HINSHI-H10-009

YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

MODEL 4JH3-TE/HTE/DTE

YANMAR DIESEL ENGINE CO.,LTD.

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History of Revision	Page No.	1

Manual Name	Service Manual for Marine Diesel Engine
Engine Model :	4JH3-TE, HTE, DTE

Number of revision	Date of revision	Reason for correction	Outline of correction	correction item No.(page)	Corrected by
● New edition	Aug. 1998				

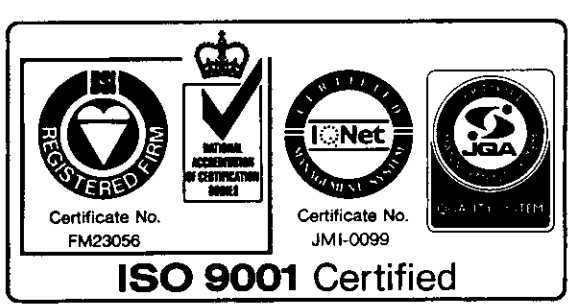
Foreword

This book describes the procedures for servicing the 4JH3 series marine diesel engine. Use this manual to help you service the engine accurately, quickly and safely. The descriptions in this manual are for the standard engine. Therefore, the specifications or components of your engine may vary, depending on the exact engine installed in the ship.

For more specific details, also refer to the service manual for the ship.

Note that modifications may be made in the specifications or parts in order to improve the engine. Any such changes which affect the contents of this manual will be noted by issuing a modification report each time a change is made.

For details about the marine gear, see the service manual for it (HINSHI-H10-011).



These products have been developed, designed, and manufactured in the facilities certified by the Standards for Quality Systems of ISO 9001.

CONTENS

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1. To Perform Service Safely

1.1 Warning Symbols

●Most accidents are caused by neglecting basic safety rules and precautions. To prevent this type of accident, always follow safe working practices.
Please read this manual carefully before starting repair or maintenances in order to gain a full understanding of the safety precautions and the appropriate inspection and maintenance procedures.
Do not attempt to perform repairs or maintenance if you don't have sufficient background knowledge, or it may result in an accident.

●It is impossible to cover every possible danger when making repairs or performing maintenance. Therefore, you must always exercise sufficient general consideration for safety, in addition to the specific matters marked with ⚠ CAUTION, both in this manual and on the product. Especially when performing a repair or maintenance procedure not described in this manual, ask for some advice from a person who has experience in that area.

●The warning symbols used in this manual and their meanings are as follows:

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

●Any issue marked with a [NOTICE] in this manual contains especially important information about servicing the engine. If the advice not followed, the product's performance and quality may not be guaranteed.

1.2 Safety Precautions (Be sure to follow the cautions below for your own safety.)

(1) Service Shop (Place)

⚠ WARNING

● Well-ventilated work area

Jobs such as running the engine, welding and polishing the paint with sandpaper should be done in a well-ventilated workplace.

【Otherwise】

It can be very dangerous to inhale poisonous gas or dust.

⚠ CAUTION

● Sufficiently wide and flat place

The floor space in a service shop where inspections or maintenance are performed should be wide enough and completely flat, without any pits or holes.

【Otherwise】

An accident may occur.

⚠ CAUTION

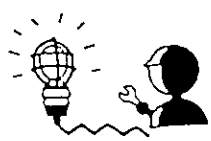
● Clean and orderly work area

No dust, mud, oil or parts should be left on the floor.

【Otherwise】

You may slip, trip or fall.

⚠ CAUTION



● Bright and safely lighted workplace

The workplace should be well lit. When performing a job in a position that is dark or difficult to see, use a portable work lamp. The bulb must be covered with a wire or plastic cage.

【Otherwise】

If the light does not have a cage, the bulb may be broken and can cause a fire.

⚠ CAUTION

● Workplace must have a fire extinguisher.

Keep a first-aid kit and a fire extinguisher close at hand, in case of injury or fire.

(2) Work Clothing

⚠ CAUTION

● Clothing for safe operation

Wear a helmet, protective clothing, safety shoes and other safety devices according to the job being performed. Make sure to wear close-fitting work clothes.

[Otherwise]

A serious accident can happen if you get caught in a machine.

(3) Tools to Be Used

⚠ WARNING

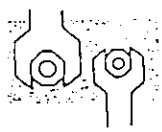
● Appropriate lifting and supporting devices

Never try to work on the engine if it is only supported with wooden blocks or by a jack. To lift and support the engine, be sure to use a crane with a sufficient lifting capacity or use a fixed jack designed for the job.

[Otherwise]

A serious accident may occur.

⚠ WARNING



● Use appropriate tools.

Use the right tools for the job to be done. Always use the correct size tool to loosen or tighten parts.

[Otherwise]

A serious injury or engine damage may occur.

(4) Use Genuine Parts, and Lubricants.

⚠ CAUTION

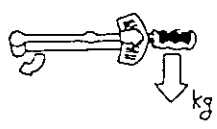
● Always use genuine parts.

[Otherwise]

The engine life may be shortened or an accident may occur.

(5) Tightening Nuts and Bolts

⚠ WARNING



● Always tighten each part to the specified torque if it is given in the manual.

[Otherwise]

Loose or falling parts may cause damage or injuries.

(6) Handling the Engine Parts

⚠ WARNING

● Be very careful of hot parts.

Do not touch the engine when it is running or immediately after it has stopped.

[Otherwise]
You may be badly burned.

⚠ WARNING

● Be careful around rotating parts

Keep your clothing and tools well away from any rotating parts.

[Otherwise]
You or the tools may be caught and you may be seriously injured.

⚠ WARNING

● Electrical shorts

Disconnect the terminal ⊖ at the battery before servicing the engine.

[Otherwise]
A short in the wires may cause a fire to break out.

⚠ WARNING

● Battery charging

Do not allow any open flame near the battery while it is charging.

[Otherwise]
When charging, the battery produces highly flammable gas and an explosion may occur.

⚠ WARNING

● Battery acid

The battery is filled with dilute sulfuric acid. Take special care to avoid getting it on your clothing or skin.

[Otherwise]
The battery acid will eat through fabric and can give you a serious chemical burn.

(7) Waste Disposal

⚠ CAUTION

● Observe the following instructions with regard to waste disposal.

【Otherwise】
The environment may be polluted.

- Waste liquids such as engine oil and cooling water must be discharged into a container. Any spills on the ground must be wiped up right away.
- Do not discharge any waste fluids into the sewerage, a river or the ocean.
- Harmful wastes such as oils, fuels, solvents, filter elements and batteries must be treated according to the applicable laws and regulations. Ask a qualified waste collection company for more information.

(8) Safety Label

⚠ CAUTION

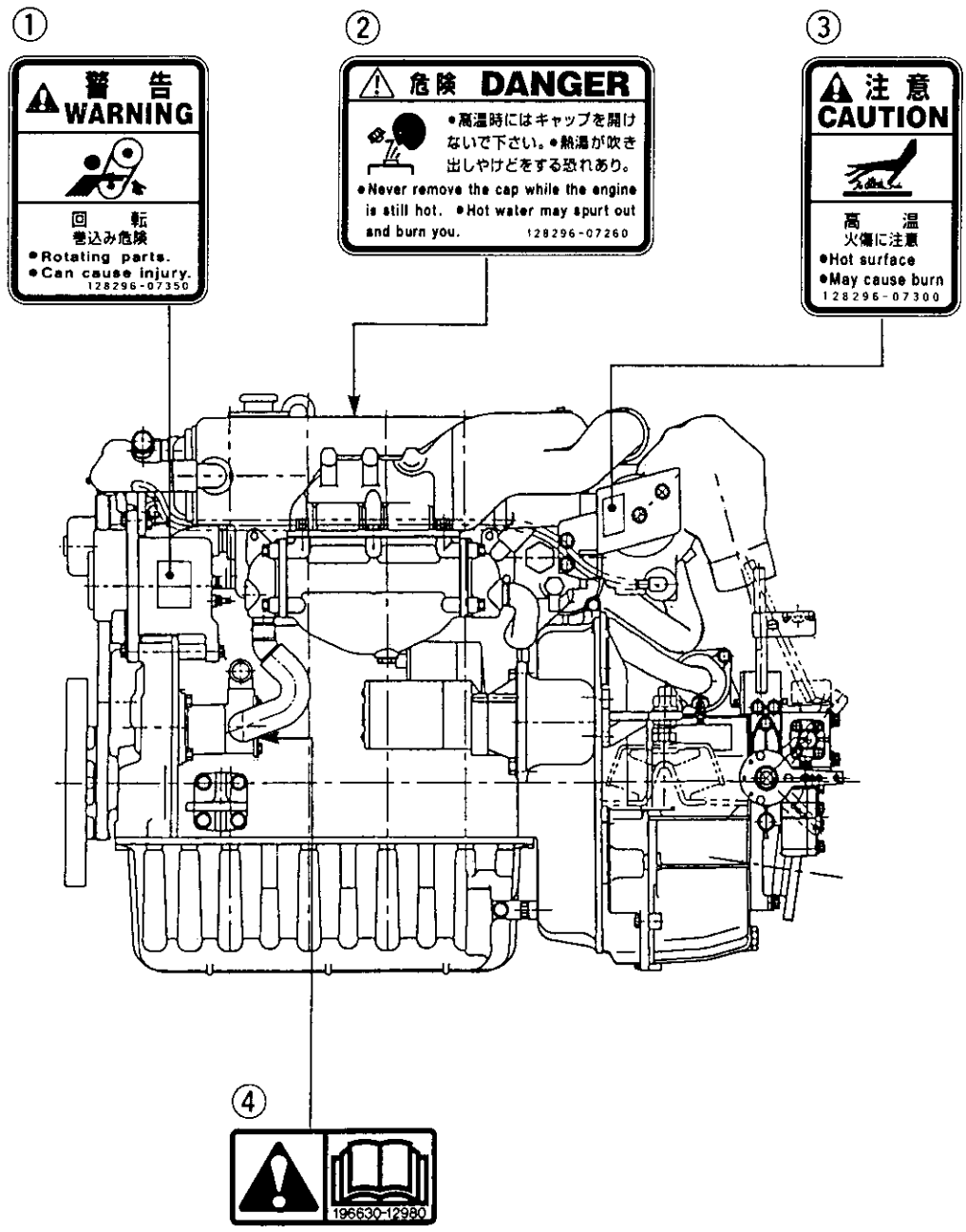
● Pay attention to the safety label warning on the product.

The safety label (caution plate) is placed on the product to improve safe operation.
If the safety label is missing or illegible, be sure to replace it with a new one.

1.3 Location of Product Safety Labels

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

Product Safety Labels, Parts Code Numbers	
①	128296-07350
②	128296-07260
③	128296-07300
④	196630-12980



2. General Description

2.1 Principal Particulars

● 4JH3-TE

Engine Model			4JH3-TE (Printed on name plate)		
			4JH3-TE	4JH3-TBE	4JH3-THE
Use			Pleasure boat		
Type			Vertical water-cooled 4-cycle diesel engine		
Number of cylinders-Bore×stroke mm			4-φ84×90		
Displacement ℓ			1.995		
Aspiration system			Turbocharger		
Cont. rating output kW{hp}/rpm			50.7{69}/3700		
Max. output kW{hp}/rpm			53.0{72}/3800		
High idling (rpm)			4,300 ± 25		
Low idling (rpm)			700 ± 25		
Combustion system			Direct injection		
Starting system			Electric starting		
Cooling system			Constant high temperature fresh water cooling		
Lubrication system			Totally enclosed and forced lubrication system with trochoid pump		
Marine gear	Model		KBW21	KM4A	KMH4A
	Type		Mechanical wet multiple disk clutch Input/output eccentric parallel drive	Mechanical wet cone clutch 7° Down angle drive	Hydraulic wet multiple disk clutch 8° Down angle drive
	Reduction ratio (Ahead/Astern)		S: 2.17/3.06 G: 2.62/3.06	SS:1.47/1.47 S: 2.14/2.14 G: 2.63/2.63 GG:3.30/3.30	S: 2.04/2.04 G: 2.45/2.45
Direction of rotation (when viewed from stern side)	Crankshaft		Counterclockwise		
	Propeller shaft		Clockwise		
Fuel injection pump			Bosh-distributor type Model VE(ZEXEL)		
Fuel injection valve			Pinhole injection nozzle YDLLAP (5 - 0.23 × 150°)		
Turbocharger			RHB52(IHI) Water cooling and forced lubrication system		
Elec. devices	Starter		DC12V - 1.4kW		
	Alternator		DC12V - 55A(option:80A)		
Lube oil capacity ℓ (raked angle)	Engine oil	Oil pan	6.5 (7°)	5.8 (0°)	
		Total	7.7 (7°)	7.0 (0°)	
	Clutch oil		1.2	1.3	2.0
Cooling water capacity ℓ	Fresh water tank		6.0		
	Subtank		0.8		
Dimensions (L×W×H) mm			898×560×635	888×565×635	886×565×635
Dry weight kg			249	247	250
Engine installation style			On the flexible rubber engine mount		
Recommended battery capacity			12V - 80A(5HR) or greater		
Recommended engine room ventilator			12m³ / min. or greater		

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● 4JH3-HTE

Engine Model			4JH3-HTE(Printed on name plate)		
			4JH3-HTE	4JH3-HTBE	4JH3-HTHE
Use			Pleasure boat		
Type			Vertical water-cooled 4-cycle diesel engine		
Number of cylinders-Bore×stroke mm			4-φ84×90		
Displacement ℓ			1.995		
Aspiration system			Turbocharger, intercooler		
Cont. rating output kW{hp}/rpm			67.7{92}/3700		
Max. output kW{hp}/rpm			70.6{96}/3800		
High idling (rpm)			4,300 ± 25		
Low idling (rpm)			700 ± 25		
Combustion system			Direct injection		
Starting system			Electric starting		
Cooling system			Constant high temperature fresh water cooling		
Lubrication system			Totally enclosed and forced lubrication system with trochoid pump		
Marine gear	Model		KBW21	KM4A	KMH4A
	Type		Mechanical wet multiple disk clutch Input/output eccentric parallel drive	Mechanical wet cone clutch 7° Down angle drive	Hydraulic wet multiple disk clutch 8° Down angle drive
	Reduction ratio (Ahead/Astern)		S: 2.17/3.06 G: 2.62/3.06	SS:1.47/1.47 S:2.14/2.14 G:2.63/2.63 GG:3.30/3.30	S: 2.04/2.04 G: 2.45/2.45
Direction of rotation (when viewed from stern side)	Crankshaft		Counterclockwise		
	Propeller shaft		Clockwise		
Fuel injection pump			Bosh-distributor type Model VE(ZEXEL)		
Fuel injection valve			Pinhole injection nozzle YDLLAP(5-0.26×150°)		
Turbocharger			RHB52(IHI) Water cooling and forced lubrication system		
Elec. devices	Starter		DC12V - 1.4kW		
	Alternator		DC12V - 55A(option:80A)		
Lube oil capacity ℓ (raked angle)	Engine oil	Oil pan	6.5 (7°)	5.8 (0°)	
		Total	7.7 (7°)	7.0 (0°)	
	Clutch oil		1.2	1.3	2.0
Cooling water capacity ℓ	Fresh water tank		7.2		
	Subtank		0.8		
Dimensions (L×W×H) mm			886×581×660		
Dry weight kg			260		
Engine installation style			On the flexible rubber engine mount		
Recommended battery capacity			12V - 80A (5HR) or greater		
Recommended engine room ventilator			16m³/ min. or greater		

● 4JH3-DTE

Engine Model			4JH3-DTHE(Printed on name plate)
			4JH3-DTHE
Use			Pleasure boat
Type			Vertical water-cooled 4-cycle diesel engine
Number of cylinders - Bore×stroke mm			4-φ84×90
Displacement ℓ			1.995
Aspiration system			Turbocharger, intercooler
Cont. rating output kW{hp}/rpm			85.3{116}/3700
Max. output kW{hp}/rpm			88.3{120}/3800
High idling (rpm)			4,300 ± 25
Low idling (rpm)			700 ± 25
Combustion system			Direct injection
Starting system			Electric starting
Cooling system			Constant high temperature fresh water cooling
Lubrication system			Totally enclosed and forced lubrication system with trochoid pump
Marine gear	Model		KMH4A
	Type		Hydraulic wet multiple disk clutch 8° Down angle drive
	Reduction ratio (Ahead/Astern)		S: 2.04/2.04 G: 2.45/2.45
Direction of rotation (when viewed from stern side)	Crankshaft		Counterclockwise
	Propeller shaft		Clockwise
Fuel injection pump			Bosh-distributor type Model VE(ZEXEL)
Fuel injection valve			Pinhole injection nozzle YDLLAP(5-0.26×150°)
Turbocharger			RHB52(IHI) Water cooling and forced lubrication system
Elec. devices	Starter		DC12V - 1.4kW
	Alternator		DC12V - 55A(option:80A)
Lube oil capacity ℓ (raked angle)	Engine oil	Total	5.8 (0°)
		Oilpan	7.0 (0°)
	Clutch oil		2.0
Cooling water capacity ℓ	Fresh water tank		7.2
	Subtank		0.8
Dimensions (L×W×H) mm			888×581×660
Dry weight kg			260
Engine installation style			On the flexible rubber engine mount
Recommended battery capacity			12V - 80A (5HR) or greater
Recommended engine room ventilator			20m³/ min. or greater

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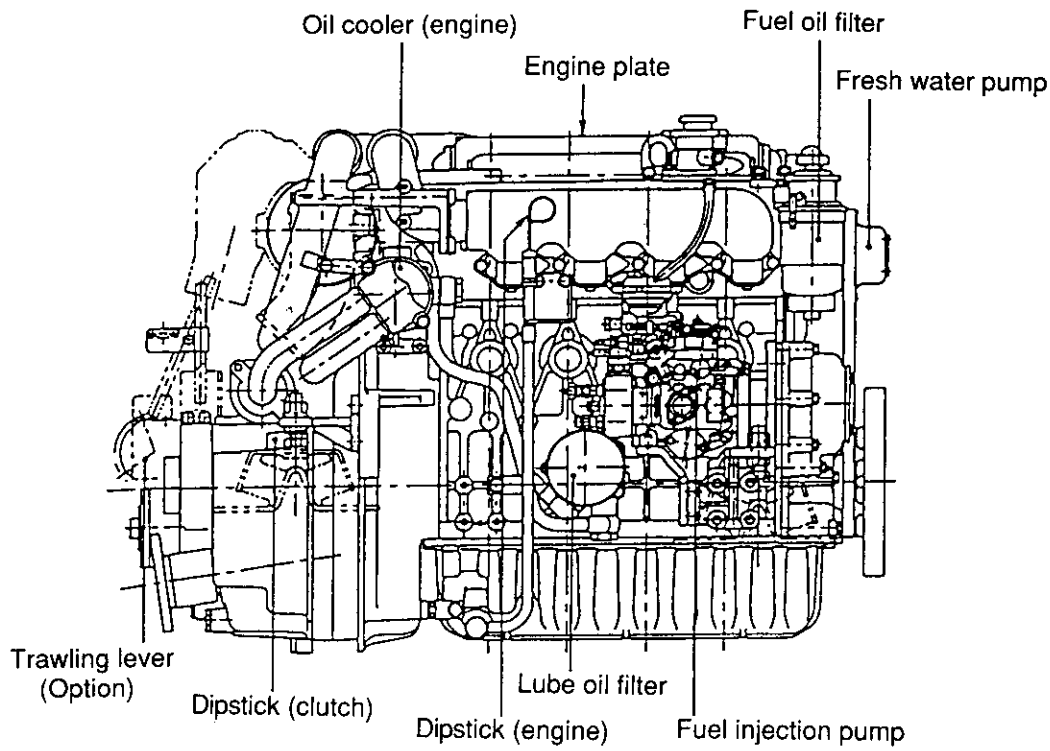
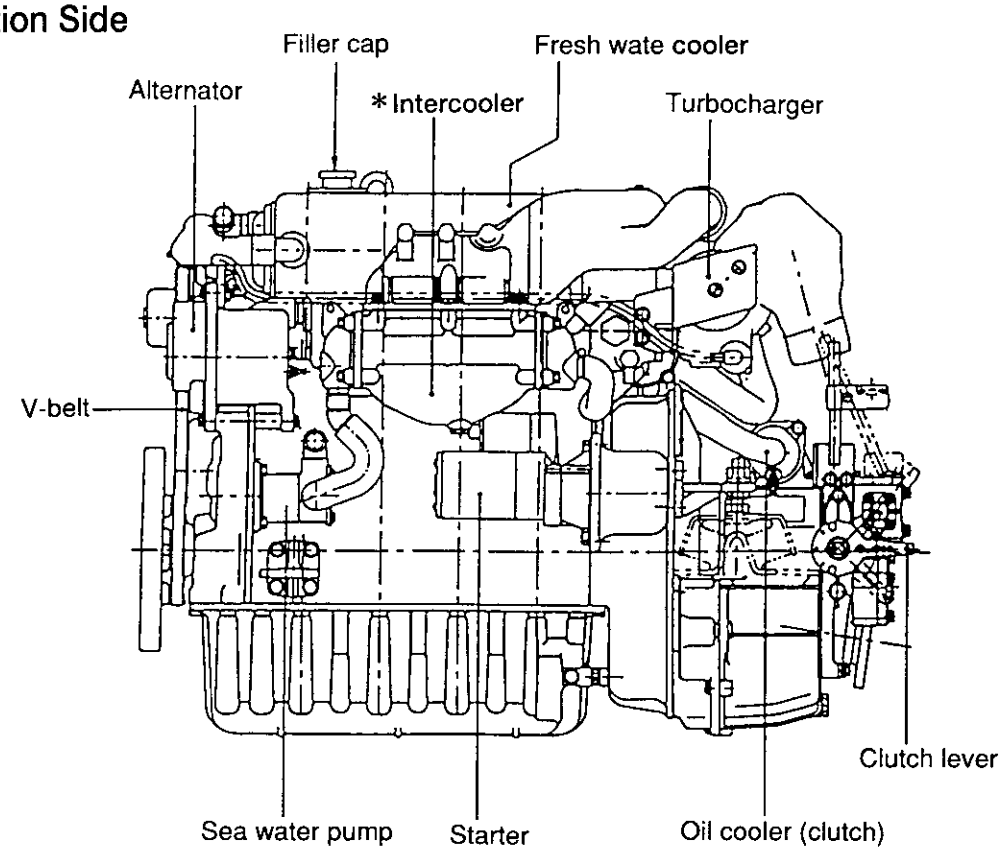
2.2 Appearance and Names of Parts

● Operation Side (Right side as viewed from the propeller.) Contains the main parts necessary for operation



● Non-Operation Side

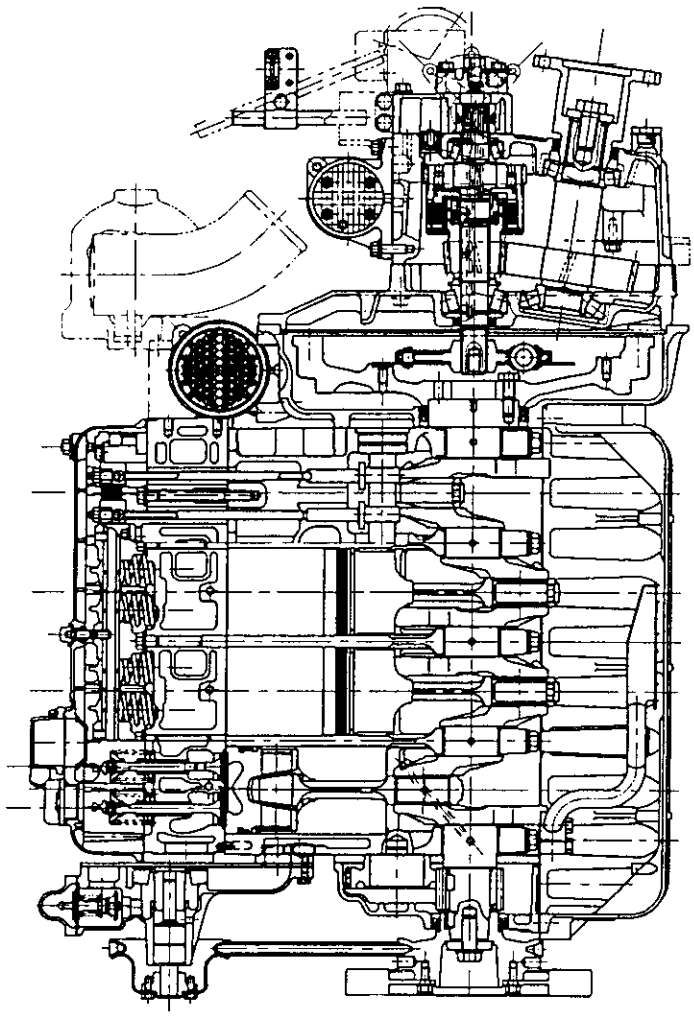


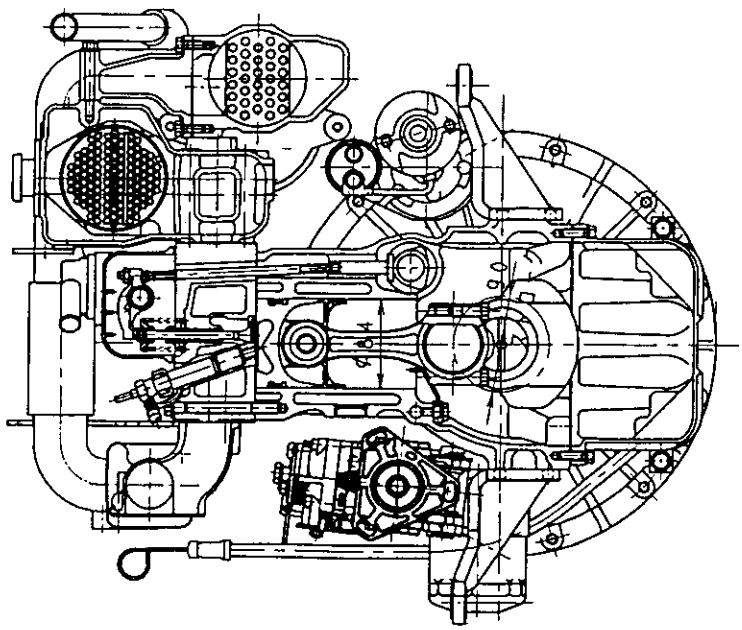
[NOTE]

The 4JH3-DTE engine (with KMH4A clutch) is used as the example for the above diagram.

The 4JH3-TE Series is not equipped with an intercooler (indicated by * mark in the diagram).

2.3 Cross-sectional Drawing



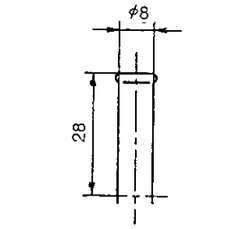


[NOTE]
The 4JH3-DTE engine (with KMH4A marine gear) is used as the example.

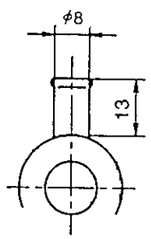
2.4 Piping Diagram

- 4JH3-TE,

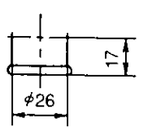
MARKS OF PIPING	NAME
RH	RUBBER HOSE
SGP STS	STEEL PIPE
C1201T	COPPER PIPE
	(UNION) SCREW JOINT
	FLANGE JOINT
	EYE JOINT
	INSERTION JOINT
	DRILL HOLE
	COOLING FRESH WATER PIPING
	COOLING SEA WATER PIPING
	LUB. OIL PIPING
	FUEL. OIL PIPING



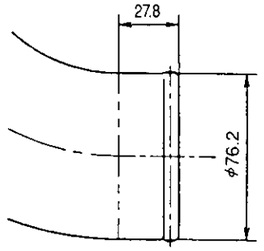
DETAIL OF PART Ⓐ



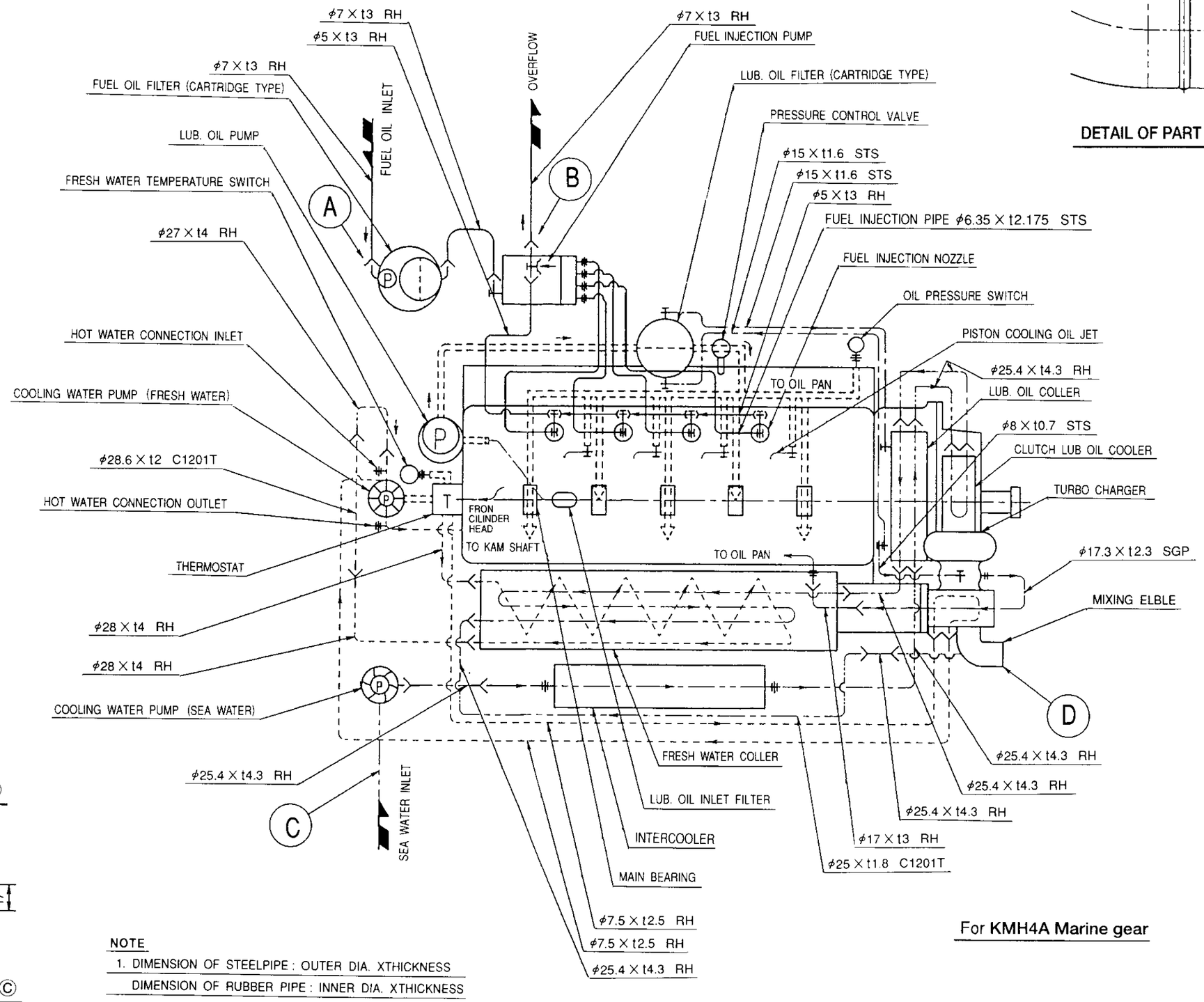
DETAIL OF PART Ⓑ



DETAIL OF PART Ⓒ



DETAIL OF PART Ⓓ



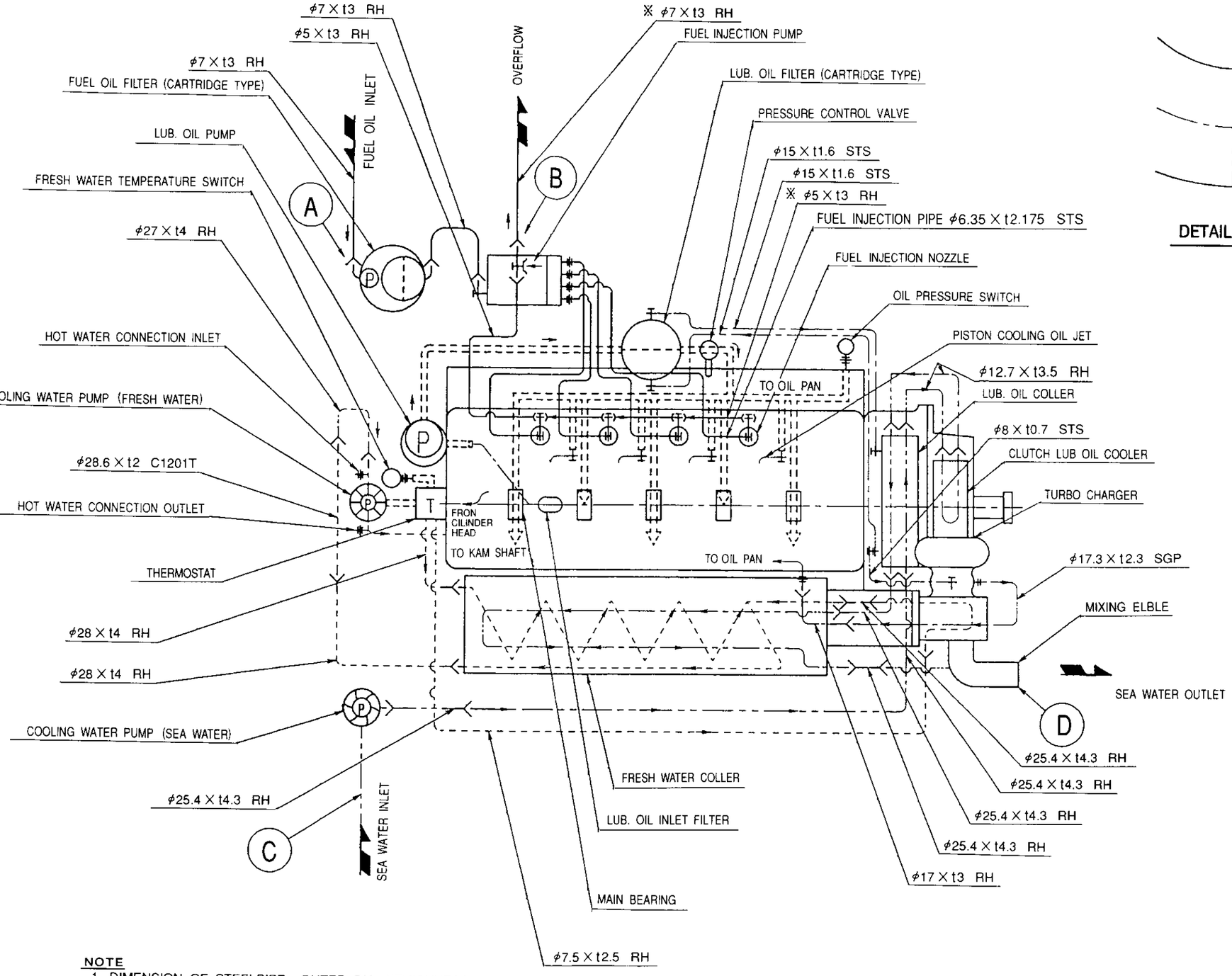
For KMH4A Marine gear

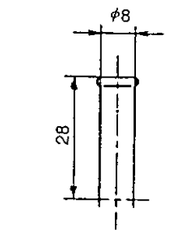
NOTE

1. DIMENSION OF STEELPIPE : OUTER DIA. XTHICKNESS
   DIMENSION OF RUBBER PIPE : INNER DIA. XTHICKNESS

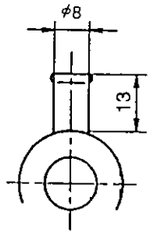
• 4JH3-HTE,DTE

MARKS OF PIPING	NAME
RH	RUBBER HOSE
SGP STS	STEEL PIPE
C1201T	COPPER PIPE
	(UNION) SCREW JOINT
	FLANGE JOINT
	EYE JOINT
	INSERTION JOINT
	DRILL HOLE
	COOLING FRESH WATER PIPING
	COOLING SEA WATER PIPING
	LUB. OIL PIPING
	FUEL. OIL PIPING

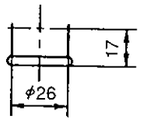




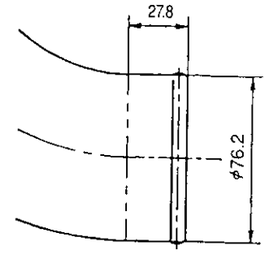
DETAIL OF PART Ⓐ



DETAIL OF PART Ⓑ



DETAIL OF PART Ⓒ



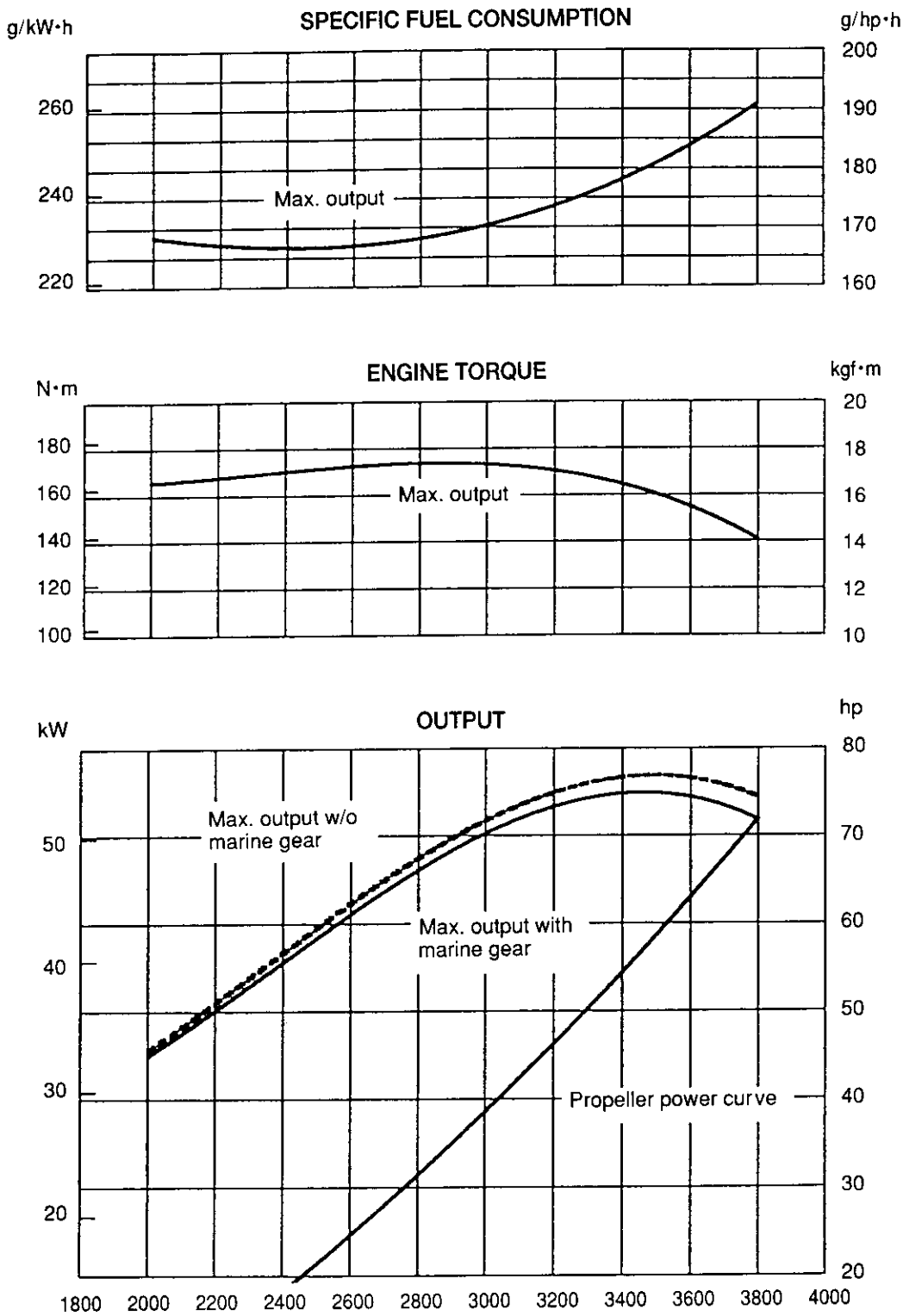
DETAIL OF PART Ⓓ

NOTE
1. DIMENSION OF STEELPIPE : OUTER DIA. XTHICKNESS
   DIMENSION OF RUBBER PIPE : INNER DIA. XTHICKNESS
2. FUEL RUBBER PIPES ARE SATISFIED MITH
   THE SPECIFICATION OF MANUFACTUER
   (NO. KH-500-0) (MARKED ※)

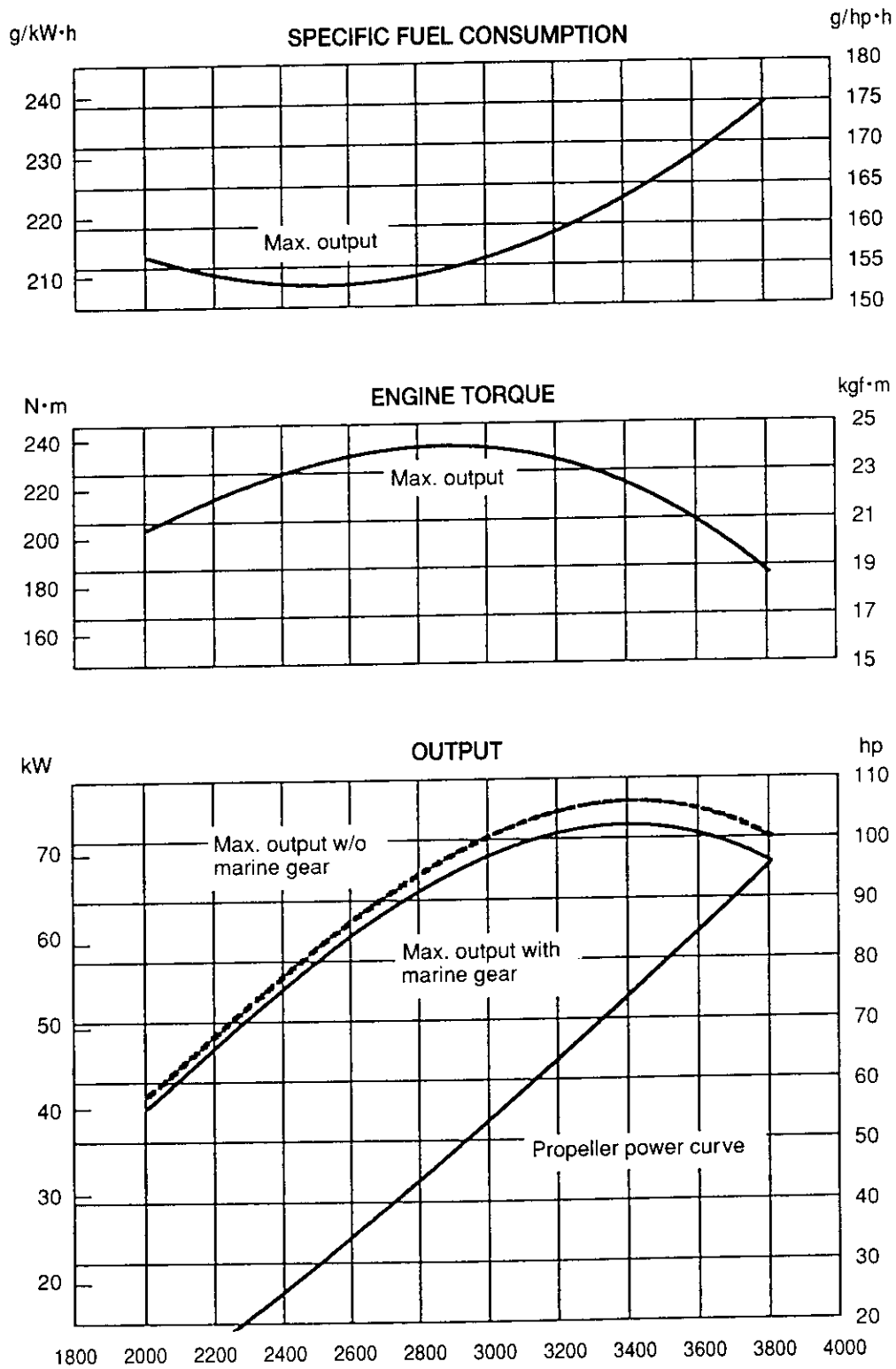
For KM4A and KBW21 Marine gear

2.5 Performance Curves

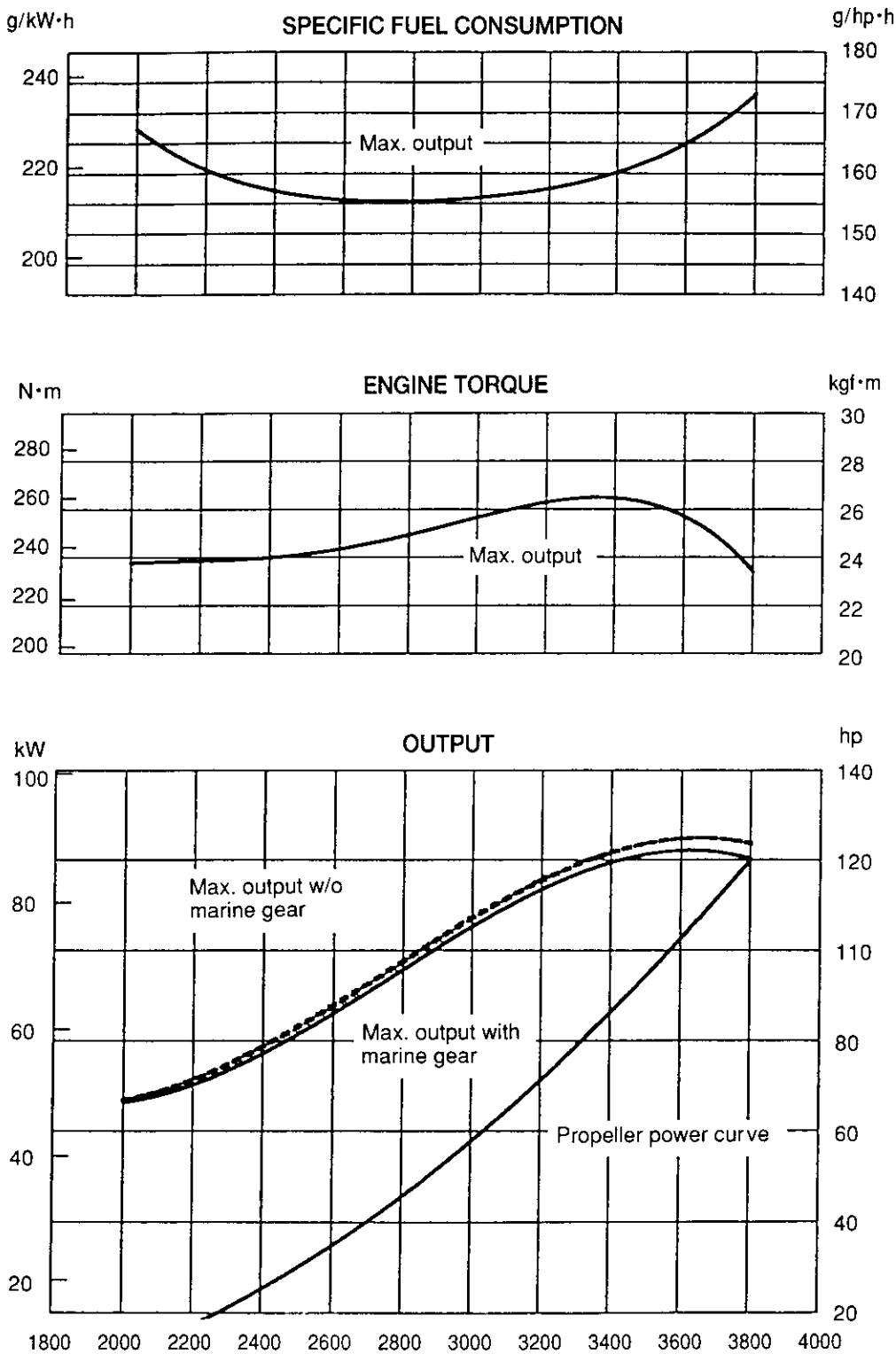
● 4JH3-TE (Max.output : 53.0kW/3800rpm with marine gear)



● 4JH3-HTE (Max.output : 70.6kW/3800rpm with marine gear)



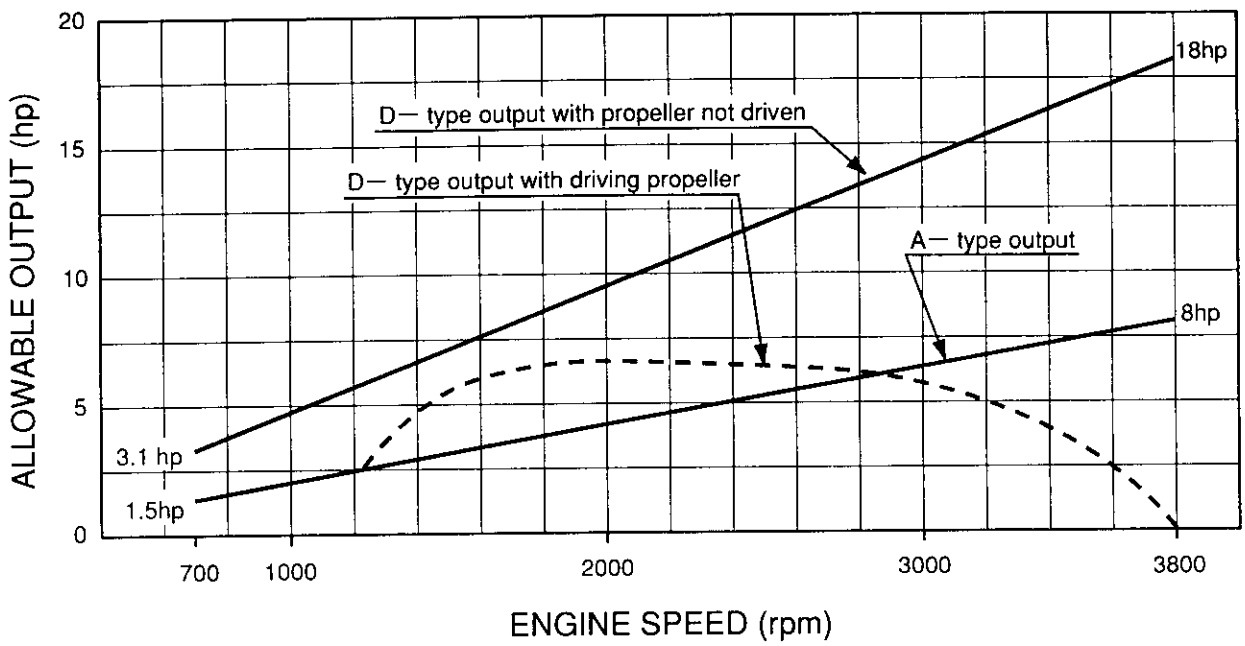
● 4JH3-DTE (Max.output : 88.3kW/3800rpm with marine gear)



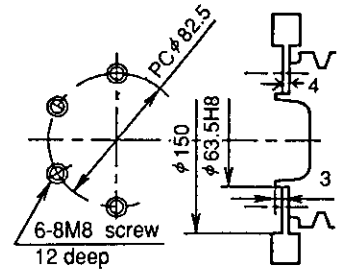
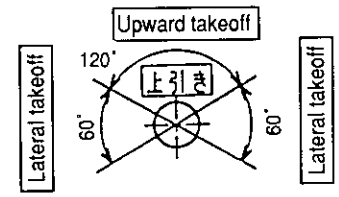
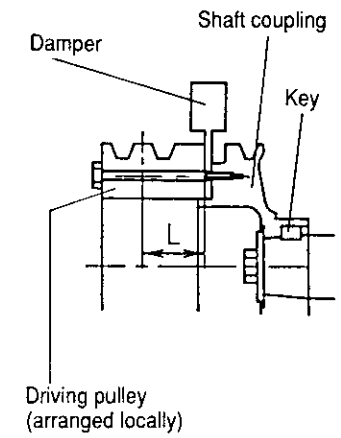
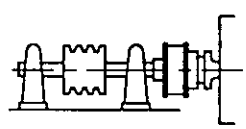
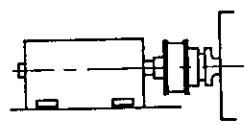
2.6 Front Power Take-off

(1) Allowable Output

● 4JH3-TE, HTE, DTE



(2) Power takeoff method

				Schematic drawing	Remarks
Power takeoff	Shaft coupling		Material : S45C (129693 / -21650)		To install the power takeoff pulley, use bolts, SCM (JIS 10.9T equivalent) and spring washers. Torque to 3.8 Kgfm (37.3N·m)
Power takeoff method	Method A	Lateral takeoff	8hp (Max)		
		Upward takeoff	Unallowable		
		Condition ①	L (shown in the figure) = 44mm or less Pulley outside diameter = 200 mm or less Pulley GD² = 0.2 Kg·m² or less (If L exceeds 44 mm, calculate the horsepower using the equation shown in the right column.)	Drive the belt without external bearing. 	①Correction equation for permissible takeoff horsepower (hP) at L in excess of 44 mm $hp = \frac{182}{L+138} \times hp.$ L : Both ends of the shaft coupling to the pulley groove center (mm) hpo : Allowable output in the diagram of page 2-11 ②The total weight of the support and driven machine must be 10 kg or less. If it is exceeded, the rubber cushions must be changed.
		Condition ②	The driven machine must be installed on the support which extends from the engine side. If the takeoff horsepower is 4 hp or less (lateral takeoff), a Yanmar tension clutch (VC 5 type) may be used in place of the support above.		
	Method D	Takeoff	Max. 23hp (4JH3(C)E) 18hp (4JH3-TE,-HTE,-DTE)	DI 1 method: The bearings at both ends are supported through a universal joint. 	———
		Condition	A universal joint (128695-21700) must be used.	DI 2 method: The working machine is directly coupled through a universal joint. 	

2.7 Fuel Oil

(1) Selection of Fuel Oil

Use the following diesel fuels and select fuels of a higher quality for best engine performance.

[Diesel fuel standard for various countries]

- **ISO 8217 DMA**
- **ASTM D 975 Grade No.1-D or No.2-D**
- **JIS K2204 Grade No.2, No.3 or special-No.3**
- **BS 2869 Part-1 class-A1 or A2**

At low temperatures, fuel oil becomes difficult to ignite and will not flow easily, making starting difficult. Select fuel oil of a cetane of 45 or greater to insure ignitability, and use the outside temperature as a guide for selecting the proper grade to insure fluidity.

(2) Handling of Fuel Oil

- Keep the fuel oil in a clean container. Store the container in a place away from rain and dirt as water and dust mixed in with the fuel cause engine failure.
- Keep the fuel container stationery for several hours to allow any dirt or water to settle to the bottom. Use a pump to extract the clear, filtered fuel from the top of the container for use.

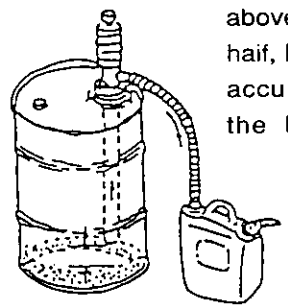
(3) Fuel Piping CUSTOMER

Install the fuel pipe from the fuel tank to the fuel pump in accordance with the diagram to the right. Be sure to attach a drain cock to the fuel tank to enable dirt and water which have settled at the bottom of the tank to be drained off. The oil/water separator (optional) is placed at the center section of the line.

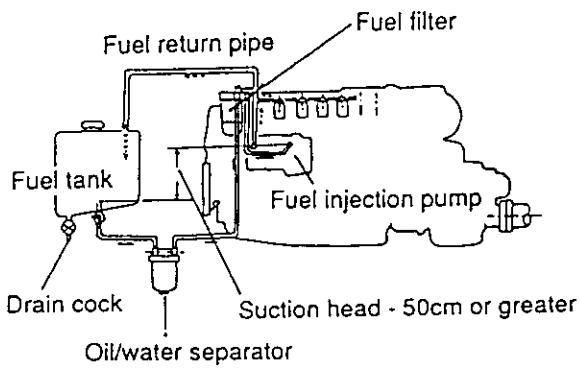
[NOTICE]

When other than the specified fuel oil is used, the engine will not perform to full capacity and parts may be damaged

Sample for recommended fuel oil		
Standard for fuel oil	JIS K2204	ASTM D975
Pour point (Temperature)		
-7.5℃ or greater	Grade No.2	Grade No.2-D
-20℃ or greater	Grade No.3	Grade No.1-D
-30℃ or greater	Grade No.3-Sp.	
Cetane fuel numbe	45 or greater	40 or greater



Pump up only fuel above the down haif, leaving dreg accumulated on the bottem.



2-8 Lube oil

(1) Selection of Engine Lube Oil

Use the following lube oil:

*API Classification·····CD
(Standards of America Petroleum Institute)
*SAE Viscosity ·····15W40
(Standards of Society of Automotive Engineering)

[NOTICE]

Using other than the specified lube oil will lead to seizure of parts inside the engine and gear device, abnormal wear, and shorten engine life. It will also effect the starting ability and power output.

(2) Selection of Marine Gear Oil

Refer to the operation manual for the marine gear for the selection of the proper lube oil.

(3) Handling the Lube Oil

- When handling and storing lube oil, be careful not to allow dust and water to enter the lube oil. Clean around the filler port before refilling.
- Do not mix lube oils of different types or brands.
  Mixing may reduce the lubricating performance. Different oils are used for the engine and the marine drive unit.
  Be careful to use the correct oil for each one and store in separate clearly labeled containers.

2-9 Cooling Water

- Always use soft water (tap water) for the fresh water. Never use dirty water or hard water. Impurities in the cooling water cause scale and rust to build up in the cooling system reducing cooling efficiency and causing the engine to overheat.
- During the cold season, add antifreeze to the cooling water to prevent freezing.
  Failure to add antifreeze will result in damage to various parts in the cooling water system.
- Consult your Yanmar dealer or distributor on the use of antifreeze, anti-rust, and detergents.

[NOTICE]

- **Refer to the instructions accompanying the antifreeze for the proper mixing ratio. Select the ratio for the lowest temperature of the cold season. If the mixture is too thick, the cooling efficiency will be reduced.**
- **Do not mix different brands of antifreeze or anti-rust. Mixing reduces cooling efficiency and leads to parts damage.**
- **When the amount of cooling water is too low, refill with fresh water only.**

3. Overhaul

3.1 Operating Cautions

(1) Safe operation

To operate this equipment safely, read the safety precautions at the beginning of this manual carefully.

(2) Checking the engine history

Preparations are necessary to overhaul these engines accurately and efficiently. Check the engine history by looking through the customer's service records.

(2.1) When was the last time the engine was overhauled?
(2.2) How long has the engine been used since the previous overhaul was performed?
(2.3) What problems were found the last time the engine was overhauled? What measures were taken to deal with them?
(2.4) What replacement parts are expected to be used during this overhaul?
(2.5) Are there records or check lists that will be necessary for this overhaul?

(3) Preparation for disassembly

(3.1) Assemble the general tools, specialized tools, measuring instruments, lubricants, disposable parts, replacement parts, etc.
(3.2) When complicated components are disassembled, put ID marks or alignment-marks on the parts removed so that they can be reassembled correctly and efficiently.

(4) Cautions during disassembly

(4.1) When each part is removed, examine the conditions of the area where the part was installed and check both for deformation, damage, rough surfaces or flaws.
(4.2) Lay out the parts in the order you remove them. Divide them into parts which need to be replaced and parts which will be reused.
(4.3) Wash and clean the parts to be reused thoroughly.

(5) Checking and measuring

(5.1) Check and measure any part which will be reused, as necessary. Check to determine if it is reusable.

(6) Assembling

(6.1) Assemble the parts in the correct order by performing the steps according to the specified criteria (tightening torque, adjustment values, etc.). On specified important bolts and nuts, apply oil before tightening them.
(6.2) Be sure to use genuine replacement parts.
(6.3) A new oil seal, O-ring and packing must be used.
(6.4) In some places where packing is used, apply seal packing as necessary. Apply oil or grease to sliding surfaces. Grease the lip of oil seals before they are installed.

(7) Adjusting and checking

(7.1) Adjust to the specified service tolerances using a gauge and tester.

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3.2 Overhaul Preparations

Before overhauling the engine, make the following preparations.

①Secure the engine on a strong flat workbench.

⚠ Caution

The engine must be secured tightly. Otherwise the engine could fall during the overhaul, causing serious injury or damage to parts.

②Drain the engine cooling water, lubricating oil and fuel oil.

③Clean any dirt, oil, or dust off the engine with compressed air or by steam cleaning it.

[NOTICE]

Take care to keep dust out of the engine when cleaning it.

⚠ Caution

When compressed air or steam is used, make sure to wear eye protection.
Loose material may be blown into your eyes.

[NOTICE]

- **Replace any part which is found to be defective during a check or measurement. Also, replace any part whose measured value is out of the specified standard value or limits.**
- **Even when the measured value of a part is with in the specified reference value or limit, replace the part if you expect it to wear out before the next overhaul.**

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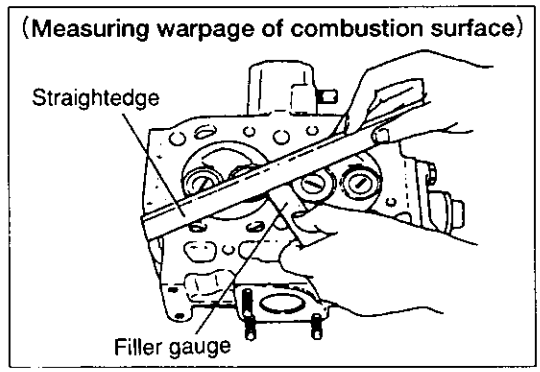
3.3 Overhaul

3.3.1 Cylinder Head



(Measuring warpage of combustion surface)

(1) Combustion surface

① Inspect the warpage of combustion surface

a) Clean the cylinder head.

b) With a straightedge put in four places on each side and opposite two places respectively, measure a clearance between the straightedge and combustion surface using a filler gauge.

(mm)

	Standard	Limit
Head distortion	0.05 or less	0.15

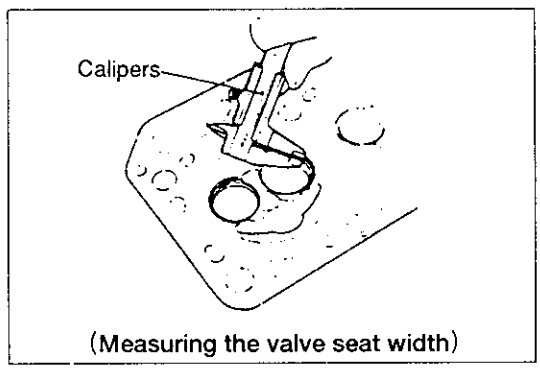
② Check on the combustion surface
Remove the fuel valve, intake and exhaust valve. Clean the combustion surface and check it for discoloration, deformation or crack.

(2) Valve seat

①Remove the intake and exhaust valve.
Check the seat surface and seat width. If the seat is too wide or if the seat surface is considerably rough, correct the seat surface using a seat grinder.

(mm)

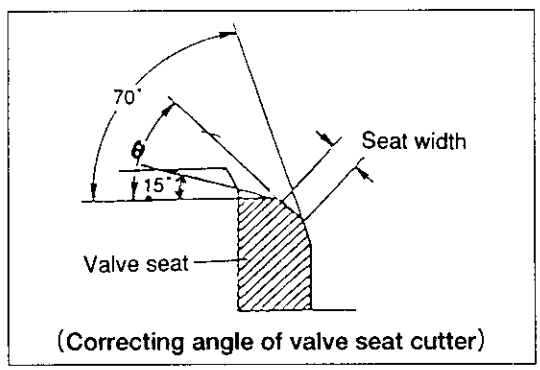
Valve seat width	Standard	Limit
Intake	2.0	2.5
Exhaust	1.3	1.8



(Measuring the valve seat width)

②If the valve seat is wider than the standard, grind the seat surface using a 70° grinder first and then finish the seat width to the specified size using a 15° grinder.

Angle	θ
Intake	30°
Exhaust	40°



(Correcting angle of valve seat cutter)

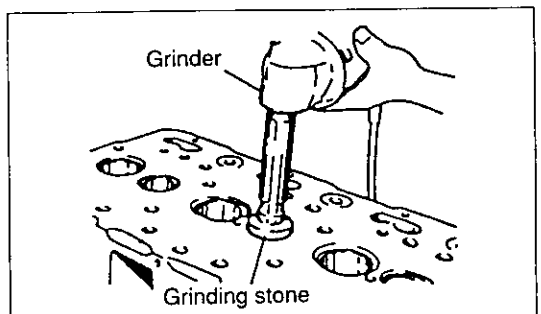
[NOTICE]

If correcting the valve seat is needed, be sure to check a clearance between the valve stem and valve guide. If the clearance exceeds the limit, replace the valve or valve guide first and then correct the seat.

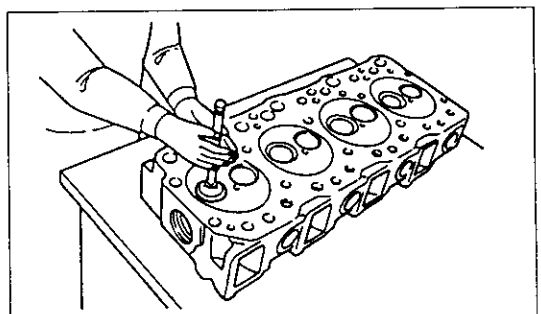
③Knead a valve compound with oil and lap the valve and valve seat using it.
④Tap it with oil only and finish.

[NOTICE]

- **After correcting the valve seat, fully clean the valve and cylinder head with fuel oil until a residual lapping compound or abrasive is removed completely.**
- **For slightly poor smoothness, the steps ③ and ④ will do.**

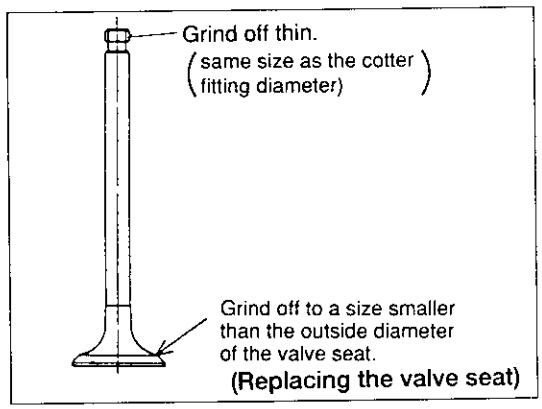


(Correcting the valve seat)

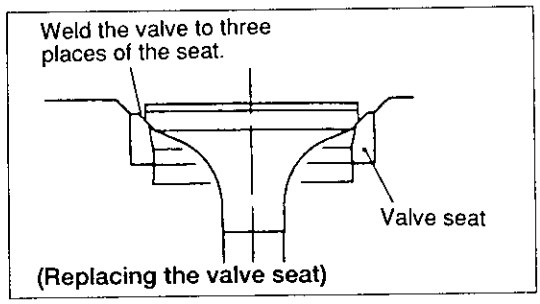

(Lapping valve and valve seat)

⑤Replacing the valve seat
If the valve seat cannot be corrected due to great wear or eccentric wear, replace the valve seat

- Pulling out valve seat
  - ■ Grind off the valve head of a intake/exhaust valve in use or out of service to a size smaller than the outside diameter of the valve seat.
  - ■ Grind off the end of valve stem until its outside diameter is the same as the diameter where the cotter is fitted.
  - ■ Weld three places of the valve head of the intake/exhaust valve to the valve seat.
  - ■ Tap the end of the intake/exhaust valve stem and tap out the valve seat.

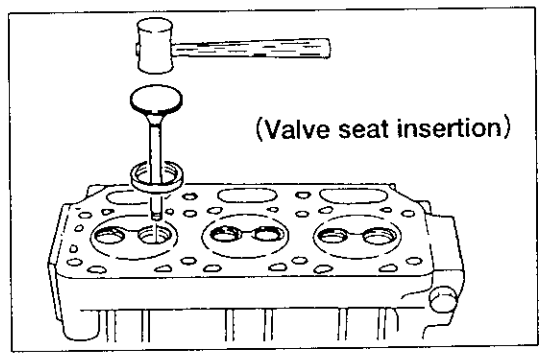


(Replacing the valve seat)



(Replacing the valve seat)

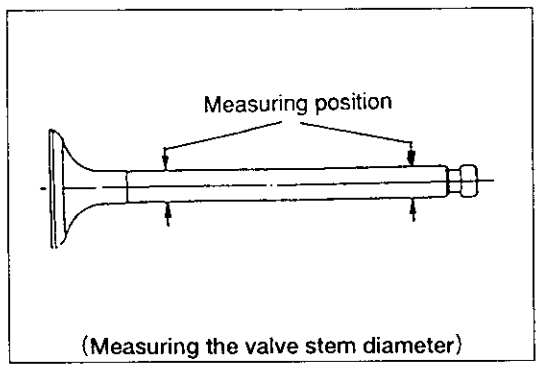
- Inserting a valve seat
  - ■ Put a valve seat in liquid nitrogen to cool it fully. Alternatively, put dry ice in a container filled with ether or alcohol and put the valve seat in the container.
  - ■ Heat the periphery of the valve seat insertion position on the cylinder head to 80 to 100℃ using a dryer.
  - ■ Securely insert the fully cooled valve seat into the cylinder head using a new intake/exhaust valve by tapping the valve head of the intake/exhaust valve.
  - ■ Let the entire cylinder head stand until it cools uniformly to the surrounding temperature.


(Valve seat insertion)

(3) Intake/exhaust valve and valve guide

①Valve stem and valve guide

Replace a worn-out valve stem or valve guide.
Install a valve stem with oil applied to it.



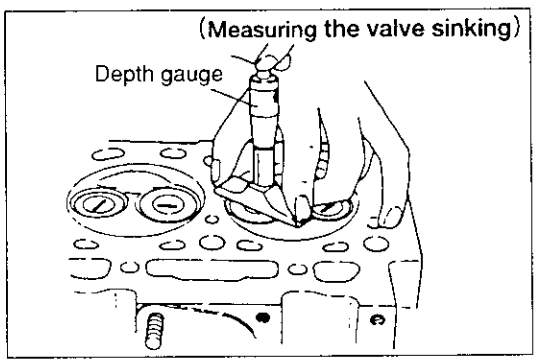
(Measuring the valve stem diameter)

(mm)

		Standard		Standard oil clearance	Max.oil clearance	Limit
Intake valve	Stem diameter	φ8	−0.025 −0.040	0.035~0.065	0.2	−0.1
	Valve guide inside diameter		+0.025 +0.010			+0.1
Exhaust valve	Stem diameter	φ8	−0.030 −0.045	0.045~0.075	0.2	−0.1
	Valve guide inside diameter		+0.030 +0.015			+0.1

②Valve sinking

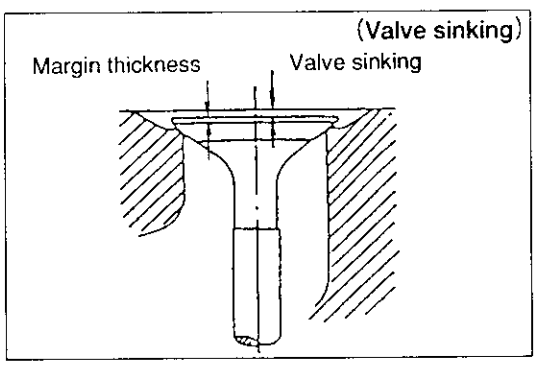
Over long periods of use and repeated the lapping combustion efficiency may drop. Measure the valve sinking and replace the valve and valve seat if the valve sinking exceeds the limit.



(Measuring the valve sinking)

(mm)

Intake/exhaust valve	Standard	Limit
Valve sinking	0.4±0.1	1.5
Margine thickness	1.2	0.7

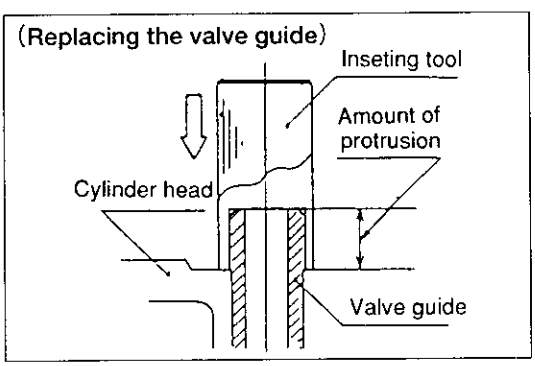


(Valve sinking)

③Replacing the valve guide

- Pull out the valve guide from the cylinder head using a puller tool.
- Put dry ice in a container filled with ether or alcohol. Put the valve guide in the container to cool it. Tap the valve guide in to the cylinder head using a valve guide inserting tool.
- Check the inside diameter. Finish it to the standard.
  inside diameter as necessary using a reamer.
- Check the amount of protrusion from the cylinder head.

Amount of protrusion 14.7~15.0 mm

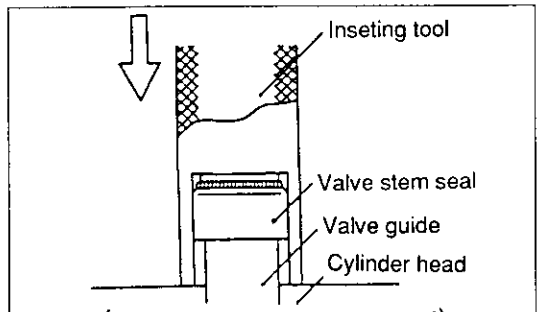


(Replacing the valve guide)

⚠ Caution

Do not touch a cooled valve guide with bare hands. Damage to the skin may result.

④Replacing the valve stem seal
Any disassembled intake/exhaust valve must be replaced with a new valve stem seal.
Take care not to confuse the intake with exhaust side.
- Apply engine oil to the valve stem seal lip.
- To install the valve stem seal, push it in using an inserting tool.



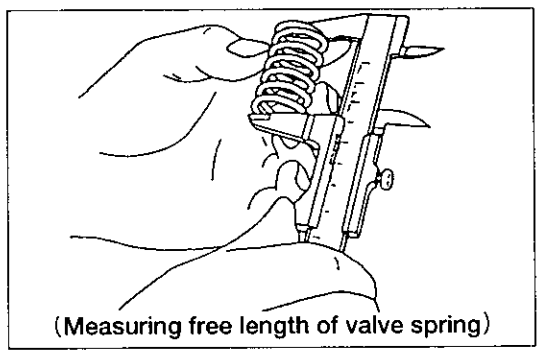
(Installing the valve stem seal)

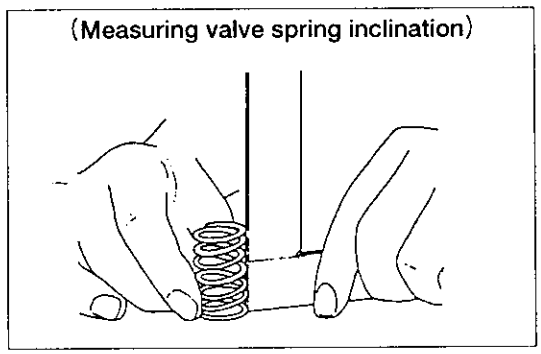
(4) Valve spring

Check the valve spring. Any valve spring in excess of the limit must be replaced.
①Check the appearance for flaw or corrosion.
②Measure the free length.
③Measure the inclination.
④Measure the spring tension using a spring tension tester.

(mm)

Valve spring	Standard	Limit
Free length	44.4	−1.4
Inclination	1.9	2.2
Tension (when compressed 1 mm)	K_1=2.71 kgf K_2=3.61 kgf	——


(Measuring free length of valve spring)

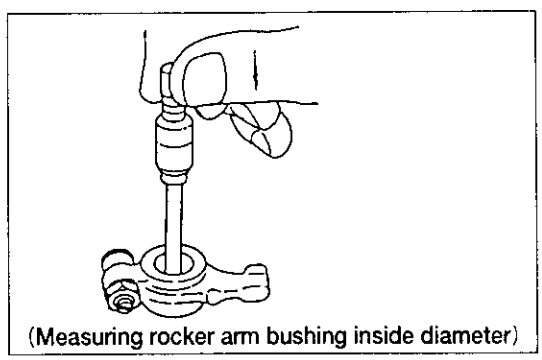

(Measuring valve spring inclination)

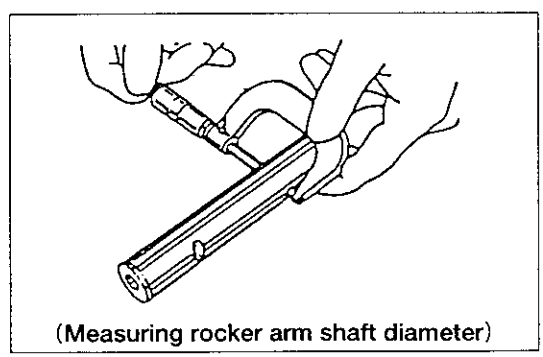
(5) Rocker arm and push rod

The rocker arm opens or closes a valve. The engine performance such as the output depends on the valve timing.
①Rocker arm shaft and rocker arm bushing
Measure the rocker arm shaft diameter and rocker arm bushing inside diameter. Any rocker arm shaft or rocker arm bushing in excess of the limit must be replaced.

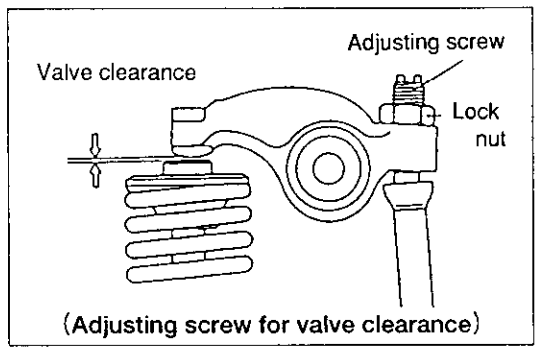
(mm)

	Standard	Limit
Rocker arm shaft diameter	$\phi 16\ ^{-0.016}_{-0.034}$	−0.1
Rocker arm bushing inside diameter	$\phi 16\ ^{+0.018}_{-0}$	0.05
Oil clearance	0.016~0.052	0.15

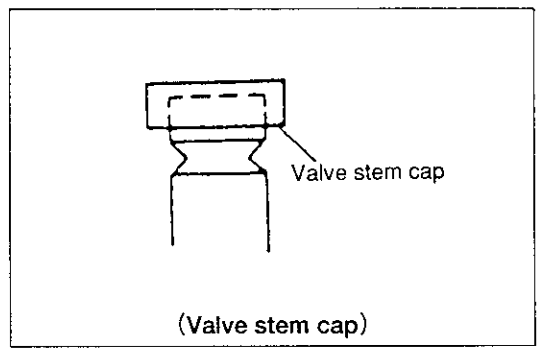

(Measuring rocker arm bushing inside diameter)


(Measuring rocker arm shaft diameter)

②Check on the rocker arm and valve stem cap
Check the contacting surface between the rocker arm and the valve stem cap and the contacting part between the valve clearance adjusting screw and the push rod for wearing and flaking. Replace it if worn or flaked.



(Adjusting screw for valve clearance)

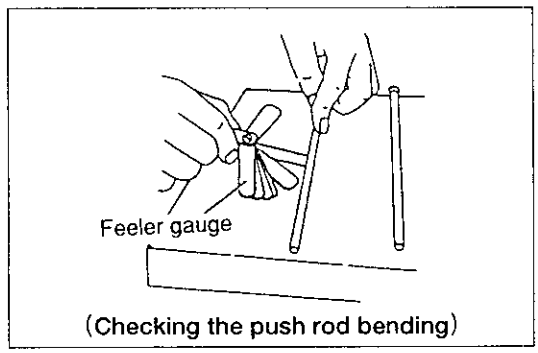


(Valve stem cap)

③Checking the push rod for damage or bending

(mm)

Push rod	Standard	Limit
Bending	TIR 0.03	0.06



(Checking the push rod bending)

④Adjustment of valve clearance
When the engine is cold, make sdjusting valve clearance at the compression top dead center. (T.D.C/compression)

(mm)

Valve clearance	0.2 ±0.05

(6) Installing the cylinder head

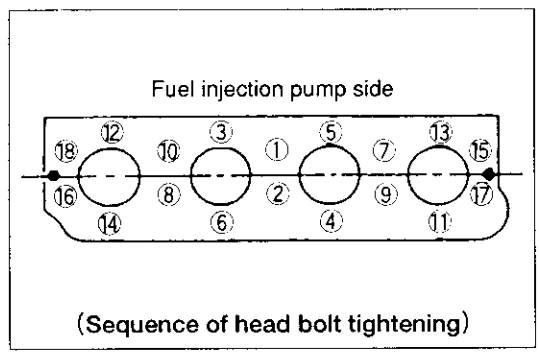
To install the cylinder head, the clamping bolts must be tightened in the specified sequence using a torque wrench to prevent the head from being distorted.

①The sequence of tightening is shown in the figure.

②Apply engine oil to the threaded portions and the seat of head bolts, tighten them in two steps.

(N・m)

	First step	Second step
Tightening torque	5	9.3±0.3(91.4±0.94)



(Sequence of head bolt tightening)

3-3-2 Piston

The piston is made of aluminum alloy casting with less thermal expansion and excellent cooling characteristics. The ellipticity of the piston is so designed that the piston will smoothly contact the cylinder surface during operation to minimize the oil consumption.
The piston ring consists of two compression rings and one oil ring.
The piston cooling oil nozzle fixed to each cylinder injects lubricating oil for cooling. For the piston and cylinder block, a combination of size marks is used.

(1) Piston

①Combination of piston and cylinder block size marks
To optimize the oil clearance between the piston and cylinder block, a size mark (L, M, S) is shown (on the top face of a piston and on the top of the cylinder block, respectively). The same marks must be used in combination. During disassembly, take care to use a proper combination of cylinders.

○ : OK × : NO

Combination		Piston			
		L	ML	MS	S
Cylinder block	L	○	○	×	×
	M	×	○	○	×
	S	×	×	○	○

②Cleaning the piston top and combustion surface
Clean the carbon deposits off the piston top and combustion surface. Take care not to damage the piston. Check the combustion surface for damage.

③Measurement of the piston diameter

- Measure the piston diameter at the position of 22 to 25 mm from the piston bottom in a direction at right angles to the piston pin hole.
- If the piston periphery and the ring groove are worn or damaged, replace them.

(mm)

	Mark	Standard		Wearing limit
Piston diameter	L	φ83.932	+0.015 +0.005	−0.25
	ML		0.005 0	
	MS		0 0.005	
	S		−0.005 −0.015	

(2) Piston pin

The piston pin is of floating type. During the replacement of a piston, the piston pin can be pushed into the piston pin hole at room temperature by hand.

(mm)

	Standard		Wearing limit
Diameter of piston pin hole	φ28	+0.009 0	+0.05
Piston pin diameter		0 −0.013	−0.05
Oil clearance		0~0.022	0・10

(3) Piston ring

①Measurement of piston ring thickness

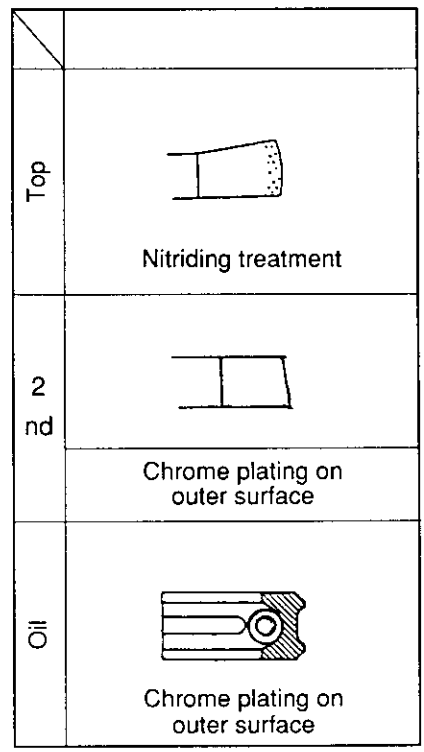
For the ring thickness, measure the clearance created when the ring is pushed into the ring groove. If it is in excess of the limit, replace the ring.

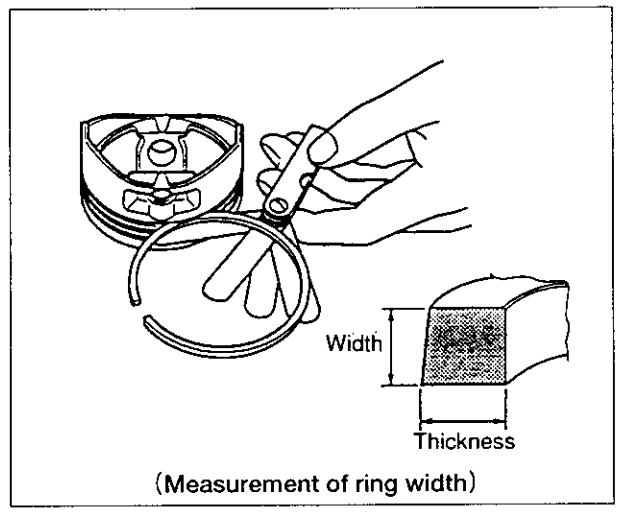
(mm)

		Standard			Limit	
2nd ring	Groove width	2	+0.065 +0.050	0.06~0.095	+0.15	0.20
	Width		−0.010 −0.030		−0.10	
Oil ring	Groove width	4	+0.035 +0.020	0.03~0.065	+0.15	0.20
	Width		−0.010 −0.030		−0.10	

(Note) The top ring, which is a keystone ring, cannot be measured.

Ring shape



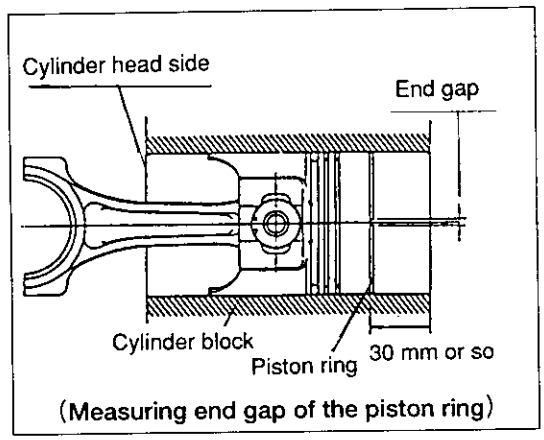


(Measurement of ring width)

②Measuring end gap of the piston ring
Push a piston ring into the cylinder on the top part of the piston and measure the end gap of the ring using a thickness gauge. The position where it is inserted must be 30 mm or so away from the cylinder bottom.

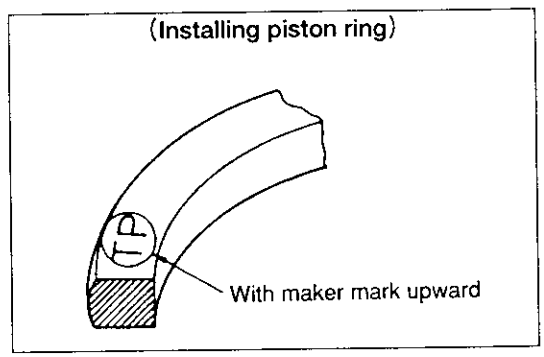
(mm)

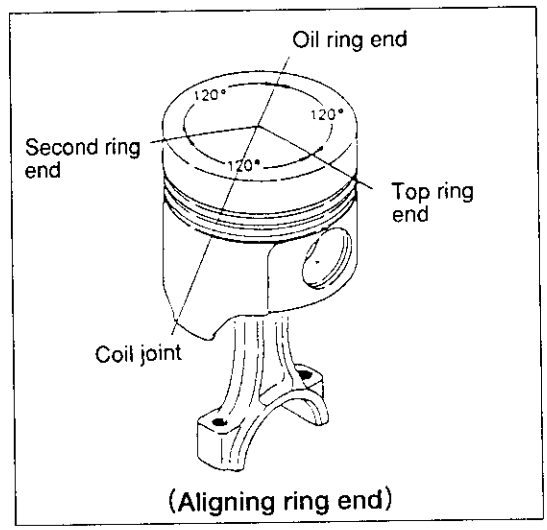
End gap	Standard	Limit
All rings	0.2~0.4	1.5



(Measuring end gap of the piston ring)

③Replacing the piston ring
In replacing the ring, carefully clean the groove. Install the piston ring so as to prevent it from stretching excessively using the piston ring expander with the ring end surface on which the maker mark is shown upward.





3.3.3 Cylinder Block

For the cylinder bore of the cylinder block, a sleeveless structure (integration of a cylinder block and liner) is employed. Therefore, replacing the cylinder liners, which is performed for a conventional engine, cannot be conducted.

Instead, the cylinder unit is so designed that it can be overhauled using an oversize piston with the cylinder reboring.

①Check on the cylinder block

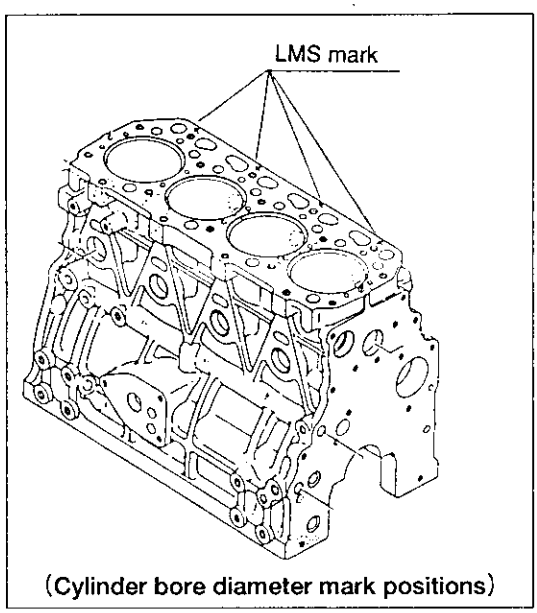
- Make a visual check for leakage of water or oil and crack in the external surface. If a crack is suspected, make a color check to locate the crack.
- If there is any unamendable damage, replace the cylinder block.
- Completely clean each oil hole and check it for clogging.

②Cylinder bore diameter and size mark

- There are size marks L, M and S which show a cylinder bore diameter on the top of the cylinder block.

(mm)

	Size mark	Reference value		Limit
Cylinder bore diameter	L	φ84	+0.03 +0.02	+0.2
	M		+0.02 +0.01	
	S		+0.01 0	
	Circularity	0.01 or less		0.03
	Cylindricity	0.01 or less		0.03

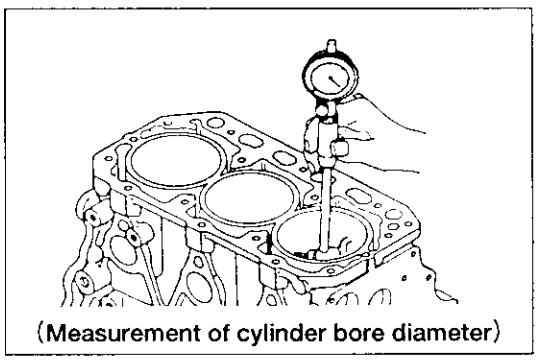


(Cylinder bore diameter mark positions)

- The cylinder bore diameter must be measured at three places:10 mm from the cylinder top face, 20 mm from the cylinder bottom and the center.

  Circularity: Difference between the maximum and minimum in the same cross section

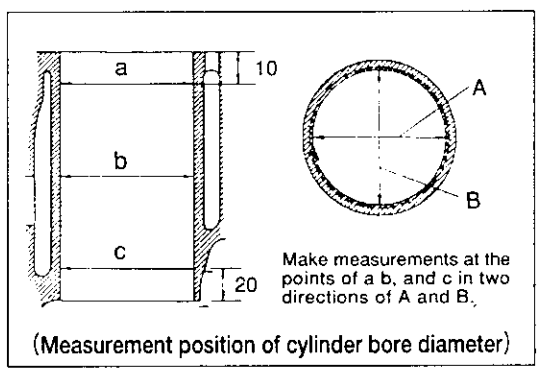
  Cylindricity: Difference between the maximum and minimum in the same direction


(Measurement of cylinder bore diameter)

③Honing

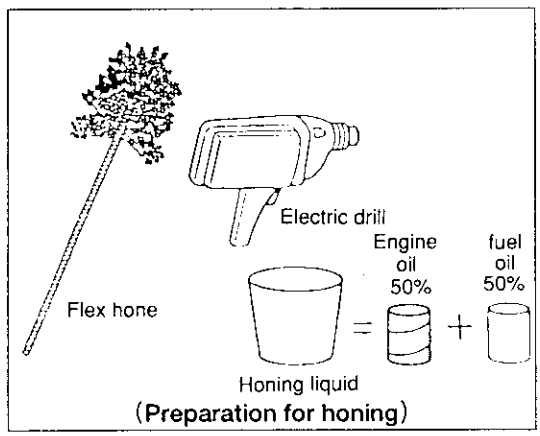
If a cylinder suffers eccentric wear or flaw, perform the honing or boring.

For slight eccentric wear or flaw, the honing with a flex hone will do. For great eccentric wear, however, the honing must be performed after the boring.



(Measurement position of cylinder bore diameter)

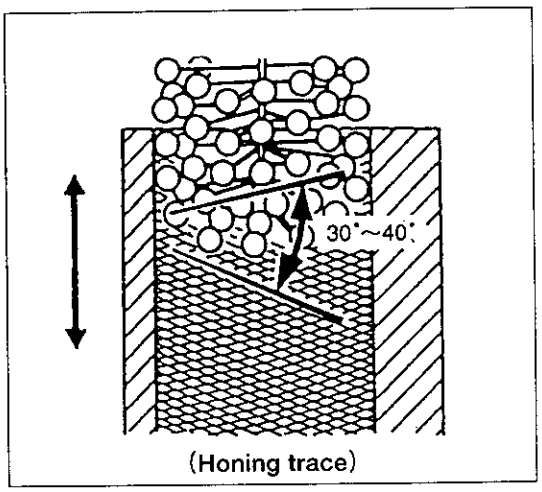
- Preparations for honing
  - ■ Flex hone
  - ■ Electric drill
  - ■ Honing liquid (mixture of 50% of engine oil and 50% of fuel oil)



(Preparation for honing)

● Procedures for honing

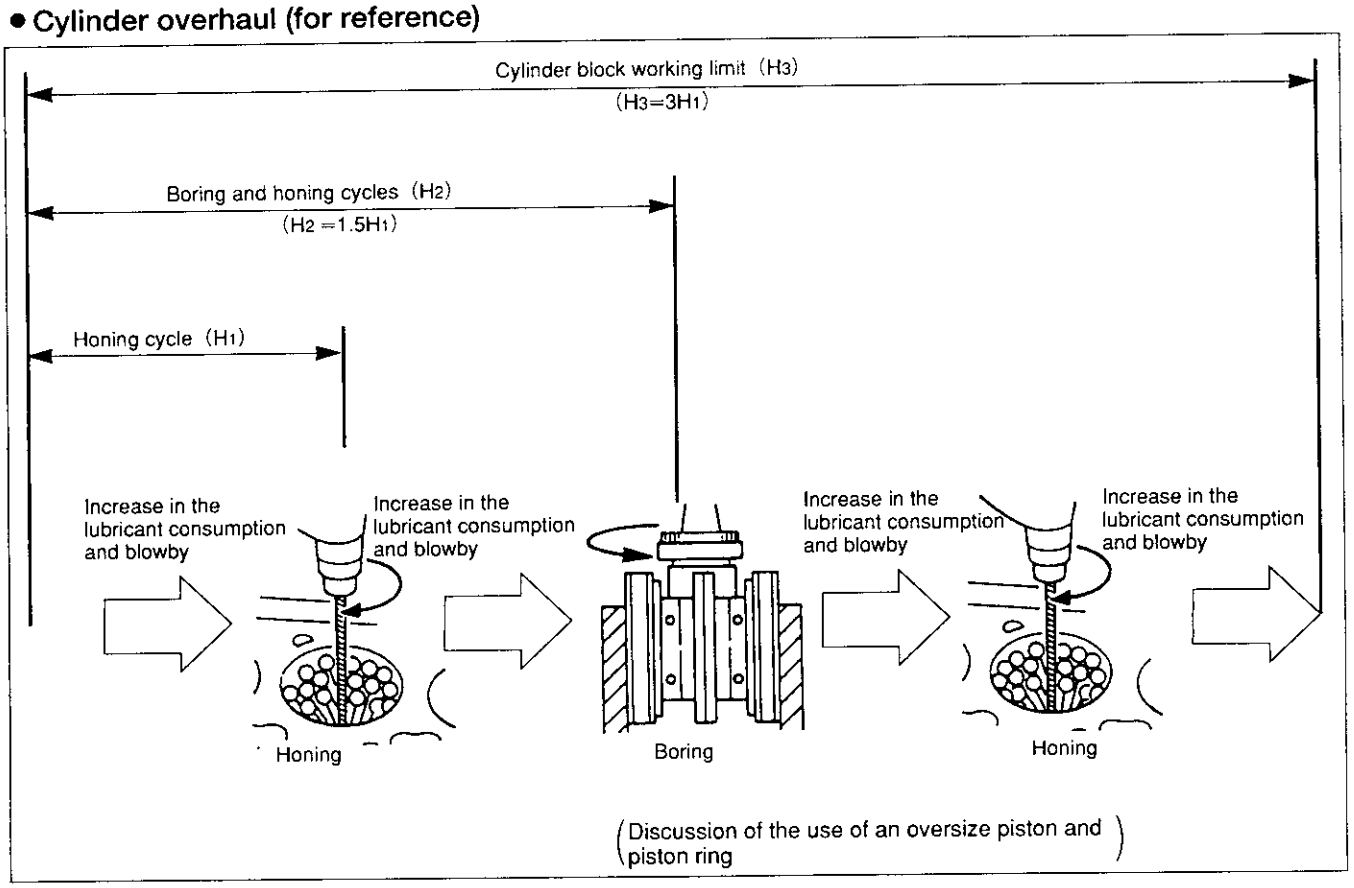
With a honing liquid applied to the flex hone, insert the electric drill which rotates at 300 to 1200 rpm into the cylinder bore and move the flex hone upward or downward so that honing traces will be obtained at an angle of 30 to 40 degrees.



[NOTICE]

(1) Avoid a high speed rotation in excess of 1200 rpm. Such a high speed rotation may cause damage.
(2) The hone will cause damage to the cylinder if the hone is inserted or removed with it stopped.
(3) The grinding amount per honing must be limited to 1/1000 mm or so.

● Cylinder overhaul (for reference)



3.3.4 Connecting Rod

The connecting rod is a carbon steel casting with high strength. Aluminum metal is attached to the big end which is horizontally split type and a winding bushing of two-layer copper alloy is used for the small end.

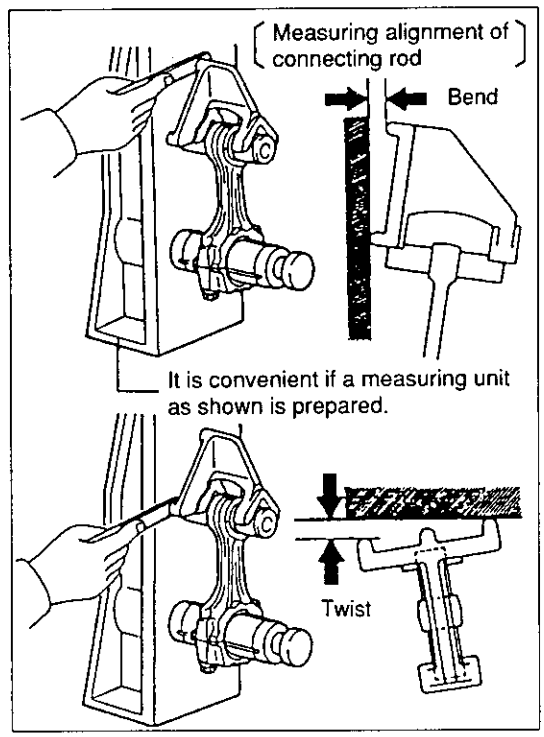
(1) Connecting rod

①Bend and twist of connecting rod

If the piston ring end moves during operation or if the piston is one-sidedly hit strongly, measure the torsion and parallelism. If these values exceed the limit, correct or replace the rod.

(mm)

	Standard	Limit
Bend and twist	0.03 or less/ 100 mm	0.07

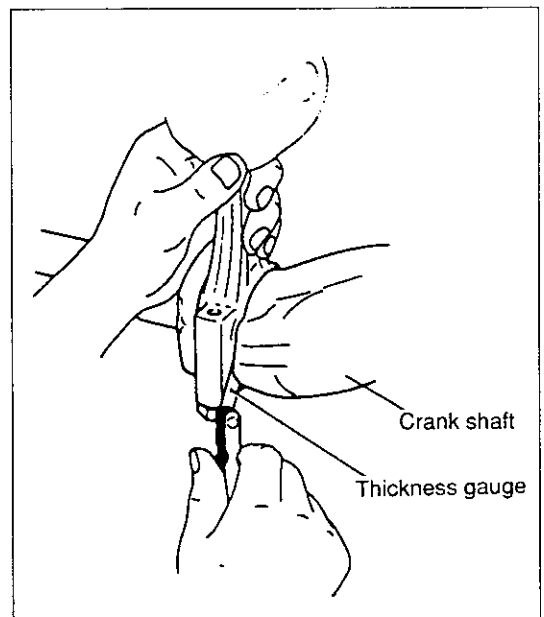


②Thrust clearance of connecting rod

Install the connecting rod to each crank pin and check the thrust clearance in the crank shaft direction using a thickness gauge.

(mm)

	Standard	Limit
Thrust clearance	0.20～0.40	0.55



(Measuring thrust clearance of connecting rod)

(2) Crank pin metal

①Check on crank pin metal

Make a check for flaking, melting or seizing of metal surface.

②Measuring oil clearance

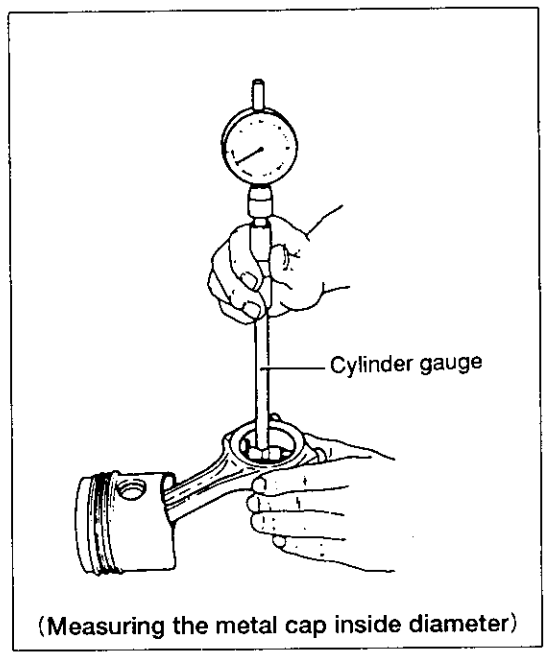
- Measure the inside diameter of the crank pin metal.
- Measure the Crank pin diameter.

(mm)

	Standard	Limit
Metal cap inside diameter	$\phi 51\ ^{+0.019}_{0}$	—
Metal thickness	$1.5\ ^{0}_{-0.013}$	−0.02
Crank pin diameter	$\phi 48\ ^{-0.038}_{-0.048}$	−0.07
Oil Clearance	0.038~0.093	0.13

Tightening torque of rod bolt kgf·m (N·m)
$5.0\ ^{+0.5}_{0}\ (49.00\ ^{+4.90}_{0})$

(Note) Apply engine oil to the threaded portion of the bolt and the seat.



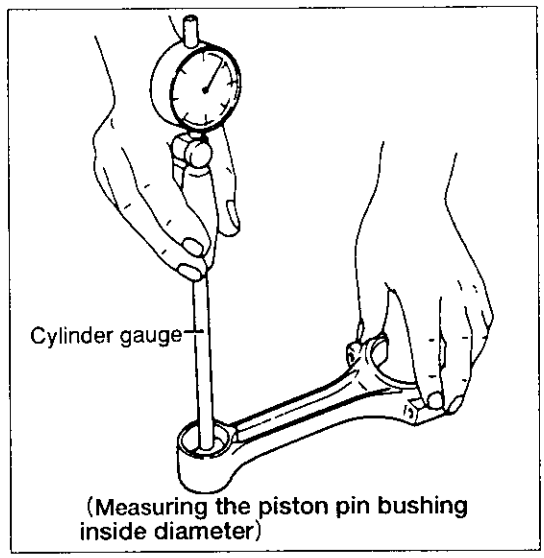
(Measuring the metal cap inside diameter)

(3) Piston pin bushing

Inspect the piston pin bushing for excessive wear which would cause damage to the piston pin or piston. Check the oil clearance. Calculate the oil clearance between the piston pin and bushing by measuring the piston pin diameter and piston pin bushing inside diameter.

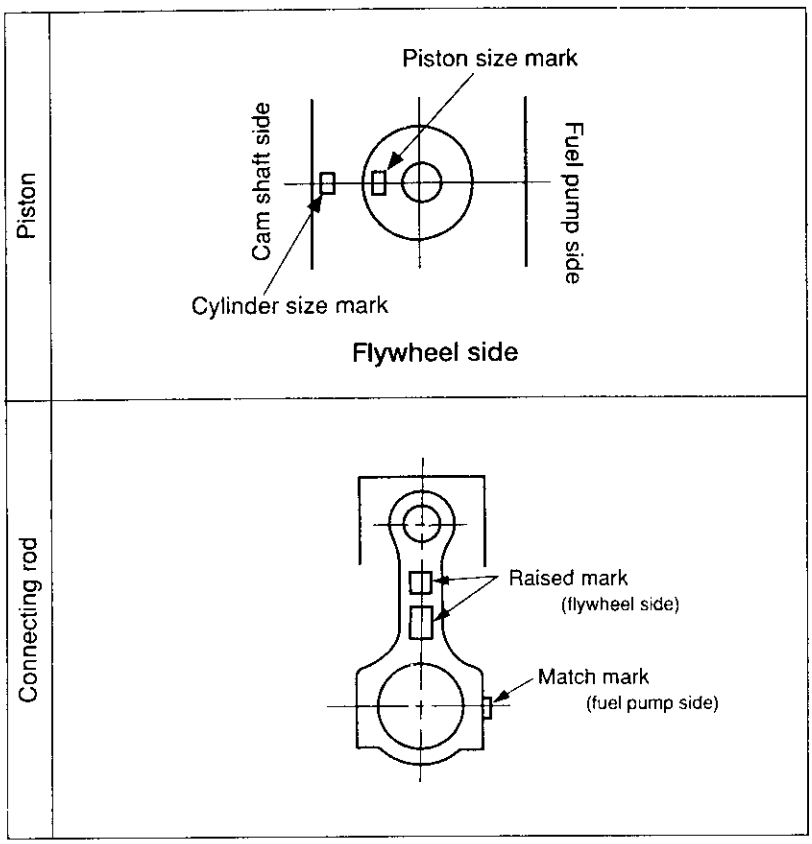
(mm)

	Standard		Limit
Piston pin bushing inside diameter	$\phi 28$	$^{+0.038}_{+0.025}$	+0.05
Piston pin diameter		$^{0}_{-0.013}$	−0.05
Oil clearance		0.025~0.051	0.07



(Measuring the piston pin bushing inside diameter)

(4) Assembling piston and connecting rod

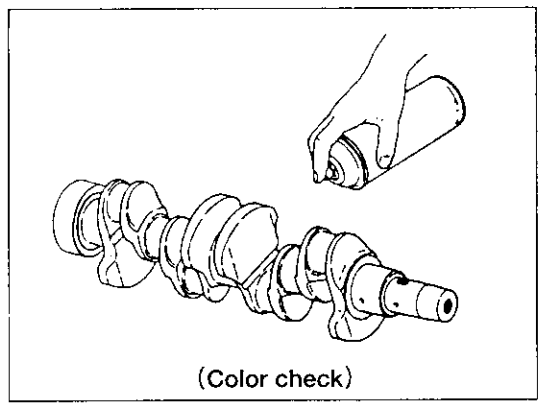


[NOTICE]

Ensure that the indentation in the combustion chamber is closer to the fuel pump viewed from the top of the piston.

3.3.5 Crankshaft and Main Bearing

The crankshaft is made of precision forging meterial. For the main bearing, aluminum metal with high durability is used.


(Color check)

(1) Crankshaft

①Color check of the crankshaft

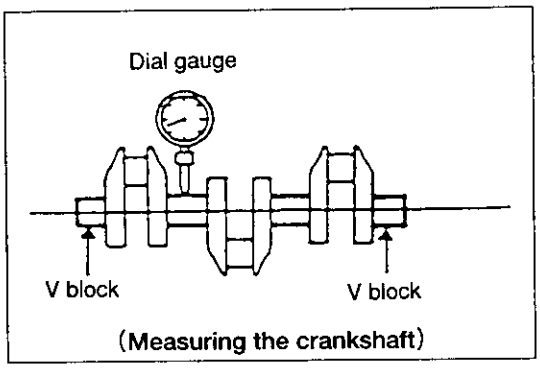
Clean the crankshaft and check it with a color check agent. If the crankshaft is cracked or damaged seriously, replace it. For minor damage, regrind for correction.

②Bend in crankshaft

Set the journals at both ends of the crankshaft on V blocks and measure the deflection of the central journal using a dial gauge while rotating it to mesure for a bend.

(mm)

	Standard	Limit
Crankshaft bend	TIR 0.02以下	0.03



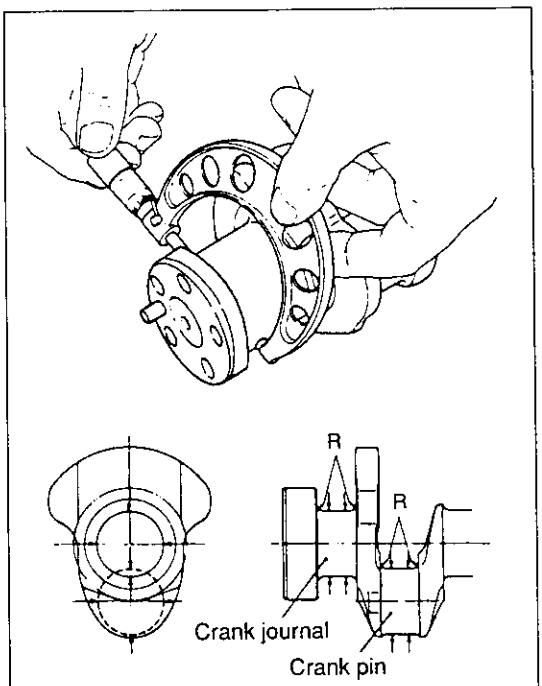
(Measuring the crankshaft)

③Measuring crank pin and crank journal

Measure the crank pin and crank jounal diameter. If there is abnormal wear, but the diameter is within the limit, re-grind for correction. If each diameter exceeds, the specified limit replace crankshaft. For the crank pin, refer to the description of the crank pin metal (3.3.4 (2)).

(mm)

Journal	Standard	Limit
Inside diameter of main bearing cap	$\phi 54\ ^{+0.019}_{0}$	——
Bearing thickness	$2.0\ ^{0}_{-0.013}$	−0.02
Crank journal diameter	$\phi 50\ ^{-0.038}_{-0.048}$	−0.07
Oil clearance	0.038~0.093	0.13



(Measuring positions of crankpin and journal)

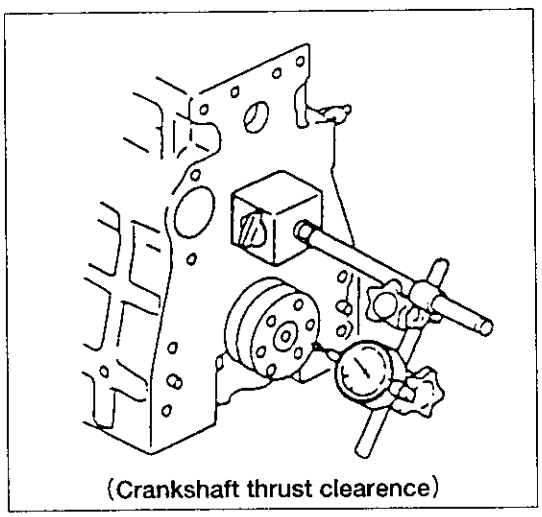
④Thrust clearence of crankshaft

Install the crank shaft and tighten the main bearing cap to the specified torque. Using a dial gauge put on the shaft end, push the shaft to the left and right to measure the thrust clearance.

If the thrust clearence exceeds the specified limit, replace the thrust metal.

(mm)

	Standard	Limit
Thrust clearence	0.09~0.27	0.33


(Crankshaft thrust clearence)

(2) Main bearing

①Check on main bearing

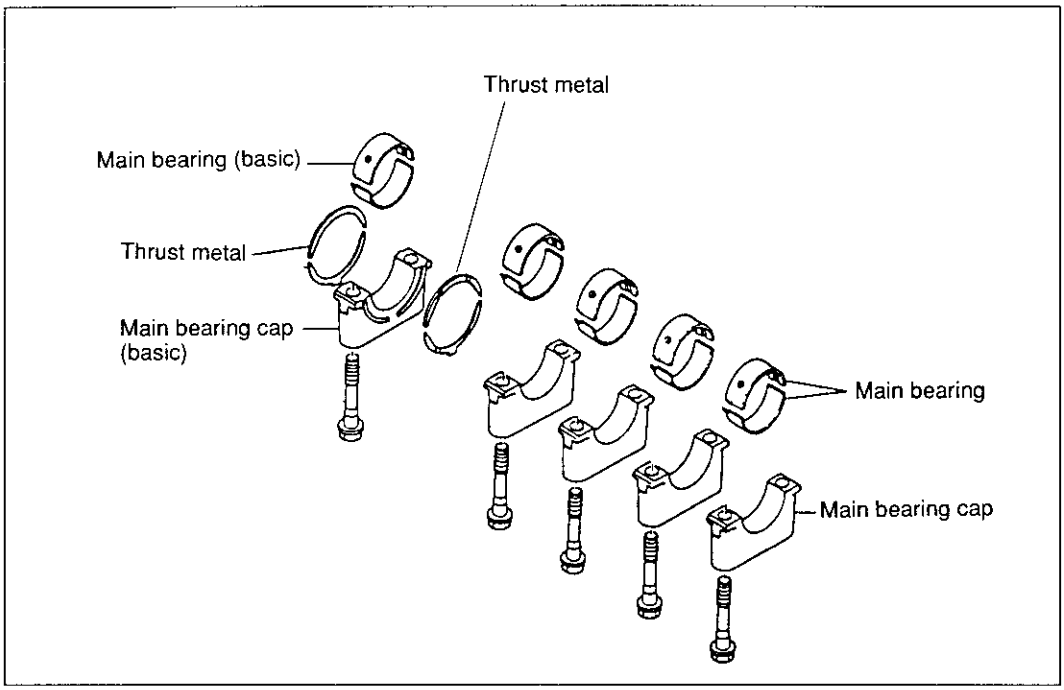
Check for flaking, melting or seizing If any damage on the bearing surface, replace the bearing.

②Measuring metal inside diameter

Tighten the cap to the specified torque and measure the metal inside diameter.

Main bearing cap bolt tightening torque kgf·m (N·m)
11±0.5 (107.91±4.9)

(Note) Apply engine oil to the threaded portion of the bolt and the seat.



[NOTICE]

To install the main bearing cap,

a) Note that the upper metal (on the block side) has an oil groove and that the lower metal has no oil groove.

b) Check the match No. to the cylinder block.

c) Set the alighing mark "FW" of the cap to the flywheel side.

d) Keep away from foreign matters between the metal cap and metal. Otherwise seizing or unsmooth surface bearing may result.

3.3.6 Camshaft and Tappet

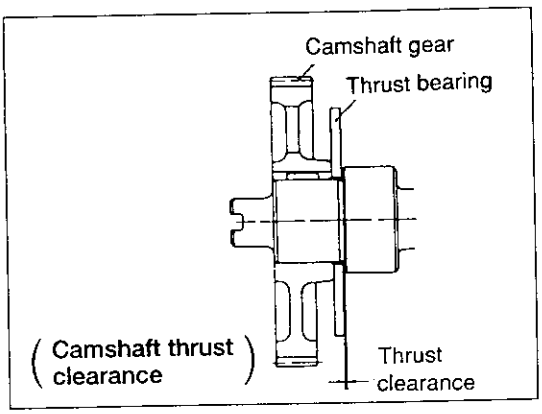
(1) Camshaft

For the camshaft, check the working face between the tappet and cam. Check the bearing for seizing or wear. Also check the camshaft gear for damage

①Camshaft thrust clearance

For the camshaft, the thrust load is supported by the thrust bearing end face of the gear side. Wear on the bearing end face will increase a thrust clearance. Before disassembly, check the thrust clearance.

To replace the thrust bearing, pull out the camshaft gear and camshaft together, since the camshaft gear is shrinkage fitted to the camshaft. Heat the camshaft gear to 200℃ or less, pull out the gear and replace the thrust bearing.



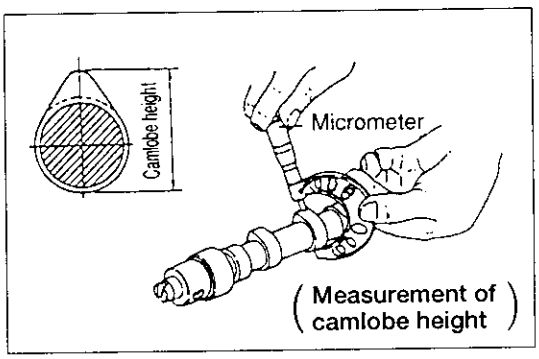
(mm)

	Standard	Limit
Thrust clearence	0.05~0.20	0.25

②Camlobe height

(mm)

Camlobe height(H)	Standard	Limit
Intake	38.7±0.04	−0.3
Exhaust	38.9±0.04	



③Camshaft bearing oil clearance

Measure the camshaft diameter and the inside diameter of the camshaft bearing. Replace if mesured diameter or oil clearance exceeds the specified limit.

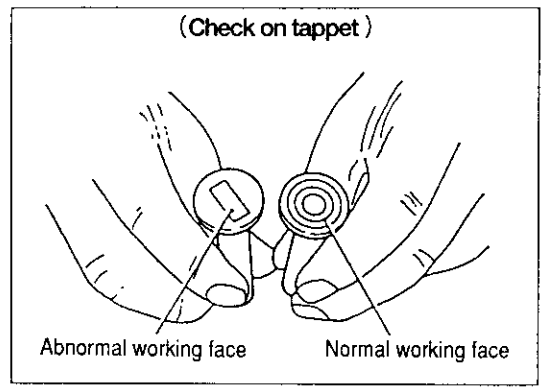
(mm)

		Standard	Standard oil clearance	Limit
With camshaft bearing	Camshaft diameter	$\phi 45^{-0.050}_{-0.075}$	0.04~0.103	−0.15
	Sylinder block camshaft bearing hole diameter	$\phi 48^{+0.025}_{0}$		—
	Camshaft bearing thickness	$1.5^{+0.005}_{-0.015}$		−0.025
	Camshaft bearing inside diameter	$45^{-0.028}_{-0.010}$		45.05
Without camshaft bearing (midpoint and flywheel side)	Cam shaft diameter	$\phi 45^{-0.050}_{-0.075}$	0.05~0.10	—
	Sylinder block camshaft hole diameter	$\phi 45^{+0.025}_{0}$		—

(2) Tappet

①Tappet working face

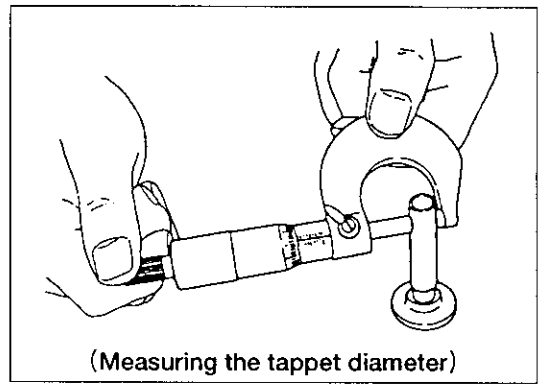
The tappet is offset and rotated during operation to prevent uneven wear. Check the conditions of the working face. If it suffers uneven wear or contact, replace it and correct the cam as well.



②Measuring tappet diameter and tappet hole diameter

Measure the tappet diameter.

If the tappet diameter exceeds the specified limit, replace the tappet.

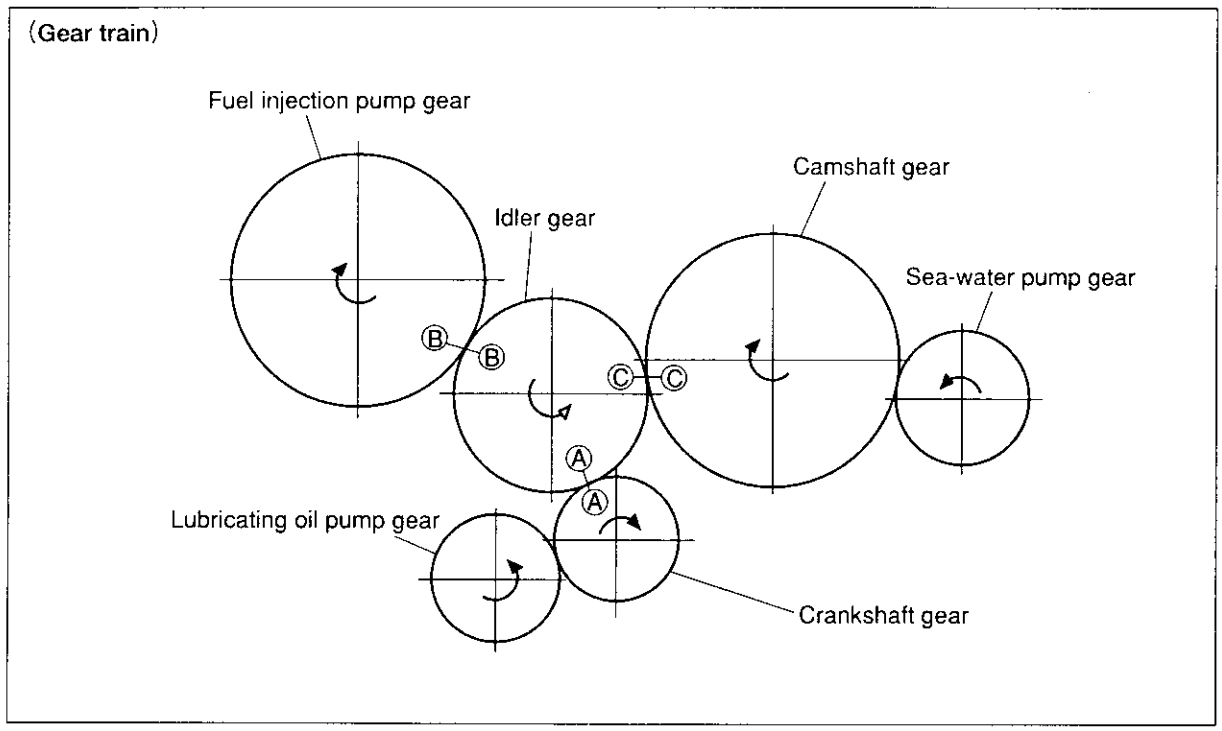


(mm)

	Standard	Limit
Tappet diameter	$\phi 12\ ^{-0.010}_{-0.025}$	−0.07
Tappet hole diameter	$\phi 12\ ^{+0.018}_{0}$	+0.05
Oil clearance	0.010~0.043	0.10

3.3.7 Gear Train

For the gear, a helical gear is employed to reduce noise.



(1) Check on gears

①Check the tooth surface for damage or wear. Replace a worn or damaged gear.

②Measure the backlash of gears engaged. If the backlash is in excess of the limit, replace them together.

[NOTICE]

An improper backlash will cause noise and tooth scuffing during operation. It will also disturb the valve timing and fuel injection timing resulting in a malfunction in the engine.

● **Backlash** (mm)

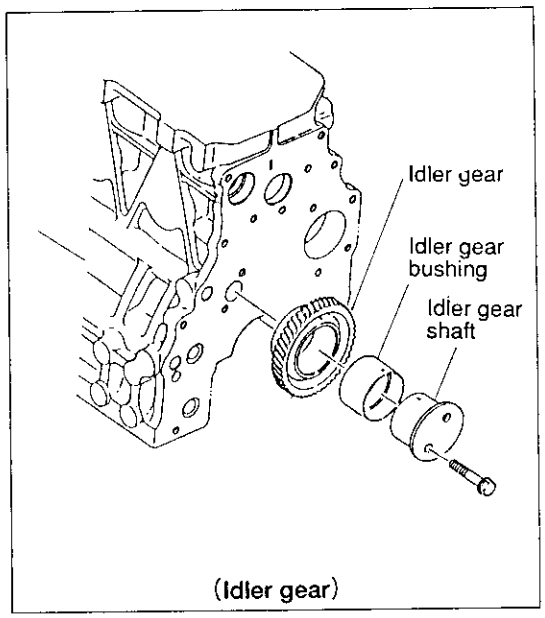
	Standard	Limit
Crank gear	0.08±0.04	0.2
Idler gear		
Cam gear		
Fuel injection pump gear		
Sea-water pump gear		
Lubricating oil pump gear	0.15±0.04	

(2) Idler gear

Idler gear bushing is press fitted into the idler gear. Measure the inside diameter of the Idler gear bushing and the idler gear shaft diameter to check the oil clearance. If the oil clearance is in excess of the limit, replace the idler gear bushing or idler gear shaft. There is a mark A. B. C on the end face of the idler gear. Install it in such a way that this mark is placed on the opposite side of the cylinder block. Also, position the idler gear shaft with the side where two oil holes are made upward.

(mm)

Idler gear	Standard	Limit
Idler gear shaft diameter	$\phi 46^{-0.025}_{-0.050}$	−0.10
Idler gear bushing inside diameter	$\phi 46^{+0.025}_{0}$	+0.05
Oil clearance	0.025~0.075	0.15
Thrust clearance	0.1~0.3	0.4

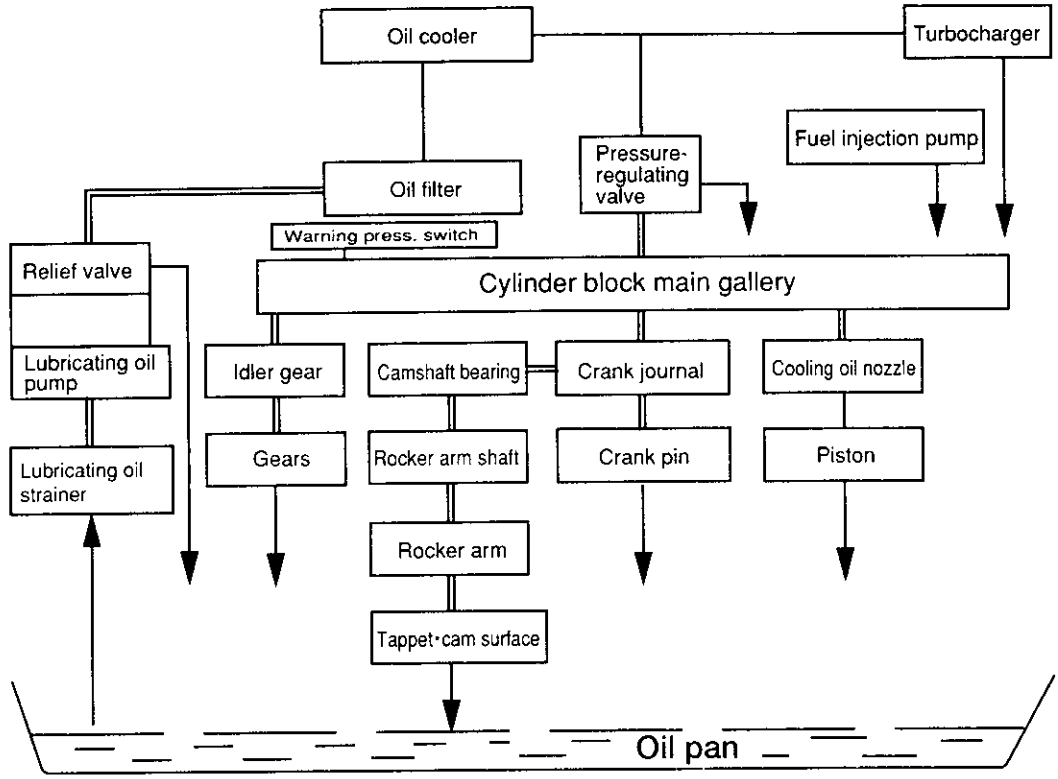


(Idler gear)

3.3.8 Lubrication System

The lubricating oil pump is the trochoidal gear pump which sucks engine oil from the oil pan through the oil strainer and forcibly lubricates the main bearing and each rocker arm through the following paths.
The warning pressure switch is installed in the paths to detect the lubricating oil low pressure.

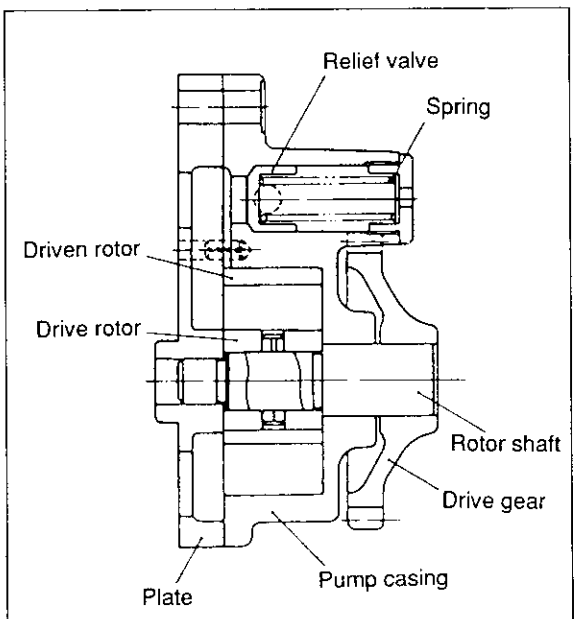
(1) Lubricating oil path diagram



(2) Lubricating oil pump

①Particulars of lubricating oil pump

Item	Unit	
Engine speed	rpm	3600
Gear ratio (crank/pump)	——	28/29
Oil pump speed	rpm	3477
Capacity	ℓ /min	36
Delivery pressure	kgf/cm² (MPa)	3.0 (0.29)
Relief valve pressure	kgf/cm² (MPa)	12±1 (1.17±0.10)



(Components of lubricating oil pump)

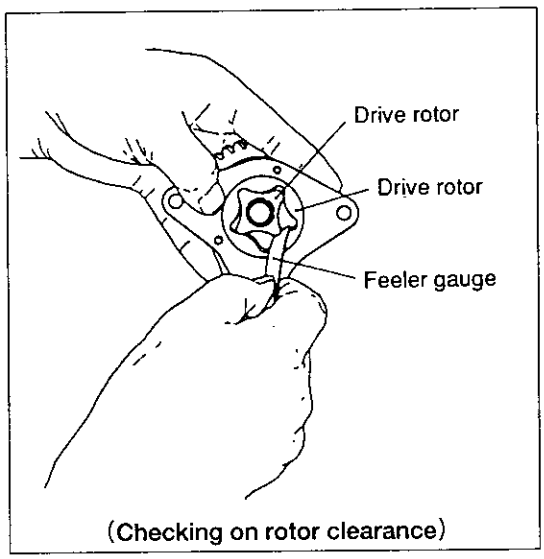
②Disassembling the lubricating oil pump

The pump cover (plate) may be disassembled. However, other disassembled parts cannot be reused. If measured clearance exceeds the specified limit, replace the oil pump assmbly.

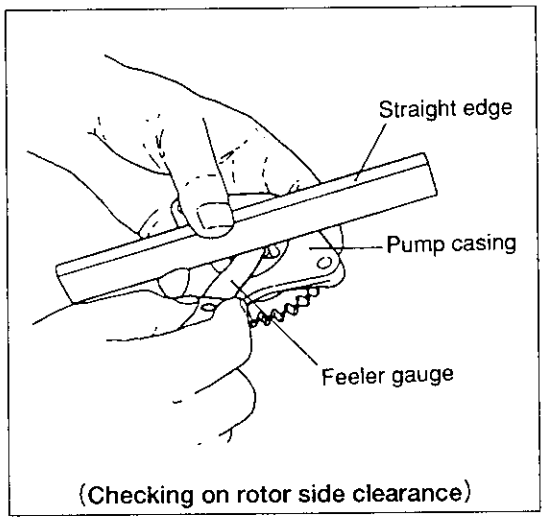
③Check on the lubricating oil pump

(mm)

Clearance	Standard	Limit
Driven rotor and pump casing	0.10~0.17	0.25
Drive rotor and driven rotor	0.05~0.11	0.15
Rotor side clearance	0.03~0.09	0.13



(Checking on rotor clearance)



(Checking on rotor side clearance)

(3) Pressure regulating valve and lubricating oil filter

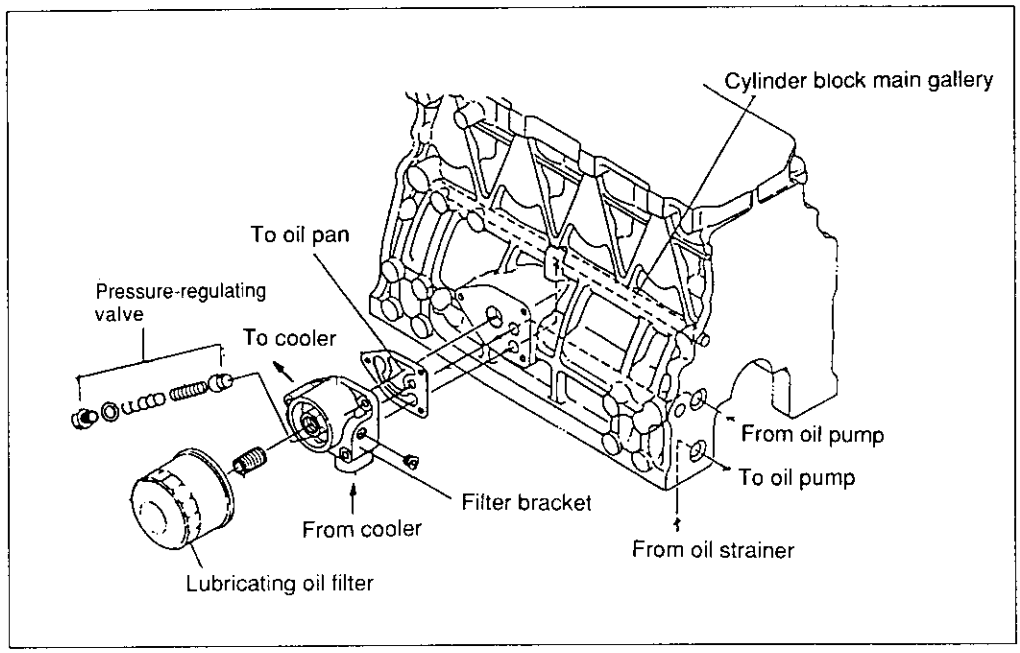
①Pressure regulating valve

This valve is built in the oil filter bracket and adjusted by varying the adjusting shim.

Set pressure of pressure regulating valve	4.0±0.5 kgf/cm²(0.39±0.05 Mpa) (at 3600rpm engine speed)
Adjusting shim	Adjusting shim thickness 1 mm changes 0.5 kgf/cm² (0.05 MPa) oil pressure or so.

②Lubricating oil filter

The lubricating oil filter has a built-in reliet valve which opens under a differential pressure of 1 kgf/cm² (0.1 MPa) obtained before and after the paper element. In the event of clogging, the lubricating oil will flow in the bypass circuit.

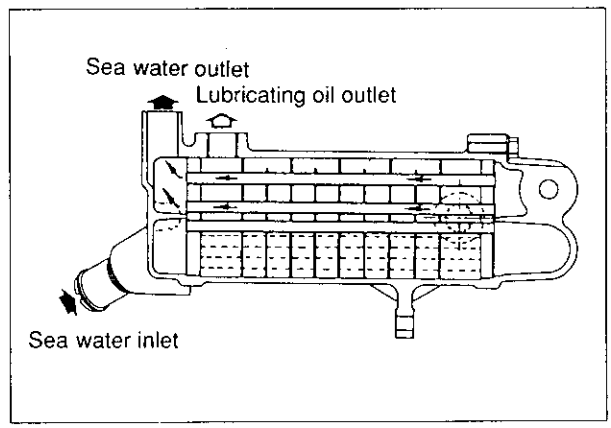


(4) Lubricating oil cooler

The lubricating oil cooler is of multitubular type.

①In disassembling and cleaning during a periodical check, use a scale remover.

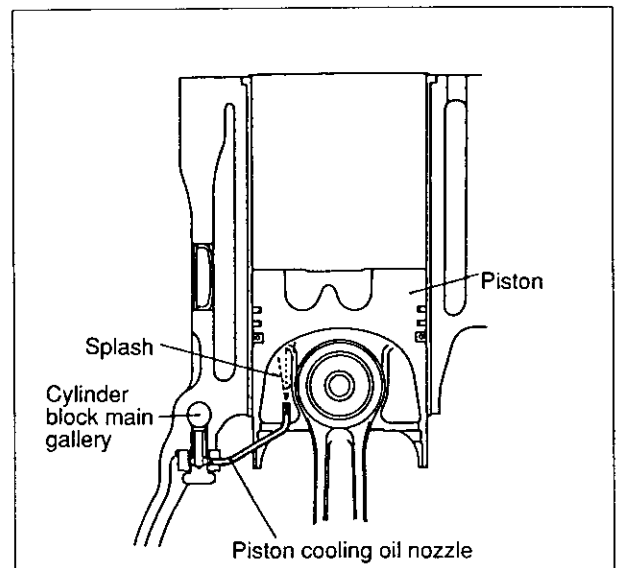
②To check the cooling tube for leakage, apply air pressure of 5 kgf/cm² (0.49 Mpa) through the sea water inlet and place the tube in water.



(5) Piston cooling oil nozzle

①Check the hole (ϕ 1.8mm) in the nozzle end for dust or foreign matters.

②Check the brazed portion of the copper tube for breakage due to vibration.

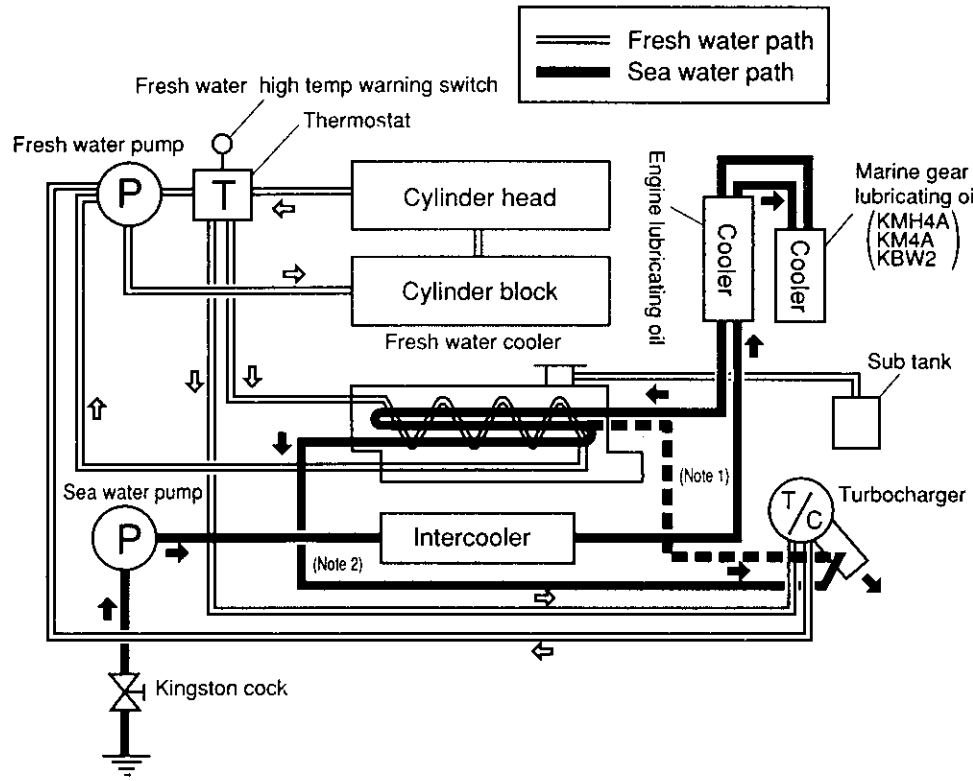


(Piston cooling oil nozzle)

3.3.9 Cooling Water System

The cooling water system is of fresh water high constant temperature cooling type (sea-water indirect cooling) where the cooling water temperature is held constant with a thermostat irrespective of load.
The cylinder block, cylinder head, exhaust manifold and turbocharger are cooled by fresh water, whereas the lubricating oil cooler, intercooler and fresh water cooler are cooled by sea water.

(1) Cooling water system



(Note 1) : Sea water outlet of 4JH3-TE
(Note 2) : Sea water outlet of 4JH3-HTE, -DTE

(2) Sea water pump

The sea water pump is of rubber impeller type. It is installed on the gear case and driven by the cam gear.

(Sea water pump particulars)

Engine speed	rpm	3600
Gear ratio (crank/pump)	——	28/31
Pump speed	rpm	3252
Suction head	mAq (Pa)	0.5 (4900)
Total head	mAq (Pa)	9.5 (93100)
Capacity	ℓ/h	3250

①Disassembling and assembling the sea water pump

(Disassembly)

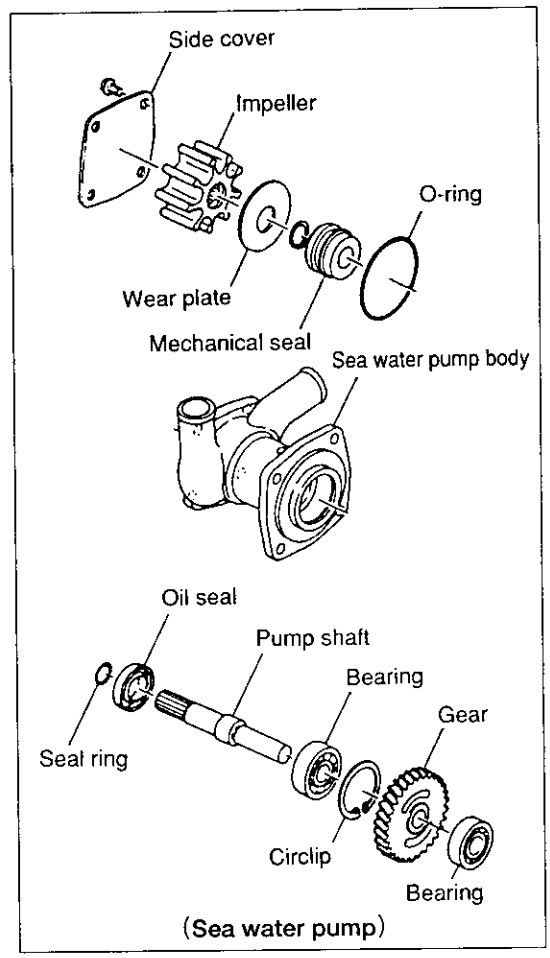
- Removing the side cover allows you to take out the impeller, wear plate and mechanical seal.
- Remove the circlip on the drive side and take out the pump shaft from the drive side by tapping it.
- Put the pump shaft on a workbench and pull out the bearings from the pump shaft by tapping them.

(Assembly)

- Install the bearings on the pump shaft.
- Insert the pump shaft into the pump body to which the oil seal is fitted, from the drive side and fit the circlip.
  (Grease the oil seal lip.)
- Install the mechanical seal. Assemble the wear plate and impeller. Install the side cover.

(Note 1) Grease the pump shaft and the inside and outside of the impeller.

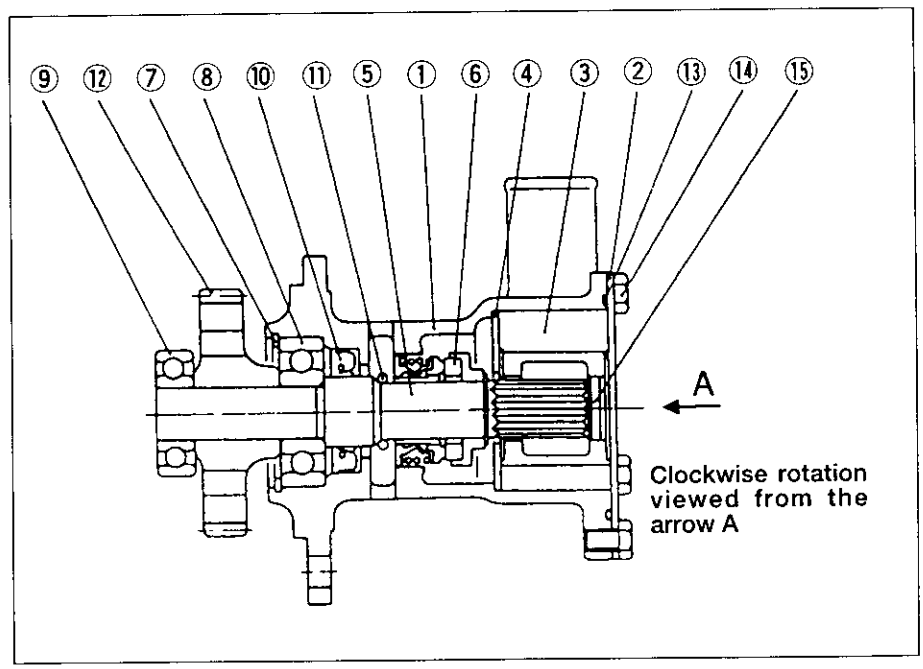
(Note 2) Fit the impeller by turning it in the direction of rotation.



(Sea water pump)

②Check on the sea water pump

- Remove the side cover and check the impeller for damage. If the impeller is damaged, replace it.
- If the sliding surface in the pump body is worn or damaged seriously, replace the pump body.
- If there is increased leakage of water from the drain, replace the mechanical seal.



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

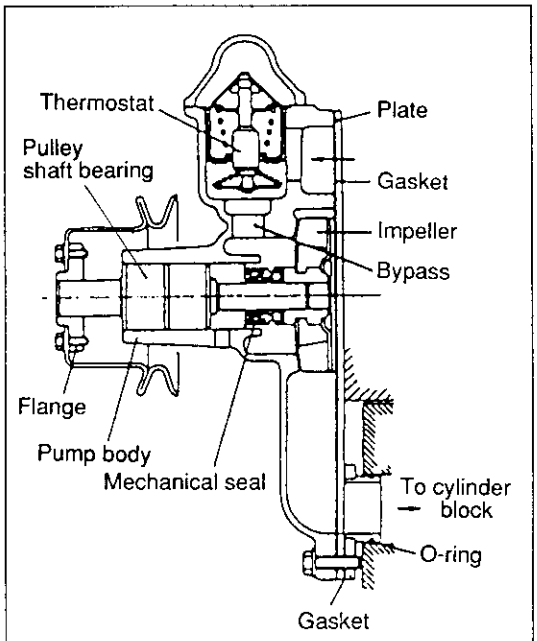
(3) Servicing standards for sea water pump

——	Standard	Side clearance	Limit	
Impeller width	31.6~3.18	0~0.3	0.8	31.3
Wear plate thickness	2			1.8
Housing width	33.8~33.9			——
Side cover thickness	2			1.8

(4) Fresh water pump and thermostat

①Particulars of fresh water pump

Pulley diameter (crank/pump)	mm	ϕ 132/120
Pump speed	rpm	3250
Capacity	ℓ /min	70
Total head	mAq (Pa)	4 (39200)



(Componeuts of Fresh water pump)

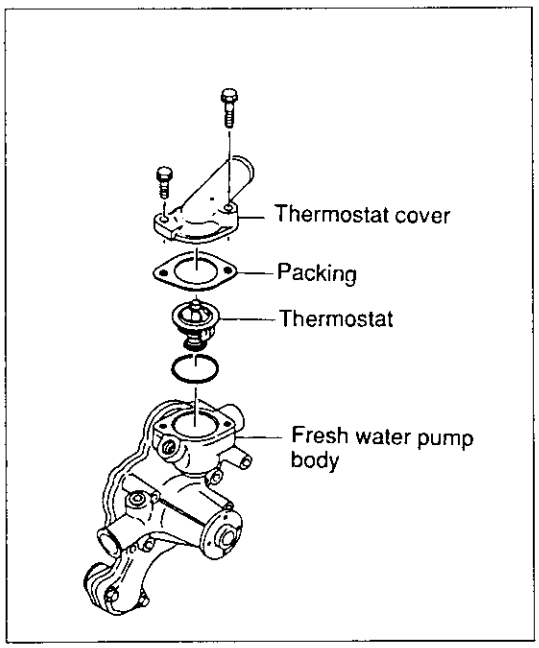
②Check on the fresh water pump

The pump body of the fresh water pump and the shaft bearing are press fitted together. If they are defective, replace them together.

③Thermostat

The thermostat holds the temperature of cooling water (fresh water) constant at all times to prevent the engine from being cooled excessively.

Part No.	Valve opening temperature	Full opening temperature	Valve lift
129470-49801	76.5℃	90℃	8 mm



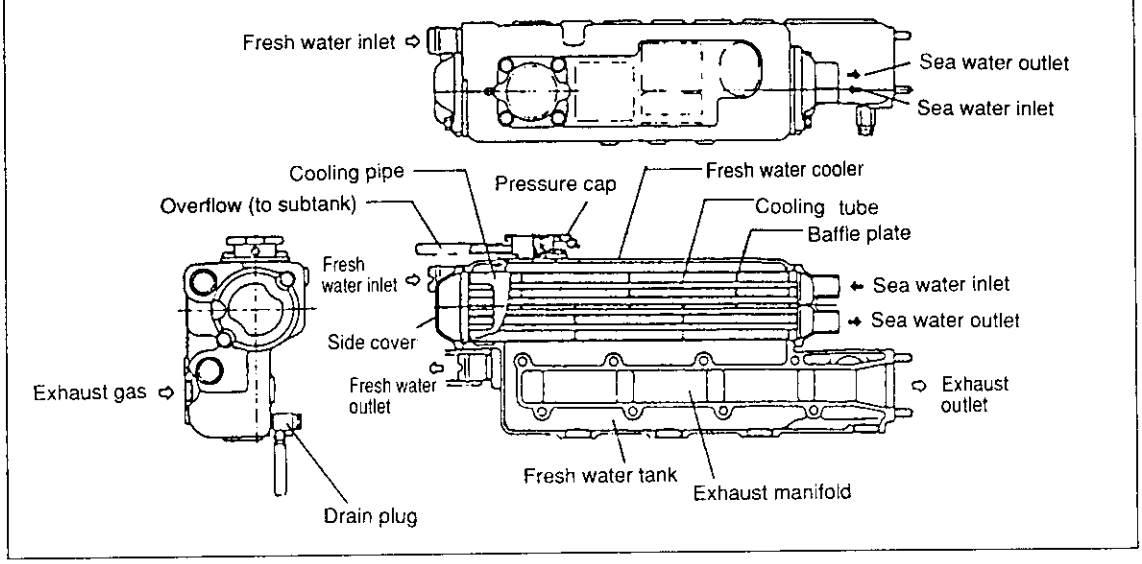
(5) Fresh water cooler

①Fresh water cooler

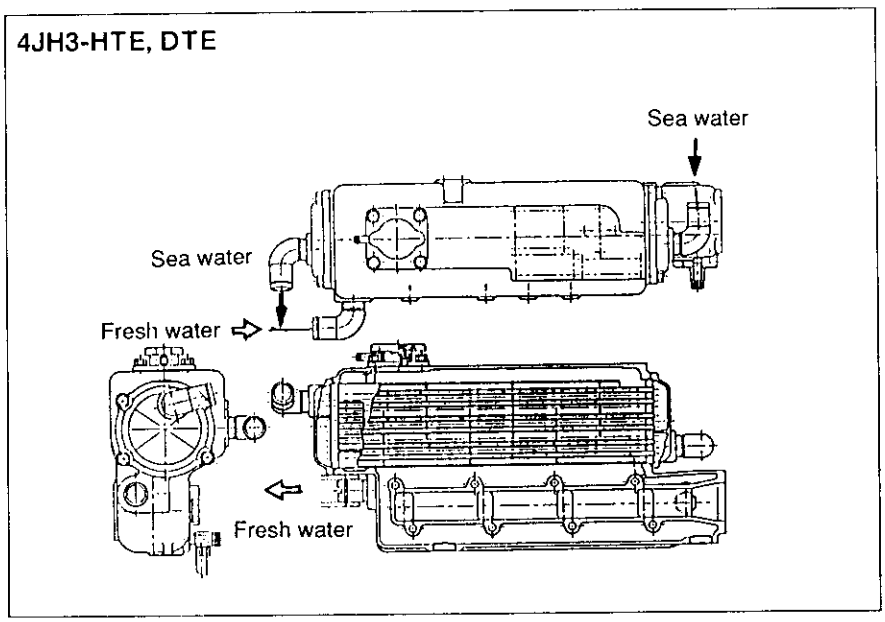
Sea water which flows in a tube cools the fresh water which flows outside the tube.

A integrated fresh water tank is provided under the tube to cool the exhaust manifold.

4JH3-TE

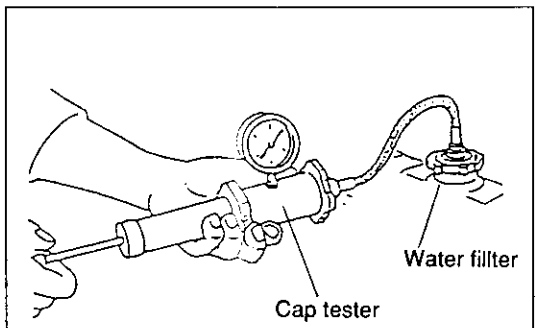


4JH3-HTE, DTE



②Checking the fresh water path for water leakage

- Fill the fresh water tank and engine with fresh water and attach the cap tester to the water filler.
- Inclease the pressure to 0.9 kgf/cm² (0.09 Mpa) by captester and check that the pressure does not drop.



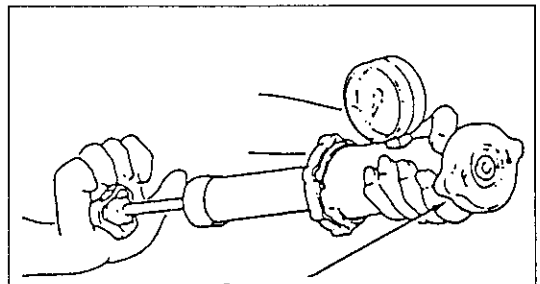
(Checking fresh water system for water leakage)

⚠ WARNING

Never remove the pressure cap while the engine and freshwater tank are hot. Otherwise, you will be burnt by hot water and steam.

③Checking the pressure cap

Attach the pressure cap to the cap tester and measure the pressure cap valve opening pressure applying pressure to the pressure cap. If the measured valve opening pressure is out of 0.9± 0.15kg/cm²(0.09±0.015Mpa). Replace the pressure cap.



(Checking the pressure cap)

[NOTICE]

For the use of a cap tester, carefully read the instruction manual for the cap tester.

3.3.10 Fuel System

The fuel injection pump is VE typ (ZEXEL made).

[NOTICE]

The disassembly and adjustment of a fuel injection pump need expertise and facilities. Make a request to ZEXEL service shop for them.

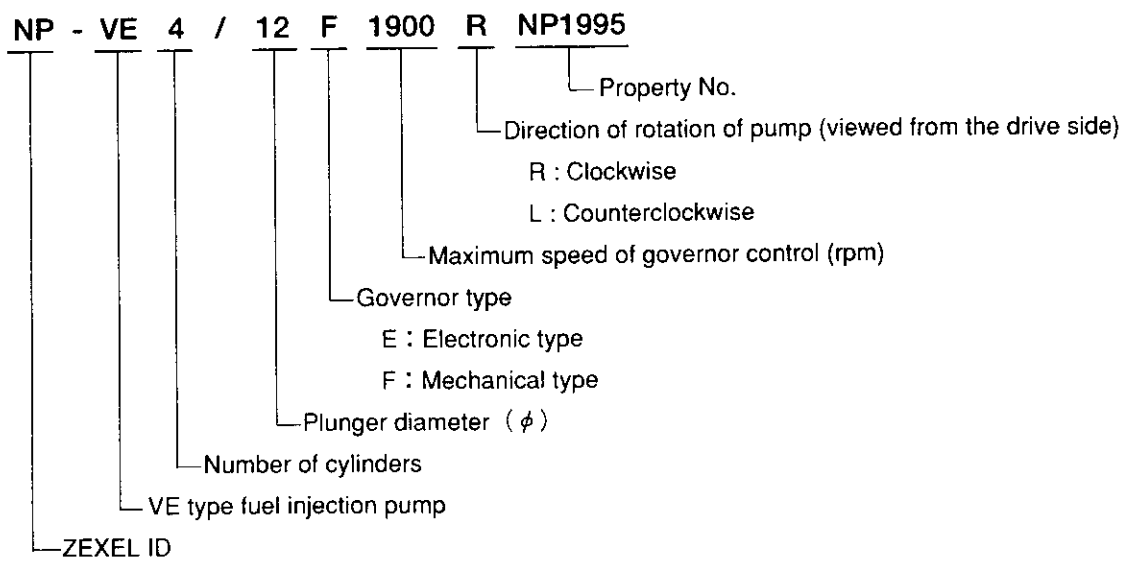
Fuel injection pump	VE type
Fuel feed pump	Vane type (built-in)
Timer	Hydraulic (built-in)

(1) Fuel Injection pump

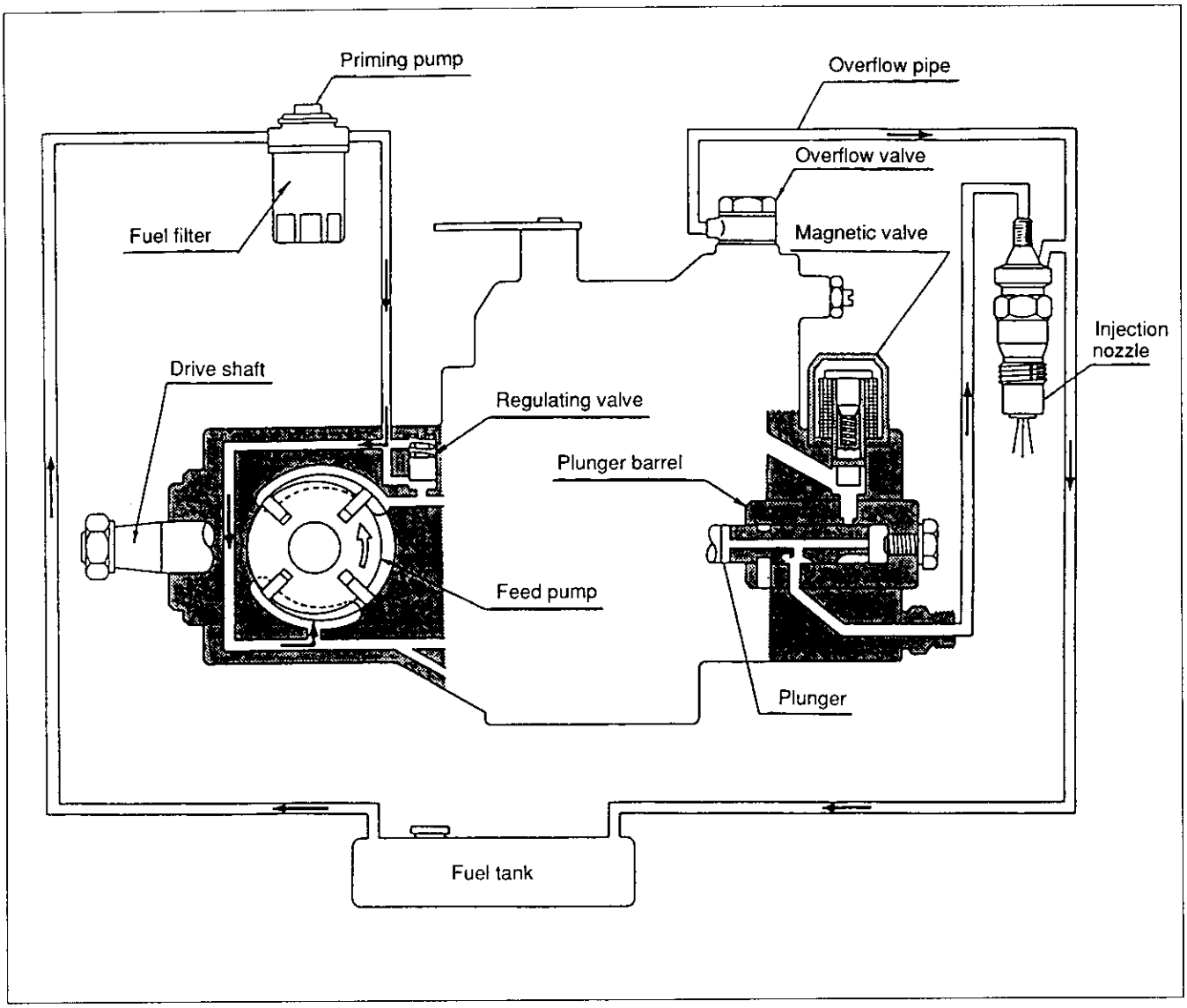
①Particulars

Model	VE4/12F
Direction of rotation	Clockwise (viewed from the drive side)
Plunger diameter	ϕ 12 mm
Governor type	All speed
Fuel feed type	Vane
Timer advancing angle	2°/ 600 to 1500 rpm (pump speed)
Lubricating method	Fuel oil lubricating
Fuel cut method	1) Magnetic valve (normal open) 2) With a manual stop lever
Additional device	Boost compensator

Model notation

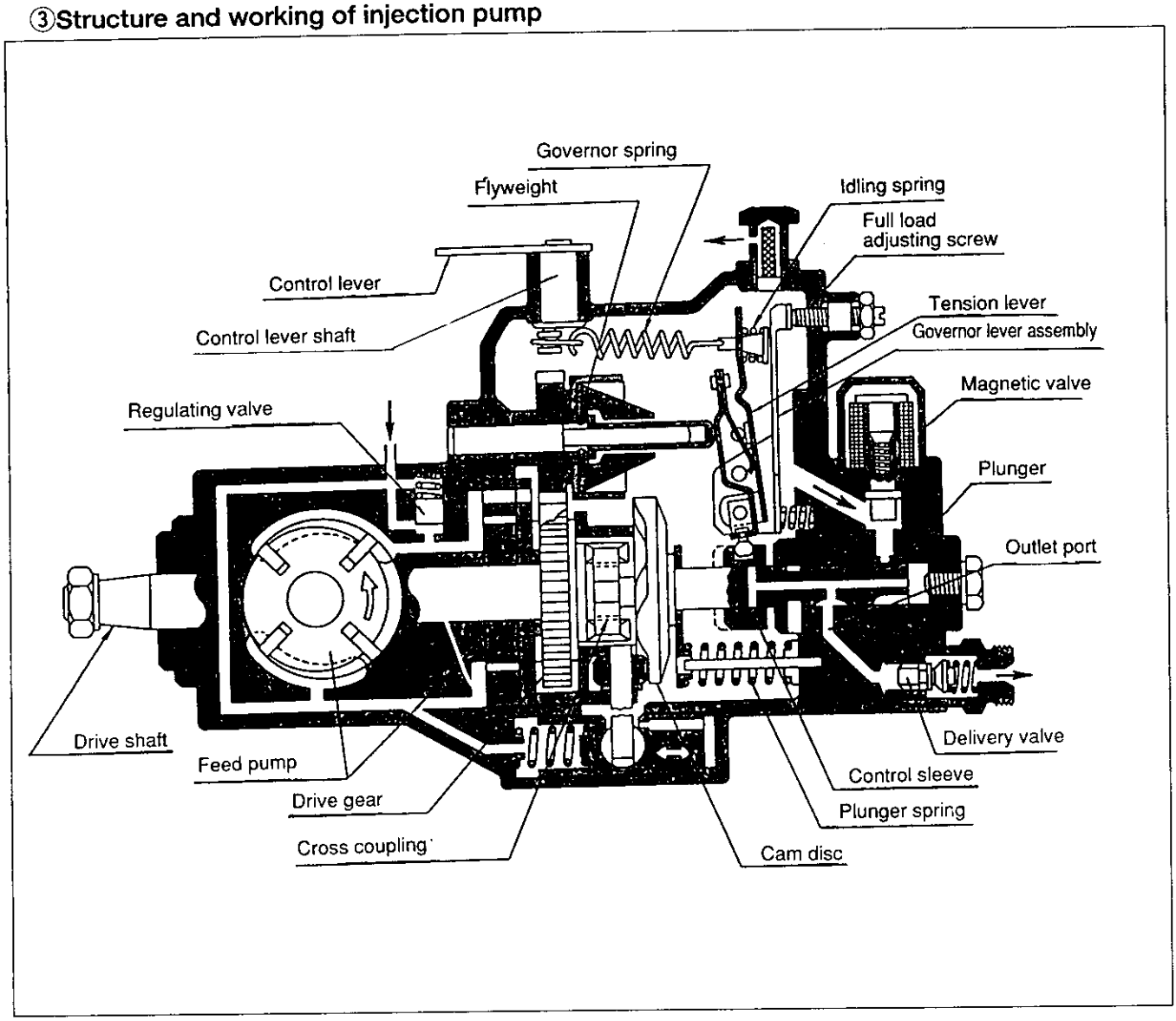


②Fuel path diagram



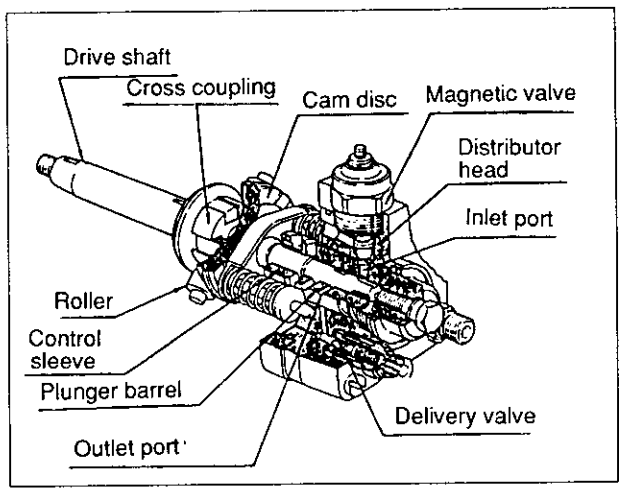
a) Fuel oil in the fuel tank is sucked by the feed pump built in the pump through the fuel filter (with a built-in water separator which is located at the bottom) and sent to the fuel inlet of the fuel injection pump.
b) There is an air breathe bolt on the side of the priming pump, and a sensor for detecting collected water at the bottom of the fuel filter.
c) The fuel oil sent to the fuel inlet is pressurized by the feed pump and supplied to the pump chamber. The pressure of the fuel in the pump chamber is proportional to the pump speed. However, if the specified pressure is exceeded, the regulating valve will return excessive fuel to the suction side.
d) The fuel in the pump chamber is sent to the plunger through the fuel passage located in the distributor head. The pressure of the fuel is then increased by the plunger and the fuel is sent to the nozzle holder under pressure through the fuel injection pipe.
e) The overflow valve located on the top of the pump holds the fuel oil pressure in the pump chamber constant and returns excessive fuel to the fuel tank.

③Structure and working of injection pump



Plunger

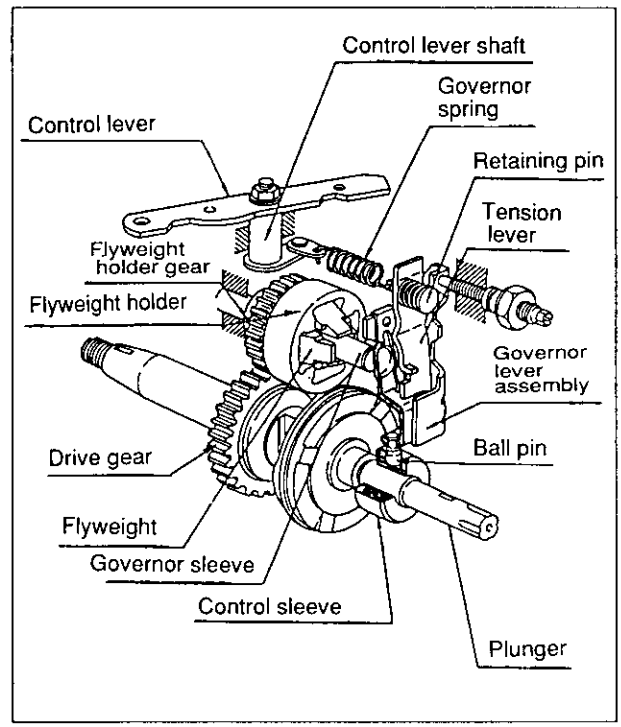
a) The drive shaft directly receives the engine rotation by means of gears and transfers the rotation to the cam disc through the cross coupling. The positioning pin press-fitted to the cam disc is also inserted in the groove of the plunger flange, so that the plunger and cam disc rotate in the same direction. The cam disc has a face cam to reciprocate by a specified cam lift on the roller of the roller holder assembly.



b) There are two plunger springs having setting forces on the outside of the plunger. They return the plunger which is pushed up by the cam disc, in the descending process. That is, the plunger rotates by means of the drive shaft and reciprocates by means of the cam disc. When the fuel whose pressure is increased by the plunger is sent to the outlet port, the delivery valve opens to allow the fuel to be injected into the combustion chamber through the fuel injection nozzle.

- **Governor**

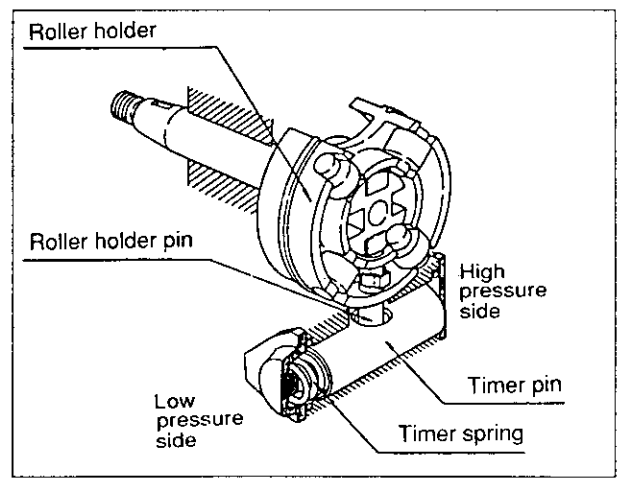
①The governor, which is located above the pump house, consists of a flyweight holder, governor lever assembly, etc. The flyweight holder holds four flyweights and governor sleeve and is supported by the governor shaft. The drive gear engages with the flyweight holder gear and speeds up the drive shaft rotation to rotate the flyweight holder assembly. The governor lever assembly is supported by the pivot bolt in the pump housing and the ball pin located at the bottom of it is inserted in the control sleeve which slides on the outside surface of the plunger.



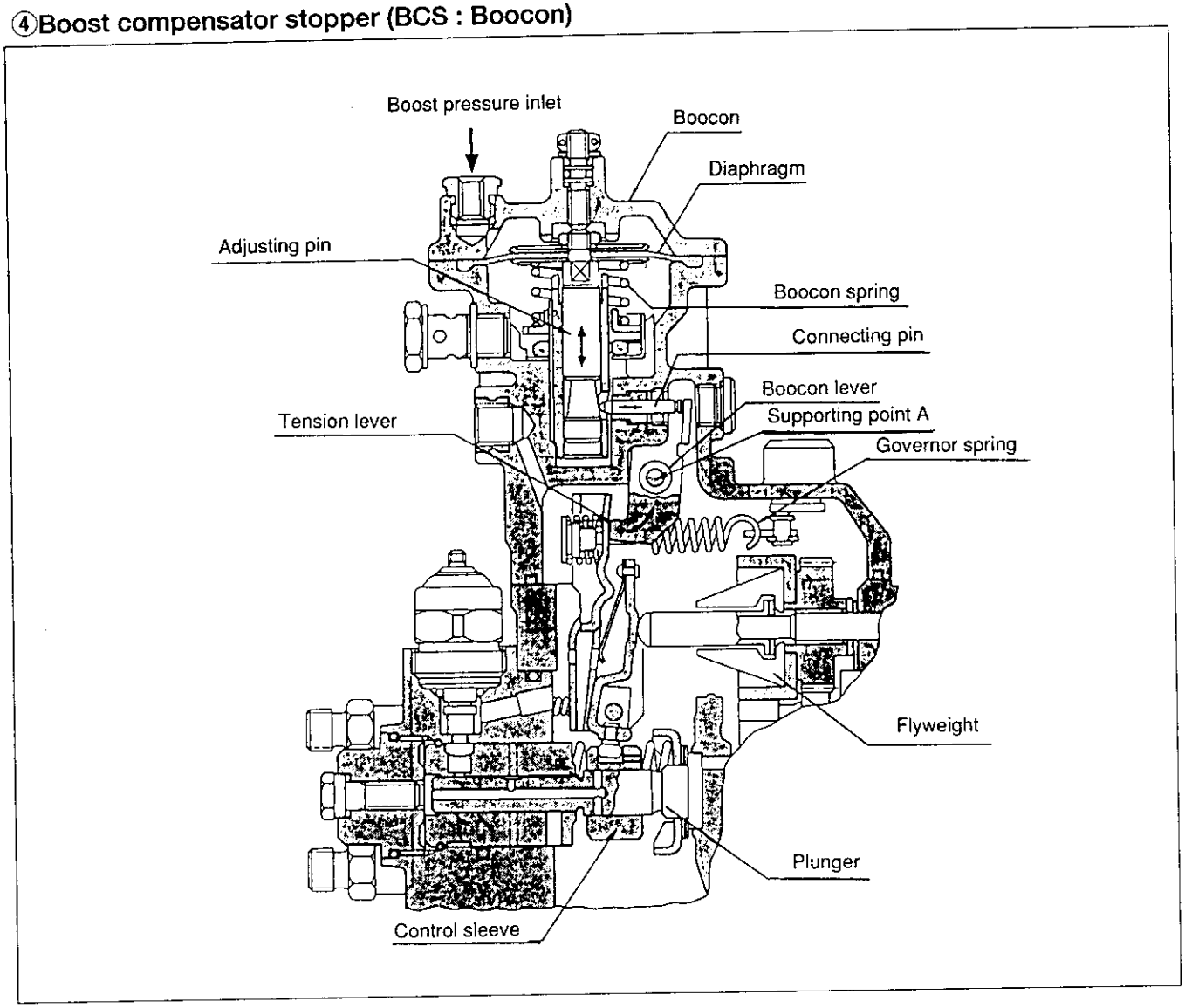
②The governor spring located at the top of it is connected to the tension lever with the retaining pin and the governor spring end face is connected to the control lever through the control lever shaft.
The control lever is linked to the governor handle through the link to vary the setting force of the governor spring according to the inclined angle. A difference between the setting force of the governor spring and the centrifugal force of the flyweight corresponds to the control sleeve movement which increases or decreases the injection quantity.

- **Timer**

There is a built-in timer at the bottom of the injection pump. A timer spring having a setting force is installed on the low pressure side. The fuel pressure in the pump house is directly applied to the opposite side (high pressure side). The position of the timer piston varies according to the relation between this fuel pressure and timer spring force and the roller holder is rotated through the roller holder pin.
When the piston moves in the direction where the timer spring is shrunk, a lead of angle takes place (the roller holder moves in the reverse direction of rotation) to advance the injection timing. That is, the timer controls the injection timing according to the fuel oil pressure in the pump house.



④Boost compensator stopper (BCS : Boocon)



a) The boost compensator stopper (abbreviated to "boocon") is a device which increases the injection quantity when the air quantity (turbocharging boost) supplied to the suction manifold is increased.

b) The boocon is installed on the top of the injection pump governor. There is a diaphragm in an upper part of the boocon and the boost pressure is applied to the upper part with this diaphragm as the boundary. A boocon spring with a setting force is installed under the diaphragm. An adjusting pin is directly connected to the diaphragm so that it will move in conjunction with the diaphragm. A specified amount of lubricant necessary for sliding is stored at the bottom of the adjusting pin.

c) The tension lever in the injection pump is drawn to the right by the governor spring. This motion causes the boocon lever to rotate counterclockwise round the supporting point A to push the connecting pin against the taper of the adjusting pin. Therefore, when the adjusting pin moves downward or upward through the diaphragm, this movement is transferred to the connecting pin boocon lever tension lever, so that the control sleeve position (injection quantity) can be changed directly.

d) For the boocon, the set value cannot be changed.

(Note) The description above is given based on the service manual issued by the Service Department of ZEXEL.

⑤Adjustment of fuel injection pump

• 4JH3-TE,HTE

Conditions	Nozzle type		ZEXEL 105780-0060 (NP-DN0SD1510)		
	Nozzle opening pressure		133kgf/cm² (13MPa)		
	Fuel injection pipe (outside diameter×inside diameter-length)		φ6×2-450mm		
	Fuel oil feed pressure		0.2kgf/cm² (0.02MPa)		
Adjustment value	Item \ Engine model	Pump speed (rpm)	4JH3-TE	4JH3-HTE	Ununiformity (mm³/st)
	Full load injection quantity mm³/st	400	——	——	——
		500	(43.2±4.5)	(42.6±6.0)	——
		600	(42.4±4.5)	(41.5±6.0)	——
		900	(47.4±4.5)	(51.3±4.5)	——
		1350	(62.0±4.5)	(71.6±4.5)	——
		1600	(66.5±4.5)	(74.5±1.0)	6
		1900	(66.0±4.5)	(70.1±4.0)	——
		2150	7.0±4.5	6.0±4.5	——
	Idle injection quantity mm3/st	350	12.1±2.5	14.0±2.5	3
	Start injection quantity mm3/st	100	(85±20)		——
	Timer stroke mm	1050	——	(0.8±0.4)	——
		1350	0.8±0.4	——	——
		1900	$1.7^{+0.4}_{+0.5}$		——
	Pressure in pump house kgf/cm² (MPa)	1050	——	5.2±0.4 (0.51±0.039)	——
		1350	4.4±0.4 (0.43±0.039)	——	——
Pump code		——	129671-51900	129672-51900	——

(Note) A numeric in parentheses is a reference value.

The disassembly and adjustment of a fuel injection pump need expertise and facilities. Make a request to ZEXEL service shop for them.

● 4JH-DTE

Conditions	Nozzle type			ZEXEL 105780-0060 (NP-DN0SD1510)	
	Nozzle opening pressure			133kgf/cm² (13MPa)	
	Fuel injection pipe (outside diameter x inside diameter-length)			φ6X2-450mm	
	Fuel oil feed pressure			0.2kgf/cm² (0.02MPa)	
Item \ Engine model		Pump speed (rpm)	Boost pressure mmHg (kPa)	4JH3-DTE	Ununiformity (mm³/st)
Adjustment value	Full load injection quantity mm³/st	400	0	(30.0以上)	——
		500	0	(34.8)	——
		950	0	(49.4)	——
		950 (BCS)	180±10 (24.0±1.3)	58.6±1	——
		950 (FULL)	500±10 (66.7±1.3)	72.3±1	6
		1330	500±10 (66.7±1.3)	(75.5±5)	——
		1900	500±10 (66.7±1.3)	(84.3±5)	——
		2150	500±10 (66.7±1.3)	11.2±5	4
	Idle injection quantity mm³/st	338	0	20.2±2.5	3
	Start injection quantity mm³/st	100	0	(87.3±20)	——
	Timer stroke mm³/st	1050	——	0.8±0.4	——
		1900	——	$1.7^{+0.4}_{-0.5}$	——
	Pressure in pump house kgf/cm² (Mpa)	1050	——	5.2±0.4 (0.51≠0.04)	——
Pump code		——		129698-51901	——

(Note) A numeric in parentheses is a reference value.

The disassembly and adjustment of a fuel injection pump need expertise and facilities. Make a request to ZEXEL service shop for them.

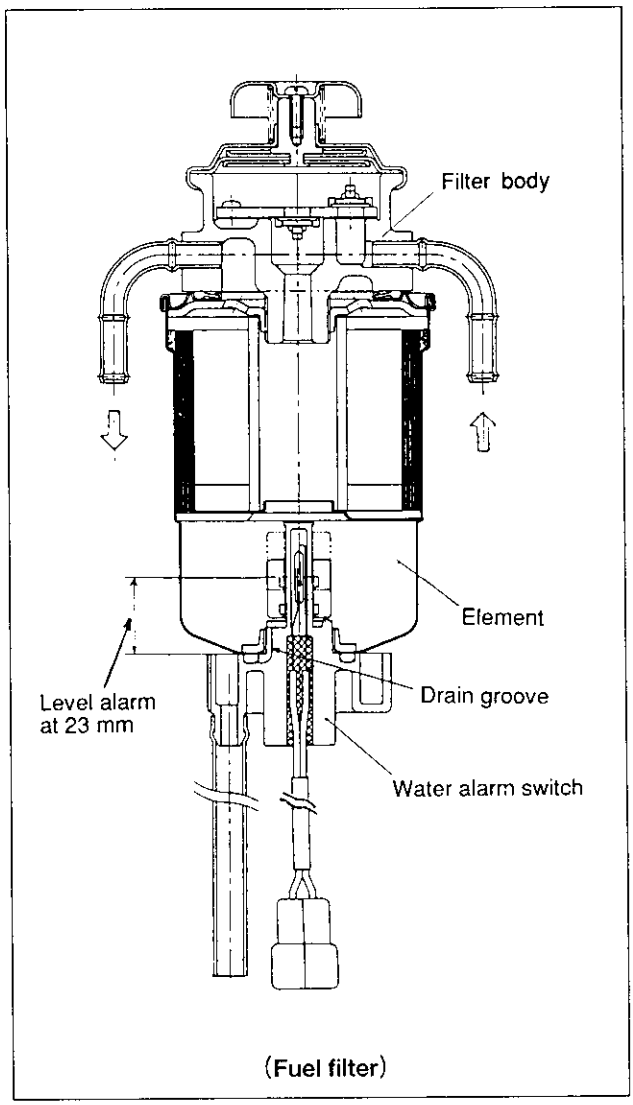
⑥Fuel filter

- Particulars

Item		Unit	Specifications
Fuel filter	Filtration method	——	Paper element
	Filtration area	m^2	0.24
	Filtration accuracy	μ	15
Priming pump	Discharge	cm^3/st	15
	Stroke	mm	8
Water separation	Alarm capacity	cm^3	80±10
	Maximum capacity	cm^3	120

- **Drain**

  Loosening the switch slackens the seal between the switch and element to let water flow to the switch receiver for drainage from the drain groove.

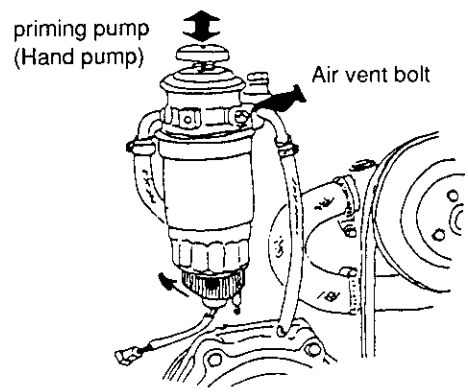


(Fuel filter)

⑦Handling of fuel system

- Air vent of fuel filter

  Air vent location on fuel filter and priming Pump (Hand pump)



(Note) To drain water from the fuel filter, loosen the cup (switch) at the bottom of the fuel filter.

(2) Fuel injection nozzle

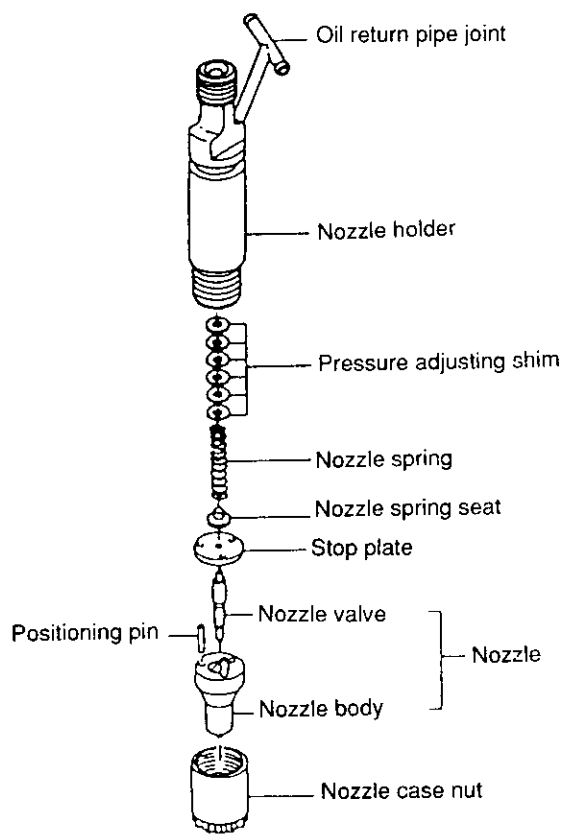
①Nozzle specifications

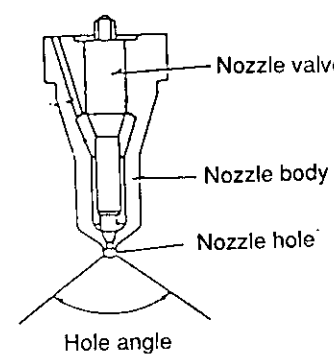
Item \ Engine model	4JH3-TE	4JH3-HTE,DTE
Nozzle type	YDLLA-P	
Hole angle	150°	
Number of nozzle holes hole diameter (mm)	5-ϕ0.23	5-ϕ0.25
Injection nozzle opening pressure	220±5kgf/cm² (21.57±0.49MPa)	
Stamp No.	150P235JA0	150P265JA0
Part code	129671-53000	129692-53000

Fuel injection nozzle stamp notation

Y DLL A - 150 P 244JD

- 244JD — Design symbol
- P — Nozzle size { Size P / Size S
- 150 — Hole angle
- A — Nozzle setting angle on the cylinder head { Symbol A : Yes / No symbol : No
- DLL — Type (DLL : Semi-long nozzle)
- Y — Maker (YANMAR)





(Nozzle cross section)

②Adjustment of fuel injection nozzle and injection test

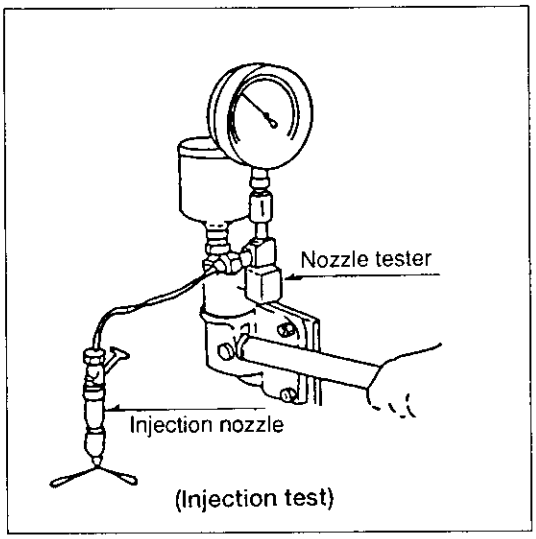
Tightening torque of nozzle case nut (width across flat of nut 15 mm)	$4^{+0.5}_{0}$ kgf·m

a) Install the nozzle injection nozzle on a nozzle tester and adjust the injection nozzle opening pressure with the adjusting shim.

Injection nozzle opening pressure	220±5kgf/cm² (21.58±0.49MPa)

[NOTICE]

- **0.1 mm increase or decrease in the adjusting shim thickness changes the pressure by 19 kgf/cm² (186.4 N/cm) or so.**



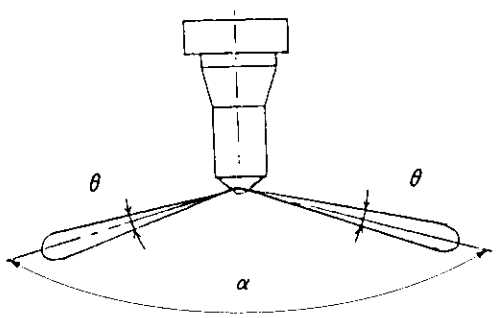
(Injection test)

b) Inject two or three times and increase the pressure gradually. Keep the pressure just before the injection nozzle opening pressure of 20 kgf/cm²(1.96MPa) is reached for five seconds and check that there is no drop of fuel oil from the injection nozzle.

c) Operate the nozzle tester lever at the rate of once or twice a second to check that there is no trouble with the injection.

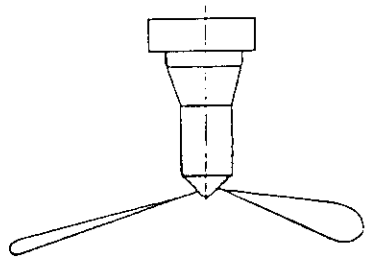
(Condition of spray)

(Good)



Uniform injection from each nozzle hole

(Bad)



- Extreme difference in angle (θ)
- Extreme difference in injection angle (α)
- Non-fine spray from the entire injection
- Dull injection

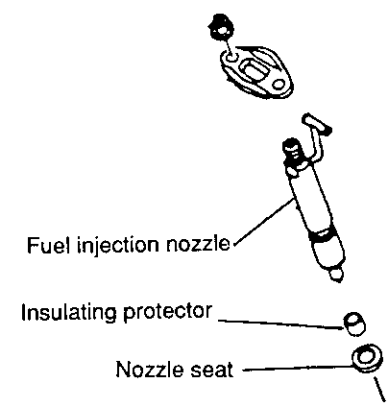
③Installing the fuel injection nozzle

- Take care not to excessively tighten the nut for the fuel injection nozzle.

Tightening torque	0.7~0.9kgf·m (6.87~8.82N·m)

(No oil application)

(Installation of fuel injection nozzle)

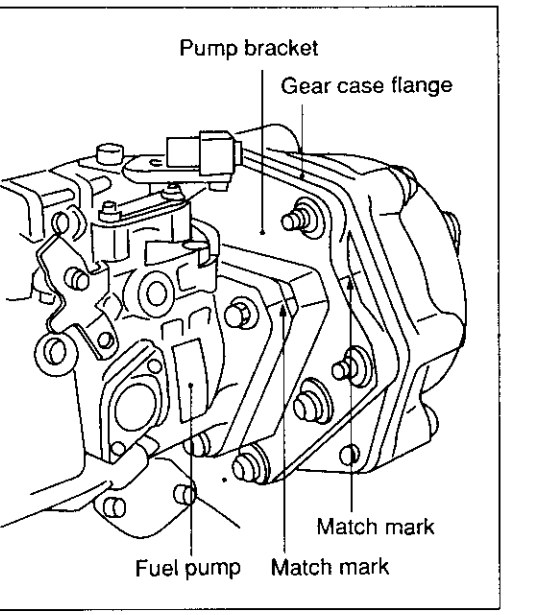


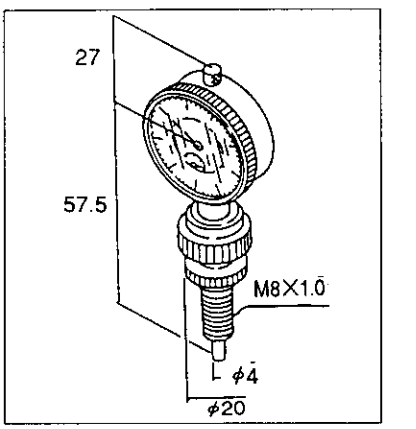
(3) Procedures for adjusting the injection timing

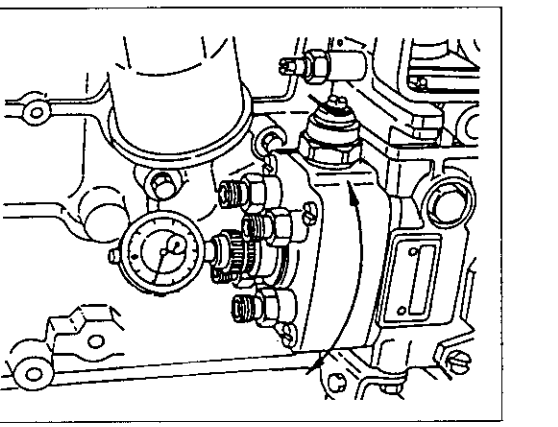
a) Check the match marks of the gear case flange and fuel pump bracket.

b) Match the match mark of the fuel pump bracket with that of the fuel pump mounting flange.

Fuel injection timing	12±1° (b.T.D.C)







(Reference)

Special tool for measuring the plunger lift as the injection timing.

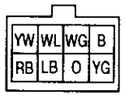
3.3.11 Electrical Equipment

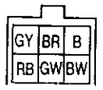
(1) Wiring Diagram

- 4JH3-TE, HTE, DTE (12V New B type)

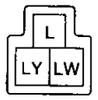
Color coding

R	Red
B	Black
W	White
Y	Yellow
L	Blue
G	Green
O	Orange
Lg	Light green
Lb	Light blue
Br	Brown
P	Pink
Gr	Gray
Pu	Purple

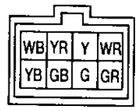




Details of coupler (View from C–C)



Details of coupler (View from B–B)



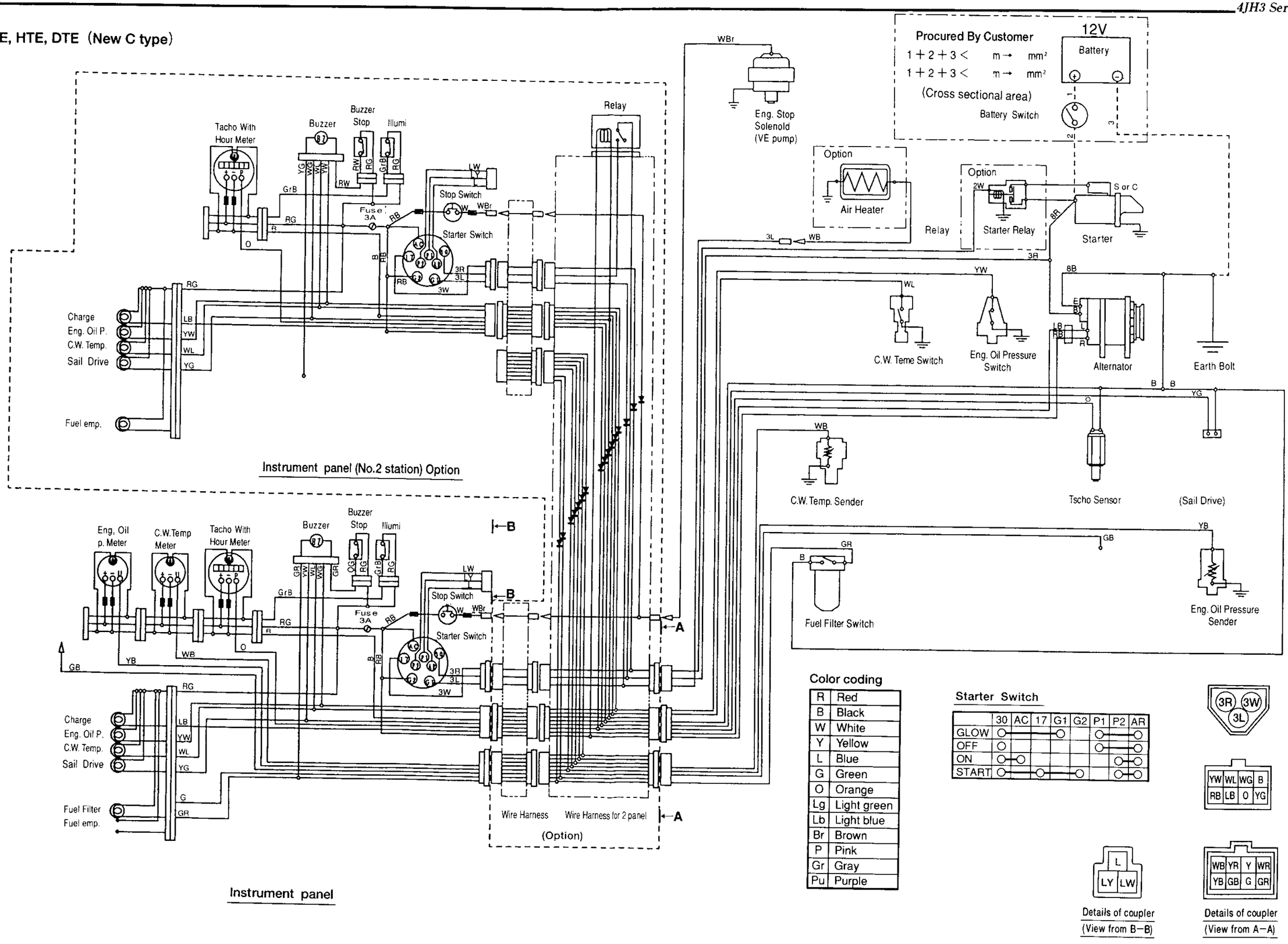
Details of coupler (View from A–A)

Starter Switch

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

HINSHI H10-009

● 4JH3-TE, HTE, DTE (New C type)



Color coding

R	Red
B	Black
W	White
Y	Yellow
L	Blue
G	Green
O	Orange
Lg	Light green
Lb	Light blue
Br	Brown
P	Pink
Gr	Gray
Pu	Purple

Starter Switch

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

Details of coupler (View from B–B)

Details of coupler (View from A–A)

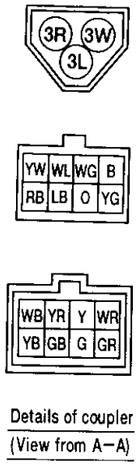
● 4JH3-TE, HTE, DTE (12V B type)

Color coding

R	Red
B	Black
W	White
Y	Yellow
L	Blue
G	Green
O	Orange
Lg	Light green
Lb	Light blue
Br	Brown
P	Pink
Gr	Gray
Pu	Purple

Starter Switch

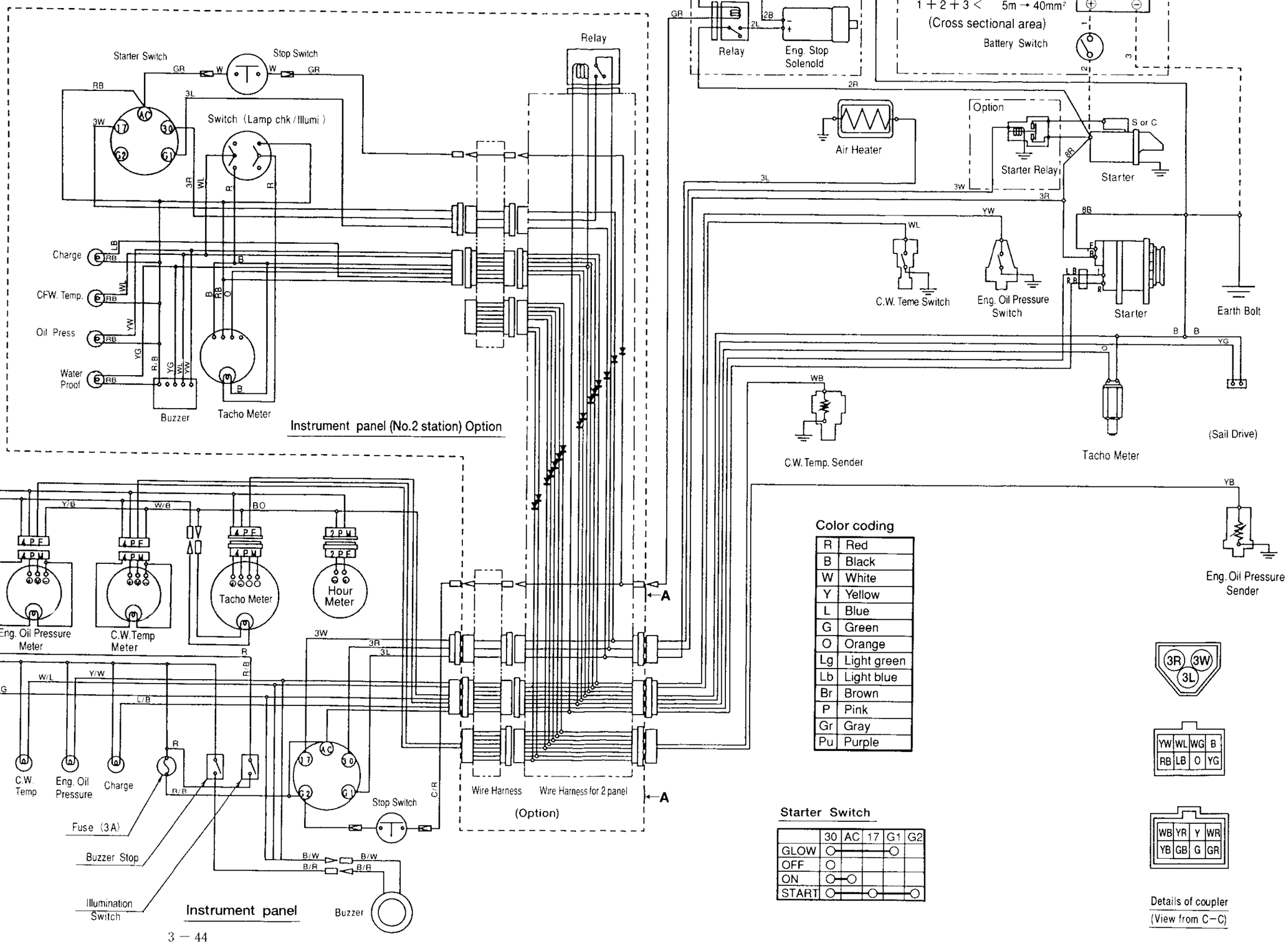
	30	AC	17	G1	G2
GLOW	○	———		○	
OFF	○				
ON	○	—○			
START	○	———	○	———	○



Details of coupler
(View from A–A)

Instrument panel

● 4JH3-TE, HTE, DTE (12V C type)



Color coding

R	Red
B	Black
W	White
Y	Yellow
L	Blue
G	Green
O	Orange
Lg	Light green
Lb	Light blue
Br	Brown
P	Pink
Gr	Gray
Pu	Purple

Starter Switch

	30	AC	17	G1	G2
GLOW	○			○	
OFF	○				
ON	○	○			
START	○		○		○

Details of coupler
(View from C–C)

(2) Starter

For the starter disassembling and assembling procedures, refer to "Starter service manual".

Specifications and service standards.

	Item			Unit	4JH3-TE,HTE,DTE
Specifications	Yanmar code			—	171008-77010
	Model (Hitach)			—	S114-483
	Nominal output			kW	1.4
	Direction of rotation (viewed from the pinion side)			—	Clockwise
	Engagement method			—	Magnetic shift
	No load	Terminal voltage/current		V/A	12/100 or less
		Starter speed		rpm	4300 or more
	Load	Terminal voltage/current		V/A	9.8/200
		Torque/starter speed		kgf·m (N·m) /rpm	0.45 (4.41)/1900
	Clutch type			—	Over running
	Pinion shift voltage			V	8 or less
	Pinion DP/Number of teeth			—	DP10/15
	Mass			kg(N)	5.0(49.05)
Service standards	Brush	Spring force		kgf(N)	1.84～2.24 (18.05～21.95)
		Standard height/limit height		mm	15/12
	Magnetic switch resistance	Series C/shunt C		Ω	0.26/0.59
	Commutator	Outside diameter	Standard/limit	mm	30/29
		Difference between maximum and minimum diameters	Standard/limit	mm	0.05/0.2
		Under cut depth	Standard/limit	mm	0.5～0.8/0.2
	Armature shaft bearing No.	Pinion side		mm	BB6903
		Rear cover side		mm	BB608
	Pinion shaft bearing No.	Pinion gear side		mm	BB6004
		Rear side		mm	BB6904

(3) Alternator

The alternator is a rotating-field type three-phase AC generator. The generated alternating current is converted to a direct current through full-wave rectification with diodes and stored in a battery.
For the alternator disassembling and assembling procedures, refer to "Alternator service manual".

Specifications and service standards

	Item			Unit	—
Specifications	Yanmar code			—	129772-77200
	Model (Hitachi)			—	155-20B
	Nominal output			V/A	12/55
	Rated speed			rpm	5000
	Operating speed			rpm	1000~9000
	Output current/Rated speed			A/rpm	53/5000
	Speed for 13.5 V			rpm	1000 or less
	Direction of rotation (viewed from the pulley side)			—	Clockwise
	Number of poles / earthpolarity			—	12/negative-earth
	Regulated voltage			V	14.5±0.3
	Regulator type			—	IC
	Pulley	Belt type/pulley outside diameter		—/mm	A/74
		Pulley ratio		—	2.2
	Mass			kg(N)	4.3(42.18)
Service standards	Resistance	Rotor coil		Ω	3.34
		Stator coil (1 phase)		Ω	0.077
	Brush	Spring force		gf(N)	255~345(2.50~3.38)
		Standard height/limit height		mm	16.0/9.0
	Slip ring	Standard outside diameter/limit outside diameter		mm	31.6/30.6
		Run-out/limit		mm	0.05/0.3
	Shaft	Front side	Outside diameter/bearing	mm/—	40/6203 BM
		Rear side	Outside diameter/bearing	mm/—	32/6101 SD

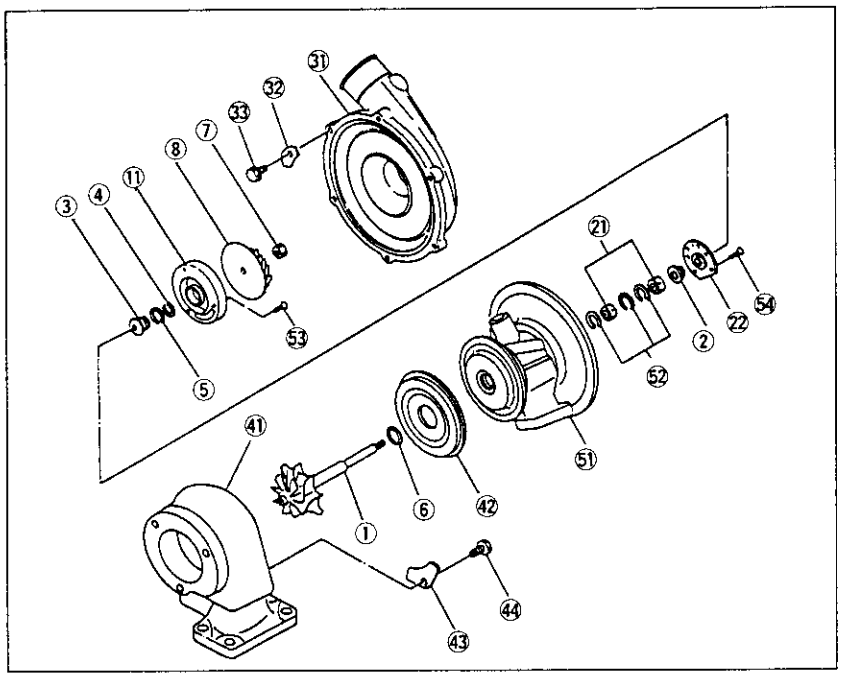
3.3.12 Tourbocharger

(1) Particulars and structure

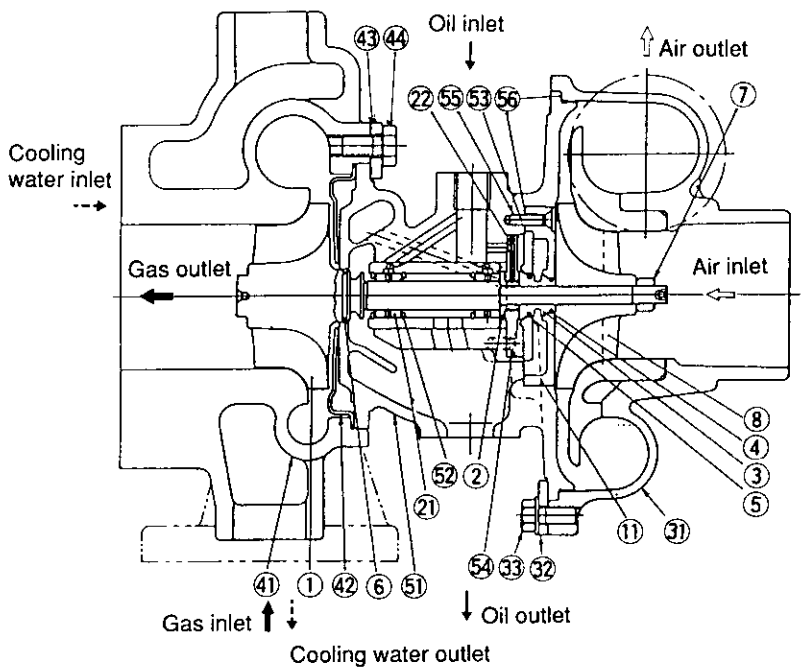
①Specifications

Model	RHB52W (IHI)
Spec. No.	9000IVP15NWTCW137
Turbine	Radial flow type
Compressor	Centrifugal type
Lubricating	Engine system oil
Bearing	Full floating
Cooling	Fresh water cooling
Dry Mass	3.6kg (35.3)

②Components



③Sectional view and tightening torque



The mark ● shows non-reusable part.

	No.	Components	Quantity	Tightening torque kgf·cm(N·cm)
	①	Turbine shaft	1	
	②	Thrust bushing	1	
	③	Oil thrower	1	
●	④	Compressor side seal ring (small)	1	
●	⑤	Compressor side seal ring (large)	1	
●	⑥	Turbine side seal ring	1	
	⑦	Shaft end nut/(left-hand thread)	1	20±2 (196±19)
	⑧	Compressor impeller	1	
	⑪	Seal plate	1	
	㉑	Floating bearing	2	
	㉒	Thrust bearing	1	
	㉛	Compressor housing	1	
	㉜	Compressor side plate washer	4	
	㉝	Hexagon bolt with flange	6	48±5 (471±49)
	㊶	Turbine housing	1	
	㊷	Thermal insulation plate	1	
	㊸	Turbine side plate washer	5	
	㊹	Hexagon bolt	5	285±5 (2796±49)
	㊺	Bearing housing	1	
	㊷	Retaining ring	3	
●	㊸	TORXT screw bolt	3	13±1 (128±10)
●	㊹	TORXT screw bolt	4	13±1 (128±10)
	㊺	Loctite	—	
	㊻	Liguid gasket	—	Three-bond 1207

(2) Checking and servicing procedures

①Service interval

Item	Check cycle
Check on the conditions of turbine shaft rotation	Every 500 h
Check on play in the turbine shaft	Every 1000 h
Overhaul	Every 4000 h

②Checking Procedures

a) Check on the conditions of turbine shaft rotation

Check the conditions of turbine shaft rotation by listening to an abnormal sound during rotation.

To make a check using a listening bar, strongly push the end of the bar against the turbocharger case and gradually increase the engine speed.

In the event of trouble, a high-pitched sound will be produced every 2 to 3 seconds.

When such a phenomenon occurs, the bearing or turbine shaft may be defective. Replace or overhaul the turbocharger.

b) Check on play in the turbine shaft

Dismount the turbocharger from the engine. Check end play and radial play in the turbine shaft as shown below.

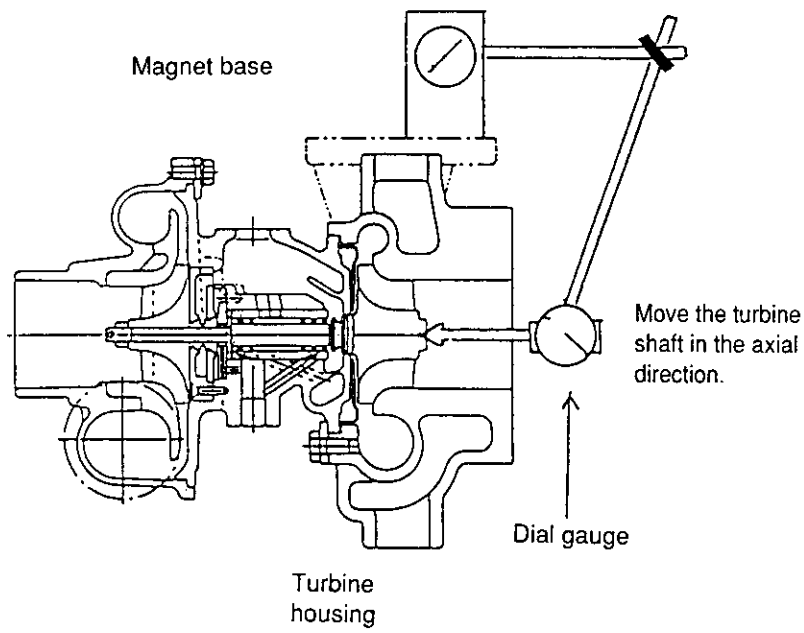
When the turbocharger is dismounted from the engine, be sure to block the oil inlet/outlet with gummed cloth tape.

- **End play in the turbine shaft**

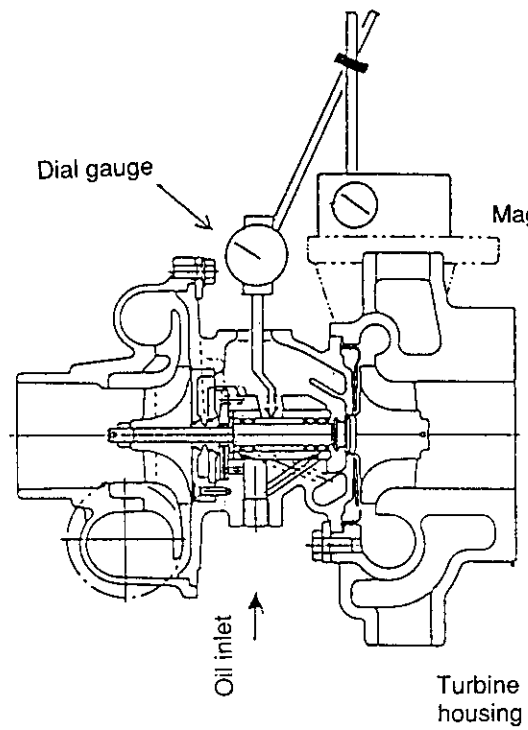
End play

Service standard : 0.03 to 0.06 mm

Wear limit : 0.09 mm



● **Radial play in the turbine shaft**



Service standard : 0.08 to 0.06 mm
Wear limit : 0.17 mm

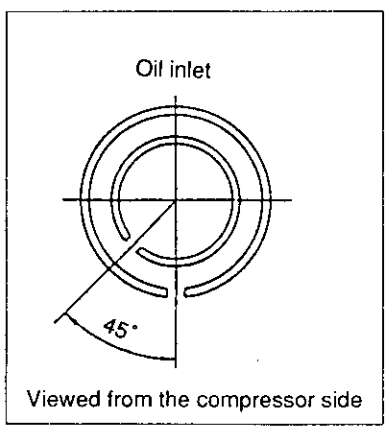
Move the turbine shaft on the left and right sides simultaneously in the radial direction.

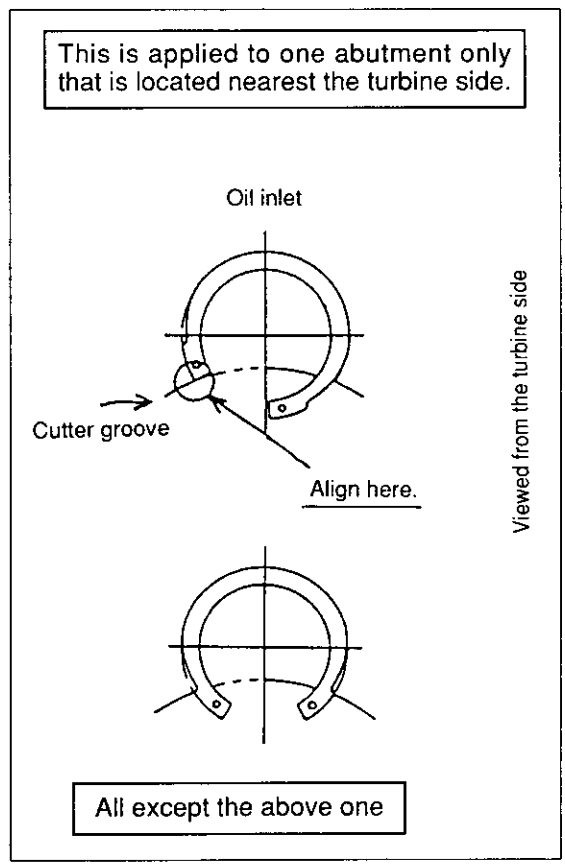
③ **Cautions about assembly**

a) Retaining ring ㊷
- Install the abutment as shown in the figure.
- Put the round ring surface on the metal side.

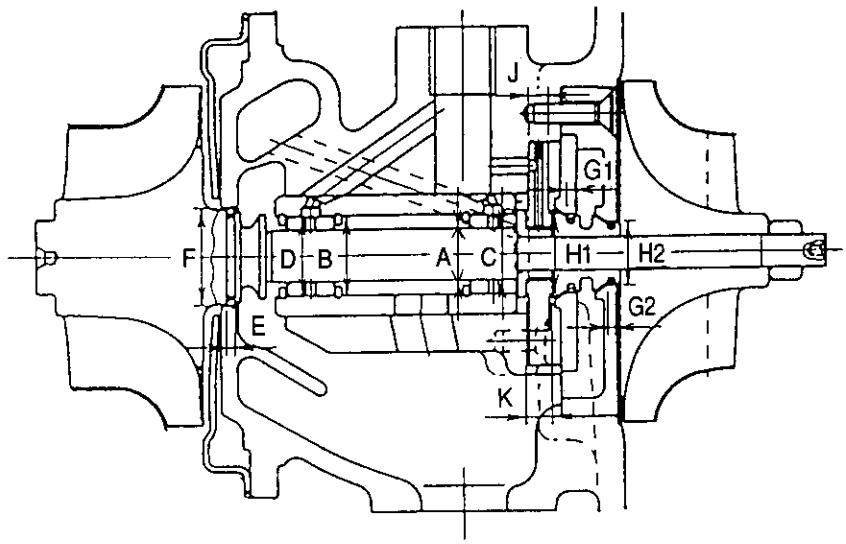
b) Seal ring on the turbine side ⑥
- Put the abutment on the oil inlet side.

c) Seal ring on the compressor side ④, ⑤
- Insert the abutment as shown in the figure.





④Service Standards



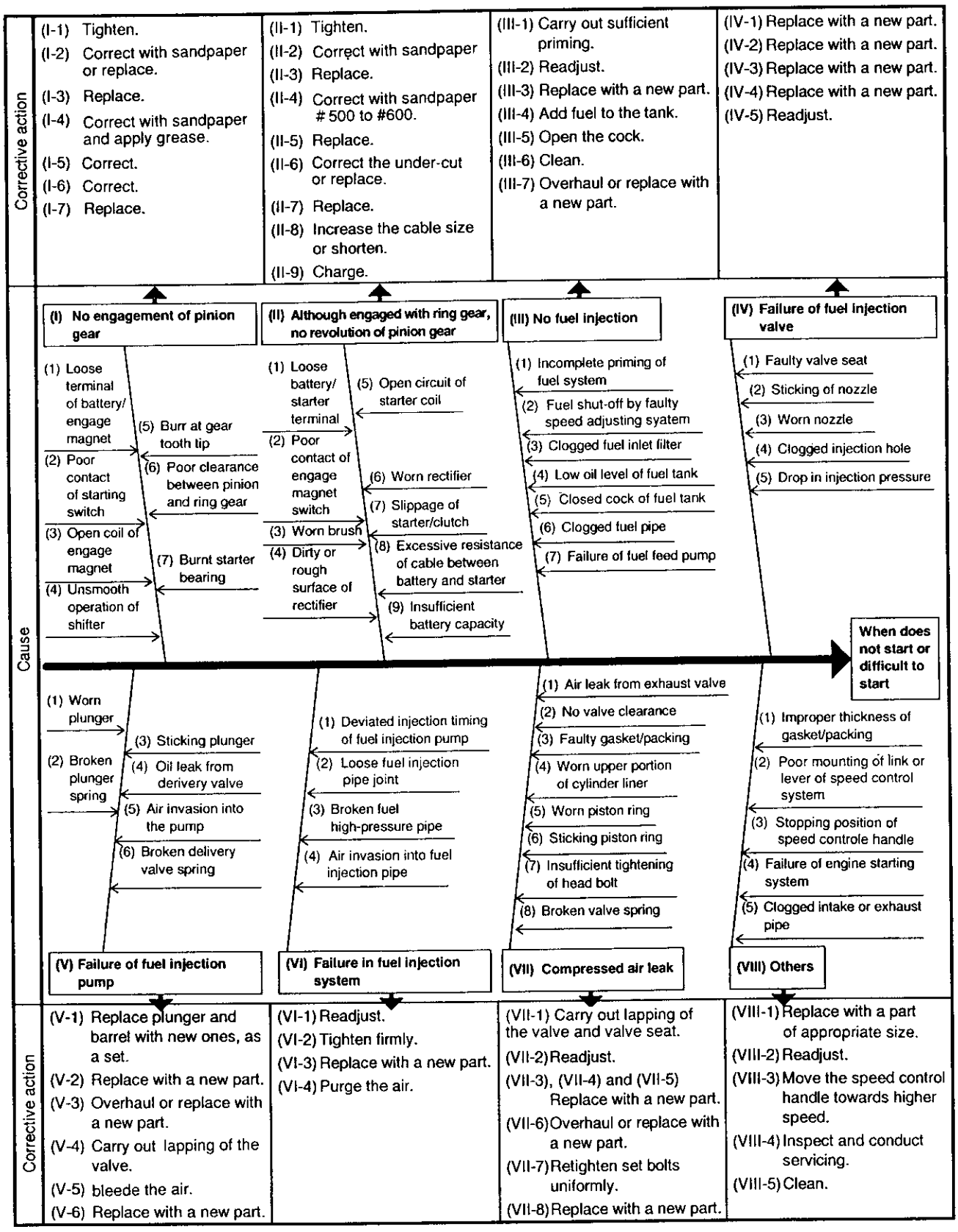
(Unit: mm)

	Check item	Usable limit	Remarks
Turbine shaft	Outside diameter (A) of turbine shaft journal	7.98	———
	Seal ring groove width (E) on turbine side	1.29	
	Seal ring groove width (G1) on compressor side	1.31	
	Seal ring groove width (G2) on compressor side	1.11	
	Turbine shaft run-out	0.011	
Bearing	Floating bearing inside diameter (C)	8.04	———
	Floating bearing outside diameter (D)	12.31	
	Bearing case inside diameter (B)	12.42	
Thrust bearing	Thrust bearing width (J)	3.98	———
	Distance (K) between thrust bearing grooves	4.07	
Seal ring inserting area	Turbine side (bearing housing) (F)	15.05	———
	Compressor side (seal plate) (H1)	12.45	
	Compressor side (seal plate) (H2)	10.05	
End play in the turbine shaft		0.09	Standard 0.03 to 0.06
Radial play in the turbine shaft		0.17	Standard 0.08 to 0.13

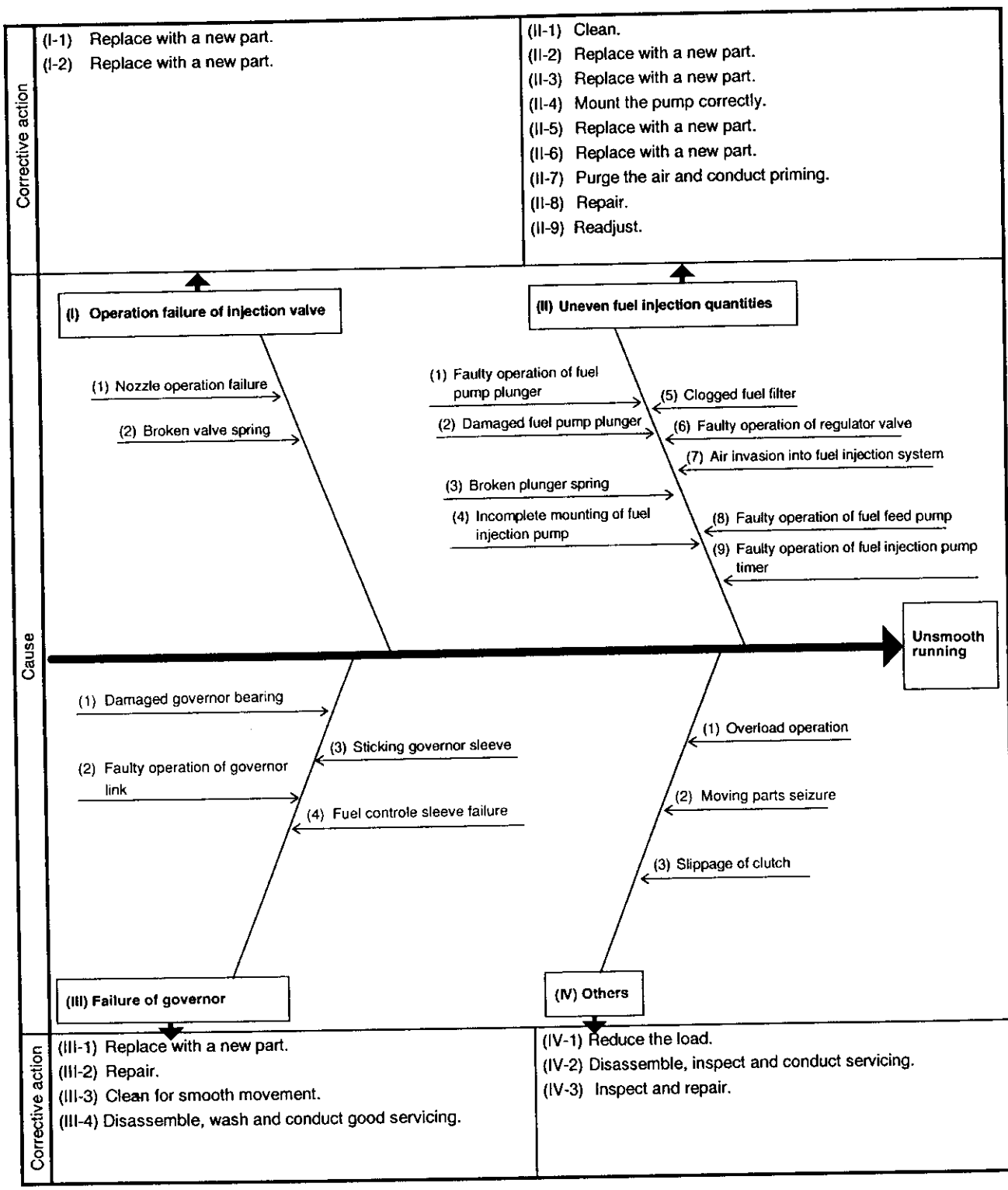
4. Troubleshooting

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

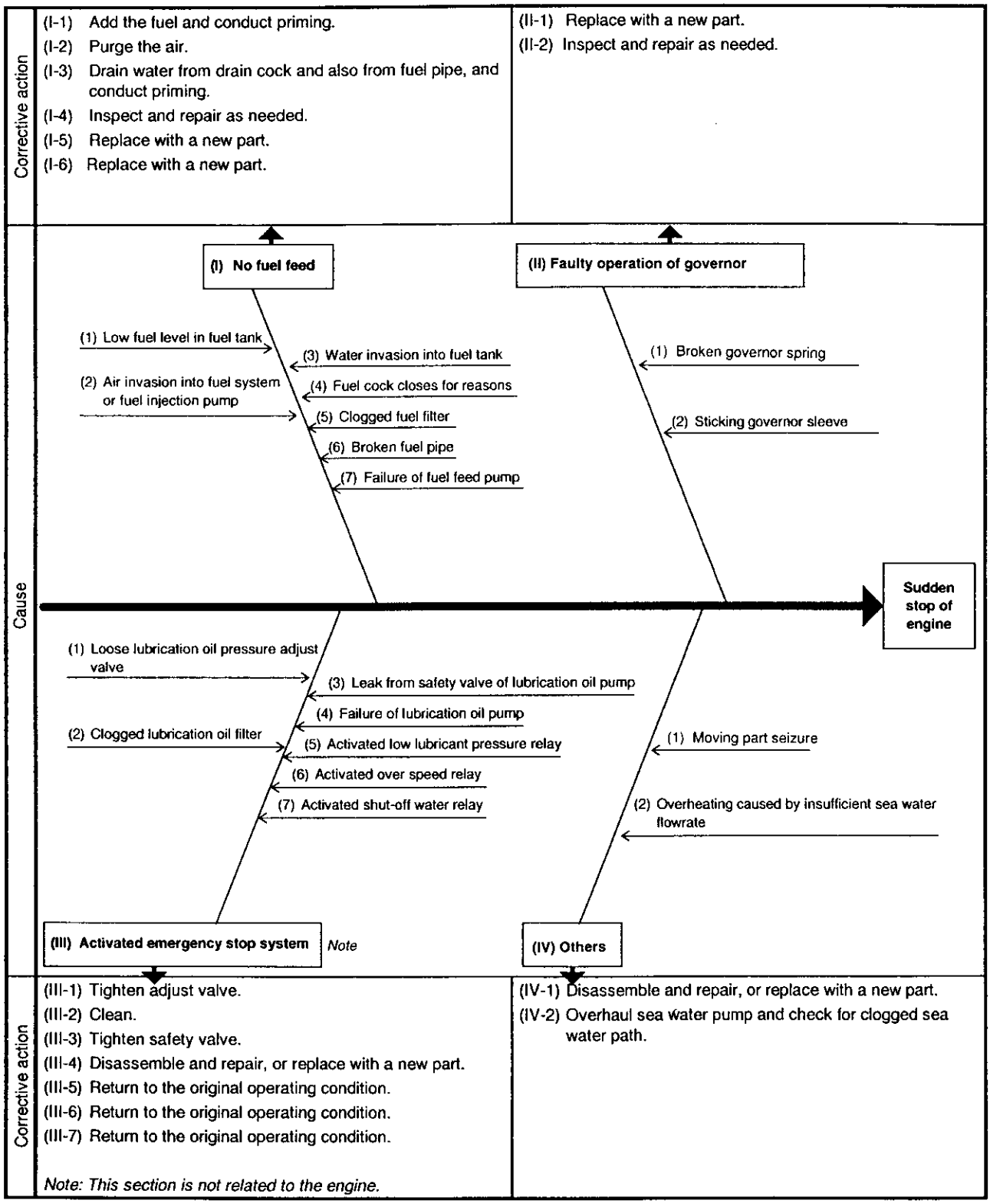
4.1 Does not Start or Difficult to Start



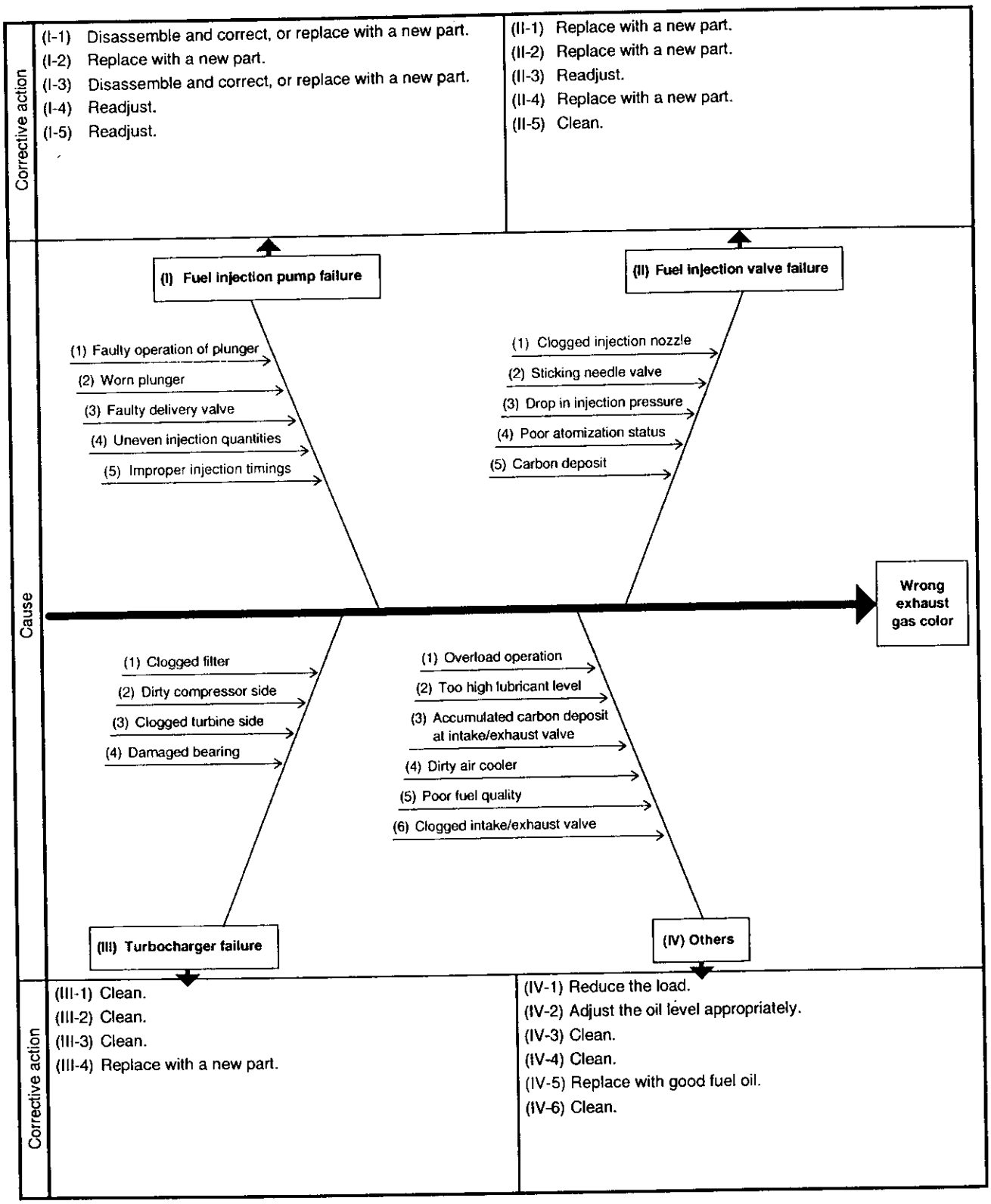
4.2 Unsmooth Running



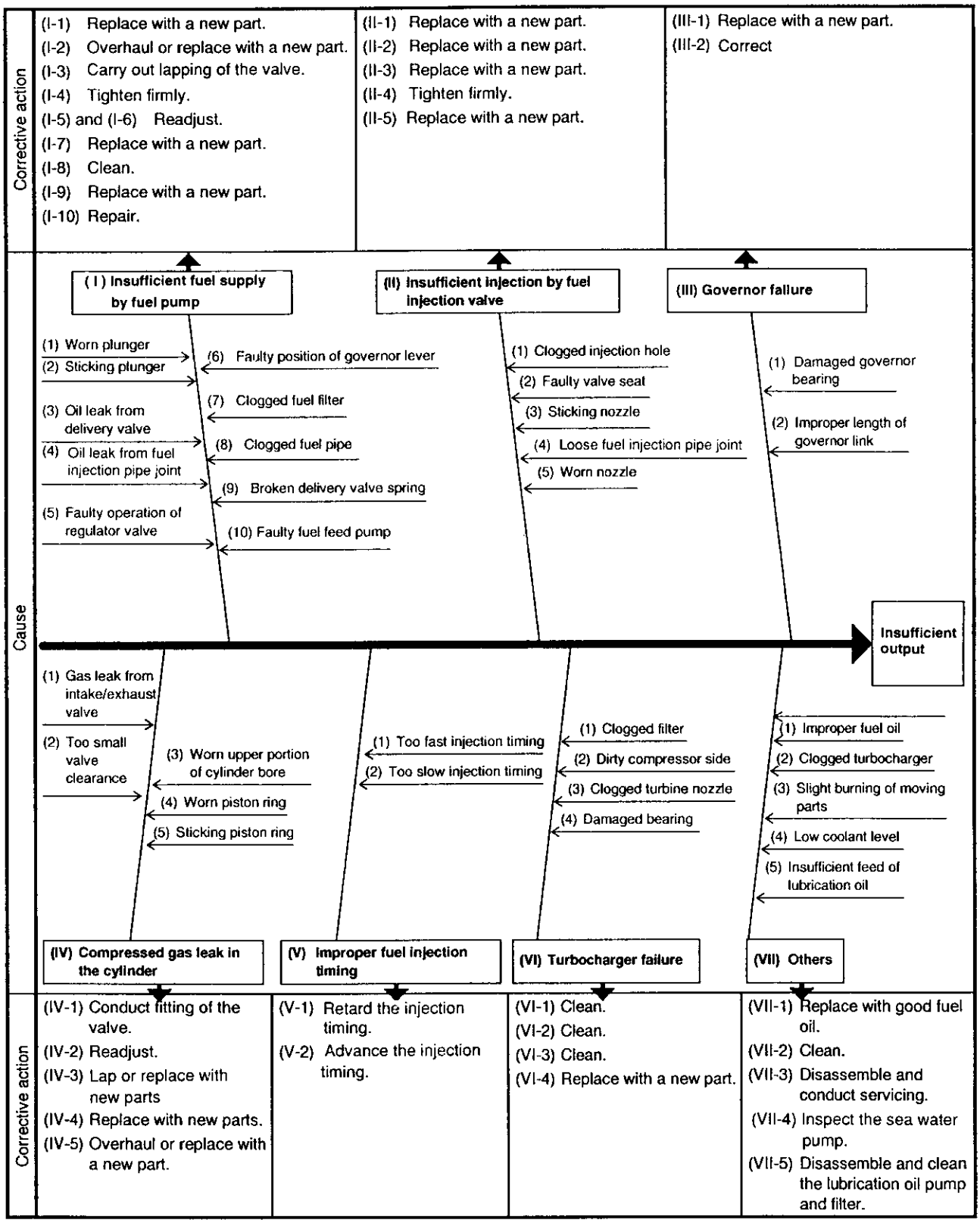
4.3 Sudden Engine Stop



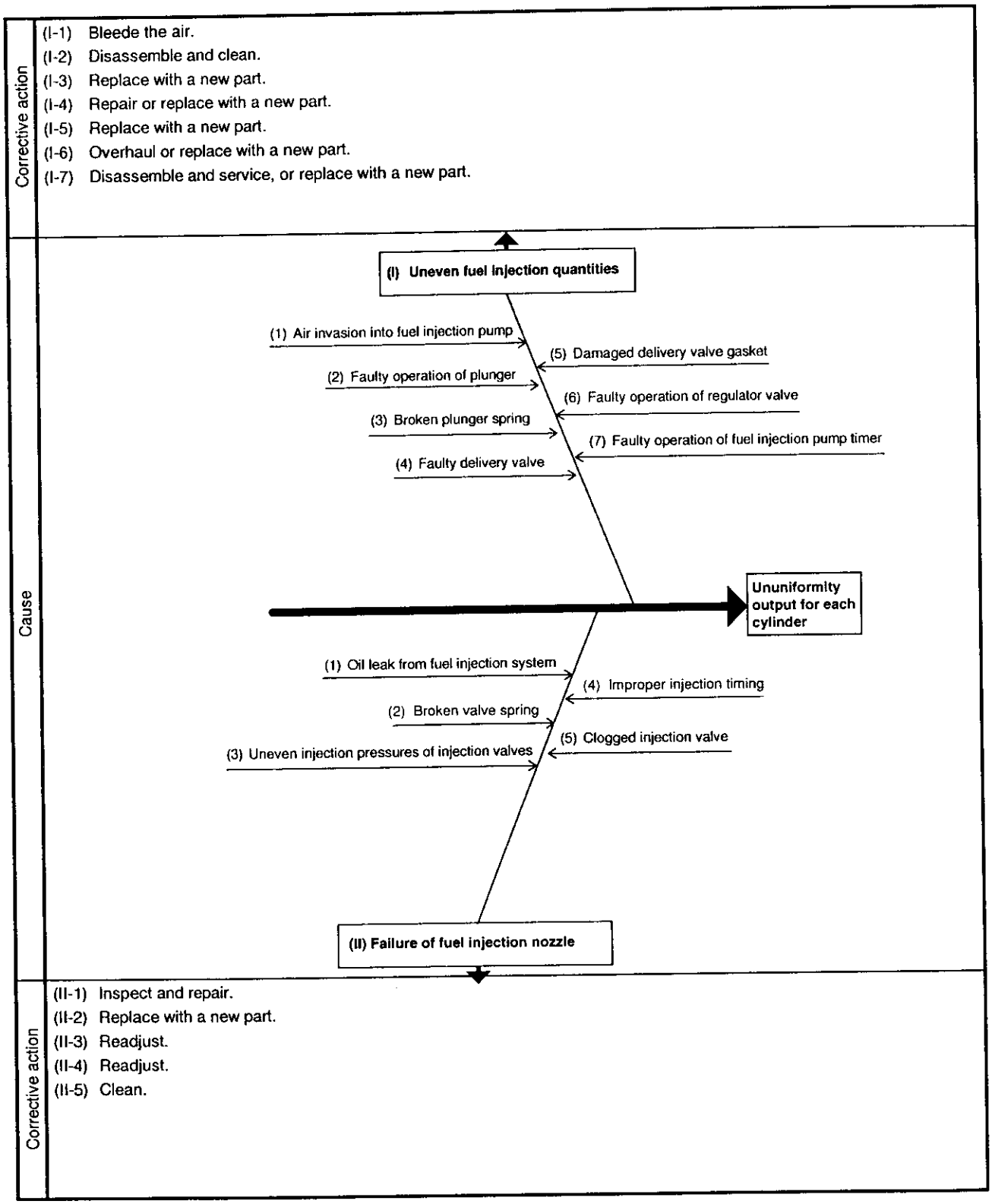
4.4 Poor Exhaust Gas Color



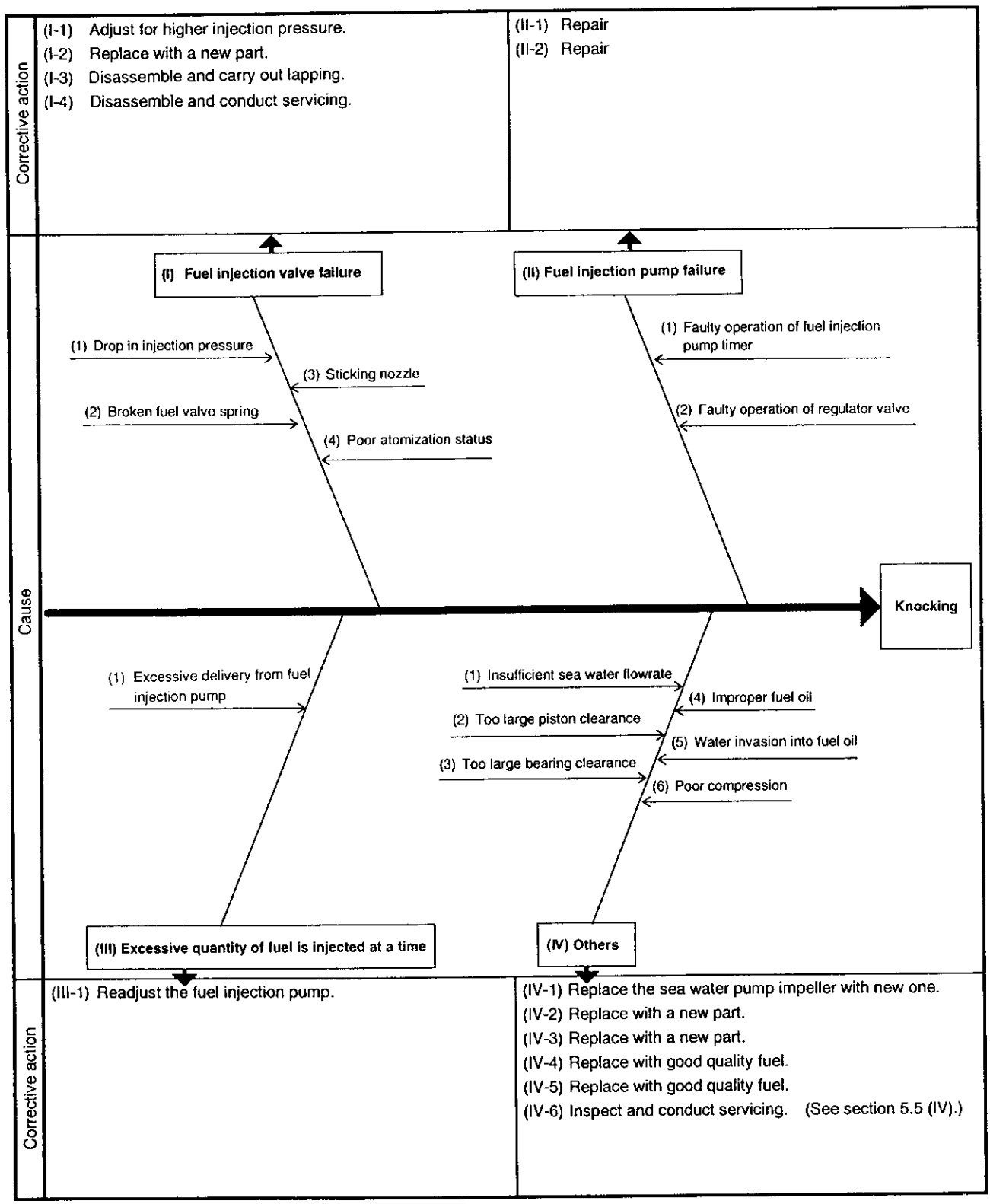
4.5 Insufficient Output



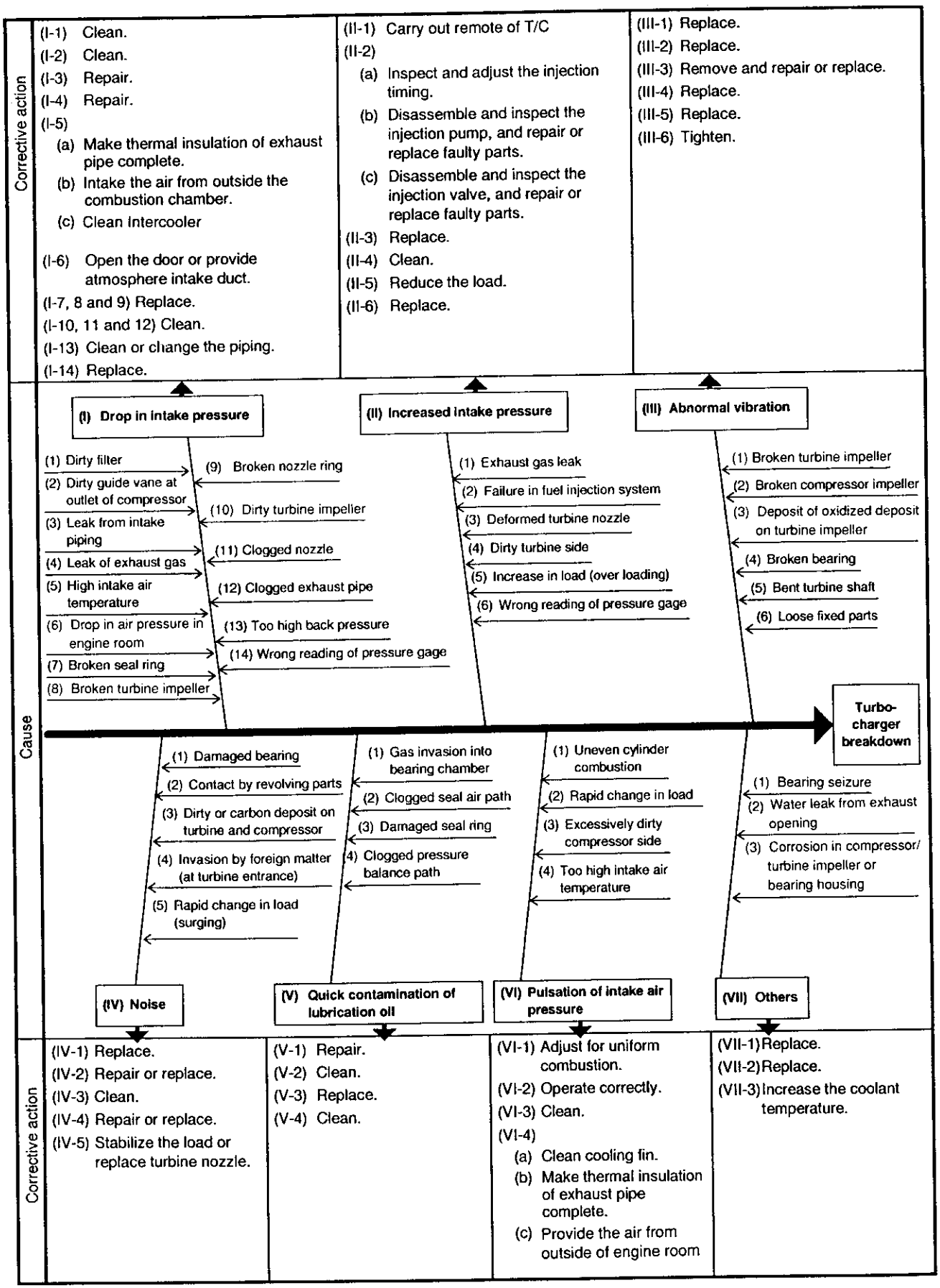
4.6 Ununiformity Output for Each Cylinder



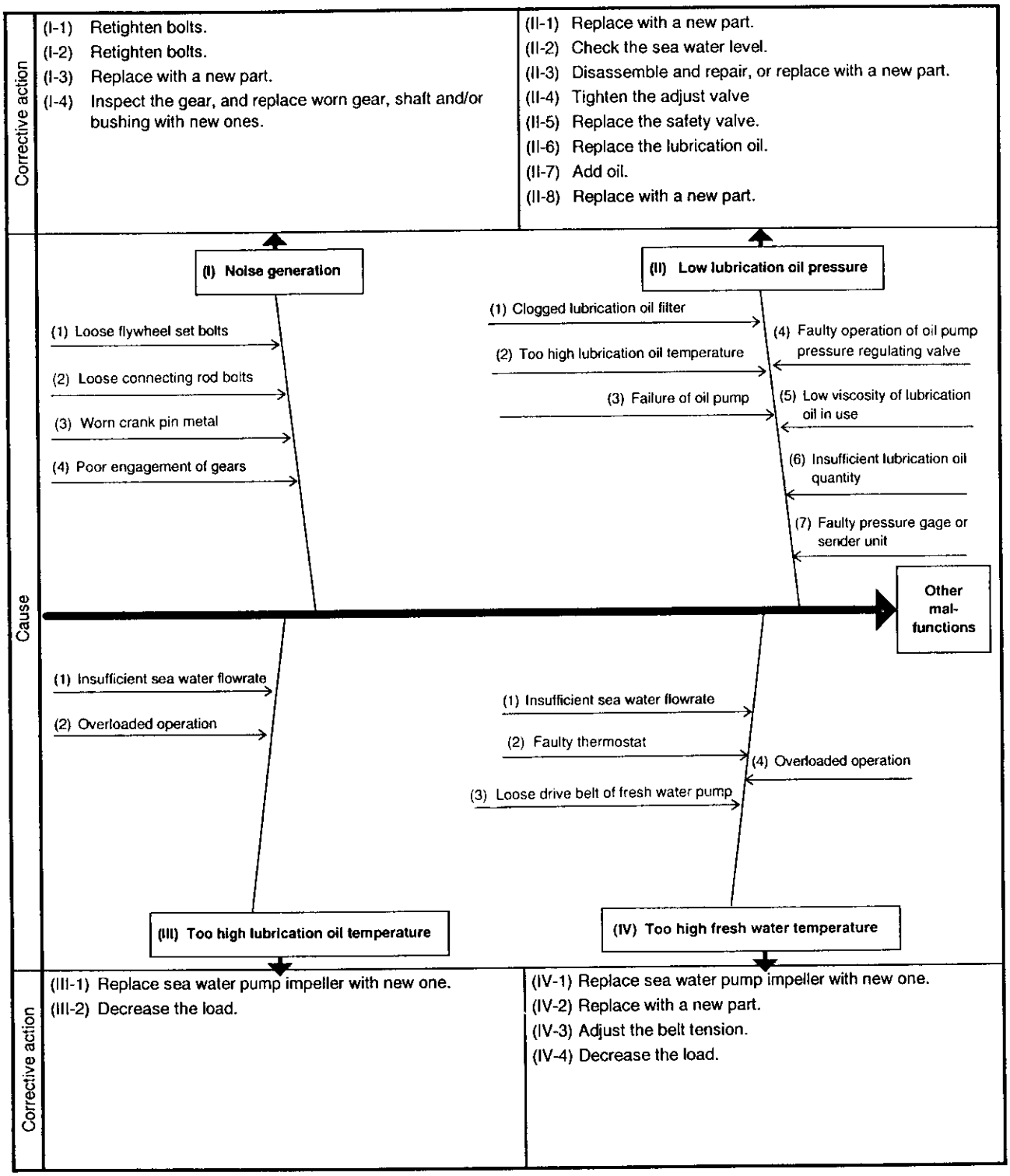
4.7 Knocking


Corrective action
(I-1) Adjust for higher injection pressure.
(I-2) Replace with a new part.
(I-3) Disassemble and carry out lapping.
(I-4) Disassemble and conduct servicing.
(II-1) Repair
(II-2) Repair
Cause
(I) Fuel injection valve failure
(II) Fuel injection pump failure
(1) Drop in injection pressure
(3) Sticking nozzle
(2) Broken fuel valve spring
(4) Poor atomization status
(1) Faulty operation of fuel injection pump timer
(2) Faulty operation of regulator valve
Knocking
(1) Excessive delivery from fuel injection pump
(1) Insufficient sea water flowrate
(4) Improper fuel oil
(2) Too large piston clearance
(5) Water invasion into fuel oil
(3) Too large bearing clearance
(6) Poor compression
(III) Excessive quantity of fuel is injected at a time
(IV) Others
Corrective action
(III-1) Readjust the fuel injection pump.
(IV-1) Replace the sea water pump impeller with new one.
(IV-2) Replace with a new part.
(IV-3) Replace with a new part.
(IV-4) Replace with good quality fuel.
(IV-5) Replace with good quality fuel.
(IV-6) Inspect and conduct servicing. (See section 5.5 (IV).)

4.8 Trouble Related to Turbocharger



4.9 Other Malfunctions



5. Periodic Checking List

The periodic checking internal of the engine varies with the use, load, quality of fuel and lubricating oil, and handling. Therefore, this section shows a general one.

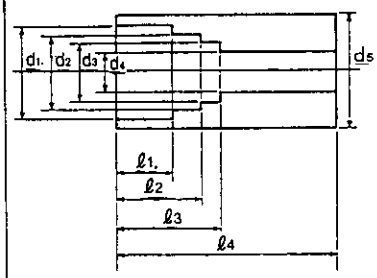
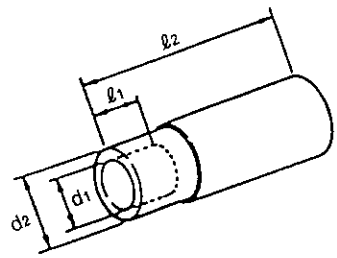
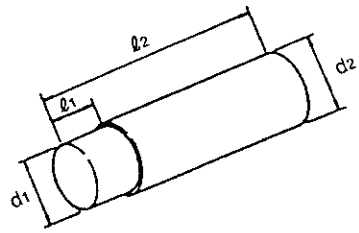
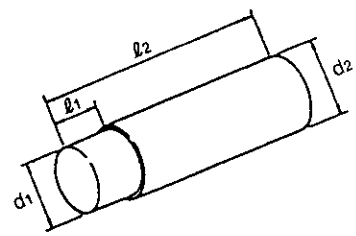
○Check ●Replacement of part

System division	Checking/servicing item	Everyday check-up	Periodic checking				
			Every 50 hours	Every 250 hours	Every 500 hours	Yearly or every 1000 hours	Biyearly or every 2000 hours
Fuel oil	Check and supply of fuel oil of the tank	○					
	Drain the fuel tank		○				
	Drain fuel filter		○				
	Replace fuel filter element			＊1 ●	＊2 ●		
Lube oil	Check the lube oil level	○					
	Replace the lube oil		First ●	Subsequent ●			
	Replace lube oil filter		First ●	Subsequent ●			
	Wash of lube oil cooler						○
Marine gear oil	Check the marine gear oil level	○					
	Replace the marine gear oil		First ●	Next ●		Subsequent ●	
	Cleane the strainer at the inlet		First ●	Next ●		Subsequent ●	
	Cleanie the oil cooler						○
Cooling fresh water	Check the cooling water and supply	○					
	Replace the fresh cooling water			●			
	Clean and check cooling water paths						○
cooling Sea water	Check the discharge of sea water	○					
	Check the sea water pump impeller					○	
	Clean and check cooling water paths						○
Piping	Check and Replace fuel/cooling water hose						○
	Replace mixing elbow						○
Electrical compone nts	Check the alarm lamps and device	○					
	Check and supply electrolyte		○				
Belt	Alternator V belt			○		●	
Remote control handle	Remote control handle actuation check/oiling	○					
	Adjusting control handle actuation position			○			
Intake/ exhaust system	Wash turborcharger blower			○			
	Adjust the intake/exhaust valve clearance			○			
	Lapping intake/exhaust valve						○
Fuel injection	Check and adjust the conditions of fuel injection			○			
	Check and adjust the fuel injection timing				○		

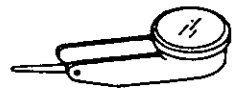
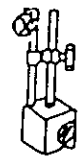
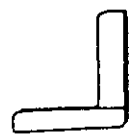
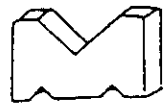
[Note] (Fuel strainer replacement) ＊1 : For a pleasure boat, ＊2 : For a work boat

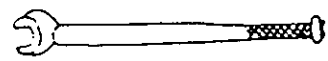
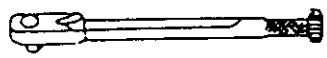
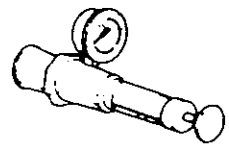
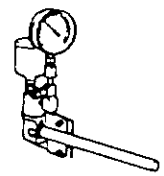
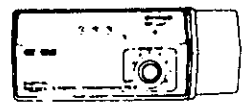
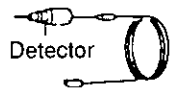
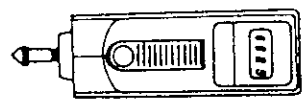
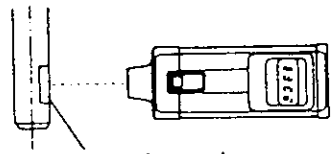
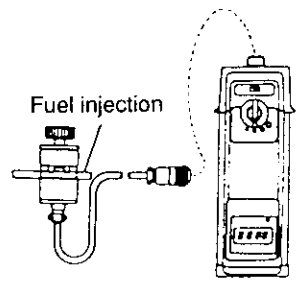
6. Tool and Measuring Instrument

(1) Tool

<table>
<tr><th>No.</th><th>Tool name</th><th>Tool size</th><th>Illustration</th></tr>
<tr><td>1</td><td>Valve stem seam insertion tool</td><td>(mm)
<table><tr><th></th><th>ℓ1</th><th>ℓ2</th><th>ℓ3</th><th>ℓ4</th><th>d1</th><th>d2</th><th>d3</th><th>d4</th><th>d5</th></tr><tr><td>Size</td><td>16.5</td><td>20</td><td>——</td><td>80</td><td>16</td><td>12.7±0.1</td><td>——</td><td>——</td><td>23</td></tr></table>※Prepared in the field</td><td>  </td></tr>
<tr><td>2</td><td>Valve guide insertion tool</td><td><table><tr><th></th><th>ℓ1</th><th>ℓ2</th><th>d1</th><th>d2</th></tr><tr><td>Size</td><td>15</td><td>80</td><td>14</td><td>20</td></tr></table>※Prepared in the field</td><td>  </td></tr>
<tr><td>3</td><td>Connecting rod bushing insertion/removal tool</td><td><table><tr><th>Size / Model</th><th>ℓ1</th><th>ℓ2</th><th>d1</th><th>d2</th></tr><tr><td>4JH3Z1</td><td>20</td><td>100</td><td>$26^{-0.3}_{-0.6}$</td><td>$29^{-0.3}_{-0.6}$</td></tr><tr><td>T,HT,DT series</td><td>20</td><td>100</td><td>$28^{-0.3}_{-0.6}$</td><td>$31^{-0.3}_{-0.6}$</td></tr></table>※Prepared in the field</td><td>  </td></tr>
<tr><td>4</td><td>Cam shaft bushing tool (cam shaft bushing removal)</td><td><table><tr><th></th><th>ℓ1</th><th>ℓ2</th><th>d1</th><th>d2</th></tr><tr><td>Size</td><td>18</td><td>70</td><td>$45^{-0.3}_{-0.6}$</td><td>$48^{-0.3}_{-0.6}$</td></tr></table>※Prepared in the field</td><td>  </td></tr>
<tr><td>5</td><td>Timer removal tool (4JH3Z1)</td><td>Timer removal thread diameter : M24×1.5
※Prepared in the field</td><td>Sleeve : 124311-92310
Bolt : 124311-92320</td></tr>
<tr><td>6</td><td>Fuel pump drive gear removal tool (T,HT,DTseries)</td><td>Fuel pump drive gear removal thread diameter
2-M8 (PC φ50)
※Prepared in the field</td><td></td></tr>
</table>

(2) Measuring instrument

No.	Name	Intended use	Illustration
1	Dial gauge	Measures a bend in a shaft, surface distortion, gap, etc.	
2	Test indicator	Measures narrow or deep places which cannot be measured with a dial gauge.	
3	Magnetic stand	When a dial gauge is used, this tool supports the dial gauge at different angles for adjustments.	
4	Micrometer	Measures the outside dimensions of a crank shaft, piston, piston pin, etc.	
5	Cylinder gauge	Measures the inside diameters of a cylinder liner, metal, etc.	
6	Calipers	Measures various outside diameters, depth, thickness, width, etc.	
7	Depth micrometer	Measures depths such as valve sink.	
8	Square	Measures a valve spring inclination, squareness of parts, etc.	
9	V-shaped block	Measures a bend in a shaft.	

No.	Name		Intended use	Illustration
10	Torque wrench		Tightens a bolt and nut to the specified torque.	 
11	Thickness gauge		Measures a valve clearance, ring and ring groove, coupling clearance during installation, etc.	
12	Cap tester		Checks the fresh water system for leakage.	
13	Battery coolant tester		Checks the concentration of non-freezing solution and charging of battery fluid.	
14	Nozzle tester		Check the spray from a fuel injection valve and injection pressure.	
15	Digital thermometer		Measures the temperature of each portion.	  Detector
16	Tachometer	Contact type	Contacts the center hole of a rotation shaft and measures the engine speed.	
		Photoelectric type	With a reflection mark put on the periphery of a rotating portion, measures the engine speed.	Rotating portion  Reflection mark
		Fuel injection pipe clamp type	Measures the engine speed irrespective of a rotating shaft center and periphery of a rotating portion.	 Fuel injection

7. Service Specifications

7.1 Engine Adjusting Standards

①Engine

Item		Unit	4JH3-TE	4JH3-HTE,DTE	Remarks
Top clearance		mm	0.8±0.09		—
Valve clearance		mm	0.2±0.05		Cold
Fuel injection timing	Before top dead center (b.T.D.C)	Degree	12±1		Note 1
Fuel injection pressure		kgf/cm²(MPa)	220±5 (21.57±0.49)		—
Fire order		—	1—3—4—2—1 (No. 1 is on the flywheel side.)		
lubricating oil	Setting oil press	kgf/cm²(MPa)	4±0.5 (0.39±0.05)		3600rpm
	Oil quantity oil pan/effective	ℓ	—		Rake 0°
			—		Rake 8°
			5.8/2.0	—	Rake 0°
			6.5/2.0	—	Rake 7°
			—	5.8/2.0	Rake 0°
			—	6.5/2.0	Rake 7°
Fresh water holding quantity Engine/sub-tank		ℓ	6/0.8	7.2/0.8	—
Thermostat valve opening temperature/Full open lift		—	At 76.5±1.5℃ / 8 mm or more 90℃		—
Alarm lamp	Charging alarm	—	Off at 450 rpm or more of engine speed		—
	Cooling water high temperature alarm	—	On at 95 ±2℃.		—
	Lubricating oil low pressure alarm	—	On at 0.2 kgf/cm² (0.02 MPa)		—
	Fuel filter water alarm	—	On at the water level of 23 mm (80cm³) or more.		—

Note 1) The injection timing is for a plunger lift of 0.46 mm.

7.2 Service Standards

①Cylinder head

● Cylinder head

Check item			Standard	Limit	Reference
Combustion surface distortion (mm)			0.05 or less	0.15	3.3.1(1)
Valve sink (mm)		Intake	0.4±0.1	1.5	3.3.1(3)
		Exhaust			
Valve seat width (mm)		Intake	2.0	2.5	3.3.1(2)
		Exhaust	1.3	1.8	
Valve seat angle Degree		Intake	120	—	
		Exhaust	90		
Valve seat	Intake (mm)	Outside diameter	37.048~37.064	—	
		Head inside diameter	37.000~37.016	—	
		Interference	0.032~0.064	—	
	Exhaust (mm)	Outside diameter	31.548~31.564	—	
		Head inside diameter	31.500~31.516	—	
		Interference	0.032~0.064	—	
Amount of protrusion of valve guide mm			14.7~15.0	—	3.3.1(3)

● Intake/exhaust valve and valve guide

Check item			Standard	Limit	Reference
Valve outside diameter mm		Intake	35±0.1	—	—
		Exhaust	30±0.1	—	
Valve guide	Intake (mm)	Valve guide inside diameter	8.010~8.025	8.10	3.3.1(3)
		Valve Stem diameter	7.960~7.975	7.90	
		Oil Clearance	0.035~0.065	0.20	
	Exhaust (mm)	Valve guide inside diameter	8.015~8.030	8.10	
		Valve stem diameter	7.055~7.070	7.90	
		Oil clearance	0.045~0.075	0.20	
Valve margine	Intake valve (mm)	Margine thickness	1.2	0.7	3.3.1(3)
	Exhaust valve (mm)				

● Valve actuation device

Check item		Standard	Limit	Reference
Tappet (mm)	Tappet hole diameter (cylinder block)	12.000 ~12.018	12.05	3.3.6(2)
	Outside diameter	11.975 ~11.990	11.93	
	Oil clearance	0.010 ~0.043	0.10	
Rocker arm (mm)	Rocker arm inside diameter	16.000 ~16.018	16.05	3.3.1(5)
	Rocker arm shaft diameter	15.966 ~15.984	15.90	
	Oil clearance	0.016 ~0.052	0.15	
Valve spring (mm)	Free length	44.4	43	3.3.1(4)
	Inclination	1.9	2.2	
Push rod (mm)	Run-out (TIR)	0.03	0.06	3.3.1(5)

②Piston and piston ring

● Piston

Check item			Standard	Limit	Reference
Piston diameter	「The measuring position is 22 to 25 mm away from the skirt bottom.」	Diameter	83.917~83.947	83.682	3.3.2(1)
		L-mark	83.937~83.947		
		ML-mark	83.932~83.937		
		MS-mark	83.927~83.932		
		S-mark	83.917~83.927		
Note) Measure in a direction at right angles to the piston pin (major axis).					
Clearance between piston and cylinder			0.025~0.085	——	3.3.2(1) 3.3.3
「Measure in a direction at right angles to the piston pin.」			0.053~0.113	——	
Selection of piston and sylinder block			Piston L ML MS S Sylinder block L M S		
Piston pin (mm)		Piston pin hole diameter (Piston)	28.000~28.009	28.05	3.3.2(2)
		Piston pin diameter	27.987~28.000	27.95	
		Clearance	0~0.022	0.10	

● Piston ring

Piston ring	Top ring (keystone) (mm)	Ring groove width	——	——	3.3.2(3)
		Ring width	——	——	
		Clearance	——	——	
		End gap	0.2~0.4	1.5	
	2nd ring (taper) (mm)	Ring groove width	2.050~2.065	2.15	
		Ring width	1.970~1.990	1.90	
		Clearance	0.060~0.095	0.20	
		End gap	0.2~0.4	1.5	
	Oil ring (with coil) (mm)	Ring groove width	4.020~4.035	4.15	
		Ring width	3.970~3.990	3.90	
		Clearance	0.030~0.065	0.20	
		End gap	0.2~0.4	1.5	

③Cylinder block

● Cylinder block

Check item		Standard	Limit	Reference
Cylinder bore (mm)	Bore diameter	84.00~84.03	84.20	3.3.3
	L-mark	84.02~84.03		
	M-mark	84.01~84.02		
	S-mark	84.00~84.01		
Circularity (mm)		0.01 or less	0.03	
Cylindricity (mm)		0.01 or less	0.03	

④Connecting rod

• Piston pin and bushing

Check item		Standard	Limit	Reference
Thrust clearence (big end)		0.20~0.40	0.55	3.3.4
Piston pin and bushing	Bushing inside diameter	28.025~28.038	26.05	
	Piston pin diameter	27.987~28.000	25.95	
	Oil clearance	0.025~0.051	0.07	
Pin hole parallelism	———	0.03/100	0.07/100	

⑤Crankshaft

• Crank pin and Crank journal

Check item		Standard	Limit	Reference
Crank shaft run-out (TIR) (mm)		0.02	0.03	3.3.5(1)
Crank pin (mm)	Crank pin diameter	47.952~47.962	47.87	3.3.4(2)
	Metal thickness	1.487~1.500	1.48	
	Oil clearance	0.038~0.093	0.13	
Crank Journal (mm)	Crank journal diameter	49.952~49.962	49.93	3.3.5(1)
	Bearing thickness	1.987~2.000	1.98	
	Oil clearance	0.038~0.093	0.13	

• Thrust metal

Check item	Reference value	Limit	Reference
Thrust clearance (mm)	0.09~0.27	0.33	3.3.5(1)
Thrust metal thickness (mm)	1.93~1.98	———	

⑥Camshaft and gear train

• Camshaft

Check item			Standard	Limit	Reference
Thrust clearance (mm)			0.05~0.20	0.25	3.3.6(1)
Camlobe height (mm)		Intake	38.696~38.704	38.4	
		Exhaust	38.896~38.904	38.6	
Camshaft bearing	Gear side (mm)	Bearing inside diameter	44.990~45.028	45.05	
		Camshaft diameter	44.925~44.950	44.85	
		Oil clearance	0.04~0.103	0.20	
	Midpoint (1 pc) (mm)	Camshaft hole diameter	45.000~45.025	45.03	
		Camshaft diameter	44.925~44.950	44.85	
		Oil clearance	0.05~0.100	0.18	
	Flywheel side (mm)	Camshaft hole diameter	45.000~45.025	45.03	
		Camshaft diameter	44.925~44.950	45.85	
		Oil clearance	0.05~0.100	0.18	

• Idler gear shaft and bushing

Check item		Standard	Limit	Reference
Idler gear shaft and bushing (mm)	Thrust clearance (mm)	0.1~0.3	0.4	3.3.7(2)
	Bushing inside diameter	46.000~46.025	46.05	
	Shaft diameter	45.950~45.975	45.90	
	Oil clearance	0.025~0.075	0.15	

• Backlash between gears

Check item	Standard	Limit	Reference
• Crank gear - idle gear (mm) • Idle gear - fuel injection pump gear • Idle gear - cam gear	0.04~0.12	0.2	3.3.7(1)
Crank gear - Lubricating oil pump gear (mm)	0.11~0.19		
Cam gear - Sea water pump gear (mm)	0.04~0.12		

⑦Lubricating oil pump

Check item	Standard	Limit	Reference
Clearance between driven rotor and pump casing (mm)	0.10~0.17	0.25	3.3.8(2)
Clearance between driven rotor and drive rotor (mm)	0.05~0.11	0.15	
Rotor side clearane (mm)	0.03~0.09	0.13	

⑧Sea water pump

	Standard	Side clearance	Limit		Reference
Impeller width (mm)	31.6~3.18	0~0.3	0.8	31.3	3.3.9(2)
Wear plate thickness (mm)	2			1.8	
Housing width (mm)	33.8~33.9			—	
Side cover width (mm)	2			1.8	

⑨Nut and bolt tightening torque

• For majour nut and bolt

Tightening parts	Thread diameter ×pitch (mm)	Tightening torque kgf·m (N·m)	Width across flat (mm)	Oil application (Note)
Cylinder head bolt	M10×1.25	9.3±0.3 (91.23±294)	14	Yes
Connecting rod bolt	M9×1.0	$5.0^{+0.5}_{0}$ $\left(49.05^{+4.90}_{0}\right)$	13	
Flywheel bolt	M10×1.25	$8.5^{+0.5}_{0}$ $\left(83.39^{+4.90}_{0}\right)$	17	
Main bearing cap bolt	M12×1.25	11±0.5 (107.9±4.90)	17	
Crank shaft V pulley bolt	M14×1.5	18±0.5 (176.58±4.90)	19	
Fuel injection nozzle mounting nut	M6×1.0	0.7~0.9 (6.87~8.83)	10	No
Nozzle case nut	Special thread	$4^{+0.5}_{0}$ $\left(39.24^{+4.90}_{0}\right)$	15	
Fuel injection pump drive gear nut	M14×1.5	6.5±0.5 (63.77±4.90)	19	Yes
Idle gear shaft bolt	M8×1.25	3.8±0.2 (37.28±1.96)	12	
Exhaust manifold mounting bolt	M8×1.25	3.8±0.2 (37.28±1.96)	12	
Viscous damper mounting bolt	M8×1.25	2.6±0.2 (25.51±1.96)	12	
Alternator mounting bolt	M8×1.25	3.8±0.3 (37.28±2.94)	12	
Output shaft coupling bolt (reamer)	M10×1.5	5±0.5 (49.05±4.90)	14	

(Note) Whether to apply oil to threaded portion and seat

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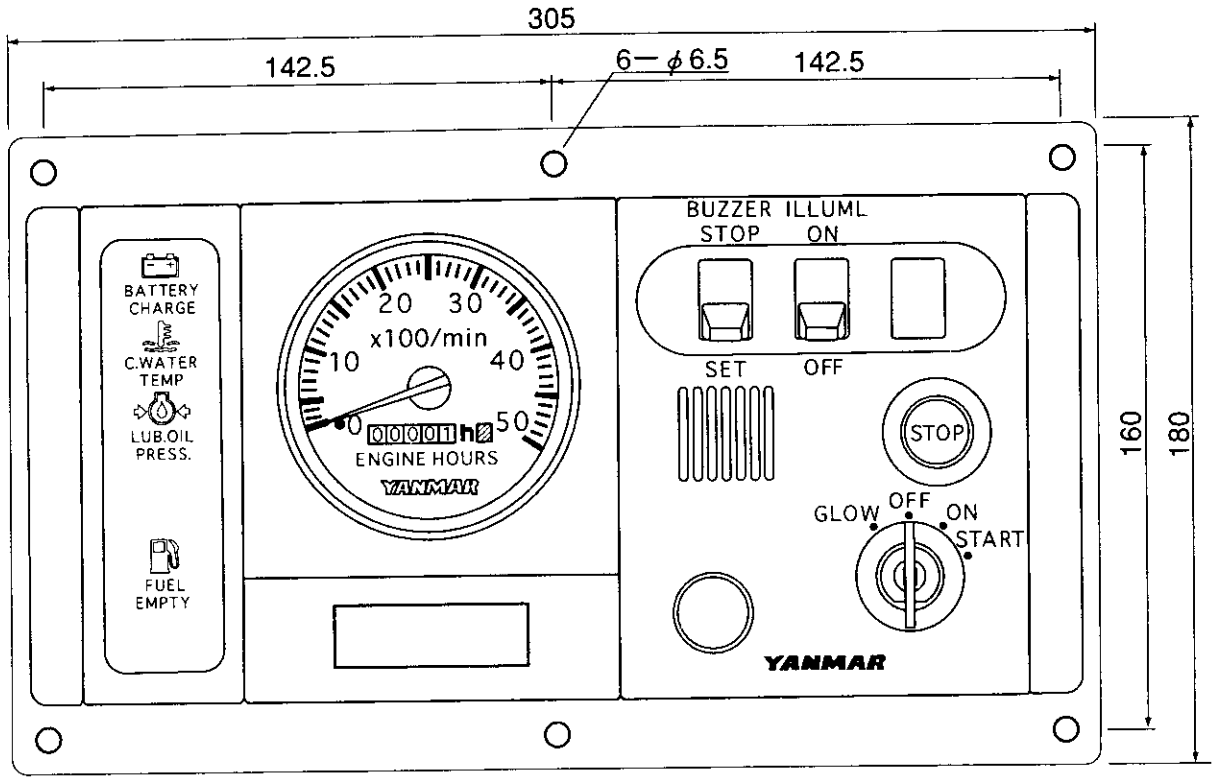
● For general

Name	Thread diameter	Tightening torque kgf-m (N·m)	Name	Thread diameter	Tightening torque kgf-m (N·m)
Hexagon bolt (7T) Hexagon nut	M6×1	1.1 (10.79)	PT plug	1/8	1.0
	M8×1.25	2.6 (25.51)		1/4	2.0
	M10×1.5	5.0 (49.05)		3/8	3.0
	M12×1.75	9 (88.29)		1/2	6.0
(note)	M14×2	14 (137.34)	Ball joint bolt	M8	1.5
	M16×2	23 (225.63)		M12	3.0
———				M14	4.5
				M16	5.5

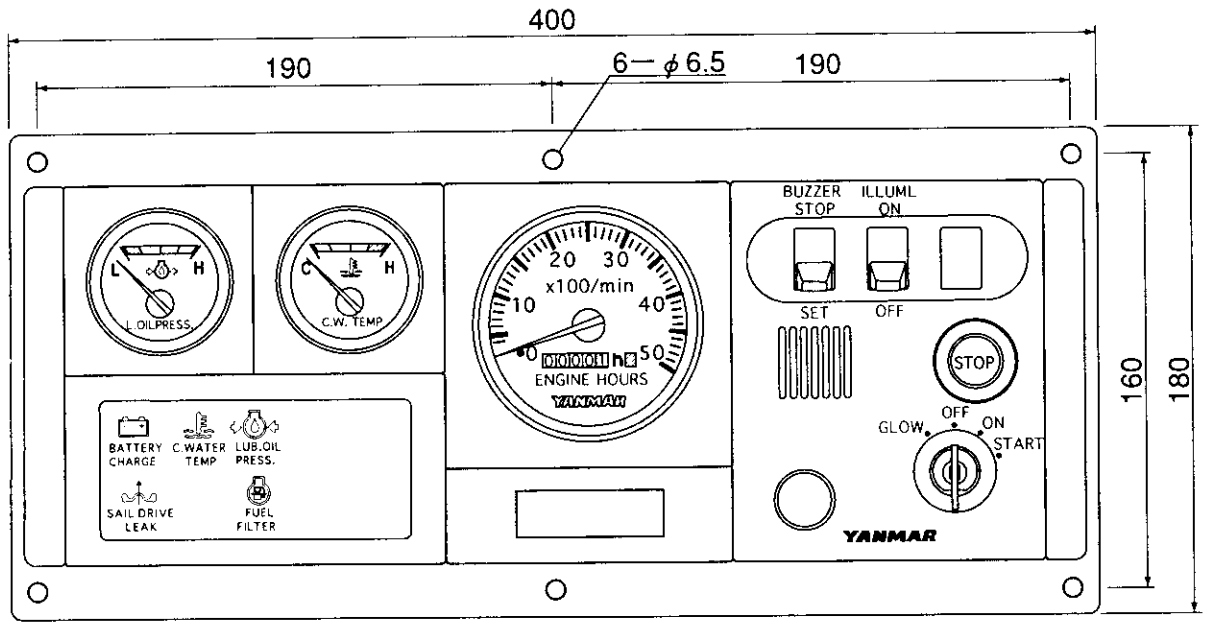
(Note) 80 % for Al material of installation side

8. Instrument Panel (Option)

● New B Type (129574-91130)



● New C Type (129574-91160)



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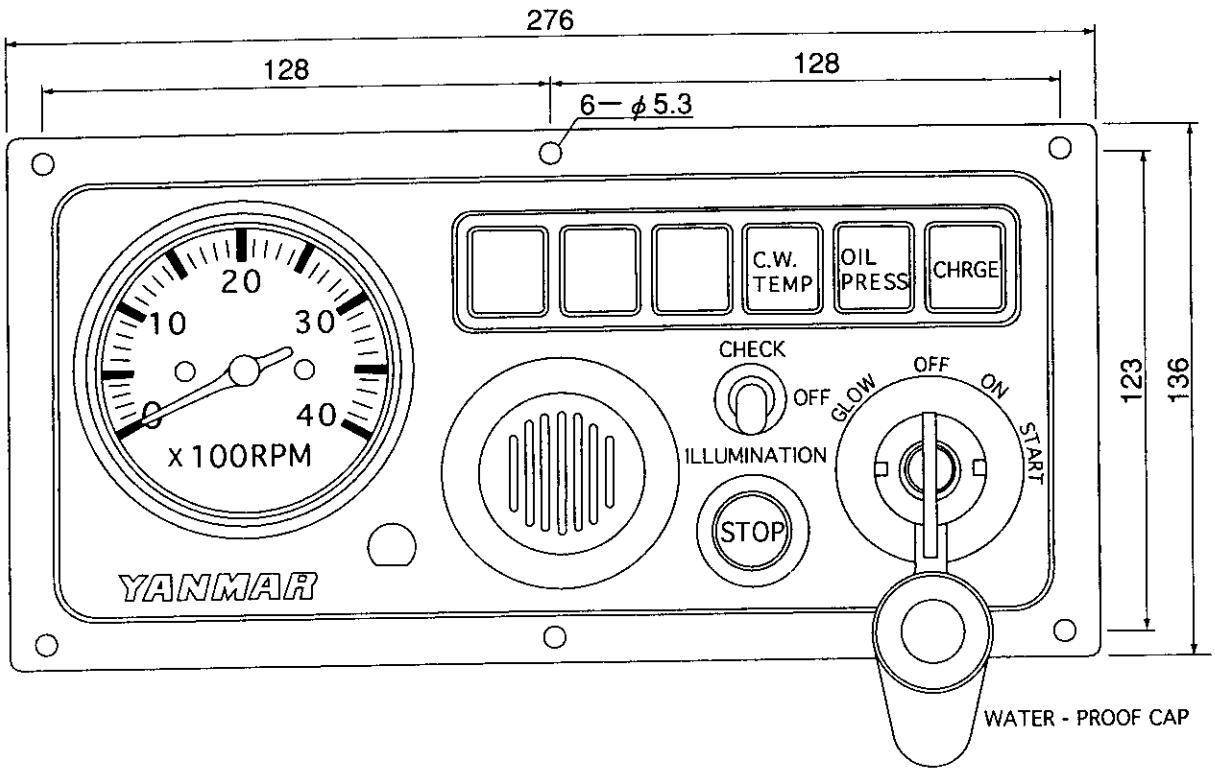

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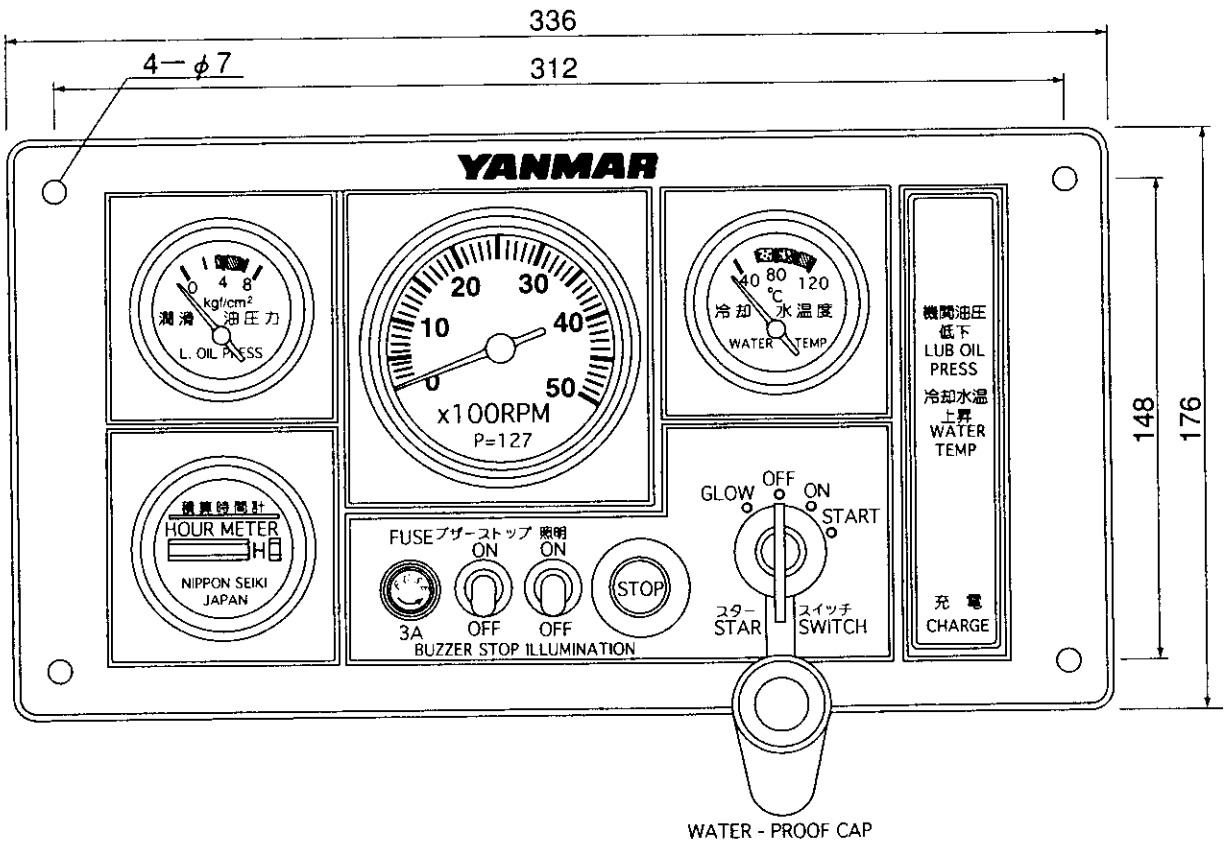

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