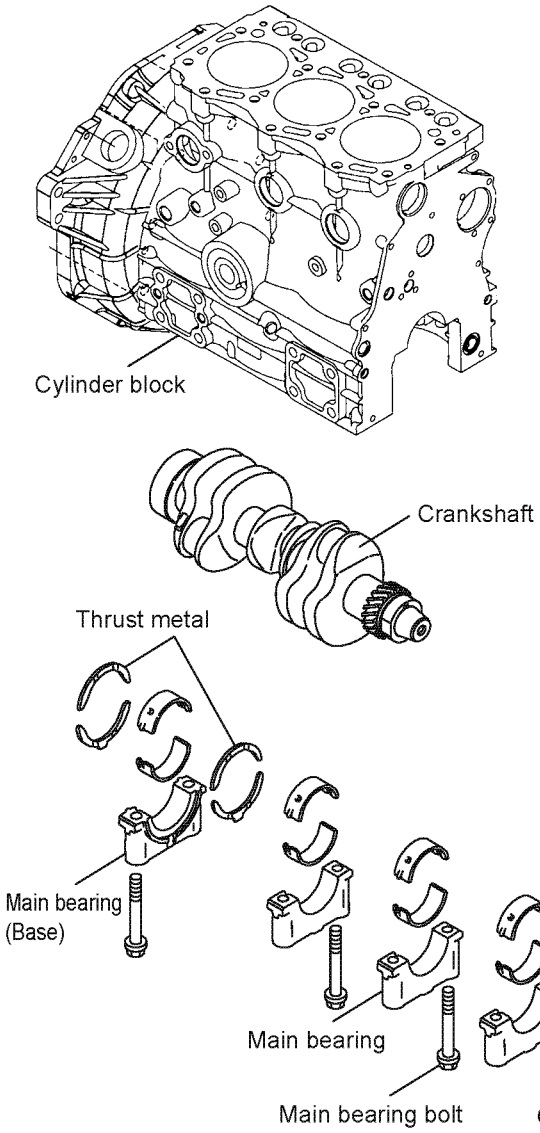
1) The thrust metal (upper) is mounted to the standard main bearing of the cylinder block.
2) Remove the main bearing metal (upper) from the cylinder block.

(36)Removing the tappets

Remove the tappets from the tappet holes in the cylinder black.

NOTE:

1) Be careful to keep all disassembled parts in order.
2) Prepare clear and adequate area for parts and a container(s).
3) Prepare a cleaner before disassembling.



(Removing main bearing and crankshaft)

4.3.2 Reassembly

(1) Clean all parts

Clean all parts using by the cloth and diesel oil (or cleaning agent) before reassembly.

NOTE:

1) If the dust remain with the parts, engine may cause the seizing or damage.
2) The cleaning agent removes even carbon adhering to disassembled parts.

(2) Putting the cylinder block upside down

Place a wood block on the floor and put the cylinder block upside down (with the cylinder head mounting surface facing down).

(3) Inserting the tappets

Coat the inside of the cylinder block tappet holes and the outside circumference of the tappets with engine oil, and insert the tappets in the cylinder block.

NOTE:

Separate the tappets to make sure that they are reassembled in the same cylinder No. and intake/ exhaust side as they came from.

(4) Mounting the crankshaft

1) The crankshaft and the crankshaft gear are shrink fitted. If the crankshaft and the crankshaft gear have been disassembled, they have to be shrink fitted [heat the crank shaft gear to 180- 200 deg. C in the hot oil and press fit to the crankshaft].
2) Coat the crank journal part of the cylinder block and the upper main bearing metal with oil and fit the upper main bearing metal onto the cylinder block.

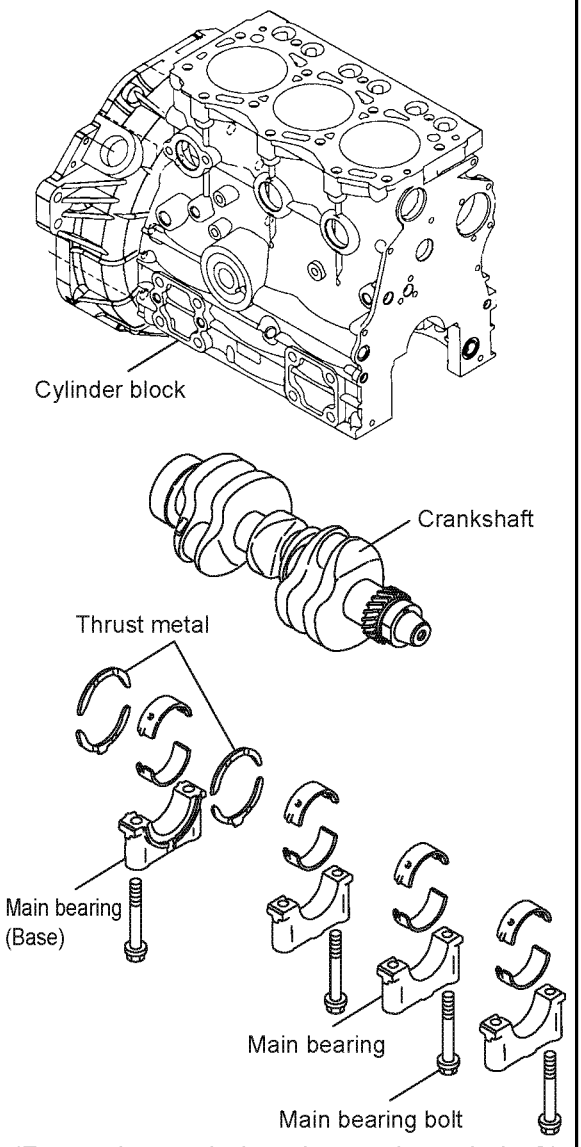
NOTE:

1) Be sure not to confuse the upper and lower main bearing metals. The upper metal has an oil groove.
2) When mounting the thrust metal, fit it so that the surface with the oil groove slit faces outwards, crankshaft side.

3) Coat the crankpins and the crank journals of the crankshaft with engine oil and place it on the upper main bearing metals.

NOTE:

1) Position so that the crankshaft gear is on the gear case side.
2) Be careful not to let the thrust metal drop.



(Removing main bearing and crankshaft)

(5) Mounting the main bearing cap

Coat the lower main bearing metal with engine oil, and mount it to the main bearing cap.

NOTE:
1) The lower main bearing metal does not have an oil hole.
2) The base bearing thrust metal is fitted with the oil groove facing outwards.

1) Coat the flange and the thread of the main bearing bolts with engine oil, put them on the crankshaft journal, and tighten the main bearing bolts to the specified torque.

Tightening torque N•m (kgf•m)

Main bearing bolt	75.5-81.5 (77-8.3)

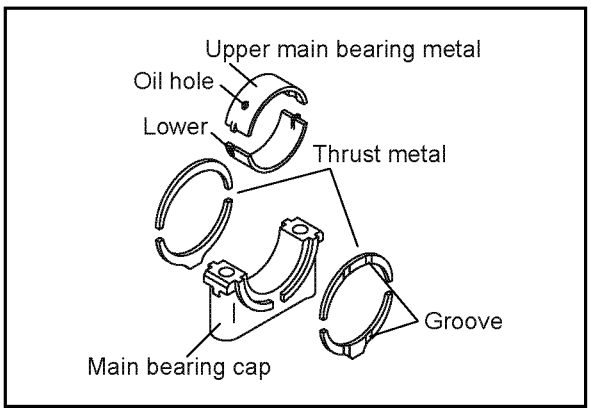
NOTE:
1) The main bearing cap should be mounted with the arrow on the cap pointing towards the flywheel.
2) Make sure to have the correct cylinder alignment number.

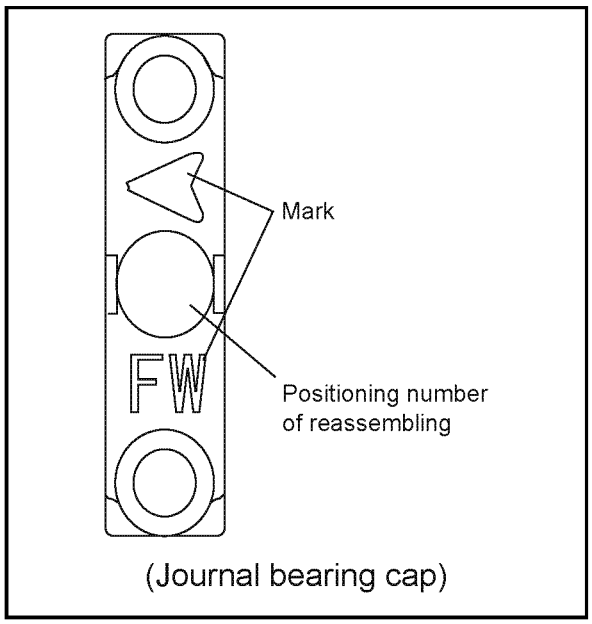
2) Measure the crankshaft side clearance.

mm

	Standard	Limit
Crankshaft side clearance	0.133-0.233	0.28

3) Make sure that the crankshaft rotates smoothly and easily.



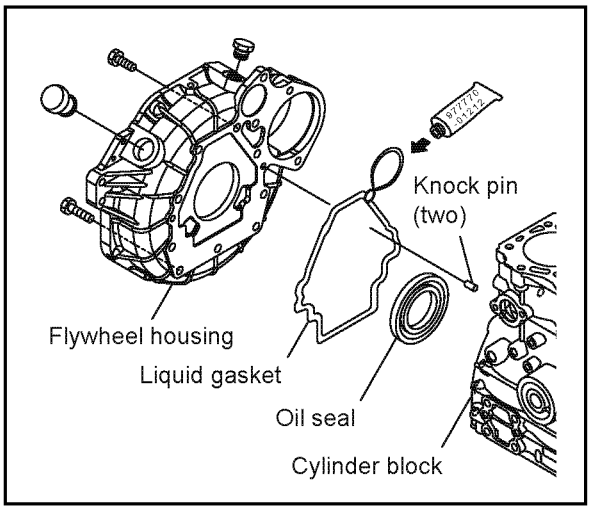


(Journal bearing cap)

(6) Mounting the flywheel housing

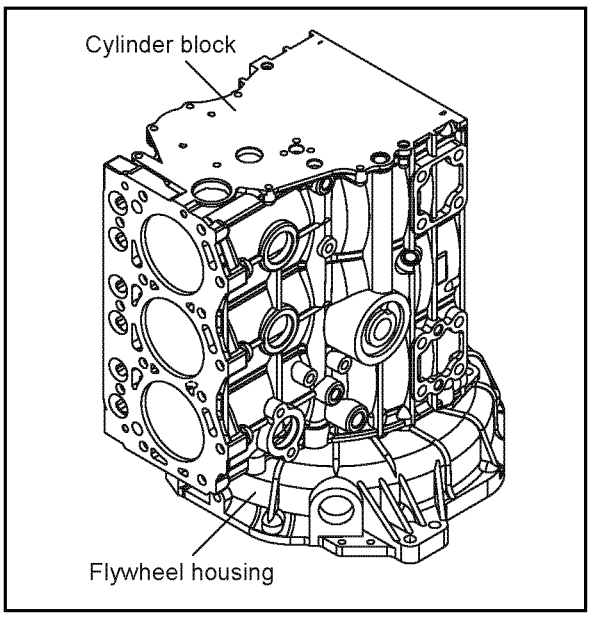
1) Replace the used oil seal with new one. Press fit the oil seal in the flywheel housing, and coat the lip of the oil seal with engine oil.
2) Apply the liquid gasket on the mounting surface of the flywheel housing and mount the flywheel housing to the cylinder block, while matching up with the knock pins.

NOTE:
Be careful that the liquid gasket does not protrude onto the oil pan mounting surface.



(7) Turning the engine over

Stand up the engine on the flywheel housing.



(8) Mounting the gear case

Apply the liquid gasket to the gear case and mount the gear case and lube oil line O-ring onto the cylinder block.

NOTE:

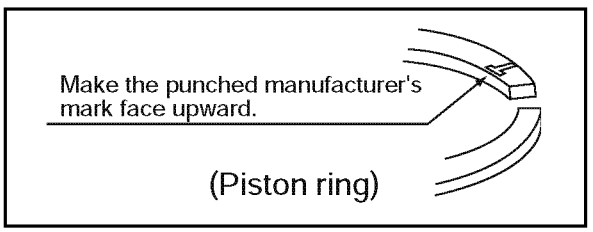
1) When mounting the gear case, match up the two knock pins of the cylinder block.
2) Be sure to coat the O-ring for the cylinder block lube oil line with grease when assembling, so that it does not get out of place.

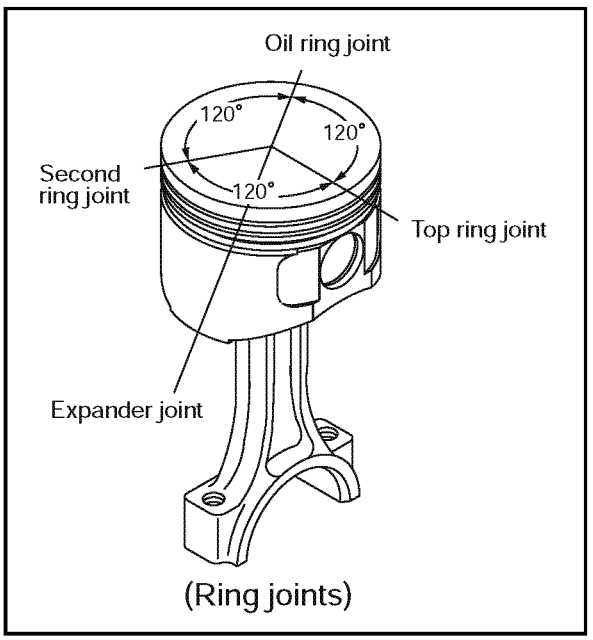
(9) Mounting the piston and connecting rod

1) Reassemble the piston and connecting rod.

NOTE:

1) When reassembling the piston and connecting rod, make sure that the parts are assembled with the correct orientation.
2) Install each piston ring on the piston, with the punched manufacturer's mark facing upward.
3) The piston ring joints shall be staggered at by 120° intervals. Do not position the top ring joint vertical to the piston pin. The coil expander joint shall be opposite to the oil ring joint.





2) Coat the outside of the piston and the inside of the connecting rod crank pin metal with engine oil and insert the piston with the piston insertion tool.

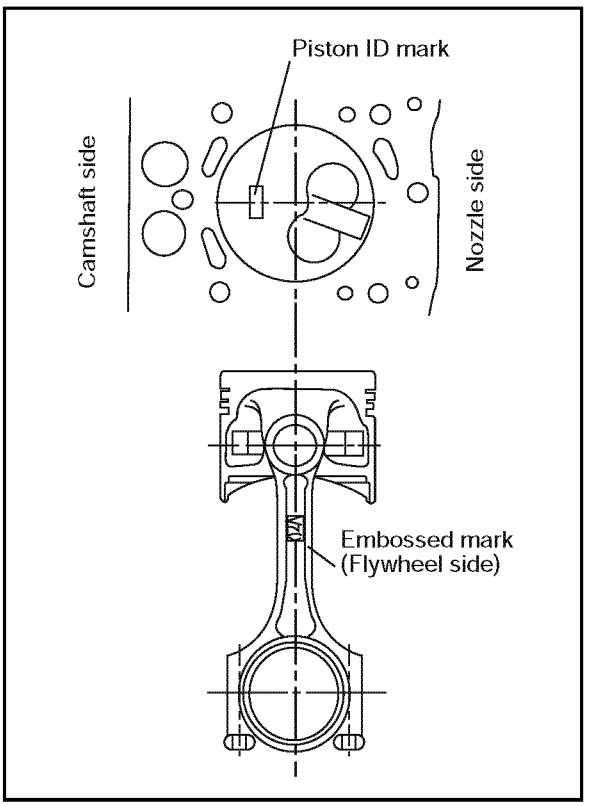
NOTE:
1) Insert the piston so that the match mark on the large end of the connecting rod faces the fuel nozzle, and the manufacture's embossed mark on the stem faces toward the flywheel.
2) After inserting the piston, make sure the ID mark on the piston top is located at the camshaft side, looking from the top of the piston.

3) Align the large end match mark, mount the cap, and tighten the connecting rod bolts.

Tightening torque N•m (kgf•m)

Connecting rod bolt	22.6-27.5(2.3-2.8)

NOTE:
If a torque wrench is not available, match up with the mark made before disassembly.



(10) Mounting the camshaft

1) If the camshaft and the camshaft gear have been disassembled, shrink fit the camshaft and the camshaft gear [heat the camshaft gear to 180-200 deg. C in the hot oil and press fit].

NOTE:
When mounting the camshaft and the camshaft gear, be sure not to forget assembly of the thrust metal. Also make sure they are assembled with the correct orientation.

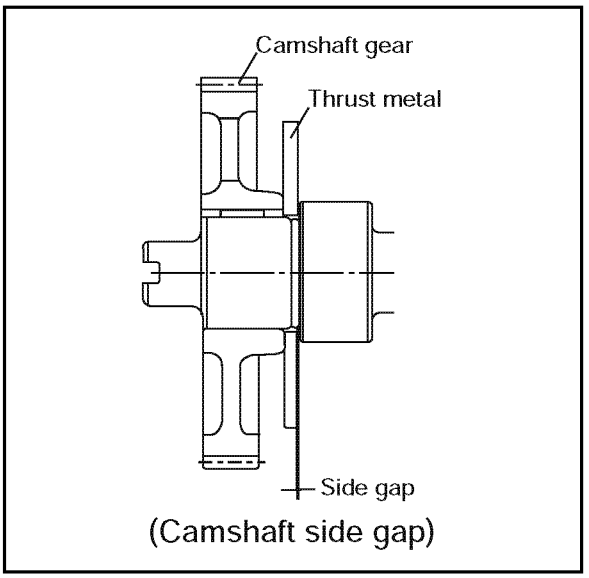
2) Coat the cylinder block camshaft bearings and camshaft with engine oil, insert the camshaft in the cylinder block, and tighten the thrust metal bolts.

3) Measure the camshaft side gap.

mm

Camshaft side gap	Standard	Limit
	0.05-0.15	0.25

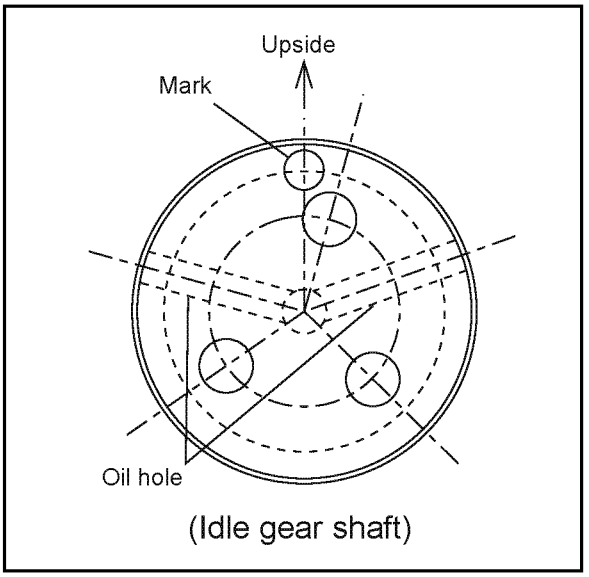
4) Make sure that the camshaft rotates smoothly.



(Camshaft side gap)

(11) Mounting the idling gear

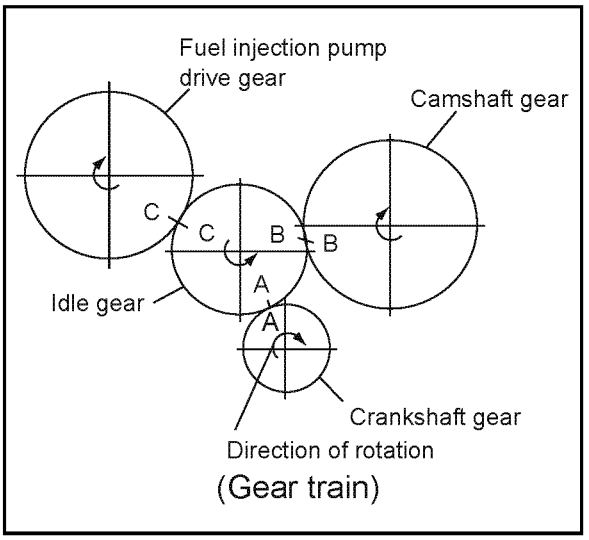
1) Mount the idling gear so that the mark of the idle gear shaft upward.



2) Align the "A" and "B" match marks of the idle gear with the match marks of the crankshaft gear and the camshaft gear.
3) Measure the idle gear, camshaft gear and crankshaft gear backlash.

mm

	Standard	Limit
Backlash	0.07-0.15	0.17



(12) Mounting the lube oil pump

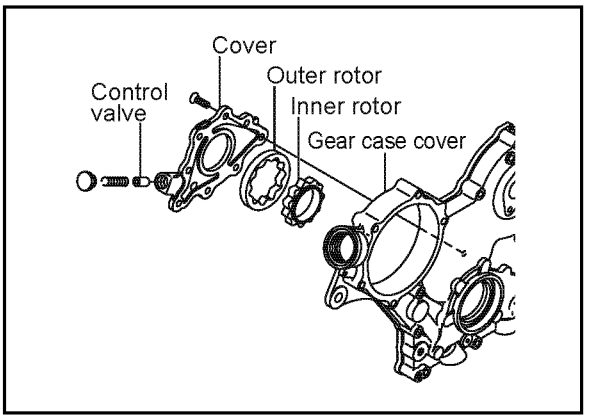
Tighten the lube oil pump with bolts to the gear case cover.

Lube oil applied N•m (kgf•m)

Tightening torque	5.9-7.9 (0.6-0.8)

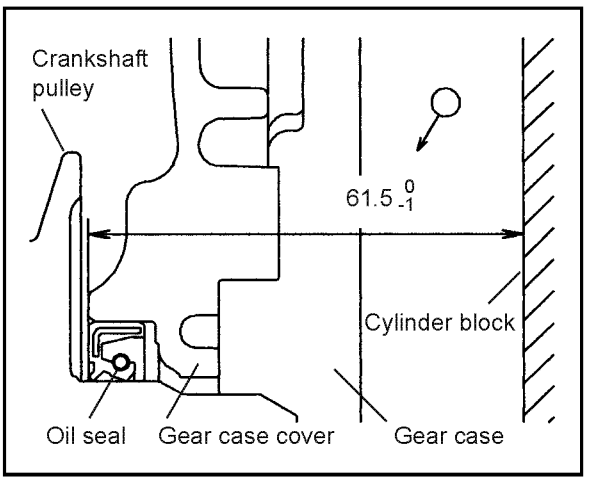
NOTE:

1) Before installing the outer /inner rotors, coat them with lube oil (10W30 lube oil).
2) Assemble the rotor so that the mark of the rotor may come to the cover side.
3) Confirm that the rotor rotates smoothly.

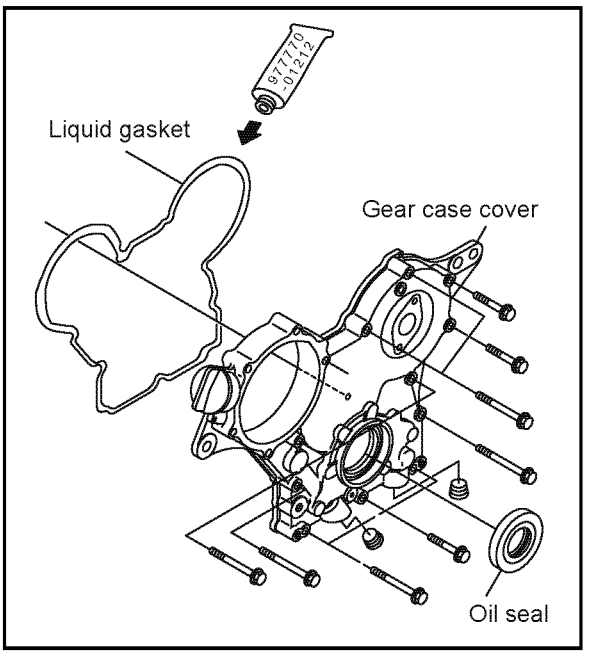


(13) Mounting the oil seal and gear case cover

1) Replace the used oil seal with a new one when the gear case cover is disassembled.
2) Insert a new oil seal by using the oil seal insertion tool on the position of the gear case cover end face (61.5 0/-1 mm distance from the end of the cylinder block). (Refer to the right figure.)
3) Apply lithium grease to the oil seal lips.
4) When wear is found on the oil seal contact part of a crankshaft pulley, replace the pulley with a new one. Carefully install the pulley so as not to damage the oil seal.
5) Apply the liquid gasket to the gear case cover. Position the two knock pins and tighten the bolts of the gear case cover.



NOTE:
Trim the liquid gasket if it protrudes onto the oil pan mounting surface.



(14) Mounting the lube oil inlet pipe

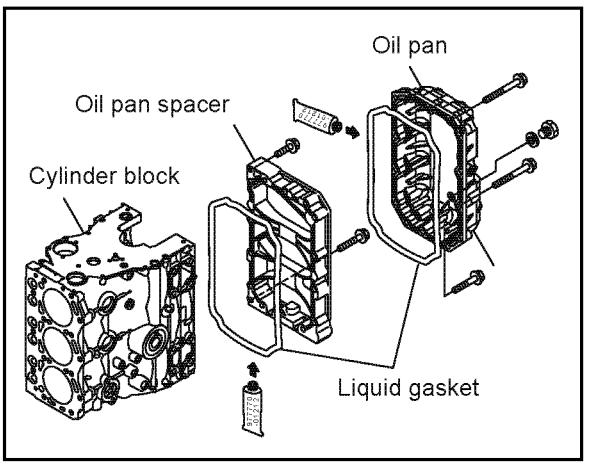
Mount the lube oil inlet pipe on the bottom of the cylinder block, using new gasket.

Tightening torque N•m (kgf•m)

Lube oil inlet pipe	26 (2.6)

(15) Mounting the oil pan spacer and the oil pan

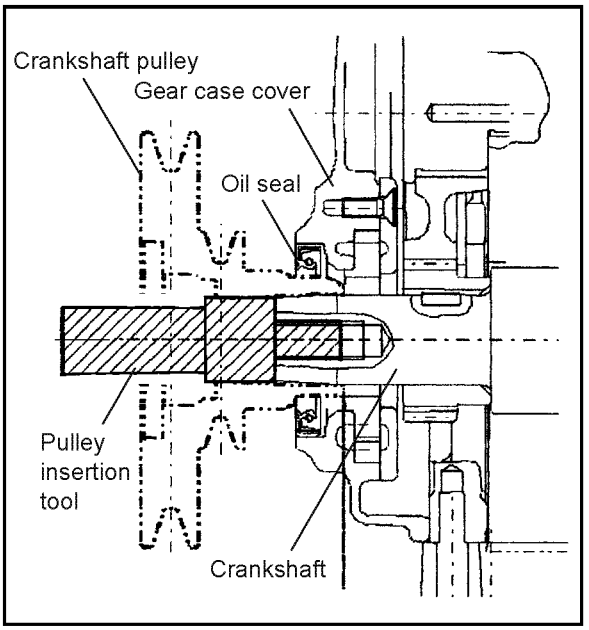
1) Apply the liquid gasket to the surfaces of the gear case cover, gear case and flywheel housing that contact with the cylinder block.
2) Apply the liquid gasket to the spacer. Mount the spacer to the cylinder block and tighten the bolts.
3) Apply the liquid gasket to the oil pan. Mount the oil pan to the spacer and tighten the bolts.
4) Mount the dipstick and dipstick guide.



(16) Mounting the crankshaft pulley

1) Coat the oil seal with oil.
2) Make sure to wipe off oil on the taper surfaces of the crankshaft and the pulley.
3) Mount the pulley insertion tool to the crankshaft and install the pulley on the crankshaft so that the oil seal may not be damaged.
4) Tighten the pulley to the specified torque.

Tightening torque	N•m (kgf•m)
V-pulley bolt (Material : casting iron)	83.3-93.3 (8.5-9.5)



(17) Mounting the engine mounting feet and turning the engine upright.

1) Mount the engine mounting feet.
2) Turn the engine upright (Oil pan is the bottom side).

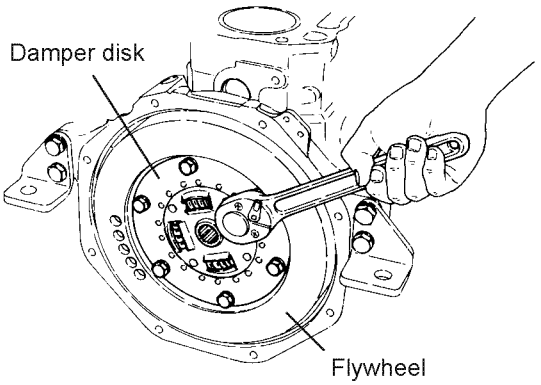
(18) Mounting the flywheel

1) Coat the flywheel bolts threads with engine oil.
2) Align the positioning pins, and tighten the flywheel bolts to the specified torque.

Tightening torque	N•m (kgf•m)
Flywheel bolt	80.4-86.4 (8.2-8.8)

(19) Mounting the marine gearbox

1) Mount the damper disk to the flywheel.
   Align the damper disk with the input shaft spline and insert.
2) Mount the marine gearbox to the flywheel housing.

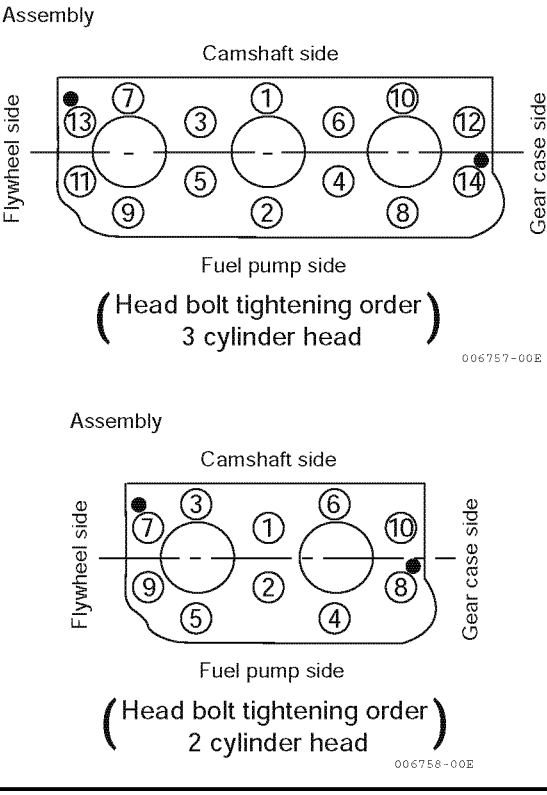


(20) Mounting the cylinder head

1) Put the cylinder head gasket on the cylinder block, aligning it with the cylinder block positioning pins.
2) Lift the cylinder head horizontally and mount it aligning with the cylinder head gasket.
3) Coat the flange part and thread of the cylinder head bolt with engine oil, and lightly tighten the bolts in the specified order first. Then tighten completely, in the same order.

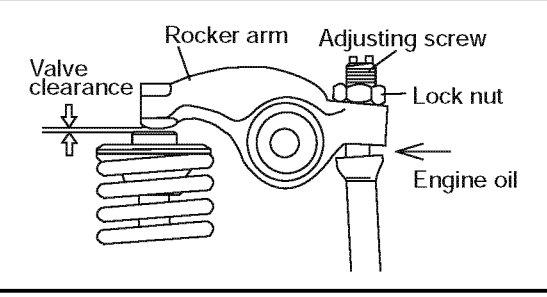
Tightening torque N•m (kgf•m)

	1st step	Final
Cylinder head bolt	24-32 (2.5-3.3)	53.9-57.9 (5.5-5.9)



(21) Mounting the rocker arm shaft assembly and pushrods

1) Fit the pushrod to the tappet.
2) Coat the top of the pushrod and the adjusting screw of the rocker arm with engine oil. (Apply lube oil to the screw and lock nut.)
   Mount the rocker arm shaft assembly to the cylinder head and tighten the bolts.
3) Adjust valve clearance



mm

Intake/exhaust valve clearance	0.15-0.25

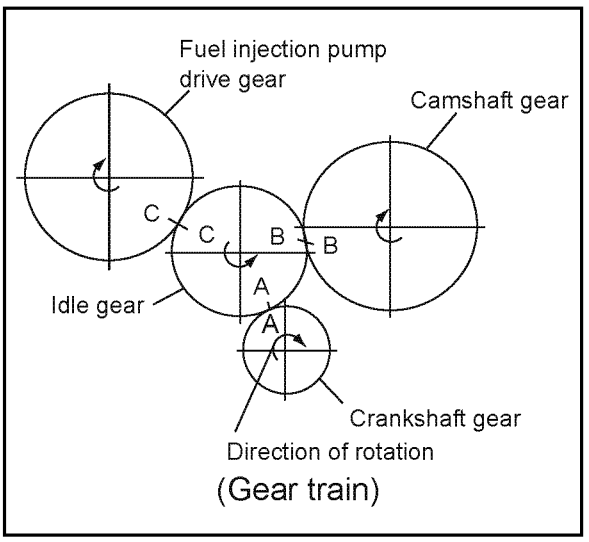
4) Coat the rocker arm and valve spring with engine oil and mount the rocker arm cover.

(22) Mounting the fuel injection pump

1) Lightly fit the fuel injection pump on the gear case. (After adjusting injection timing, tighten the fuel injection pump. Before mounting the heat exchanger to the cylinder head, adjust the injection timing.).

NOTE:
Be careful not to scratch the O-ring between the fuel injection pump and gear case.

2) Fit the fuel injection pump drive gear to the fuel pump camshaft.
3) Align the "C" match marks on the fuel injection pump drive gear and idle gear.
4) Tighten the pump drive gear nut to the specified torque. (Do not apply lube oil to the nut.)



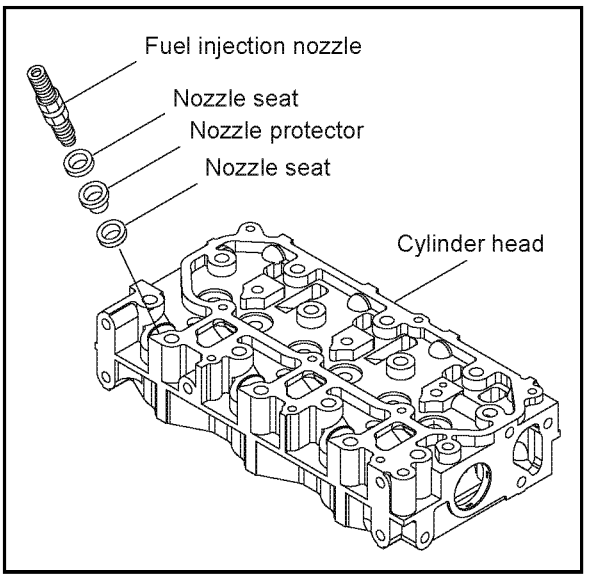
Tightening torque	N•m (kgf•m)
Pump drive gear nut	58.9-68.7 (6.0-7.0)

5) Measure the backlash of the fuel injection pump drive gear.

Backlash	mm
Fuel injection pump drive gear	0.06-0.12

(23) Mounting the fuel injection nozzle

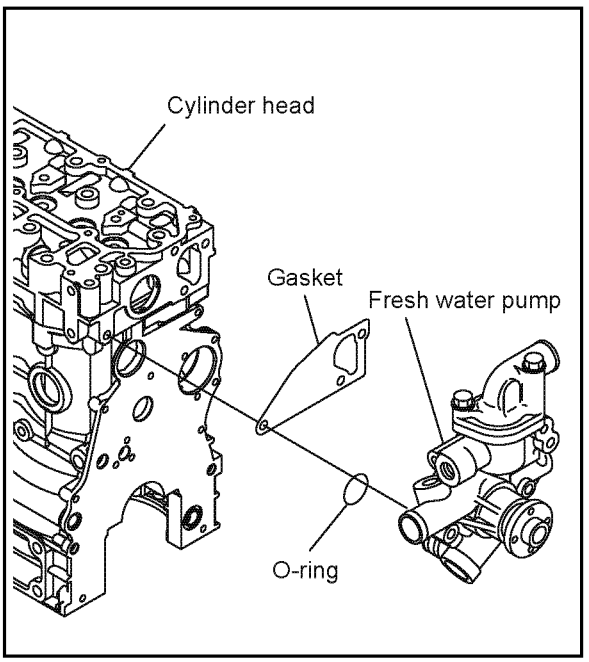
1) Replace the used fuel nozzle protector and fuel nozzle seat with new ones. Put the seat in the cylinder head and the protector to the nozzle tip. Mount the fuel injection nozzle to the cylinder head.
2) Tighten the fuel nozzle retainer bolt to the specified torque. (Do not apply lube oil to the bolt.)



Tightening torque	N•m (kgf•m)
Fuel nozzle retainer bolt	49.0-53.0 (5.0-5.4)

(24) Mounting the fresh water pump

1) Thoroughly coat both sides of the gasket with adhesive.
2) Renew the O-ring for the connecting part of the pump, which is inserted in the cylinder block, and tighten the fresh water pump.



(25) Mounting the fuel injection pipe and fuel return pipe

1) Mount the fuel injection pipe and then assemble the fuel injection pipe retainer to prevent the pipe vibration.

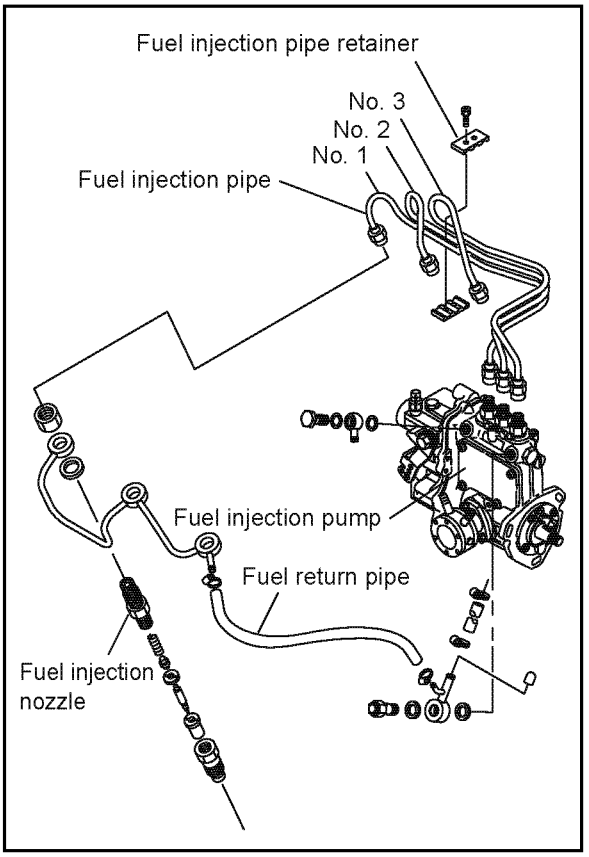
NOTE:
Lightly tighten the pipe joint nuts on both ends of the fuel injection pipe. Completely tighten after adjusting the injection timing.

Standard tightening torque N•m (kgf•m)

fuel injection pipe joint nut	29.4-34.4 (3.0-3.5)

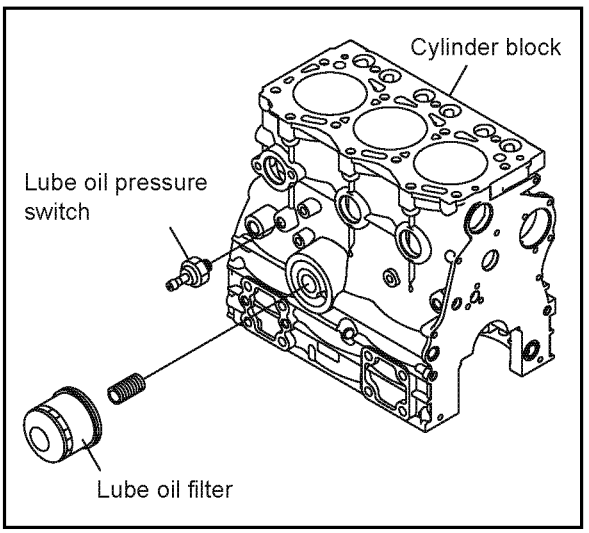
2) Mount the fuel return pipe with the clamp (fuel injection nozzle-fuel injection pump).

NOTE:
When tightening the fuel return pipe to fuel injection nozzle, tighten the nut with holding the return pipe by hand so that the pipe may not break. (Refer to 4.3.1(13).)



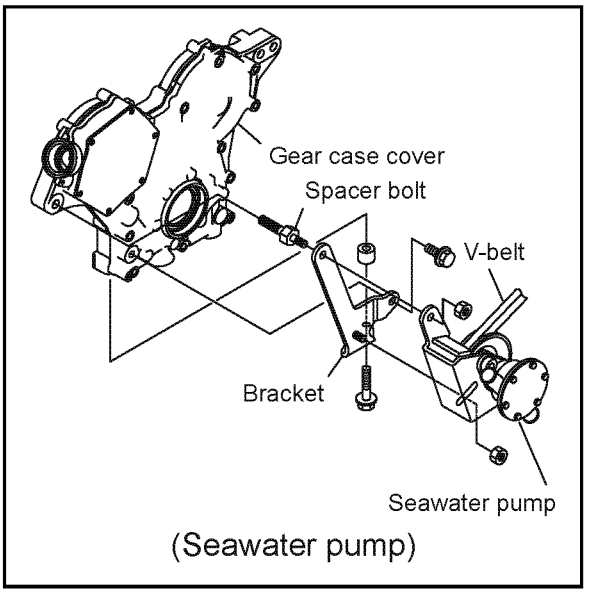
(26) Mounting the lube oil filter.

Mount the lube oil filter with the tool of the filter case remover.



(27) Mounting the seawater pump

1) Tighten the spacer bolt to the gear case cover.
2) Mount the bracket and the seawater pump assembly to the gear case cover.



(Seawater pump)

(28) Mounting the heal exchanger (exhaust manifold, fresh water tank unit).

Mount the gasket and heal exchanger (exhaust manifold).

Note:

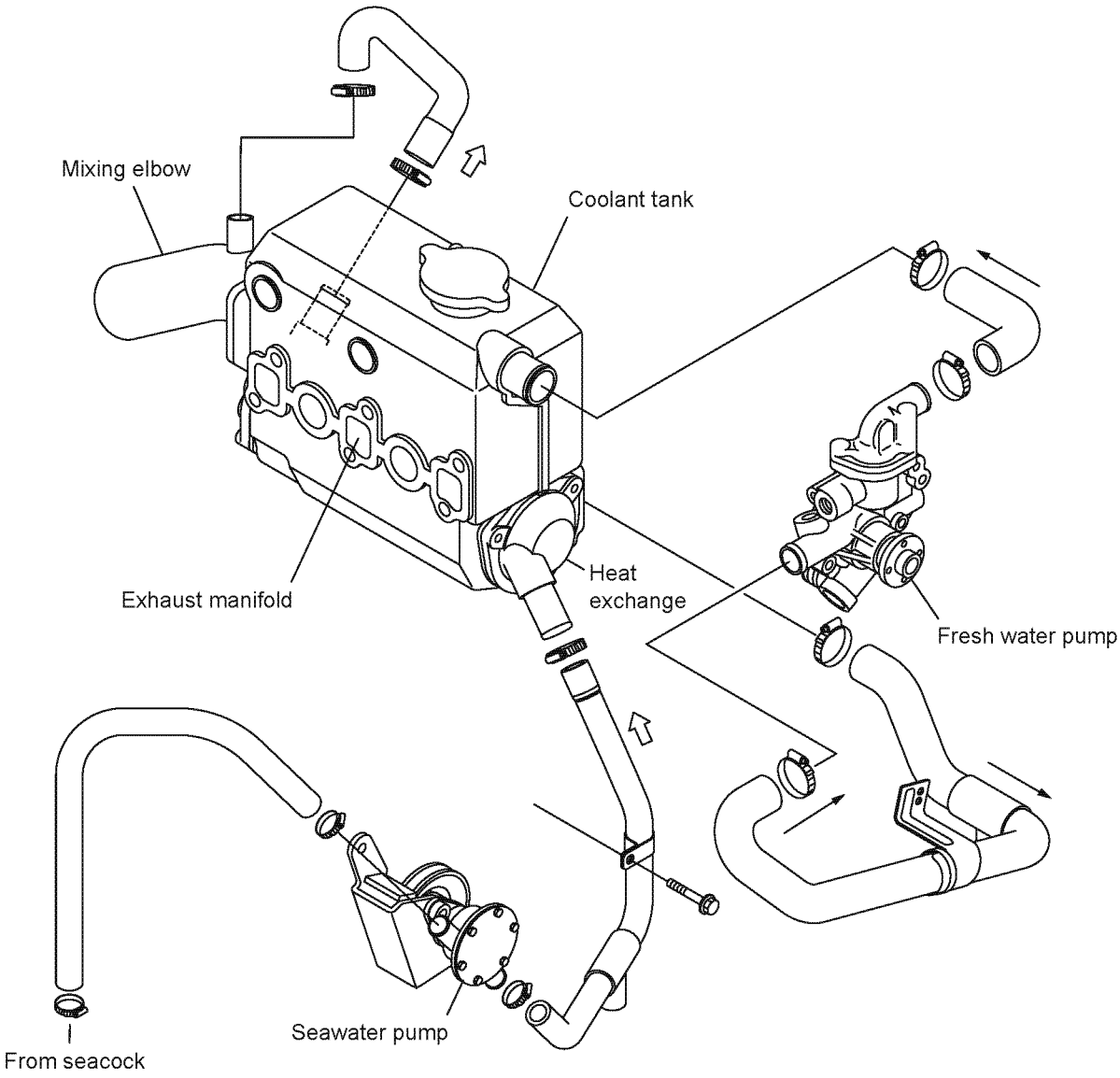
After adjusting injection timing and tightening the fuel injection pump, mount the heat exchanger. Because it is harder to tighten the fuel pump nuts after installing the heat exchanger.

(29) Mounting the mixing elbow

1) Mount the mixing elbow on the exhaust manifold outlet.
2) Mount the cooing seawater pipe (rubber hose) with the hose clips (heat exchanger-mixing elbow).

(30) Mounting the cooling water pipes (seawater / fresh water)

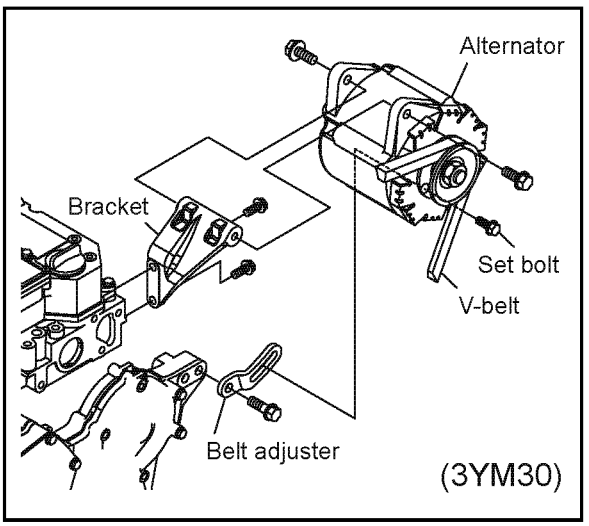
1) Mount the seawater pipes with the hose clips (seawater pump-heat exchanger).
2) Mount the fresh water pipes with the hose clips (exhaust manifold - fresh water pump, fresh water pump-heat exchanger).



(Cooling water pipes)

(31) Mounting the alternator

1) Mount the bracket on the cylinder head and the adjuster on the gear case cover, and then the alternator.
2) Adjust V-belt tension with the adjuster, and tighten the set bolt.

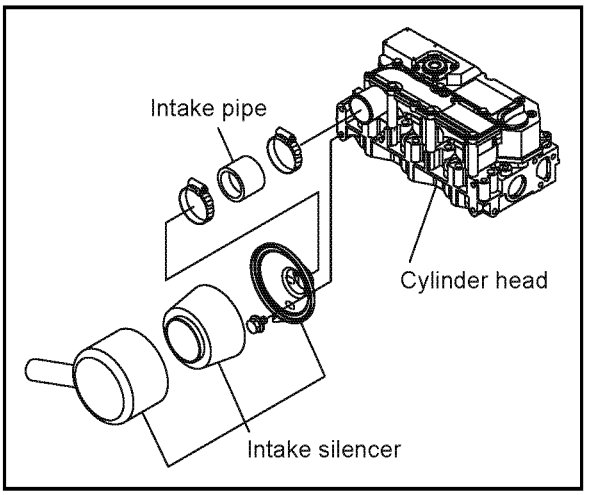


(32) Mounting the starting motor

Fit the starting motor on the flywheel housing.

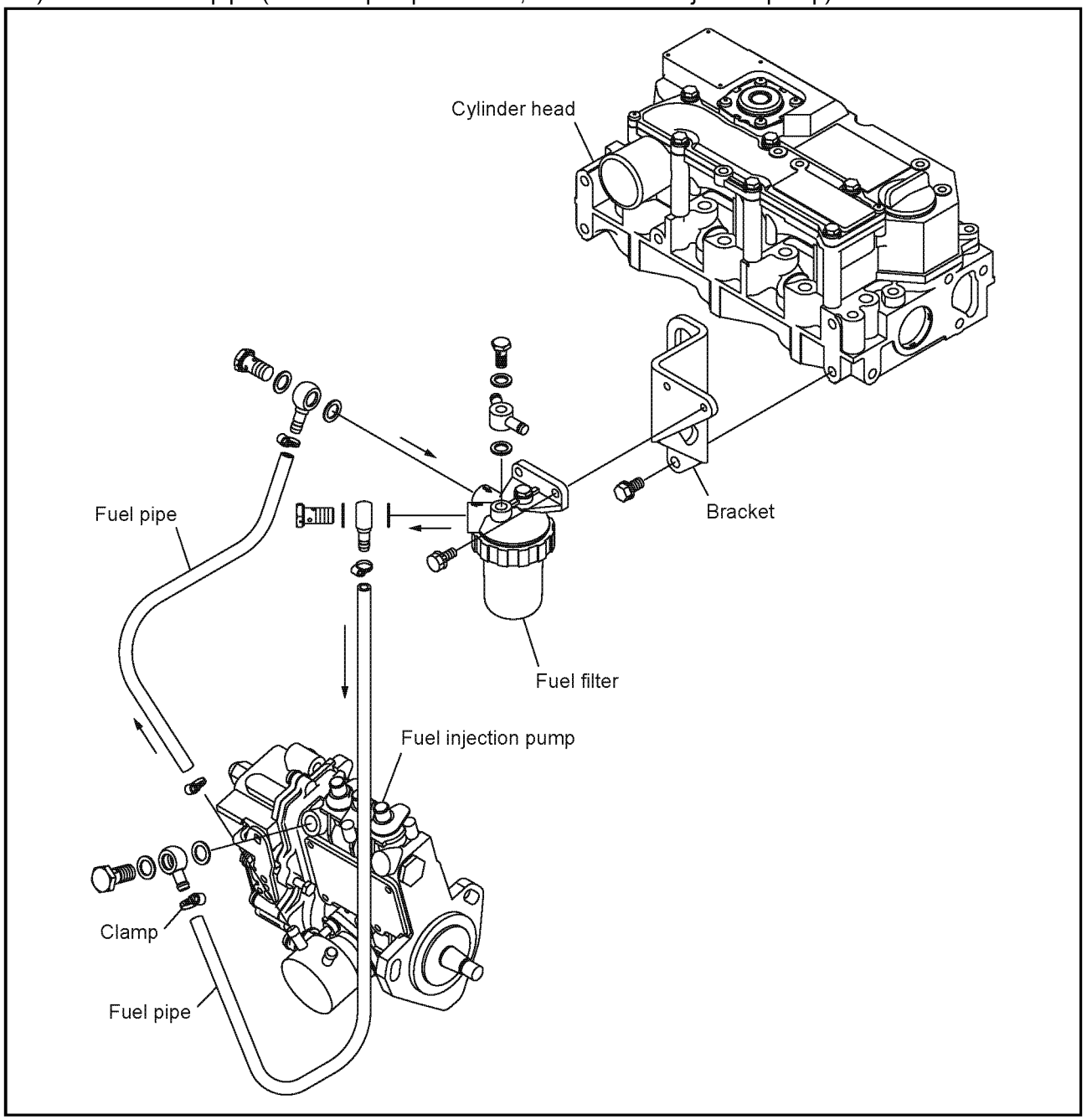
(33) Mounting the intake silencer

Mount the intake pipe on the intake manifold inlet coupling and tighten the intake silencer to the cylinder head.



(34) Mounting the fuel filter and fuel pipe

1) Mount the fuel filter on the bracket, which is tightened to the cylinder head.
2) Mount the fuel pipe (fuel feed pump-fuel filter, fuel filter-fuel injection pump).



(35) Electrical Wiring

Connect the wiring to the proper terminals, observing the color coding to make sure the connections are correct.

(36) Installation in a boat and completion of the piping and wiring

Mount the engine on the engine bed in the engine room of a boat after all engine assembly has been completed. Connect the cooling water pipes, fuel pipes, other pipes on the boat and the exhaust hoses. Connect the battery, instrument panel, remote control cable and other wiring.

(37) Filling with lube oil

Fill the engine with lube oil from the filler port on top of the gear case or the rocker arm cover. Fill the marine gearbox from the filler port on top of the clutch case.

(38) Filling with cooling water

1) Open the coolant (fresh water) tank cap and fill with water.

Model	Engine capacity L (quart)
3YM30(C)	4.9 (5.2)
3YM20(C)	4.1 (4.3)
2YM15(C)	3.0 (3.2)

2) Fill with water until the level in the coolant recovery tank is between the full and low marks.

Coolant recovery tank capacity (full)	0.8 L (0.8 quart)

(39) Test running

Refer to “Adjusting operation” of 2.6 in chapter 2.

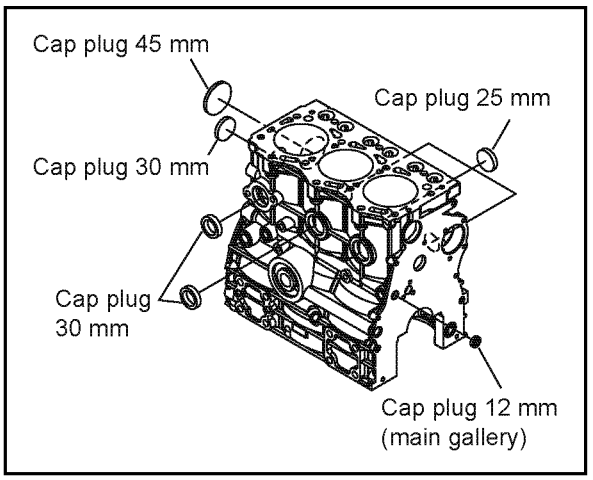
5. Inspection and servicing of basic engine parts

5.1 Cylinder block

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

5.1.1 Inspection of parts

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

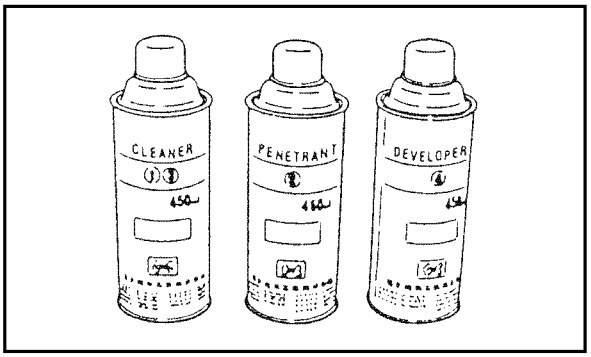


5.1.2 Cleaning of oil holes

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

Color check kit

	Quantity
Penetrant	1
Developer	2
Cleaner	3



5.1.3 Color check procedure

(1) Clean the area to be inspected.

(2) Color check kit
The color check test kit consists of an aerosol cleaner, penetrant and developer.

(3) Clean the area to be inspected with the cleaner.
Either spray the cleaner on directly and wipe, or wipe the area with a cloth moistened with cleaner.

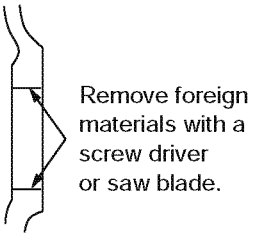
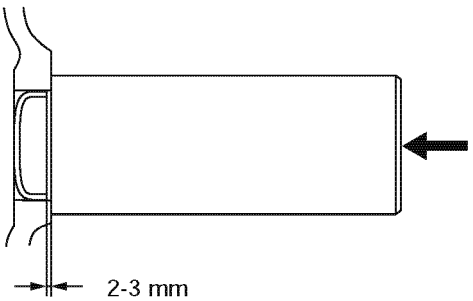
(4) Spray on red penetrant
After cleaning, spray on the red penetrant and allow 5-10 minutes for penetration. Spray on more red penetrant if it dries before it has been able to penetrate.

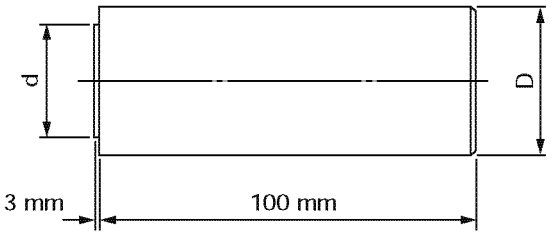
(5) Spray on developer
Remove any residual penetrant on the surface after the penetrant has penetrated, and spray on the surface after the penetrant has penetrated, and spray on the developer. If there are any cracks in the surface, red dots or a red line will appear several minutes after the developer dries.
Hold the developer 300-400 mm away from the area the surface uniformly.

(6) Clean the surface with the cleaner.

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

5.1.4 Replacement of cap plugs

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



mm

Plug dia.	d	D
ϕ12	ϕ11.9-12.0	ϕ20
ϕ25	ϕ24.9-25.0	ϕ35
ϕ30	ϕ29.9-30.0	ϕ40
ϕ45	ϕ44.9-45.0	ϕ55

5.1.5 Cylinder bore measurement

Especially clean head surface, cylinder bores and oil holes, and check the below items after removing any carbon deposit and bonding agent.

(a) Appearance inspection

Check if there is any discoloration or crack. If crack is suspected, perform color check. Sufficiently clean the oil holes and check they are not clogged.

(b) Cylinder bore and distortion

Measure at 20 mm below the crest of the liner, at 20 mm from the bottom end and at the center in two directions A and B as shown in the below figure.

Roundness:

Roundness is found as follows though it is the simple method. Measure cylinder diameters of the A direction and the B direction on each section of a, b and c.

Roundness is the maximum value among those difference values.

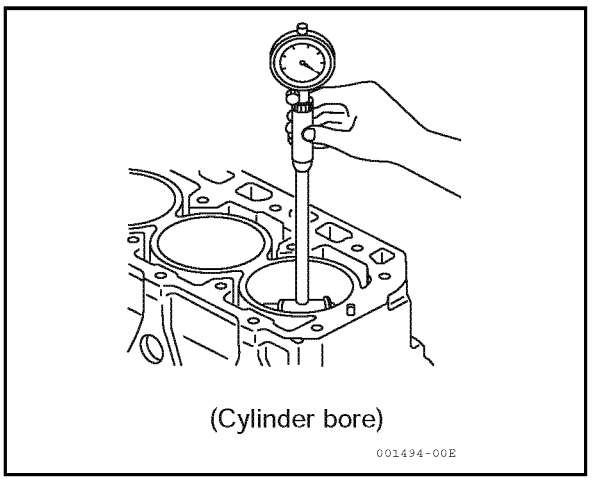
Cylindricity:

Cylindricity is found as follows though it is the simple method.

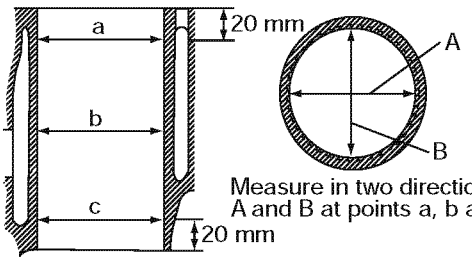
Measure cylinder diameters of a, b and c sections in the A direction, and calculate the difference in maximum value and minimum value of the measured diameters.

In the same way measure and calculate the difference in the B direction.

Cylindricity is the maximum value between those difference values.



(Cylinder bore)



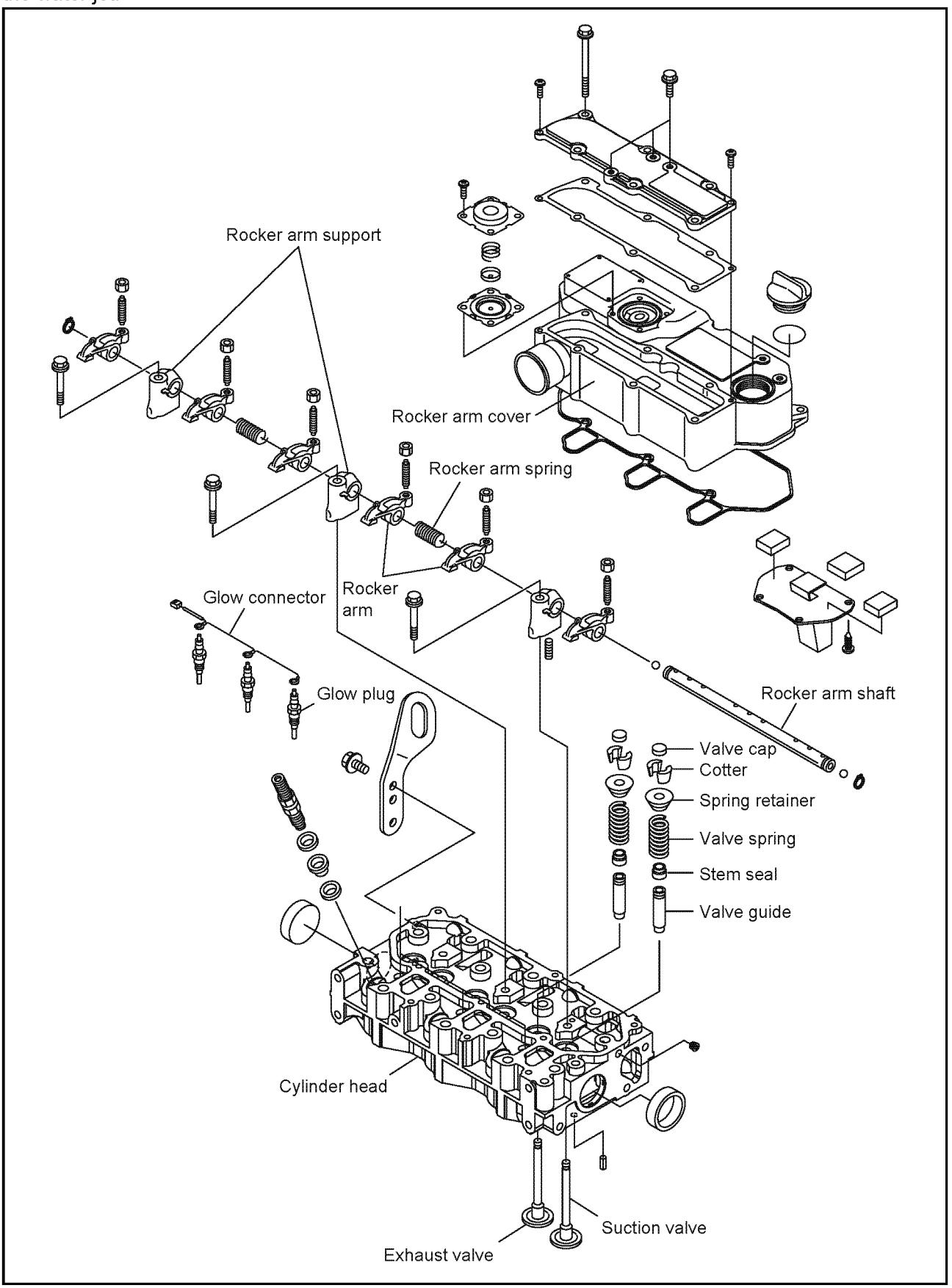
(Cylinder bore measurement positions)

mm

Item	Model	Standard	Limit
Cylinder bore diameter	3YM30	76.000-76.030	76.200
	3YM20/2YM15	70.000-70.030	70.200
Cylinder roundness /Inclination		0.01 or less	0.03

5.2 Cylinder head

The cylinder head is of 3-cylinder integral construction, mounted with 14 bolts. Special alloy stellite with superior resistance to heat and wear is fitted on the seats, and the area between the valves is cooled by the water jet.



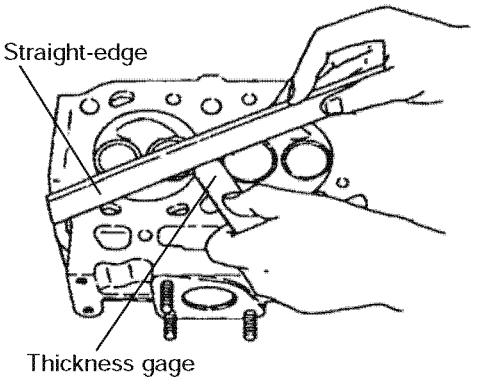
5.2.1 Inspecting the cylinder head

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

(1) Distortion of the combustion surface

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

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



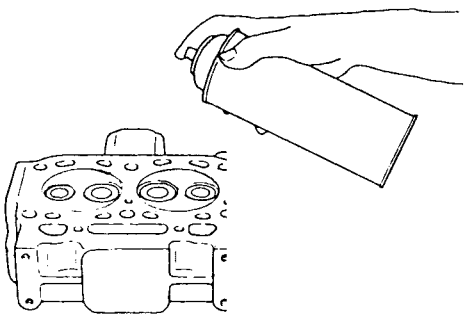
(Distortion at combustion surface)

mm

	Standard	Wear limit
Cylinder head distortion	0.05 or less	0.15

(2) Checking for cracks in the combustion surface

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

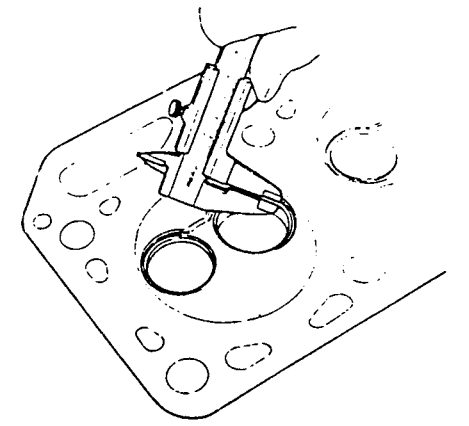


(3) Checking the intake and exhaust valve seats

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

Seat angle	Intake	120°
	Exhaust	90°

Seat width	Standard	Limit
Intake	1.07-1.24	1.74
Exhaust	1.24-1.45	1.94

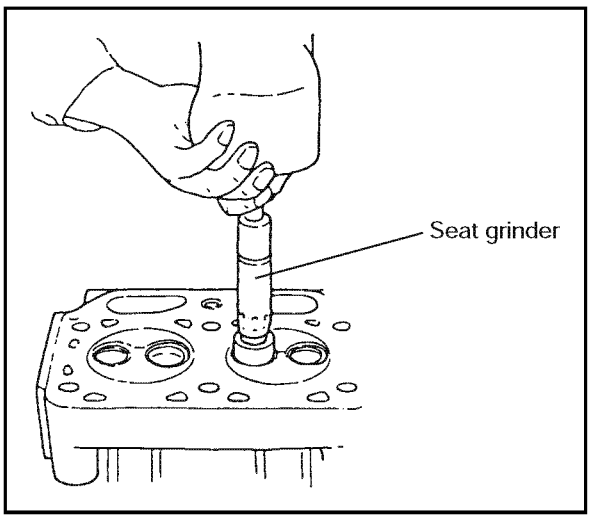


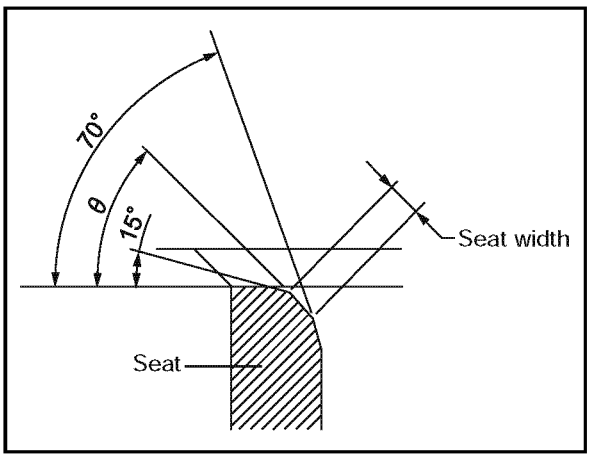
5.2.2 Valve seat correction procedure

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

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

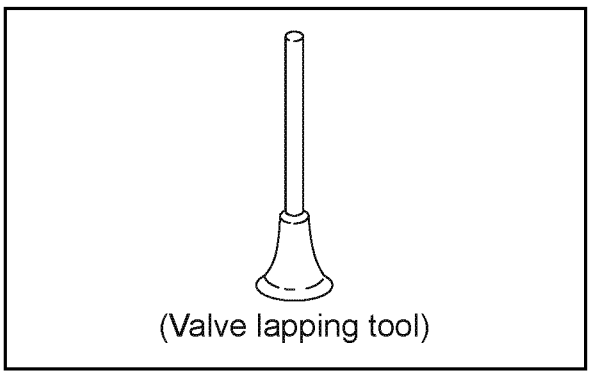
NOTE:
When seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.





(2) Knead valve compound with oil and finish the valve seat with a lapping tool.

(3) Final finishing should be done with oil only.



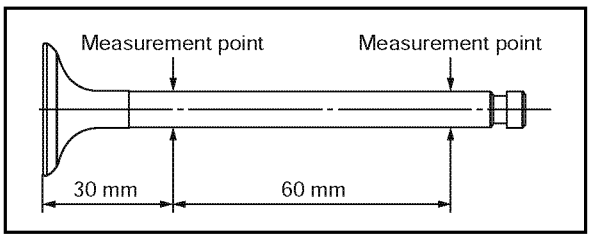
Lapping tool
Use a rubber cap type lapping tool for cylinders without a lapping tool groove with oil only.

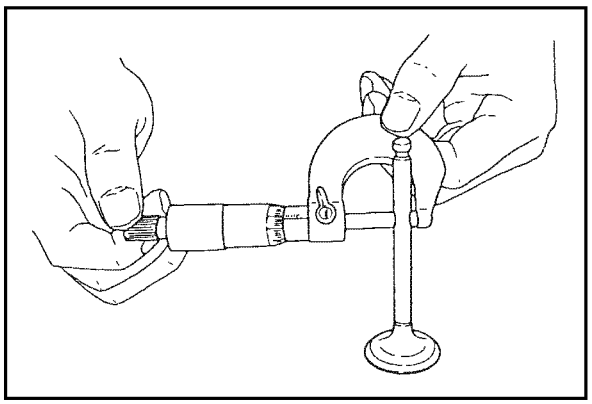
NOTE:
Clean the valve and cylinder head with light oil or the equivalent after valve seat finishing is completed and make sure that there are no grindings remaining.

NOTE:

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

5.2.3 Intake/exhaust valves, valve guides





(1) Wearing and corrosion of valve stem

Replace the valve stem is excessively worn or corroded.

mm

Valve stem outside dia.	Standard	Limit
Intake	5.960-5.975	5.90
Exhaust	5.945-5.960	5.90

(2) Inspection of valve seat wear and contact surface

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

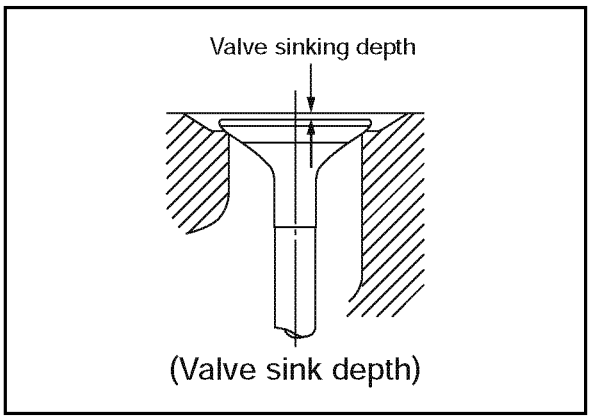
NOTE:
Keep in mind the fact that the intake and discharge valve have different diameters.

(3) Valve sink

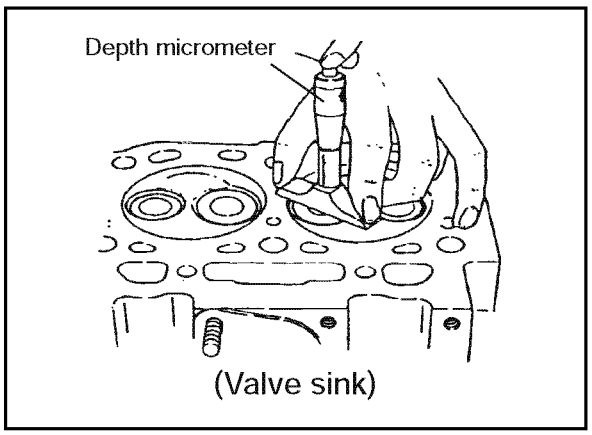
Over long periods of use and repeated lapping, combustion efficiency may drop. Measure the sinking distance and replace the valve and valve seat if the valve sink exceeds the tolerance.

mm

	Standard	Limit
Valve sink	0.4-0.6	0.8



(Valve sink depth)



(Valve sink)

(4) Valve guide

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

mm

		Standard	Limit
Valve guide inside dia.	Intake	6.000-6.012	6.08
	Exhaust	6.000-6.012	6.08
Clearance	Intake	0.025-0.052	0.16
	Exhaust	0.040-0.067	0.17

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

2) Replacing the valve guide
Use the insertion tool and tap in the guide with a mallet.
The intake valve guide and exhaust valve guide are of different dimensions.

3) Valve guide projection
a) Put liquid nitrogen or ether (or alcohol) with dry ice added in a container and put the valve guide for replacement in it for cooling. Then insert it in with a valve guide inserting tool.

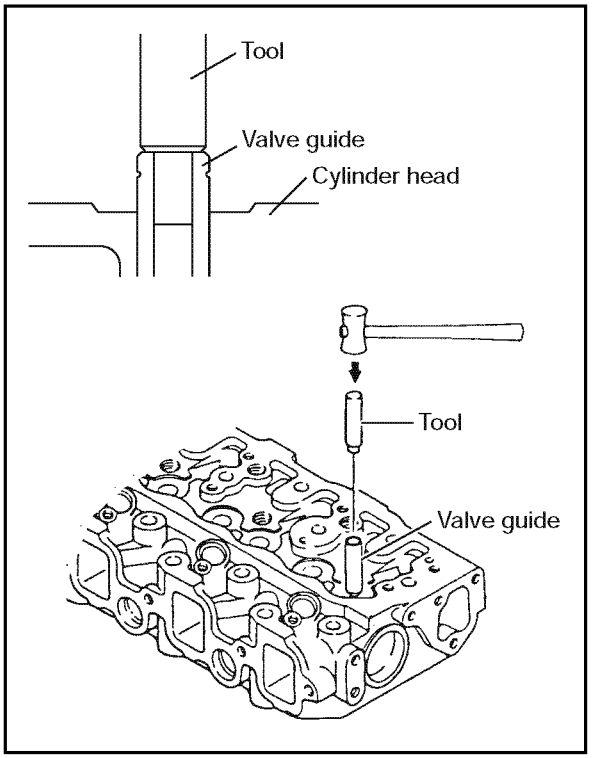
⚠ CAUTION

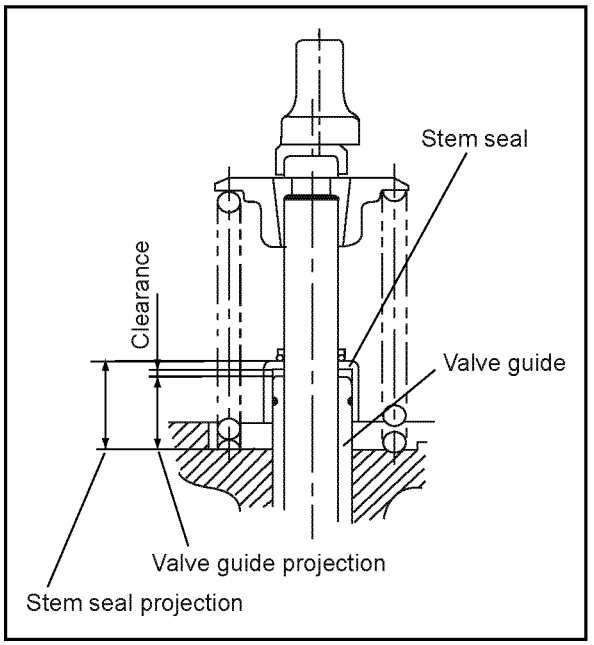
Do not touch the cooled valve guide with bare hands to avoid skin damage.

b) Check the inside diameter and finish to the standard inside diameter as required with a reamer.

Check the projection from the seat surface of the valve spring.

Valve guide projection (mm)
9.8-10.0





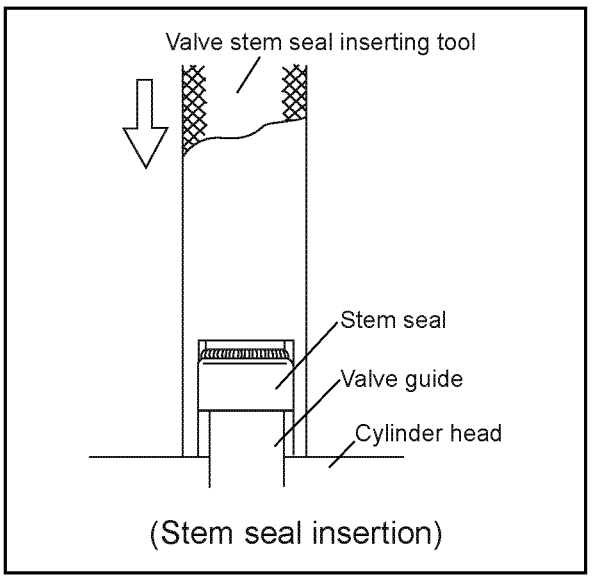
4) Valve stem seals
The valve stem seals in the intake/exhaust valve guides cannot be re-used. When they are removed, be sure to replace them.
When assembling the intake/exhaust valves, apply an adequate quantity of engine oil on the valve stem before inserting them.

Exhaust stem seal is marked by yellow. Intake stem seal is not marked.

a) Apply lube oil to the lip.
b) Push with the inserting tool for installation.

Measure and check the projection of valve stem seal to keep proper clearance between valve guide and stem seal.

Valve stem seal projection (mm)
10.9-11.2

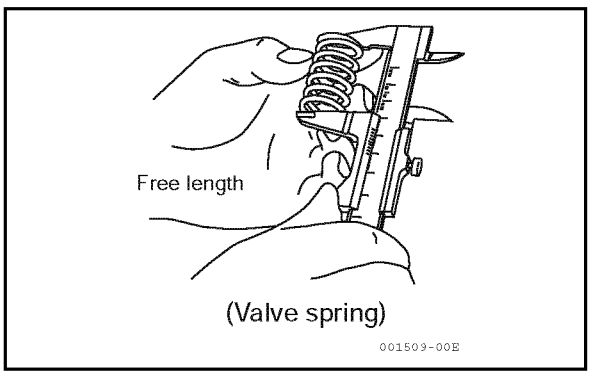


(Stem seal insertion)

5.2.4 Valve springs

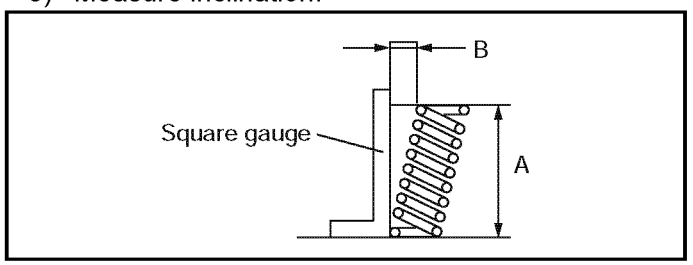
(1) Checking valve springs

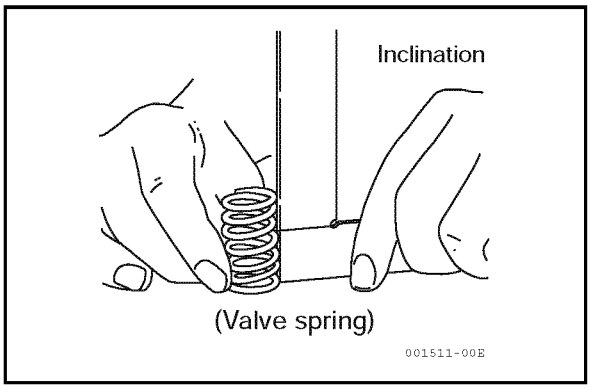
1) Check the spring for scratches or corrosion.
2) Measure the free length of the spring.



(Valve spring)
001509-00E

3) Measure inclination.

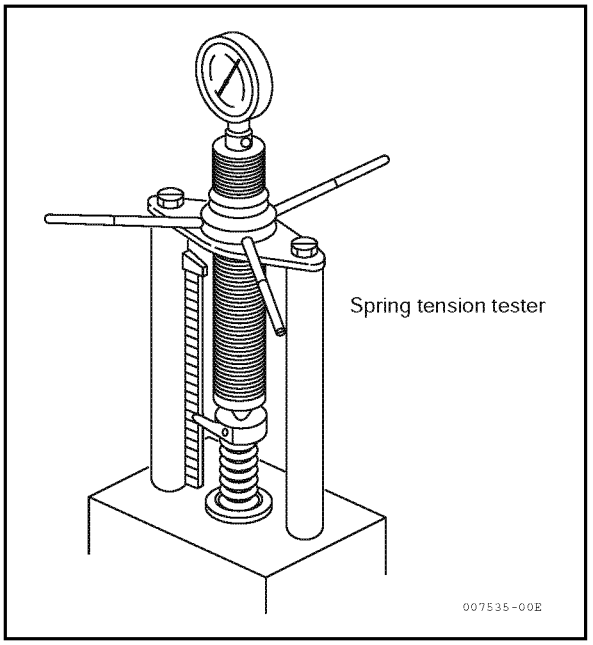




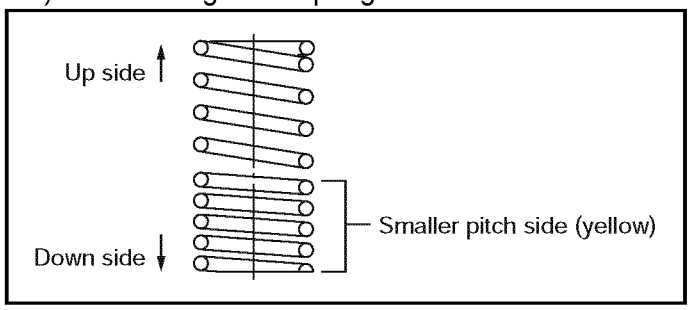
(Valve spring)
001511-00E

4) Measure spring tension.

Valve spring	Unit	Standard	Limit
Free length A	mm	37.8	36.3
Inclination B	mm	-	1.3
Tension (1 mm pressure) (Smaller pitch/ Larger pitch)	N/mm (kgf/mm)	26.6/35.4 (2.71/3.61)	-



5) Assembling valve springs.



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

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

5.2.5 Assembling the cylinder head

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

(1) Clean out the cylinder head bolt holes.

(2) Check for foreign matter on the cylinder head surface where it comes in contact with the block.

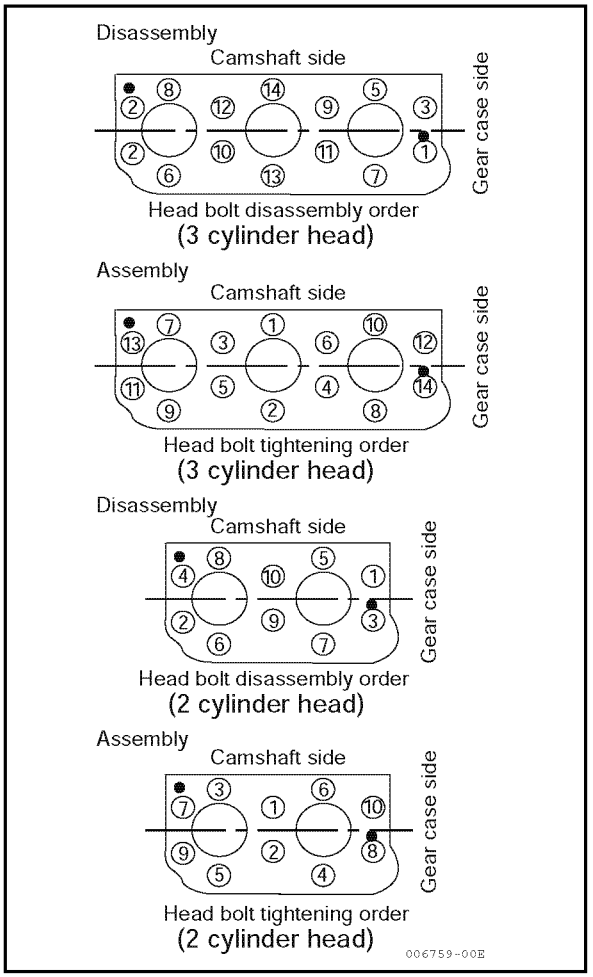
(3) Coat the head bolt threads and nut seats with lube oil.

(4) Use the positioning pins to line up the head gasket with the cylinder block.

(5) Match up the cylinder head with the head gasket and mount.

N•m (kgf•m)

	First	Second
Cylinder head bolt tightening torque	27.0-33.0 (2.8-3.4)	53.9-57.9 (5.5-5.9)



5.2.6 Measuring top clearance

(1) Place a high quality fuse (ø1.5 mm, 10 mm long) in three positions on the flat part of the piston head.

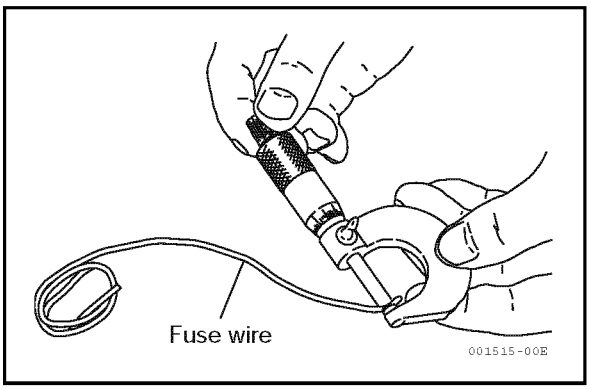
(2) Assemble the cylinder head gasket and the cylinder head and tighten the bolts in the specified order to the specified torque.

(3) Turn the crank, (in the direction of engine revolution), and press the fuse against the piston until it breaks.

(4) Remove the head and take out the broke fuse.

(5) Measure the three positions where each fuse is broken and calculate the average.

Model	Top clearance (mm)
3YM30	0.747-0.891
3YM20/2YM15	0.697-0.841



5.2.7 Intake and exhaust rocker arms

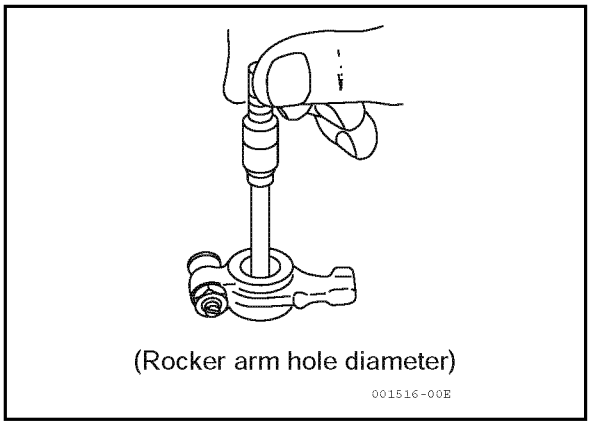
The wear of rocker arm and rocker arm bushing may change opening/closing timing of the valve, and may in turn affect the engine performance according to the extent of the change.

(1) Rocker arm shaft and rocker arm bushing

Measure the outer diameter of the shaft and the inner-diameter of the bushing, and replace if wear exceeds the limit.

mm

	Standard	Limit
Outside dia of intake and exhaust rocker arm shaft.	11.966-11.984	11.94
Intake and exhaust rocker arm bushing inside dia.	12.000-12.020	12.07
Rocker arm shaft and bushing clearance at assembly	0.016-0.054	0.13



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

(2) Rocker arm spring

Check the rocker arm spring and replace it if it is corroded or worn.

(3) Rocker arm and valve top retainer wear

(4) Inspect the contact surface of the rocker arm and replace it if there is abnormal wear or flaking.

5.2.8 Adjustment of valve clearance

(1) Make adjustments when the engine is cool.
(Refer to 2.2.2(8).)

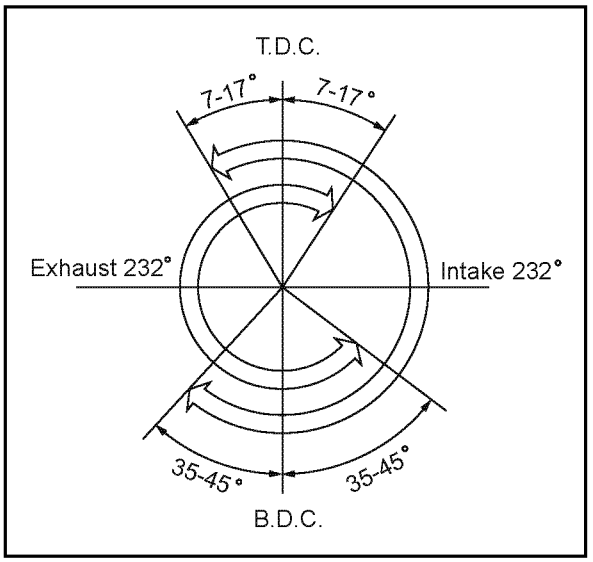
mm

Intake and exhaust valve clearance	0.15-0.25

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

deg.

Intake valve Open	b.TDC.	7-17
Intake valve Closed	a.BDC.	35-45
Exhaust valve Open	b.BDC.	35-45
Exhaust valve Closed	a.TDC.	7-17



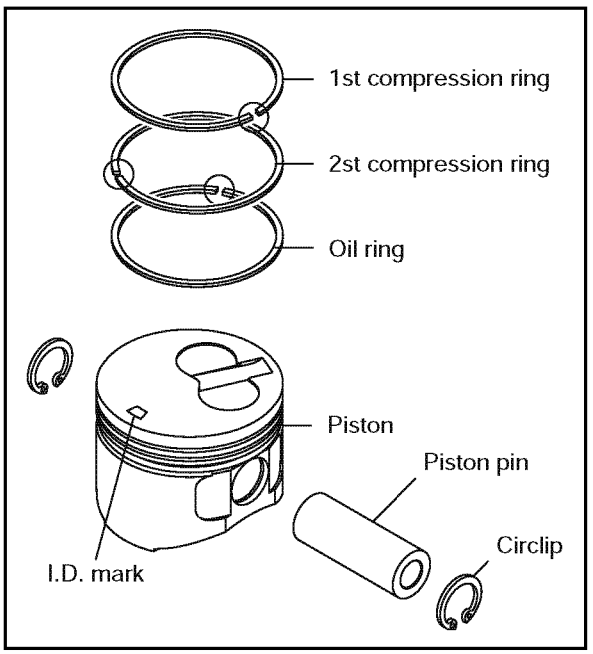
5.3 Piston and piston pins

Pistons are made of a special light alloy with superior thermal expansion characteristics, and the top of the piston forms a combustion chamber.

ID marks for piston size
ML
MS

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

Model	ID marks for engine model
3YM30	76K
3YM20/2YM15	70



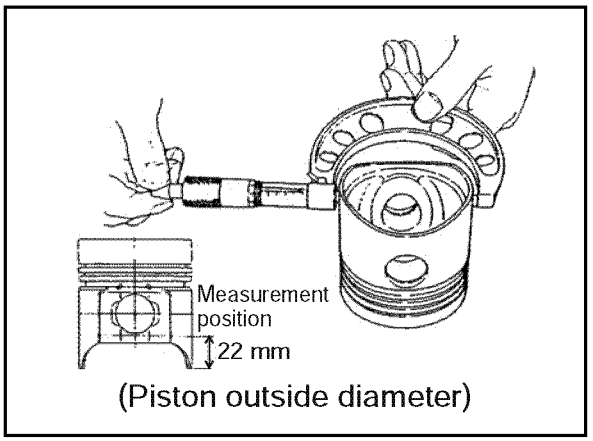
5.3.1 Piston

(1) Piston head and combustion surface

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

(2) Measurement of piston outside diameter/ inspection

1) Replace the piston if the outsides of the piston or ring grooves are worn.
2) Measure the outside diameter in the position of 22mm from the piston bottom in the right angle direction of the piston pin.



(Piston outside diameter)

Piston outside diameter

Model	Standard	Limit	Clearance between piston and cylinder
3YM30	75.965-75.975	75.920	0.035-0.055
3YM20 2YM15	69.970-69.980	69.925	0.030-0.050

If the piston outside diameter exceed the limit, replace the piston with new one.

Selective pairing of cylinder and piston

Piston must be paired with cylinder according to the below table. The size mark of a piston is shown on the top surface of the piston and the size mark of a cylinder block is shown on the non-operating side of the cylinder block. The service parts of pistons are provided.

			Piston outside diameter. D2	
	Tolerance		below + 0.005 0 min.	below 0 -0.005 min.
		Size mark	ML	MS
Cylinder inside diameter D1	+0.030 max. +0.020 min.	L	○	X
	below +0.020 +0.010 min.	M	○	○
	below +0.010 0 min.	S	X	○

Model	Cylinder inside diameter D1	Piston outside diameter. D2
3YM30	76	75.970
3YM20/2YM15	70	69.975

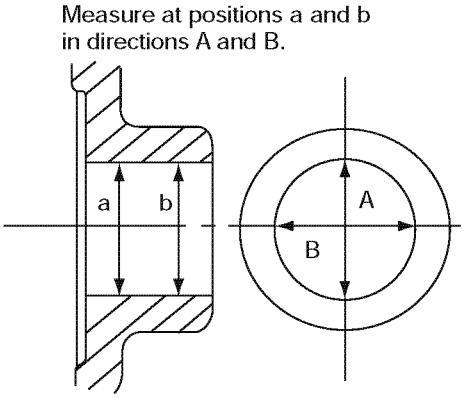
(3) Removing the piston pin

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

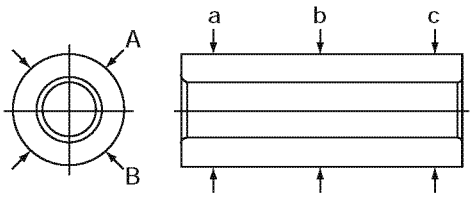
5.3.2 Piston pin

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

	Standard	Limit
Piston pin hole inside dia.	22.000-22.009	22.039
Piston pin outside dia.	21.995-22.000	21.965
Clearance	0.000-0.014	0.074



(Piston pin hole)



(Piston pin outside diameter)