



YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

3JH4E/4JH4E/4JH4-TE/4JH4-HTE

YANMAR CO., LTD.

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New edition		February 2004					
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FOREWORD

This service manual has been compiled for engineers engaged in sales, service, inspection and maintenance. Accordingly, descriptions of the construction and functions of the engine are emphasized in this manual, while items, which should already be common knowledge, are omitted.

One characteristic of a marine diesel engine is that its performance in a vessel is governed by the applicability of the vessel's hull construction and its steering system.

Engine installation, fitting out and propeller selection have a substantial effect on the performance of the engine and the vessel. Moreover, when the engine runs unevenly or when trouble occurs, it is essential to check a wide range of operating conditions - such as installation to the full and suitability of the ship's piping and propeller - and not just the engine itself. To get maximum performance from this engine, you should completely understand its functions, construction and capabilities, as well as proper use and servicing.

Use this manual as a handy reference in daily inspection and maintenance, and as a text for engineering guidance.

Model 3JH4E and 4JH4-TE have been used for the illustrations in this service manual, but they apply to other models in the JH4 series engines.

California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.
(only for 3JH4E)

California Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.
Wash hands, after handling.
(only for 3JH4E)

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FOR SAFETY

1. SAFETY LABELS

- Most accidents are caused by negligence of basic safety rules and precautions. For accident prevention, it is important to avoid such causes before development to accidents.
Please read this manual carefully before starting repair or maintenance to fully understand safety precautions and appropriate inspection and maintenance procedures.
Attempting at a repair or maintenance job without sufficient knowledge may cause an unexpected accident.
- It is impossible to cover every possible danger in repair or maintenance in the manual. Sufficient consideration for safety is required in addition to the matters marked **▲ CAUTION**. Especially for safety precautions in a repair or maintenance job not described in this manual, receive instructions from a knowledgeable leader.
- Safety marks used in this manual and their meanings are as follows:



DANGER-indicates an imminent hazardous situation which, if not avoided, WILL result in death or serious injury.



WARNING-indicates a potentially hazardous situation which, if not avoided, COULD result in death or serious injury.



CAUTION-indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

- **NOTICE** - indicates that if not observed, the product performance or quality may not be guaranteed.

2. Safety Precautions

(1) SERVICE AREA

⚠ WARNING



• Sufficient Ventilation

Inhalation of exhaust fumes and dust particles may be hazardous to ones health. Running engines welding, sanding, painting, and polishing tasks should be only done in well ventilated areas.

⚠ CAUTION

• Safe / Adequate Work Area

The service area should be clean, spacious, level and free from holes in the floor, to prevent "slip" or "trip and fall" type accidents.

⚠ CAUTION

• Clean, orderly arranged place

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

[Failure to Observe]

An unexpected accident may be caused.

⚠ CAUTION



• Bright, Safely Illuminated Area

The work area should be well lit or illuminated in a safe manner. For work in enclosed or dark areas, a "drop cord" should be utilized. The drop cord must have a wire cage to prevent bulb breakage and possible ignition of flammable substances.

⚠ CAUTION

• Safety Equipment

Fire extinguisher(s), first aid kit and eye wash / shower station should be close at hand (or easily accessible) in case of an emergency.



(2) WORK - WEAR (GARMENTS)

CAUTION

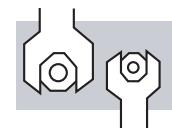


• Safe Work Clothing

Appropriate safety wear (gloves, special shoes / boots, eye / ear protection, head gear, harness', clothing, etc.) should be used / worn to match the task at hand. Avoid wearing jewelry, unbuttoned cuffs, ties or loose fitting clothes around moving machinery. A serious accident may occur if caught in moving / rotating machinery.

(3) TOOLS

WARNING



• Appropriate Lifting / Holding

When lifting an engine, use only a lifting device (crane, jack, etc.) with sufficient lifting capacity. Do not overload the device. Use only a chain, cable, or lifting strap as an attaching device. Do not use rope, serious injury may result.

To hold or support an engine, secure the engine to a support stand, test bed or test cart designed to carry the weight of the engine. Do not overload this device, serious injury may result.

Never run an engine without being properly secured to an engine support stand, test bed or test cart, serious injury may result.

• Appropriate Tools

Always use tools that are designed for the task at hand. Incorrect usage of tools may result in damage to the engine and or serious personal injury.

(4) GENUINE PARTS and MATERIALS

CAUTION

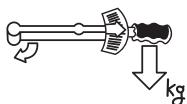


• Genuine Parts

Always use genuine YANMAR parts or YANMAR recommended parts and goods. Damage to the engine, shortened engine life and or personal injury may result.

(5) FASTENER TORQUE

⚠ WARNING



• Torquing Fasteners

Always follow the torque values and procedures as designated in the service manual. Incorrect values, procedures and or tools may cause damage to the engine and or personal injury.

(6) Electrical

⚠ WARNING



• Short Circuits

Always disconnect the (-) Negative battery cable before working on the electrical system. An accidental "short circuit" may cause damage, fire and or personal injury. Remember to connect the (-) Negative battery cable (back onto the battery) LAST

⚠ WARNING



• Charging Batteries

Charging wet celled batteries produces hydrogen gas. Hydrogen gas is extremely explosive. Keep sparks, open flame and any other form of ignition away. Explosion may occur causing severe personal injury.

⚠ WARNING



• Battery Electrolyte

Batteries contain sulfuric acid. Do NOT allow it to come in contact with clothing, skin and or eyes, severe burns will result.

(7) WASTE MANAGEMENT

⚠ CAUTION

Observe the following instructions with regard to hazardous waste disposal. Negligence of these will have a serious impact on environmental pollution concerns.

- 1) Waste fluids such as lube oil, fuel and coolant shall be carefully put into separate sealed containers and disposed of properly.
- 2) Do NOT dispose of waste materials irresponsibly by dumping them into the sewer, overland or into natural waterways.
- 3) Waste materials such as oil, fuel, coolant, solvents, filter elements and batteries, must be disposed of properly according to local ordinances. Consult the local authorities or reclamation facility.

(8) FURTHER PRECAUTIONS

⚠ WARNING



• Fueling / Refueling

Keep sparks, open flames or any other form of ignition (match, cigarette, etc.) away when fueling / refueling the unit. Fire and or an explosion may result.

⚠ CAUTION



• Hot Surfaces.

Do NOT touch the engine (or any of its components) during running or shortly after shutting it down. Scalding / serious burns may result. Allow the engine to cool down before attempting to approach the unit.

⚠ WARNING



• Rotating Parts

Be careful around moving / rotating parts. Loose clothing, jewelry, ties or tools may become entangled causing damage to the engine and or severe personal injury.

⚠ DANGER



• Preventing burns from scalding

- 1) Never open the filler cap shortly after shutting the engine down. Steam and hot water will spurt out and seriously burn you. Allow the engine to cool down before attempt to open the filler cap.
- 2) Securely tighten the filler cap after checking the coolant. Steam can spurt out during engine running, if tightening loose.

⚠ CAUTION

• Safety Label Check

Pay attention to the product safety label.

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

3. Precautions for Service Work

(1) Precautions for Safety

Read the safety precautions given at the beginning of this manual carefully and always mind safety in work.

(2) Preparation for Service Work

Preparation is necessary for accurate, efficient service work. Check the customer ledger file for the history of the engine.

- Preceding service date
- Period / operation hours after preceding service
- Problems and actions in preceding service
- Replacement parts expected to be required for service
- Recording form / check sheet required for service

(3) Preparation before Disassembly

- Prepare general tools, special service tools, measuring instruments, oil, grease, non-reusable parts, and parts expected to be required for replacement.
- When disassembling complicated portions, put match-marks and other marks at places not adversely affecting the function for easy reassembly.

(4) Precautions in Disassembly

- Each time a part is removed, check the part installed state, deformation, damage, roughening, surface defect, etc.
- Arrange the removed parts orderly with clear distinction between those to be replaced and those to be used again.
- Parts to be used again shall be washed and cleaned sufficiently.
- Select especially clean locations and use clean tools for disassembly of hydraulic units such as the fuel injection pump.

(5) Precautions for Inspection and Measurement

Inspect and measure parts to be used again as required to determine whether they are reusable or not.

(6) Precautions for Reassembly

- Reassemble correct parts in correct order according to the specified standards (tightening torques, and adjustment standards). Apply oil important bolts and nuts before tightening when specified.
- Always use genuine parts for replacement.
- Always use new oil seals, O-rings, packing and cotter pins.
- Apply sealant to packing depending on the place where they are used. Apply of grease to sliding contact portions, and apply grease to oil seal lips.

(7) Precautions for Adjustment and Check

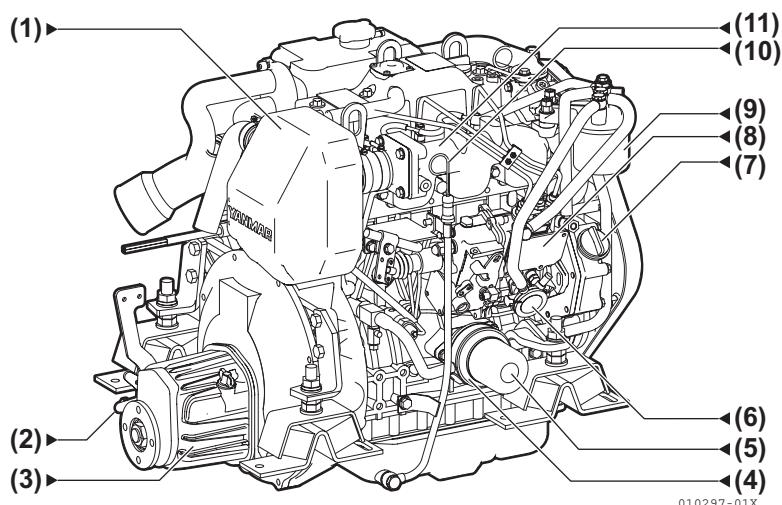
Use measuring instruments for adjustment to the specified service standards.

1. General

1.1 Exterior views

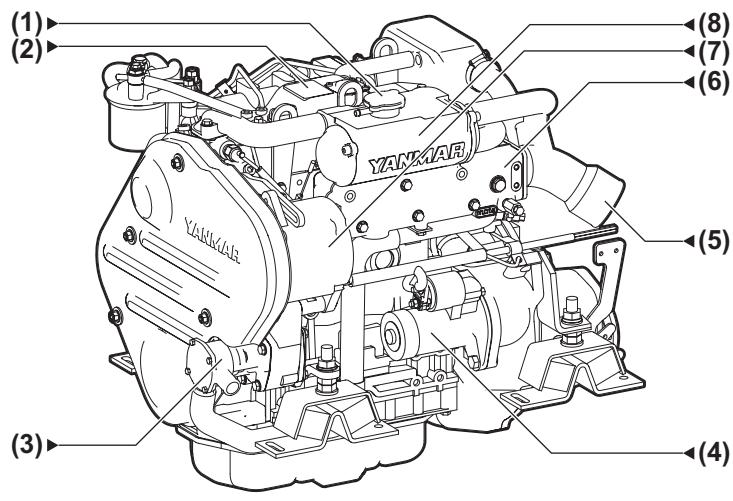
(1) 3JH4E

- Operation side



(1)	Intake silencer	(5)	Lube oil filter	(9)	Fuel filter
(2)	Shift lever	(6)	Fuel feed pump	(10)	Dipstick
(3)	Marine gear	(7)	Oil filter cap	(11)	Intake manifold
(4)	Oil cooler	(8)	Fuel injection pump		

- Non operation side



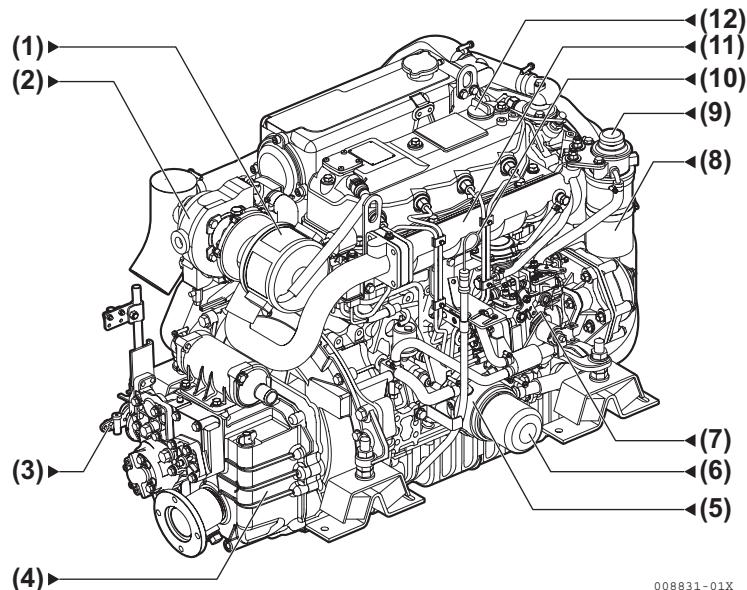
(1)	Coolant filler cap	(4)	Starter motor	(7)	Alternator
(2)	Engine name plate (on the rocker arm cover)	(5)	Exhaust mixing elbow	(8)	Coolant tank/Heat exchanger
(3)	Seawater pump	(6)	Exhaust manifold		

<Note> This illustration shows the 3JH4E with Yanmar marine gear (Model:KM35P).

1. General

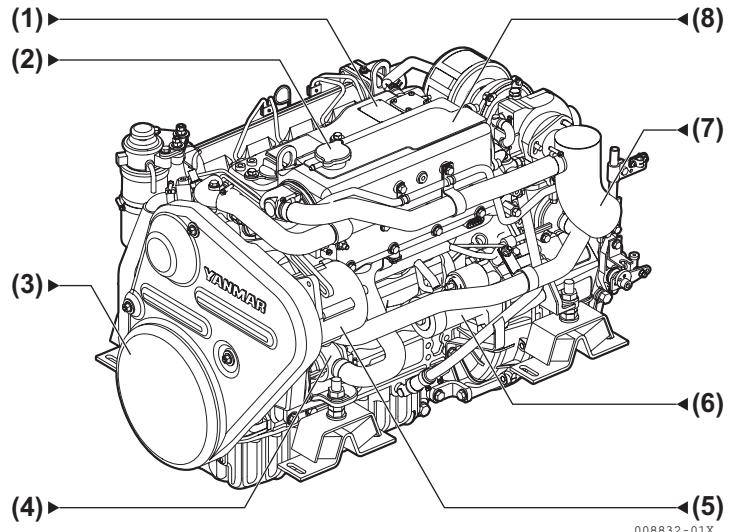
(2) 4JH4-TE

• Operation side



(1)	Intake silencer	(5)	Lube oil cooler	(9)	Fuel priming pump
(2)	Turbocharger	(6)	Lube oil filter	(10)	Dipstick
(3)	Shift lever	(7)	Fuel injection pump	(11)	Intake manifold
(4)	Marine gear (KMH4A)	(8)	Fuel filter	(12)	Oil filler cap

• Non operation side

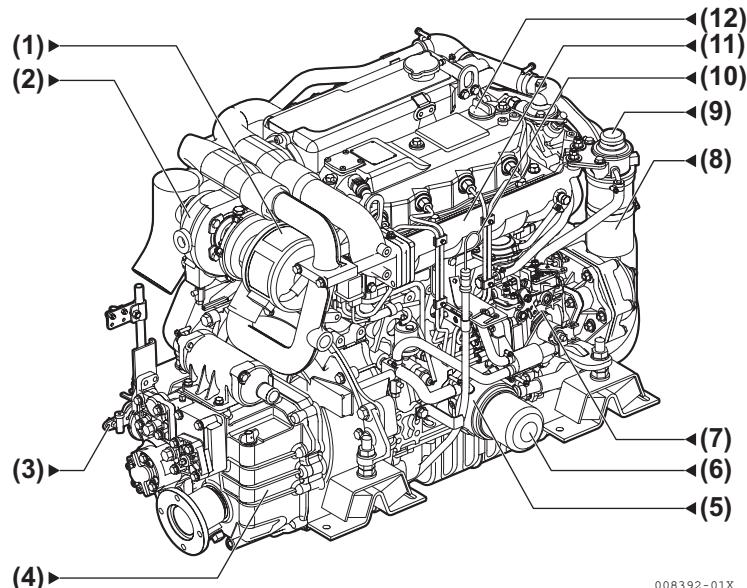


(1)	Engine name plate (on the rocker arm cover)	(4)	Seawater pump	(7)	Exhaust mixing elbow
(2)	Coolant filler cap	(5)	Alternator	(8)	Coolant tank/Heat exchanger
(3)	Belt cover	(6)	Starter motor		

<Note> This illustration shows the 4JH4-TE with Yanmar marine gear (Model: KMH4A).

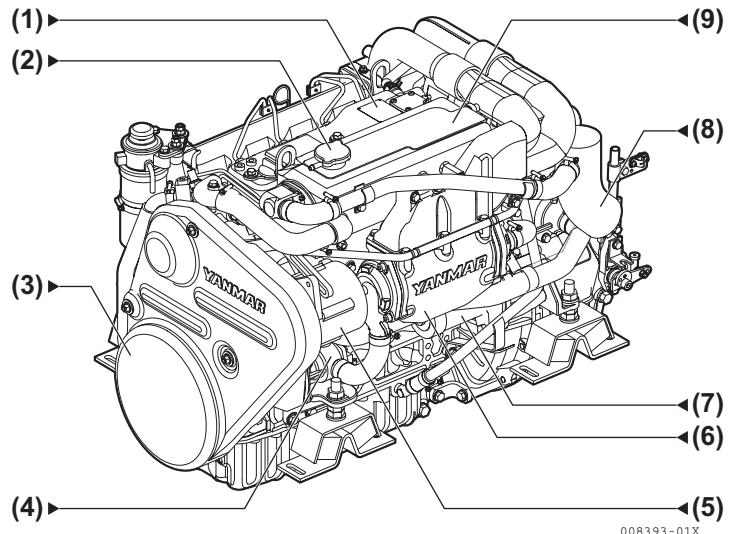
(3) 4JH4-HTE

- Operation side



(1)	Intake silencer	(5)	Lube oil cooler	(9)	Fuel priming pump
(2)	Turbocharger	(6)	Lube oil filter	(10)	Dipstick
(3)	Shift lever	(7)	Fuel injection pump	(11)	Intake manifold
(4)	Marine gear (KMH4A)	(8)	Fuel filter	(12)	Oil filler cap

- Non operation side



(1)	Engine name plate (on the rocker arm cover)	(4)	Seawater pump	(7)	Starter motor
(2)	Coolant filler cap	(5)	Alternator	(8)	Exhaust mixing elbow
(3)	Belt cover	(6)	Intercooler	(9)	Coolant tank/Heat exchanger

<Note> This illustration shows the 4JH4-HTE with Yanmar marine gear (Model: KMH4A).

1.2 Specifications

(1) 3JH4E series (3JH4E, 3JH4BE, 3JH4CE, 3JH4ME)

Official engine model name		unit	3JH4E		
Company internal model name	-	3JH4E	3JH4BE	3JH4CE	3JH4ME
Marine gear model	-	KM35P	KM35A	SD50	Bobtail
Use	-	Pleasure use			
Type	-	Vertical water cooled 4 cycle diesel engine			
Combustion system	-	Direct injection			
Air charging	-	Naturally aspirated			
Number of cylinders	-	3			
Bore x stroke	mm(inch)	88 x 90 (3.46 x 3.54)			
Displacement	L	1.642			
Continuous power	Output at crankshaft / Engine speed	kW(HP)/min ⁻¹	26.7(36.3) / 2907		
Fuel stop power	Output at crankshaft / Engine speed	kW(HP)/min ⁻¹	29.4(40.0) / 3000 (at Fuel temp. 25°C) 28.7(39.0) / 3000 (at Fuel temp. 40°C)		
	Output at propeller shaft / Engine speed	kW(HP)/min ⁻¹	28.0(38.1) / 3000 (at Fuel temp. 25°C) 27.4(37.3) / 3000 (at Fuel temp. 40°C)	-	-
Installation	-	Flexible mounting			
Fuel injection timing	deg b.T.D.C.	FID 12±1 (FIC-Air 13±1)			
Fuel injection opening pressure	MPa (kgf/cm ²)	21.6±0.5 (220±5)			
Main power take off	-	At flywheel side			
Direction of rotation	Crankshaft	-	Counter-clockwise viewed from stern		
	Propeller shaft (Ahead)	-	Clockwise viewed from stern	-	-
Cooling system	-	Fresh water cooling with heat exchanger			
Lubrication system	-	Complete enclosed forced lubrication			
Coolant capacity (fresh)	L(quart)	Engine:4.5 (4.8), Coolant recovery tank : 0.8 (0.8)			
Lubricating oil capacity (engine)	Rake angle	deg.	at rake angle 8 deg	at rake angle 0 deg	
	Total (Note 4)	L(quart)	5.0±0.3 (5.3±0.3)	5.5±0.3 (5.8±0.3)	5.5±0.3 (5.8±0.3)
	Oil pan only		4.5±0.3 (4.8±0.3)	5.0±0.3 (5.3±0.3)	5.0±0.3 (5.3±0.3)
	Effective (Note 5)		1.1 (1.2)	1.2 (1.3)	1.2 (1.3)
Starting system	Type	-	Electric		
	Starting motor	V-kW	DC 12V-1.4 kW		
	AC generator	V-A	12V-80A (12V-60A optional)		
Engine dimension	Overall length	mm(inch)	777 (30.6)	776 (30.6)	700 (27.6)
	Overall width		539 (21.2)	539 (21.2)	539 (21.2)
	Overall height		623 (24.5)	623 (24.5)	623 (24.5)
Flywheel major dimension	mm(inch)	Ø300 x 66 (11.8 x 2.6)			
Engine dry mass (include marine gear)	kg	185	186	213 (engine:173)	173

(Note)

1. Rating condition: ISO 3046-1, ISO 8665

- Fuel temperature 25°C at the inlet of the fuel injection pump. (ISO 3046-1, 1995)
- Fuel temperature 40°C at the inlet of the fuel injection pump. (ISO 8665)

2. 1HP (metric horse power) ≈ 0.7355 kW

3. Fuel condition: Density at 15°C = 0.842

4. The "Total" oil quantity includes: Oil in oil pan and oil in channels, coolers and filter.

5. The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.

(2) 4JH4E series (4JH4E, 4JH4FE, 4JH4BE, 4JH4B4E, 4JH4CE, 4JH4ME)

Official engine model name	unit	4JH4E											
Company internal model name	-	4JH4E	4JH4FE	4JH4BE	4JH4B4E	4JH4CE	4JH4ME						
Marine gear model	-	KM35P	ZF30M	KM35A2	KM4A1	SD50	Bobtail						
Use	-	Pleasure use											
Type	-	Vertical water cooled 4 cycle diesel engine											
Combustion system	-	Direct injection											
Air charging	-	Naturally aspirated											
Number of cylinders	-	4											
Bore x stroke	mm(inch)	88 x 90 (3.46 x 3.54)											
Displacement	L	2.190											
Continuous power	Output at crankshaft/ Engine speed	kW(HP)/min ⁻¹	36.8(50.0) / 2907										
Fuel stop power	Output at crankshaft/ Engine speed	kW(HP)/min ⁻¹	40.5(55.1) / 3000 (at Fuel temp. 25 °C) 39.6(53.8) / 3000 (at Fuel temp. 40 °C)										
	Output at propeller shaft / Engine speed	kW(HP)/min ⁻¹	38.5(52.3) / 3000 (at Fuel temp. 25 °C) 37.6(51.1) / 3000 (at Fuel temp. 40 °C)			-							
Installation	-	Flexible mounting											
Fuel injection timing	deg b.T.D.C.	FID 13± 1 (FIC-Air 14± 1)											
Fuel injection opening pressure	MPa	21.6±0.5											
Main power take off	-	At flywheel side											
Direction of rotation	Crankshaft	-	Counter-clockwise viewed from stern										
	Propeller shaft (Ahead)	-	Clockwise viewed from stern			-							
Cooling system	-	Fresh water cooling with heat exchanger											
Lubrication system	-	Complete enclosed forced lubrication											
Coolant capacity (fresh)	L (quart)	Engine 6.0(6.3), Coolant recovery tank: 0.8(0.8)											
Lubricating oil capacity (engine)	Rake angle	deg.	at rake angle 8 deg		at rake angle 0 deg								
	Total (Note 4)		5.0±0.3(5.3±0.3)		5.5±0.3(5.8±0.3)								
	Oil pan only	L (quart)	4.5±0.3(4.8±0.3)		5.0±0.3(5.3±0.3)								
	Effective (Note 5)		1.2(1.3)		1.4(1.5)								
Starting system	Type	-	Electric										
	Starting motor	V-kW	DC 12V-1.4 kW										
	AC generator	V-A	12V-80A (12V-60A optional)										
Engine dimension	Overall length	mm(inch)	871(34.3)	950(37.4)	864(34.0)	922(36.3)	795(31.3)						
	Overall width		560(22.0)	560(22.0)	560(22.0)	560(22.0)	560(22.0)						
	Overall height		618(24.3)	618(24.3)	618(24.3)	618(24.3)	618(24.3)						
Flywheel major dimension	mm(inch)	Ø300 x 66(11.8 x 2.6)											
Engine dry mass (include marine gear)	kg	212	228	213	228	240 (engine:200)	200						

(Note)

1. Rating condition: ISO 3046-1, ISO 8665

- Fuel temperature 25°C at the inlet of the fuel injection pump. (ISO 3046-1, 1995)
- Fuel temperature 40°C at the inlet of the fuel injection pump. (ISO 8665)

2. 1HP (metric horse power) ≈ 0.7355 kW

3. Fuel condition: Density at 15°C = 0.842

4. The "Total" oil quantity includes: Oil in oil pan and oil in channels, coolers and filter.

5. The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.

1. General

Marine gear and sail drive for 3JH4E and 4JH4E

Marine gear or sail drive	Model	-	KM35P		KM35A (down angle: 7)		KM35A2 (down angle: 7)	
	Type	-	Mechanical cone clutch					
	Reduction ratio (Forward/Reverse)	-	2.36/3.16	2.61/3.16	2.33/3.04	2.64/3.04	2.33/3.06	2.64/3.06
	Propeller speed (Forward/Reverse)*	min ⁻¹	1231/921	1114/921	1246/955	1103/955	1246/950	1103/950
	Lubrication system	-	Splash					
	Lubricating oil capacity (total)	L (quart)	0.5 (0.5)		0.65 (0.69)		0.65 (0.69)	
	Lubricating oil capacity (effect)		0.05 (0.05)		0.15 (0.16)		0.15 (0.16)	
	Cooling system	-	Air cooling by fan on flywheel					
	Mass	kg	12		13		13	

Marine gear or sail drive	Model	-	ZF30M		kM4A1				SD50 (coupled at boat builder)
	Type	-	Mechanical multi plate clutch		Mechanical cone clutch				
	Reduction ratio (Forward/Reverse)	-	2.15/2.64	2.70/2.64	1.47/ 1.47	2.14/ 2.14	2.63/ 2.63	3.30/ 3.30	2.32
	Propeller speed (Forward/Reverse)*	min ⁻¹	1353/1103	1078/1103	1983/ 1983	1360/ 1360	1106/ 1106	882/ 882	1253
	Lubrication system	-	Splash		Centrifugal pump				Oil bath
	Lubricating oil capacity (total)	L (quart)	1.1 (1.2)		1.3 (1.4)				2.1(2.2)
	Lubricating oil capacity (effect)		0.2 (0.2)		0.2 (0.2)				-
	Cooling system	-	Seawater cooling						
	Mass	kg	27.5		27.5				40

* At continuous power engine speed 2907 min⁻¹

(3) 4JH4-TE series (4JH4-TFE, 4JH4-TBE, 4JH4-THE, 4JH4-TIE, 4JH4-TCE, 4JH4M-TE)

Official engine model name	unit	4JH4-TE										
Company internal model name	-	4JH4-TFE	4JH4-TBE	4JH4-THE	4JH4-TIE	4JH4-TCE	4JH4M-TE					
Marine gear model	-	ZF30M	KM4A2	KMH4A	ZF25A	SD50-4T	Bobtail					
Use	-	Pleasure use										
Type	-	Vertical water cooled 4 cycle diesel engine										
Combustion system	-	Direct injection										
Air charging	-	Turbocharged										
Number of cylinders	-	4										
Bore x stroke	mm (inch)	84 x 90 (3.31 x 3.54)										
Displacement	L	1.995										
Continuous power	Output at crankshaft/ Engine speed	kW (HP)/min ⁻¹	50.2(68.3) / 3101									
Fuel stop power	Output at crankshaft/ Engine speed	kW (HP)/min ⁻¹	55.2(75.1) / 3200 (at Fuel temp. 40 °C)									
	Output at propeller shaft/ Engine speed	kW (HP)/min ⁻¹	53.0(72.1) / 3200 (at Fuel temp. 40 °C)			-						
Installation	-	Flexible mounting										
Fuel injection timing	deg b.T.D.C.	Plunger lift at Top Dead Center: 1.26±0.01mm (when W-C.S.D. is released) FIT (at plunger lift 1.00mm with W-C.S.D. released): 2.55±1										
Fuel injection opening pressure	MPa	21.6±0.5										
Main power take off	-	At flywheel side										
Direction of rotation	Crankshaft	-	Counter-clockwise viewed from stern									
	Propeller shaft (Ahead)	-	Clockwise viewed from stern	Clockwise or counter-clockwise (Bi-rotation)			-					
Cooling system	-	Fresh water cooling with heat exchanger										
Lubrication system	-	Complete enclosed forced lubrication										
Coolant capacity (fresh)	L (quart)	Engine: 7.2(7.6), Coolant recovery tank: 0.8(0.8)										
Lubricating oil capacity (engine)	Rake angle	deg.	7 deg	0 deg			7 or 0 deg					
	Total (Note 4)	L (quart)	5.7±0.3 (6.0±0.3)	6.9±0.3 (7.3±0.3)			Refer to left					
	Oil pan only		5.2±0.3 (5.5±0.3)	6.4±0.3 (6.8±0.3)			Refer to left					
	Effective (Note 5)	2.4(2.5)										
Starting system	Type	-	Electric									
	Starting motor	V-kW	DC 12V-1.4 kW									
	AC generator	V-A	12V-80A (12V-60A optional)									
Engine dimension	Overall length	mm (inch)	923(36.3)	903(35.6)	933(36.7)	1017(40.0)	782(30.8)					
	Overall width		616(24.3)									
	Overall height		659(25.9)									
Flywheel major dimension	mm (inch)	D339 x 66 (13.3 x 2.6)										
Engine dry mass (include marine gear)	kg	235	237	238	237	249 (engine 207)	207					

(Note)

1. Rating condition: ISO 8665

- Fuel temperature 40°C at the inlet of the fuel injection pump. (ISO 8665)

2. 1HP (metric horse power) ≈ 0.7355 kW

3. Fuel condition: Density at 15°C = 0.842

4. The "Total" oil quantity includes: Oil in oil pan and oil in channels, coolers and filter.

5. The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.

1. General

(4) 4JH4-HTE series (4JH4-HTFE, 4JH4-HTBE, 4JH4-HTHE, 4JH4-HTIE, 4JH4M-HTE)

Official engine model name	unit	4JH4-HTE							
Company internal model name	-	4JH4-HTFE	4JH4-HTBE	4JH4-HTHE	4JH4-HTIE	4JH4M-HTE			
Marine gear model	-	ZF30M	KM4A2	KMH4A	ZF25A	Bobtail			
Use	-	Pleasure use							
Type	-	Vertical water cooled 4 cycle diesel engine							
Combustion system	-	Direct injection							
Air charging	-	Turbocharged with intercooler							
Number of cylinders	-	4							
Bore x stroke	mm (inch)	84 x 90 (3.31 x 3.54)							
Displacement	L	1.995							
Continuous power	Output at crankshaft/ Engine speed	kW (HP)/min ⁻¹	73.6(100) / 3101						
Fuel stop power	Output at crankshaft/ Engine speed	kW (HP)/min ⁻¹	*1 80.9(110) / 3200						
	Output at propeller shaft/ Engine speed	kW (HP)/min ⁻¹	*1 77.7(106) / 3200			-			
Installation	-	Flexible mounting							
Fuel injection timing	deg b.T.D.C.	Plunger lift at Top Dead Center: 1.26±0.01mm (when W-C.S.D. is released) FIT (at plunger lift 1.00mm with W-C.S.D. released): 2.55±1							
Fuel injection opening pressure	MPa	21.6±0.5							
Main power take off	-	At flywheel side							
Direction of rotation	Crankshaft	-	Counter-clockwise viewed from stern						
	Propeller shaft (Ahead)	-	Clockwise viewed from stern	Clockwise or counter-clockwise (Bi-rotation)		-			
Cooling system	-	Fresh water cooling with heat exchanger							
Lubrication system	-	Complete enclosed forced lubrication							
Cooling water capacity (fresh)	L (quart)	Engine: 7.2(7.6), Coolant recovery tank: 0.8(0.8)							
Lubricating oil capacity (engine)	Rake angle	deg.	7 deg	0 deg		7 or 0 deg			
	Total (Note 4)	L (quart)	5.7±0.3 (6.0±0.3)	6.9±0.3 (7.3±0.3)		Refer to left			
	Oil pan only		5.2±0.3 (5.5±0.3)	6.4±0.3 (6.8±0.3)		Refer to left			
	Effective (Note 5)		2.4(2.5)						
Starting system	Type	-	Electric						
	Starting motor	V-kW	DC 12V - 1.4 kW						
	AC generator	V-A	12V-80A (12V-60A optional)						
Engine dimension	Overall length	mm (inch)	923(36.3)	903(35.6)	933(36.7)	1017(40.0)	782(30.8)		
	Overall width		616(24.3)						
	Overall height		659(25.9)						
Flywheel major dimension	mm (inch)	D339 x 66 (13.3 x 2.6)							
Engine dry mass (include marine gear)	kg	245	247	248	247	217			

(Note)

1. Rating condition: ISO 8665

* Fuel temperature 40°C at the inlet of the fuel injection pump. (ISO 8665)

2. 1HP (metric horse power) ≈ 0.7355 kW

3. Fuel condition: Density at 15°C = 0.842

4. The "Total" oil quantity includes: Oil in oil pan and oil in channels, coolers and filter.

5. The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.

Marine gear and sail drive for 4JH4-TE and 4JH4-HTE

Model	-	ZF30M	KM4A2			KMH4A		ZF25A		SD50-4T (coupled at boat builder)
Down angle	deg.	0	7			8		8		-
Applicable engine model	-	4JH4-TE 4JH4-HTE						4JH4-TE		
Type	-	Mechanical wet multiple disk clutch	Mechanical cone clutch			Hydraulic wet multiple disk clutch	Hydraulic wet multiple disk clutch		Mechanical cone clutch	
Reduction ratio (Forward/Reverse)	-	2.15/ 2.64	2.70/ 2.64	1.47/ 1.47	2.14/ 2.14	2.63/ 2.63	2.04/ 2.04	2.45/ 2.45	1.93/ 1.93	2.48/ 2.48
Propeller speed (Forward/Reverse)*	min ⁻¹	1444/ 1176	1150/ 1176	2115/ 2113	1451/ 1450	1180/ 1179	1520/ 1520	1263/ 1263	1607/ 1607	1250/ 1250
Lubrication system	-	Splash	Centrifugal pump			Trochoid pump	Trochoid pump		Oil bath	
Lube oil	-	ATF	API CD or higher SAE #20 or #30					ATF		QuickSilver High Performance gear lube only
Lube oil capacity (total)	L (quart)	1.1(1.2)		2.0(2.1)			2.0(2.1)		1.8(1.9)	
Lube oil capacity (effect)		0.2(0.2)		0.2(0.2)			0.2(0.2)		-	
Cooling system	-	Seawater cooling								-
Mass	kg	27.5	30			31		30		42

* At Continuous power: Engine speed 3101 min⁻¹

1.3 Fuel oil, lubricating oil and coolant

1.3.1 Fuel oil

IMPORTANT:

Only use the recommended fuel to obtain the best engine performance and to keep the durability of the engine, also to comply with the emission regulations.

(1) Selection of fuel oil

Diesel fuel oil should comply with the following specifications.

- The fuel specifications need to comply with each national standard or international standards.
- ASTM D975 No.1-D

No.2-D for USA

- EN590: 96 for EU
- ISO 8217 DMX International
- BS 2869-A1 or A2 for UK
- JIS K2204 for JAPAN

The following requirements also need to be fulfilled.

- Cetane number should be equal to 45 or higher.
- Sulphur content of the fuel.

It should not exceed 0.5% by volume.
(Preferably it should be below 0.05%)

- Water and sediment in the fuel oil should not exceed 0.05% by volume.

- Ash should not exceed 0.01% by mass.

- 10% carbon residue content of the fuel.
It should not exceed 0.35% by volume.
(Preferably it should be below 0.1%)

- Aromatics (total) content of the fuel.

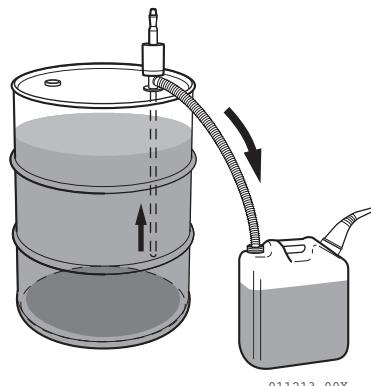
It should not exceed 35% by volume.
(Preferably it should be below 30% and aromatics (PAH*) content of the fuel preferably it should be below 10%)

PAH*: Polycyclic aromatic hydrocarbons.

- DO NOT use Biocide.
- DO NOT use Kerosene, residual fuels.

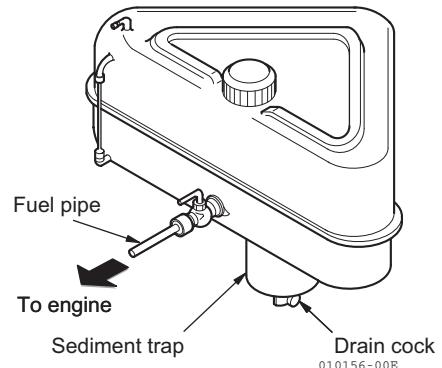
(2) Fuel handling

- Water and dust in the fuel oil can cause operation failure. Use containers which are clean inside to store fuel oil. Store the containers away from rain water and dust.
- Before supplying fuel, let the fuel container rest for several hours so that water and dust in the fuel are deposited on the bottom. Pump up only the clean fuel.



(3) Fuel tank

Be sure to attach a drain cock, precipitation trap and primary strainer to the fuel tank as shown illustration right.



1.3.2 Lubricating oil

IMPORTANT:

Use of other than the specified engine oil may cause inner parts seizure or early wear, leading to shorten the engine service life.

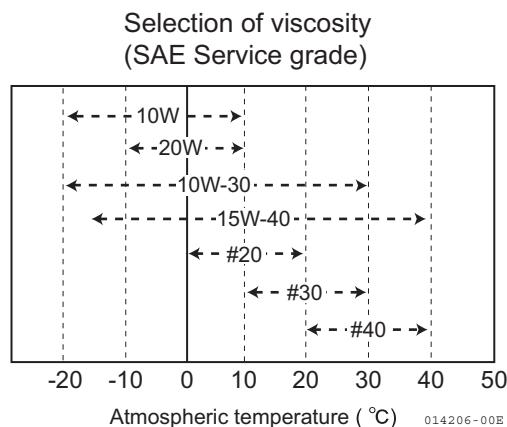
(1) Selection of engine lube oil

Use the following engine oil

- API classificationCD or higher
(Standards of America Petroleum Institute)
- SAE viscosity 10W-30, 15W-40
(Standard of Society of Automotive Engineering)

Engine oil 10W30 and 15W-40 can be used throughout the year.

(Refer to the right figure.)



(2) Selection of marine gear lube oil

KM35P, KM35A2 for 3JH4E series

KM35P, KM35A2 and KM4A1 for 4JH4E

KM4A2, KMH4A for 4JH4-TE and 4JH4-HTE

Use the following engine oil

- API classificationCD or higher
(Standards of America Petroleum Institute)
- SAE viscosity #20 or #30
(Standard of Society of Automotive Engineering)

Apply ATF oil to marine gear ZF30M for 4JH4E and ZF30N, ZF25A for 4JH4-TE and 4JH4-HTE.

(3) Selection of lube oil for sail drive unit

SD50 (or SD40) for 3JH4E and 4JH4E

- API service gradeGL4, 5

- SAE Viscosity#90 or 80W90

or QuickSilver High Performance Gear Lube
QuickSilver® is registered trademark of
Brunswick Corporation.

SD50-4T for 4JH4-TE

QuickSilver® High Performance Gear Lube
must be selected only for SD50-4T.

(4) Handling of engine oil

- Carefully store and handle the oil so as to prevent dust or dirt entrance. When supplying the oil, pay attention and clean around the filler port.
- Do not mix different types of oil as it may adversely affect the lubricating performance.

CAUTION

When touching engine oil by hand, the skin of the hand may become rough. Be careful not to touch oil with your hands without protective gloves. If touch, wash your hands with soap and water thoroughly.

1.3.3 Coolant

- (1) Choose antifreeze, which will not have any adverse effects on the materials (cast iron, aluminum, copper, etc.) of the engine's fresh water cooling system.

Consult your Yanmar dealer or distributor on the use of coolant/antifreeze, and detergents. Coolant/antifreeze, which provides good performance for example, are shown below.

- TEXACO LONG LIFE COOLANT ANTI-FREEZE, both standard and pre-mixed.
Product code 7997 and 7998.
- HAVOLINE EXTENDED LIFE ANTIFREEZE/COOLANT.
Product code 7994

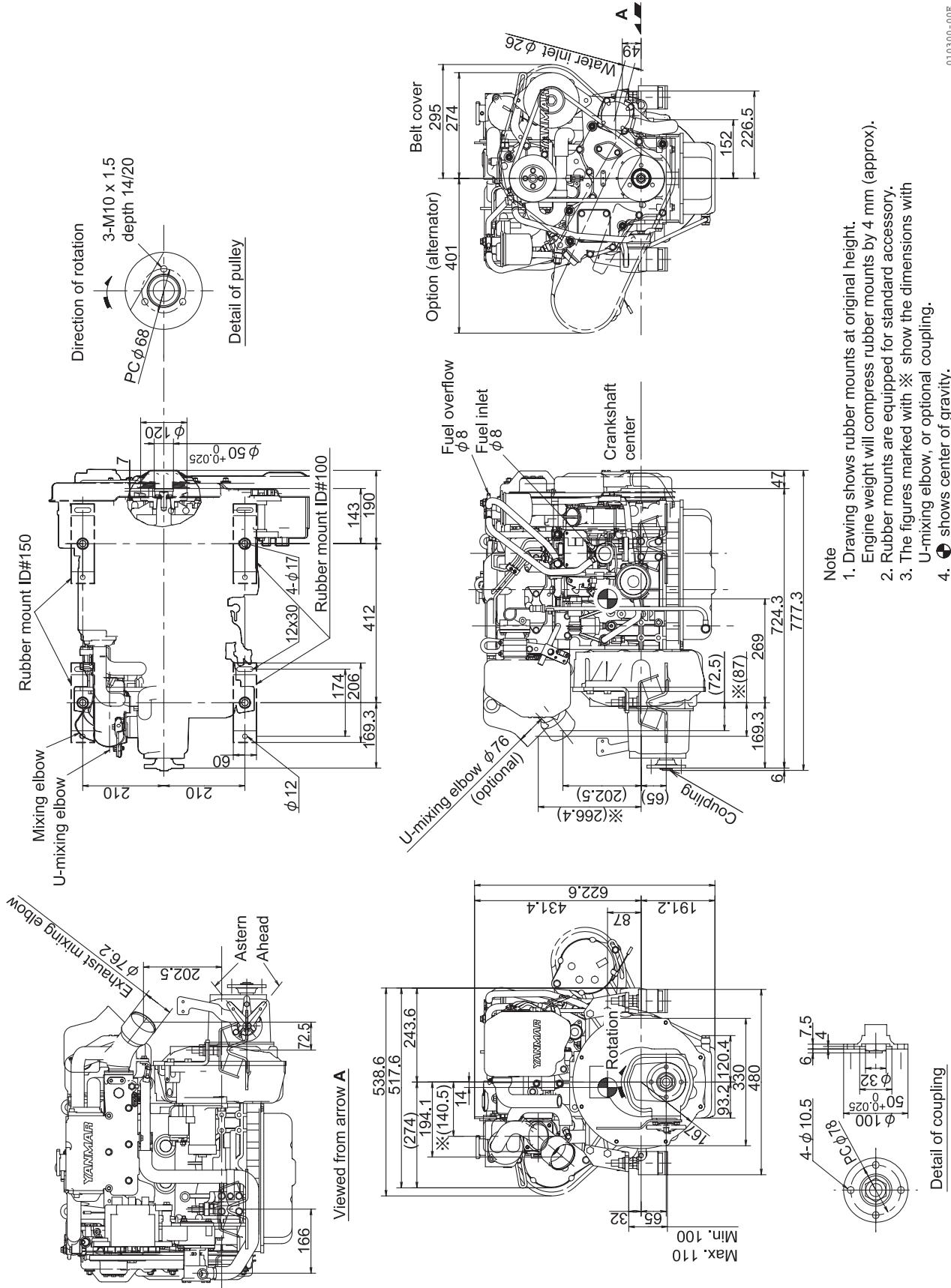
- (2) Use the proper mixing ratio of antifreeze to fresh water strictly as instructed by the antifreeze maker depending on the ambient temperature. LLC concentration should be 30% as a minimum and 50% as a maximum.
- (3) Replace the coolant periodically, according to the maintenance schedule given in the operation manual.
- (4) Remove the scale from the cooling water system periodically, according to the instructions in the operation manual.
- (5) Use the proper mixing ratio of antifreeze to fresh water strictly, as instructed by the antifreeze maker. If too much antifreeze is used, the cooling performance of the coolant will drop and the engine may become overheated.
- (6) Do not mix different brands of antifreeze.
Chemical reactions may make the antifreeze useless and engine trouble could result.

NOTICE

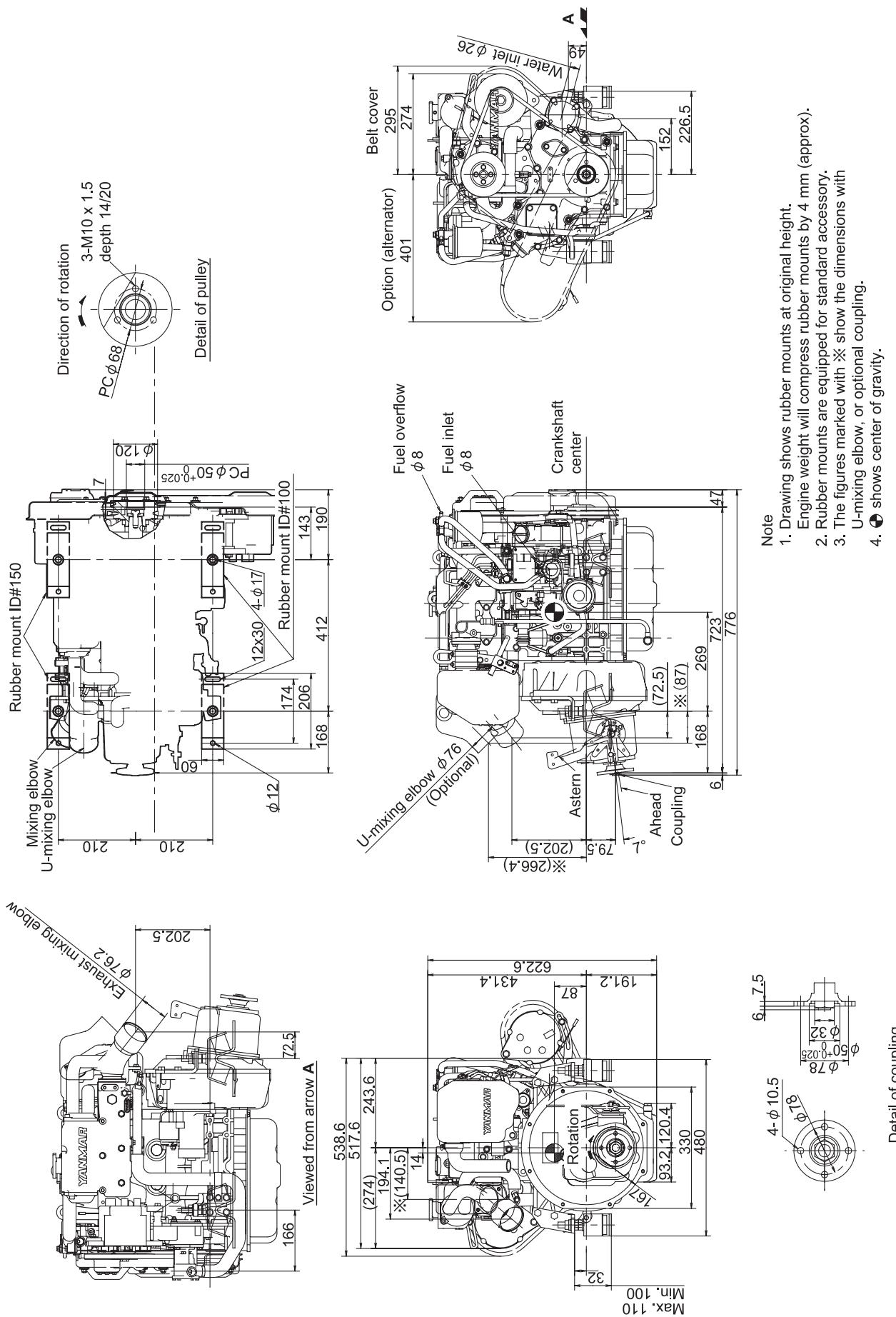
Excessive use of antifreeze also lowers the cooling efficiency of the engine. Be sure to use the mixing ratios specified by the antifreeze maker for temperature range.

1.4 Engine outline

(1) 3JH4E (with KM35P marine gear)

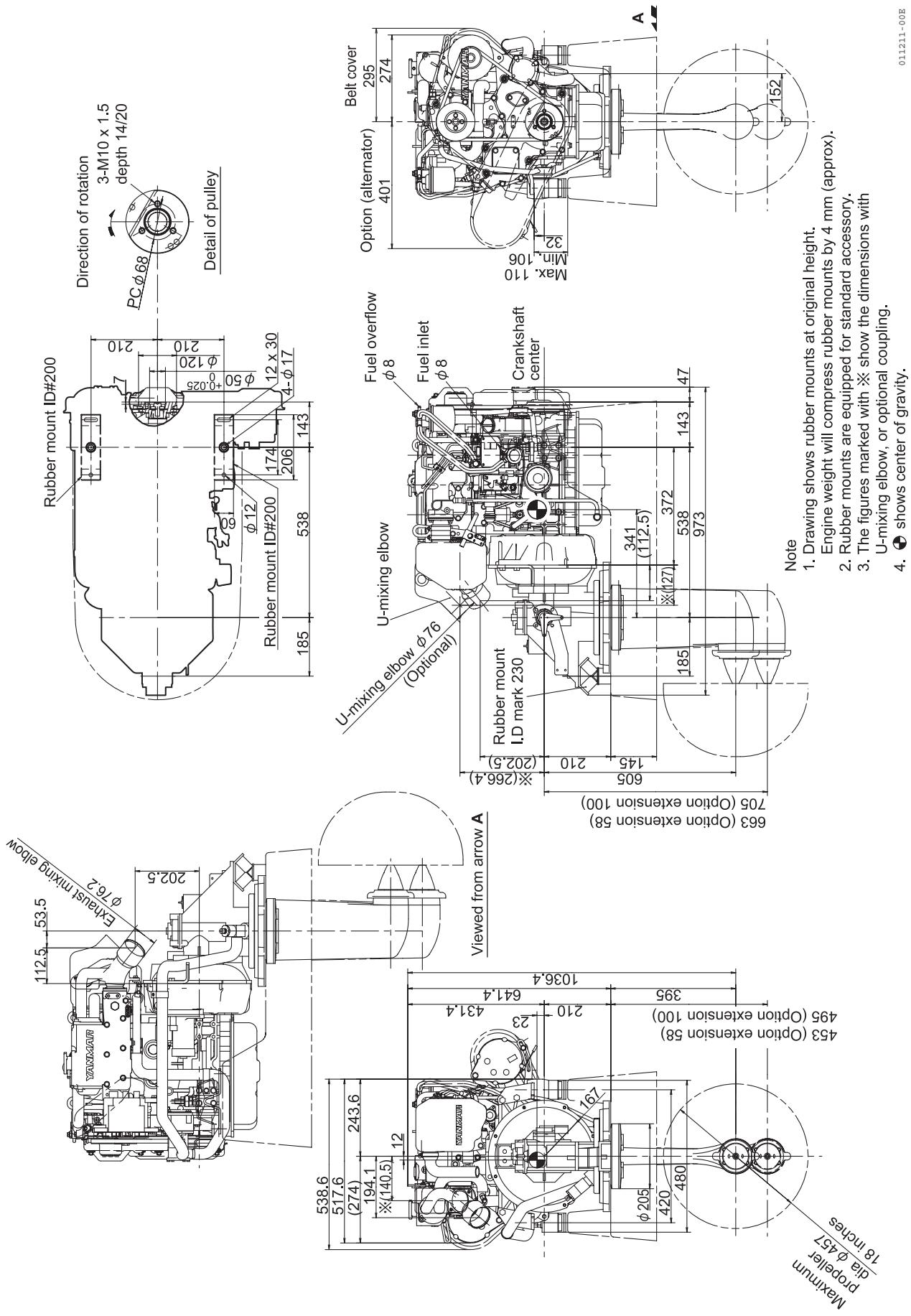


(2) 3JH4BE (with KM35A marine gear)

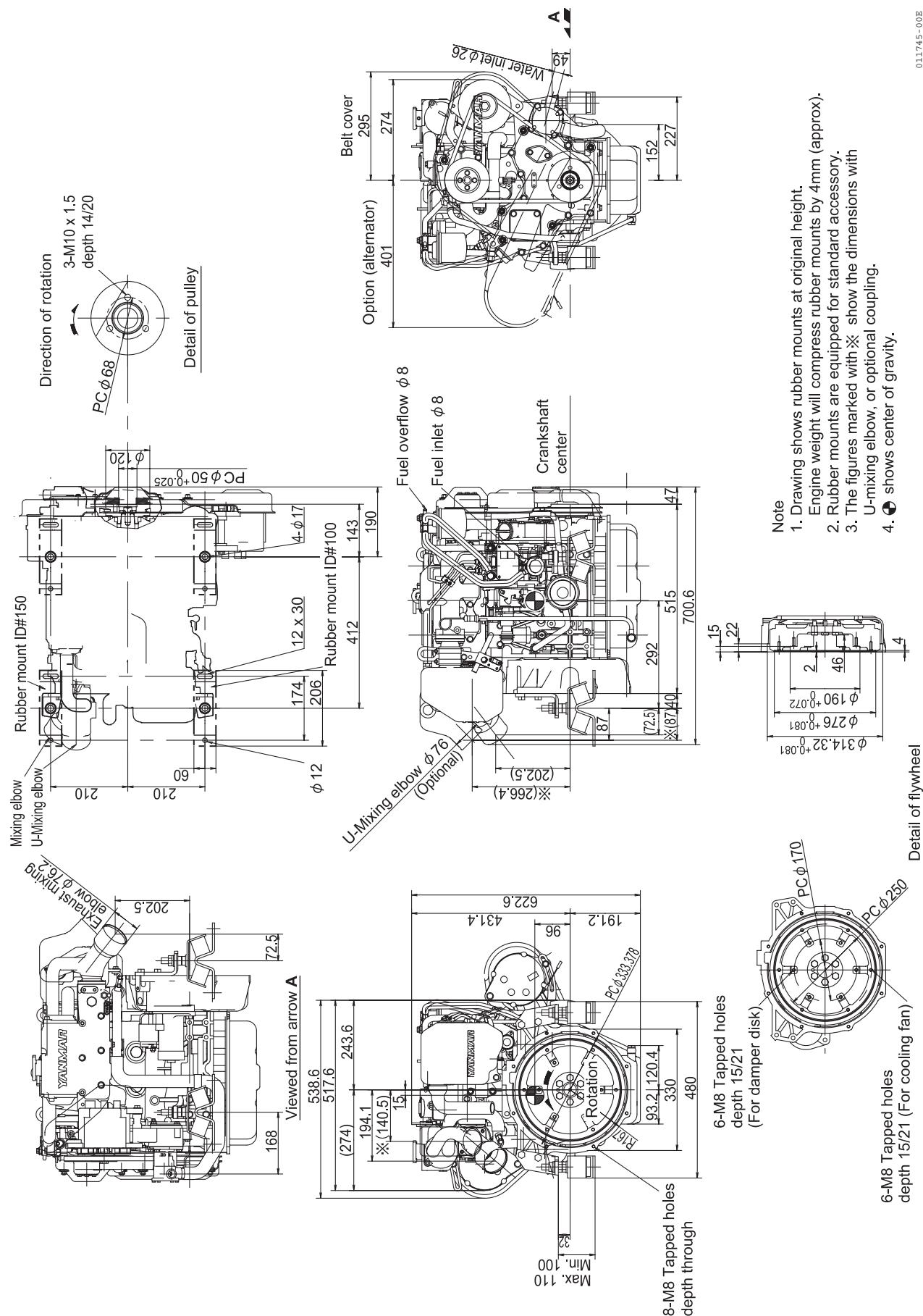


1. General

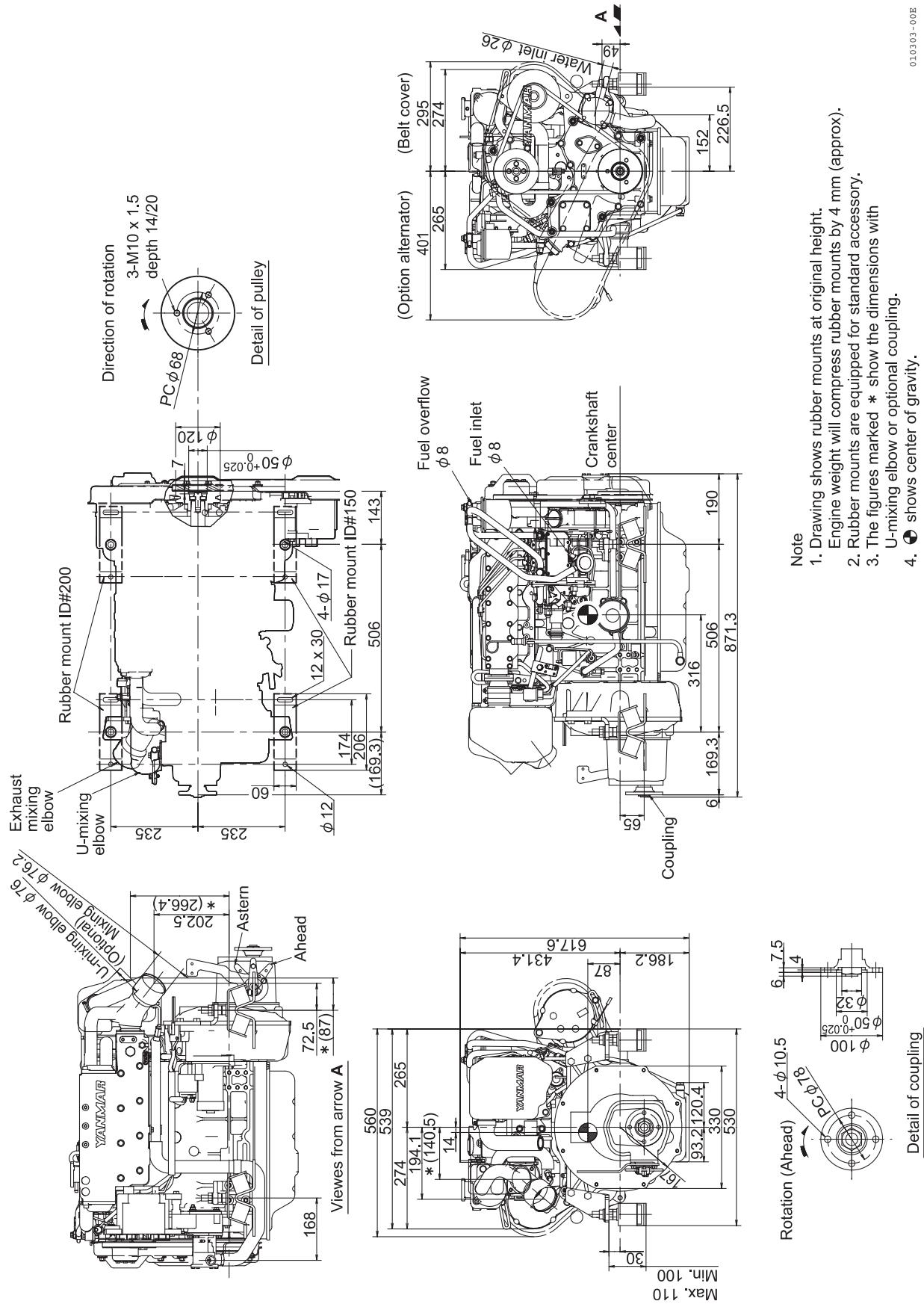
(3) 3JH4CE (with SD50/SD40 sail drive)



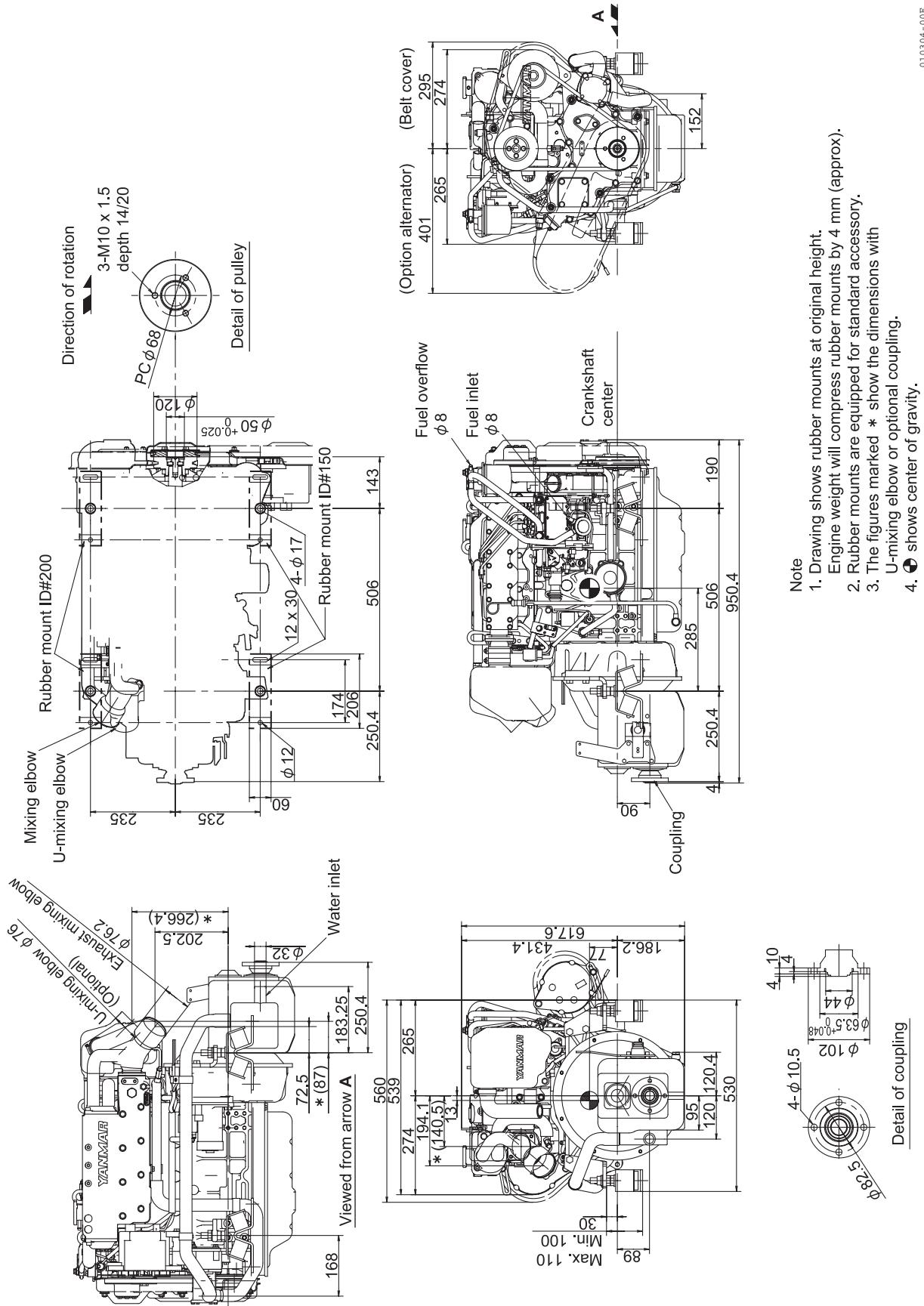
(4) 3JH4ME (Bobtail)



(5) 4JH4E (with KM35P marine gear)

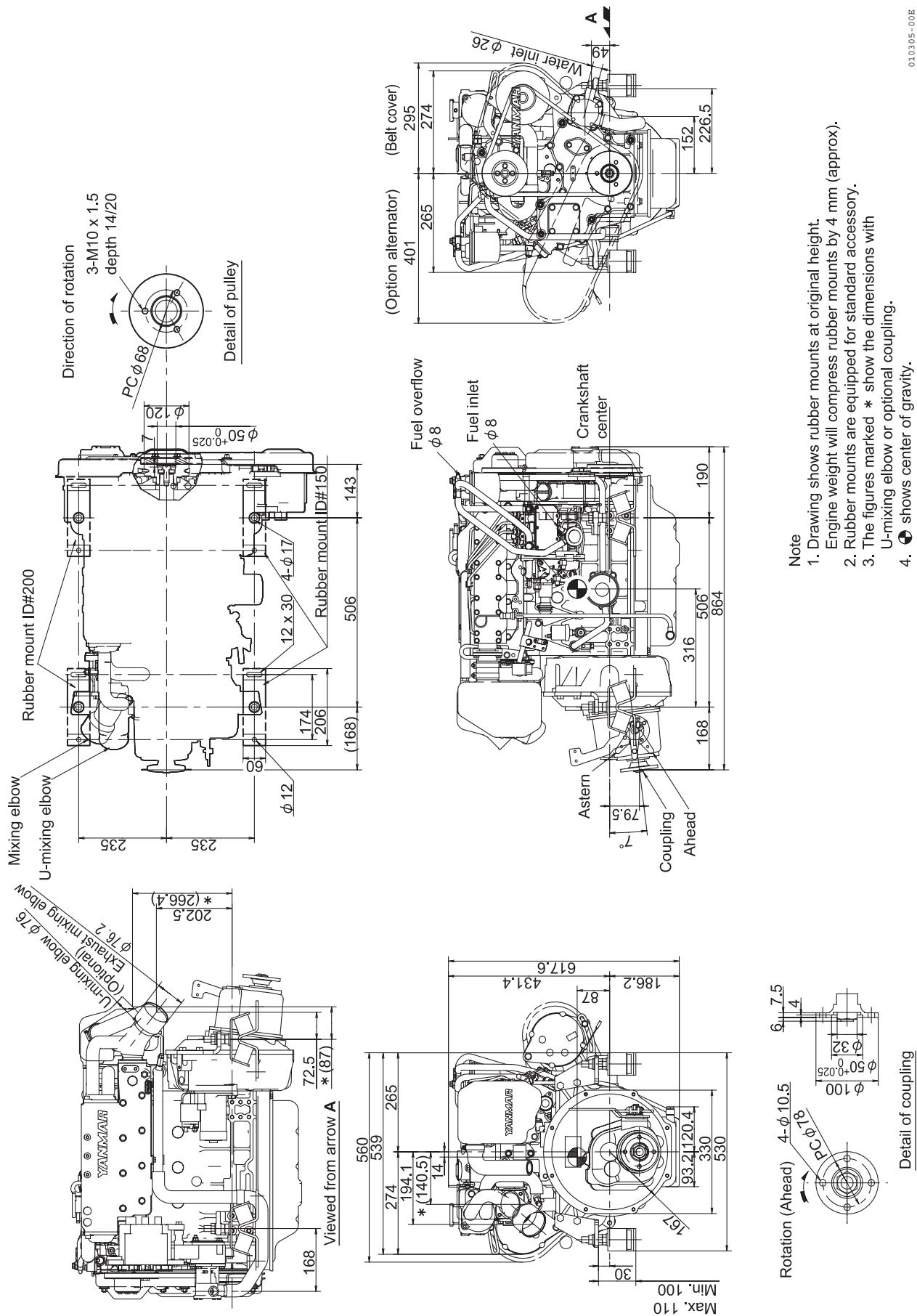


(6) 4JH4FE (with ZF30M marine gear)

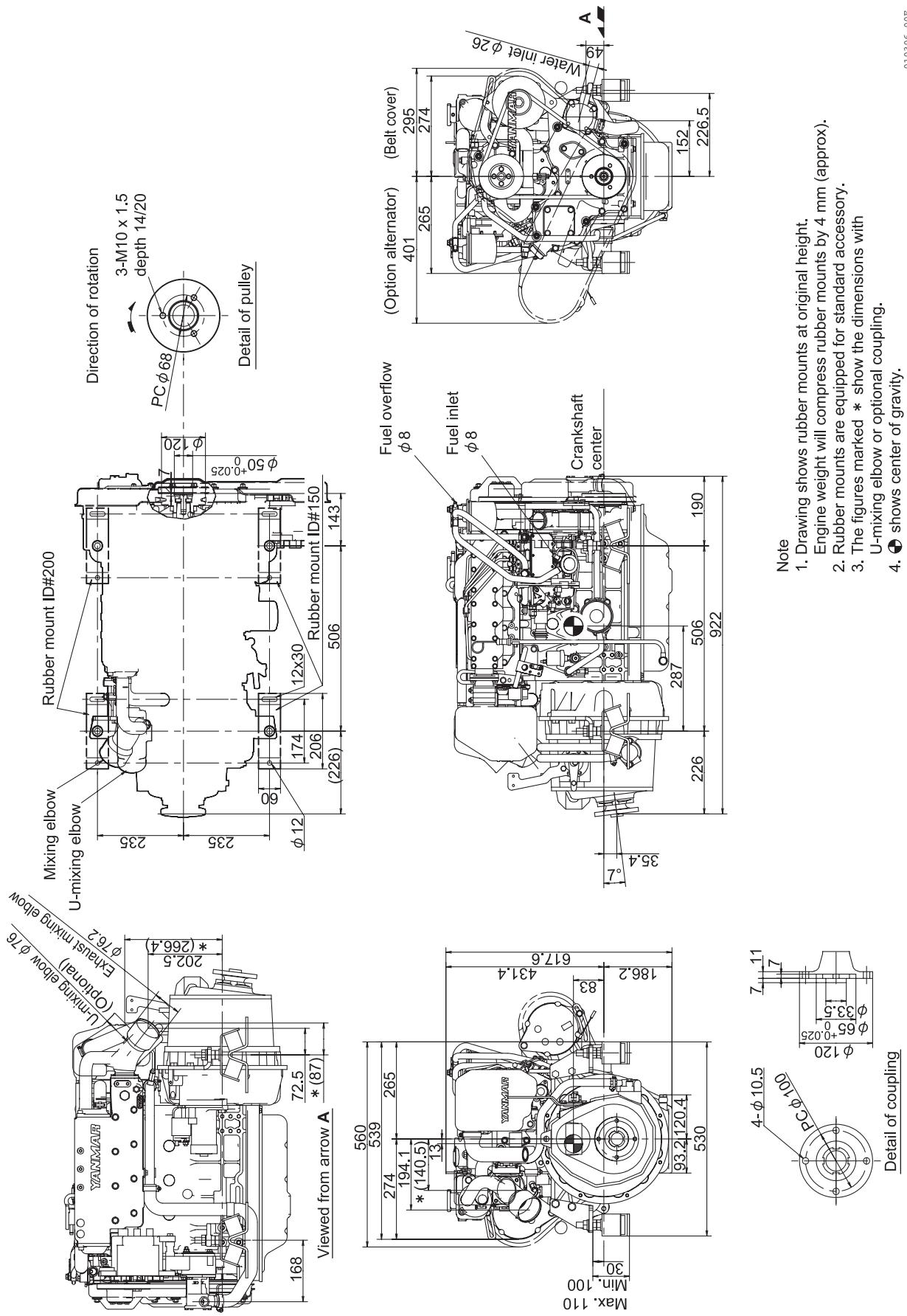


1. General

(7) 4JH4BE (with KM35A2 marine gear)

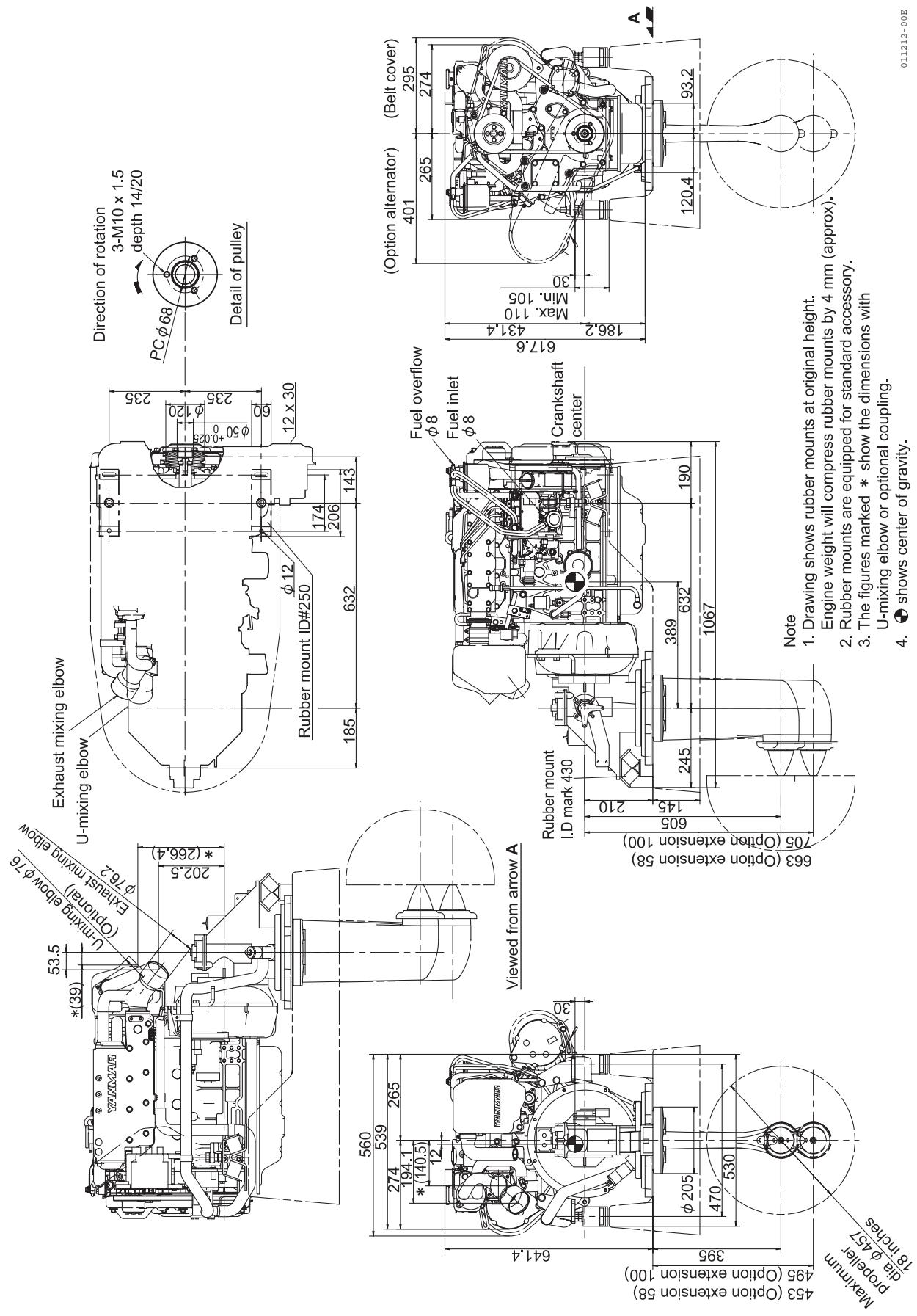


(8) 4JH4B4E (with KM4A1 marine gear)

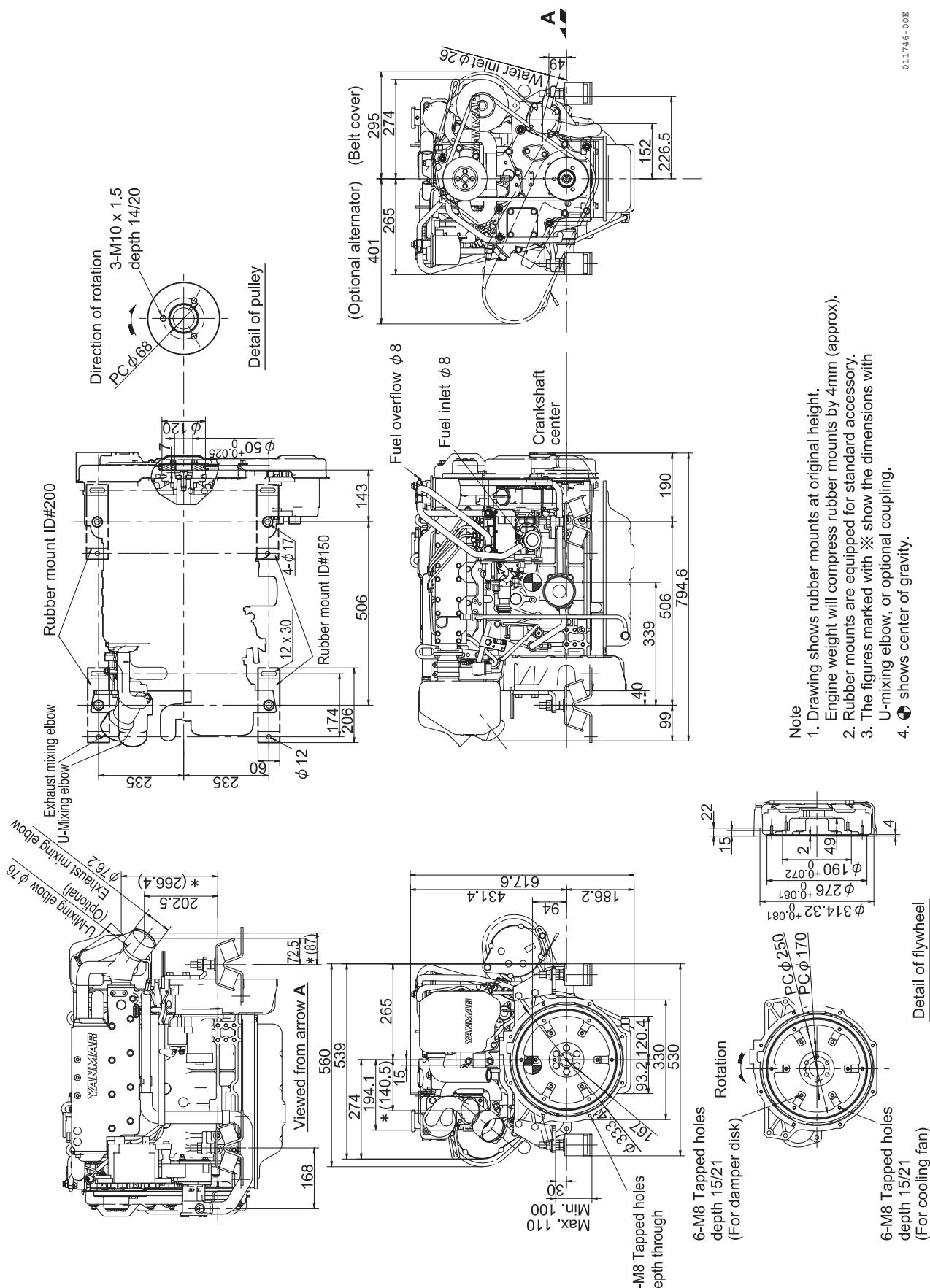


1. General

(9) 4JH4CE (with SD50/SD40 sail drive)

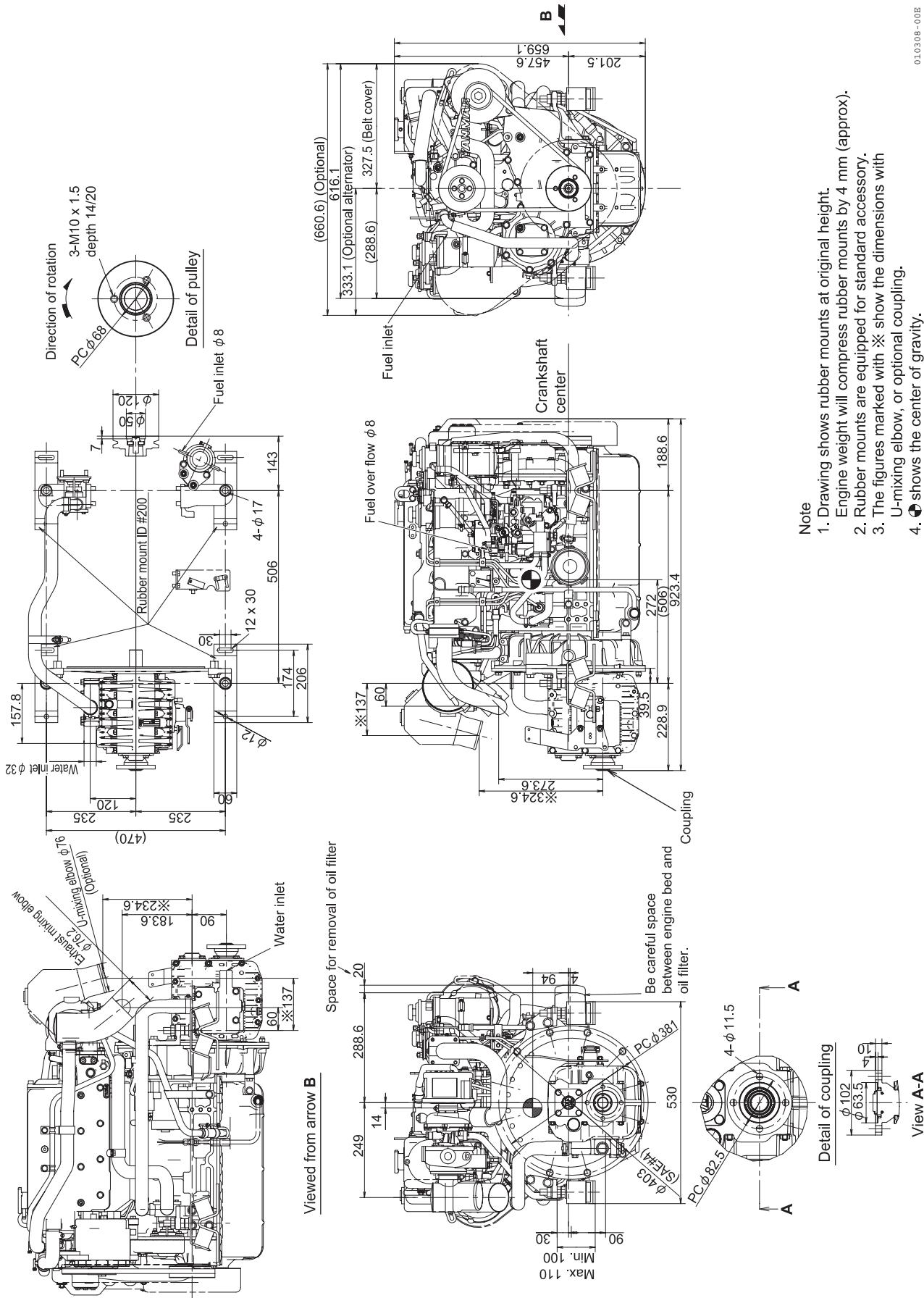


(10) 4JH4ME (Bobtail)

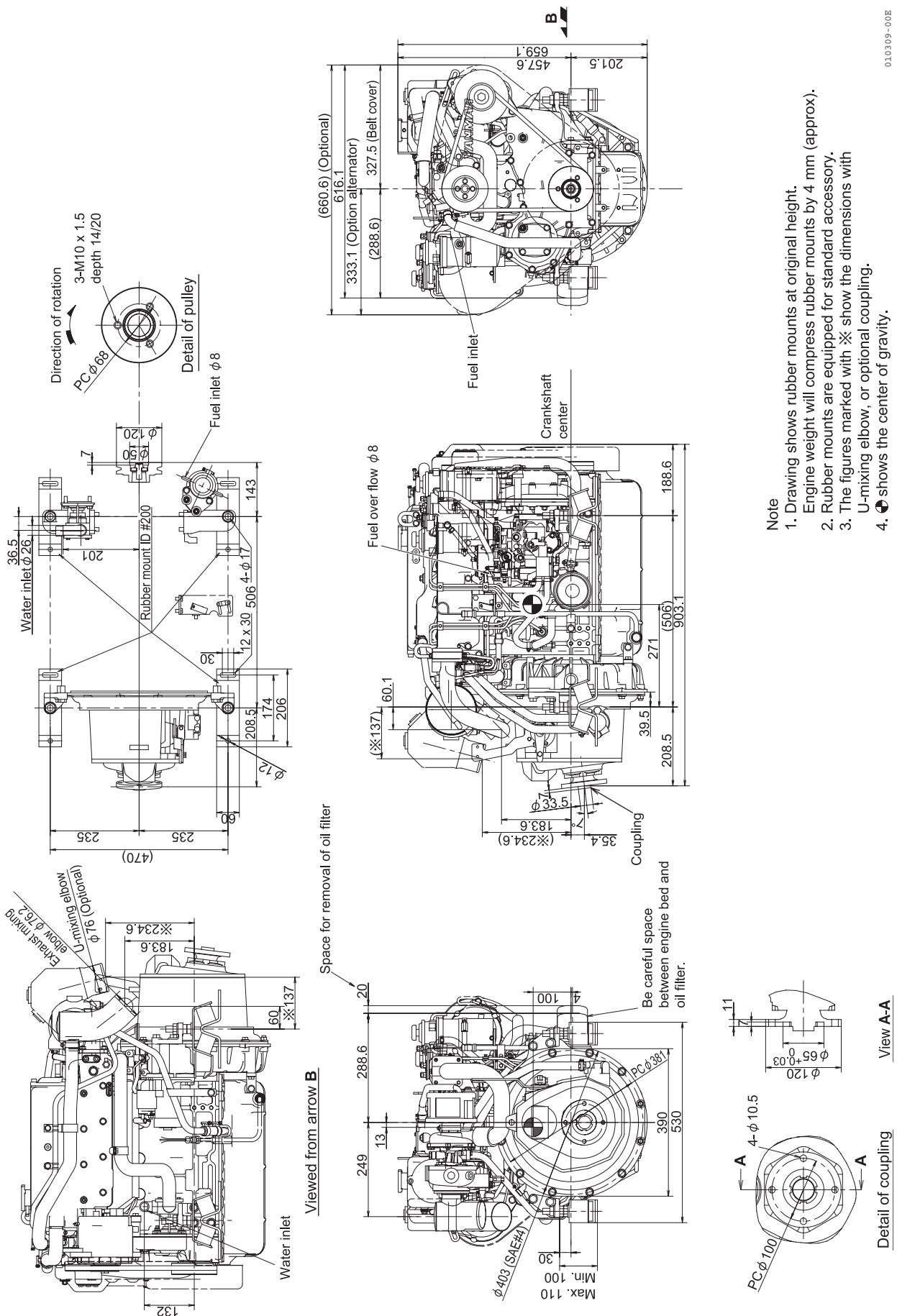


1. General

(11) 4JH4-TFE (with ZF30M marine gear)

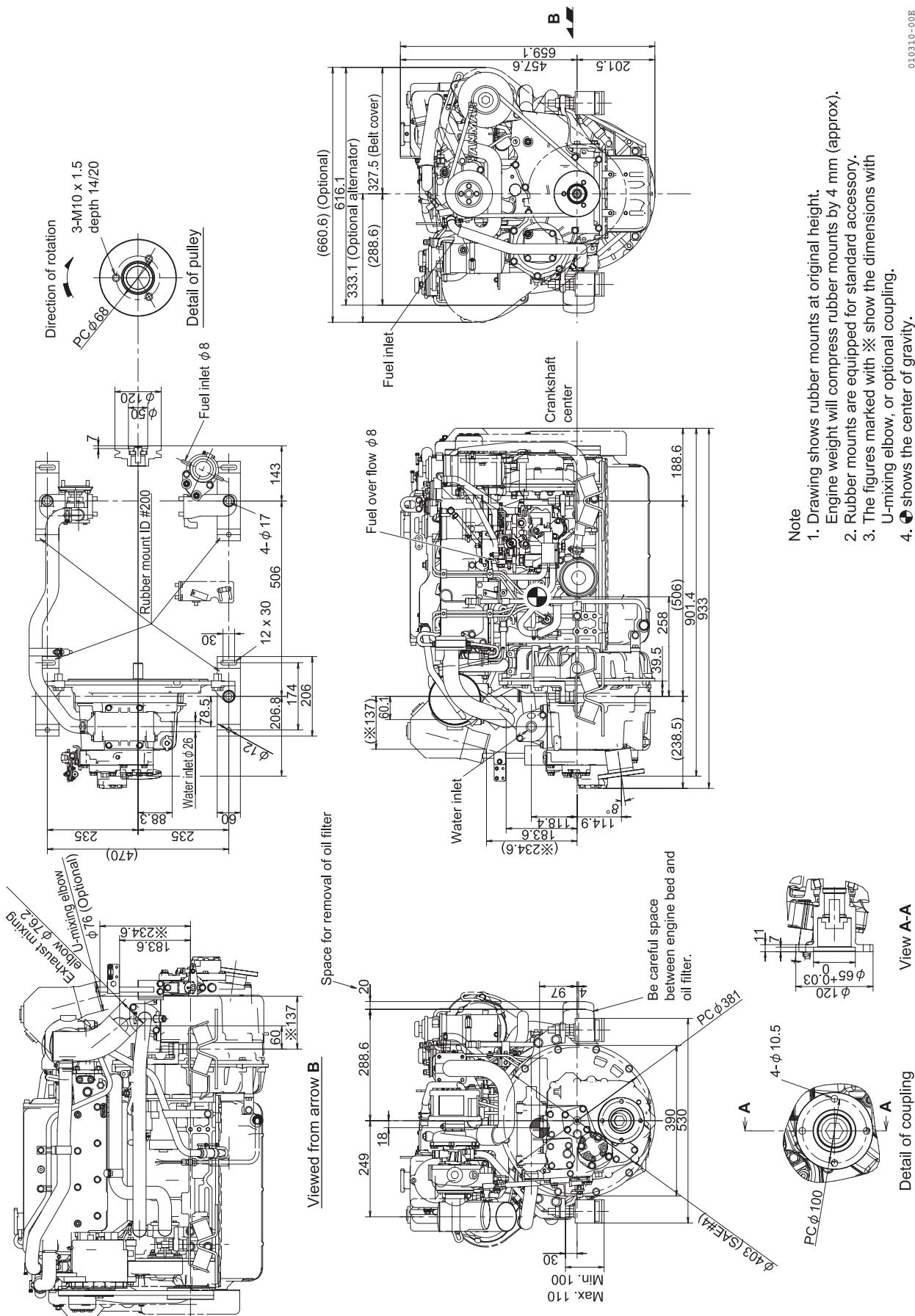


(12) 4JH4-TBE (with KM4A2 marine gear)

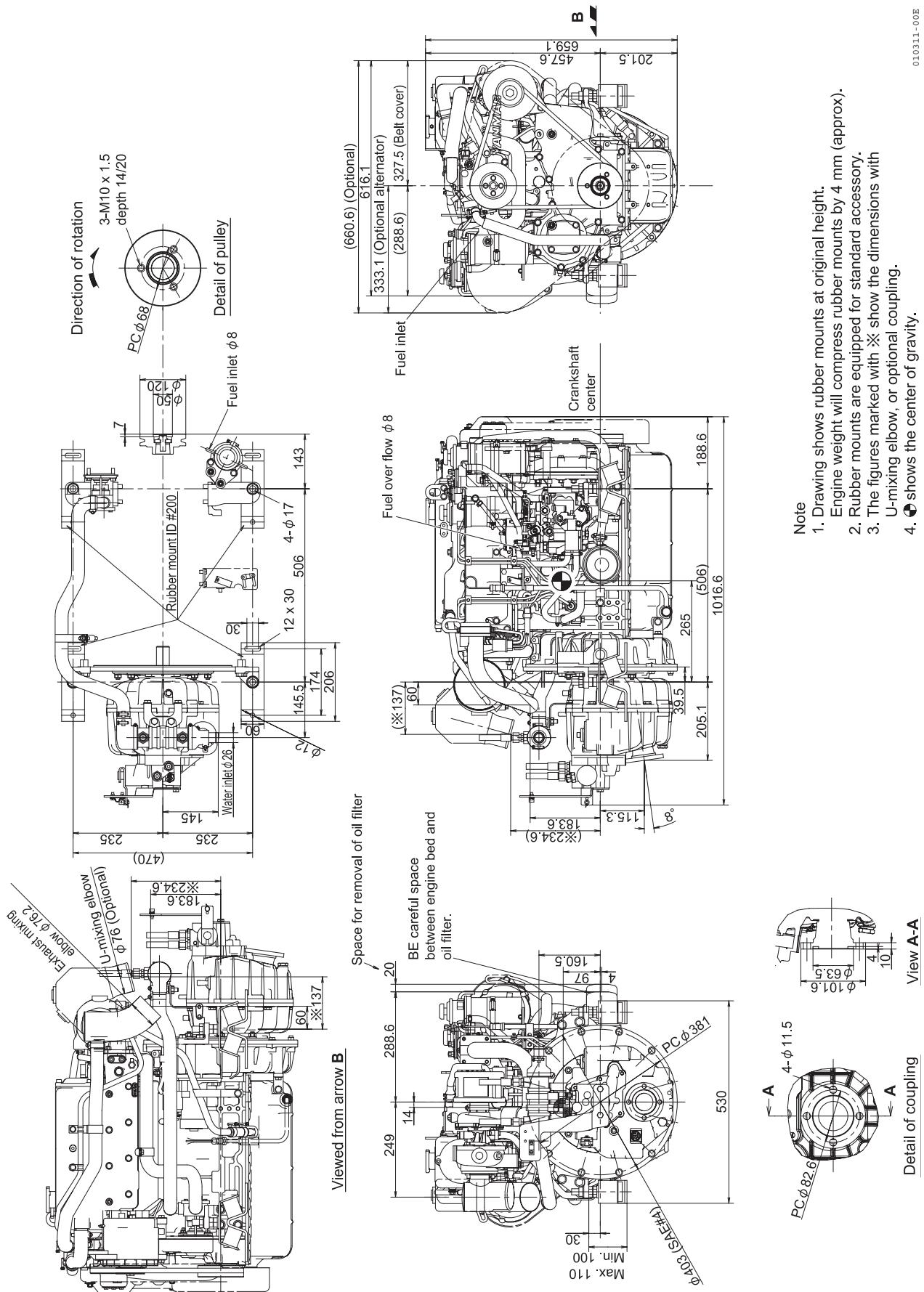


1. General

(13) 4JH4-THE (with KMH4A marine gear)

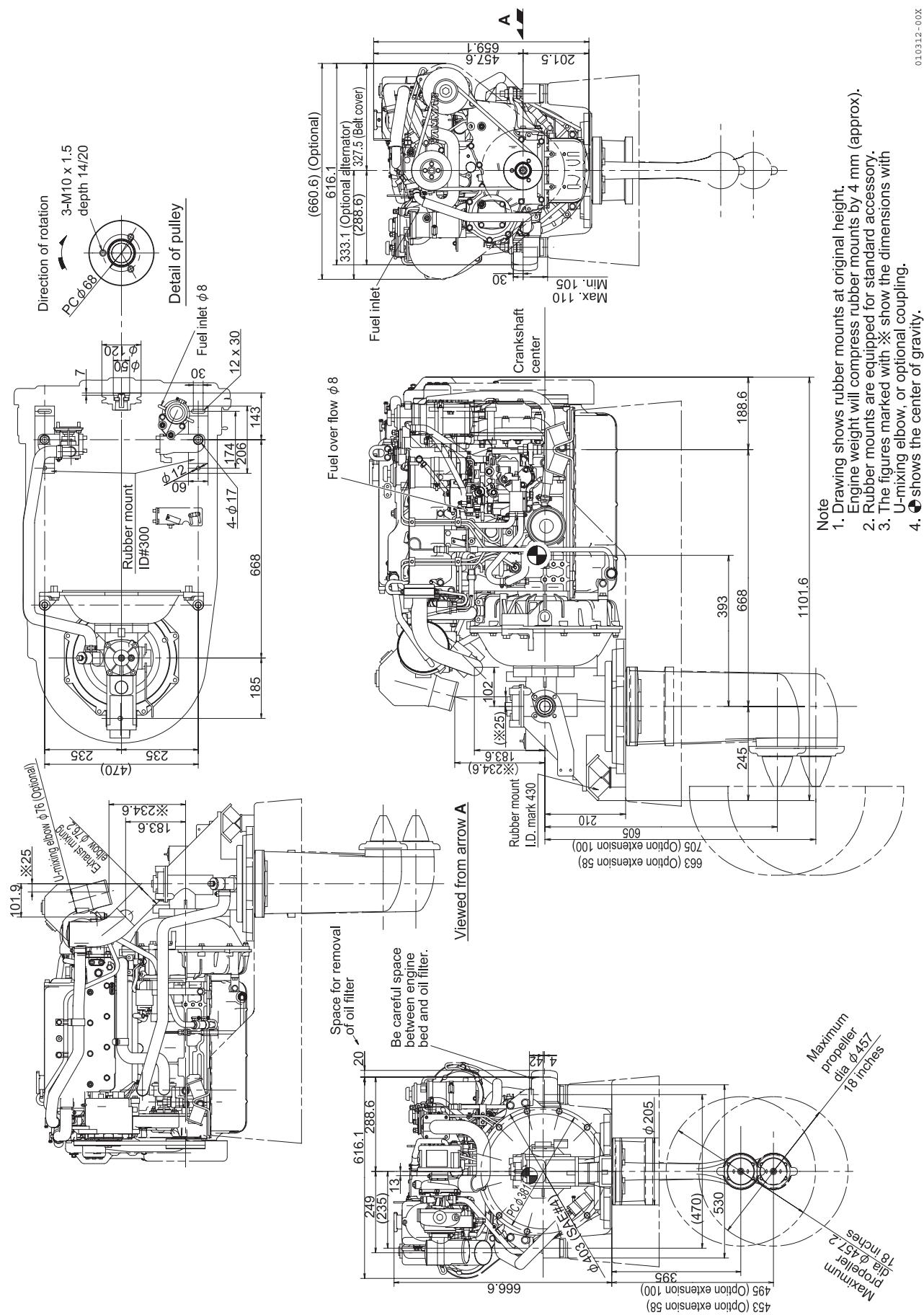


(14) 4JH4-TIE (with ZF25A marine gear)

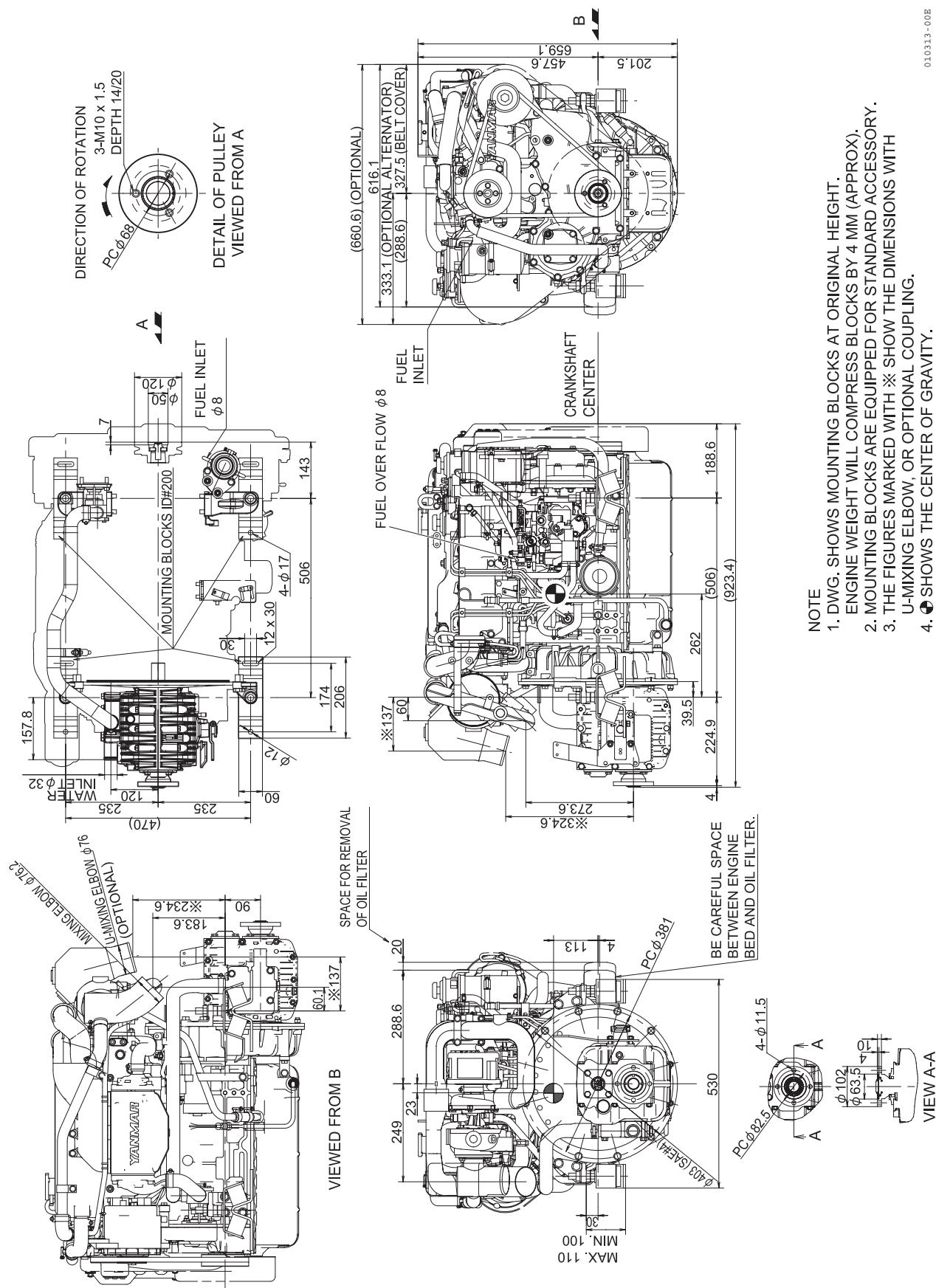


1. General

(15) 4JH4-TCE (with SD50-4T sail drive)

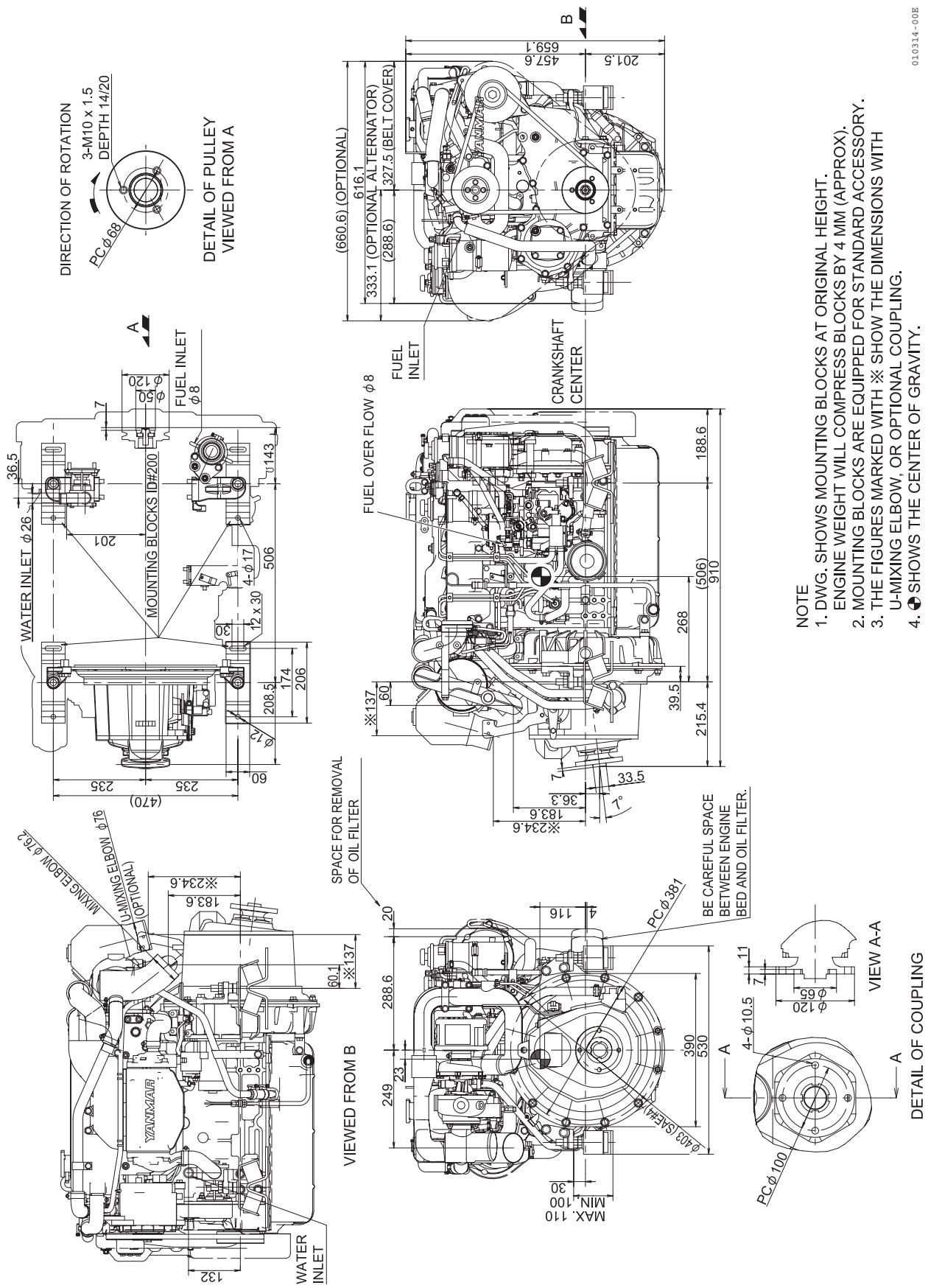


(16) 4JH4-HTFE (with ZF30M marine gear)

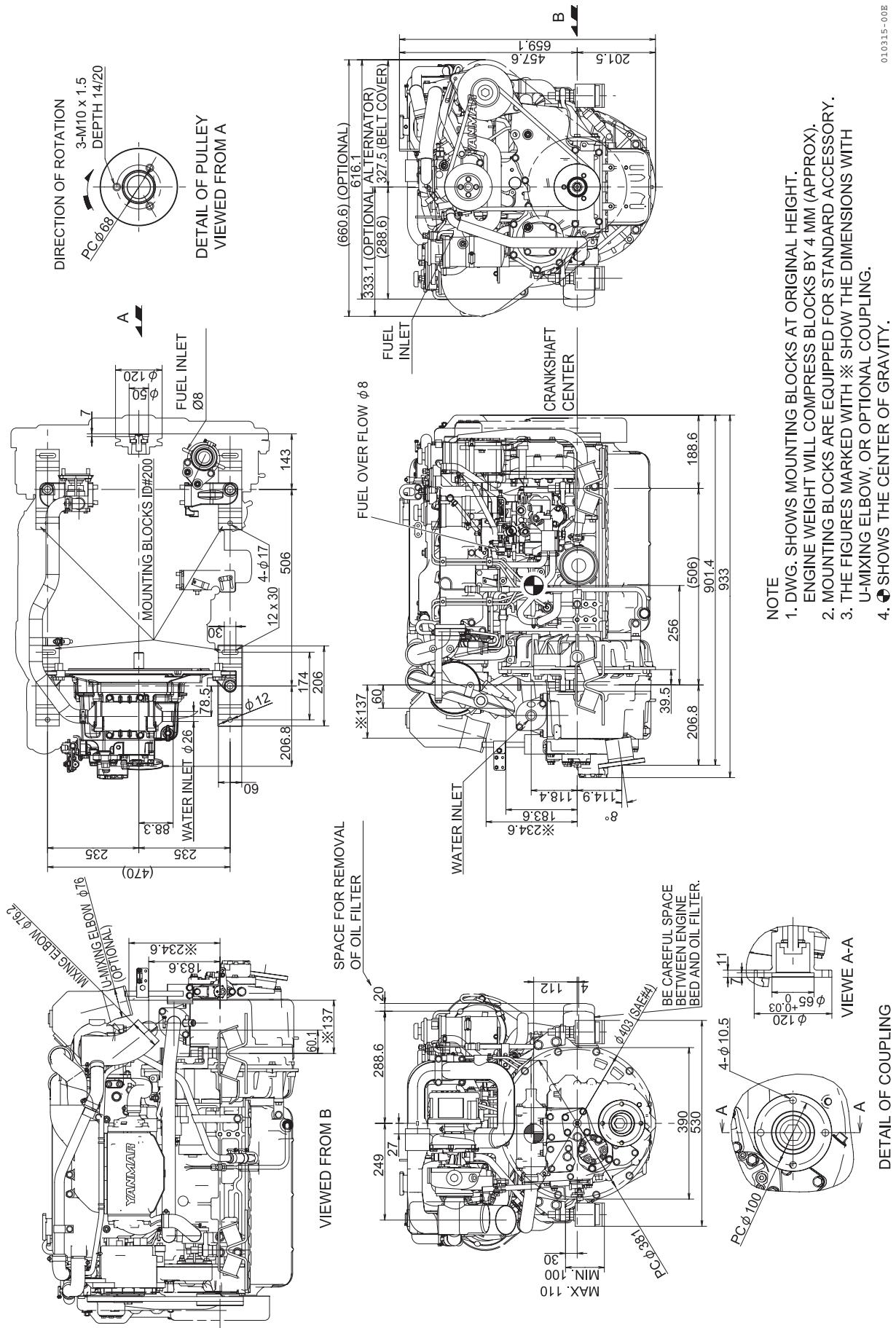


1. General

(17) 4JH4-HTBE (with KM4A2 marine gear)

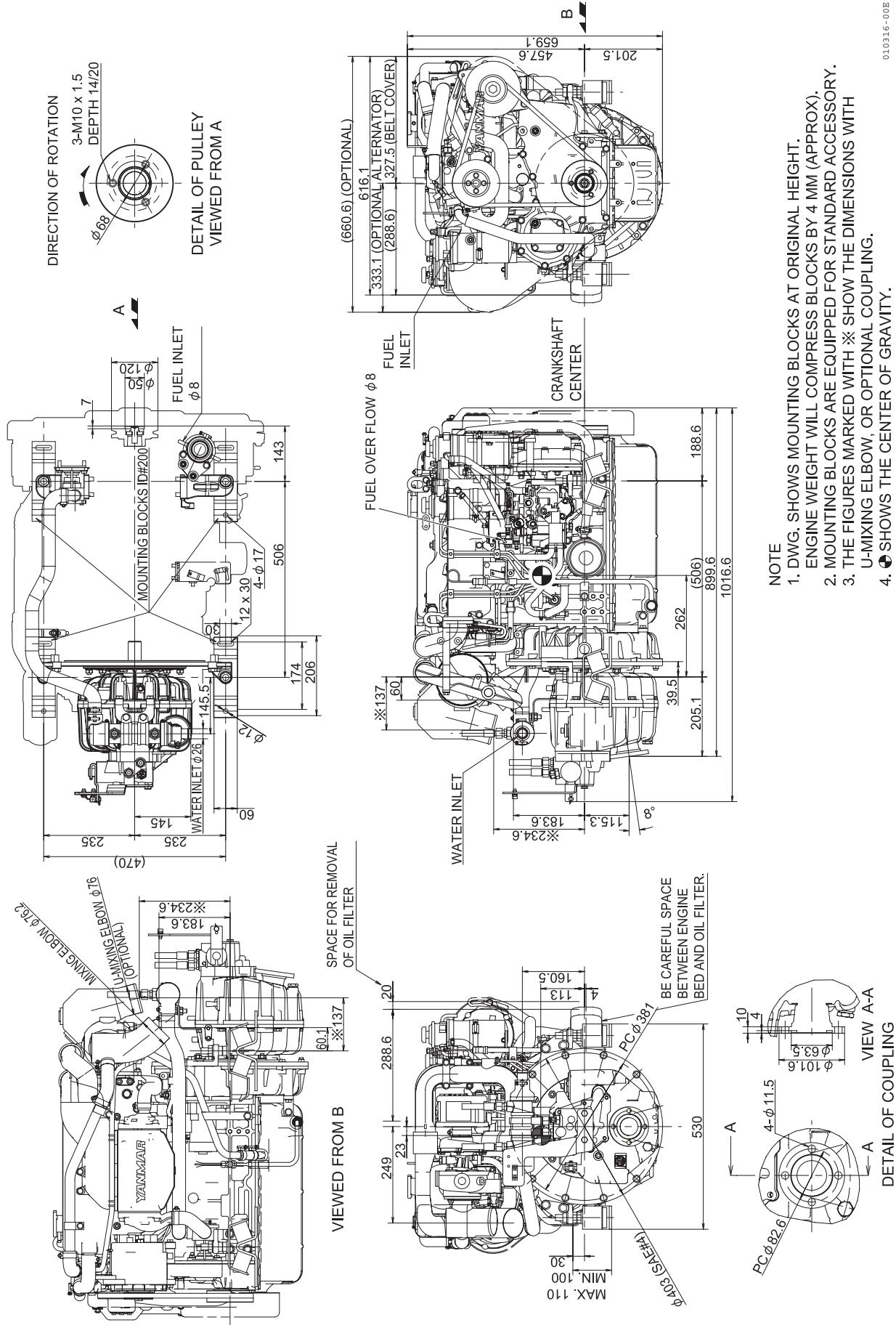


(18) 4JH4-HTHE (with KMH4A marine gear)



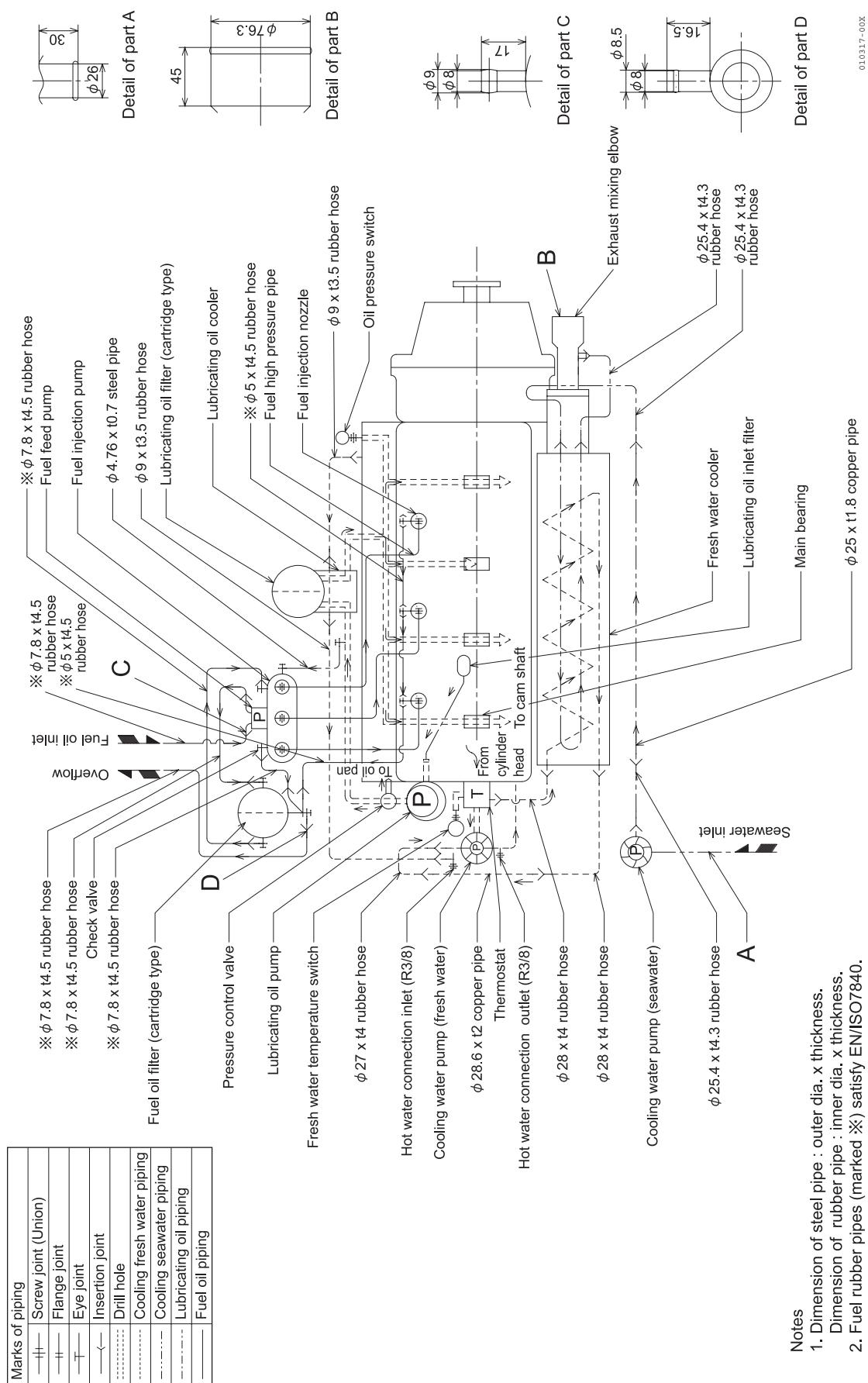
1. General

(19) 4JH4-HTIE (with ZF25A marine gear)



1.5 Piping diagrams

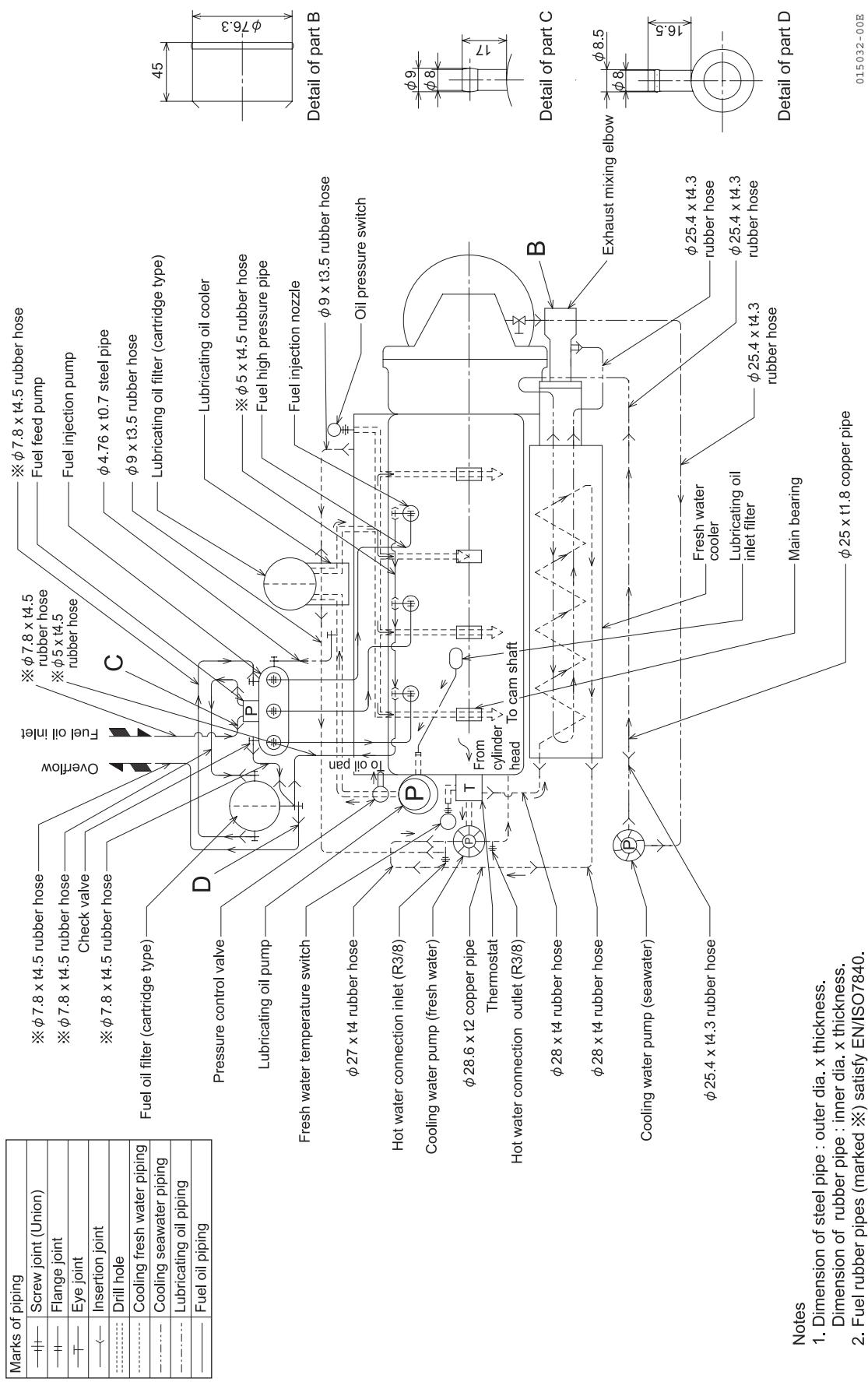
(1) 3JH4 (B) E



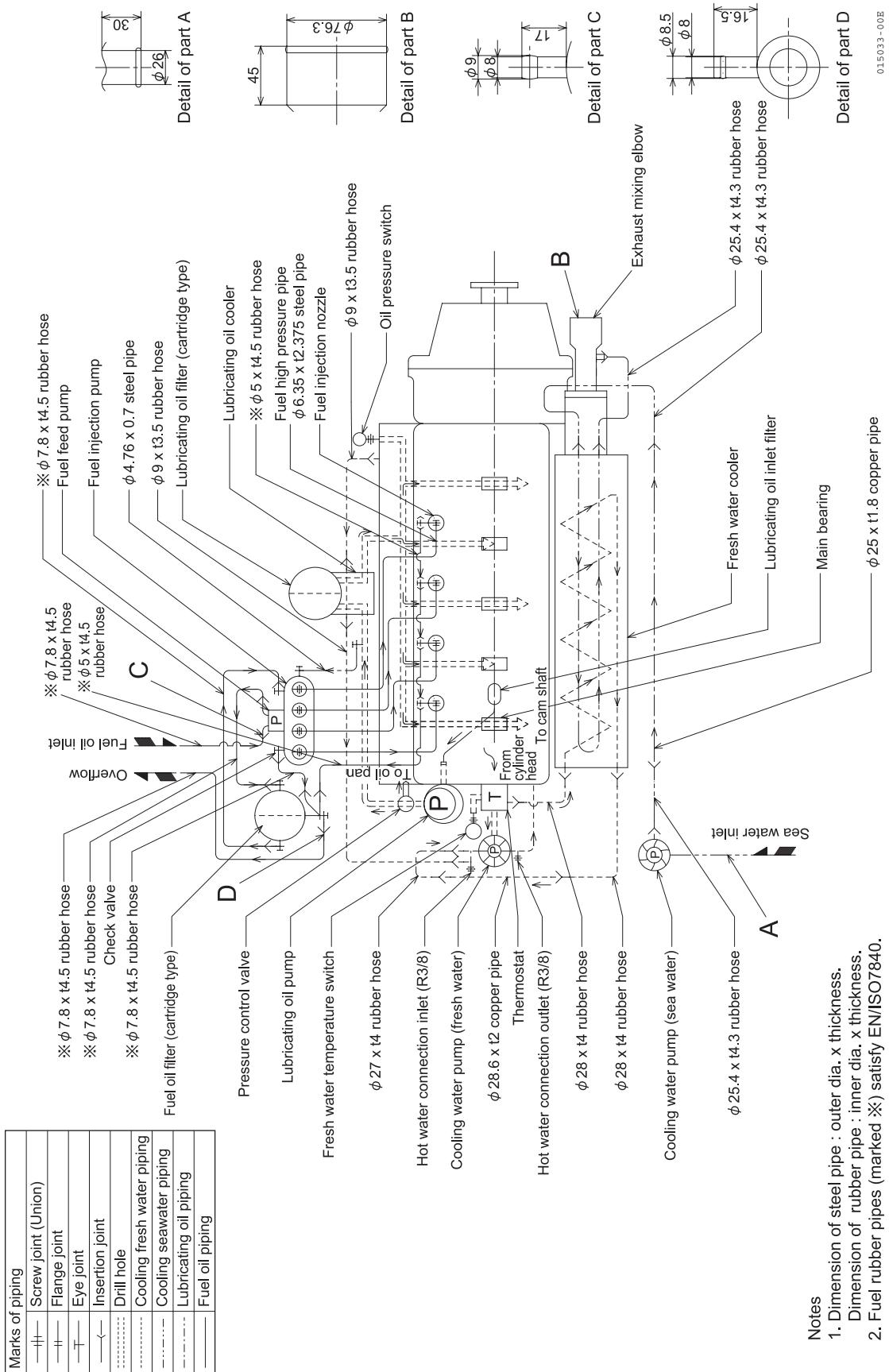
Note: The following piping diagram is for the 3JH4(B)E model.

1. General

(2) 3JH4CE (with SD50/SD40 sail drive)

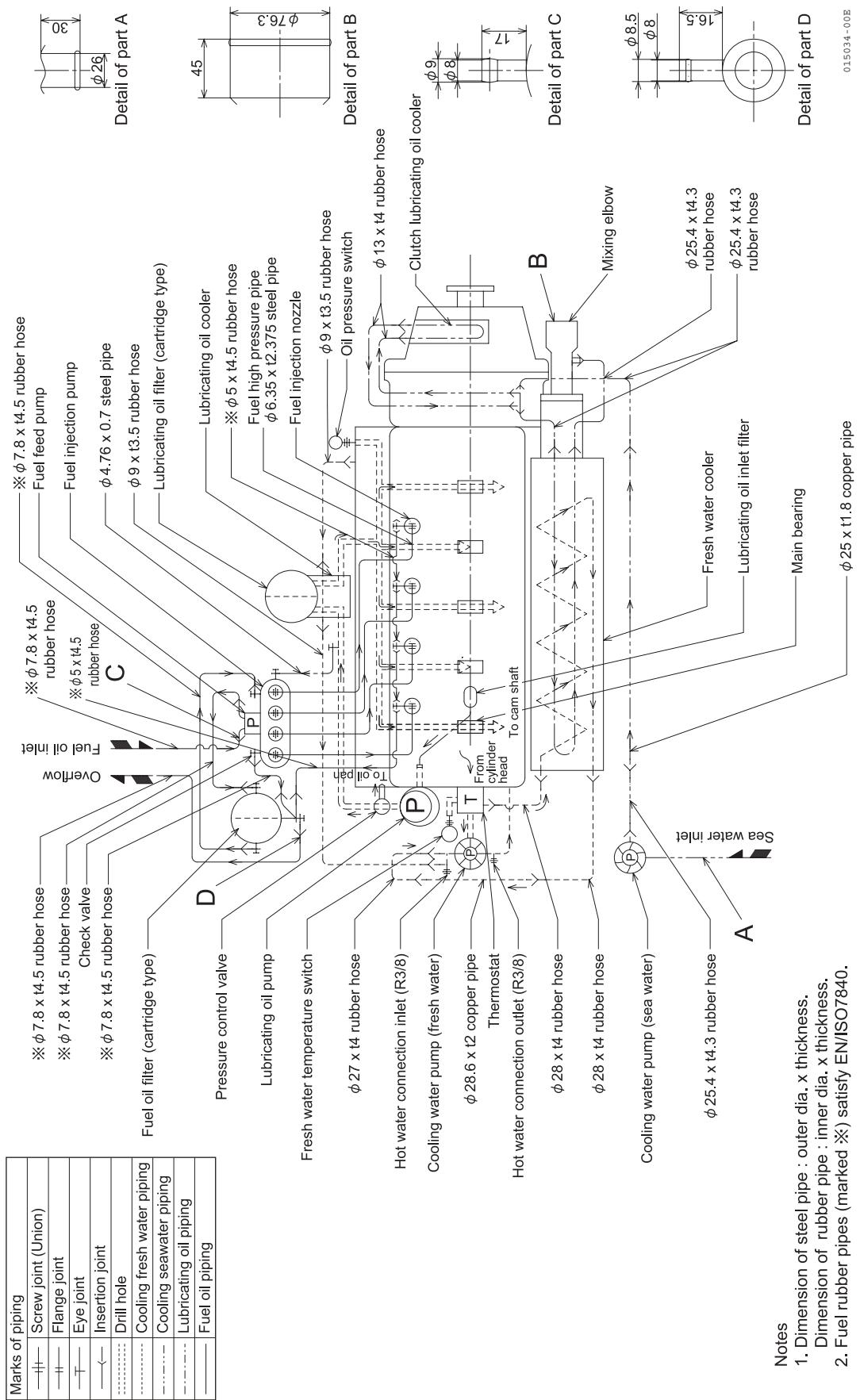


(3) 4JH4(B)E (with KM35P, KM35A2 marine gear)

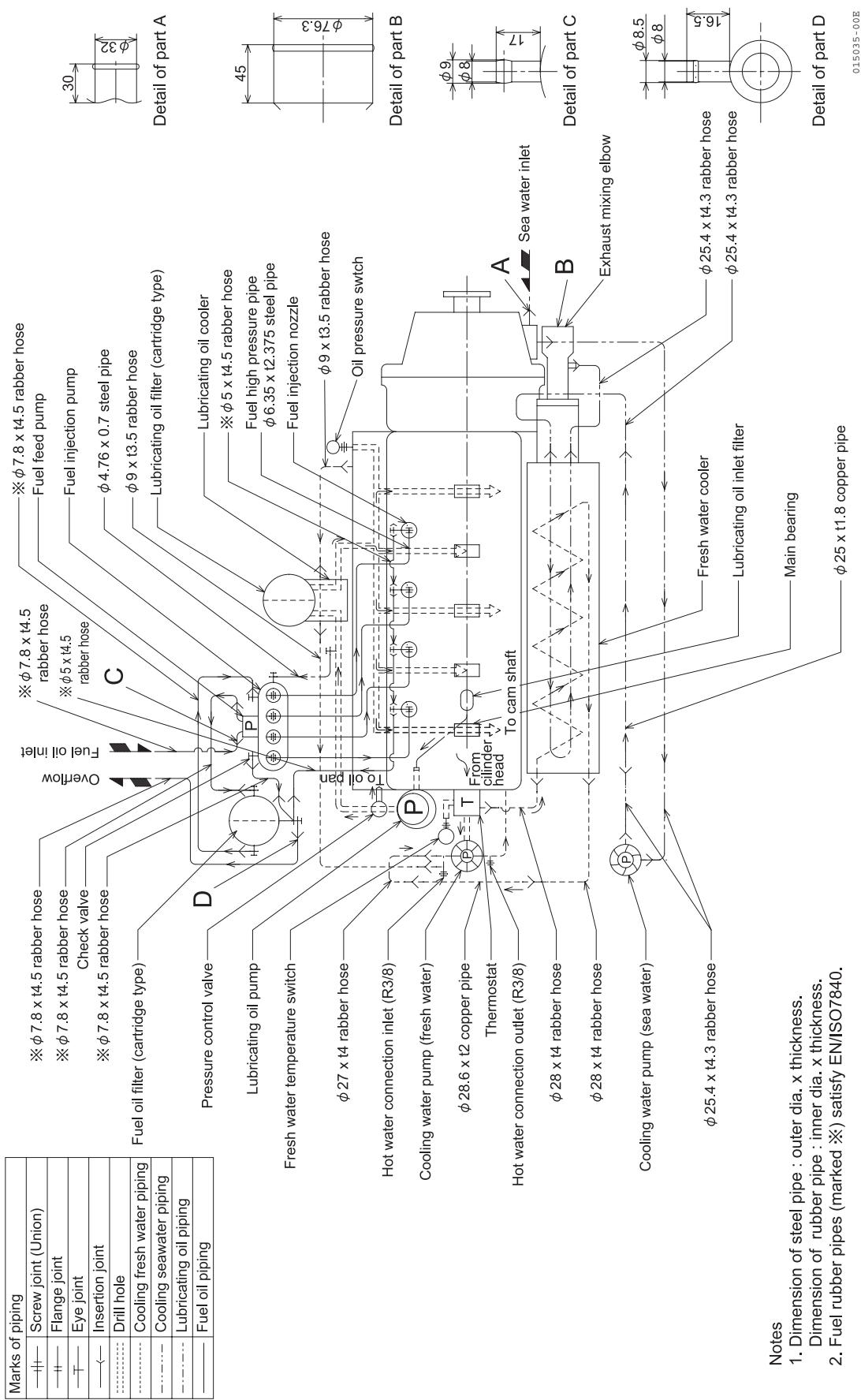


1. General

(4) 4JH4B4E (with KM4A1 marine gear)

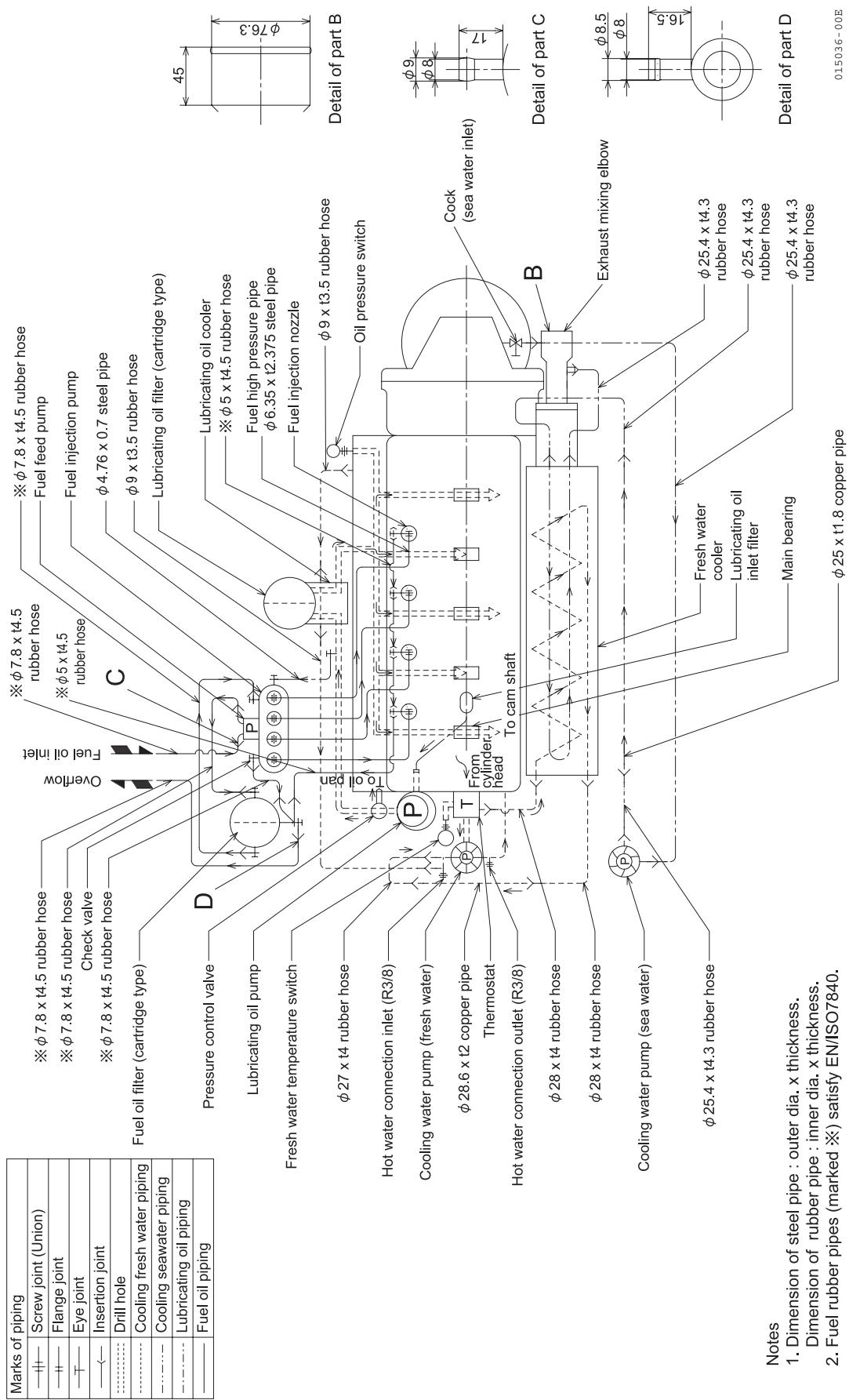


(5) 4JH4FE (with ZF30M marine gear)

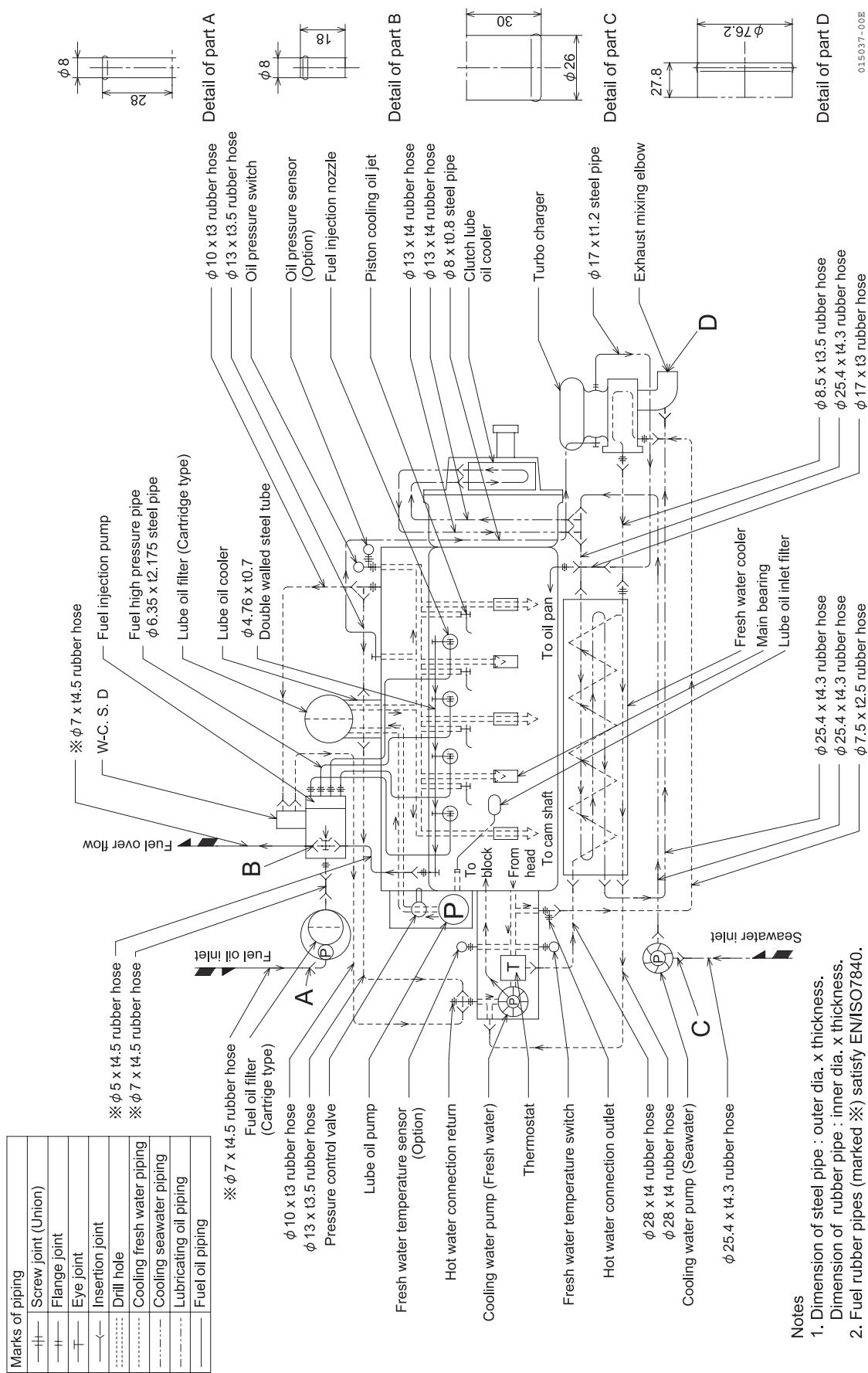


1. General

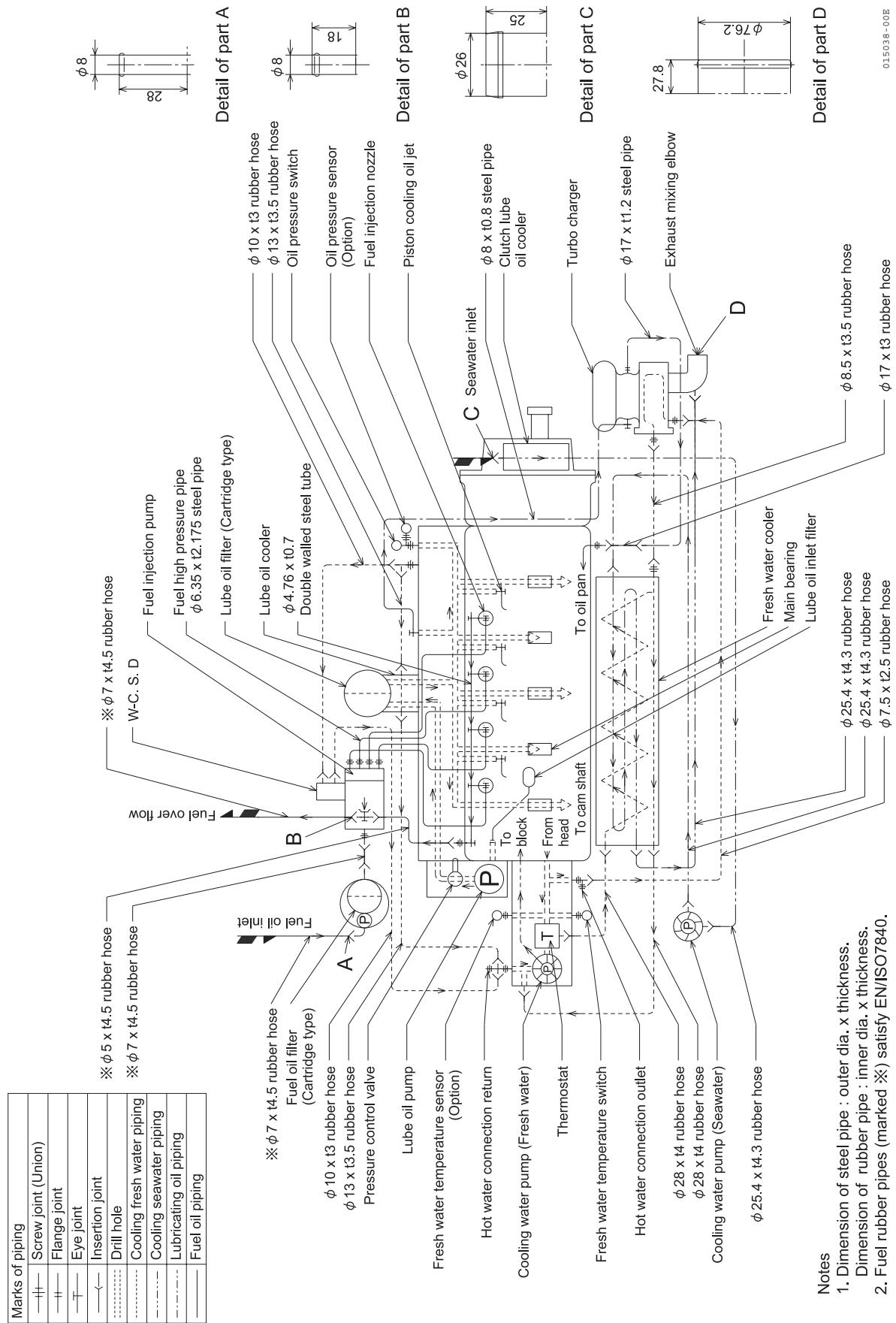
(6) 4JH4CE (with SD50/SD40 sail drive)



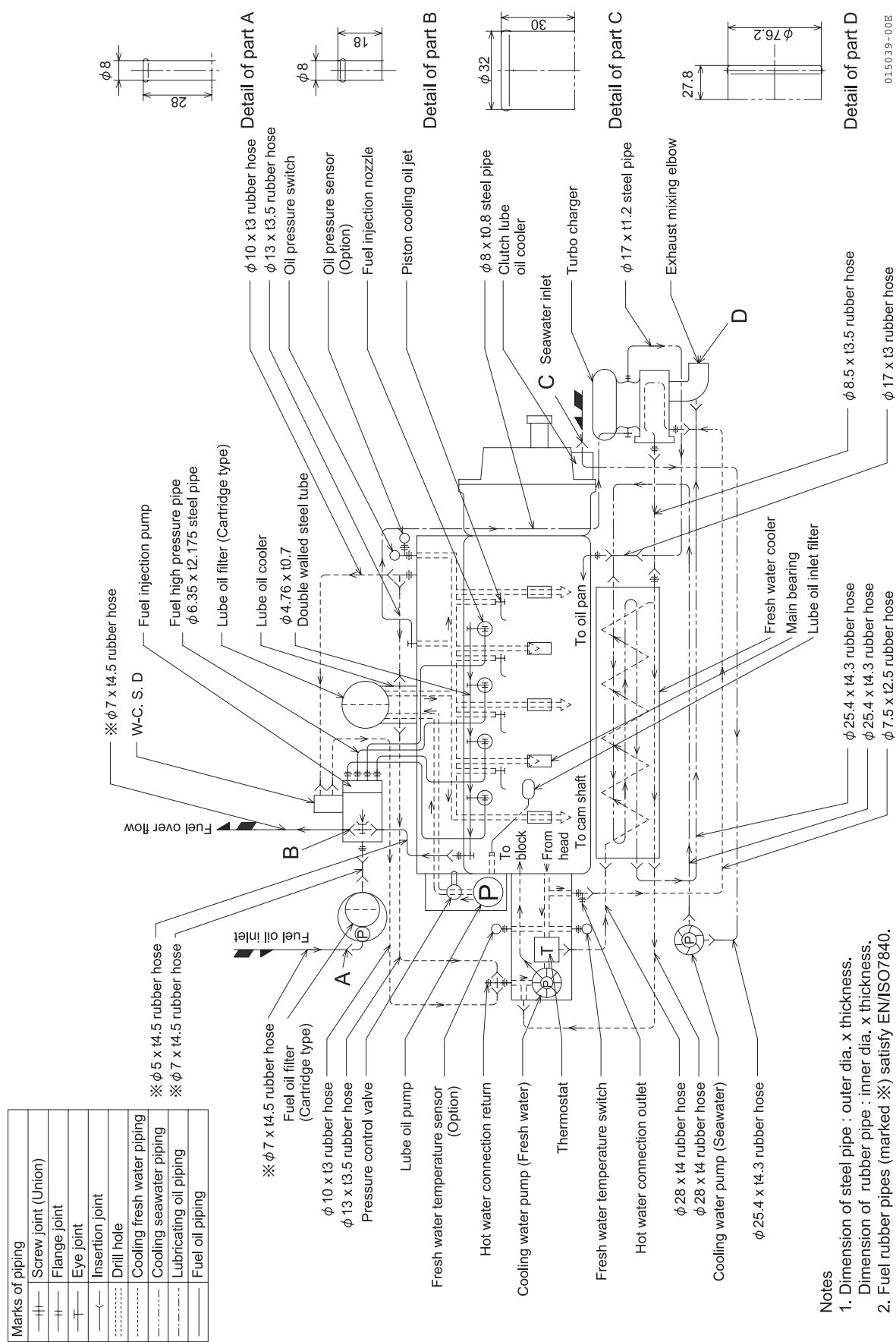
(7) 4JH4-TE (with KM4A2 marine gear)



(8) 4JH4-TE (with KMH4A and ZF25A marine gear)

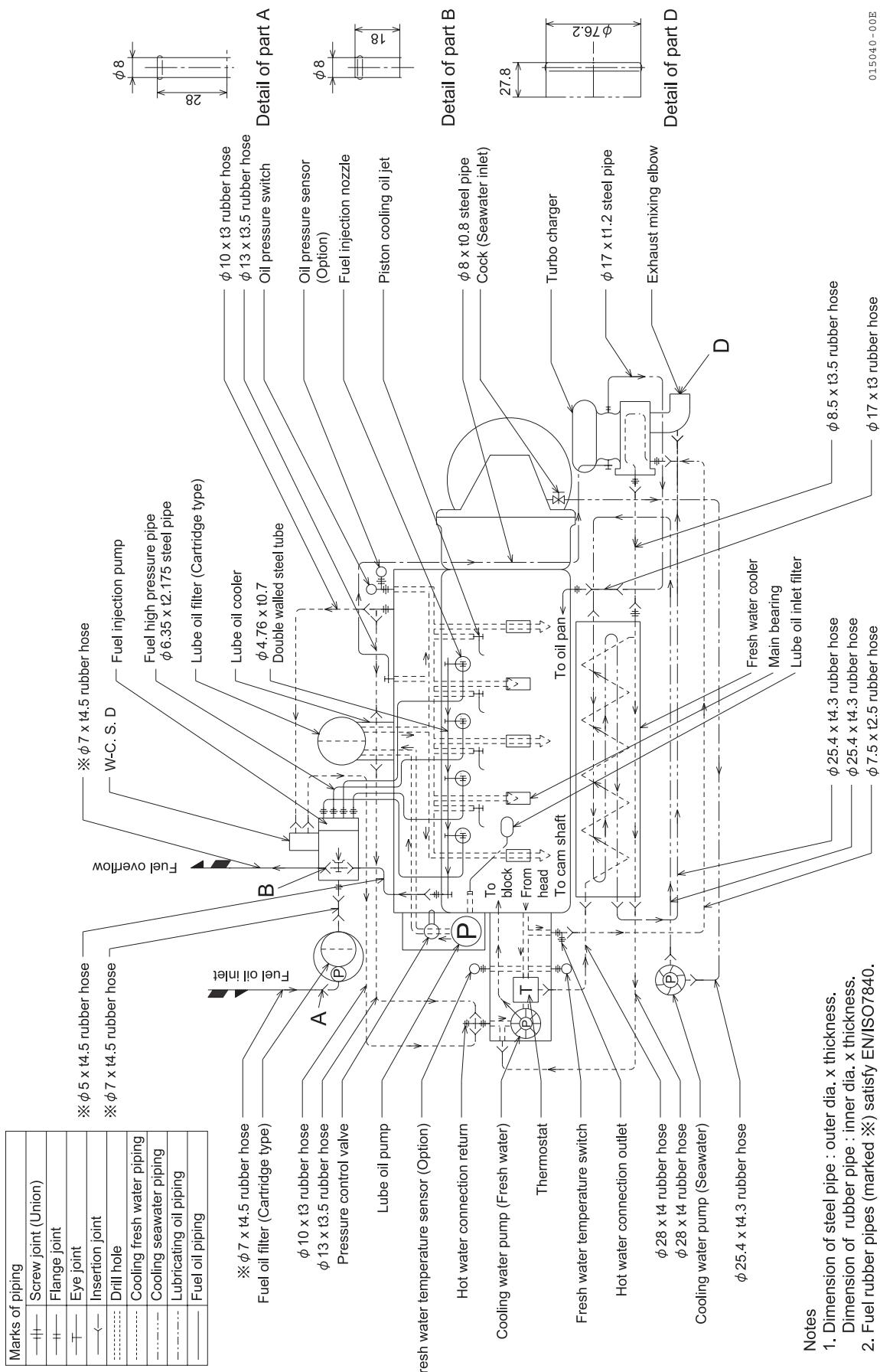


(9) 4JH4-TE (with ZF30M marine gear)

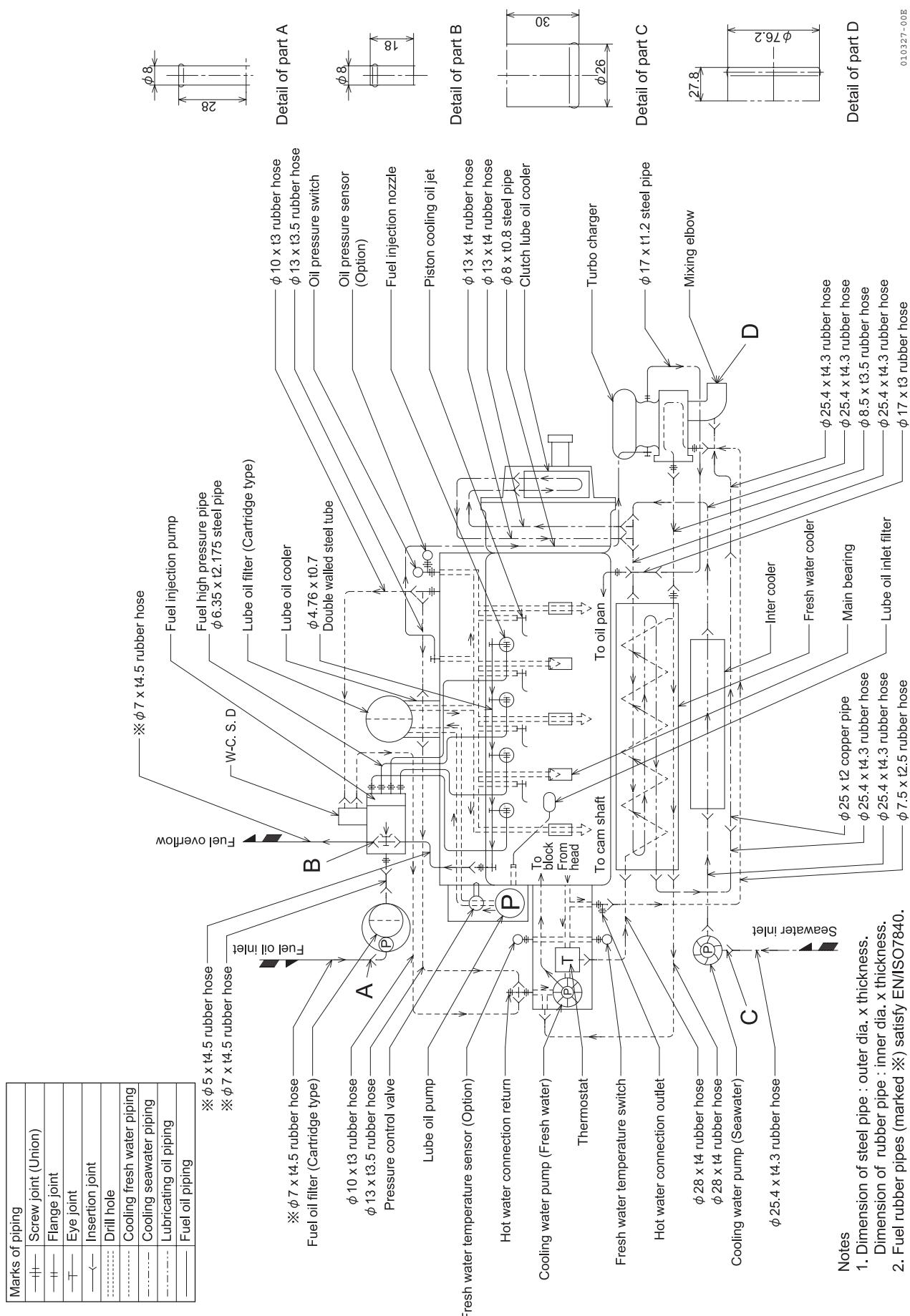


1. General

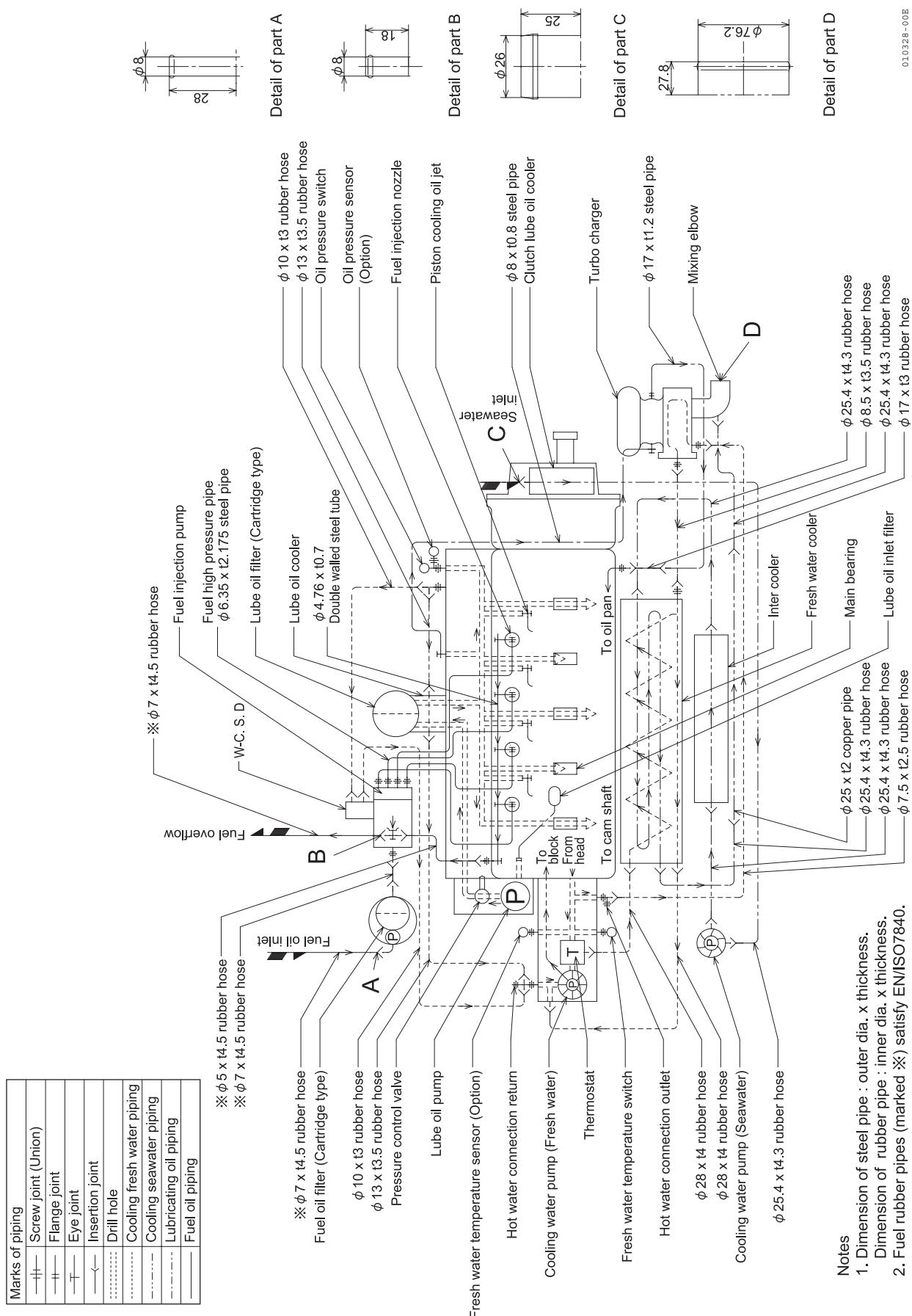
(10) 4JH4-TE (with SD50-4T sail drive)



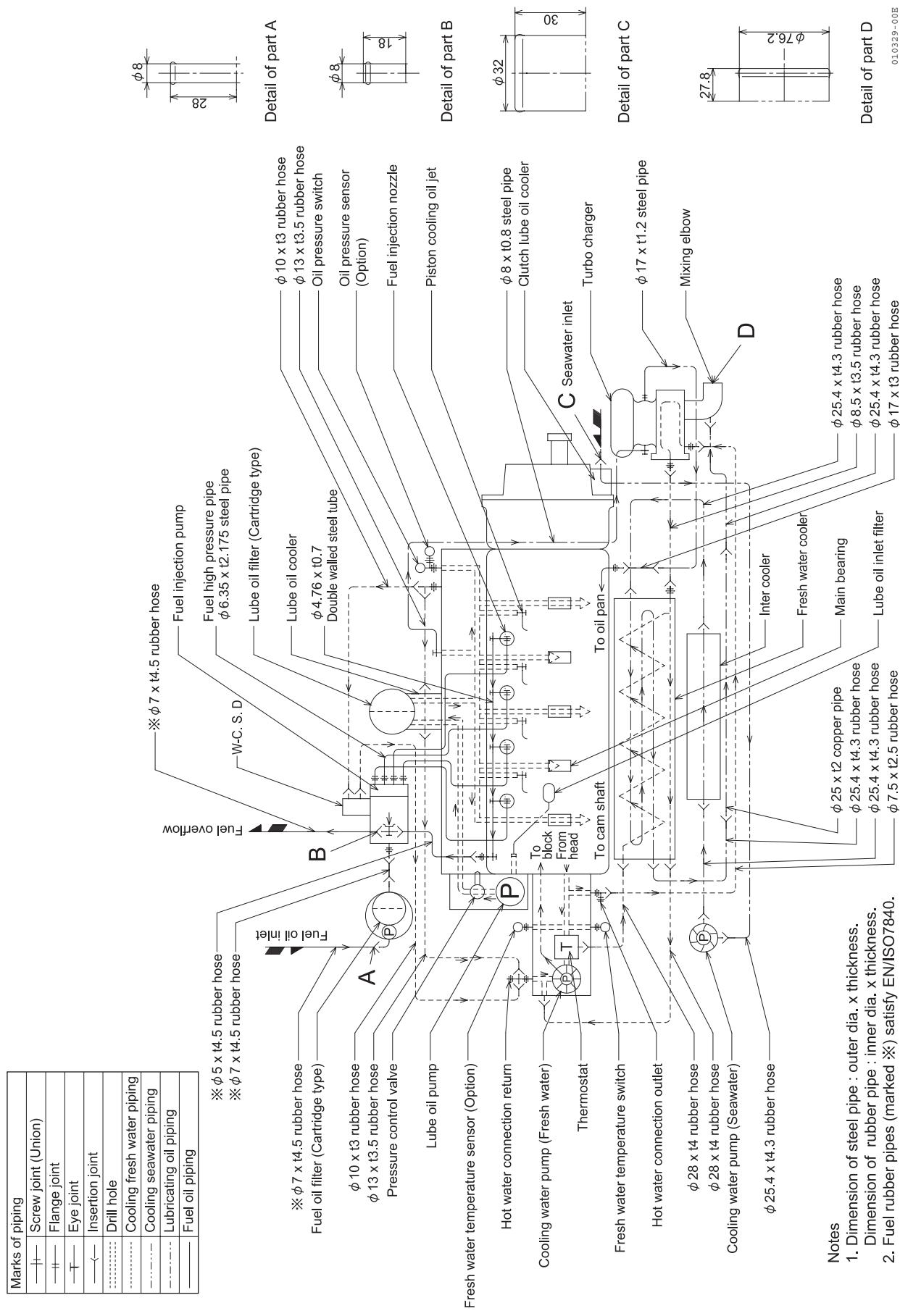
(11) 4JH4-HTE (with KM4A2 marine gear)



(12) 4JH4-HTE (with KMH4A and ZF25A marine gear)



(13) 4JH4-HTE (with ZF30M marine gear)



1.6 Exhaust Gas Emission Regulation in U.S.A. only

Engines below 37kW are regulated by Off-road Compression Ignition engines regulations of the EPA and ARB (California Air Resources Board) in USA.

Engines more than 37kW will be regulated by EPA Emission Regulations for Marine CI Engines in USA.

1.6.1 Engines under 37kw: 3JH4E

Off-road Compression Ignition engines regulations of the EPA and ARB are applied to engines below 37kW and explained in the following.

(1) Engine identification

With the regulations on exhaust gas emission worldwide, it has become necessary to identify engines in a manner to determine which regulations they comply with, hence.

a) Emission control label

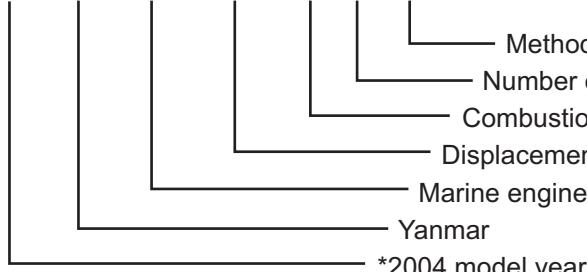
(Note) Emission Control is accomplished through Engine Modification (EM-Design).

- The tamper resistance device is installed with EPA/ARB certified 3JH4E series engines to prevent illegal change of fuel injection volume and high idling speed.

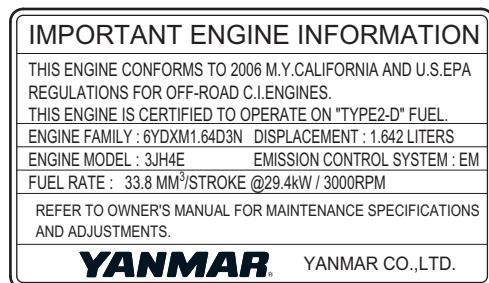
(Fuel injection volume: cap type, High idling speed: cap type.)

- Engine family name as assigned by EPA/ARB identifying engine family group.
4YDXM1.64D3N and this identifies
YYDXM1.64D3N and this identifies

4 YDX M 1.64 D 3 N

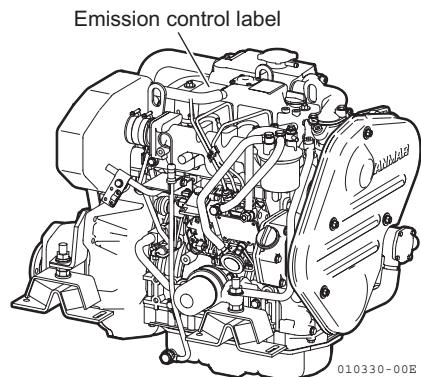


EPA and ARB label



Model year
4*: 2004
5 : 2005
6 : 2006
7 : 2007
8 : 2008
9 : 2009

b) Label location:



(2) Emission standard

The below table shows the emission standard of the EPA Off-road CI engines regulations for 19kW and under 37kW engines.

g/kWh (g/HPhr)

Engine power	Tier	Model year	NOx	HC	NMHC + NOx	CO	PM
19 ≤ kW < 37 (25 ≤ hp < 50)	Tier 1	1999 -	-	-	9.5 (7.1)	5.5 (4.1)	0.80 (0.60)
	Tier 2	2004 -	-	-	7.5 (5.6)	5.5 (4.1)	0.60 (0.45)

Note:

1. The transit smoke (ACC/LUG/PEAK) is not applicable.
2. The EPA recommended fuel is used.
3. The ARB standard is the same as the EPA's.
4. "Model year" means the year when the regulation is enforced.

(3) Guarantee conditions for emission standard

In addition to making sure that these conditions are met, check for any deterioration that may occur before the required periodic maintenance times.

- 1) Requirement on engine installation condition
 - a) Air intake negative pressure.

kPa (mmAq)

Permissible
≤3.9 (400)

- b) Exhaust gas back pressure.

kPa (mmAq)

Permissible
≤14.7 (1500)

- 2) Fuel oil and lubricating oil
 - a) Fuel: Diesel fuel oil, ASTM D975 No.1-D or No.2-D, equivalent (Cetane No. 45 minimally).
 - b) Lube oil: API grade, class CD.

1. General

- 3) Do not remove the caps restricting injection quantity and engine speed.
- 4) Perform maintenance without fail.
Inspection and maintenance for EPA emission related parts are shown in the chart below.

Note:

Inspections to be carried out by the user and by the maker are divided and set down in the "List of Periodic Inspection" on the operation manual and should be checked carefully.

EPA allows to apply Maintenance schedule for Emission related parts as follows.

Inspection and maintenance not noted below are the same as the periodic maintenance in this manual.

		Maintenance period
Parts Power rating	Fuel nozzle cleaning	Adjustment, cleaning, repairs for fuel nozzle, fuel pump, etc.
19≤kW<37	Every 1500 hours	Every 3000 hours

Note:

The inspection and maintenance shown above are to be performed at Yanmar dealer or distributor.

- 5) Quality guarantee period for exhaust emission related parts.

For exhaust emission related parts, follow the inspections outlined in the "List of Periodic Inspections", on the operation manual, and use the table below to carry out inspections based on operation hours or time in years. Whichever comes first is the guarantee period.

19≤kW<37	3000 hours or 5 years
----------	-----------------------

The specific emissions-related parts for 3JH4E are

- a) Fuel injection nozzle.
- b) Fuel injection pump.

1.6.2 Engines of 37kW or more: 4JH4-TE and 4JH4-HTE

EPA Emission Regulations for Marine CI Engines are applied to engines of 37kW or more in the U.S.A. Model 4JH4-TE is an EPA approved engine as commercial application and Model 4JH4-HTE is an EPA approved engine as recreational application.

(1) Engine identification

With the regulations on exhaust gas emission worldwide, it has become necessary to identify engines in a manner to determine which regulations they comply with, hence.

Model 4JH4-TE and 4JH4-HTE have the following EPA label (Emission control labels) attached:

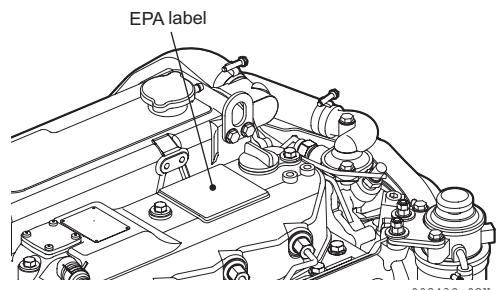
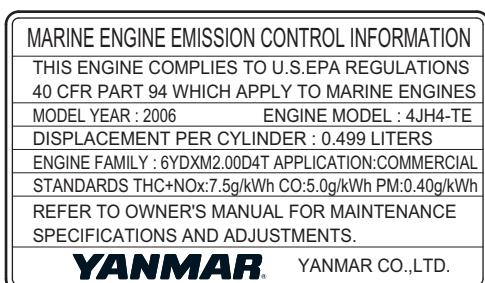
Emission control label (EPA label) and location.

The model year and engine family name in EPA label are changed every year.

The below figure shows an example.

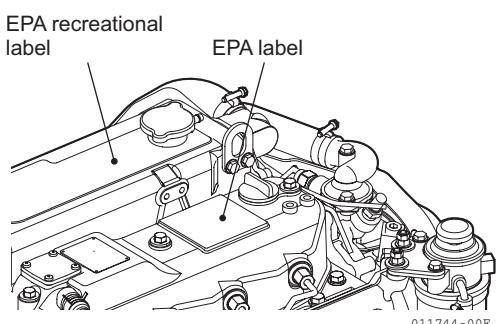
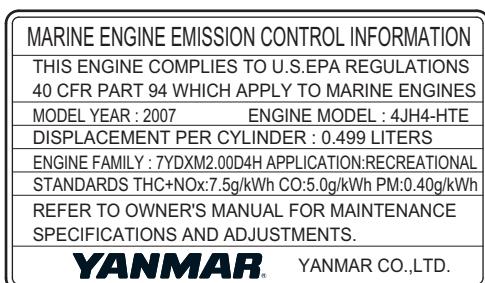
- 4JH4-TE

EPA label



- 4JH4-HTE

EPA label



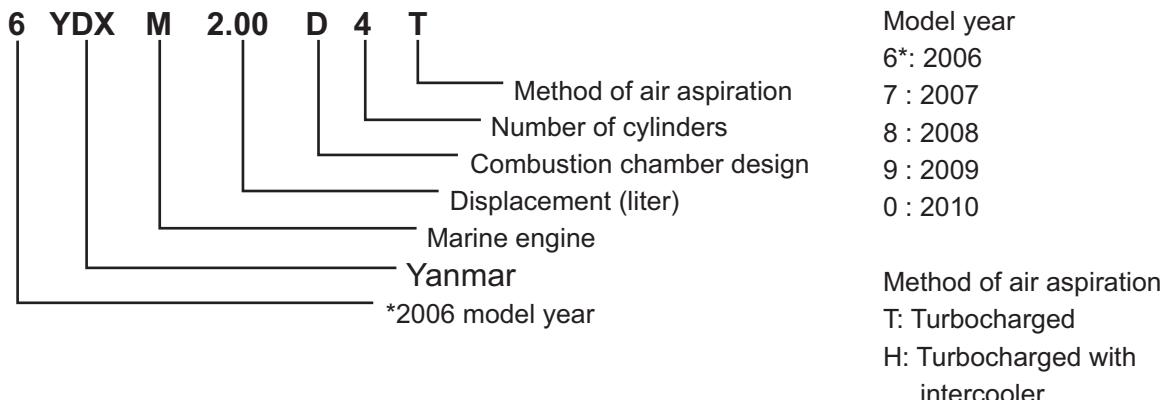
Only 4JH4-HTE has the EPA recreational label attached on the fresh water cooler.

EPA recreational label

THIS ENGINE IS CATEGORIZED AS A RECREATIONAL
MARINE ENGINE UNDER 40 CFR PART 94. INSTALLATION
OF THIS ENGINE IN ANY NONRECREATIONAL VESSEL IS A
VIOLATION OF FEDERAL LAW SUBJECT TO CIVIL PENALTY.

1. General

- Engine family name as assigned by EPA identifying engine family group.
6YDYM2.00D4T and this identifies



(2) Emission standard

The below table shows the emission standard of the EPA Emission Regulations for Marine CI Engines for engines with less than 0.9 liter per cylinder.

Engine Power	Tier	NOx	HC	NMHC + NOx	CO	PM	g/kWh
≥ 37kW	Tier 2	-	-	7.5	5.0	0.40	

Note: The EPA recommended fuel is used.

(3) Guarantee conditions for emission standard

In addition to making sure that these conditions are met, check for any deterioration that may occur before the required periodic maintenance periods.

- 1) Requirement on engine installation condition.
 - a) Air intake negative pressure.

kPa (mmAq)

Permissible
≤2.0 (200)

- b) Exhaust gas back pressure.

kPa (mmAq)

Permissible
≤20 (2,000)

- 2) Fuel oil and lubricating oil
 - a) Fuel: The diesel fuel oil, ASTM D975 No.1-D or No.2-D, equivalent (Cetane No. 45 minimally).
 - b) Lube oil: API grade, class CD or higher.
- 3) Do not remove the caps restricting injection quantity and engine speed.

4) Perform maintenance without fail.

Note:

Inspections to be carried out are divided by the user and by the maker and set down in the "List of Periodic Inspection" on the operation manual and should be checked carefully. The inspection and maintenance shown below are to be performed at Yanmar dealer or distributor.

EPA allows to apply Maintenance schedule for Emission related parts as follows.

Inspection and maintenance not noted below are the same as the periodic maintenance in this manual.

Parts	Interval
Check fuel injection nozzle (cleaning)	1500 hours
Check fuel injection nozzle (adjustment)	
Check fuel pump (adjustment)	3000 hours
Check turbocharger (adjustment)	

These must be performed to keep the emission values of the engine in the standard values during the warranty period. The warranty period is determined by the age of the engine or the number of hours of operation.

(Refer to the "Warranty statement" attached to the operation manual.)

Warranty period for exhaust emission related parts.

4JH4-TE	Commercial application	5 years or 5,000 hrs, whichever comes first
4JH4-HTE	Recreational application	5 years or 2,000 hrs, whichever comes first

2. Inspection and adjustment

2.1 Periodic maintenance schedule

The engine periodic inspection timing is hard to determine as it varies with the application, load status, qualities of the fuel and lubricating oils used and handling status. General rules are described here.

○ : User-maintenance ○ : Parts replacement ● : Shop-inspection

System	Item		Before starting	* ² Initial 50hrs. or one month	* ² Every 50hrs. or one month	* ² Every 250 hrs. or one year	* ² Every 500 hrs. or 2 years	* ² Every 1000 hrs. or 4 years
Whole	Visual inspection of engine outside		○					
Fuel system	Check the fuel level, and refill		○					
	Drain the fuel tank			○		○		
	Drain the fuel/water separator				○			
	Replace the fuel filter					○		
	Check the injection timing							●
	Check the injection spray condition							●* ¹
Lubricating system	Check the lube oil level	Crankcase	○					
		Marine gear	○					
	Replace the lube oil	Crankcase		○		○		
		Marine gear		○		○		
	Replace the lube oil filter.	Engine		○		○		
		Marine gear		○		○		
Cooling system	Seawater outlet		○ (During operation)					
	Check coolant level		○					
	Check the impeller of the seawater pump					○		○
	Replace the fresh water		Every year When long life coolant of the specified type is used, the replacement period of two years can be obtained.					
	Clean and check the water passages							●
						●*		
Air intake and exhaust system	Wash turbocharger blower					●*		
	Clean the exhaust/water mixing elbow					○	○	
	Clean air cleaner					○		
	Diaphragm assembly inspection							●

○ : User-maintenance ○ : Parts replacement ● : Shop-inspection

System	Item	Before starting	* ² Initial 50hrs. or one month	* ² Every 50hrs. or one month	* ² Every 250 hrs. or one year	* ² Every 500 hrs. or 2 years	* ² Every 1000 hrs. or 4 years
Electrical system	Check the alarm lamps and devices	○					
	Check the electrolyte level in the battery			○			
	Adjust the tension of the alternator driving belt		○		○		○
	Check the wiring connectors				○		
Cylinder head, etc.	Check the leakage of water, lube oil and fuel.	○ (After starting)					
	Retighten all major nuts and bolts				●		
	Adjust intake/exhaust valve clearance		●				●
Remote control system, etc.	Check/adjust the remote control operation	○	○				●
	Adjust the propeller shaft alignment		●				●
	Replace rubberized hoses (for water and fuel)		Every two years or 2,000hrs of operation * ²				

*¹ For EPA requirements see also 1.6 in chapter 1.

*² Whichever comes first.

Inspection and maintenance for the EPA emission related parts.

Parts	Interval
Check fuel injection nozzle (cleaning)	1,500 hours
Check fuel injection nozzle (adjustment)	3,000 hours
Check fuel injection pump (adjustment)	
Check turbocharger (adjustment)	

2.2 Periodic inspection and maintenance procedure

2.2.1 Check before starting

Be sure to check the following points before starting an engine every day.

No.	Inspection item
(1)	Visual inspection of engine outside
(2)	Check the fuel level, and refill
(3)	Check the lube oil level (Crankcase/Marine gear)
(4)	Seawater outlet
(5)	Check cooling water level
(6)	Check the alarm lamps and devices
(7)	Check the leakage of water, lube oil and fuel.
(8)	Check/adjust the remote control operation

(1) Visual inspection of engine outside

If any problem is found, do not use before the engine repairs have been completed.

- Oil leakage from the lubrication system.
- Fuel leakage from the fuel system.
- Cooling water leakage from the cooling water system.
- Damaged parts.
- Loosened or lost bolts.
- Fuel, coolant tank rubber hoses, V belt cracked, loosened clamp.

(2) Check the fuel level, and refill

Check the remaining fuel oil level in the fuel tank and refuel the recommended fuel if necessary.

(3) Check the lube oil level (Crankcase/Marine gear)

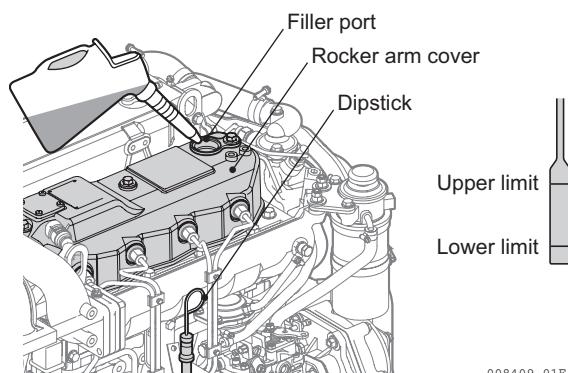
1) Checking engine lube oil level

- a) Check the lube oil level of a engine with a dipstick. Insert the dipstick fully and check the oil level. The oil shall not be contaminated heavily and have appropriate viscosity. No cooling water or diesel fuel shall be mixed.

Standard

The level shall be between the upper and lower limit lines on the dipstick.

- b) If the remaining engine oil level is low, fill the oil pan with the specified engine oil to the specified level through the filler port.



008409-01E

Engine model	Marine gear sail drive	Engine lube oil capacity L(quart)			Rake angle (deg.)
		Total	Oil pan only	Effective	
3JH4E	KM35P	5.0 ± 0.3 (5.3 ± 0.3)	4.5 ± 0.3 (4.8 ± 0.3)	1.1 (1.2)	8
	KM35A SD50 (SD40)	5.5 ± 0.3 (5.8 ± 0.3)	5.0 ± 0.3 (5.3 ± 0.3)	1.2 (1.3)	0
4JH4E	KM35P ZF30M	5.0 ± 0.3 (5.3 ± 0.3)	4.5 ± 0.3 (5.3 ± 0.3)	1.2 (1.3)	8
	KM35A2 KM4A1 SD50 (SD40)	5.5 ± 0.3 (5.8 ± 0.3)	5.0 ± 0.3 (5.3 ± 0.3)	1.4 (1.5)	0
4JH4-TE 4JH4-HTE	ZF30M	5.7 ± 0.3 (6.0 ± 0.3)	5.2 ± 0.3 (5.5 ± 0.3)	2.4 (2.5)	7
	KMH4A KM4A2 ZF25A SD50-4T (only 4JH4-TE)	6.9 ± 0.3 (7.3 ± 0.3)	6.4 ± 0.3 (6.8 ± 0.3)	2.4 (2.5)	0

[NOTICE]

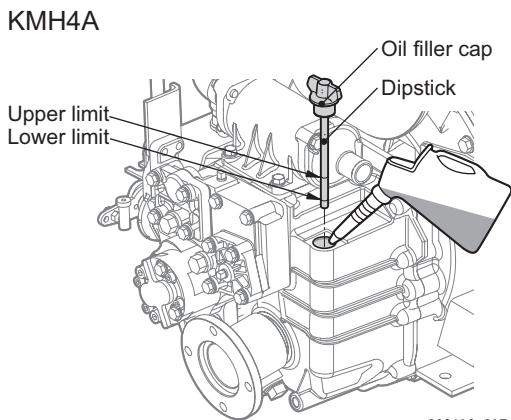
The engine oil should not be overfilled to exceed the upper limit line. If engine oil is overfilled, the engine may suck the engine oil in the combustion chamber during the operation, and white smoke, oil hummer or over speed rotation may occur, because the blowby gas is reduced in the suction air flow.

2) Checking marine gear lube oil level

- a) Check the lube oil level of the marine gear with a dipstick.

Unit: liter (pint)

Marine gear oil capacity	Full	Effect
KM35P	0.50 (1.1)	0.05 (0.11)
KM35A, KM35A2	0.65 (1.4)	0.15 (0.32)
ZF30M	1.1 (2.3)	0.2 (0.42)
KM4A1	1.3 (2.7)	0.2 (0.42)
KM4A2	2.0 (4.2)	0.2 (0.42)
KMH4A	2.0 (4.2)	0.2 (0.42)
ZF25A	1.8 (3.8)	-
SD40 old type	1.8 (3.8)	0.1 (0.21)
SD50	2.1 (4.4)	0.1 (0.21)
SD50-4T	2.1 (4.4)	0.1 (0.21)



- b) When the level is low, remove a filler port cap at the top of the housing, and fill it with marine gear-clutch-lube oil to the upper limit on the dipstick.

- c) Tighten the filler port cap securely by hand.

(4) Seawater outlet

Check whether seawater comes out just after the engine has started.

If seawater doesn't come out, shut down the engine immediately.

Check the leakage of seawater in the seawater pass and the damage of the seawater pump impeller.

(5) Check cooling water level

Daily inspection of cooling water should be done only by coolant recovery tank.

⚠ WARNING



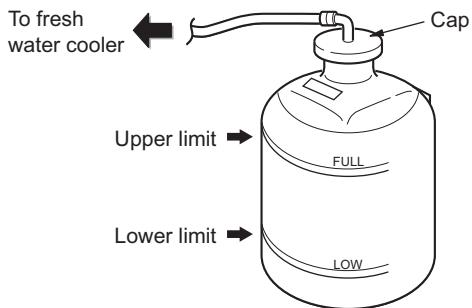
- Never open the filler cap while the engine is still hot. Steam and hot water will spurt out and seriously burn you. Wait until the engine is cooled down after the engine stopped, wrap the filler cap with a rag piece and turn the cap slowly to gently release the pressure inside the flesh water tank.
- Securely tighten the filler cap after checking the flesh water tank. If the cap is tightened loosely, steam can spurt out during operation.

1) Checking cooling water volume

Check the cooling water level in the coolant recovery tank. If the water level is close to the LOW mark, open the coolant recovery tank cap and replenish the coolant recovery tank with clean soft water to the FULL mark.

Standard

The water level of the coolant recovery tank shall be between the upper and lower limit lines.



2) Replenishing engine with water

If the cooling water leveling the coolant recovery tank is lower than the LOW mark, open the filler cap and check the cooling water level in the coolant tank. Replenish the engine with the cooling water, if the level is low.

- Check the cooling water level when the engine is cool.

Checking when the engine is hot is dangerous. And the water volume is expanded due to the temperature.

- Daily cooling water level check and replenishing shall be done only at the coolant recovery tank. Usually do not open the filler cap to check or replenish.

Standard

Cooling water volume

Unit: liter (quart)

Engine model	Engine	Coolant recovery tank
3JH4E	4.5 (4.8)	0.8 (0.8)
4JH4E	6.0 (6.3)	0.8 (0.8)
4JH4-TE/4JH4-HTe	7.2 (7.6)	0.8 (0.8)

IMPORTANT:

If the cooling water runs short quickly or when the coolant tank runs short of water with the coolant recovery tank level unchanged, water may be leaking or the air tightness may be lost. Increase in the water level of the coolant recovery tank during operation is not abnormal.

The increased water in the coolant recovery tank returns to the coolant tank when the engine is cooled down.

If the water level is normal in the coolant recovery tank but low in the coolant tank, check loosened clamping of the rubber hose between the coolant tank and coolant recovery tank or tear in the hose.

2. Inspection and adjustment

(6) Check the alarm lamps and devices

Before and after starting the engine, check to see that the alarm functions normally. Failure of alarm cannot warn the lack of the engine oil or the coolant. Make it a rule to check the alarm operation before and after starting engine every day.

When the sensor detects a problem during operation, the lamp comes on and the buzzer goes off.

Alarm lamps are located on the panel, buzzer is located on the back of panel.

Under normal conditions, the monitors are off. When there is a problem, the monitors light up.

	Battery low charge alarm	When the alternator output is too low, the lamp will come on. When charge begins, the lamp will turn off. (The alarm buzzer will not sound, when the lamp comes on.)
	Coolant high temperature alarm	When the temperature reaches the maximum (95°C [203F] or higher), the lamp will light. Continuing operation at temperatures exceeding the maximum limit will result in damage and seizure. Check the load and the fresh water cooling system for any abnormalities.
	Lubricating oil low pressure alarm	When the lubricating oil pressure falls below normal, the oil pressure sensor will register this and the lamp will come on and alarm will sound. Continuing operation with insufficient oil pressure will result in damage and seizure. Check the oil level.
	Water in sail drive seal alarm	When seawater is detected between the seals of sail drive, the lamp will come on and the alarm will sound.
	Water in fuel filter alarm (C type only)	This function is available only for 4JH4-TE and 4JH4-HTE.
	Seawater insufficient flow alarm (C type only)	This function is not available on this engine.

Normal action of alarm devices

Alarm devices act as shown below. Check that the alarm lamps and buzzer are working normally, when the key is turned on.

Key switch		OFF → ON	START → ON
Engine		Before start	Running
Alarm buzzer		Goes on	Stop
Alarm lamps	Battery low charge alarm	Light	Off
	Coolant high temperature alarm	Off	Off
	Lubricating oil low pressure alarm	Light	Off
	Water in sail drive seal alarm	Off	Off

- (7) Check the leakage of water, lube oil and fuel.

Before and after starting the engine, check the leakage of coolant and seawater from coolant system. Also check the leakage of lube oil and fuel.

- (8) Check/adjust the remote control operation

Make sure that the accelerator of a boat can be operated smoothly before starting the engine. If it feels heavy to manipulate, lubricate the accelerator cable joints and pivots. Adjust the accelerator cable if there is a dislocation or excessive play between the accelerator and the governor lever.

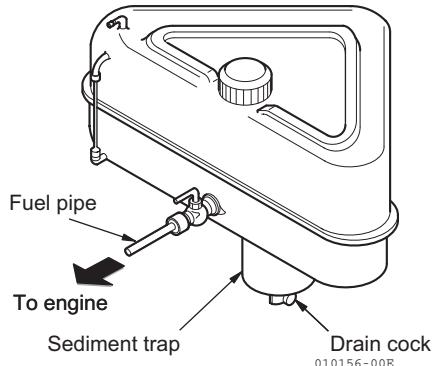
2.2.2 Inspection after initial 50 hours or one month operation

Be sure to check the following points after initial 50 hours or one month operation, whichever comes first.

No.	Inspection item
(1)	Drain the fuel tank.
(2)	Replace the engine lube oil and the lube oil filter.
(3)	Replace the marine gear lube oil and the lube oil filter.
(4)	Adjust the tension of the alternator driving belt.
(5)	Adjust the intake/exhaust valve clearance.
(6)	Check/adjust the remote control operation.
(7)	Adjust the propeller shaft alignment.

(1) Drain the fuel tank

- 1) Put a pan under the drain cock to catch the fuel.
- 2) Open the drain cock and drain off any water or dirt collected.
- 3) When the water and dirt are drained off and the fuel comes out, close the drain cock.



(2) Replace the engine lube oil and the lube oil filter.

During the operation of an engine, the oil is quickly contaminated due to the initial wear of internal parts. The lube oil must therefore be replaced early. It is easiest and most effective to drain the engine lubricating oil after operation while the engine is still warm.

Replace the lube oil filter at the same time.

CAUTION

Beware of oil splashes if extracting the lube oil while it is hot.

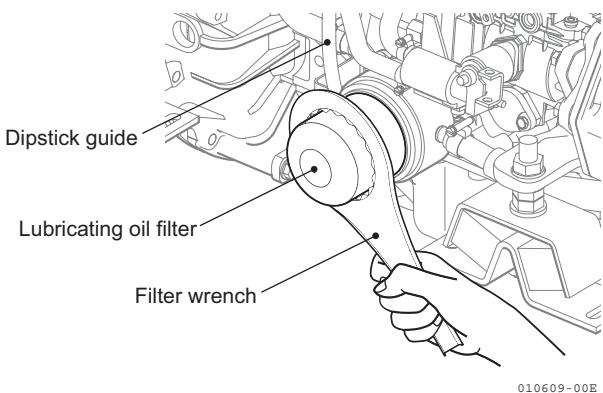
- 1) Remove the lubricating oil dipstick and also the oil filler cap at the top of the rocker arm cover. Attach the oil drain pump to the dipstick guide and drain off the lube oil.

[NOTICE]

For easier draining, remove the oil filler cap (yellow) at the top of the rocker arm cover. When lubricating oil is absorbed without removing a oil filler cap, negative pressure grows big in the crankcase and it may cause the rubber of the diaphragm cracked.

- 2) Turn the lubricating oil filter counter-clockwise using a filter wrench to remove it.
- 3) Moisten the new oil filter gasket with the engine oil and install the new engine oil filter manually turning it clockwise until it comes into contact with the mounting surface, and tighten it further to 3/4 of a turn with the filter wrench.

Tightening torque: 20-24Nm (177-212 lb-in)



Applicable oil filter Part No.
119305-35150

- 4) Fill with new lubricating oil. Refer to 2.2.1(3) for the standard of the engine lube oil capacity.
- 5) Perform a trial run of the engine and check the oil leakage.
- 6) Approximately 10 minutes after stopping the engine, check the oil level by using the oil dipstick. Add oil if the level is too low.

[NOTICE]

When checking the oil level right after the engine running, the oil level in the dipstick guide decreases drastically, and the accurate oil measurement can't be performed because the pressure in the cylinder block decreases with the function of the diaphragm in the rocker arm cover. Therefore, measure the lube oil level after removing the oil filler cap or about 10 minutes later after stopping the engine.

(3) Replace the marine gear lube oil and the lube oil filter.

During initial operation, the oil is quickly contaminated due to the initial wear of internal parts. The lube oil must therefore be replaced early.

- 1) Remove the cap from the filler port and attach the oil drain pump. Drain off the oil.
- 2) Remove the marine gear lube oil filter (only for KMH4A) and wash the lube oil filter.
 - a) Remove the side cover and then remove the filter inside the cover.
 - b) Clean the filter thoroughly with kerosene.
 - c) Hold the filter in place with the coil spring and insert them into the case. Fit an O-ring to the side cover and reattach the side cover. Tighten the side cover bolts.
- 3) Fill with new lube oil. Refer to 2.2.1(3) for the standard of the marine gear lube oil capacity.
- 4) Perform a trial run of the engine and check the oil leakage.

(4) Adjust the tension of the alternator drive belt

When there is not enough tension in the V-belt, it will slip and the cooling water pump will fail to supply cooling water. Engine overheating and the seizure will occur.

When there is too much tension in the V-belt, the belt will become damaged more quickly and the bearing of the cooling water pump may be damaged.

Check and adjust the V-belt tension (deflection) in the following manner.

[NOTICE]

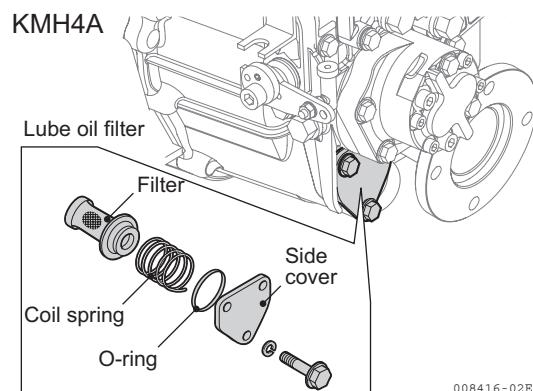
Be especially careful not to splash engine oil on the V-belt, because it will cause slipping, stretching and aging of the belt.

- 1) Remove the belt cover. Check the tension of the V-belt by pressing down on the middle of the belt with your finger [approx. 98N (10kgf)].

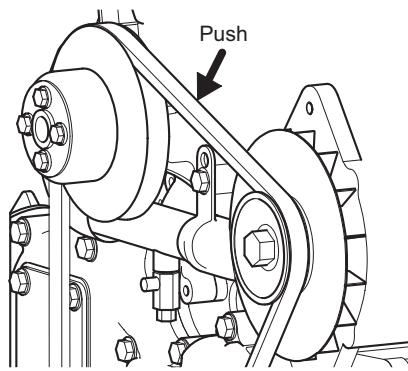
The specified deflection should be as follows.

For used V-belt	8-10 mm (0.315-0.393 inches)
For new V-belt	6-8 mm (0.236-0.315 inches)

- "New V-belt" refers to a V-belt which has been used less than 5 minutes on a running engine.
- "Used V-belt" refers to a V-belt which has been used on a running engine for 5 minutes or more.



008416-02E



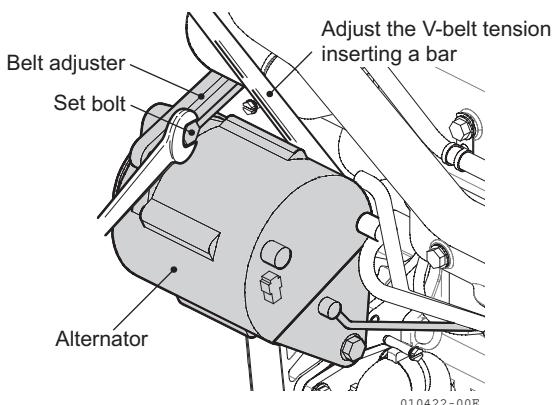
008436-01E

- 2) If necessary, adjust the V-belt tension (deflection). To adjust the V-belt tension, loosen the set bolt for the belt adjuster and move the alternator to tighten the V-belt.
- 3) Visually check the V-belt for cracks, oiliness or wear. If any, replace the V-belt with new one.

[NOTICE]

When the V-belt will be replaced with new one, loosen the set bolt and move the alternator and also loosen the V-pulley set bolts for the cooling water pump. Remove the V-belt.

After replacing with a new V-belt and adjusting the tension, run the engine for 5 minutes and readjust the deflection to the value in the table above.



(5) Checking and adjusting intake/exhaust valve clearance.

Measure and adjust while the engine is cold.

Valve clearance is defined as follows:

- 2 valves system (3JH4E, 4JH4E): gap between valve cap and rocker arm.
- 4 valves system (4JH4-TE, 4JH4-HTE): gap between valve bridge and rocker arm.

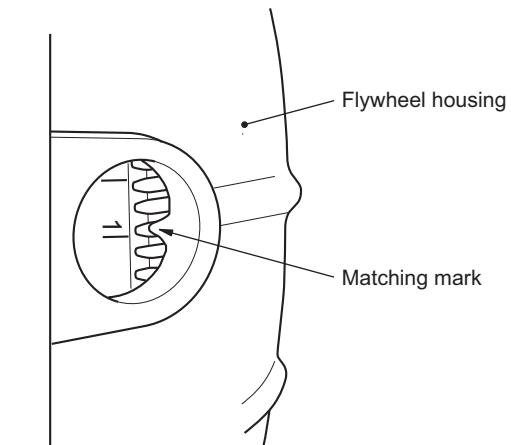
On both systems, clearance can be adjusted by the screw on the rocker arm.

1) Valve clearance measurement

- a) Remove the rocker arm cover above cylinder head.
- b) Set the No.1 cylinder (Flywheel side) in the compression Top Dead Center (TDC).

Turn the crankshaft to bring the piston of the No.1 cylinder to its compression top dead center while watching the rocker arm motion, the timing mark of the flywheel housing and the top mark of the flywheel.

(Position where both the intake and exhaust valves are closed, no movement of both intake and exhaust rocker arms.)



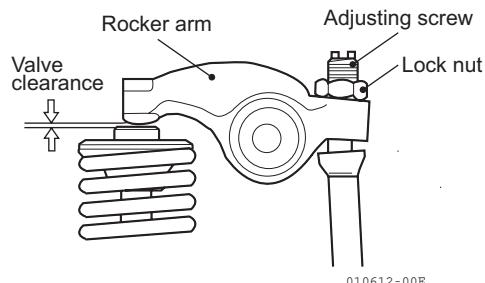
Notes:

- The crankshaft shall be turned clockwise as seen from the gear case side.
- The cylinder number is counted from flywheel side. At compression TDC, intake and exhaust valves should have clearance, which can be checked by hand. Also see that the top mark on the flywheel aligns with the mark on the flywheel housing. If there is no valve clearance, remove cylinder head and inspect the valve seat, since the valve seat may be worn abnormally.

2. Inspection and adjustment

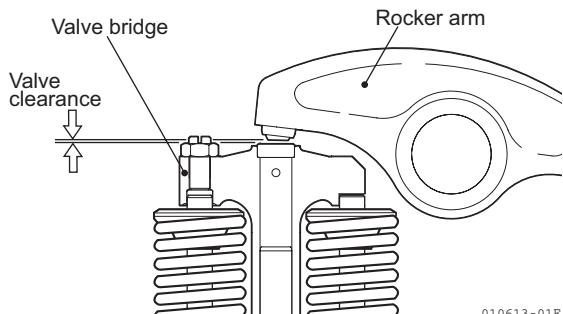
- c) Valve clearance measurement and adjustment
- (c-1) For 2 valves system (3JH4E, 4JH4E), insert a thickness gage between the rocker arm and valve cap, and record the measured valve clearance.

2-valve head



- (c-2) For 4 valves system (4JH4-TE, 4JH4-HTE), insert a thickness gage between the rocker arm and the valve bridge, and record the measured valve clearance.

4-valve head



- d) Measuring other cylinders

(d-1) 3JH4E

Turn the crankshaft 240° and make measurement and adjustment for the No.3 cylinder. Then adjust the No.2 cylinder.

The cylinder to be measured and adjusted first does not have to be the No.1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make measurement and adjustment for other cylinders in the order of ignition by turning the crankshaft 240° each time.

The measurement and adjustment method of reducing the flywheel turning numbers (for reference):

Set No.1 cylinder to the compression T.D.C. and adjust the clearance of the ● mark of the below table. Next, turn the flywheel once (the suction/exhaust valve of No.1 cylinder is in the position of the overlap T.D.C. at this time), and adjust the clearance of the ○ mark.

Ignition order of 3 cylinder engines: 1 → 3 → 2

Cylinder No.	1		2		3	
Valve	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust
No.1 compression T.D.C	●	●	●			●
No.1 overlap T.D.C				○	○	

The first time
The second time

(d-2) 4JH4E/ 4JH4-TE/ 4JH4-HTE

Turn the crankshaft 180° and make measurement and adjustment for the No.3 cylinder. Then adjust the No.4 and No.2 cylinders according to the order of injection. The cylinder to be adjusted first does not have to be the No.1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make adjustment for other cylinders in the order of ignition by turning the crankshaft 180° each time.

The measurement and adjustment method of reducing the flywheel turning numbers (for reference):

Set No.1 cylinder to the compression T.D.C. and adjust the clearance of the ● mark of the bottom table. Next, turn the flywheel once, and adjust the clearance of the ○ mark.

Ignition order of 4 cylinder engines: 1 → 3 → 4 → 2

Cylinder No.	1		2		3		4	
Valve	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust
No.1 compression T.D.C	●	●	●			●		
No.4 compression T.D.C				○	○		○	○

The first time
The second time

2) Valve clearance adjustment - 2 valves system

a) Loosen adjusting bolts

Loosen the lock nut and adjusting screw, and check the valve for any inclination of valve cap, entrance of dirt or wear.

b) Valve clearance adjustment

- Insert a 0.2 mm thickness feeler gauge between the rocker arm and valve cap.
- Adjust the valve clearance by turning the adjustment screw until there is a slight "drag" on the feeler gauge when sliding it between the rocker arm and the valve cap.

Standard intake/exhaust valve clearance (mm)
--

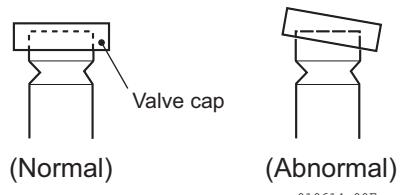
0.15-0.25

- Tighten the lock nut.
- Apply oil to the contact surface between adjusting screw and push rod.

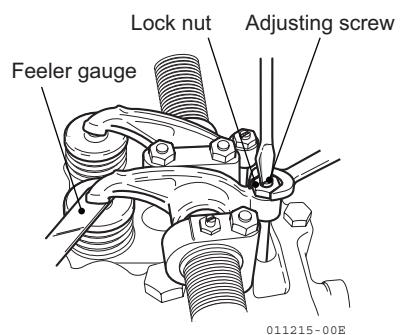
c) Adjusting other cylinders

See adjustment method for other cylinders on page 64.

2 valve cylinder head



010614-00E



011215-00E

2. Inspection and adjustment

3) Valve clearance adjustment - 4 valves system

a) Loosen adjusting bolts

The 4-valve cylinder head has a valve bridge.

Remove the injector to make space for inserting a wrench in order to hold valve bridge.

IMPORTANT

Do not loosen or tighten the valve bridge adjusting screw lock nut without holding the valve bridge. Always hold the valve bridge using a wrench to prevent bending of the valve stems and/or valve bridge guide.

- Loosen the bridge adjusting screw lock nut while holding the bridge with a wrench.
- Loosen the adjusting screw by turning it 2 turns outside.
- Check for visible clearance between screw and valve.

b) Adjust valve bridge clearance

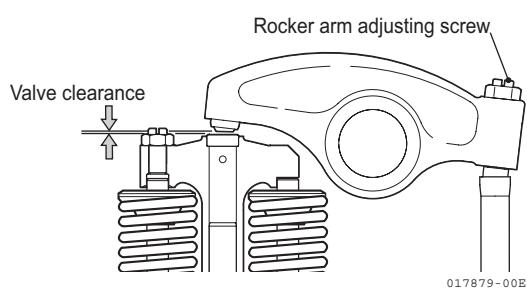
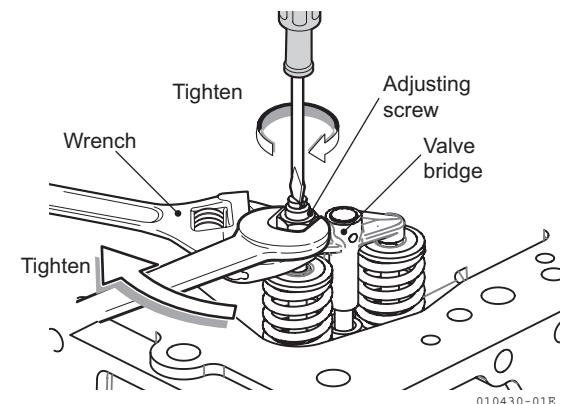
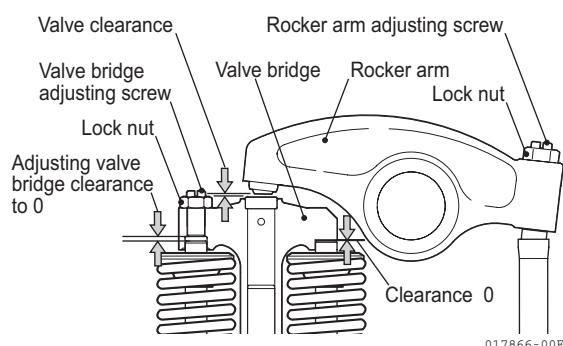
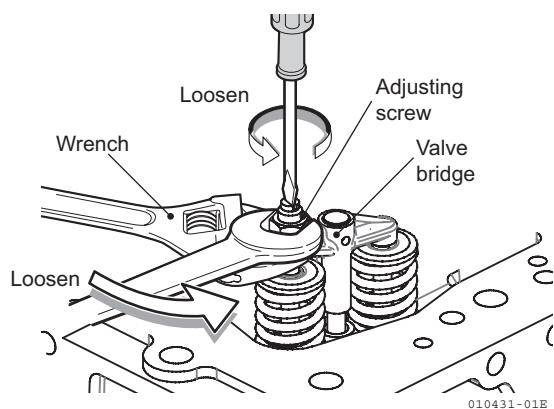
[NOTICE]

- The valve bridge on the 4-valve system enables one rocker arm to operate two valves at the same time. Therefore the valve bridge should be adjusted exactly in horizontal position.
- The clearance between the valve bridge and valves must be set before adjusting the valve clearance (between rocker arm and valve bridge).
- To assure the valve bridge has equal contact with the front and rear valves, apply light pressure (hold) by rocker arm (screw in rocker arm adjusting screw until rocker arm touches the valve bridge).
- Adjust the valve bridge adjusting screw, so there is zero "0" clearance between the adjustment screw and the front valve.
- Tighten the locknut, while holding the valve bridge with a wrench. Verify that the valve bridge clearance is zero "0".

c) Valve clearance adjustment

- Insert a 0.2 mm thickness feeler gauge between the rocker arm and valve bridge.
- Adjust the valve clearance by turning the adjustment screw until there is a slight "drag" on the feeler gauge when sliding it between the rocker arm and the valve bridge.

4 valve cylinder head



Standard intake/exhaust valve clearance (mm)
--

0.15-0.25

- Tighten the lock nut.
- Apply oil to the contact surface between adjusting screw and push rod.

d) Adjusting other cylinders

See adjustment method for other cylinders on page 64.

(6) Check and adjust the remote control operation

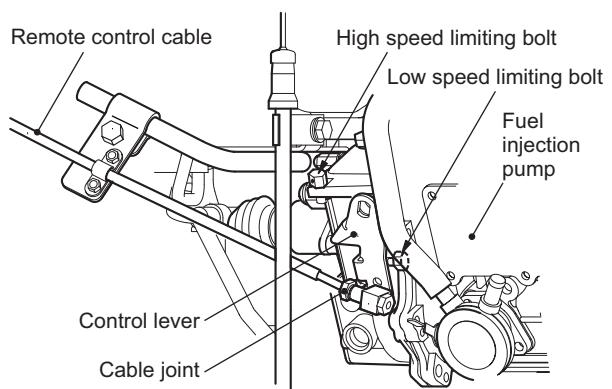
The various control levers on the engine side are connected to the remote control lever by the remote control cable. The cable will become stretched and the attachments loose after long hours of use causing deviation. It is dangerous to control operation under these conditions, and the remote control cable must be checked and adjusted periodically.

1) Adjusting the throttle remote control cable

Check to see that the control lever on the engine side moves to the high speed stop position and low speed stop position when the remote control lever is moved to H (high speed) and L (low speed) respectively.

When there is deviation, loosen the bracket for the remote control cable on the engine side and adjust.

Adjust the high speed stop position first and then adjust the low speed idling by the adjustment bolt on the remote control lever.

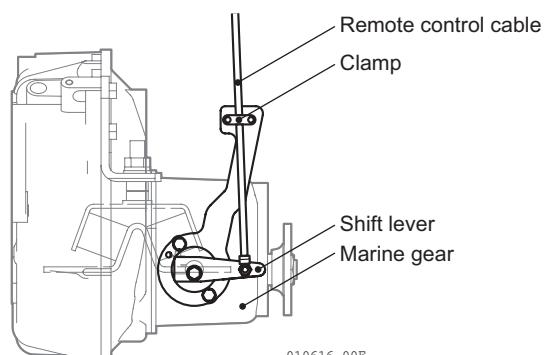

! CAUTION

Never adjust the high speed limiting bolt. This will void warranty.

2) Adjusting the marine gear remote control cable

Check that the shift lever moves to the correct position, when the remote control handle is put in NEUTRAL, FORWARD and REVERSE position.

Use the NEUTRAL position as the standard for adjustment. When there is deviation, loosen the clamp for the remote control cable and adjust the shift lever position.



(7) Adjust the propeller shaft alignment

The flexible engine mounts is compressed a little in the initial engine operation and it may cause the centering misalignment between the engine and the propeller shaft.

- 1) Check unusual noise and vibration of the engine/boat hull, while increasing the engine speed gradually and lowering it.
- 2) If there is unusual noise and/or vibration, adjust the propeller shaft alignment. (Refer to Part I, 6.4.5 "Centering the engine" in the installation manual for pleasure boat use.)

2.2.3 Inspection every 50 hours or monthly

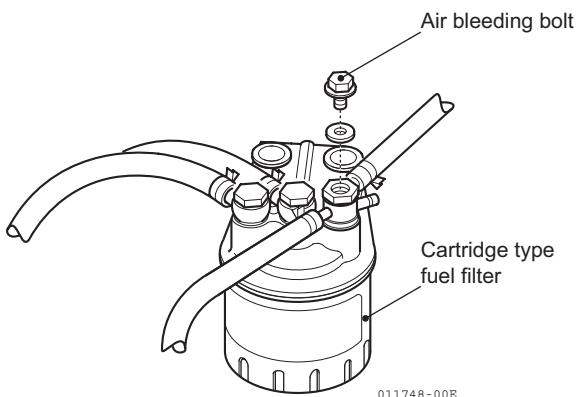
Be sure to check the following points every 50 hours or monthly, whichever comes first.

No.	Inspection item
(1)	Drain the fuel filter.
(2)	Check the electrolyte level in the battery

(1) Drain the fuel filter

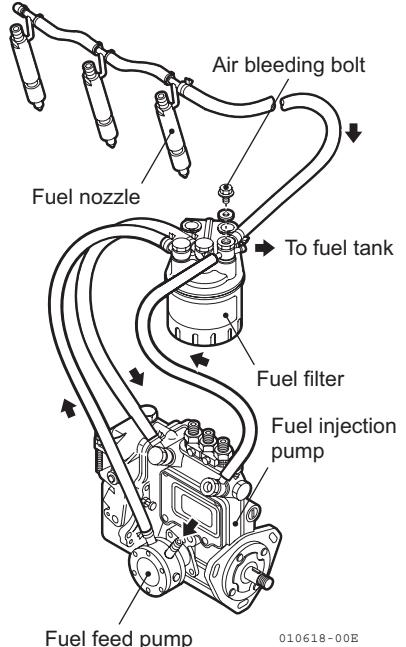
[3JH4E and 4JH4E]

- 1) Close the fuel cock of the fuel tank.
- 2) Loosen the cartridge type fuel filter by a filter wrench. Drain off any water and dirt collected inside.
- 3) After reassembly, be sure to bleed air from the fuel system.



Fuel system air bleeding procedures

- 1) Check the fuel level in the fuel tank. Replenish if insufficient.
- 2) Loosen the air bleeding bolt at the top of the fuel/water separator by turning it 2 or 3 turns. When fuel, which does not contain air bubbles, comes out of the bolt hole, tighten the air bleeding bolt.
- 3) Loosen the air bleeding bolt of the fuel filter by turning it 2 or 3 turns.
- 4) Feed fuel with the fuel feed pump by moving the lever on the left side of the feed pump up and down.
- 5) Allow the fuel containing air bubbles to flow out from the air bleeding bolt hole. When the fuel no longer contains bubbles, tighten the air bleeding bolt. This completes the air bleeding of the fuel system.
- 6) After the engine start-up, the automatic air bleeding device works to purge the air in the fuel system. No manual air-venting is required for normal engine operation.



2. Inspection and adjustment

[4JH4-TE and 4JH4-HTE]

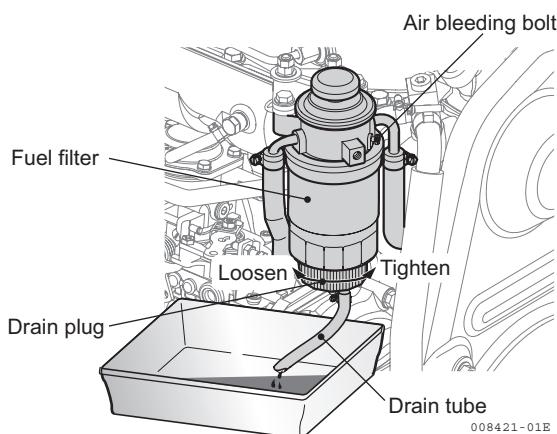
When water and dirt are mixed in with the fuel, it becomes impossible for the fuel injection pump and the fuel injection valve to work. Drain periodically to keep the filter from becoming clogged. If no water or fuel drains from the fuel / water separator, loosen the air bleeding bolt on the fuel / water separator 2 - 3 times. This occurs when the fuel level in the fuel tank is lower than the position of the fuel / water separator.

- 1) Make sure the fuel cock of the fuel tank is closed.
- 2) Loosen the hose clamp and remove the fire-resistant cover, which is installed to the lower part of the fuel filter / water separator to protect the water alarm switch.
- 3) Attach a drain tube to the drain plug.
- 4) Loosen the drain plug at the bottom of the fuel filter / water separator counterclockwise and drain off any water or dirt.

Note:

If there is a large quantity of water and sediment in the fuel / water separator, also drain the fuel tank.

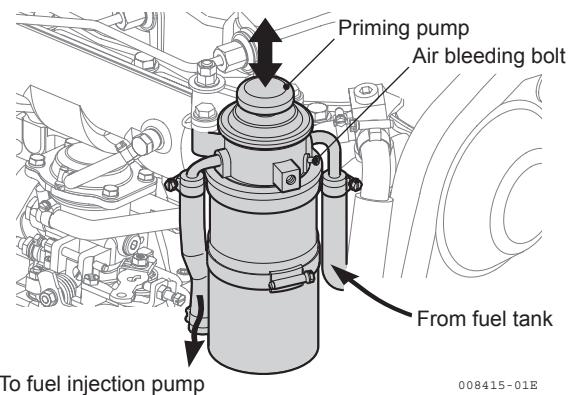
- 5) Tighten the drain plug.
- 6) Remove the drain tube.
- 7) Install the fire-resistant cover and tighten the hose clamp.
- 8) Bleed air from the fuel system.
When there is a heavy deposit, drain the fuel tank at the same time.



Fuel system air bleeding procedures

- 1) Check the fuel level in the fuel tank.
Replenish if Insufficient.
- 2) Open the fuel cock of the fuel tank.
- 3) Loosen the air bleeding bolt on the top of the fuel filter by turning it 2-3 times with a minus driver.
- 4) Feed the fuel with the priming pump. The priming pump is on the top of the fuel filter. Move the priming pump knob up and down until fuel mixed with air bubbles flows out of the air bleeding bolt.
- 5) Allow the fuel containing air bubbles to flow.
When the fuel coming out is clear and not mixed with any bubbles, tighten the air bleeding bolt.

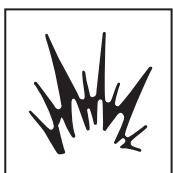
In subsequent engine operation after the start-up, the automatic air-bleeding device works to purge the air in the fuel system. No manual air bleeding is required for normal engine operation.



(2) Check the electrolyte level in the battery

⚠ WARNING**Fire due to electric short-circuit**

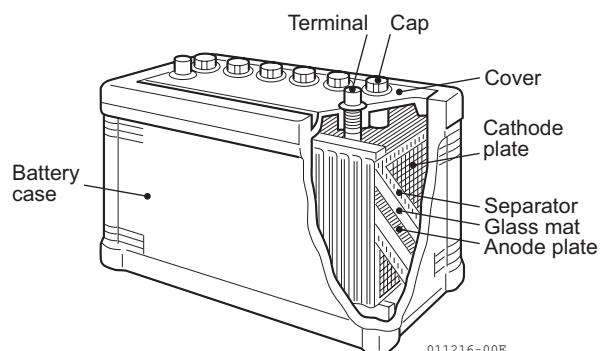
- Make sure to turn off the battery switch or disconnect the negative cable (-) before inspecting the electrical system. Failure to do so could cause short-circuiting and fires.
- Always disconnect the (-) Negative battery cable first before disconnecting the battery cables from battery. An accidental "Short circuit" may cause damage, fire and or personal injury.
And remember to connect the (-) Negative battery cable (back onto the battery) LAST.

**Proper ventilation of the battery area**

Keep the area around the battery well ventilated, paying attention to keep away any fire source. During operation or charging, hydrogen gas is generated from the battery and can be easily ignited.

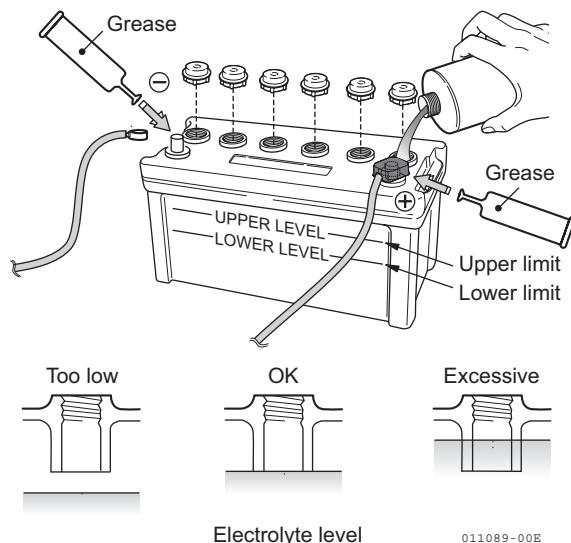
**Do not come in contact with battery electrolyte**

Pay sufficient attention to avoid your eyes or skin from being in contact with the fluid. The battery electrolyte is dilute sulfuric acid and causes burns. Wash it off immediately with a large amount of fresh water if you get any on you.

Battery structure

(1) Electrolyte level

- Check the level of fluid in the battery.
- When the amount of fluid nears the lower limit, fill with battery fluid (available in the market) to the upper limit. If operation continues with insufficient battery fluid, the battery life is shortened, and the battery may overheat and explode.
- Battery fluid tends to evaporate more quickly in the summer, and the fluid level should be checked earlier than the specified times.
 - If the engine cranking speed is so slow that the engine does not start up, recharge the battery.
 - If the engine still will not start after charging, replace the battery.
 - Remove the battery from the battery mounting of the machine unit after daily use if letting the machine unit leave in the place that the ambient temperature could drop at -15°C or less. And store the battery in a warm place until the next use the unit to start the engine easily at low ambient temperature.



(2) Battery charge

Use a battery tester or hydrometer and check the battery condition. If the battery is discharged, recharge it.

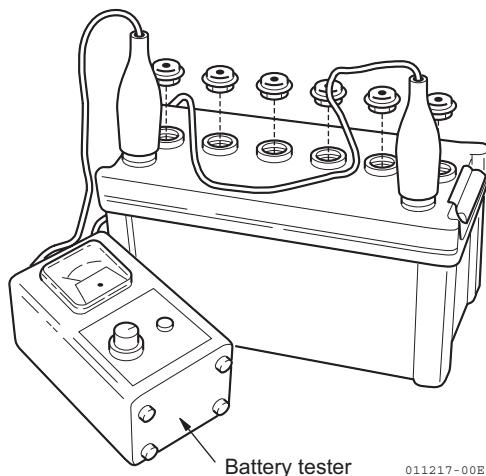
(a) Measurement with a battery tester

When checking the battery with the battery tester, connect the red clip of the tester to the battery positive (+) terminal and black clip to the battery negative (-) terminal by pinching them securely, and judge the battery charge level from the indicator position.

Green zone: Normal

Yellow zone: Slightly discharged

Red zone: Defective or much discharged



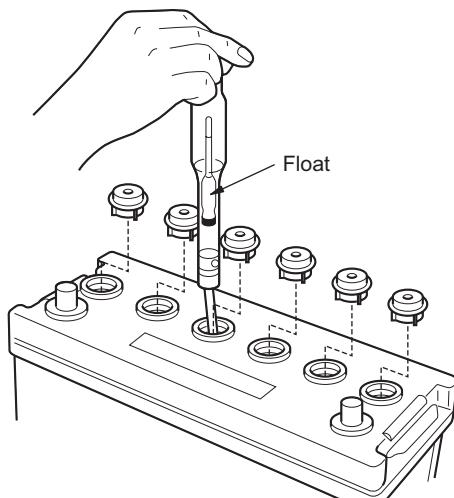
(b) Measurement with hydrometer

When using a hydrometer, the measured specific gravity must be corrected according to the temperature at the time of measurement. The specific gravity of battery electrolyte is defined with 20°C as the standard. Since the specific gravity increases or decreases by 0.0007 when the temperature varies by 1°C, correct the value according to the equation below.

$$S_{20} = S_t + 0.007 (t - 20)$$

└── Electrolyte temperature
 at measurement
 └── Specific gravity at measurement
 └── Converted specific gravity at 20°C

001348-01E



011218-00E

Specific gravity and remaining battery charge

Specific gravity (20°C)	Discharged quantity of electricity (%)	Remaining charge (%)
1.28	0	100
1.26	10	90
1.24	20	80
1.23	25	75

(3) Terminals

Clean if corroded or soiled.

(4) Mounting bracket

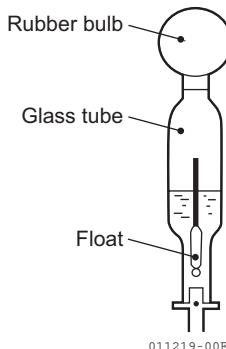
Repair or replace it if corroded.

Retighten if loosened.

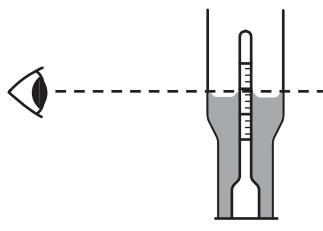
(5) Battery appearance

Replace the battery if cracked or deformed.

Clean with fresh water if contaminated.

Hydrometer structure

011219-00E

How to read hydrometer

011220-00X

2.2.4 Inspection every 250 hours or one year

Be sure to check the following points every 250 hours or one year operation, whichever comes first.

No.	Inspection item
(1)	Drain the fuel tank
(2)	Replace the fuel filter
(3)	Replace the engine lube oil and the lube oil filter.
(4)	Replace the marine gear lube oil and the lube oil filter.
(5)	Check the impeller of the seawater pump
(6)	Replace the fresh water
(7)	Wash turbocharger blower
(8)	Clean the exhaust/water mixing elbow
(9)	Clean air cleaner
(10)	Adjust the tension of the alternator driving belt
(11)	Retighten all major nuts and bolts
(12)	Check the wiring connectors

(1) Drain the fuel tank

Refer to 2.2.2(1) for the procedure.

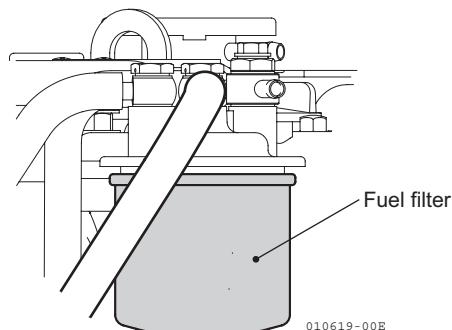
(2) Replace the fuel filter

[3JH4E and 4JH4E]

Replace the fuel filter with new one at the specified interval, before it is clogged with dust to adversely affect the fuel flow. Also, replace the fuel filter after the engine has fully been cooled.

- 1) Close the fuel cock of the fuel tank.
- 2) Remove the fuel filter using a filter wrench (customer procured). When removing the fuel filter, hold the bottom of the fuel filter with a piece of rag to prevent the fuel oil from dropping.
- 3) Clean the filter mounting surface and slightly apply fuel oil to the gasket of the new fuel filter.
- 4) Install the new fuel filter manually turning until it comes into contact with the mounting surface, and tighten it further to one turn using a filter wrench.

Tightening torque: 20-24Nm



Applicable fuel filter Part No.
129470-55703

- 5) Bleed the fuel system. Refer to 2.2.3.(1).

IMPORTANT:

Be sure to use genuine Yanmar part (super fine mesh filter). Otherwise, it results in engine damage, uneven engine performance and shorten engine life.

[4JH4-TE and 4JH4-HTE]

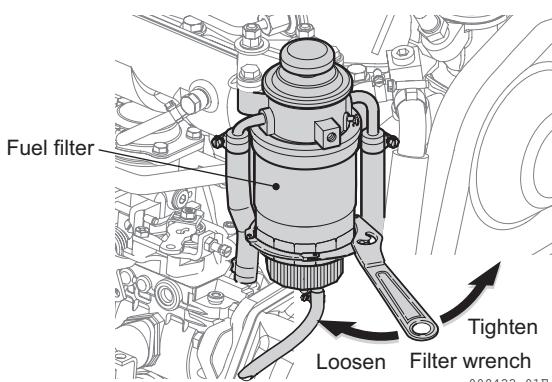
Replace the fuel filter periodically before there is clogging and the fuel flow is reduced.

- 1) Close the fuel cock of the fuel tank.
- 2) Drain the fuel from the fuel drain cock at the bottom of the fuel filter.
- 3) Remove the connectors of the wiring and remove the alarm switch using spanner.
- 4) Remove the fuel filter using the filter wrench.
- 5) Clean the fuel filter mounting face.
- 6) Replace the fuel filter with new one. Tighten the new fuel filter.

Part No. of the fuel filter: 129574-55800

- Install the alarm switch to the new fuel filter.
- Apply fuel oil to the gasket of the new fuel filter.
- Lightly screw in the fuel filter in position and tighten it by hand until the gasket comes into contact with the seat. After tightening by hand, use the filter wrench to tighten it about 3/4 of a turn.

[Tightening torque: 11.8-15.6Nm
(1.2-1.6kgf·m)]



- 7) Bleed the fuel system.

Refer to 2.2.3(1) for the air bleeding procedure.

- If you spill fuel, wipe spillage carefully.
- Start the engine to check for fuel leakage.

- (3) Replace the engine lube oil and the lube oil filter.

Refer to 2.2.2(2) for the procedure.

- (4) Replace the marine gear lube oil and the lube oil filter.

Refer to 2.2.2(3) for the procedure.

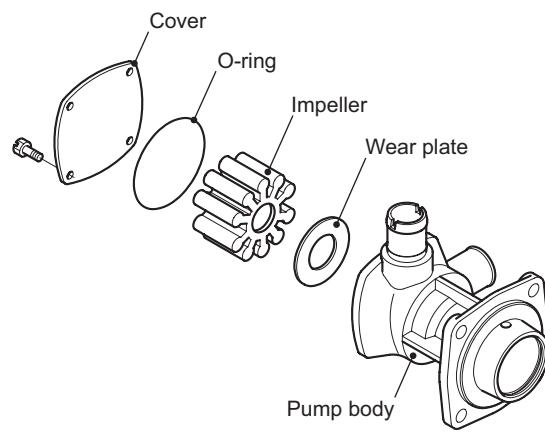
2. Inspection and adjustment

(5) Check the impeller of the seawater pump.

- 1) Remove the seawater pump cover and take out the O-ring, impeller and wear plate.
- 2) Inspect the rubber impeller, checking for splitting around the outside, damage or cracks, and replace if necessary.

Depending on the use, the inside parts of a seawater pump may deteriorate and the discharge performance may drop. At the specified interval or when the discharge volume of seawater is reduced, inspect the seawater pump in accordance with the following procedures.

- 1) Loosen the seawater pump cover set bolts and remove the side cover.
- 2) Illuminate the inside of the seawater pump with a flashlight and inspect.
- 3) If no damage is found, reassemble the cover.
- 4) If any of the following problems are found, take out the O-ring, impeller and wear plate. If necessary, replace with new one and reassemble the side cover.
 - Impeller blades are cracked or nicked. Edges or surfaces of the blades are marred or scratched.



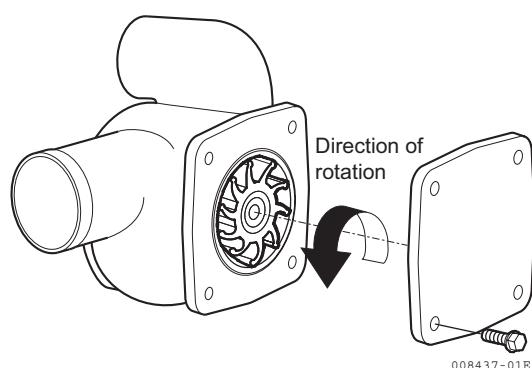
Note:

The impeller must be replaced periodically (every 1000 hrs or four years whichever comes first).

- Wear plate is damaged.
- 5) If a large amount of water leaks continuously from the water drain pipe beneath the seawater pump during engine operation, check the lip seal inside the seawater pump.

NOTICE

The seawater pump turns in the counterclockwise direction, but the impeller must be installed by turning in the clockwise direction. If the impeller has been removed for any reason and must be reassembled, be very careful not to make a mistake and turn it in the wrong direction. Additionally, if the engine is being turned manually, be careful to turn it in the correct direction. Incorrect turning will twist the impeller blades and damage it.



Removing the impeller

There are two kinds of special service tool for removing impeller:

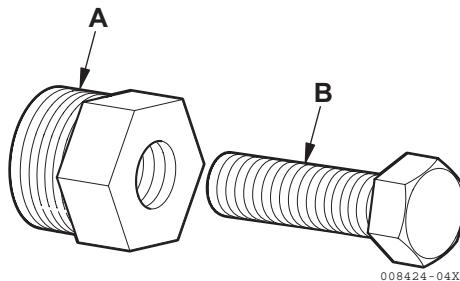
Puller A (Standard) 129671-92110

A	B
M18 x 1.5	M10-length 40mm

- 1) Remove the side cover of seawater pump.
- 2) Screw the puller A to the impeller.
- 3) Turn the M10 bolt of the puller clockwise and the impeller will come out of pump body.

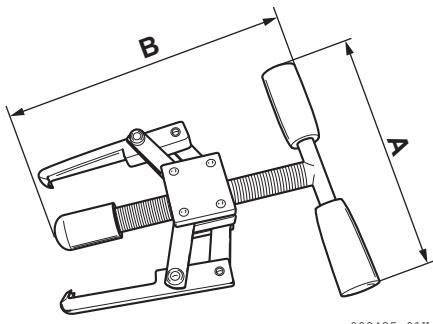
Note:

When replacing a used impeller with new one, purchase an impeller with M18 thread. Turn the M18 screw side of the impeller to the cover side, and install it.



Puller B (Option) 129671-92100 (mm)

A	B
around 110	around 140



(6) Replace the fresh water

Be sure to replace the fresh water every year. When the Long Life Coolant Antifreeze (LLC) is used of the specified type, the replacement period of two years can be obtained.

Use clean soft water and be sure to add the Long Life Coolant Antifreeze (LLC) to the cooling water in order to prevent rust built up and freezing.

Cooling performance drops when coolant is contaminated with rust and scale.

Even if antifreeze or antirust is added, the coolant must be replaced periodically because the properties of the agent will degenerate.

- 1) Open the cocks for fresh water and extract the fresh water.

Note:

One drain cock is behind the belt cover only for 3JH4E and 4JH4E. Remove the belt cover and open the cock.

2. Inspection and adjustment

2) Close the cocks for fresh water.

Model	Drain cocks in fresh water line	Drain cocks in seawater line
3JH4E	3 cocks	2 places (1 cock and a side cover of seawater pump)
4JH4E/4JH4-TE	2 cocks	2 places (a side cover of seawater pump and 1 cock on clutch cooler) Note1
4JH4-HTE	3 cocks	3 places (a side cover of seawater pump and 2 cocks on clutch cooler and intercooler) Note1

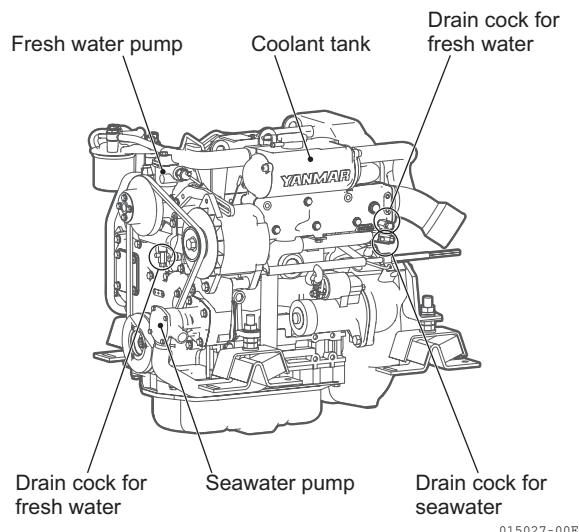
Note1:

The marine gear boxes with a drain cock of clutch cooler are as follows;

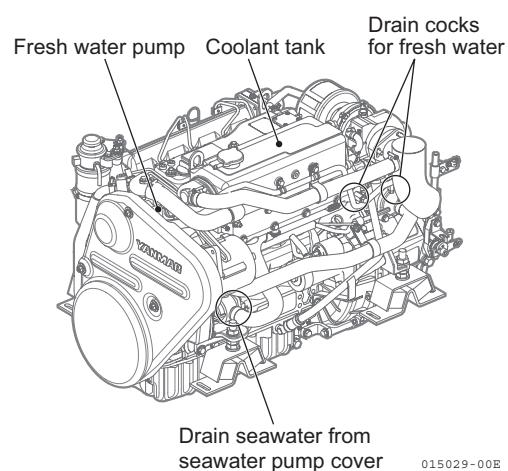
4JH4E: ZF30M, KM4A1

4JH4-TE and 4JH4-HTE: ZF30M, KM4A2, KMH4A

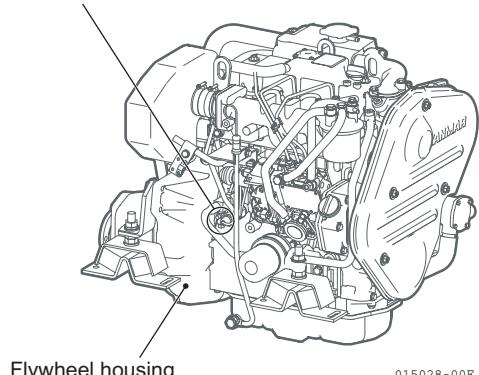
3JH4E



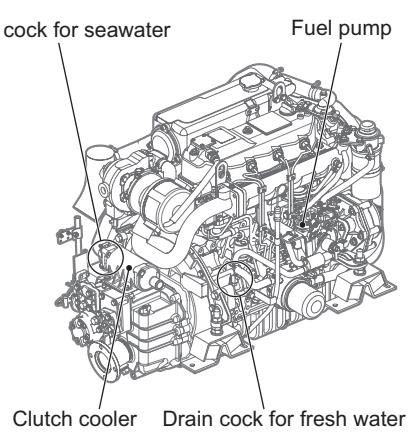
4JH4-TE



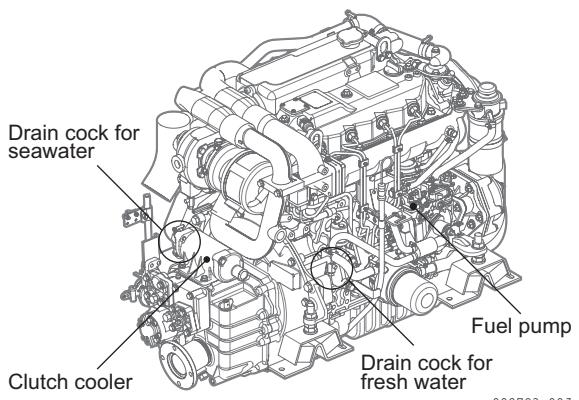
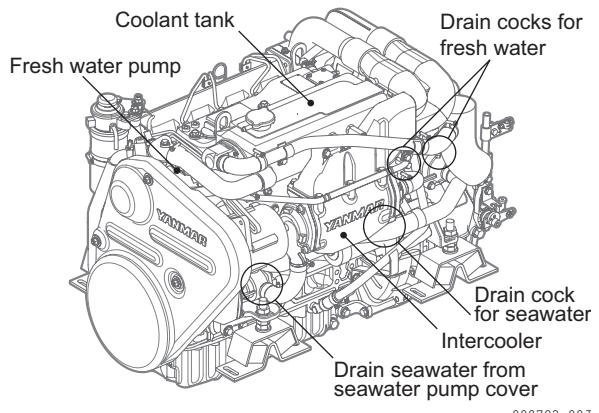
Drain cock for fresh water



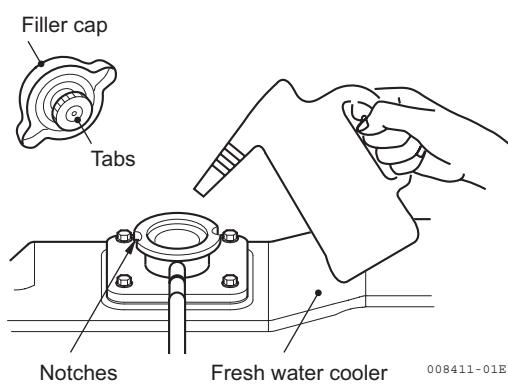
Drain cock for seawater



4JH4-HTE



- 3) Remove the filler cap of the fresh water cooler by turning the cap counterclockwise 1/3 of a turn.



2. Inspection and adjustment

- 4) Pour cooling water slowly into the coolant tank so that air bubbles do not develop. Pour until the water overflows from the filler port. Refer to 2.2.1(5) for the coolant capacity.

DANGER



If the filler cap is loose, hot steam and water will spout out which may cause burns.

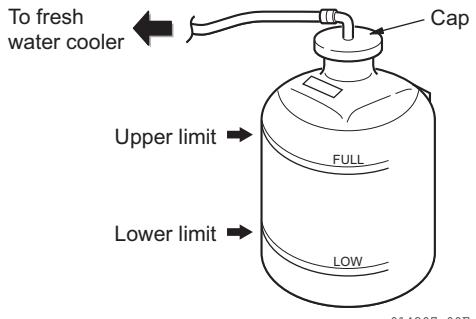
- 5) After supplying cooling water, fit the filler cap and tighten it firmly. To reassemble the cap, align the tabs on the bottom of the cap with the notches on the filler port and turn clockwise 1/3 of a turn.

- 6) Remove the coolant recovery tank cap and fill with coolant mix to the lower limit. Replace the cap to the coolant recovery tank.

Coolant recovery tank capacity: 0.8L (1.7 pints)

- 7) Check the rubber hose connecting the coolant recovery tank to the fresh water cooler. Be sure the hose is securely connected and there is no looseness or damage.

When the hose is not watertight, an excessive amount of cooling water will be used.



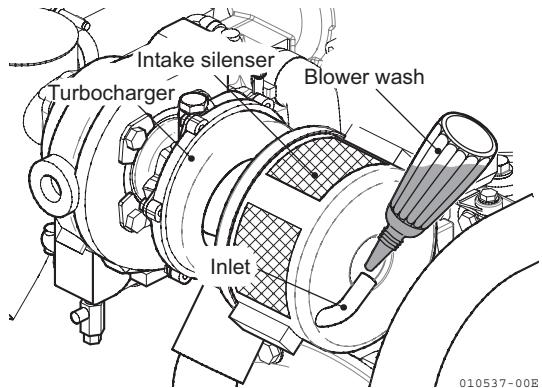
(7) Wash turbocharger blower

When engine speed seems sluggish or the exhaust color poor, the blades of the turbocharger blower may be dirty. Wash the blower in the following manner.

- 1) Prepare blower wash (liquid detergent), fresh water, and a small pitcher.
Blower wash (4L)
Parts code: 974500-00400
- 2) Put the clutch in neutral and run the engine at high speed ($2500\text{-}3000\text{ min}^{-1}$).
- 3) Slowly pour approximately 50cc of blower wash into the inlet hole of the intake silencer over a period of about 10 seconds.
- 4) After about 3 minutes, pour in approximately 50cc of fresh water in the same manner over a period of about 10 seconds.
- 5) After operating the engine for about 10 minutes, check the boost pressure and power output. If there is no improvement after washing the blower, repeat the washing process several times.

NOTICE:

Do not pour in a large amount of blower wash at one time (pour it in gradually) as this can damage the blower blades and get water hammer in the combustion chamber leading to accidents.



(8) Clean the exhaust/water mixing elbow.

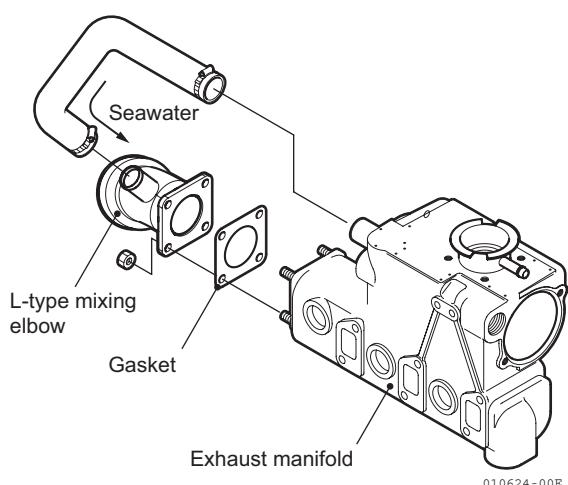
There are two types of mixing elbows, the L-type and the U-type. The mixing elbow is attached to the exhaust manifold. The exhaust gas is mixed with seawater in the mixing elbow.

- 1) Clean dirt and scale out of the air pass and seawater pass of the mixing elbow.
- 2) Repair the crack or damage of the mixing elbow by welding, or replace if necessary.

Note:

Replace the used mixing elbow with new one periodically every 500 hours or 2 years, even if any damage is not found.

- 3) Inspect the gasket and replace if necessary.



2. Inspection and adjustment

(9) Clean air cleaner

Occasionally, disassemble the intake silencer (air cleaner) and inspect it. Because the element filters the air, if it is used over a long period of time it will become clogged and this decreases the amount of intake air, and may also be a cause of decreased output and poor emission.

- 1) Disassemble the air cleaner and clean it with a neutral detergent.
- 2) Reassemble after it is completely dry.

(10) Adjust the tension of the alternator driving belt.

Refer to 2.2.2(4) for the procedure.

(11) Retighten all major nuts and bolts

After long time usage, the nuts and bolts used may loosen. Check and retighten the nuts and bolts such as;

- a) Flexible engine mount bolts
- b) Shaft coupling bolts
- c) Exhaust flange bolts
- d) Intake silencer fasteners
- e) Other nuts and bolts

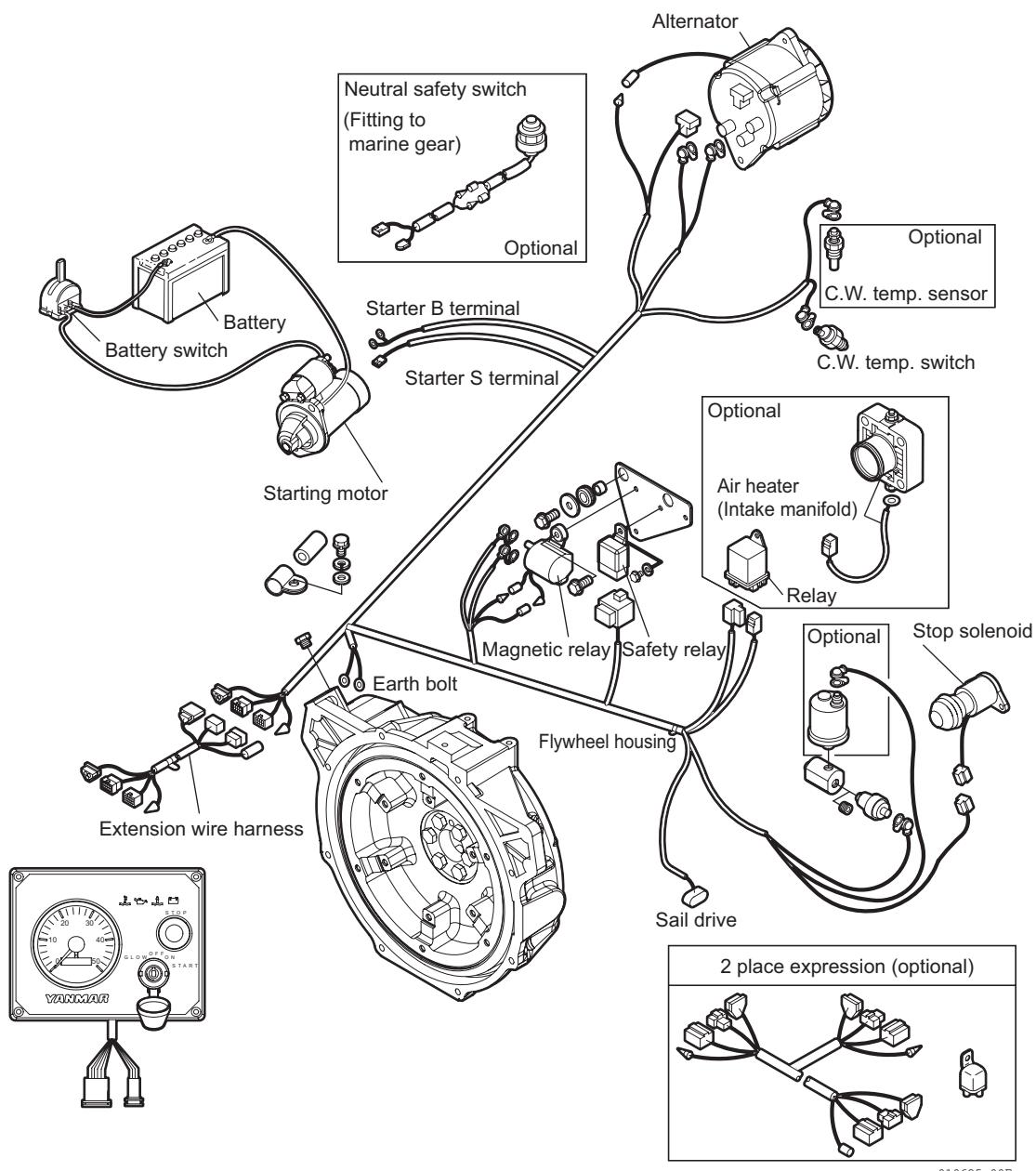
Retighten the major nuts and bolts below by the standard tightening torques.

Refer to chapter 14 for the tightening torques of the major parts.

- a) Cylinder head bolts
- b) Crankshaft pulley bolts
- c) Fuel injection nozzle set bolts
- d) Fuel injection pipe joint nut
- e) Others

(12) Check the wiring connectors.

Check whether each connection part doesn't have looseness.



010625-00E

2.2.5 Inspection every two years

When a long time will pass, rubber hoses will deteriorate because of weather resistance.

Replace rubberized hoses for water and fuel periodically every two years or 500 hours of operation, whichever comes first.

Check and replace the used hose clips with new ones, if necessary.

2.2.6 Inspection every 1,000 hours or four years

Be sure to check the following points every 1,000 hours or four years operation, whichever comes first.

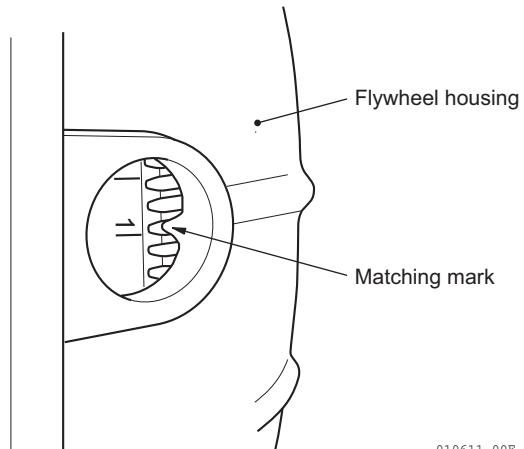
No.	Inspection item
(1)	Check the injection timing
(2)	Check the injection spray condition of a fuel nozzle
(3)	Check the impeller of the seawater pump
(4)	Clean and check the water passages
(5)	Diaphragm assembly inspection
(6)	Adjust the tension of the alternator driving belt
(7)	Adjust intake/exhaust valve clearance
(8)	Check/adjust the remote control operation
(9)	Adjust the propeller shaft alignment

(1) Check the injection timing

[3JH4E and 4JH4E]

The fuel injection timing is adjusted so that engine performance may become the best condition. As for the inspection and adjustment of the fuel pump, it is based on the service manual of the CLH pump. The fuel injection timing is adjusted by the following procedure.

- 1) Complete air bleeding from the fuel line and set the engine ready for starting.
- 2) See that the timing marks on fuel pump mounting flange and gear case are aligned.
- 3) Set the speed control lever at the operating position.
- 4) Disconnect the injection pipe on the fuel pump side for the No.1 cylinder. (Do not remove the delivery holder.)
- 5) Check the fuel discharge from the delivery holder while turning the crankshaft clockwise as seen from the gear case side, and stop turning it at the same time when the fuel comes out. Wipe out the fuel of the delivery holder exit. Next, turn the crankshaft in the opposite direction (counterclockwise), and return it to about 20 degrees before top dead center.
- 6) Check again the fuel discharge from the delivery holder while turning the crankshaft clockwise, and stop turning it at the same time when the fuel comes out.



010611-00E

- 7) Read the timing scale on the flywheel from the matching mark on the flywheel housing hole. It is standard fuel injection timing if the timing mark position meets the fuel injection timing of the below table.

	Model	Standard
Injection timing FID (FIC-Air) bTDC	3JH4E	12±1 (13±1)
	4JH4E	13±1 (14±1)

- 8) Repeat the step 5) to 7) a few times.

Note:

Injection timing check for one cylinder is generally sufficient. If it is to be checked for all cylinders, check each cylinder in the ignition order. (1-3-2-1 for 3JH4E, 1-3-4-2-1 for 4JH4E) The cylinder to be checked is not limited to the No.1 cylinder and any cylinder may be checked.

- 9) If the injection timing is out of the standard value, loosen the fuel pump mounting nut and incline the fuel injection pump toward or away from the engine for adjustment. Incline toward the engine to delay the timing, and away from the engine to advance it.

[4JH4-TE and 4JH4-HTE]

The fuel injection timing is adjusted so that engine performance may become the best condition and comply with the emission regulations.

This VE pump equips W-C.S.D (Wax type Cold Start Device), which improves the startability of the engine by advancing the injection timing according to the coolant temperature in a cold weather.

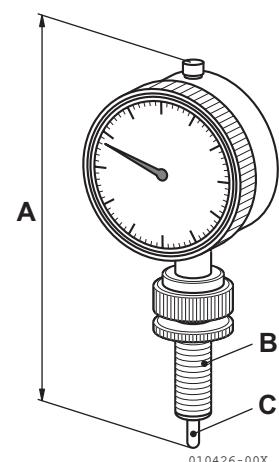
The injection timing of this engine can be adjusted by turning the VE pump, while reading the plunger lift by a dial gage. Make sure that the release of W-C.S.D is required at the time of injection timing adjustment.

The fuel injection timing is adjusted by the following procedure.

2. Inspection and adjustment

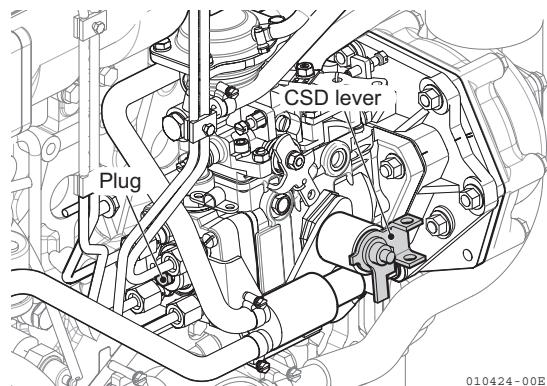
- 1) For the measurement of plunger lift , remove the plug and gasket of a VE pump and install a dial gage.

Dial gage

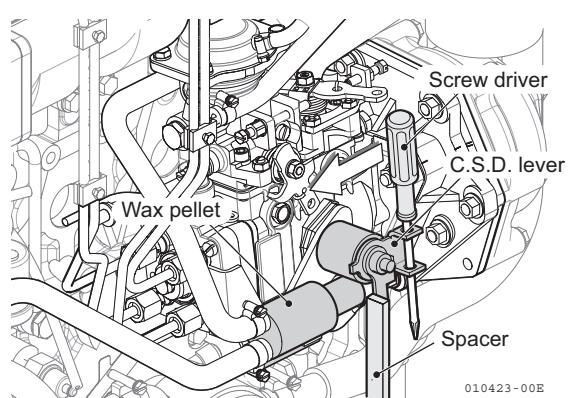


(mm)

A	B	C
95.5	M8 x 1.0	ø4

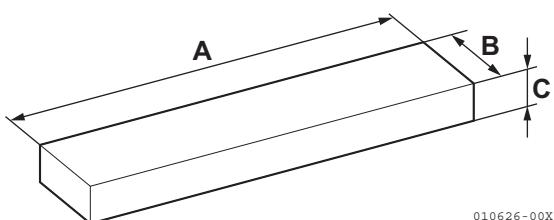


- 2) Insert a screw driver or a steel bar in the C.S.D. lever to turn the lever for canceling W-C.S.D. While turning the C.S.D. lever to the left, insert the spacer at the top of wax pellet. Thickness of the spacer is 7.5 ± 0.1 mm at the room temperature of 0-30 degrees C (when engine is cold).



Part code of C.S.D. cancel spacer:
129671-51990.

C.S.D. cancel spacer



010626-00X

(mm)

A	B	C
(150)	(20)	7.5 ± 0.1

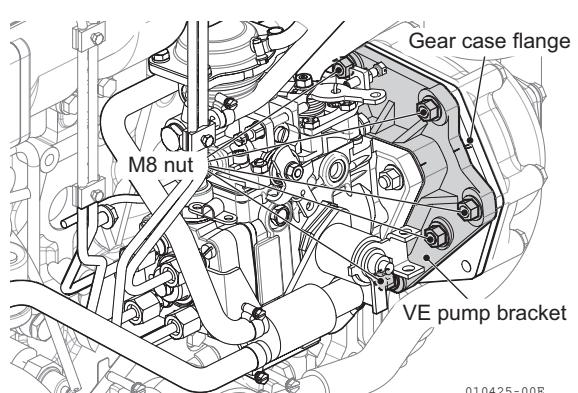
! CAUTION

1. Never turn the screw driver or steel bar to the right for W-C.S.D. release. The C.S.D. lever or wax pellet will be damaged.
2. The work under the W-C.S.D. canceled should be done for less than 1 hour. If a wax is no-loaded (canceled) for 1 hour or more, the wax pellet may be damaged and stabilizing treatment must be performed for the wax pellet to recover.
- 3) Turn the crankshaft slowly 20-30 degrees before the compression top dead center of No.4 cylinder (gear case side), and find the point (crankshaft angle) that the plunger lift is 0. Set the dial gage to 0 at the minimum value of the plunger lift. Check the minimum value is set to 0 by turning the crankshaft right and left.
- 4) Turn the crankshaft slowly to the engine rotating direction (counterclockwise viewed from stern) and set the crankshaft to the compression top dead center.
- 5) Check the dial gage. If the plunger lift comes off the standard value, loosen the 5 nuts about 90 degrees, which fix the VE pump bracket to a gear case flange.
The standard value of plunger lift (when the W-C.S.D. is released)

(mm)

Model	4JH4-TE/4JH4-HTE
Plunger lift	1.26 ± 0.01

- 6) Turn the pump for injection timing adjustment and adjust the plunger lift to the standard value.
After the adjustment of the injection timing, tighten the 5 nuts and fix the VE pump bracket.
- 7) Remove the spacer and the screw driver or steel bar.



010425-00E

⚠ CAUTION

When removing the spacer, never draw the spacer by force.
Wax pellet will be damaged by the reaction shock.
Remove the spacer and return the C.S.D. lever carefully, while turning the C.S.D. lever by using a screw driver or steel bar.

- 8) Remove the dial gage, and screw driver or steel bar. Install the plug and gasket.
Tightening torque of the plug: 20-25N·m.

(2) Check the injection spray condition of a fuel nozzle

⚠ WARNING

Wear protective glasses when testing injection from the fuel injection nozzle. Never approach the injection nozzle portion with a hand. The oil jetting out from the nozzle is at a high pressure to cause loss of sight or injury if coming into careless contact with it.

1) Injection pressure measurement

Standard MPa (kgf/cm²)

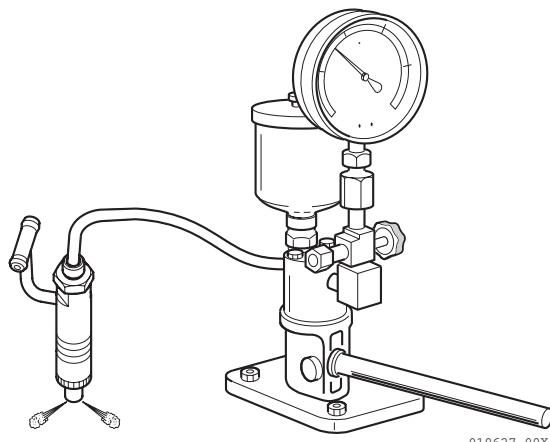
21.1-22.1 (215-225)

[NOTICE]

As for the opening pressure of the brand-new fuel nozzle, about 0.5 MPa (5 kgf/cm) declines by the engine operation for about 5 hours because of the initial wear-out of a spring etc. Therefore, adjust 0.5 MPa (5 kgf/cm) higher than the standard value of the above table when adjusting a new fuel nozzle of a spare part.

Remove carbon deposit at the nozzle hole thoroughly before measurement.

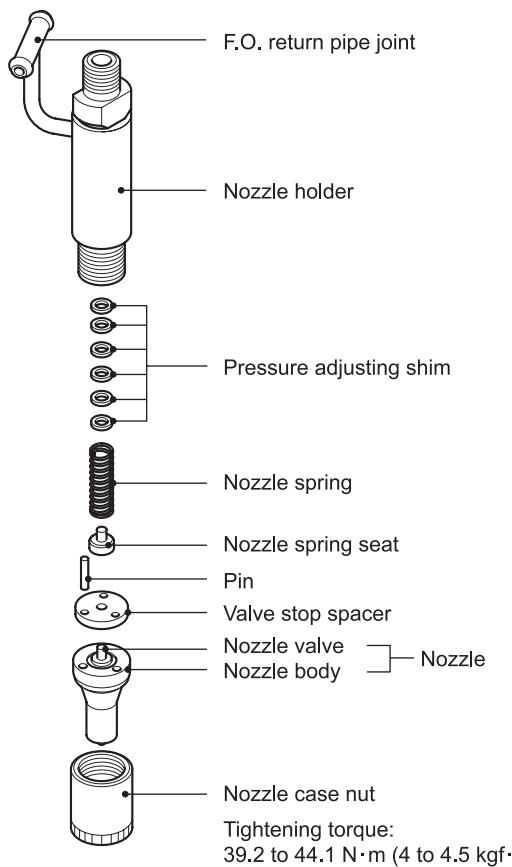
- a) Connect the fuel injection valve to the high pressure pipe of the nozzle tester.
- b) Operate the nozzle tester lever slowly and read the pressure at the moment when the fuel injection from the nozzle starts.
- c) If the measured injection pressure is lower than the standard level, replace the pressure adjusting shim with a thicker one.



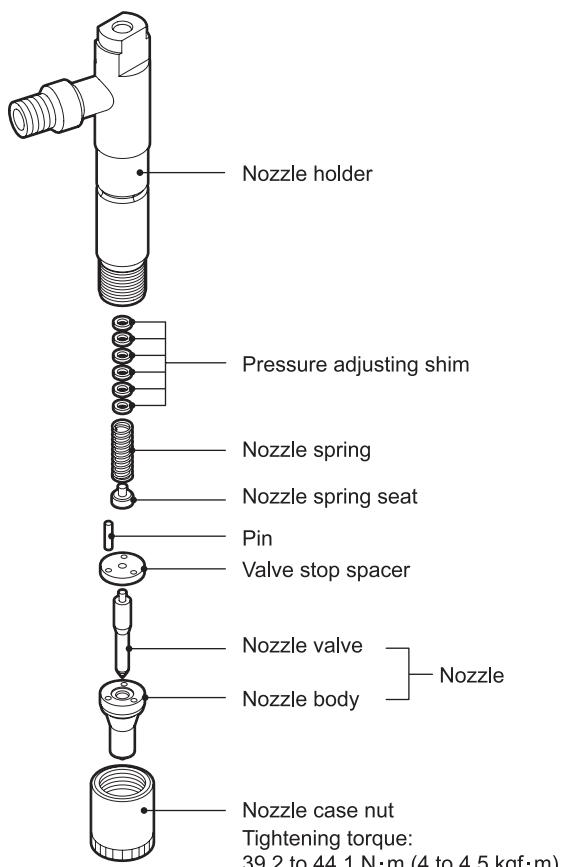
Thickness of pressure adjusting shims mm	Injection pressure adjustment
0.13, 0.15, 0.18, 0.4, 0.5, 0.8	The injection pressure is increased by approx. 1.9 MPa (19 kgf / cm ²), when the adjusting shim thickness is increased by 0.1 mm.

[Informative: Fuel injection valve structure]

2-valve head (3JH4E and 4JH4E)



4-valve head (4JH4-TE and 4JH4-HTE)



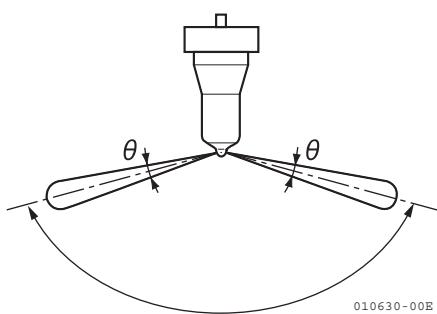
2) Spray pattern inspection

After adjustment to the specified valve opening pressure, use a nozzle tester and check the spray pattern and seat oil-tightness.

a) Seat oil tightness check

- After injecting a few times, increase the pressure gradually. Hold the pressure for about 5 seconds at a little before the valve opening pressure of 1.96 MPa (20 kgf/cm²), and check to see that oil does not drip from the tip end of the nozzle.
- If extreme oil leak from the overflow joint exists during injection by the nozzle tester, check after retightening. If much oil is leaking, replace the nozzle assembly.

Normal

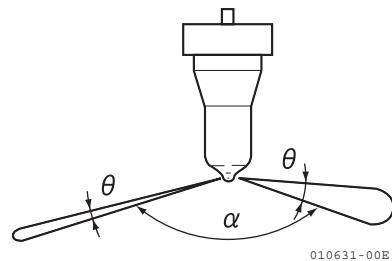


2. Inspection and adjustment

b) Spray and injection states

- Operate the nozzle tester lever at a rate of once or twice a second and check no abnormal injection.
- If normal injection as shown below cannot be obtained, replace the fuel injection valve.
- No extreme difference in angle (θ).
- No extreme injection angle difference (α).
- Finely atomized spray.
- Excellent spray condition.

Abnormal



3) Nozzle valve sliding test

Wash the nozzle valve in clean fuel oil. Place the nozzle body vertically and insert the nozzle into the body to about 1/3 of its length. The valve is normal if it smoothly falls by its own weight into the body. In case of a new nozzle, remove the seal peel, and immerse it in clean diesel oil or the like to clean the inner and outer surfaces and to thoroughly remove rust-preventive oil before using the nozzle. Note that a new nozzle is coated with rust-preventive oil and is pasted with the seal peel to shut off outer air.



010632-00X

(3) Check the impeller of the seawater pump

The impeller must be replaced with new one periodically (every 1000 hrs or four years whichever comes first).

Refer to 2.2.4 (5) for the procedure.

(4) Clean and check the water passages

When it is used for a long time, cleaning of the seawater passages is periodically necessary, because trash, scales, rust, and so on collect in the seawater passages and the cooling performance declines.

(a) Cleaning and inspection of seawater rubber hoses.

- 1) Check the dust and trash inside the hoses. If necessary, clean it.
- 2) Replace the used hose clips with new ones, if necessary.

(b) Heat exchanger (fresh water cooler) inspection

Inspect the fresh water cooler by the following procedure. The intercooler only for 4JH4-HTE can be inspected by the same way.

1) Cooler core inspection

- Inspect the inside of the tubes for rust or scale buildup from seawater, and clean with a wire brush if necessary.

Note:

Disassemble and wash when the coolant temperature reaches 85°C.

- Check the joints at both ends of the tubes for looseness or damage, and repair if loose. Replace if damaged or corroded.
- Check tubes and replace if leaking.
- Clean any scale or rust off the outside of the tubes.

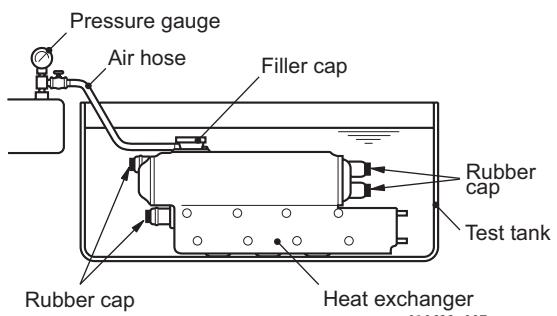
2) Heat exchanger body water leakage test

- Check heat exchanger body and side cover for dirt and corrosion. Replace, if excessively corroded, or cracked.
- Inspect seawater and fresh water inlets and outlets, retighten any joints as necessary and clean the insides of the pipes.
- Check the exhaust gas intake flange and line, and replace if corroded or cracked.

3) Heat exchanger body water leakage test

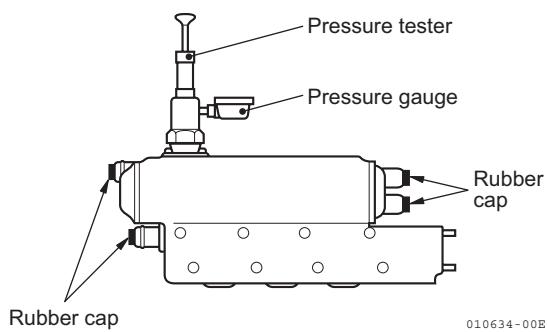
a) Compressed air/water tank test

Fit rubber covers on the fresh water and seawater inlets and outlets. Place the heat exchanger in a water tank, feed in compressed air from the overflow pipe and check for any (water) leakage, (air bubbles).



b) Use of the tester

Fit the fresh and seawater inlets and outlets with rubber covers and fill the fresh water tank with fresh water. Fit a pressure cap tester in place of the pressure cap, operate the pump for one minute and set the pressure at 0.15 MPa (1.5 kgf/cm², 21.33 lb/in.²). If there are any leaks the pressure will not rise. If there are no leaks the pressure will not fall.



4) Pressure cap inspection

DANGER



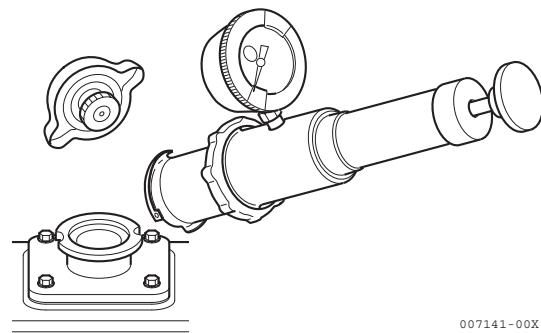
Do not open the pressure cap while the engine is running or right after stopping because high temperature steam will be blown out. Remove the cap only after the water cools down.

- Remove scale and rust and check the seat and seat valve, etc. for scratches or wear. Check the spring for corrosion or settling. Replace if necessary.

Note:

Clean the pressure cap with fresh water as it will not close completely if it is dirty.

- Fit the adopter on the tester to the pressure cap. Pump until the pressure gauge is within the specified pressure range 0.074-0.103 MPa (0.75-1.05 kgf/cm²) and note the gauge reading. The cap is normal if the pressure holds for six seconds. If the pressure does not rise, or drop immediately, inspect the cap and repair or replace as necessary.



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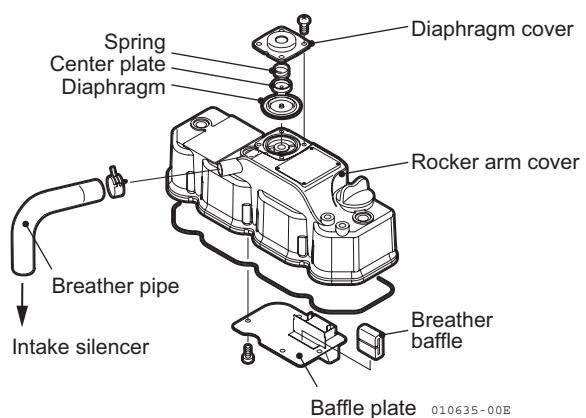
(5) Diaphragm assembly inspection

Inspect the diaphragm assembly on the rocker arm cover only for 3JH4E and 4JH4E.

- Loosen screws, remove the diaphragm assembly, and check for oil and contaminants between the diaphragm and the cover. If oil and contaminants enter into the diaphragm assembly, the diaphragm will not operate as designed.
- Inspect the diaphragm rubber and spring for damage. If necessary, replace with new ones.

[NOTICE]

- When a diaphragm is damaged, pressure control inside the crankcase becomes insufficient, and troubles such as combustion defect and so on occur.
- At lubricating oil replacement or lubricating oil supply, the amount of lubricating oil isn't to be beyond the standard upper limit. If the lubricating oil quantity is beyond the upper limit or an engine is operated beyond the allowable maximum angle of an engine, the amount of oil mist may be inducted in the combustion chamber and the oil hammer sometimes may occur.



Baffle plate 010635-00E

(6) Adjust the tension of the alternator driving belt

Replace the alternator driving belt with new one every 1000 hours or four years, whichever comes first, even if there is no crack in the surface.

Refer to 2.2.2(4) for the procedure.

(7) Adjust intake/exhaust valve clearance.

Refer to 2.2.2(5) for the procedure.

(8) Check/adjust the remote control operation.

Refer to 2.2.2(6) for the procedure.

(9) Adjust the propeller shaft alignment.

- 1) The rubber tension of the flexible engine mounts is lost after many hours' use. This leads to a drop in vibration absorption performance, and also causes centering misalignment of the propeller shaft. (Refer to 5. "Flexible Engine Mount" in the installation manual for pleasure boat use.)

Note:

Be sure to replace the Yanmar flexible engine mounts every 1000 hours or 4 years, whichever comes first.

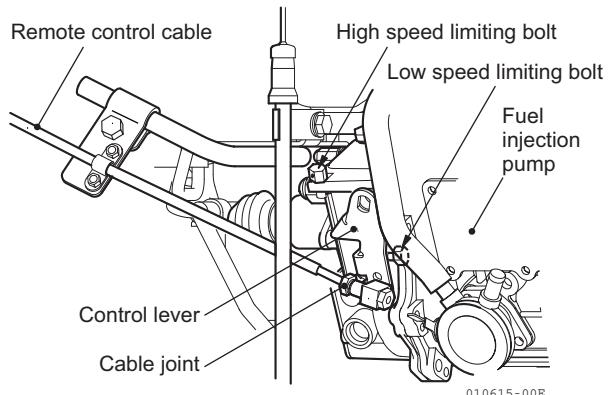
- 2) After replacing the flexible engine mounts, check unusual noise and vibration of the engine and the boat hull with increasing the engine speed gradually and lowering it.
- 3) If there is unusual noise and/or vibration, adjust the propeller shaft alignment. (Refer to 6.4.5 "Centering the Engine" in the installation manual for pleasure boat use.)

2.3 Adjusting the no-load maximum or minimum speed

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

Standards (Unit: min⁻¹)

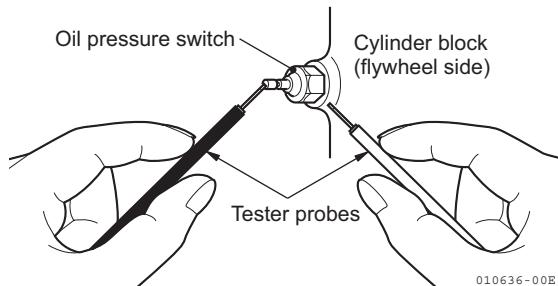
Model	No-load maximum	No-load minimum
3JH4E 4JH4E	3325±25	825±25
4JH4-TE 4JH4-HTE	3775 ⁺²⁵ ₋₇₅	800±25



2.4 Sensor inspection

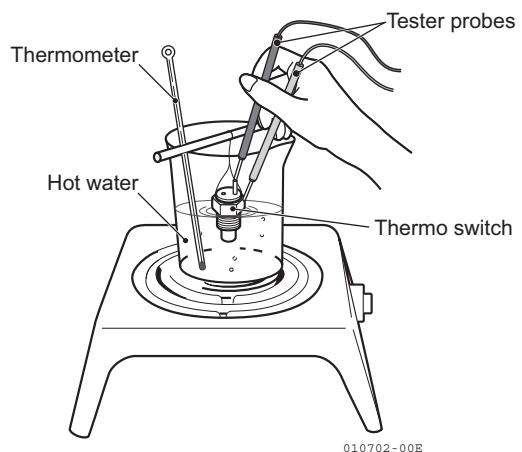
2.4.1 Oil pressure switch

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



2.4.2 Thermo switch

Place the thermo switch in a container filled with antifreeze or oil. Heat it while measuring the fluid temperature. The switch is normal if the voltameter shows continuity when the fluid temperature is 97-103 deg C.

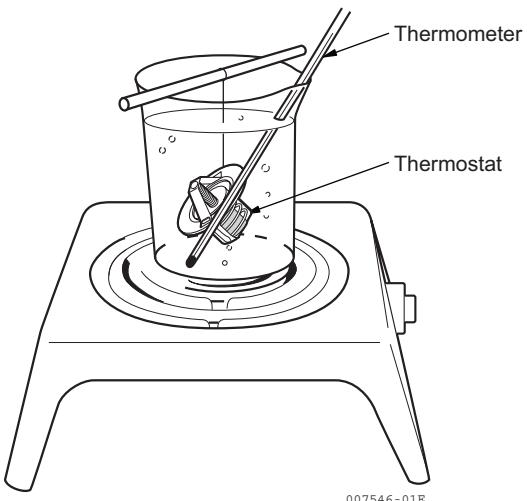


2.5 Thermostat inspection

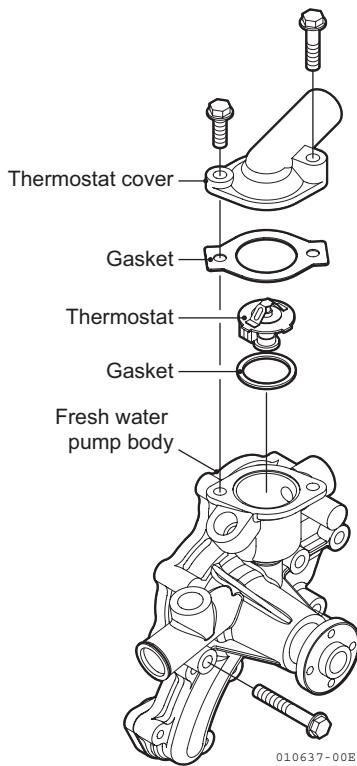
- (1) Put the thermostat in a beaker with fresh water, and heat it on an electric stove. The thermostat is functioning normally if it starts to open between 75-78 deg C, and opens until 8 mm or more at 90 deg C. Replace the thermostat if it not functioning normally.

Valve opening temperature (deg C)*	Full open lift (temperature) (mm)
75.0-78.0	8 or more (90 deg C)

* Valve opening temperature is carved on the flange.



- (2) Normally, the thermostat should be inspected every 500 hours of operation, but, it should be inspected whenever the coolant temperature rises abnormally or white smoke is emitted for a long time after engine starting.
- (3) Replace the thermostat every year or 2000 hours of operation (whichever comes first).



2.6 Adjusting operation

Perform the adjusting operation (test run) for an engine as follows after the maintenance job:

2.6.1 Preliminary precautions

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

- (1) Warm the engine up.
- (2) Remove any precipitation from the fuel filter, water separator, and fuel tank.
- (3) Use only lube oil recommended by Yanmar.
- (4) Be sure to add Long Life Coolant Antifreeze (LLC) to cooling fresh water.
- (5) Provide good ventilation in the engine room.

2.6.2 Adjusting operation procedure

- 1) Supply the fuel oil, lubricating oil and coolant.

Note:

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

- 2) Start the engine, and carry out idling at a low speed (800 to 900 min^{-1}) for a few minutes.
- 3) Run in the engine for about five minutes at the rated speed (no-load). Check any water, fuel or lube oil leakage and existence of abnormal vibration or noise. Also check the oil pressure, coolant temperature and exhaust gas color.
- 4) Adjust the no-load minimum and maximum speed. (Refer to 2.3.)
- 5) Perform loaded operation as required.

2.6.3 Check points and precautions during running

Step	Item	Instructions	Precautions
1	Checks before operation.	1) Make sure that the sea cock is open. 2) Make sure there is enough lube oil and (fresh) coolant. 3) Operate the remote control handle and check if the device connected to the engine works property.	3) Lamp should go off when engine is running.
2	No load operation; warm up operation.	1) When the lube oil temperature is raised to allow the engine to start, the pilot lamp goes off. 2) When the engine is started, check the following: • There is no leakage of water, fuel and lube oil. • Exhaust gas does not leak when the engine is started. • There is no abnormal indication on the instrument panel. • There is no abnormality in coolant discharge, engine vibration or engine sound. 3) To warm up the engine, operate at low speed for about 5 minutes, then raise the speed to the rated speed and then to max. speed.	2) • Fit leaks if any. • Check the intake/exhaust valves, fuel injection nozzle and cylinder head. 3) Do not raise the engine speed abruptly.
3	Cruising (load) operation.	1) Do not operate the engine at full load yet, but raise the speed gradually for about 10 minutes until it reaches the rated speed. 2) Make sure that exhaust gas color and temperature are normal. 3) Check the instrument panel and see if the water temperature and oil pressure are normal.	
4	Stopping the engine.	1) Before stopping the engine, operate it at $800\text{-}850 \text{ min}^{-1}$ for about 5 minutes. 2) Raise engine speed to $1,800 \text{ min}^{-1}$ just before stopping the engine and idle the engine for about 3-4 seconds.	1) Stopping the engine suddenly during high speed operation increases the temperature of engine parts. 2) This procedure prevents carbon from being deposited on the valve seats, etc.
5	Checks after stopping the engine.	1) Check again for water and oil leaks. 2) Make sure that no nuts and bolts are loose. 3) Close the sea cock and fuel cocks. 4) When the temperature is expected to fall below freezing, drain the seawater. 5) Turn off the battery switch.	1) Check the oil seal area. 2) Especially the engine installation bolts. 4) Drain from the seawater pump.

2.7 Long storage

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

- 1) Do not drain fresh water (coolant) in the cold season or before the long storage.

[NOTICE]

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

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

3. Troubleshooting

3.1 Preparation before troubleshooting

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

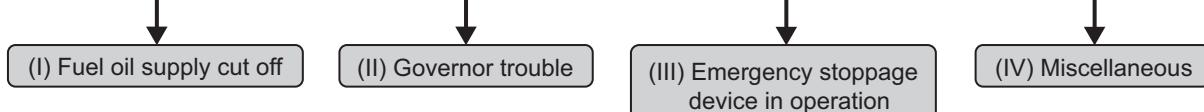
When the signs of a trouble appear in the engine or a trouble occurs, grasp the trouble conditions fully by the next point and find out the cause of sincerity according to the troubleshooting. Then repair the trouble, and prevent the recurrence of the trouble.

- 1) What's the occurrence phenomenon or the trouble situation?
(e.g. Poor exhaust color)
- 2) Investigation of the past records of the engine.
Check a client control ledger, and examine the history of the engine.
 - Investigate the engine model name and the engine number. (Mentioned in the engine label.)
 - Examine the machine unit name and its number in the same way.
 - When was the engine maintained last time?
 - How much period and/or time has it been used after it was maintained last time?
 - What kind of problem was there on the engine last time, and what kind of maintenance was done?
- 3) Hear the occurrence phenomenon from the operator of the engine in detail.
5W1H of the occurrence phenomenon: the investigation of when (when), where (where), who (who), what (what), why (why) and how (how)
 - When did the trouble happen at what kind of time?
 - Was there anything changed before the trouble?
 - Did the trouble occur suddenly, or was there what or a sign?
 - Was there any related phenomenon.
(e.g. Poor exhaust color and starting failure at the same time.)
- 4) After presuming a probable cause based on the above investigation, investigate a cause systematically by the next troubleshooting guide, and find out the cause of sincerity.

3.2 Quick reference chart for troubleshooting

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

THE ENGINE SUDDENLY STOPS



(I) Fuel oil supply cut off

No.	Cause and effect	Countermeasure
1	Insufficient oil in fuel oil tank.	Add fuel oil and prime.
2	Air in fuel oil system and fuel injection pump.	Bleed air.
3	Water in fuel oil tank.	Remove water from drain and fuel oil system and prime.
4	Fuel oil cock closed.	Check and make necessary repairs.
5	Clogging of fuel oil filter.	Clean.
6	Damage in fuel oil system.	Replace.
7	Problem with fuel feeding pump.	Check and make necessary repairs.

(II) Governor trouble

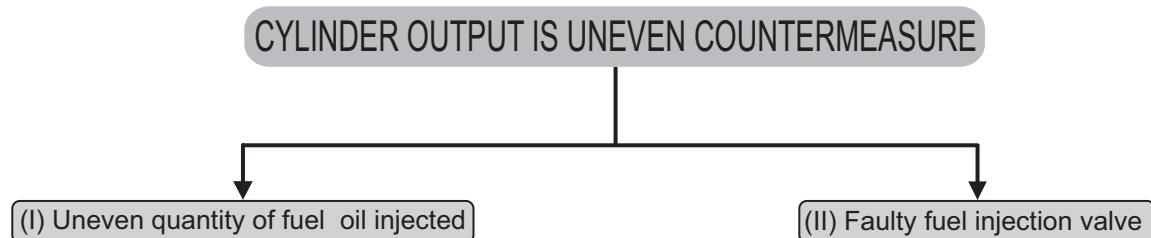
No.	Cause and effect	Countermeasure
1	Damage to governor spring.	Replace.
2	Sticking of governor sleeve.	Clean carefully to insure good working order.

(III) Emergency stoppage device in operation

No.	Cause and effect	Countermeasure
1	Loose lube oil pressure adjustment valve.	Tighten adjustment valve.
2	Clogging of lube oil filter.	Clean.
3	Leakage from lube oil safety valve.	Tighten safety valve.
4	Trouble with lube oil pump.	Remove and repair or replace.
5	Relay operation triggered by low lube oil pressure.	Return to original condition.

(IV) Miscellaneous

No.	Cause and effect	Countermeasure
1	Seizure of moving parts.	Remove and repair or replace.
2	Overloading due to insufficient coolant.	Disassemble and clean cooling water pump and check coolant system.



(I) Uneven quantity of fuel oil injected

No.	Cause and effect	Countermeasure
1	Air in the fuel injection pump.	Bleed air.
2	Faulty operation of plunger.	Disassemble and clean.
3	Damaged plunger spring.	Replace.
4	Faulty fuel oil ejection valve.	Repair or replace.
5	Damaged exhaust union packing.	Replace.
6	Loose pinion screw.	Tighten firmly.
7	Faulty fuel injection pump tappet.	Disassemble and clean and repair replace.

(II) Faulty fuel injection valve

No.	Cause and effect	Countermeasure
1	Oil leakage in injection system.	Check and repair.
2	Damaged valve spring.	Replace.
3	Insufficient injection pressure in injection valves.	Adjust.
4	Irregular injection timing.	Adjust.
5	Sticking of injection valves.	Clean.

POOR EXHAUST COLOR

- (I) Faulty fuel injection pump
- (II) Faulty fuel injection valve
- (III) Clogged intake air filter
- (IV) Miscellaneous

(I) Faulty fuel injection pump

No.	Cause and effect	Countermeasure
1	Faulty plunger operation.	Check, repair or replace.
2	Worn plunger.	Replace.
3	Faulty ejection valve.	Check, repair or replace.
4	Uneven quantity of fuel injected.	Adjust.
5	Irregular fuel injection timing.	Adjust.

(II) Faulty fuel injection valve

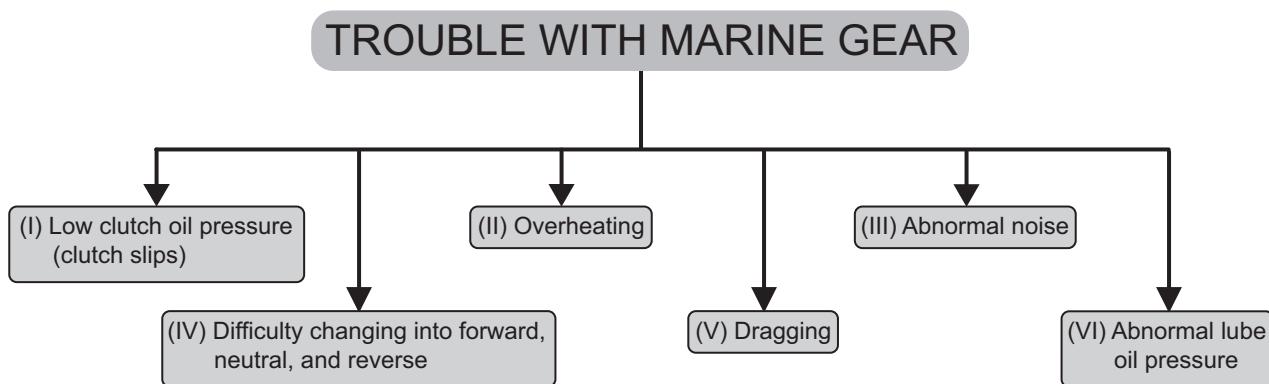
No.	Cause and effect	Countermeasure
1	Injection opening is clogged.	Clean.
2	Sticking of valve needle.	Check, repair or replace.
3	Low injection pressure.	Adjust.
4	Faulty spray condition.	Check, repair or replace.
5	Carbon deposit.	Clean.

(III) Clogged intake air filter

No.	Cause and effect	Countermeasure
1	Clogged filter.	Clean.

(IV) Miscellaneous

No.	Cause and effect	Countermeasure
1	Overloading.	Reduce load.
2	Too great a quantity of lube oil.	Adjust quantity of oil.
3	Carbon deposit in suction valves.	Clean.
4	Dirty air cooler.	Clean.
5	Poor quality fuel oil.	Replace with new oil.
6	Clogging in exhaust system Cause.	Clean.

**(I) Low clutch oil pressure (clutch slips)**

No.	Cause and effect	Countermeasure
1	Clogging of filter on suction side.	Disassemble and clean.
2	Worn oil pump.	Repair or replace.
3	Sticking of oil pressure adjustment valve.	Repair or replace.
4	Damage or old oil pressure adjustment valve spring.	Replace.
5	Damaged seal ring.	Repair.
6	Incorrect positioning of forward/reverse conversion valve.	Adjust.
7	Worn sliding parts of forward/reverse conversion valve.	Replace.
8	Damaged O-ring, V-ring in oil pressure pipe.	Replace.
9	Low speed valve handle slips.	Adjust to correct position.
10	Poor assembly of low speed valve handle.	Reassemble.
11	Insufficient oil.	Check for oil leakage and replenish.

(II) Overheating

No.	Cause and effect	Countermeasure
1	Clutch slippage due to low oil pressure.	Review (I-1, I-11).
2	Clutch slippage due to overloading.	Reduce load.
3	Damaged bearing.	Replace.
4	Too much oil.	Check oil level and adjust.
5	Problem with oil cooler.	Check water level and adjust.
6	Poor quality or inappropriate oil.	Change oil.
7	Poor operation of low speed valve.	Review manual.

(III) Abnormal noise

No.	Cause and effect	Countermeasure
1	Excessive backlash of gear.	Replace.
2	Damaged bearing.	Replace.
3	Abnormal vibration.	Eliminate dangerous rotation.

3. Troubleshooting

(IV) Difficulty changing into forward, neutral, and reverse

No.	Cause and effect	Countermeasure
1	Damaged holding spring of pipe.	Replace.
2	Foreign material in pipe system.	Clean.
3	Oil leakage where there is remote control.	Replenish oil and check. Replace seal.
4	Phase slippage.	Repair link system.

(V) Dragging

No.	Cause and effect	Countermeasure
1	Not enough warp in steel plate.	Replace.
2	Damaged holding spring of pipe.	Replace.
3	Lube oil pressure is too high.	Adjust lube oil adjustment valve.
4	Viscosity of lube oil is too high.	Change oil.

(VI) Abnormal lube oil pressure

No.	Cause and effect	Countermeasure
1	Oil leakage.	Check and repair.
2	Clogged lube oil filter.	Disassemble and clean.
3	Damaged or old lube oil adjustment valve spring.	Replace.
4	Sticking of lube oil adjustment valve.	Repair or replace.

ROTATION IS NOT SMOOTH



(I) Faulty operation of injection valve

No.	Cause and effect	Countermeasure
1	Impediment to valve needle movement.	Lap.
2	Damaged valve spring.	Replace.

(II) Uneven supply of fuel oil injected

No.	Cause and effect	Countermeasure
1	Faulty operation of fuel pump plunger.	Clean.
2	Damaged fuel pump plunger.	Replace.
3	Damaged plunger spring.	Replace.
4	Inaccurate assembly of fuel injection pump.	Correctly install pump.
5	Clogging of fuel filter.	Clean.
6	Damaged fuel cam.	Replace.
7	Air in fuel injection system.	Bleed air and prime.
8	Faulty operation of adjustment rack.	Adjust.
9	Uneven amount of fuel to cylinders.	Adjust.

(III) Faulty operation of governor

No.	Cause and effect	Countermeasure
1	Damaged governor bearing.	Replace.
2	Faulty operation of governor link.	Adjust.
3	Sticking of governor sleeve.	Clean.
4	Faulty operation of fuel oil adjustment.	Disassemble, wash and repair.

(IV) Miscellaneous

No.	Cause and effect	Countermeasure
1	Overloading.	Reduce load.
2	Seizure of moving parts.	Disassemble, check and repair.
3	Clutch slippage.	Check and adjust.

KNOCKING

- (I) Faulty fuel injection valve
- (II) Faulty fuel injected
- (III) Excessive quantity of fuel injected each time
- (IV) Miscellaneous

(I) Faulty fuel injection valve

No.	Cause and effect	Countermeasure
1	Low injection pressure.	Increase injection pressure.
2	Damaged fuel valve spring.	Replace.
3	Sticking of valve needle.	Disassemble and lap.
4	Faulty injection spray.	Disassemble and repair.

(II) Faulty fuel injected

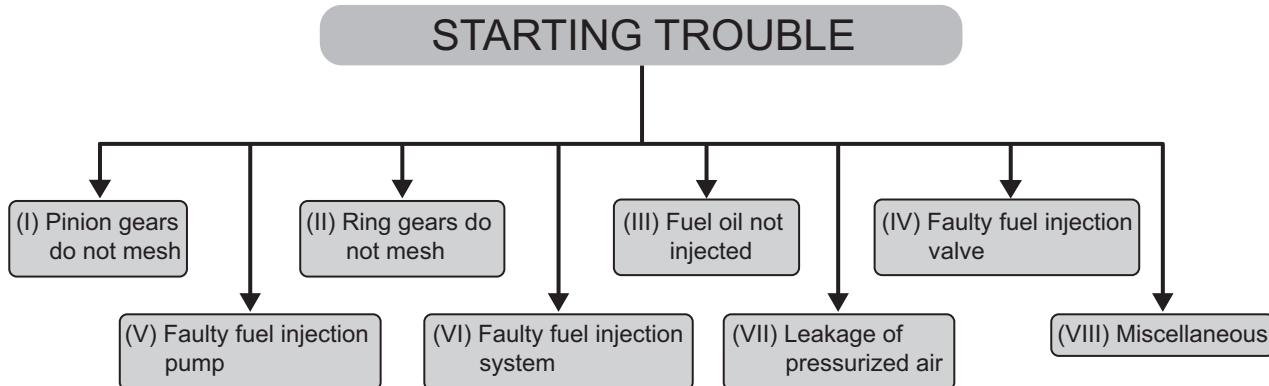
No.	Cause and effect	Countermeasure
1	Early fuel injection.	Delay injection timing.
2	Fuel pressure is too high.	Adjust standard injection pressure.

(III) Excessive quantity of fuel injected each time

No.	Cause and effect	Countermeasure
1	Excessive quantity of fuel is ejected from fuel pump.	Adjust pump adjustment rack.

(IV) Miscellaneous

No.	Cause and effect	Countermeasure
1	Insufficient coolant.	Check cooling water pump and lap valves.
2	Excess piston clearance.	Replace.
3	Excess bearing clearance.	Replace.
4	Poor quality fuel oil.	Replace with good fuel oil.
5	Water mixed in fuel oil.	Replace with good fuel oil.
6	Incorrect pressure.	Check and repair.

**(I) Pinion gears do not mesh**

No.	Cause and effect	Countermeasure
1	Loose battery engage magnet terminal.	Tighten.
2	Faulty connection in starting switch.	Repair using sandpaper or replace.
3	Cut battery engage magnet coil.	Replace.
4	Rough cap movement.	Repair using sandpaper and then grease.
5	Edges of gear teeth misshapen.	Adjust.
6	Faulty positioning of pinion and ring gears.	Adjust.
7	Seizure of starter metal.	Replace.

(II) Ring gears do not mesh

No.	Cause and effect	Countermeasure
1	Loose battery starter terminal.	Tighten.
2	Faulty connection in engage magnet switch.	Repair using sandpaper.
3	Worn brushes.	Replace.
4	Commutator rough and dirty.	Repair using sandpaper (Type 500~600).
5	Cut starter coil.	Replace.
6	Worn commutator.	Undercut and repair or replace.
7	Slippage of starter clutch.	Replace.
8	Excessive resistance between battery and starter.	Replace with thicker or shorter wire.
9	Insufficient battery charge.	Charge.

(III) Fuel oil not injected

No.	Cause and effect	Countermeasure
1	Imperfect priming of fuel oil system.	Prime well.
2	Injection cut off due to faulty governor.	Adjust.
3	Clogging of fuel inlet filter.	Clean out matter causing clogging.
4	Insufficient fuel oil in tank.	Add fuel to fuel tank.
5	Fuel oil tank cock closed.	Open cock.
6	Clogging in fuel oil pipe.	Clean.
7	Damaged fuel oil supply pump.	Disassemble and repair or replace.
8	Water in fuel oil tank.	Drain water from fuel system and prime.

3. Troubleshooting

(IV) Faulty fuel injection valve

No.	Cause and effect	Countermeasure
1	Faulty valve seat.	Lap.
2	Sticking of valve needle.	Lap.
3	Worn valve needle.	Replace.
4	Clogged outlet.	Clean or replace.
5	Low injection pressure.	Adjust.

(V) Faulty fuel injection pump

No.	Cause and effect	Countermeasure
1	Worn plunger.	Replace plunger and barrel as a unit.
2	Damaged plunger spring.	Replace.
3	Plunger sticks.	Disassemble and repair or replace.
4	Oil leakage from exhaust valve.	Lap valves.
5	Air inside pump.	Bleed air.
6	Damaged exhaust valve spring.	Replace.

(VI) Faulty fuel injection system

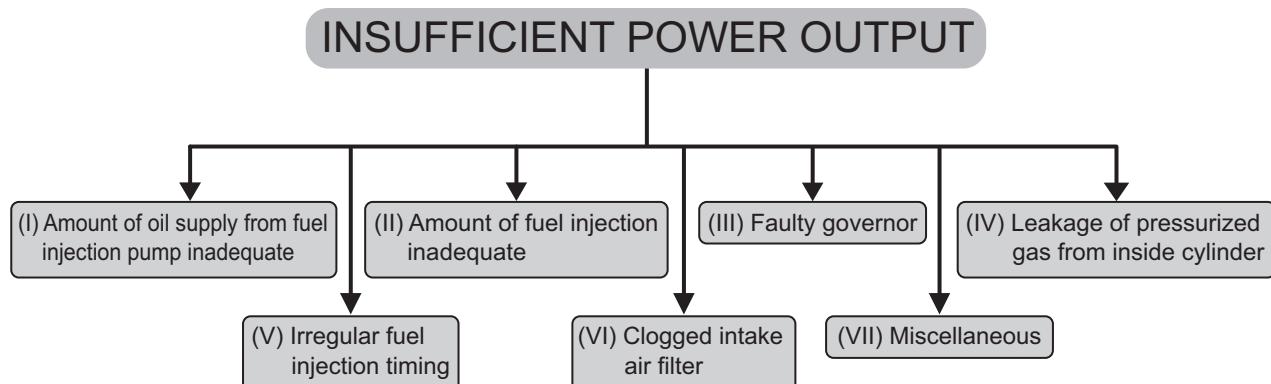
No.	Cause and effect	Countermeasure
1	Fuel injection pump timing irregular.	Adjust.
2	Loose high pressure fuel pipe.	Tighten firmly.
3	Damaged high pressure fuel pipe.	Replace.
4	Air in high pressure fuel pipe.	Bleed air.

(VII) Leakage of pressurized air

No.	Cause and effect	Countermeasure
1	Air leakage from suction/exhaust valves.	Lap valves.
2	No tappet clearance.	Adjust.
3	Faulty gasket packing.	Replace.
4	Upper part of cylinder liner worn.	Replace.
5	Worn piston ring.	Replace.
6	Piston ring sticks.	Disassemble and repair or replace.
7	Insufficient tightening of head bolts.	Tighten tightening nuts uniformly.
8	Damaged valve spring.	Replace.

(VIII) Miscellaneous

No.	Cause and effect	Countermeasure
1	Incorrect thickness of gasket packing.	Replace.
2	Faulty installation of governor ring and lever.	Adjust.
3	Governor handle is in stop position.	Move governor handle to acceleration position.
4	Faulty engine starter.	Check and repair.
5	Clogging of suction/exhaust pipes.	Clean.

**(I) Amount of oil supply from fuel injection pump inadequate**

No.	Cause and effect	Countermeasure
1	Worn plunger.	Replace.
2	Sticking of plunger.	Disassemble and repair or replace.
3	Oil leakage from exhaust valve.	Lap valves.
4	Oil leakage from joint of high pressure pipe.	Tighten firmly.
5	Faulty adjustment of fuel pump.	Adjust.
6	Inaccurate positioning of adjustment rack.	Adjust.
7	Clogging of fuel filter.	Clean.
8	Clogging of fuel oil pipe.	Clean.
9	Damaged valve spring.	Replace.
10	Faulty supply pump.	Repair.

(II) Amount of fuel injection inadequate

No.	Cause and effect	Countermeasure
1	Clogging of nozzle hole.	Clean nozzle hole or replace.
2	Faulty valve seat.	Lap or replace.
3	Sticking of valve needle.	Lap or replace.
4	Loose high pressure pipe.	Tighten firmly.
5	Worn valve needle.	Replace.
6	Clogging of filter.	Clean.

(III) Faulty governor

No.	Cause and effect	Countermeasure
1	Damaged governor bearing.	Replace.
2	Inaccurate length of governor link.	Repair.

3. Troubleshooting

(IV) Leakage of pressurized gas from inside cylinder

No.	Cause and effect	Countermeasure
1	Leakage of gas from suction/exhaust valves.	Lap valves.
2	Inadequate tapper clearance.	Adjust.
3	Worn upper part of cylinder liner.	Replace.
4	Worn piston ring.	Replace.
5	Sticking of piston ring.	Disassemble and repair or replace.

(V) Irregular fuel injection timing

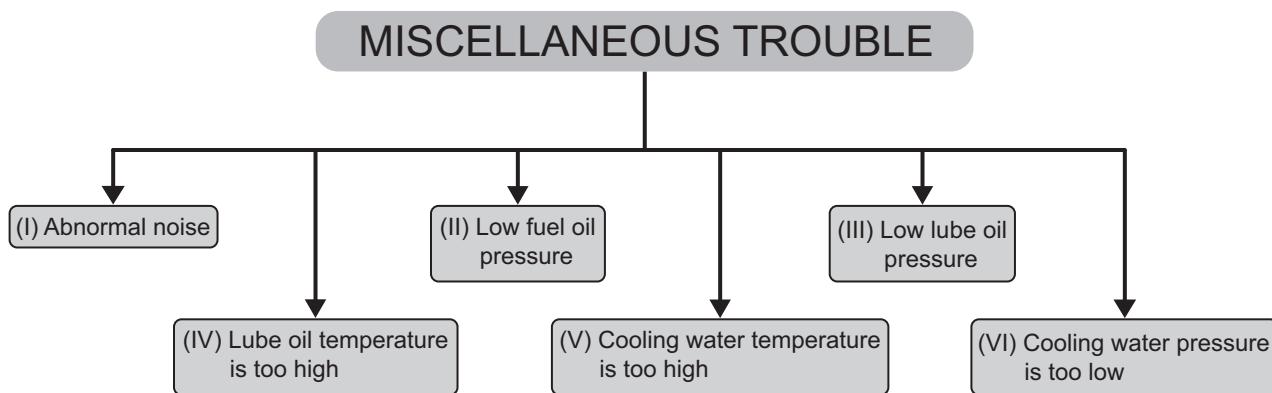
No.	Cause and effect	Countermeasure
1	Early injection.	Adjust timing to delay injection.
2	Late injection.	Adjust timing to speed injection.

(VI) Clogged intake air filter

No.	Cause and effect	Countermeasure
1	Clogging of air filter.	Clean.

(VII) Miscellaneous

No.	Cause and effect	Countermeasure
1	Poor quality fuel oil.	Replace with good fuel oil.
2	Clogging of exhaust line.	Clean.
3	Seizure of moving parts.	Disassemble, check and repair.
4	Insufficient coolant.	Lap cooling water pump suction/exhaust valves.
5	Insufficient lube oil supplied.	Disassemble and clean lube oil pump and filter.

**(I) Abnormal noise**

No.	Cause and effect	Countermeasure
1	Loose flywheel installment bolt.	Tighten nuts.
2	Loose crank pin bearing bolt.	Tighten nuts and insert pins.
3	Worn crank pin metal.	Remove adjustment liner and adjust aperture, or replace.
4	Faulty gear meshing.	Check teeth, shaft, and pushrod of gear for wear. Replace where necessary.

(II) Low fuel oil pressure

No.	Cause and effect	Countermeasure
1	Loose pressure adjustment.	Tighten adjustment valve.
2	Damaged supply pump.	Check and repair.
3	Clogged filter.	Clean.
4	Leaky pipe.	Repair.

(III) Low lube oil pressure

No.	Cause and effect	Countermeasure
1	Clogged lube oil filter.	Clean.
2	Lube oil temperature is too high.	Add cooling water.
3	Trouble with lube oil pump.	Disassemble and repair or replace.
4	Loose pressure adjustment valve.	Tighten adjustment valve.
5	Oil leakage from pump safety valve.	Tighten safety valve.
6	Inadequate viscosity of lube oil.	Change lube oil.
7	Insufficient amount of lube oil.	Add lube oil.
8	Faulty pressure gauge.	Replace.

(IV) Lube oil temperature is too high

No.	Cause and effect	Countermeasure
1	coolant temperature has risen.	Adjust the amount of returning water or check the cooling water pump and tap valves.
2	Overloading.	Reduce load.
3	Faulty lube oil temperature adjustment valve.	Clean and adjust.

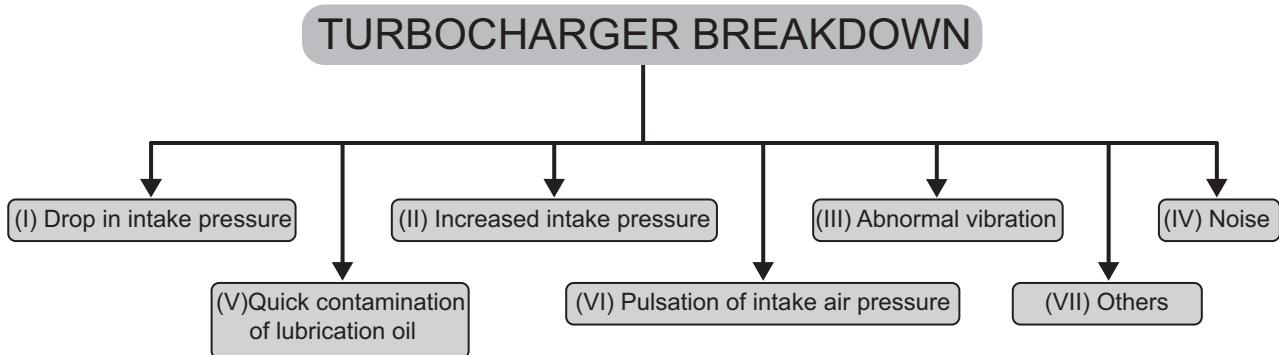
3. Troubleshooting

(V) Coolant temperature is too high

No.	Cause and effect	Countermeasure
1	Insufficient amount of coolant.	Open closed parts.
2	Trouble with cooling water pump.	Check pump and repair.
3	Amount of water returning is too great.	Adjust amount of returning water.
4	Clogging in coolant system.	Clean.
5	Air in coolant.	Check suction opening.
6	Overloading.	Reduction load.

(VI) coolant pressure is too low

No.	Cause and effect	Countermeasure
1	Clogging in coolant system.	Clean.
2	Trouble with cooling water pump.	Check pump and repair.
3	Coolant lift is too great.	Lessen lift or replace pump.
4	Air in coolant.	Check suction opening.
5	Engine outlet not constricted.	Eliminate causes for high coolant temperature and constrict.
6	Water leakage from coolant joints.	Check and repair.

**(I) Drop in intake pressure**

No.	Cause and effect	Countermeasure
1	Dirty filter.	Clean.
2	Dirty guide vane at outlet of compressor.	Clean.
3	Leak from intake piping.	Repair.
4	Leak of exhaust gas.	Repair.
5	High intake air temperature.	(a) Make thermal insulation of exhaust pipe complete. (b) Intake the air from outside the combustion chamber. (c) Clean intercooler.
6	Drop in air pressure in engine room.	Open the door or provide atmosphere intake duct.
7	Broken seal ring.	Replace.
8	Broken turbine impeller.	Replace.
9	Broken nozzle ring.	Replace.
10	Dirty turbine impeller.	Clean.
11	Clogged nozzle.	Clean.
12	Clogged exhaust pipe.	Clean.
13	Too high back pressure.	Clean or change the piping.
14	Wrong reading of pressure gage.	Replace.

(II) Increased intake pressure

No.	Cause and effect	Countermeasure
1	Exhaust gas leak.	Carry out remote of T/C.
2	Failure in fuel injection system.	(a) Inspect and adjust the injection timing. (b) Disassemble and inspect the injection pump, and repair or replace faulty parts. (c) Disassemble and inspect the injection valve, and repair or replace faulty parts.
3	Deformed turbine nozzle.	Replace.
4	Dirty turbine side.	Clean.
5	Increase in load (over loading).	Reduce the load.
6	Wrong reading of pressure gage.	Replace.

3. Troubleshooting

(III) Abnormal vibration

No.	Cause and effect	Countermeasure
1	Broken turbine impeller.	Replace.
2	Broken compressor impeller.	Replace.
3	Deposit of oxidized deposit on turbine impeller.	Remove and repair or replace.
4	Broken bearing.	Replace.
5	Bent turbine shaft.	Replace.
6	Loose fixed parts.	Tighten.

(IV) Noise

No.	Cause and effect	Countermeasure
1	Damaged bearing.	Replace.
2	Contact by revolving parts.	Repair or replace.
3	Dirty or carbon deposit on turbine and compressor.	Clean.
4	Invasion by foreign matter (at turbine entrance).	Repair or replace.
5	Rapid change in load (surging).	Stabilize the load or replace turbine nozzle.

(V) Quick contamination of lubrication oil

No.	Cause and effect	Countermeasure
1	Gas invasion into bearing chamber.	Repair.
2	Clogged seal air path.	Clean.
3	Damaged seal ring.	Replace.
4	Clogged pressure balance path.	Clean.

(VI) Pulsation of intake air pressure

No.	Cause and effect	Countermeasure
1	Uneven cylinder combustion.	Adjust for uniform combustion.
2	Rapid change in load.	Operate correctly.
3	Excessively dirty compressor side.	Clean.
4	Too high intake air temperature.	(a) Clean cooling fin. (b) Make thermal insulation of exhaust pipe complete. (c) Provide the air from outside of engine room.

(VII) Others

No.	Cause and effect	Countermeasure
1	Bearing seizure.	Replace.
2	Water leak from exhaust opening.	Replace.
3	Corrosion in compressor/turbine impeller or bearing housing.	Increase the coolant temperature.

3.3 Troubleshooting (Concerning engine and fuel injection equipment)

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

3. Troubleshooting

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

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

3.4 Troubleshooting by measuring compression pressure

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

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

In other words, the pressure drops due to increased parts wear and reduced durability resulting from long use of the engine.

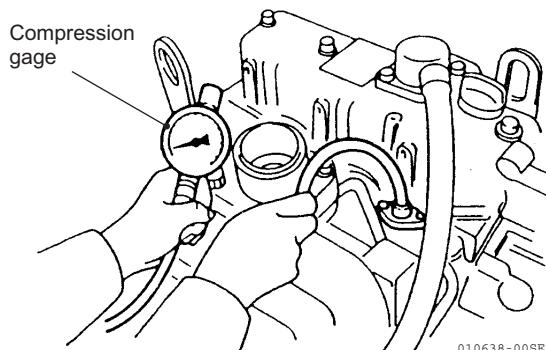
A pressure drop may also be caused by scratched cylinder or piston by dust entrance from the dirty air cleaner element or worn or broken piston ring. Measure the compression pressure to diagnose presence of any abnormality in the engine.

(1) Compression pressure measurement method

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

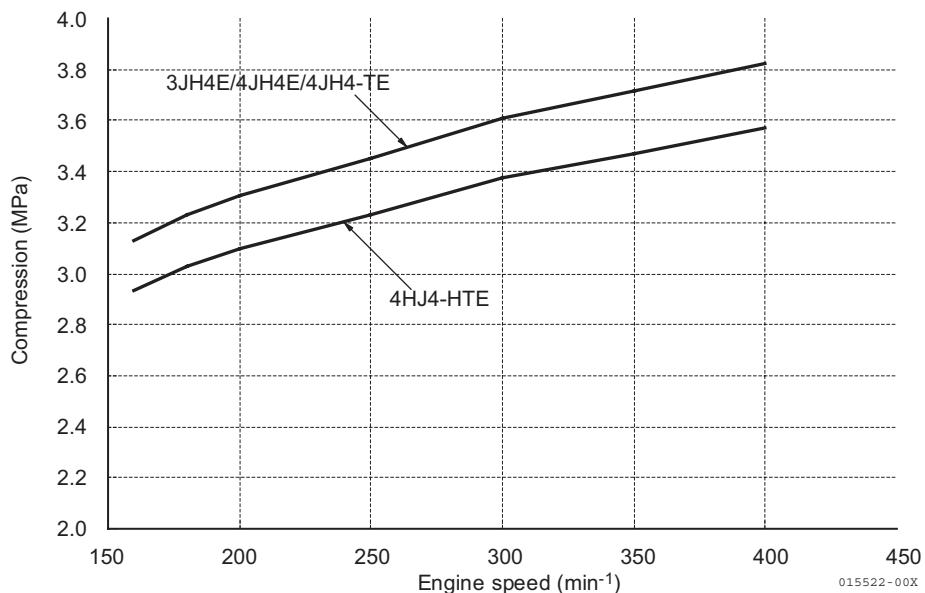
(2) Standard compression pressure

Engine compression pressure list (reference value)



Model	Compression pressure at 250 min ⁻¹ MPa (kgf/cm ²)	Deviation among cylinders MPa (kgf/cm ²)
	Standard	
3JH4E/ 4JH4E/ 4JH4-TE	3.4 ± 0.1 (35 ± 1)	0.2 to 0.3 (2 to 3)
4JH4-HTE	3.2 ± 0.1 (32 ± 1)	

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



(4) Measured value and troubleshooting

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

No.	Item	Cause	Corrective action
1	• Air cleaner element	• Clogged element • Broken element • Defect at element seal portion	• Clean the element. • Replace the element.
2	• Valve clearance	• Excessive or no clearance	• Adjust the valve clearance. (See 2.2.6(7) in Chapter 2.)
3	• Valve timing	• Incorrect valve clearance	• Adjust the valve clearance. (See 2.2.6(7) in Chapter 2.)
4	• Cylinder head gasket	• Gas leak from gasket	• Replace the gasket. • Retighten the cylinder head bolts to the specified torque. (See 14.1 in Chapter 14.)
5	• Intake/exhaust vale • Valve seat	• Gas leak due to worn valve seat or foreign matter trapping • Sticking valve	• Lap the valve seat. (See 5.2.2 in Chapter 5.) • Replace the intake/exhaust valve.
6	• Piston • Piston ring • Cylinder	• Gas leak due to scratching or wear	• Perform honing and use an oversized part.

4. Disassembly and reassembly

4.1 Disassembly and reassembly precautions

(1) Disassembly

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

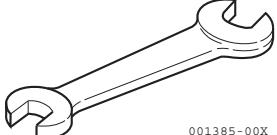
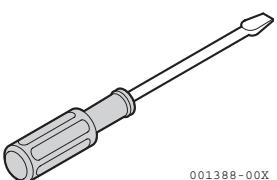
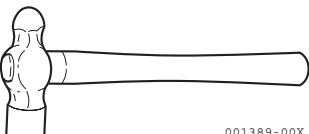
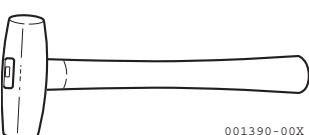
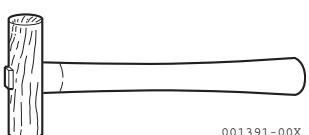
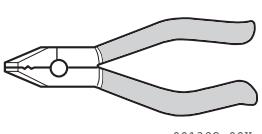
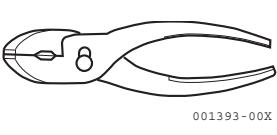
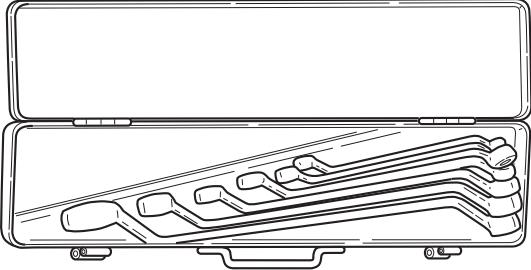
(2) Reassembly

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

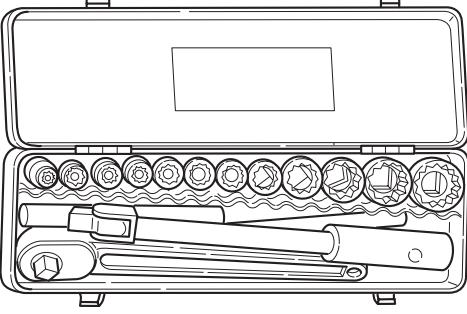
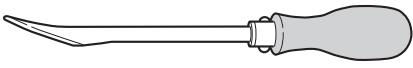
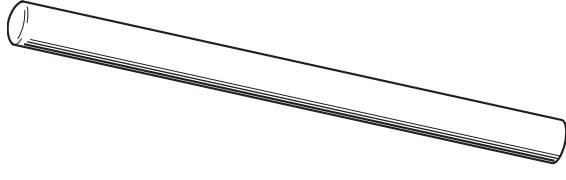
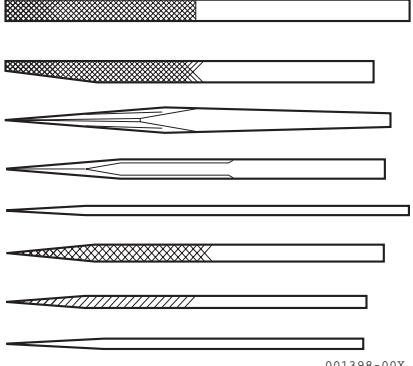
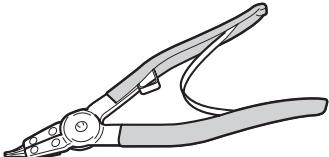
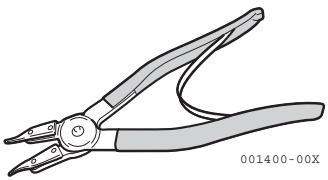
4.2 Disassembly and reassembly tools

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

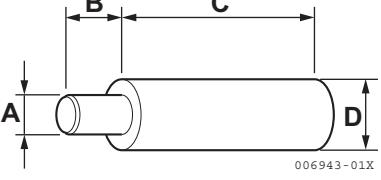
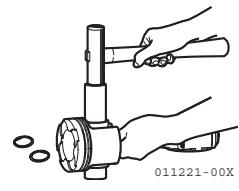
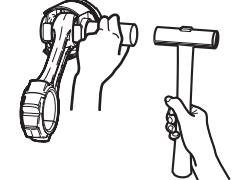
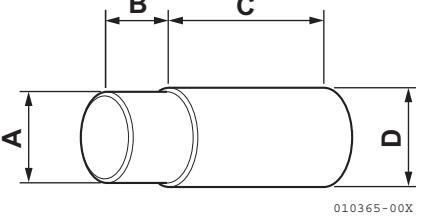
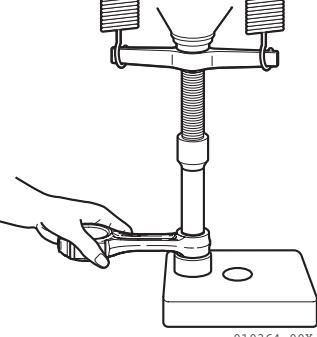
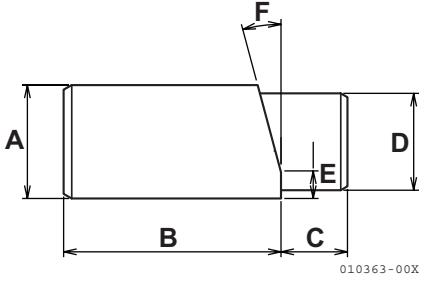
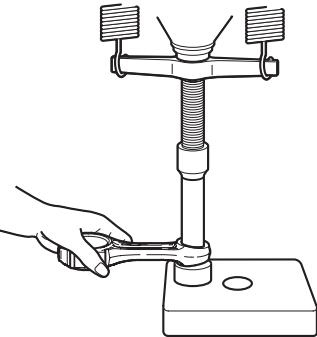
4.2.1 General hand tools

Name of tool	Illustration	Remarks
Wrench	 001385-00X	Size: 10 x 13 12 x 14 17 x 19 22 x 24
Screwdriver	 001388-00X	
Steel hammer	 001389-00X	Local supply
Copper hammer	 001390-00X	Local supply
Mallet	 001391-00X	Local supply
Nippers	 001392-00X	Local supply
Pliers	 001393-00X	Local supply
Offset wrench	 001394-00X	Local supply 1 set

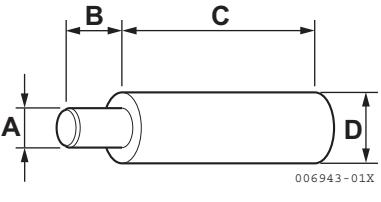
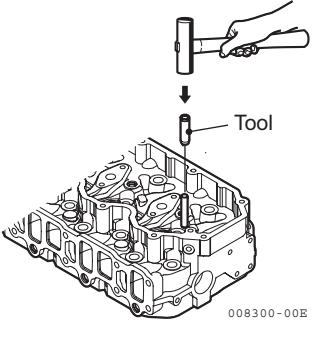
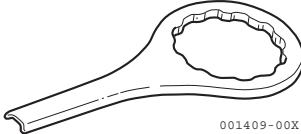
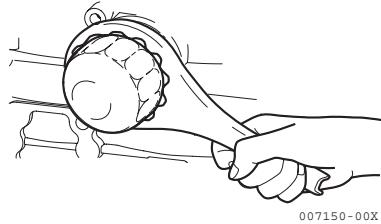
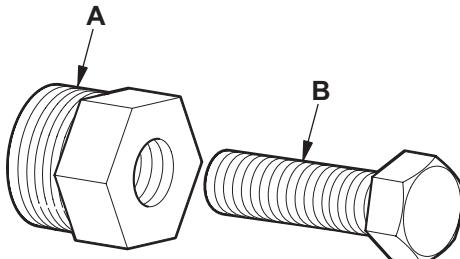
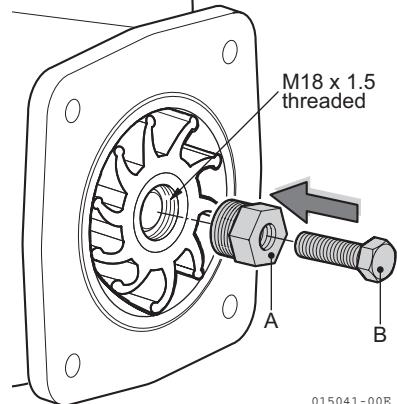
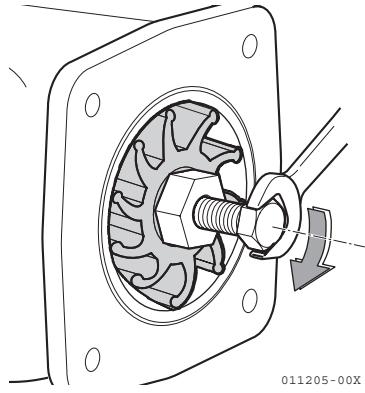
4. Disassembly and reassembly

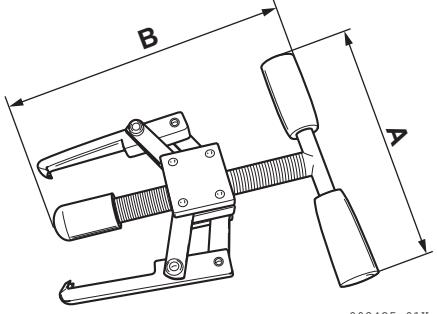
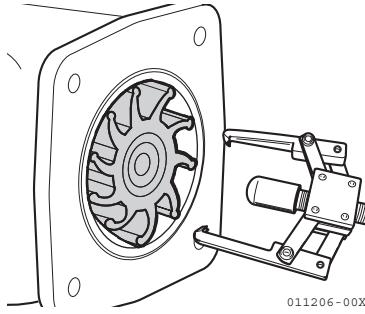
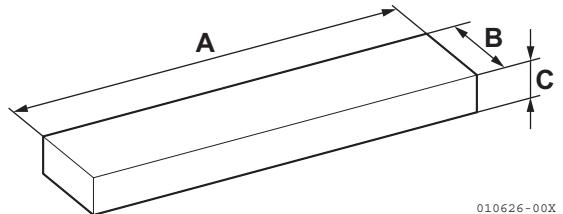
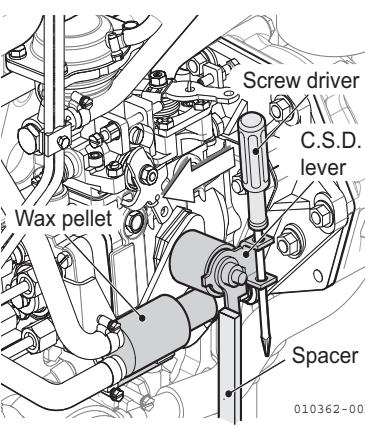
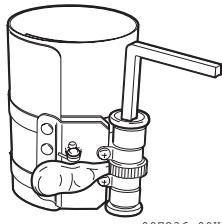
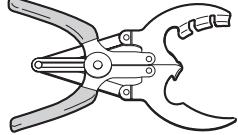
Name of tool	Illustration	Remarks
Box spanner	 001395-00X	Local supply 1 set
Scraper	 001396-00X	Local supply
Lead rod	 001397-00X	Local supply
File	 001398-00X	Local supply 1 set
Rod spanner for hexagon socket head screws	 001399-00X	Local supply Size: 6 mm 8 mm 10 mm
Starriing pliers Hole type Shaft type	 S - 0	Local supply
	 H4 - H8 S = Hole type H = Shaft type 001400-00X	

4.2.2 Special hand tools

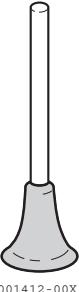
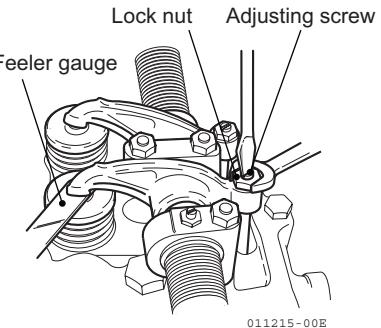
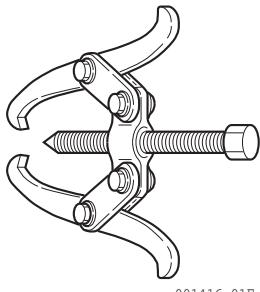
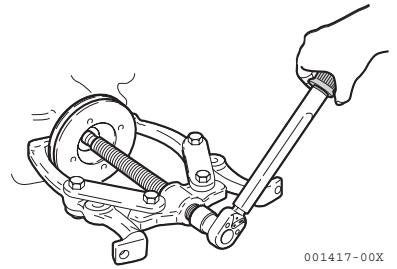
Name of tool	Illustration	Remarks												
Piston pin insertion/extraction tool	 <p>006943-01X</p> <p>mm</p> <table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> </tr> </thead> <tbody> <tr> <td>12</td> <td>20</td> <td>80</td> <td>25</td> </tr> </tbody> </table>	A	B	C	D	12	20	80	25	<p>Extraction of piston pin</p>  <p>011221-00X</p> <p>Insertion of piston pin</p>  <p>011222-00X</p>				
A	B	C	D											
12	20	80	25											
Connecting rod small end bushing insertion/extraction tool for 3JH4E / 4JH4TE	 <p>010365-00X</p> <p>mm</p> <table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> </tr> </thead> <tbody> <tr> <td>25.4-25.7</td> <td>20</td> <td>80</td> <td>28.4-28.7</td> </tr> </tbody> </table>	A	B	C	D	25.4-25.7	20	80	28.4-28.7	<p>Extraction</p>  <p>010364-00X</p>				
A	B	C	D											
25.4-25.7	20	80	28.4-28.7											
Connecting rod small end bushing insertion/extraction tool for 4JH4-TE / 4JH4-HTE	 <p>010363-00X</p> <table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> </tr> </thead> <tbody> <tr> <td>31^{-0.2}_{-0.5}</td> <td>80</td> <td>20</td> <td>28^{-0.45}_{-0.48}</td> <td>45±0.5</td> <td>9°±30°</td> </tr> </tbody> </table>	A	B	C	D	E	F	31 ^{-0.2} _{-0.5}	80	20	28 ^{-0.45} _{-0.48}	45±0.5	9°±30°	<p>Extraction</p>  <p>001404-00X</p>
A	B	C	D	E	F									
31 ^{-0.2} _{-0.5}	80	20	28 ^{-0.45} _{-0.48}	45±0.5	9°±30°									

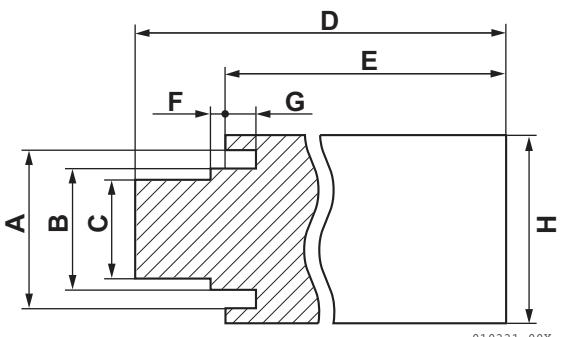
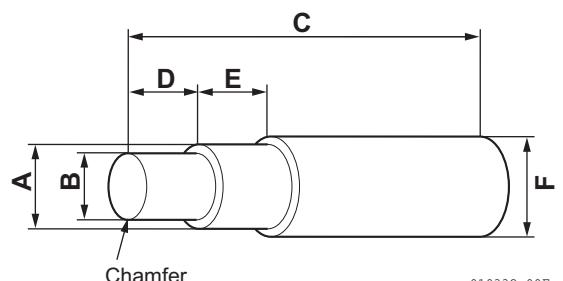
4. Disassembly and reassembly

Name of tool	Illustration	Remarks								
Intake and exhaust valve guide insertion/extraction tool	 <p style="text-align: center;">mm</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> </tr> <tr> <td>7.5</td> <td>20</td> <td>75</td> <td>11</td> </tr> </table>	A	B	C	D	7.5	20	75	11	 <p>Tool</p> <p>008300-00E</p>
A	B	C	D							
7.5	20	75	11							
Lube oil filter case remover	 <p>001409-00X</p>	 <p>007150-00X</p>								
Puller A (standard) for seawater pump impeller	<p>Puller A: 129671-92110 (standard)</p>  <p>008424-04X</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <th>A</th> <th>B</th> </tr> <tr> <td>M18 x 1.5</td> <td>M10-length 40 mm</td> </tr> </table>	A	B	M18 x 1.5	M10-length 40 mm	 <p>M18 x 1.5 threaded</p> <p>A</p> <p>B</p> <p>015041-00E</p>  <p>011205-00X</p>				
A	B									
M18 x 1.5	M10-length 40 mm									

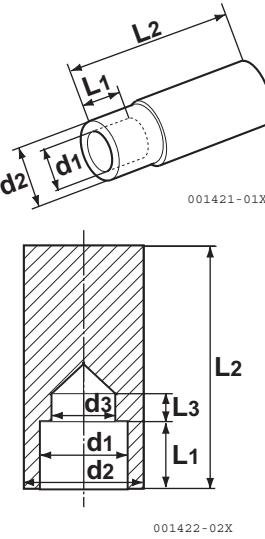
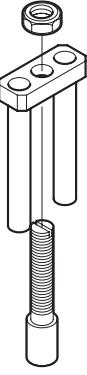
Name of tool	Illustration	Remarks						
Puller B (option) for seawater pump impeller	<p>Puller B: 129671-92100 (option)</p>  <table border="1"> <tr> <td>A</td> <td>B</td> </tr> <tr> <td>Around 110</td> <td>Around 140</td> </tr> </table>	A	B	Around 110	Around 140			
A	B							
Around 110	Around 140							
C.S.D. cancel spacer for the adjustment of fuel injection timing	<p>Spacer: 129671-51990</p>  <table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> </tr> <tr> <td>(150)</td> <td>(20)</td> <td>7.5 ± 0.1</td> </tr> </table>	A	B	C	(150)	(20)	7.5 ± 0.1	
A	B	C						
(150)	(20)	7.5 ± 0.1						
Piston ring compressor								
Piston ring replacer (for removal / insertion of piston ring)								

4. Disassembly and reassembly

Name of tool	Illustration	Remarks
Valve lapping tool (Rubber cap type)	 001412-00X	
Valve lapping powder	 001413-00X	
Feeler gauge	 001414-00X	 011215-00E
Pulley puller	Local supply  001416-01E	Removing the coupling  001417-00X

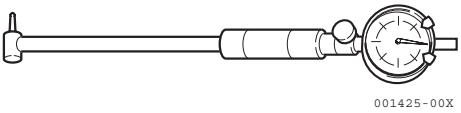
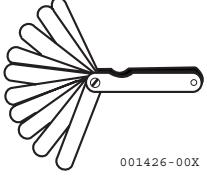
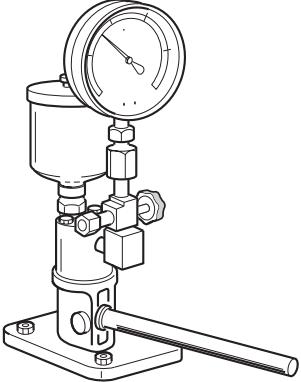
Name of tool	Illustration	Remarks																
Press tool 1 for filler neck	<p>Tool 1</p>  <p style="text-align: center;">mm</p> <table border="1"> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> <th>G</th> <th>H</th> </tr> <tr> <td>ø35.5</td> <td>ø27.5</td> <td>ø25</td> <td>105</td> <td>89</td> <td>1</td> <td>2</td> <td>ø40</td> </tr> </table>	A	B	C	D	E	F	G	H	ø35.5	ø27.5	ø25	105	89	1	2	ø40	-
A	B	C	D	E	F	G	H											
ø35.5	ø27.5	ø25	105	89	1	2	ø40											
Press tool 2 for filler neck copper tube	<p>Tool 2</p>  <p style="text-align: center;">mm</p> <table border="1"> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> </tr> <tr> <td>ø28</td> <td>ø24.2</td> <td>170</td> <td>30</td> <td>30</td> <td>ø30</td> </tr> </table>	A	B	C	D	E	F	ø28	ø24.2	170	30	30	ø30	-				
A	B	C	D	E	F													
ø28	ø24.2	170	30	30	ø30													

4. Disassembly and reassembly

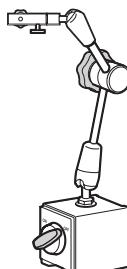
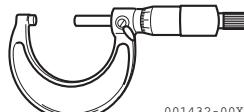
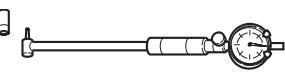
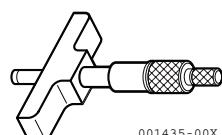
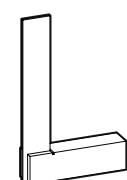
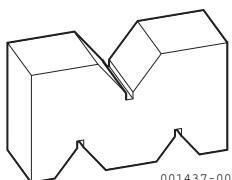
Name of tool	Illustration	Remarks												
Stem seal insertion (for inserting stem seal)	 <p style="text-align: center;">mm</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <th>d1</th> <th>d2</th> <th>d3</th> <th>L1</th> <th>L2</th> <th>L3</th> </tr> <tr> <td>16.2</td> <td>22</td> <td>13.5</td> <td>18.8</td> <td>65</td> <td>4</td> </tr> </table>	d1	d2	d3	L1	L2	L3	16.2	22	13.5	18.8	65	4	
d1	d2	d3	L1	L2	L3									
16.2	22	13.5	18.8	65	4									
Fuel nozzle extraction tool	 <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>Part No.</td> </tr> <tr> <td>129470-92300</td> </tr> </table>	Part No.	129470-92300											
Part No.														
129470-92300														

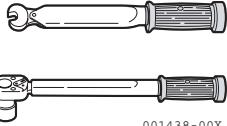
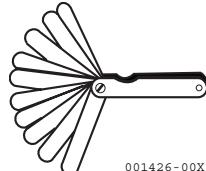
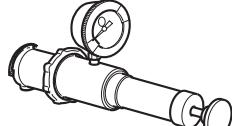
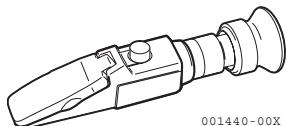
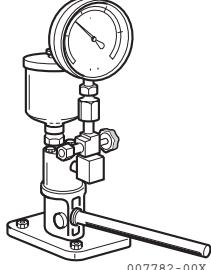
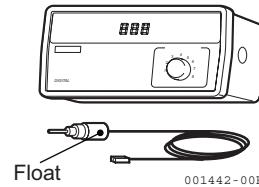
4.2.3 Measuring instruments

(1) Application of tools

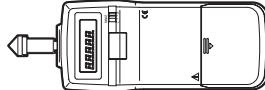
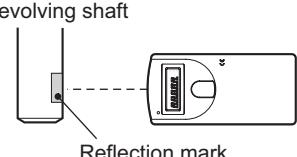
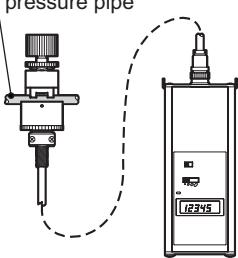
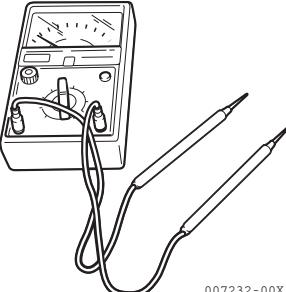
Name of tool	Illustration	Application
Vernier calipers	 001423-00X	0.05 mm 0-150 mm
Micrometer	 001432-00X	0.01 mm 0-25 mm 25-50 mm 50-75 mm 75-100 mm 100-125 mm 125-150 mm
Cylinder gauge	 001425-00X	0.01 mm 18-35 mm 35-60 mm 50-100 mm
Thickness gauge	 001426-00X	0.05-2 mm
Torque wrench	 007235-00X	128 Nm (0-13 kgf·m)
Nozzle tester	 010640-00X	0-49 Mpa (0-500 kgf/cm²)

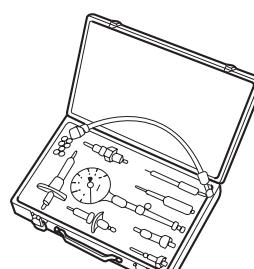
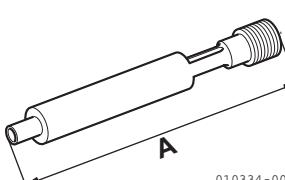
(2) Use of tools

No.	Name of tool	Use	Illustration
1	Dial gauge	Measures shaft bending, distortions of levelness, and gaps.	 001429-00X
2	Test indicator	Measures narrow and deep places, which cannot be measured with dial gauge.	 001430-00X
3	Magnetic stand	Keeps the dial gauge firmly in position, thereby permitting it to be used at various angles.	 001431-00X
4	Micrometer	Measures the outer diameter of the crank shaft, piston, piston pin, etc.	 001432-00X
5	Cylinder gauge	Measure the inner diameter of the cylinder liner and rod metal.	 001433-00X
6	Vernier calipers	Measures various outer diameter, thickness, and width.	 001434-00X
7	Depth micrometer	Measures sinking of valves.	 001435-00X
8	Square	Measures distortion in position of springs and perpendicularity of parts.	 001436-00X
9	V Block	Measures shaft distortion.	 001437-00X

No.	Name of tool	Use	Illustration
10	Torque wrench	Used to tighten bolts and nuts to standard torque.	 001438-00X
11	Thickness gauge	Measures the distance between the ring and ring groove, and between the shaft and shaft joint at time of assembling.	 001426-00X
12	Cap tester	Check for leakage in the fresh water system.	 001439-00X
13	Battery current tester	Checks density of antifreeze and charging condition of battery fluid.	 001440-00X
14	Nozzle tester	Checks the shape and pressure of spray emitted from the fuel injection valve at the time of injection.	 007782-00X
15	Digital thermostat	Measures temperature of various parts.	 001442-00E Float

4. Disassembly and reassembly

No.	Name of tool		Use	Illustration
16	Rotation gauge	Contact type	Measures rotation speed by using a reflector seal which is placed on the exterior of the revolving shaft.	 001443-00X
	Photoelectric type		Measures rotation speed by using a reflector seal which is placed on the exterior of the revolving shaft.	 Revolving shaft Reflection mark 001444-00E
	High pressure fuel pipe clamp type		Measures rotation speed without reference to revolving shaft center or the exterior of the revolving shaft.	 High pressure pipe 001445-00E
17	Circuit tester		Measure the resistance, voltage, and continuity of the electric circuit.	 007232-00X

No.	Name of tool	Use	Illustration		
18	Compression gauge	<p>Measures the pressure of the compression.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>Gauge set code No.</td> </tr> <tr> <td>TOL-97190080</td> </tr> </table>	Gauge set code No.	TOL-97190080	 001448-00X
Gauge set code No.					
TOL-97190080					
		<p>Adapter for direct injection 2-valve head.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>Adapter code No.</td> </tr> <tr> <td>119802-92950</td> </tr> </table>	Adapter code No.	119802-92950	 010334-00X
Adapter code No.					
119802-92950					
		<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>A</td> </tr> <tr> <td>130</td> </tr> </table>	A	130	
A					
130					
		<p>Adapter for direct injection 4-valve head.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>Adapter code No.</td> </tr> <tr> <td>129906-92950</td> </tr> </table>	Adapter code No.	129906-92950	 010334-00X
Adapter code No.					
129906-92950					
		<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>A</td> </tr> <tr> <td>165</td> </tr> </table>	A	165	
A					
165					

4.2.4 Other material

Items		Usual contents	Features and application
Liquid gasket	Three Bond No.1 TB1101	200 g (1 kg also available)	Non-drying liquid gasket; solvent less type, easy to remove, superior in seawater resistance, applicable to various mating surfaces.
	Three Bond No.2 TB1102	200 g (1 kg also available)	Non-drying liquid gasket; easy to apply, superior in water resistance and oil resistance, especially superior in gasoline resistance.
	Three Bond No.3 TB1103	150 g	Drying film, low viscosity and forming of thin film, appropriate for mating surface of precision parts.
	Three Bond No.4 TB1104	200 g (1 kg also available)	Semi-drying viscoelastic material, applicable to non-flat surface having many indentations and protrusions, superior in heat resistance, water resistance, and oil resistance.
	Three Bond No.10 TB1211	100 g	Solvent-less type silicone-base sealant, applicable to high temperature areas. (-50 °C to 250)
	Three Bond TB1212	100 g	Silicone-base, non-fluid type, thick application possible.
Adhesive	Three Bond TB1401	200 g	Prevention of loose bolts, gas leakage, and corrosion. Torque required to loosen bolt: 10 to 20% larger than tightening torque.
	Lock tight SUPER TB1324	50 g	Excellent adhesive strength locks bolt semi-permanently.
Seal Tape		5 m round tape	Sealing material for threaded parts of various pipes. Ambient temperature range: -150 °C to 200 °C
O-ring kit		Ø1.9 x 2 m: 1 Ø2.4 x 2 m: 1 Ø3.1 x 2 m: 1 Ø3.5 x 2 m: 1 Ø5.7 x 2 m: 1	O-ring of any size can be prepared, whenever required. (Including adhesive, release agent, cutter, and jig)
EP lubricant (molybdenum disulfate)	Brand name (LOWCOL PASTE)	50 g	For assembly of engine cylinders, pistons, metals shafts, etc. Spray type facilitates application work.
	Brand name (PASTE SPRAY)	330 g	
	Brand name (MOLYPASTE)	50 g	Prevention of seizure of threaded parts at high temperature. Applicable to intake and exhaust valves. (stem, guide, face)

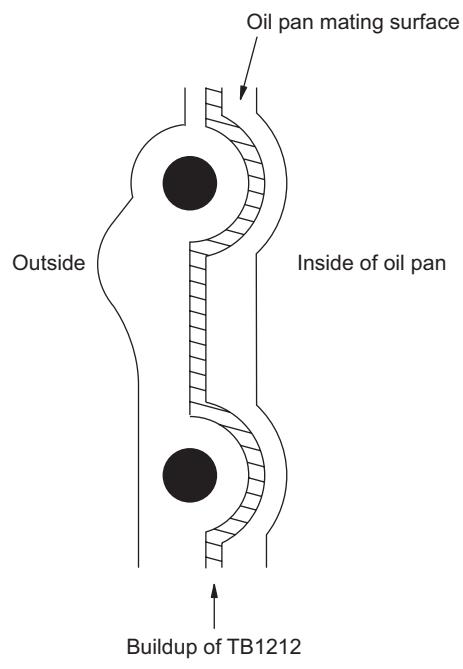
Items		Usual contents	Features and application
Scale solvent	Scale solvent	1 box (4 kg x 4 removers)	<ul style="list-style-type: none"> The scale solvent removes scale in a short time. (1 to 10 hours) Prepare water (seawater is possible) in an amount that is about 10 times the weight of the solvent. Mix the solvent with water. Just dipping disassembled part into removes scale.
	Neutralizer (caustic soda)	1 box (2 kg x 4 neutralizers)	To shorten removal time, stir remover mixture.
	pH test paper		<ul style="list-style-type: none"> If cleaning performance drops, replace remover mixture with new remover mixture. Neutralize used mixture, and then dispose of it. To judge cleaning performance of mixture, put pH test paper into mixture. If test paper turns red, remover mixture is still effective.
Anti freeze			Add antirust to fresh water system at the cold area to engine operate.
Cleaning agent			<ul style="list-style-type: none"> The cleaning agent removes even carbon adhering to disassembled parts. If a cleaning machine is used, prepare 4 to 6% mixture of 60° to 80° to ensure more effective cleaning.
Cleaning agent for turbocharger		4ℓ x 4 18ℓ x 1 15sets: 1, 500cc x 6	Special cleaning agent that requires no water, specially designed for blower of turbocharger and intercooler.

[NOTICE]

It is recommended that the liquid gasket of Three Bond TB1212 should be used for service work.

Before providing service, observe the cautions below:

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



001449-01E

4.3 Disassembly and reassembly

4.3.1 Disassembly

• Preparation on a boat

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

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

• Disassembling an engine in a workshop

(1) Drain seawater

- 1) Open the seawater drain cock(s) to drain the seawater.

Note:

Don't forget to open a drain cock on a clutch cooler for 4JH4E, 4JH4-TE and 4JH4-HTE.

- 2) Open the cocks for fresh water and extract the fresh water.

Note:

One drain cock is behind the belt cover only for 3JH4E and 4JH4E.

Remove the belt cover and open the cock.

Model	Drain cocks in fresh water line	Drain cocks in seawater line
3JH4E	3 cocks	2 places (1 cock and a side cover of seawater pump)
4JH4E	2 cocks	2 places (a side cover of seawater pump and 1 cock on clutch cooler)
4JH4-TE	3 cocks	Note1
4JH4-HTE	3 cocks	3 places (a side cover of seawater pump and 2 cocks on clutch cooler and intercooler) Note 1

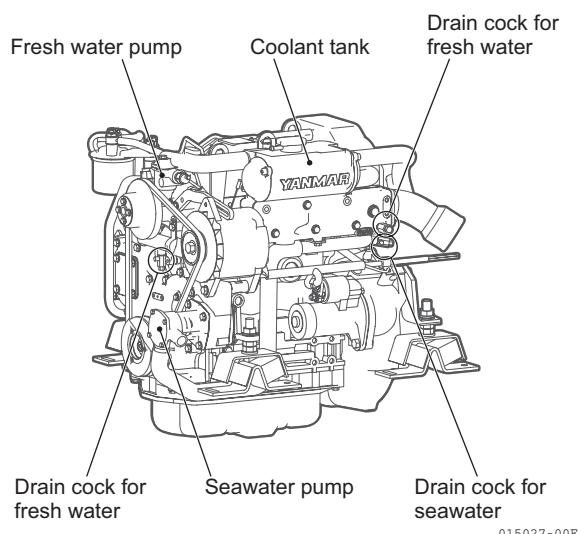
Note1:

The marine gear boxes with a drain cock of clutch cooler are as follows;

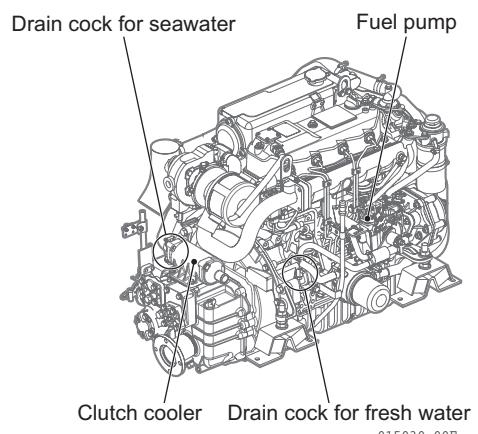
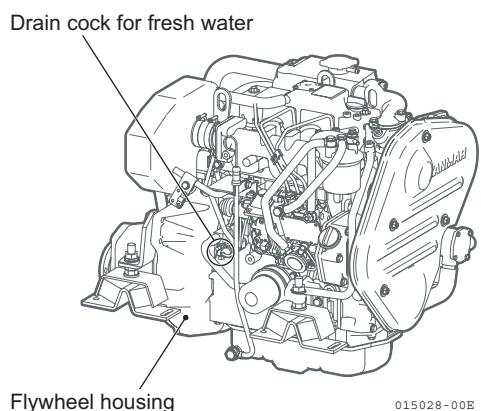
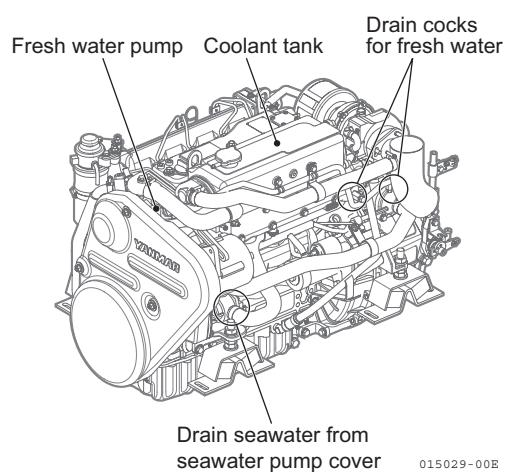
4JH4E: ZF30M, KM4A1

4JH4-TE and 4JH4-HTE: ZF30M, KM4A2, KMH4A

3JH4E

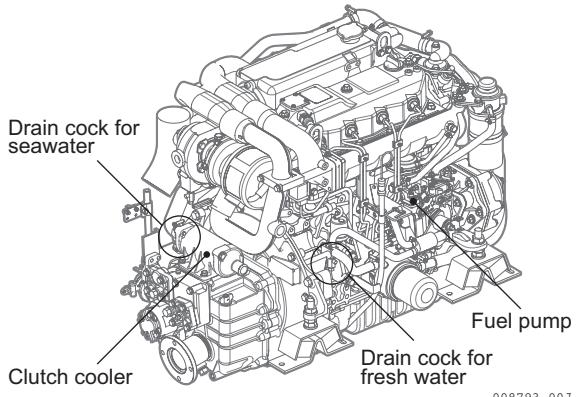
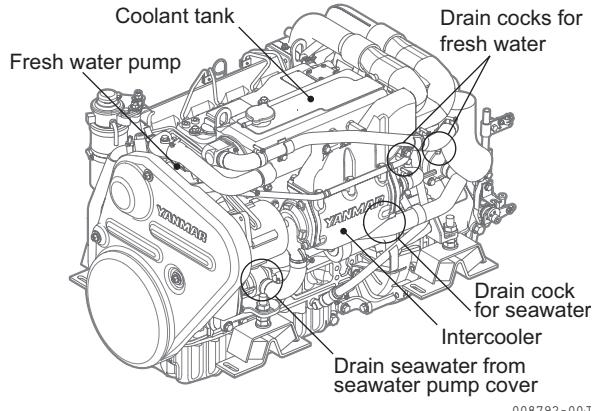


4JH4-TE



4. Disassembly and reassembly

4JH4-HTE



(2) Drain lube oil

- 1) Remove the pipe coupling bolt, which holds the lube oil dipstick guide, and drain the lube oil from the engine.

Note:

For easier draining, remove the oil filler cap (yellow) at the top of the rocker arm cover.

When not removing a oil filler cap and draining, negative pressure grows big in the crankcase and it may cause the rubber of the diaphragm cracked only for 3JH4E and 4JH4E.

- 2) Remove the drain plug on the lower part of the case, and drain the lube oil from the marine gearbox.

Note:

When using a lube oil supply / discharge pump, place the intake hose in the dipstick guide for the engine or in the oil hole on top of the marine gear case.

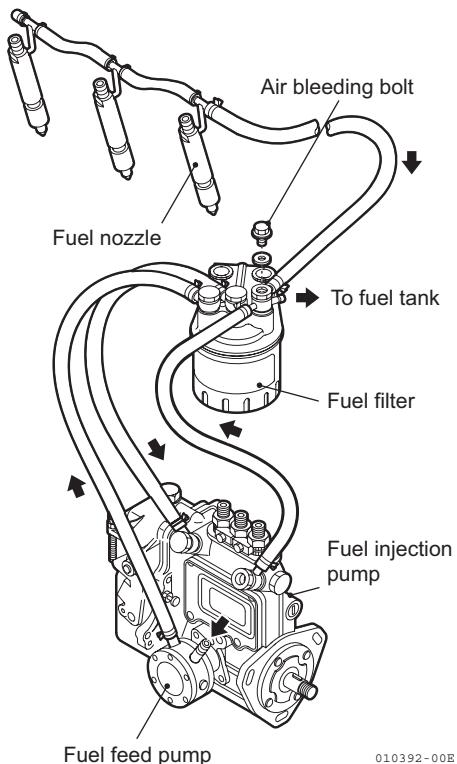
(3) Removing (electrical) wiring

Remove the wiring from the engine. (Refer to 2.2.4(12))

(4) Removing the fuel filter and fuel pipe

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

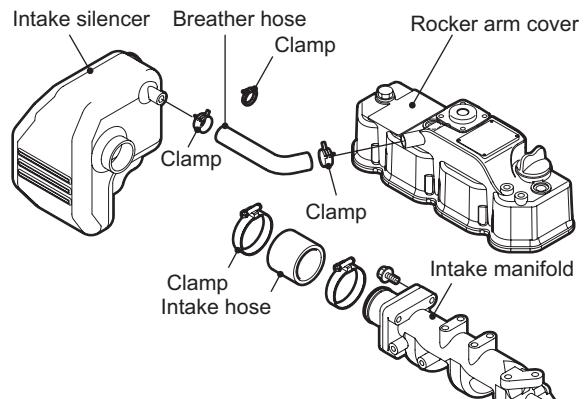
3JH4E



(5) Removing the intake silencer

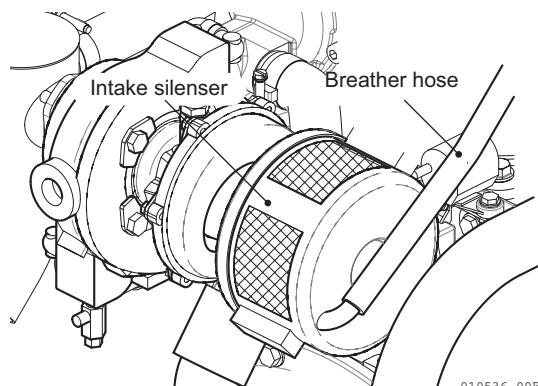
- 1) Remove the breather hose attached to the intake silencer-rocker arm cover.
- 2) Remove the intake silencer from intake manifold.

3JH4E/ 4JH4E



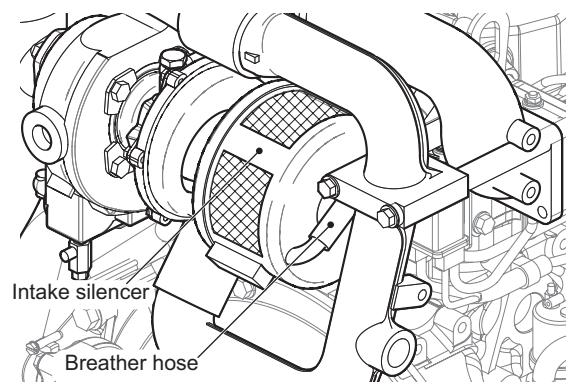
010393-00E

4JH4-TE



010536-00E

4JH4-HTE

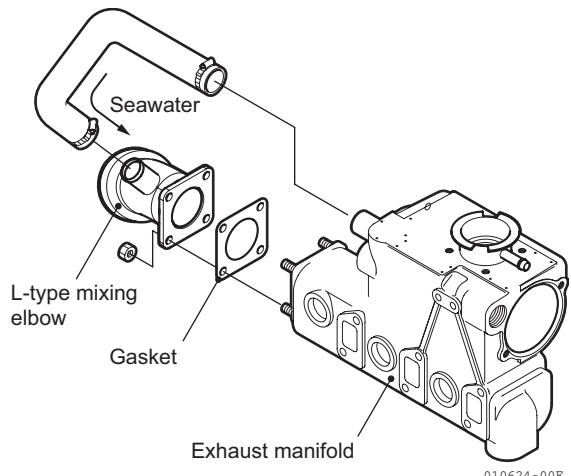


014221-00E

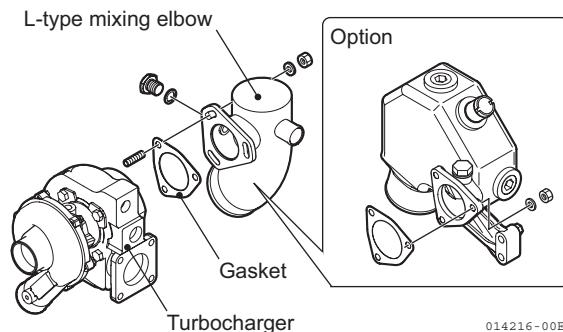
(6) Removing the mixing elbow

- 1) Remove the seawater rubber hose connecting a heat exchanger and a mixing elbow.
- 2) Remove the mixing elbow from the exhaust manifold for 3JH4E and 4JH4E or from the turbocharger for 4JH4-TE and 4JH4-HTE.

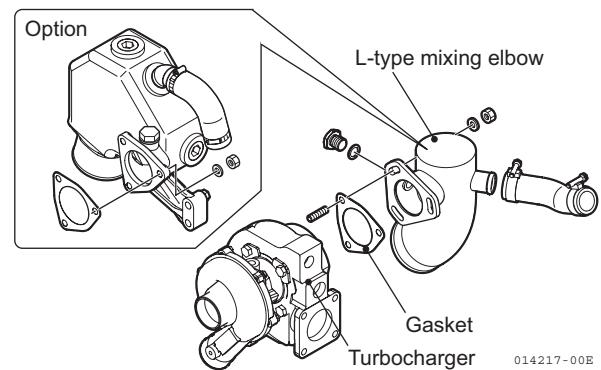
3JH4E/ 4JH4E



4JH4-TE



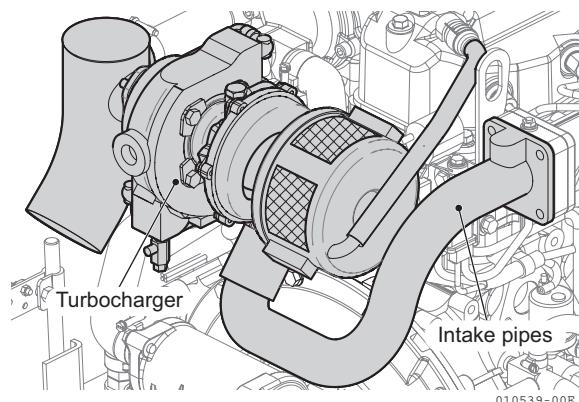
4JH4-HTE



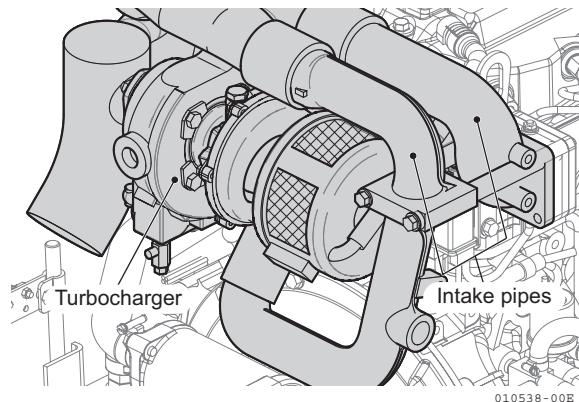
(7) Removing the turbocharger
(only for 4JH4-TE and 4JH4-HTE)

- 1) Remove the intake pipes (turbine-intercooler-intake manifold for 4JH4-HTE).
- 2) Remove the pipes and hoses for the turbine.
- 3) Remove the turbine.

4JH4-TE

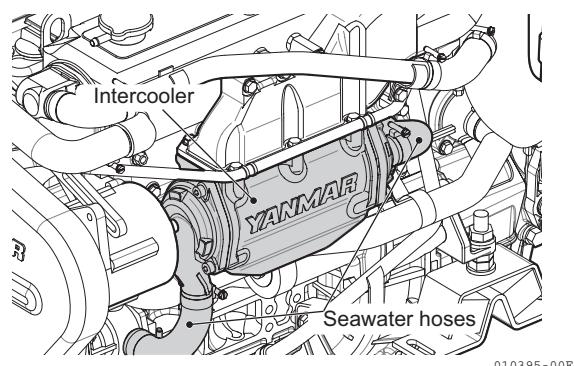


4JH4-HTE



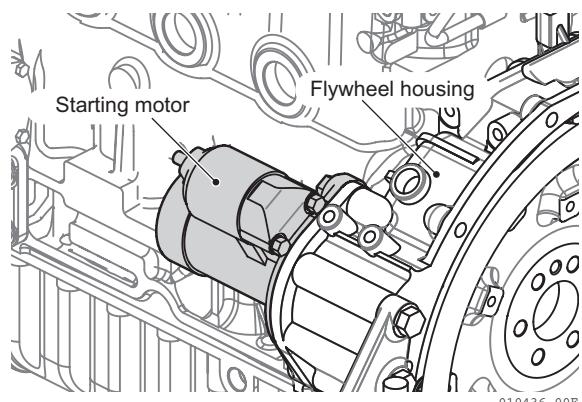
(8) Removing the intercooler
(only for 4JH4-HTE)

- 1) Remove the seawater rubber hoses.
(Heat exchanger- intercooler- lube oil cooler)
- 2) Remove the intercooler.

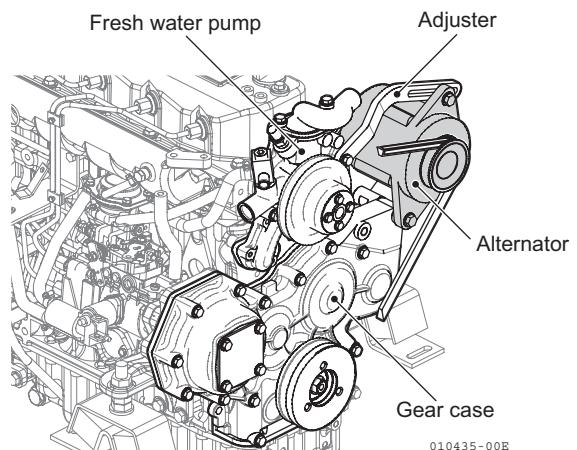


(9) Removing the starting motor

Remove the starting motor from the flywheel housing.

**(10) Removing the alternator**

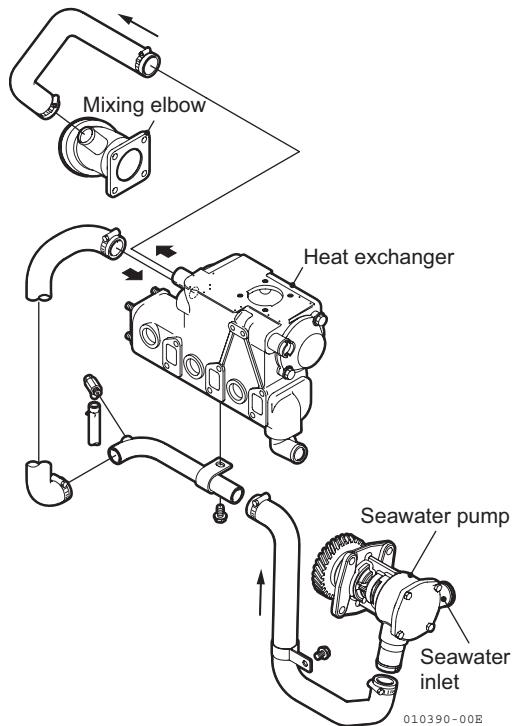
- 1) Loosen the alternator adjuster bolt and remove the V-belt.
- 2) Removing the adjuster from the fresh water pump, and remove the alternator from the gear case (with distance piece).



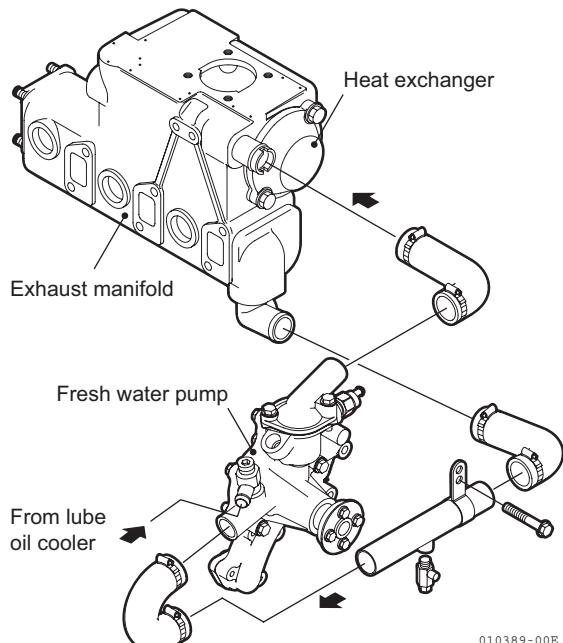
4. Disassembly and reassembly

(11) Removing the cooling water pipe (seawater/ fresh water)

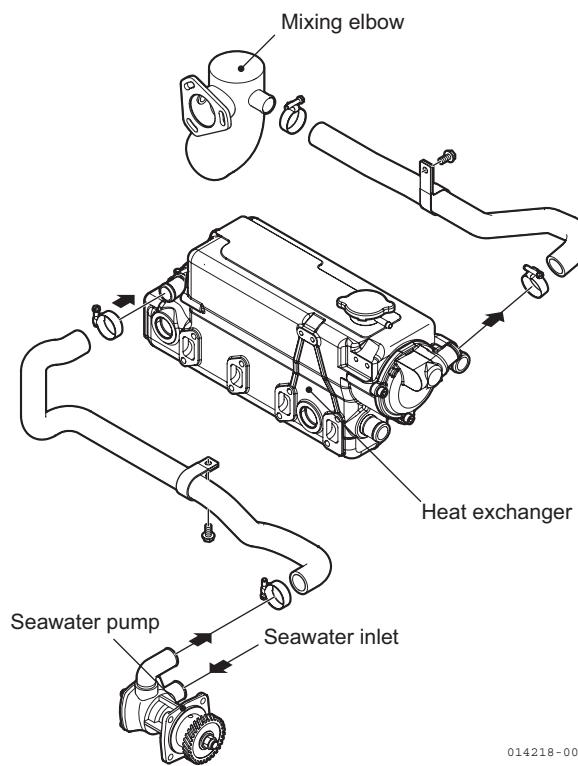
3JH4E
Seawater pipe



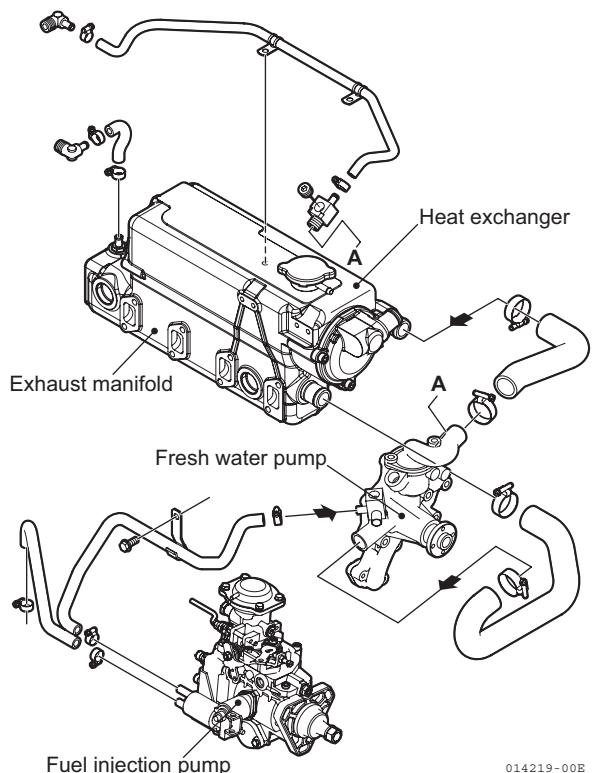
3JH4E
Fresh water pipe



4JH4-TE and 4JH4-HTE
Seawater pipe



4JH4-TE and 4JH4-HTE
Fresh water pipe



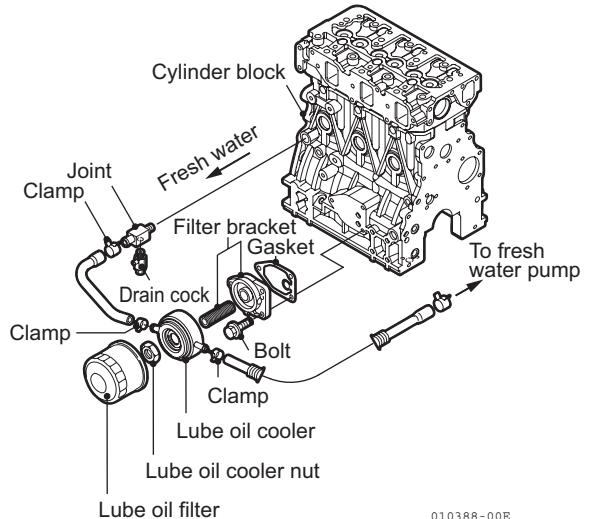
- 1) Remove the seawater pipe (seawater pump - heat exchanger).
- 2) Remove the fresh water pipe (fresh water pump - heat exchanger, exhaust manifold - fresh water pump).
- 3) Remove the fresh water pipe (cylinder block - lube oil cooler, lube oil cooler - fresh water pump).

(12) Removing the heat exchanger (exhaust manifold, fresh water tank unit)
Remove the heat exchanger and gasket packing.

(13) Removing the seawater pump
Remove the seawater pump from the gear case.

(14) Removing the lube oil filter and lube oil cooler

- 1) Remove the fresh water pipe (cylinder block - lube oil cooler, lube oil cooler outlet)
- 2) Remove the lube oil filter from the lube oil cooler.
- 3) Remove the lube oil cooler nut and lube oil cooler. Loosen the bolts for the filter bracket and remove the filter bracket.
- 4) Remove the lube oil dipstick and guide.



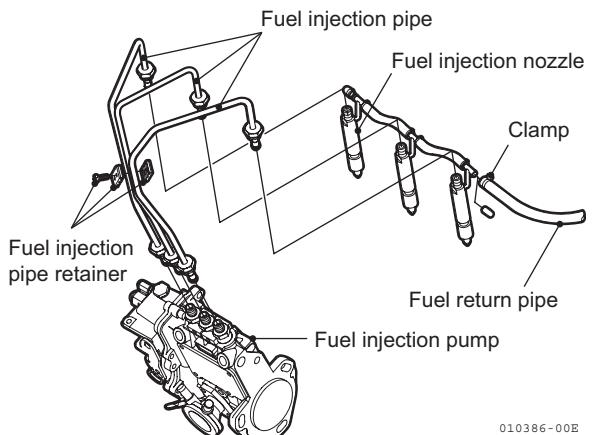
010388-00E

4. Disassembly and reassembly

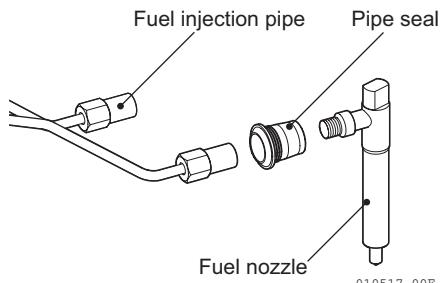
(15) Removing the fuel injection pipe

- 1) Remove the fuel injection pipe retainer.
- 2) Loosen the cap nuts on both ends of the fuel injection pipe and remove the fuel injection pipe.
- 3) Remove the fuel return pipe (fuel nozzle - fuel oil filter)

3JH4E



4JH4-TE and 4JH4-HTE

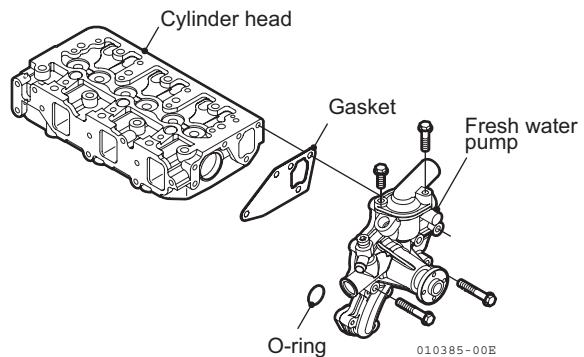


(16) Removing the intake manifold

Remove the intake manifold and gasket.

(17) Removing the fresh water pump

Remove the fresh water pump and gasket from the cylinder head.



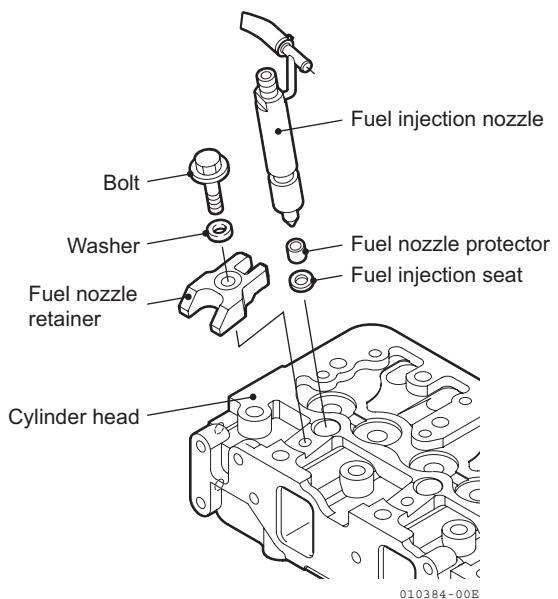
(18) Removing the fuel injection nozzles

3JH4E and 4JH4E (2-valve head)

Remove the bolt for the fuel nozzle retainer, and pull out the fuel nozzle retainer and fuel injection nozzle.

Note:

If the fuel nozzle protector stays in the cylinder head, make a note of the cylinder number and be sure to remove it when disassembling the cylinder head.



4JH4-TE and 4JH4-HTE (4-valve head)

- 1) Remove the pipe seals from rocker arm cover.

Insert a minus driver in the slit part of the rocker arm cover, and remove it.

Take off the rocker arm cover after removing the pipe seals.

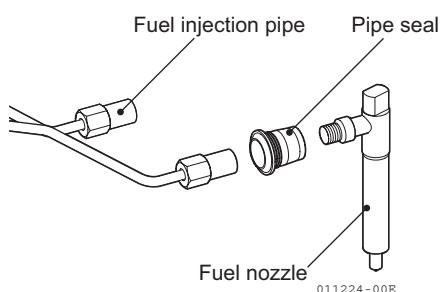
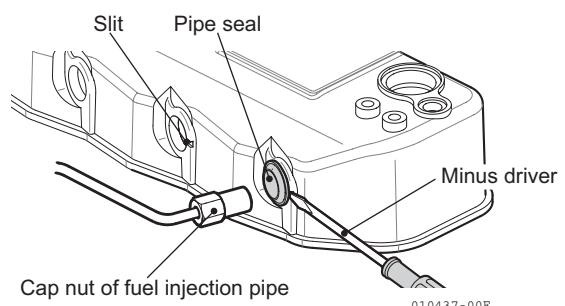
[NOTICE]

The fuel nozzles are caught in the pipe seals. The pipe seals will be damaged if the rocker arm cover is lifted with a pipe seal sticking to the rocker arm cover.

- 2) Loosen the tightening bolts on the fuel injection nozzle retainers and extract the fuel injection nozzles.

[NOTICE]

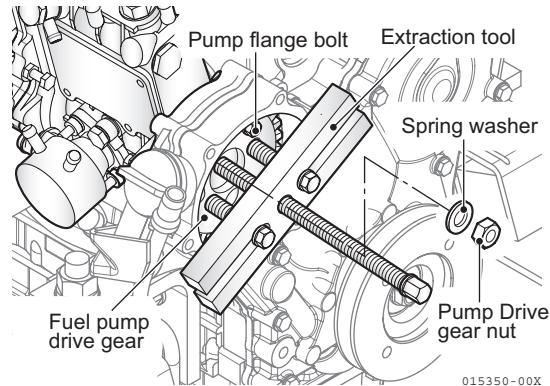
- 1) If nozzle seat is left in the cylinder head, extract the nozzle seat after removing the cylinder head from cylinder block.
- 2) Whenever extracting fuel injection nozzle, replace the used nozzle protector with a new one.



4. Disassembly and reassembly

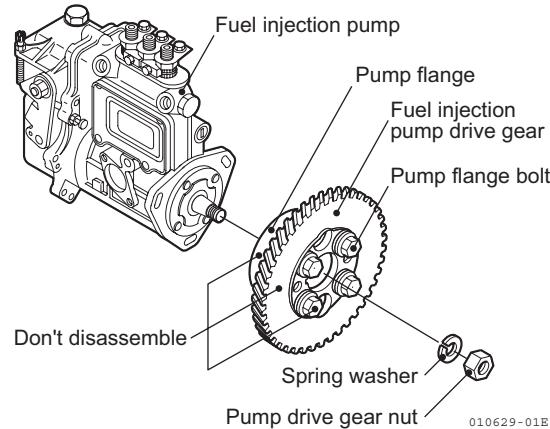
(19) Removing the fuel injection pump

- 1) Loosen the nut for fuel pump drive gear, and pull out the fuel pump drive gear/flange assembly with an extraction tool. Don't disassemble pump flange, fuel pump drive gear and pump flange bolt.



- 2) Remove the fuel injection pump and O-ring from the gear case flange. (3JH4E and 4JH4E).

Remove the fuel injection pump and O-ring from the VE pump bracket, which is fixed to the gear case flange (4JH4-TE and 4JH4-HTE).



(20) Removing the rocker arm shaft assembly

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

(21) Removing the cylinder head

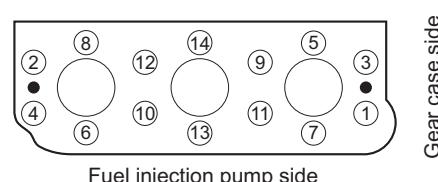
- 1) Loosen the cylinder head bolts with a torque wrench, and remove the cylinder head.

Note:

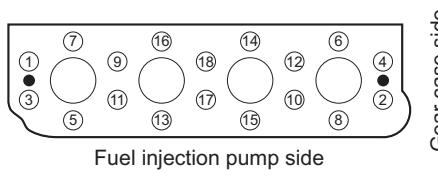
- Loosen the cylinder head bolts in two steps in the illustrated order.
- Place the cylinder head on a paper board to prevent the combustion surface from any damage.

- 2) Remove the cylinder head gasket.

Disassembly (Head bolt disassembly order)



Disassembly (Head bolt disassembly order)



(22) Removing the marine gearbox

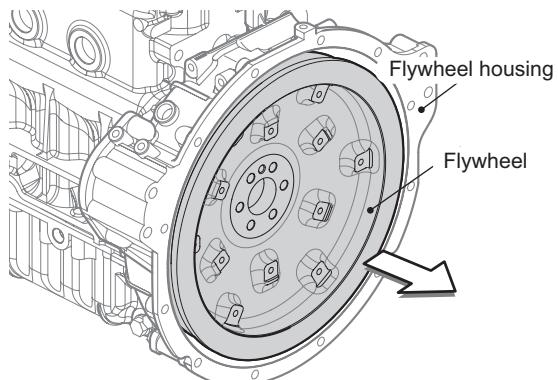
Loosen the bolts for the clutch case flange, and remove the gearbox assembly

(23) Removing the flywheel

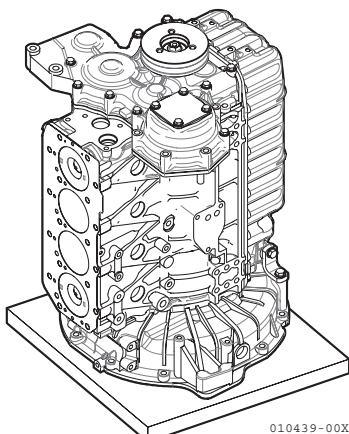
Loosen the flywheel bolts and remove the flywheel.

Note:

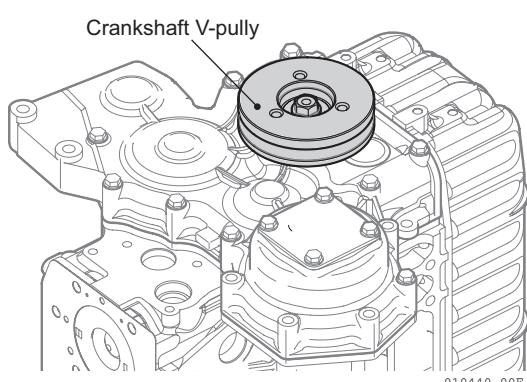
Be careful not to scratch the ring gear.

**(24) Turning the engine over**

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

**(25) Removing the crankshaft V-pulley**

Loosen the bolt tightening the crankshaft V-pulley and remove the crankshaft V-pulley with an extraction tool.

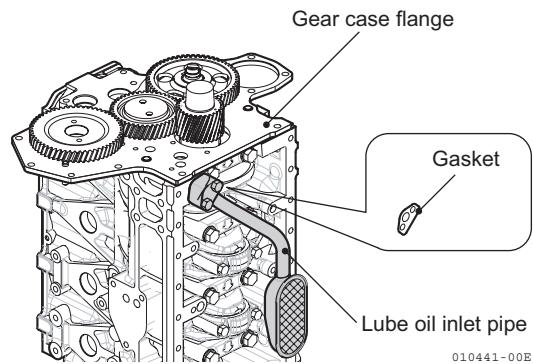
**(26) Removing the oil pan**

Remove the oil pan and spacer.

4. Disassembly and reassembly

(27) Removing the lube oil inlet pipe

Remove the lube oil inlet pipe and gasket.

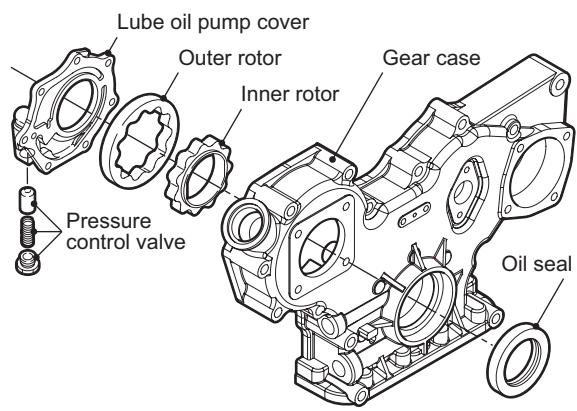


(28) Removing the gear case

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

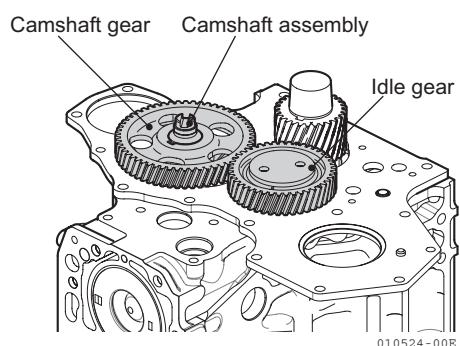
(29) Removing the lube oil pump

Remove the lube oil pump from the gear case.



(30) Removing the idle gear

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

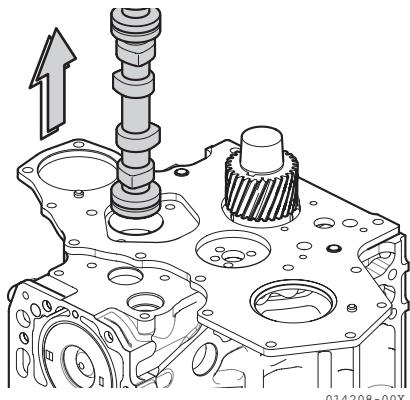


(31) Removing the camshaft

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

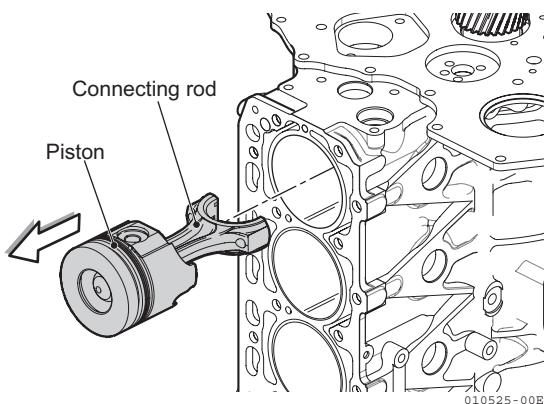
Note:

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



(32) Removing the pistons and connection rods

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

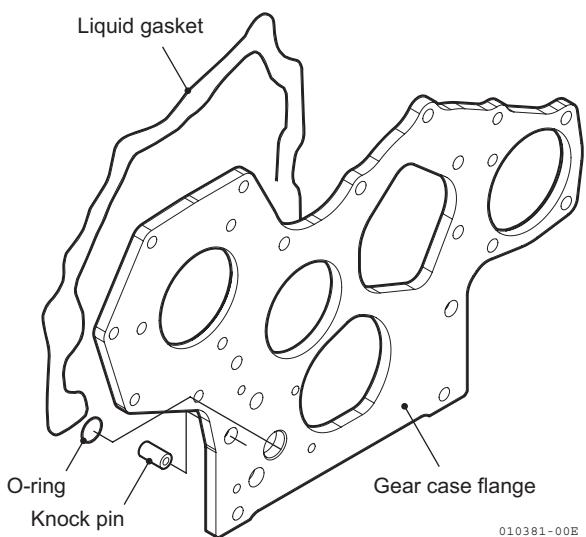


(33) Removing the gear case flange

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

Note:

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



(34) Loosening the main bearing bolts.

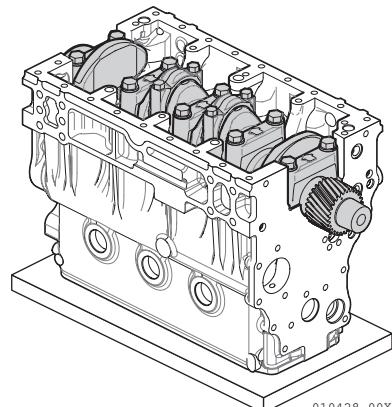
Loosen the main bearing bolts. Don't remove them yet.

(35) Turning the engine over

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

Note:

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



010428-00X

(36) Removing the flywheel housing and oil seal case

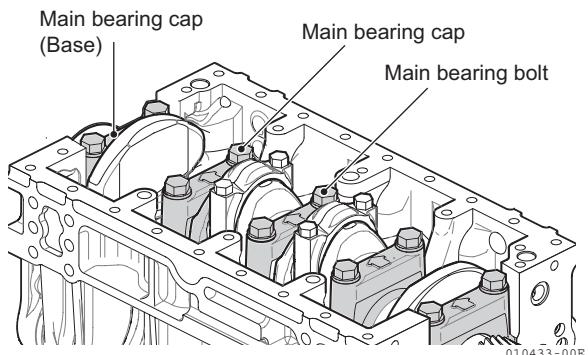
Remove the flywheel housing and oil seal case from the cylinder block.

(37) Removing the main bearing.

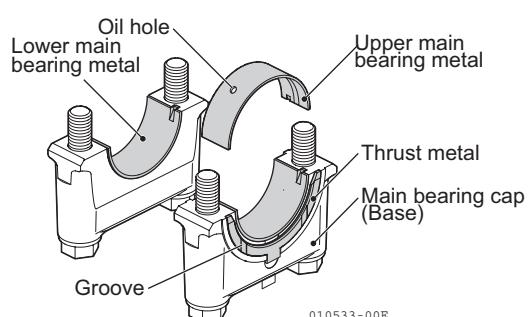
- 1) Remove the main bearing bolts.
- 2) Remove the main bearing cap and lower main bearing metal.

Note:

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



010433-00E



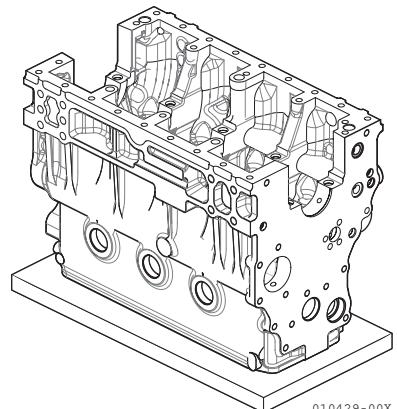
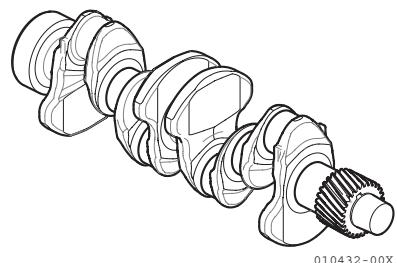
010533-00E

(38) Removing the crankshaft

- 1) Remove the crankshaft.

Note:

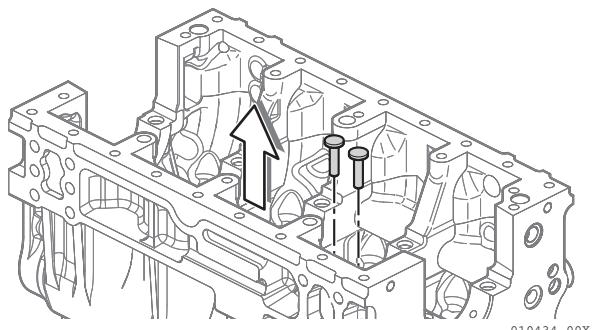
- 1) The thrust metal (upper) is mounted to the standard main bearing.
- 2) Remove the main bearing metal (upper) from the cylinder block.

**(39) Removing the tappets**

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

Note:

- 1) Be careful to keep all disassembled parts in order.
- 2) Clear and adequate area for parts and prepare a container.
- 3) Prepare a cleaner and cleaning can before disassembling start.



4.3.2 Reassembly

(1) Clean all parts

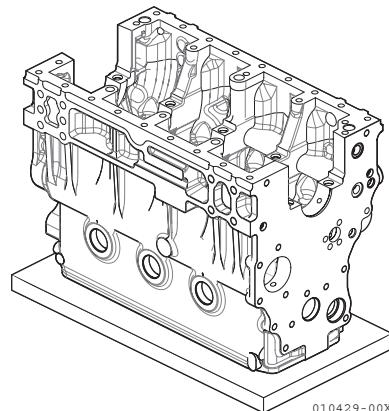
Clean all parts using by the cloth and diesel oil (or cleaning agent) before reassembly.

Note:

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

(2) Putting the cylinder block upside down

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

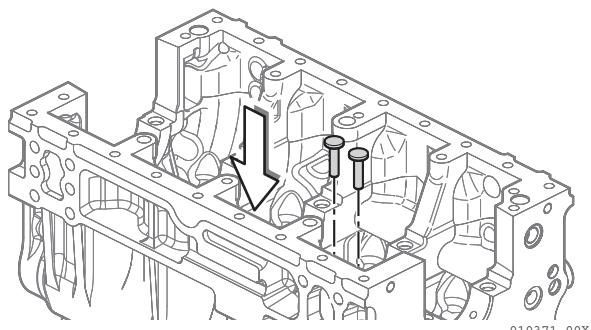


(3) Inserting the tappets

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

Note:

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



(4) Mounting the crankshaft

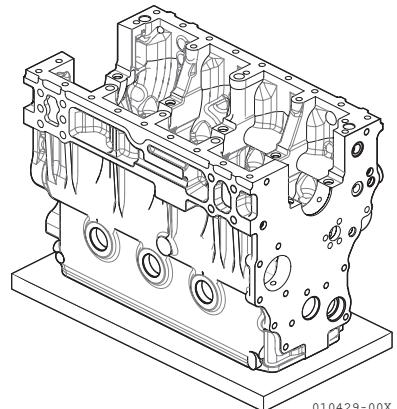
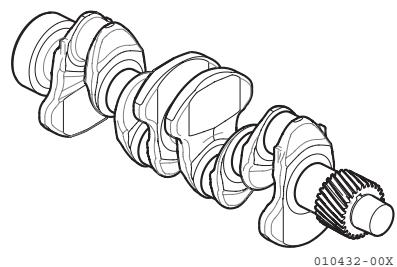
- 1) The crankshaft and the crankshaft gear are shrink-fitted. If the crankshaft and the crankshaft gear have been disassembled, they have to be shrink-fitted [heat the crank shaft gear to 180- 200 deg. C in the hot oil and press fit to the crankshaft].
- 2) Coat the crank journal part of the cylinder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

Note:

- 1) Be sure not to confuse the upper and lower main bearing metals. The upper metal has an oil groove.
- 2) When mounting the thrust metal, fit it so that the surface with the oil groove slit faces outwards, crankshaft side.
- 3) Coat the crank pins and the crank journals of the crankshaft with engine oil and place it on the upper main bearing metals.

Note:

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

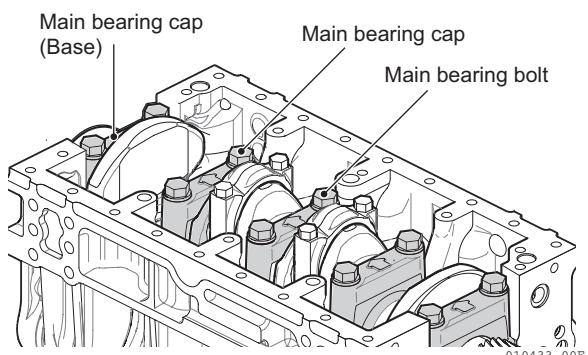


(5) Mounting the main bearing cap

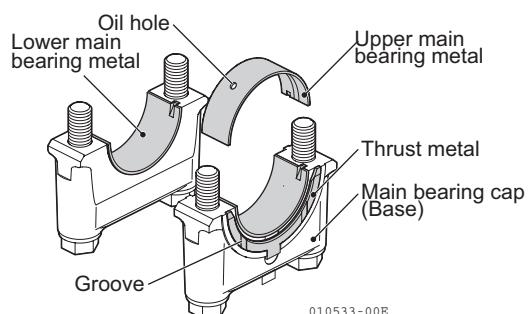
Coat the lower main bearing metal with engine oil, and mount it to the main bearing cap.

Note:

- 1) The lower main bearing metal does not have an oil hole.
- 2) The base bearing thrust metal is fitted with the oil groove facing outwards.
- 1) Coat the flange and the thread of the main bearing bolts with engine oil, put them on the crankshaft journal, and tighten the main bearing bolts to the specified torque.



Tightening torque	Nm (kgf·m)
Main bearing bolt	96-100 (9.8-10.2)



4. Disassembly and reassembly

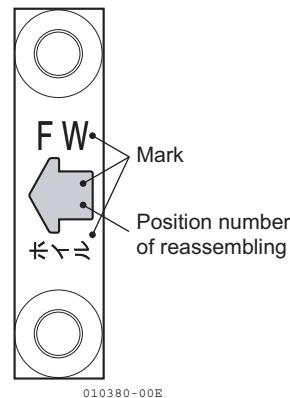
Note:

- 1) The main bearing cap should be mounted with the arrow on the cap pointing towards the flywheel.
- 2) Make sure to have the correct cylinder alignment number.
- 2) Measure the crankshaft side clearance.

mm

Crankshaft side clearance	Standard	Limit
	0.140-0.220	0.28

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



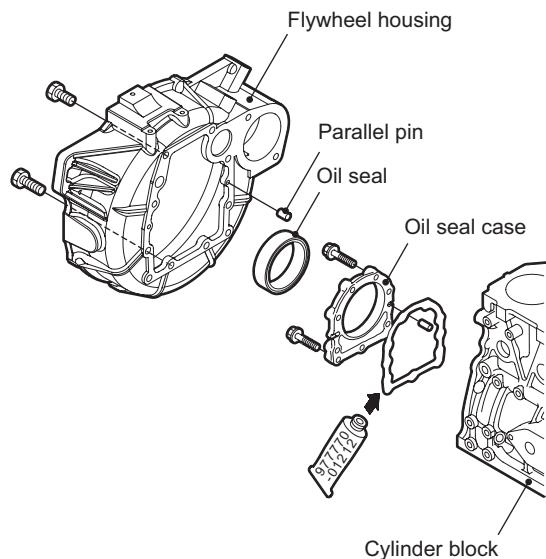
(6) Mounting the oil seal case and the flywheel housing

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

Note:

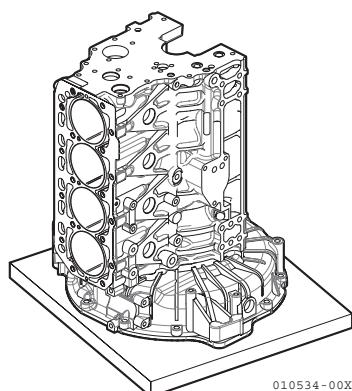
Be careful that the liquid gasket does not protrude onto the oil pan mounting surface.

- 3) Mount the flywheel housing to the cylinder block, while matching up with the cylinder block positioning pins.



(7) Turning the engine over

Stand up the engine on the flywheel housing.

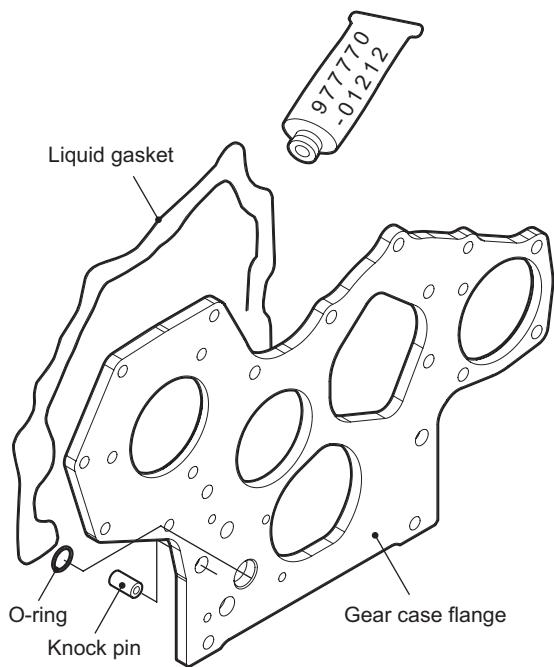


(8) Mounting the gear case flange

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

Note:

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



010378-00E

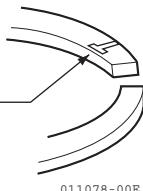
(9) Mounting the piston and connecting rod

- 1) Reassemble the piston and connecting rod.

Note:

- 1) When reassembling the piston and connecting rod, make sure that the parts are assembled with the correct orientation.
- 2) Install each piston ring on the piston, with the punched manufacturer's mark facing upward.

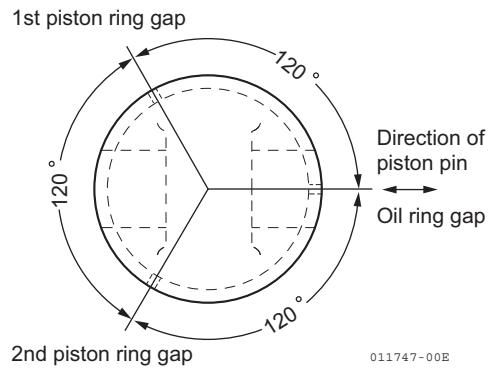
Make the punched manufacturer's mark face upward.



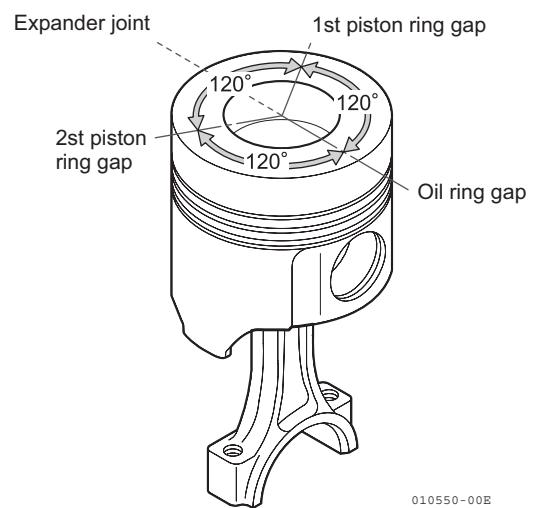
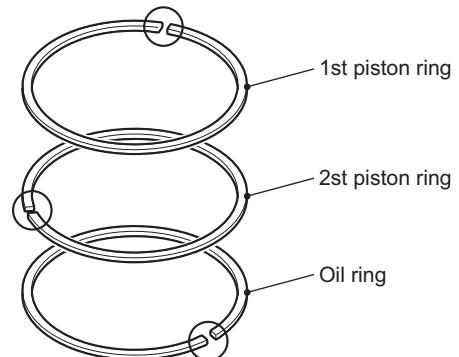
011078-00E

4. Disassembly and reassembly

- 3) The piston ring joints shall be staggered at 120° in the interval. Do not position the top ring joint vertical to the piston pin. The coil expander joint shall be opposite to the oil ring joint.



011747-00E



010550-00E

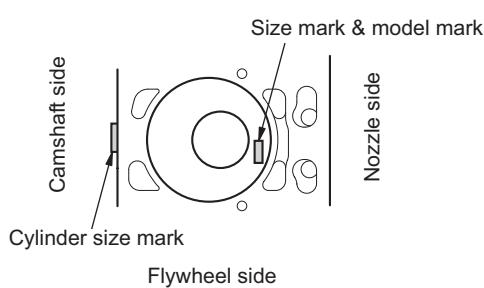
- 2) Coat the outside of the piston and the inside of the crank pin metal with engine oil and insert the piston by using the piston insertion tool.

Note:

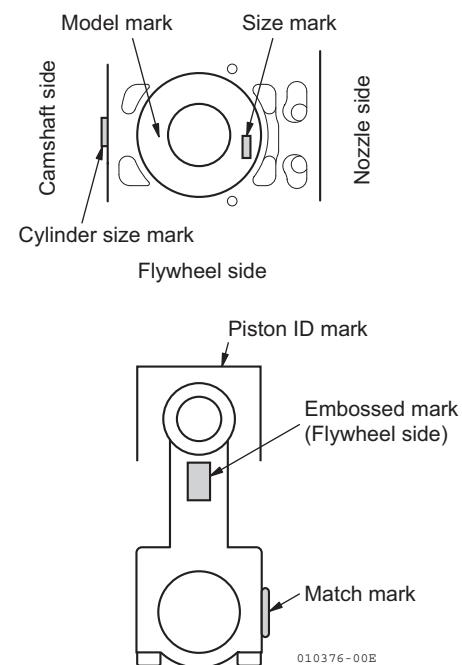
- 1) Insert the piston so that the match mark on the large end of the connecting rod faces the fuel nozzle, and the manufacturer's embossed mark on the stem faces toward the flywheel.
- 2) After inserting the piston, make sure the ID marks (size mark and model mark) on the piston top is correct, looking from the top of the piston.
- 3) When inserting the piston/connecting rod assembly to the cylinder, be careful not to hit the large end of the connecting rod with the piston cooling nozzle (4JH4-TE and 4JH4-HTE) mounted to the back of the cylinder block. The cooling nozzle may warp or be damaged.

Assembly direction of connectingrod and piston

3JH4E and 4JH4E



4JH4-TE and 4JH4-HTE



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

Tightening torque

Nm (kgf•m)

Connecting rod bolt	44.1-49.1(4.5-5.0)
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Note:

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

4. Disassembly and reassembly

(10) Mounting the camshaft

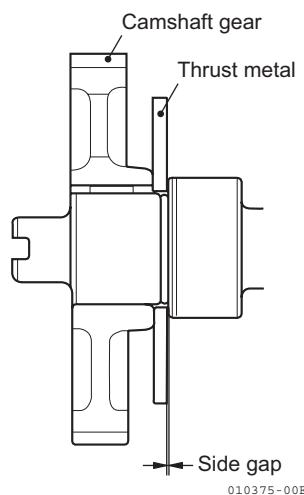
- 1) If the camshaft and the camshaft gear have been disassembled, shrink fit the camshaft and the camshaft gear [heat the camshaft gear to 180-220 deg. C in the hot oil and press fit].

Note:

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

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

Camshaft side gap	Standard	Limit
	0.05-0.20	0.30



010375-00E

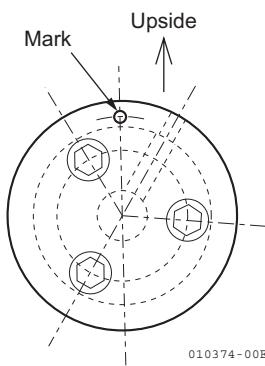
- 4) Make sure that the camshaft rotates smoothly.

(11) Mounting the idling gear

- 1) Mount the idling gear so that the oil hole of the idle gear shaft faces up.

Note:

The idle gear shaft must be mounted with the mark of the shaft upward.

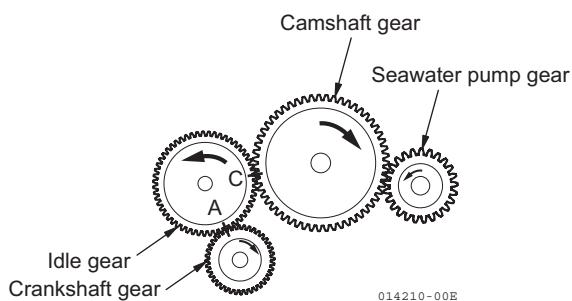


010374-00E

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

Backlash	Standard	Limit
	0.07-0.15	0.17

mm



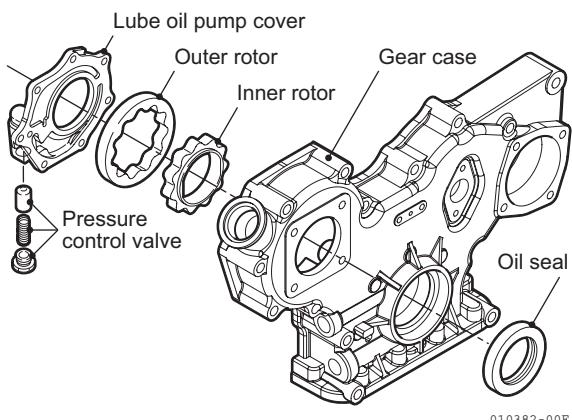
(12) Mounting the lube oil pump

Mount the lube oil pump to the gear case.

Tightening torque	Nm (kgf·m)
Flush bolt	5.4-8.4 (0.55-0.86)

Note:

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



(13) Mounting the gear case

- 1) Replace the used oil seal with new one. Coat the inside and outside of the oil seals with engine oil and press fit it into the gear case.
- 2) Apply the liquid gasket to the gear case. Position the two knock pins and tighten the bolts of the gear case.

Note:

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

(14) Mounting the lube oil inlet pipe

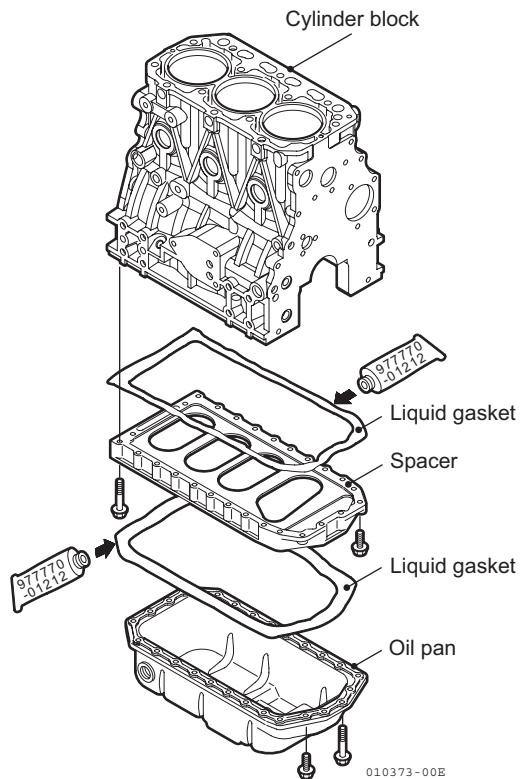
Mount the lube oil inlet pipe on the bottom of the cylinder block, using new gasket.

Tightening torque	Nm (kgf·m)
Lube oil inlet pipe	26 (2.6)

4. Disassembly and reassembly

(15) Mounting the spacer and the oil pan

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



(16) Mounting the crankshaft V-pulley

- 1) Coat the oil seal with oil.
- 2) Make sure to wipe off oil on the taper surface.
- 3) Tighten to the specified torque.

Tightening torque	Nm (kgf·m)
V-pulley bolt (Material : casting iron)	83.2-93.2 (8.48-9.50)

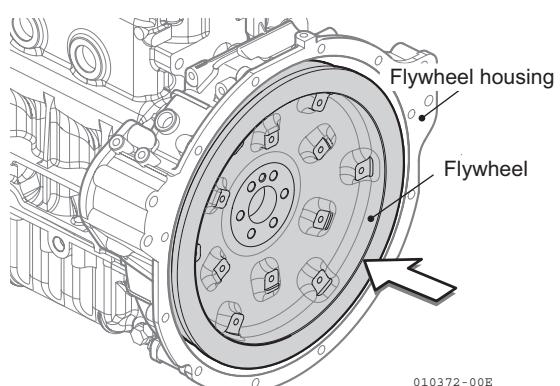
(17) Mounting the engine mounting feet and turning the engine upright.

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

(18) Mounting the flywheel

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

Tightening torque	Nm (kgf·m)
Flywheel bolt	83.3-88.3 (8.49-9.00)



(19) Mounting the marine gearbox

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

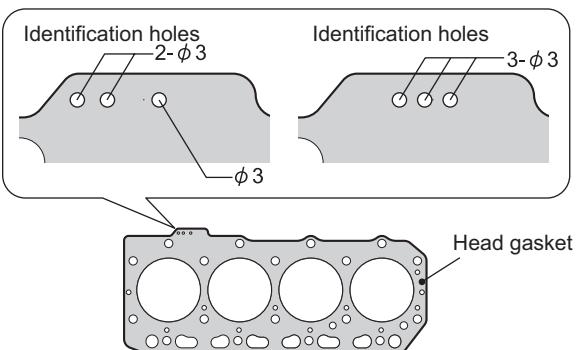
(20) Mounting the cylinder head

- 1) Put the cylinder head gasket on the cylinder block, aligning it with the cylinder block positioning pins.

Note:

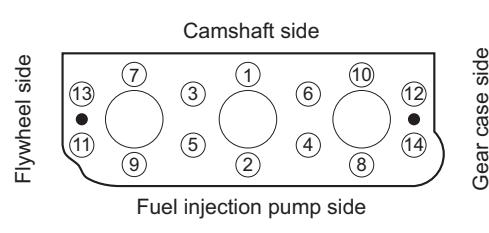
Select the proper head gasket by the holes for identifying.

4JH4E

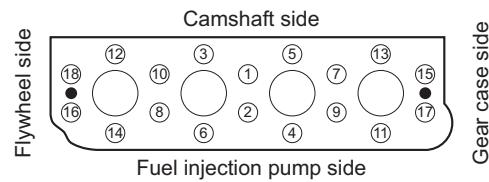


4JH4-TE/ 4JH4-HTE

Assembly (Head bolt tightening order)



Assembly (Head bolt tightening order)



Tightening torque

Nm (kgf·m)

	1st step	Final
Cylinder head bolt	39.2-49.1 (4.0-5.0)	85.2-91.2 (8.69-9.30)

- 4) Measure the top clearance
Refer to 5.2.6

mm

Top clearance	0.74±0.06
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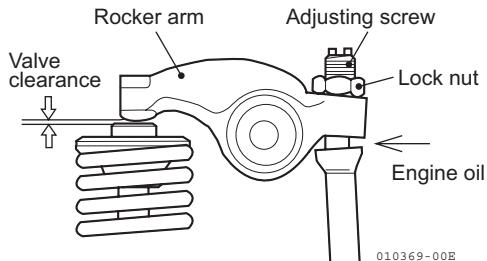
4. Disassembly and reassembly

(21) Mounting the rocker arm shaft assembly and push rods

- 1) Fit the push rod to the tappet.
- 2) Coat the top of the push rod and the adjusting screw of the rocker arm with engine oil. Mount the rocker arm shaft assembly to the cylinder head. (Apply lube oil to the screw and lock nut.)

Tightening torque	Nm (kgf·m)
Rocker arm shaft support	24-27(2.4-2.8)

2-valve head

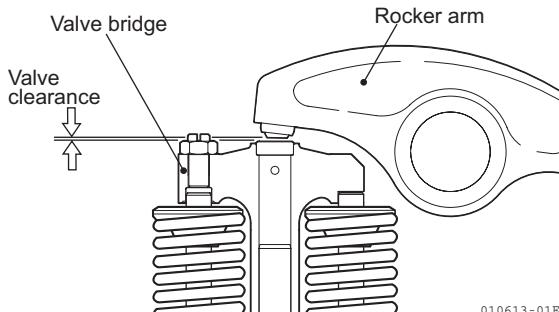


- 3) Adjust valve clearance

	mm
Intake/exhaust valve clearance	0.15-0.25

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

4-valve head



(22) Mounting the fuel injection pump

For 3JH4E and 4JH4E

- 1) Lightly fit the fuel injection pump on the gear case flange. (After adjusting injection timing, tighten the fuel injection pump).

Note:

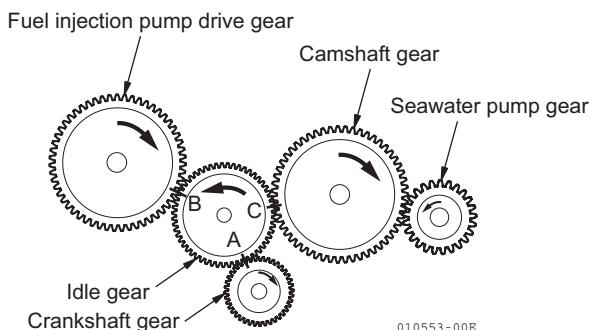
Be careful not to scratch the O-ring between the fuel injection pump and gear case flange.

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

Tightening torque	Nm (kgf·m)
Pump drive gear nut	78.2-98.2 (7.97-10.0)

- 5) Measure the backlash between the fuel injection pump drive gear and idle gear.

Backlash	mm
Fuel injection pump drive gear	0.07-0.15



For 4JH4-TE and 4JH4-HTE

- 1) Install the VE pump bracket and O-ring to the gear case flange while adjusting both mark-off lines of the bracket and gear case flange.
- 2) Install the fuel injection pump and O-ring to the VE pump bracket while adjusting both mark-off lines of the bracket and VE pump. Lightly tighten the 3 nuts. (After adjusting injection timing, tighten the fuel injection pump).

Note:

Be careful not to scratch the O-ring between the fuel injection pump and bracket.

- 3) Fit the pump drive gear to the pump camshaft.
- 4) Align the "B" match marks on the pump drive gear and idle gear.
- 5) Tighten the pump drive gear nut, which fastens the pump gear and camshaft, to the specified torque. (Apply lube oil to the nut.)

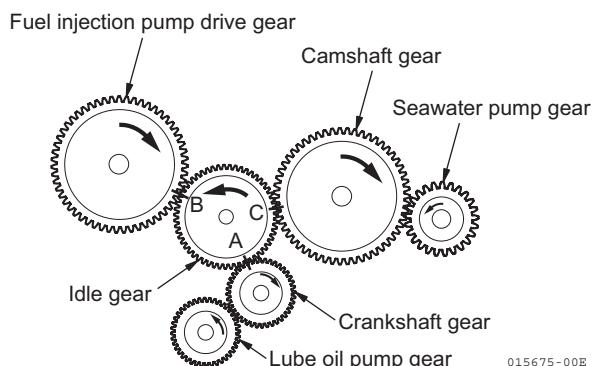
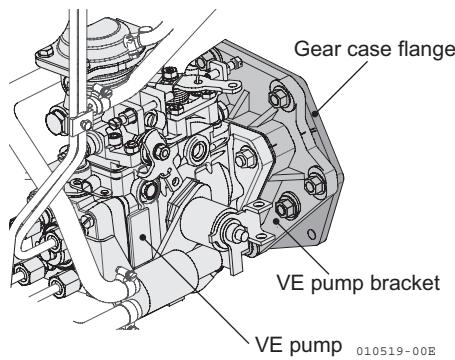
Tightening torque	Nm (kgf·m)
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Pump drive gear nut	59-69 (6.0-7.0)
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- 6) Measure the backlash between the pump drive gear and idle gear.

mm

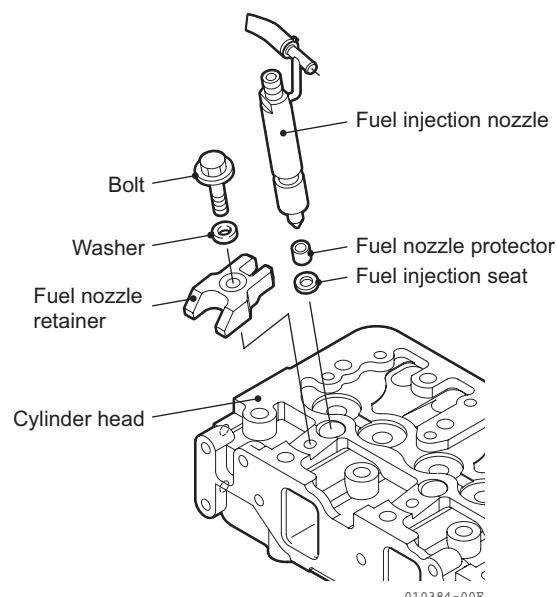
Backlash	0.07-0.15
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(23) Mounting the fuel injection nozzle

- 1) Replace the used fuel nozzle protector and fuel nozzle seat with new ones. Put the seat in the cylinder head and the protector to the nozzle tip. Mount the fuel injection nozzle to the cylinder head.

2-valve head



4. Disassembly and reassembly

Note:

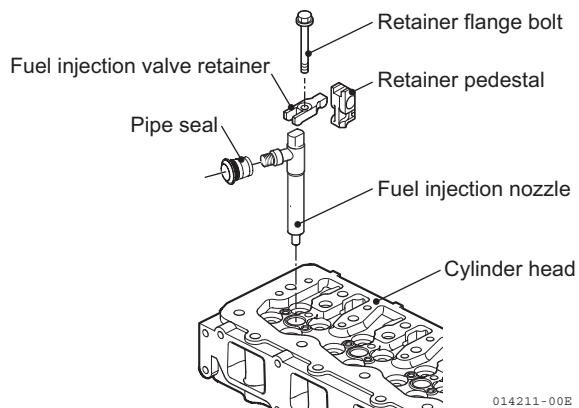
In case of 4-valve head the fuel inlet of the fuel nozzle must align the pipe seal, which is installed to the rocker arm cover. Replace the used pipe seal with new one.

- 2) Tighten the fuel nozzle retainer bolt to the specified torque. (Do not apply lube oil to the bolt.)

Tightening torque Nm (kgf·m)

Fuel nozzle retainer bolt	24.4-28.4 (2.49-2.90)
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4-valve head

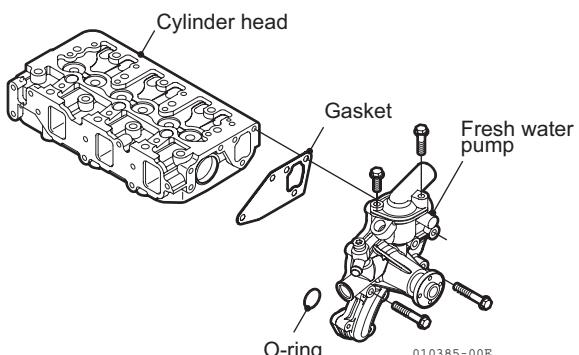


(24) Mounting the fresh water pump

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

Tightening torque Nm (kgf·m)

Fresh water pump	6.9-11 (0.7-1.1)
------------------	------------------



(25) Mounting the intake manifold

Thoroughly clean the inside of the intake manifold, and mount the gasket packing and intake manifold.

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

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

Note:

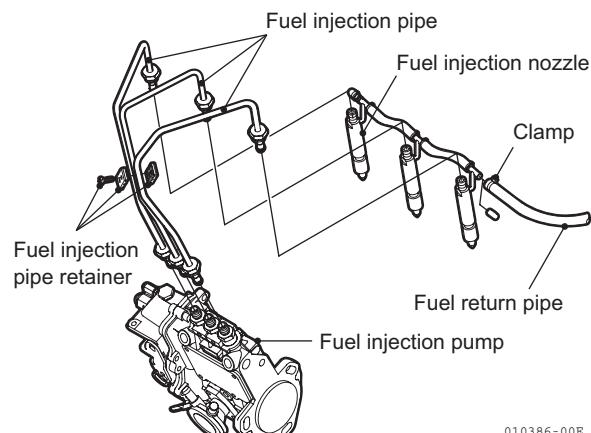
Lightly tighten the pipe joint nuts on both ends of the fuel injection pipe. Completely tighten after adjusting the injection timing.

Standard tightening torque Nm (kgf·m)

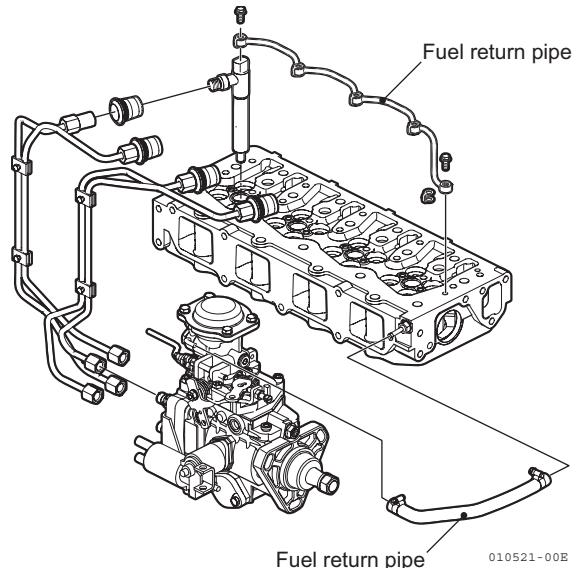
Fuel injection pipe joint nut	29.4-34.4 (3.00-3.51)
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- 2) Mount the fuel return pipe with the clamp (fuel injection nozzle - fuel filter).

3JH4E and 4JH4E

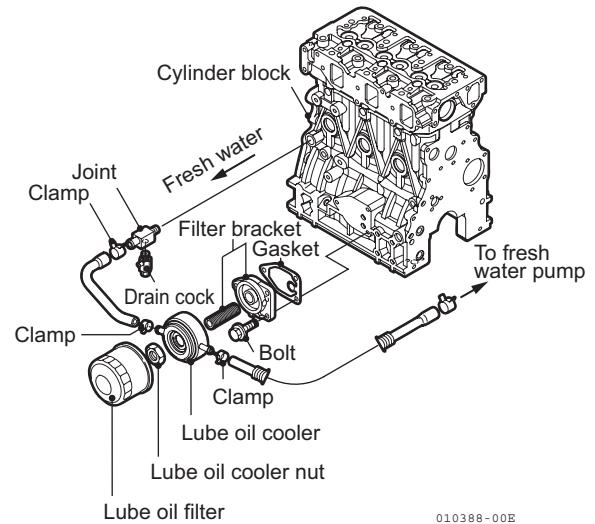


4JH4-TE and 4JH4-HTE



- (27) Mounting the lube oil cooler and the lube oil filter.

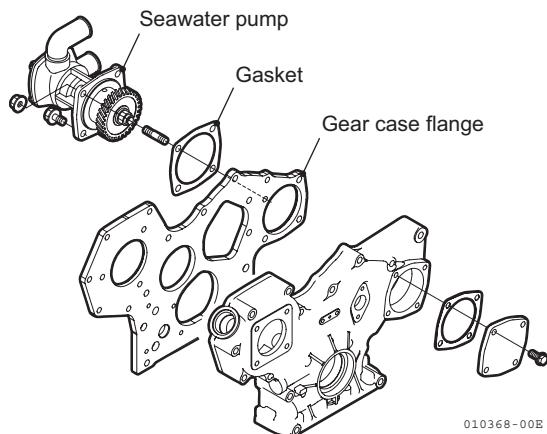
- 1) Mount the filter bracket and gasket on the cylinder block.
- 2) Mount the lube oil cooler to the filter bracket and tighten the lube oil cooler nut.
- 3) Mount the fresh water pipes (cylinder block-lube oil cooler, lube oil cooler-fresh water pump)
- 4) Mount the lube oil filter with the tool of the filter case remover.



4. Disassembly and reassembly

(28) Mounting the seawater pump

- 1) Mount the seawater pump assembly and gasket to the gear case.
- 2) Lightly tap the gear case side bearing rest with a wood hammer, and tighten the bolts.



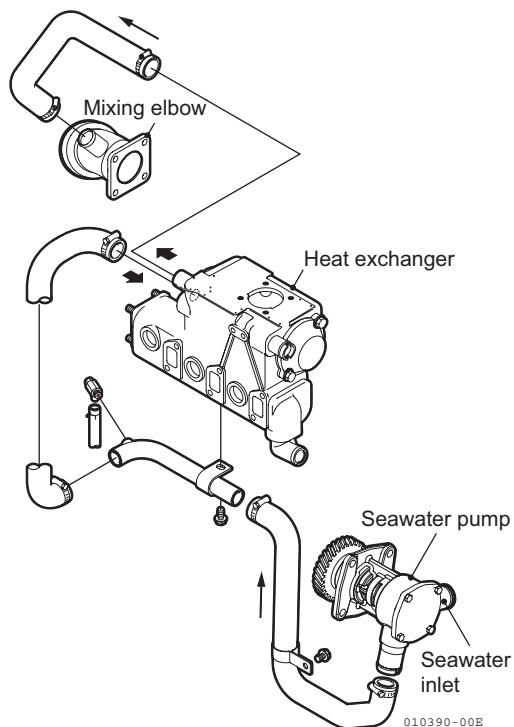
(29) Mounting the heat exchanger (exhaust manifold, fresh water tank unit).

Mount the gasket and heat exchanger (exhaust manifold) to the cylinder head.

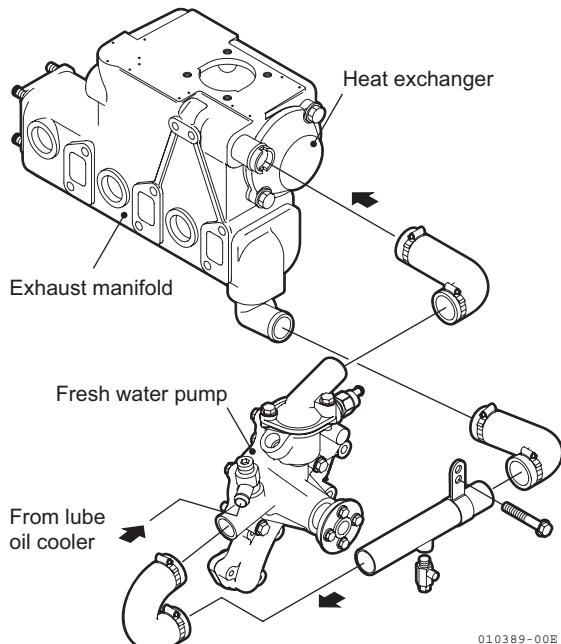
(30) Mounting the cooling water pipes (seawater / fresh water)

The example shows the seawater / fresh water lines of 3JH4E.

Seawater pipe



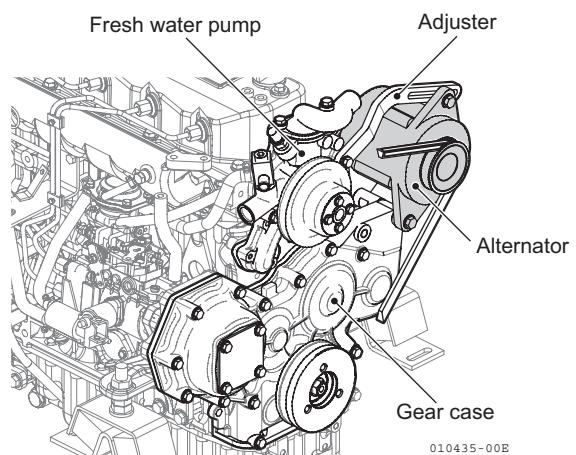
Fresh water pipe



- 1) Mount the seawater pipes with the hose clips (seawater pump-heat exchanger).
- 2) Mount the fresh water pipes with the hose clips (exhaust manifold - fresh water pump, fresh water pump - heat exchanger).
- 3) Mount the fresh water pipes (cylinder block - lube oil cooler, lube oil cooler - fresh water pump).

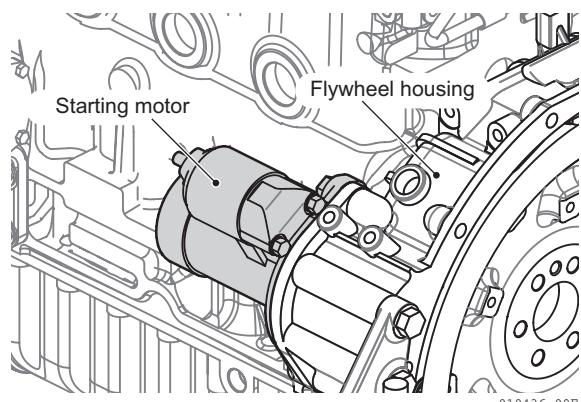
(31) Mounting the alternator

- 1) Mount the adjuster on the fresh water pump, the distance piece on the gear case, and then the alternator.
- 2) Adjust V-belt tension with the adjuster, and tighten the mounting bolts.



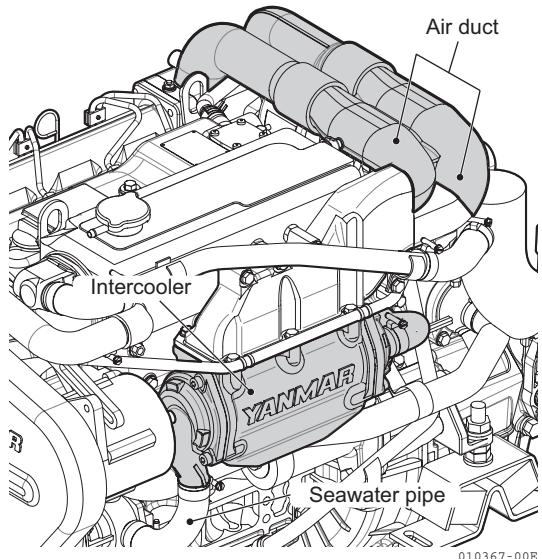
(32) Mounting the starting motor

Fit the starting motor in the flywheel housing.



(33) Mounting the intercooler
(only for 4JH4-HTE)

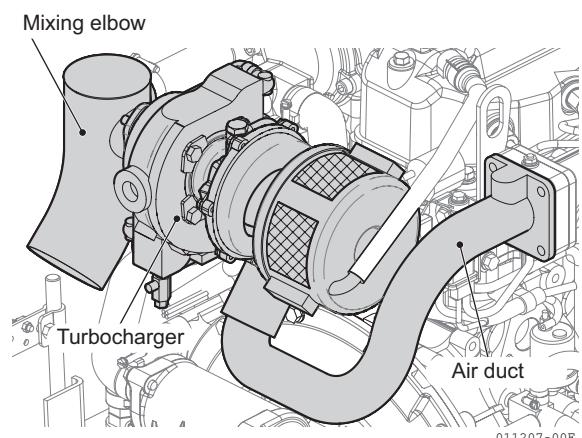
- 1) Mount the intercooler.
- 2) Mount the seawater pipes with the hose clips.
- 3) Mount the air duct from the intercooler to the intake manifold. Mount the air duct from the turbocharger to the intercooler.



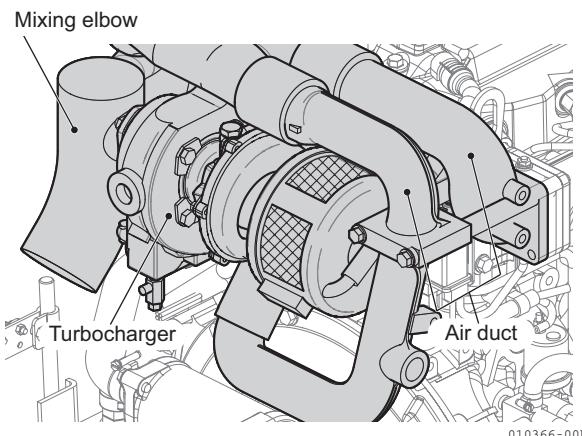
(34) Mounting the turbocharger
(only for 4JH4-TE and 4JH4-HTE)

- 1) Mount the turbocharger to the exhaust manifold.
- 2) Install the lube oil pipe and the fresh water pipe to the turbocharger.

4JH4-TE



4JH4-HTE



(35) Mounting the mixing elbow

- 1) Mount the mixing elbow on the exhaust manifold outlet for 3JH4E and 4JH4E and on the turbocharger for 4JH4-TE and 4JH4-HTE.
- 2) Mount the cooling seawater pipe (rubber hose) with the hose clips (heat exchanger-mixing elbow).

(36) Mounting the intake silencer

- 1) Mount the intake silencer on the intake manifold inlet coupling for 3JH4E and 4JH4E and on the turbocharger for 4JH4-TE and 4JH4-HTE.
- 2) Mount the breather hose to the silencer with the hose clips (intake silencer-rocker arm cover).

(37) Mounting the fuel filter and fuel pipe

- 1) Mount the fuel filter.
- 2) Mount the fuel pipe (fuel feed pump-fuel filter, fuel filter-fuel injection pump).

(38) Electrical wiring

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

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

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

(40) Filling with lube oil

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

4. Disassembly and reassembly

(41) Filling with coolant

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

(L)

3JH4E	4.5
4JH4E	6.0
4JH4-TE/ 4JH4-HTE	7.2

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

(L)

Coolant recovery tank capacity (full)	0.8
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(42) Check fuel injection timing

Refer to 2.2.6(1) in chapter 2.

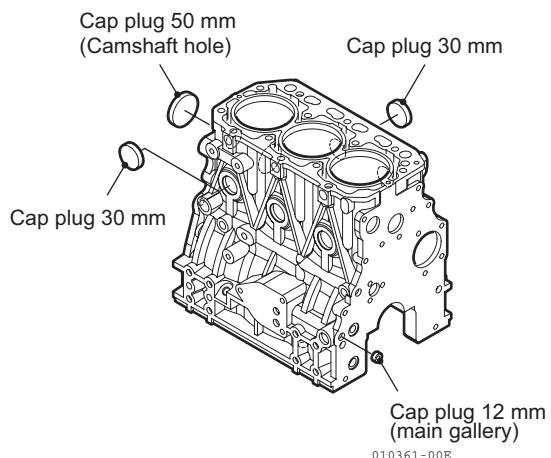
(43) Test running

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

5. Inspection and servicing of basic engine parts

5.1 Cylinder block

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



5.1.1 Inspection of parts

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

5.1.2 Cleaning of oil holes

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

Color check kit

	Quantity
Penetrant	1
Developer	2
Cleaner	3



5.1.3 Color check procedure

(1) Clean the area to be inspected

(2) Color check kit

The color check test kit consists of an aerosol cleaner, penetrant and developer.

(3) Clean the area to be inspected with the cleaner

Either spray the cleaner on directly and wipe, or wipe the area with a cloth moistened with cleaner.

(4) Spray on red penetrant

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

(5) Spray on developer

Remove any residual penetrant on the surface after the penetrant has penetrated, and spray on the surface after the penetrant has penetrated, and spray on the developer. If there are any cracks in the surface, red dots or a red line will appear several minutes after the developer dries.

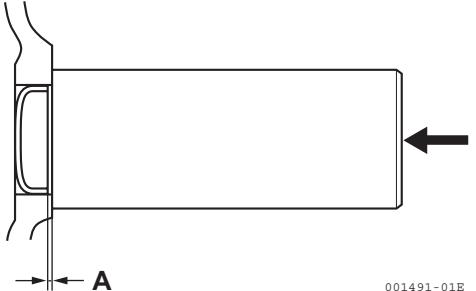
Hold the developer 300-400 mm away from the area the surface uniformly.

(6) Clean the surface with the cleaner.

Note:

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

5.1.4 Replacement of cup plugs

Step No.	Description	Procedure	Tool of material used																			
1	Clean and remove glue from the hole into which the cap plug is to be driven. (Remove scale and sealing material previously applied.)	 Remove foreign materials with a screw driver or saw blade. 001490-01E	Screw driver or saw blade Thinner																			
2	Remove grease from the cap plug.	Visually check the nick around the plug.	Thinner																			
3	Apply Threebond No.4 to the seat surface where the plug is to be driven in.	Apply over the whole outside of the plug.	Threebond No.4																			
4	Insert the plug into the hole.	Insert the plug so that it sits correctly.																				
5	Place a driving tool on the cap plug and drive it in using a hammer.	Drive in the plug parallel to the seating surface. <ul style="list-style-type: none"> • Driving tool • Hammer 																				
	 001491-01E	 001492-02X	mm <table border="1"> <tr> <td>A</td> <td>B</td> </tr> <tr> <td>2-3</td> <td>100</td> </tr> </table> mm <table border="1"> <tr> <td>Plug dia.</td> <td>d</td> <td>D</td> </tr> <tr> <td>ø12</td> <td>ø11.9-12.0</td> <td>ø20</td> </tr> <tr> <td>ø25</td> <td>ø24.9-25.0</td> <td>ø35</td> </tr> <tr> <td>ø30</td> <td>ø29.9-30.0</td> <td>ø40</td> </tr> <tr> <td>ø45</td> <td>ø44.9-45.0</td> <td>ø55</td> </tr> </table>	A	B	2-3	100	Plug dia.	d	D	ø12	ø11.9-12.0	ø20	ø25	ø24.9-25.0	ø35	ø30	ø29.9-30.0	ø40	ø45	ø44.9-45.0	ø55
A	B																					
2-3	100																					
Plug dia.	d	D																				
ø12	ø11.9-12.0	ø20																				
ø25	ø24.9-25.0	ø35																				
ø30	ø29.9-30.0	ø40																				
ø45	ø44.9-45.0	ø55																				

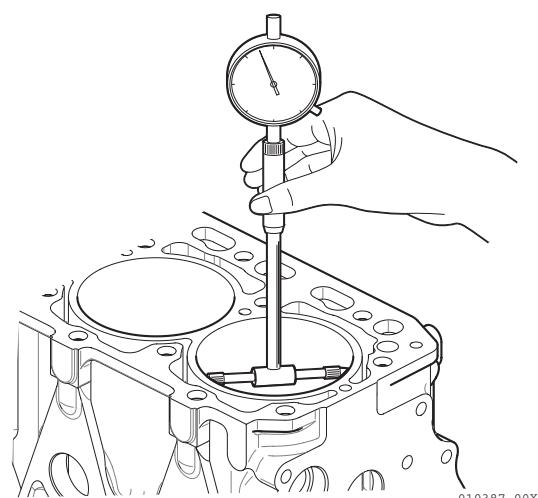
*Using the special tool, drive the cup plug so that the edge of the plug is 2 mm (0.0787 in) below the cylinder surface.

5.1.5 Cylinder bore measurement

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

(a) Appearance inspection

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



(b) Cylinder bore and distortion

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

Roundness:

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

Roundness is the maximum value among those difference values.

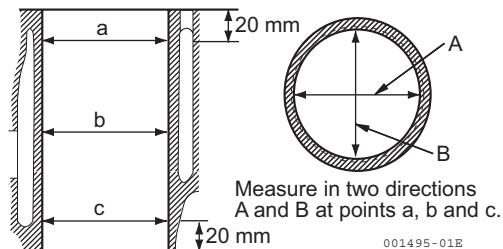
Cylindricity:

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

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

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

Cylindricity is the maximum value between those difference values.

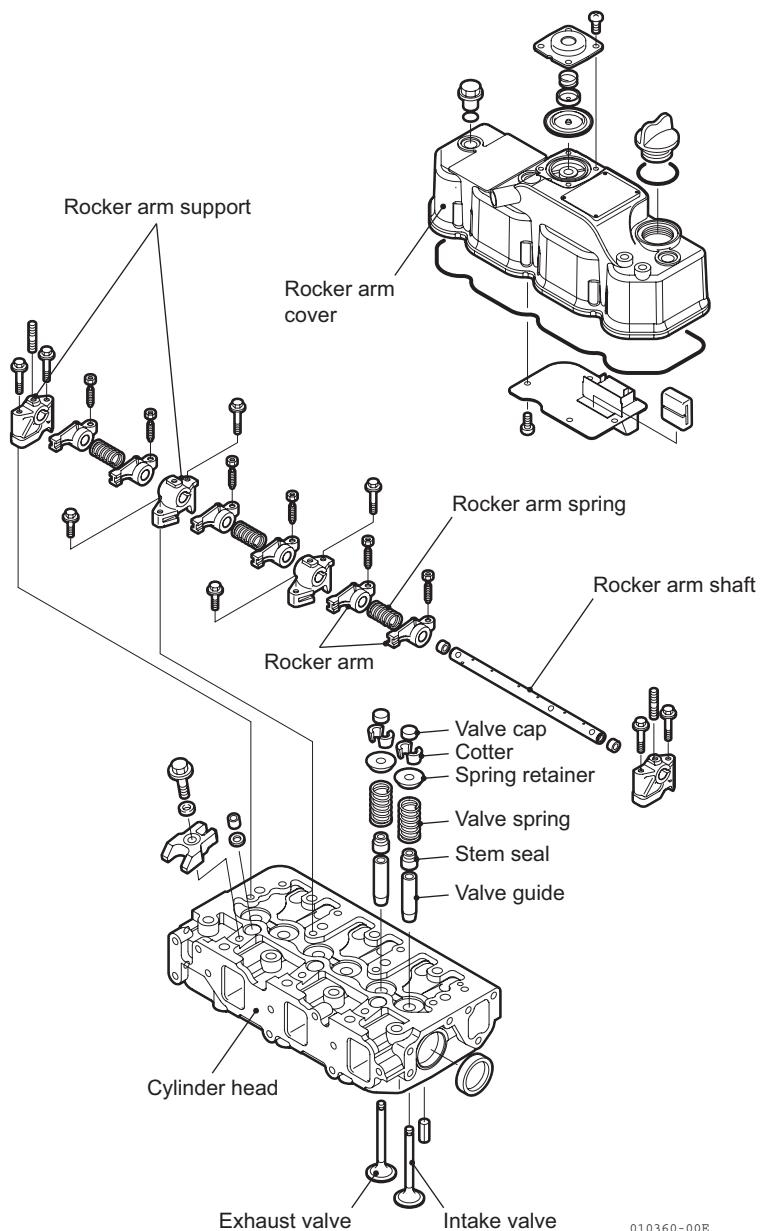


Item		Standard	Limit
Cylinder bore diameter	3/4JH4E	88.000~88.030	88.200
	4JH4-TE 4JH4-HTE	84.000~84.030	84.200
Cylinder roundness/ Inclination		0.01 or less	0.03

5.2 Cylinder head

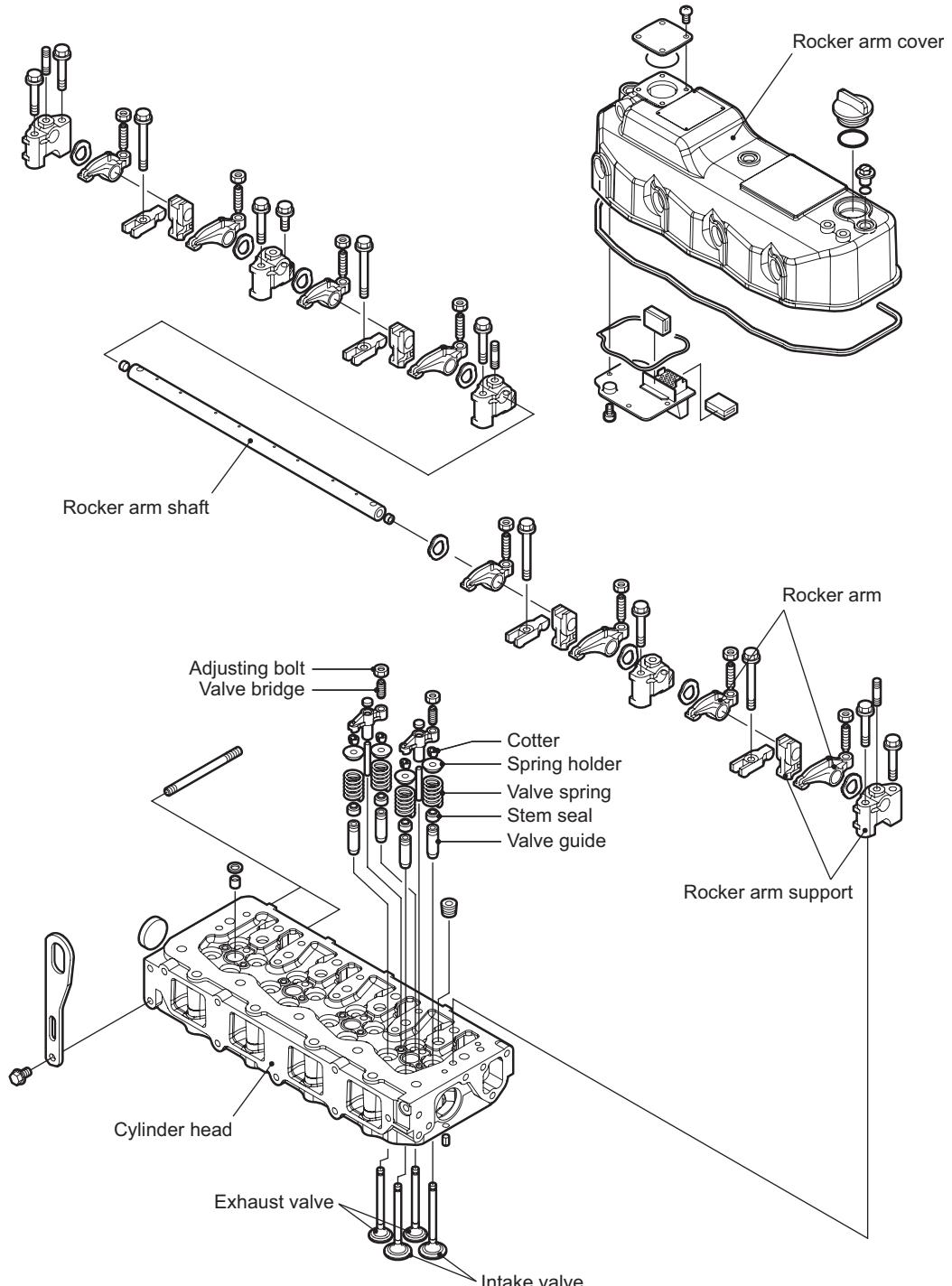
The cylinder head is of 3-cylinder or 4-cylinder integral construction. Special alloy stellite with superior resistance to heat and wear is fitted on the valve seats, and the area between the intake/ exhaust valves is cooled by the water jet.

2-valve cylinder head



010360-00E

4-valve cylinder head



010359-00E

5.2.1 Inspecting the cylinder head

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

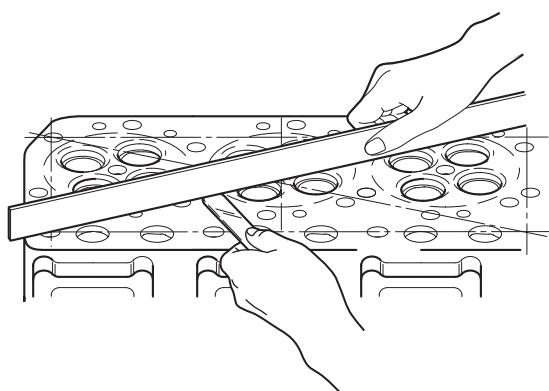
(1) Distortion of the combustion surface

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

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

mm

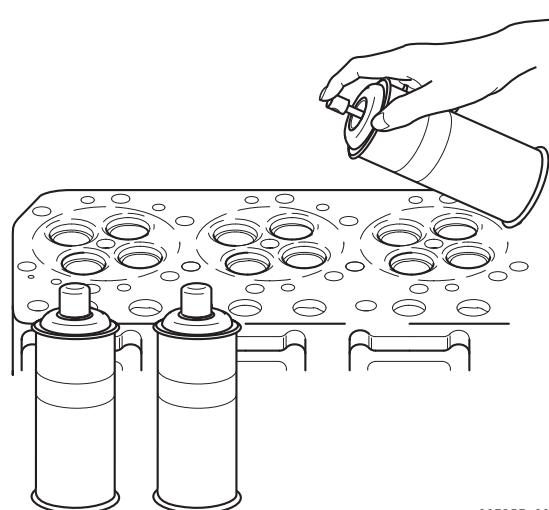
	Standard	Limit
Cylinder head distortion	0.05 or less	0.15



007087-00X

(2) Checking for cracks in the combustion surface

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



007357-00X

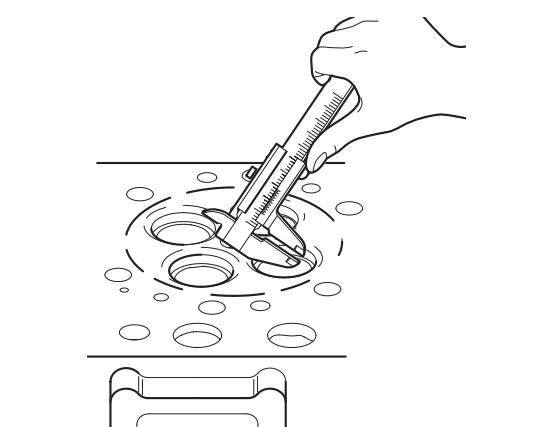
(3) Checking the intake and exhaust valve seats

Check the surface and width of the valve seats.

If they are too wide, or if the surfaces are rough, correct to the following standards:

Seat angle	Intake	120°
	Exhaust	90°

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



007358-00X

5.2.2 Valve seat correction procedure

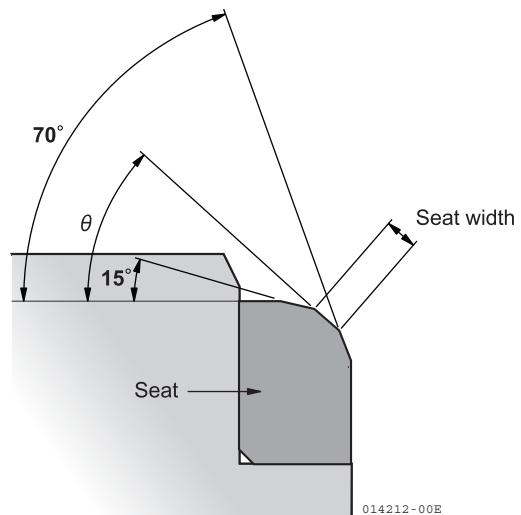
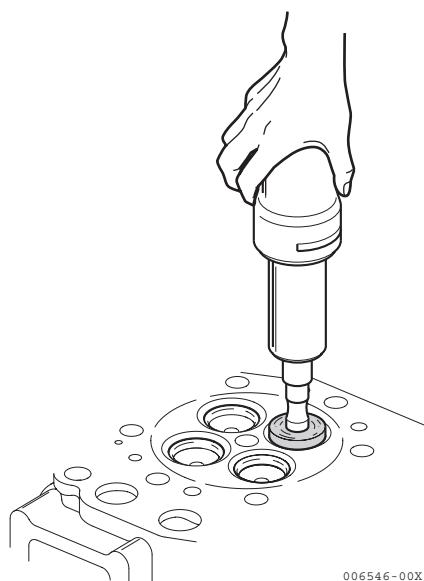
The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

- (1) Use a seat grinder to make the surface even.

As the valve seat width will be enlarged, first use a 70° grinder, then grind the seat to the standard dimension with a 15° grinder.

Note:

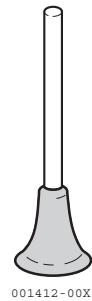
When seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.



- (2) Knead valve compound with oil and finish the valve seat with a lapping tool.
- (3) Final finishing should be done with oil only.

Lapping tool

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



001412-00X

Note:

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

Note:

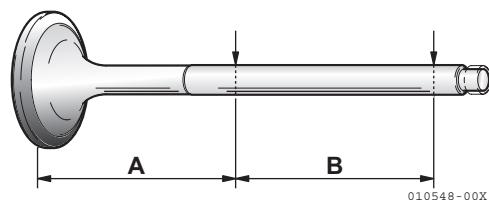
- 1) Insert adjusting shims between the valve spring and cylinder head when seats have been refinishing with a seat grinder.
- 2) Measure valve distortion after valve seat refinishing has been completed, and replace the valve and valve seat if it exceeds the tolerance.

5.2.3 Intake/exhaust valves, valve guides

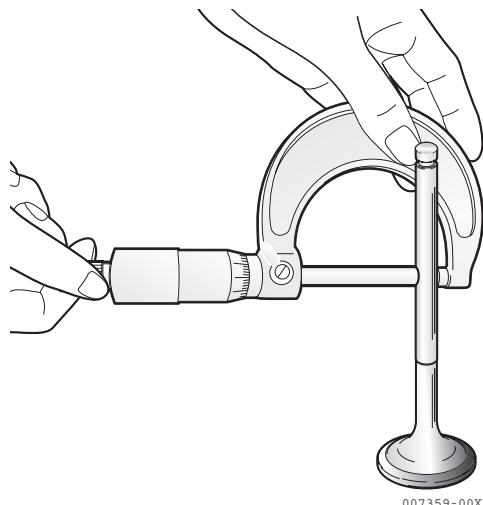
(1) Wearing and corrosion of valve stem

Replace the valve stem if excessively worn or corroded.

	Valve stem outside dia.	Standard	Limit
3JH4E	Intake	$\varnothing 7.955\text{--}\varnothing 7.975$	$\varnothing 7.90$
4JH4E	Exhaust	$\varnothing 7.955\text{--}\varnothing 7.970$	$\varnothing 7.90$
4JH4-TE	Intake	$\varnothing 5.960\text{--}\varnothing 5.975$	$\varnothing 5.90$
4JH4-HTE	Exhaust	$\varnothing 5.945\text{--}\varnothing 5.960$	$\varnothing 5.90$



A	B
40	50



(2) Inspection of valve seat wear and contact surface

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

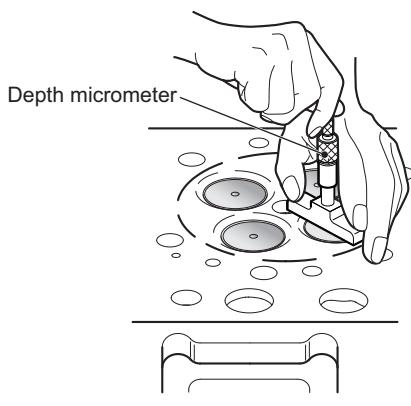
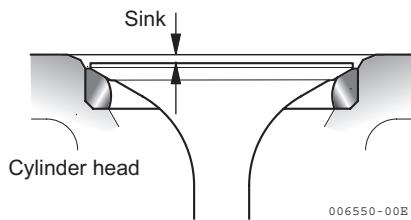
Note:

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

(3) Valve sink

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

	mm	Standard	Limit
Valve sink	0.30-0.50	0.8	



(4) Valve guide

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

			Standard	Limit
3JH4E 4JH4E	Valve guide inside diameter	Intake	8.010-8.025	8.2
		Exhaust	8.015-8.030	8.2
	Clearance	Intake	0.035-0.070	0.18
		Exhaust	0.045-0.075	0.18
4JH4-TE 4JH4-HTE	Valve guide inside diameter	Intake	6.000-6.015	6.1
		Exhaust	6.000-6.015	6.1
	Clearance	Intake	0.025-0.055	0.16
		Exhaust	0.040-0.070	0.18

Note:

The inside diameter standard dimensions assume a pressure fit.

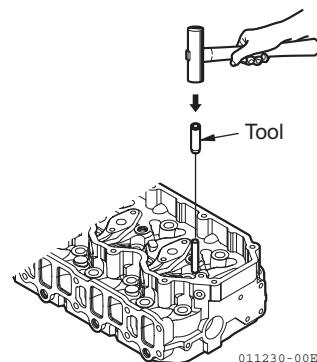
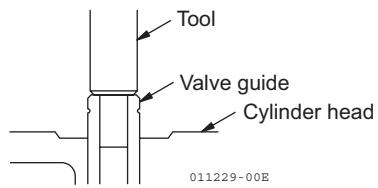
- 2) Replacing the valve guide
 - a) Use a valve guide extraction tool and extract the valve guide from the cylinder head.

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

CAUTION

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

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

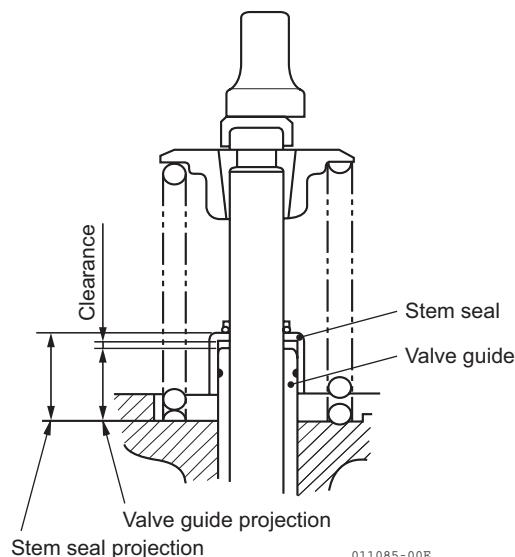


3) Valve guide projection

Check the projection from the cylinder head.

mm

	Valve guide projection
3JH4E/ 4JH4E	15 ⁰ _{-0.3}
4JH4-TE/ 4JH4-HTE	8.5 ⁰ _{-0.3}



4) Valve stem seals

The valve stem seals on the intake/exhaust valve guides cannot be re-used once they are removed. Be sure to replace them.

Install the valve stem seal to the valve guide by using a tool.

The stem seal projection is as follows. The clearance between the stem seal and the upper surface of valve guide is around 0.2 mm to 0.8 mm.

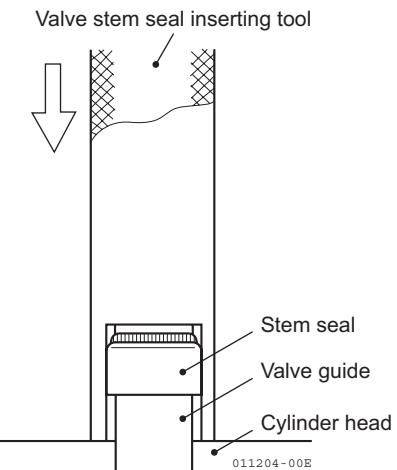
	mm
	Valve stem seal projection
3JH4E/ 4JH4E	$19^0_{-0.3}$
4JH4-TE/ 4JH4-HTE	$10.2^0_{-0.3}$

The intake valve guide and exhaust valve guide are of different dimensions.

The stem seal is marked by color for the distinction.

	Intake	Exhaust
3JH4E/ 4JH4E	No mark	Yellow
4JH4-TE/ 4JH4-HTE	White	Black

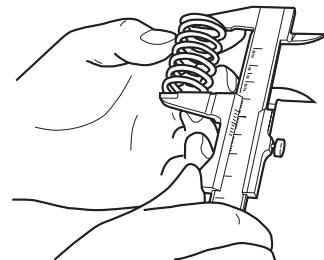
When assembling the intake/exhaust valves, apply an adequate quantity of engine oil on the valve stem before inserting them.



5.2.4 Valve springs

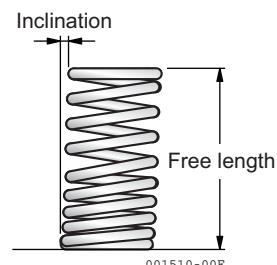
(1) Checking valve springs

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

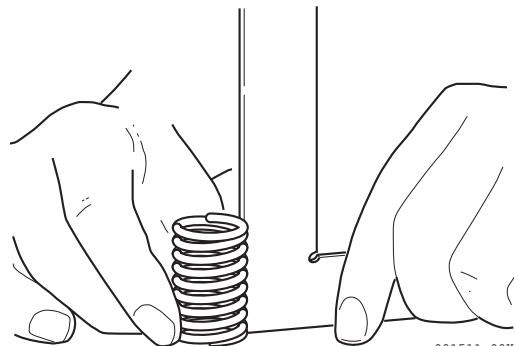


001509-01X

- 3) Measure inclination.



001510-00E



001511-00X

- 4) Measure spring tension.

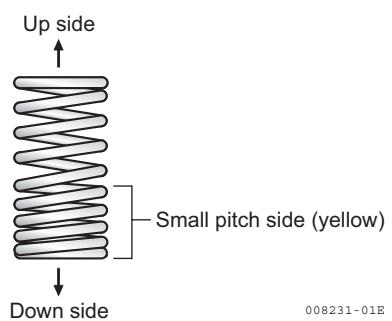
		3JH4E/4JH4E		4JH4-TE/4JH4-HTE	
Valve spring	Unit	Standard	Limit	Standard	Limit
Free length A	mm	44.4	43.0	37.4	36.9
Inclination B	mm	—	1.1	—	1.0

5) Assembling valve springs.

The side with the smaller pitch (painted yellow) should face down (cylinder head).

Note:

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



008231-01E

6) Spring retainer and spring cotter

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

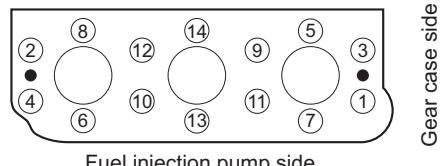
5.2.5 Assembling the cylinder head

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

- (1) Clean out the cylinder head bolt holes.
- (2) Check for foreign matter on the cylinder head surface where it comes in contact with the block.
- (3) Coat the head bolt threads and nut seats with lube oil.
- (4) Use the positioning pins to line up the head gasket with the cylinder block.
- (5) Match up the cylinder head with the head gasket and mount.

	Nm (kgf·m)	
	First	Second
Cylinder head bolt tightening torque	44-54 (4.5-5.5)	85.2-91.2 (8.69-9.30)

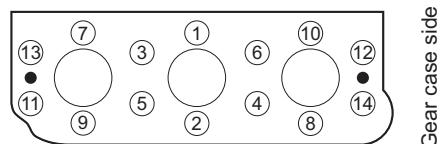
Disassembly (Head bolt loosening order)



Fuel injection pump side

011225-00E

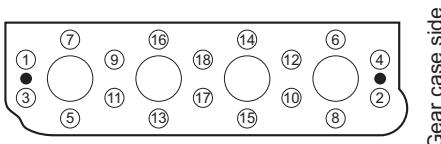
Assembly (Head bolt tightening order)



Fuel injection pump side

011231-00E

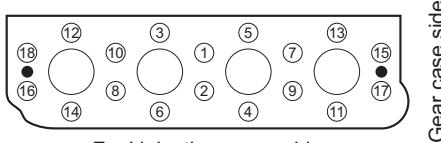
Disassembly (Head bolt loosening order)



Fuel injection pump side

011226-00E

Assembly (Head bolt tightening order)

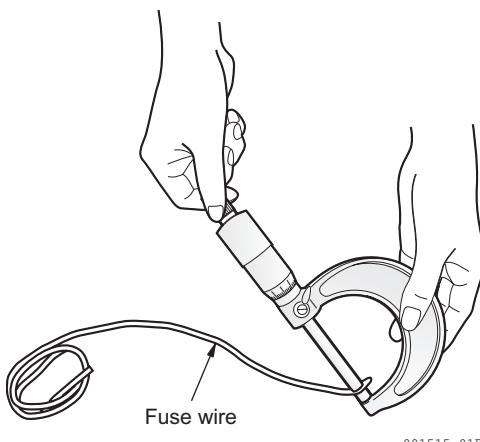


Fuel injection pump side

011232-00E

5.2.6 Measuring top clearance

- (1) Place a high quality fuse ($\varnothing 1.2$ mm, 10 mm long) in three positions on the flat part of the piston head.
- (2) Assemble the cylinder head gasket and the cylinder block and tighten the bolts in the specified order to the specified torque.
- (3) Turn the crank, (in the direction of engine revolution), and press the fuse against the piston until it breaks.
- (4) Remove the head and take out the broke fuse.
- (5) Measure the three positions where each fuse is broken and calculate the average.



001515-01E

mm

Top clearance	0.68-0.80
---------------	-----------

5.2.7 Intake and exhaust rocker arms

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

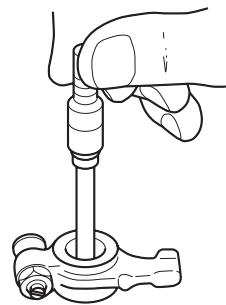
(1) Rocker arm shaft and rocker arm bushing

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

mm

	Standard	Limit
Outside dia of intake and exhaust rocker arm shaft.	15.966-15.984	15.955
Intake and exhaust rocker arm bushing inside dia.	16.000-16.020	16.090
Rocker arm shaft and bushing clearance at assembly	0.016-0.054	0.140

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



011086-00X

(2) Rocker arm spring

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

(3) Rocker arm and valve cap retainer.

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

5.2.8 Adjustment of valve clearance

- (1) Make adjustments when the engine is cool.
(Refer to 2.2.2(5).)

mm

Intake and exhaust valve clearance	0.15-0.25
------------------------------------	-----------

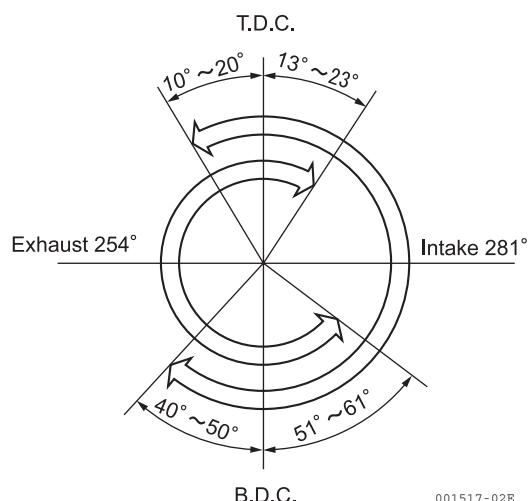
(2) Valve timing

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

The valve timing of the JH4 series engines is the same.

deg.

Intake valve Open	b.TDC.	10°-20°
Intake valve Closed	a.BDC.	40°-50°
Exhaust valve Open	b.BDC.	51°-61°
Exhaust valve Closed	a.TDC.	13°-23°



001517-02E

5.3 Piston and piston pins

Pistons are made of a special light alloy with superior thermal expansion characteristics.

The back of the piston combustion chamber is oil-jet cooled.

The ID marks (model mark and size mark) are incused on the top surface of the piston.

Model mark

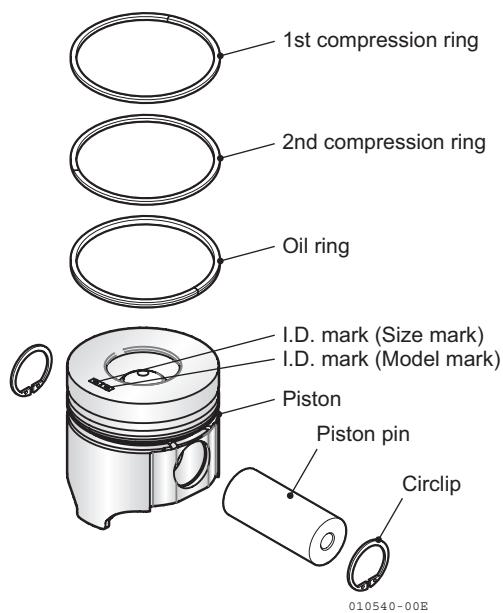
Model	Mark
3JH4E	V88
4JH4E	4JH4
4JH4-TE	TE
4JH4-HTE	HTE

Size mark

Size mark
ML
MS

IMPORTANT:

Piston shape differs among engine models. If any incorrect piston is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark.



5.3.1 Piston

(1) Piston head and combustion surface

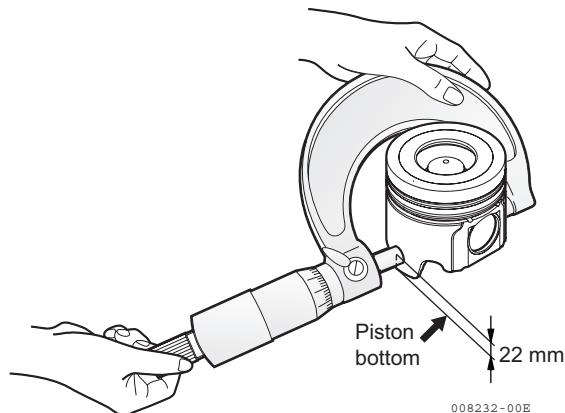
Remove the carbon that has accumulated on the piston head and combustion surface, taking care not to scratch the piston. Check the combustion surface for any damage.

(2) Measurement of piston outside diameter/ inspection

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

Piston outside diameter

Model	Standard	Limit	Clearance between piston and cylinder
3JH4E	87.950-87.960	87.900	0.045-0.075
4JH4E	87.935-87.945	87.885	0.060-0.090
4JH4-TE 4JH4-HTE	83.930-83.940	83.880	0.065-0.095



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

Selective pairing of cylinder and piston

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

		Piston outside diameter. D2 = 87.955 mm		
Tolerance		below + 0.005 0 min.	below 0 -0.005 min.	
		Size mark	ML	MS
Cylinder inside diameter D1 = 88.000 mm	+0.030 max. +0.020 min.	L	○	X
	below +0.020 +0.010 min.	M	○	○
	below +0.010 0 min.	S	X	○

Model	Cylinder inside diameter D1 (mm)	Piston outside diameter. D2 (mm)
3JH4E	88	87.955
4JH4E		87.940
4JH4-TE 4JH4-HTE	84	83.935

(3) Removing the piston pin

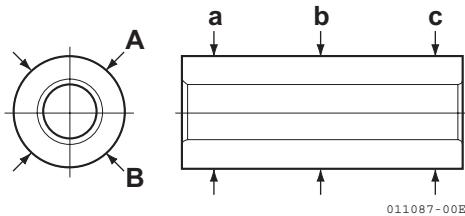
A floating type piston pin is used in this engine. The piston pin can be pressed into the piston pin hole at room temperature (Coat with oil to make it slide easily).

5.3.2 Piston pin

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

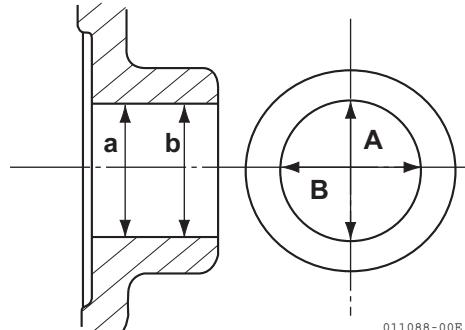
	3JH4E/4JH4E		4JH4-TE/4JH4-HTE	
	Standard	Limit	Standard	Limit
Piston pin hole inside dia.	26.000-26.009	26.020	28.000-28.009	28.020
Piston pin outside dia.	25.995-26.000	25.965	27.995-28.000	27.965
Clearance	0-0.014	0.074	0-0.014	0.074

Measure at positions a, b and c in directions A and B.



011087-00E

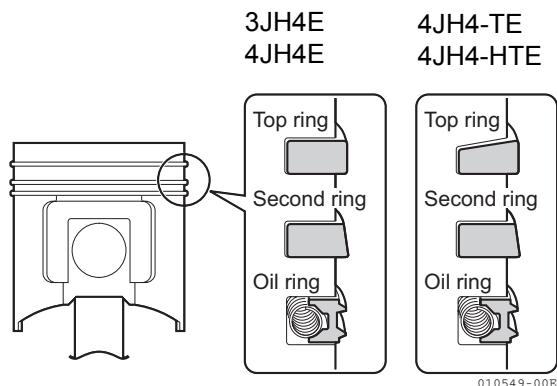
Measure at positions a and b in directions A and B.



011088-00E

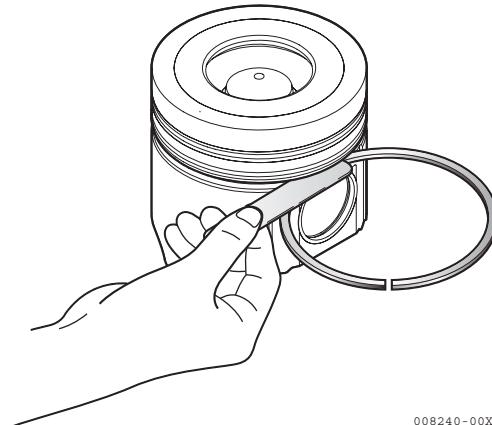
5.3.3 Piston rings

Two compression rings and one oil ring are applied. The absence of an oil ring on the piston skirt prevents oil from being kept on the thrust surface and in turn provides good lubrication.



(1) Measuring the rings.

Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceeds the limit.



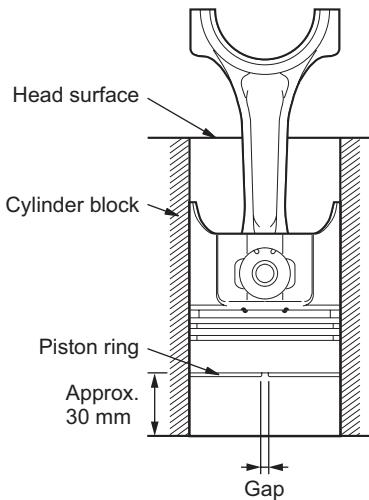
mm

		3JH4E/4JH4E		4JH4-TE/4JH4-HTE	
		Standard	Limit	Standard	Limit
Top ring	Groove width	2.060-2.075	2.170	2.060-2.080	2.180
	Ring width	1.970-1.990	1.950	1.970-1.990	1.950
	Clearance	0.070-0.105	0.200	(half-keystone)	-
Second ring	Groove width	2.025-2.040	2.140	2.050-2.065	2.170
	Ring width	1.970-1.990	1.950	1.970-1.990	1.950
	Clearance	0.035-0.070	0.190	0.060-0.095	0.220
Oil ring	Groove width	4.015-4.030	4.130	4.020-4.035	4.135
	Ring width	3.970-3.990	3.950	3.970-3.990	3.950
	Clearance	0.025-0.060	0.180	0.030-0.065	0.180

(2) Measuring piston ring gap (End clearance)

Press the piston ring onto a piston liner and measure the piston ring gap with a gauge. Press on the ring about 30mm from the bottom of the liner.

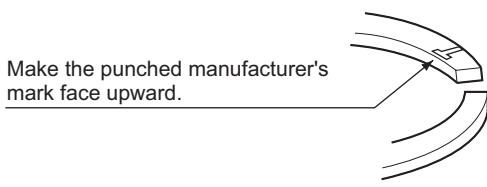
	Standard	Limit
Top ring gap	0.200-0.400	0.490
Second ring gap	0.200-0.400	0.490
Oil ring gap	0.200-0.400	0.490



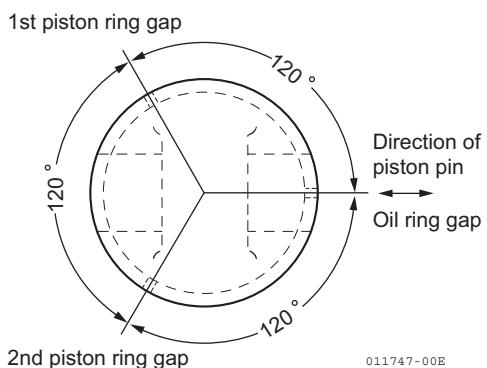
001524-01E

(3) Removing the piston rings

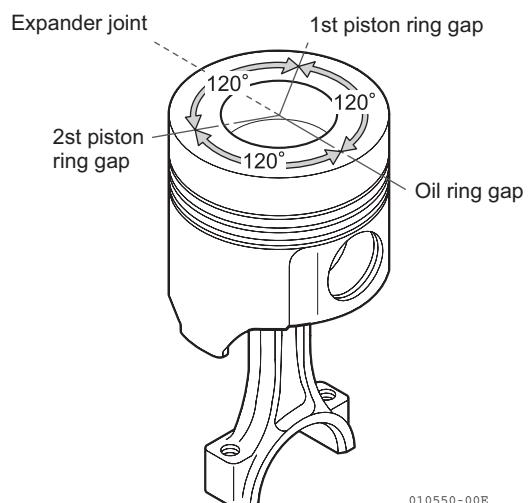
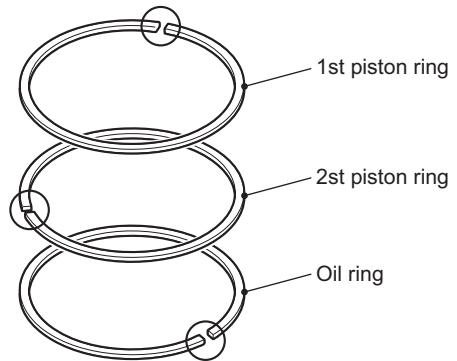
- 1) Thoroughly clean the ring grooves when removing piston rings.
- 2) The side with the manufacturer's mark should face up.
- 3) After fitting the piston ring, make sure it moves easily and smoothly.
- 4) Adjust the piston ring gaps at 120° intervals, making sure they don't line up.



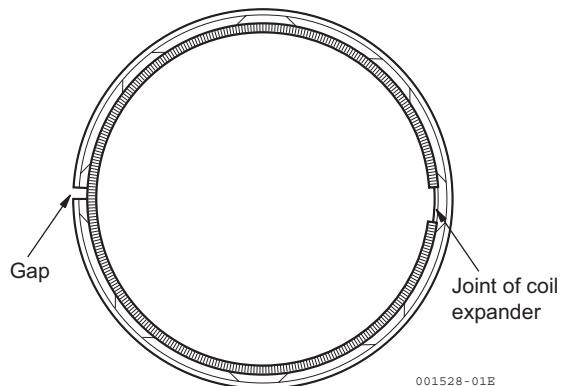
011078-00E



011747-00E



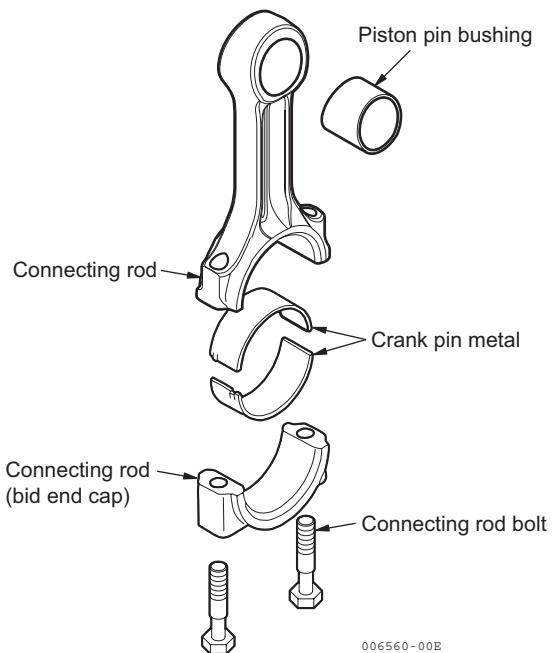
- 5) The oil ring is provided with a coil expander. The coil expander joint should be opposite (staggered 180°) the oil ring gap.



5.4 Connecting rod

The connecting rod is made of high-strength forged carbon steel.

The large end with the aluminium metal can be separated into two and the small end has a 2-layer copper alloy coil bushing.



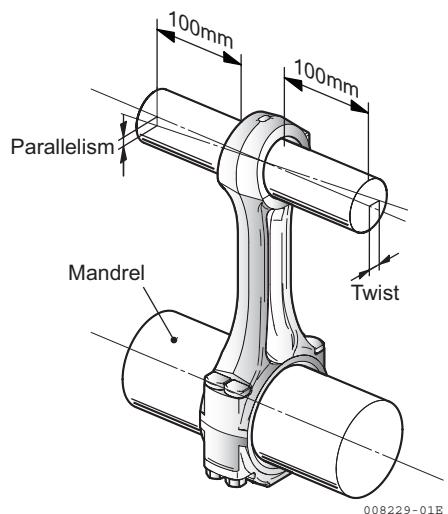
006560-00E

5.4.1 Inspecting the connection rod

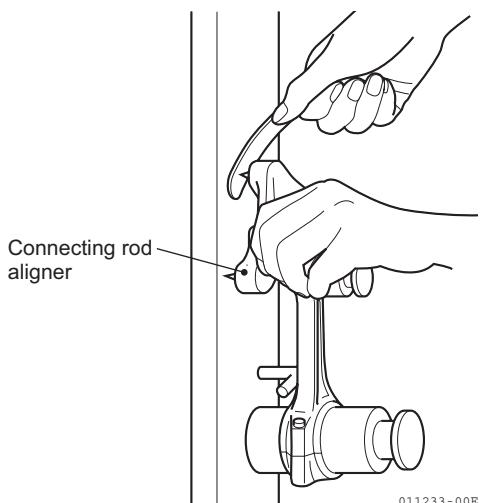
(1) Twist and parallelism of the large and small ends

Insert the measuring tool into the large and small ends of the connecting rod. Measure the extent of twist and parallelism and replace if they exceed the tolerance.

	Standard	Limit
Connecting rod twist and parallelism	Less than 0.03 (at 100 mm)	0.08



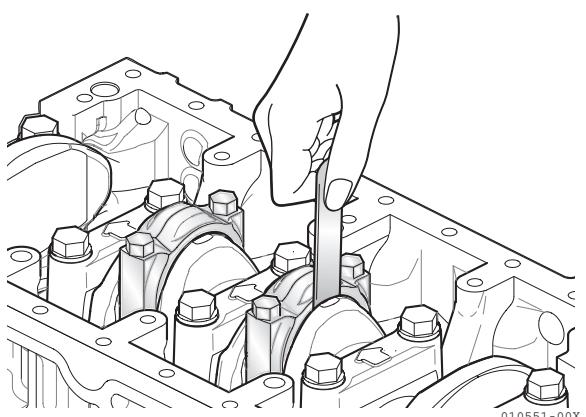
Twist measurement using a connecting rod aligner



(2) Checking the side clearance of a connecting rod

Fit the respective crank pins to the connecting rod and check to make sure that the side clearance in the crankshaft direction is correct.

	Standard	Limit
Connecting rod side clearance	0.20-0.40	0.55



5.4.2 Crank pin metal

(1) Checking crank pin metal

Check for flaking, melting or seizure on the contact surface of the crank pin metal.

(2) Measuring crank pin oil clearance

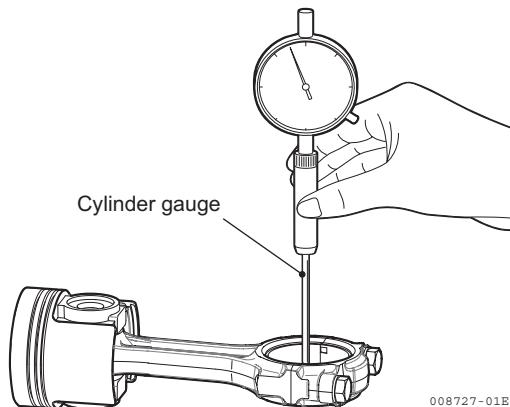
Measure the crankpin outside diameter and the crank pin metal inside diameter. Calculate the oil clearance from the measured values. (Refer to 5.5.1(3) for measuring the crank pin outside diameter.)

Replace the crank pin metal if the oil clearance becomes about the limit dimension of the below table.

Correct by grinding if unevenly wear, roundness exceeding the limit or insufficient outside diameter is found. Also use an undersized metal if necessary.

[NOTICE]

When measuring the inside diameter of the rod big end, install the crank pin metal in the rod big end not to mistake the top and bottom of the metals and tighten the rod bolts by the standard torque.



008727-01E

Nm (kgf·m)

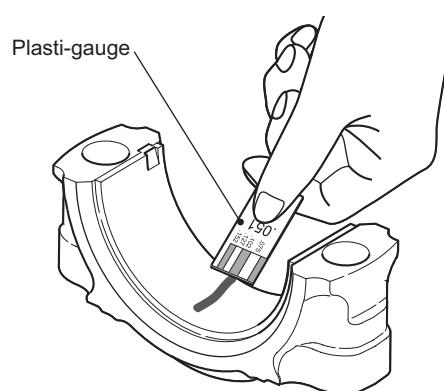
Rod bolt tightening torque	44.1-49.1 (4.50-5.01)
----------------------------	--------------------------

mm

Item	Standard	Limit
Rod metal I.D.	48.000-48.026	-
Crankpin O.D.	47.952-47.962	47.902
Metal thickness	1.492-1.500	-
Clearance	0.038-0.074	0.150

- Other procedure of measuring crank pin oil clearance

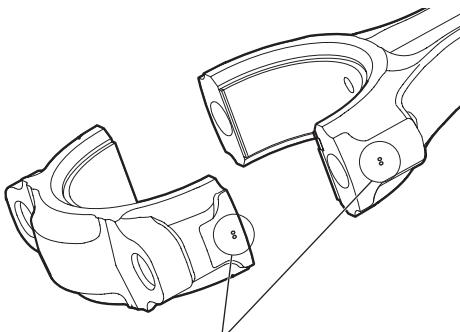
- 1) Use the press gauge (Plasti-gauge) for measuring the oil clearance of the crank pin.
- 2) Mount the connecting rod on the crank pin (tighten to specified torque).
- 3) Remove the connecting rod and measure the broken plasti-gauge with measuring paper.



008286-01E

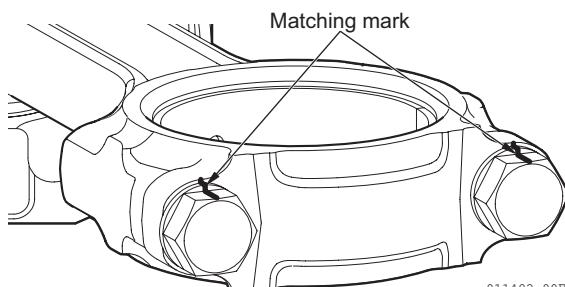
(3) Precautions on replacement of crank pin metal

- 1) Wash the crank pin metal.
- 2) Wash the large end cap, mount the crank pin metal and make sure that it fits tightly on the large end cap.
- 3) When assembling the connecting rod, match up the large end and large end cap alignment marks. Coat the bolts with engine oil and gradually tighten them alternately to the specified torque.



Alignment marks (Punched mark)
011491-00E

If a torque wrench is not available, make match marks on the bolt heads and large end cap before disassembling (to indicate the proper torque position) and retighten the bolts to those positions.



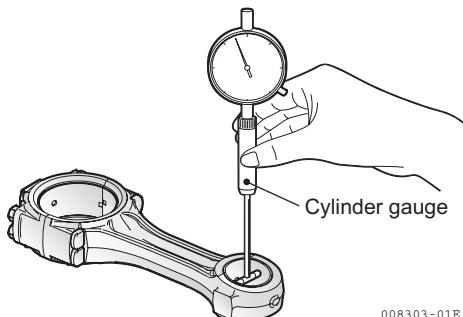
011492-00E

- 4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.

5.4.3 Piston pin bushing

(1) Measuring piston pin clearance.

Excessive piston pin bushing wear may result in damage to the piston pin or the piston itself. Measure the piston pin bushing inside diameter and the piston pin outside diameter. Calculate the oil clearance from the measured values. (Refer to 5.3.2 for the piston pin.)



mm

	3JH4E/4JH4E		4JH4-TE/4JH4-HTE	
	Standard	Limit	Standard	Limit
Piston pin bushing inside dia.	26.025-26.038	26.068	28.025-28.038	28.068
Oil clearance	0.025-0.043	0.101	0.025-0.043	0.101

Note:

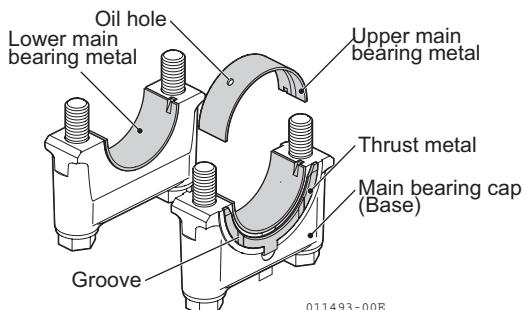
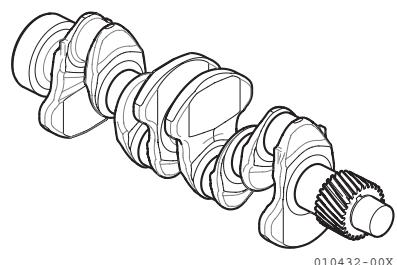
Since the rod small end is tapered, bush insertion is extremely difficult. Any minor mistake will cause abnormalities such as twist and bite.

Do not insert the bush on-site.

(No piston pin bush spare part is available. It is included in the connecting rod assembly supplied as a spare part.)

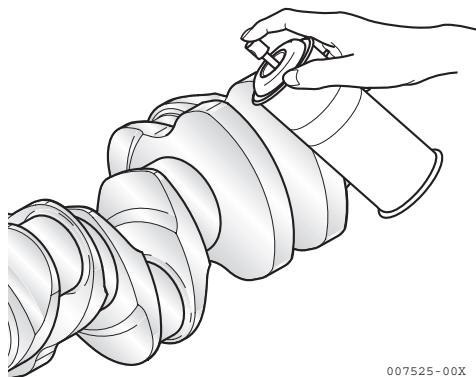
5.5 Crankshaft and main bearing

The crank pin and crank journal have been induction hardened for superior durability, and the crankshaft is provided with balance weights for optional balance. The crankshaft main bearing is of the hanger type. The upper metal (cylinder block side) is provided with an oil groove. There is no oil groove on the lower metal (bearing cap side). The bearing cap (location cap) of the flywheel side has a thrust metal which supports the thrust load.



5.5.1 Crankshaft

- (1) Color check after cleaning the crankshaft, and replace the crank shaft if there is any cracking or considerable damage.

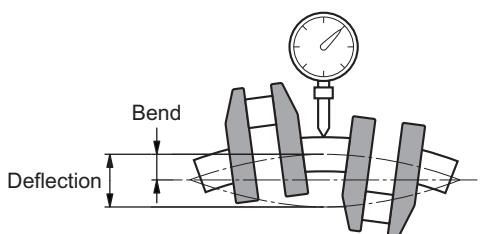


- (2) Bending of the crankshaft

Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check the extent of crankshaft bending.

mm

Crankshaft bend limit (1/2 the dial gauge reading)	0.02
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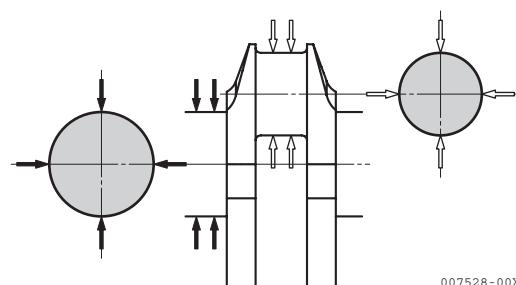
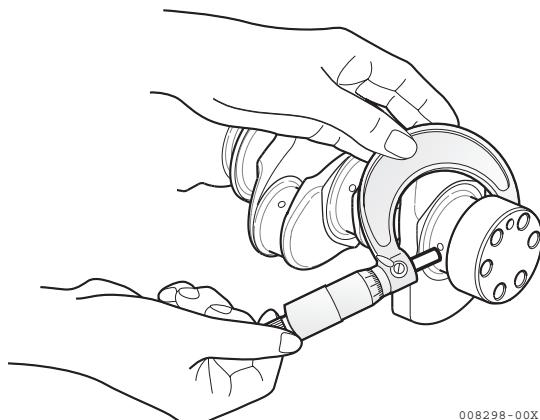
(3) Measuring the crank pin and journal

Measure the outside diameter, roundness and taper at each crank pin and journal. Correct by grinding if unevenly wear, roundness exceeding the limit or insufficient outside diameter is found. Replace if the defect is excessive.

Item	Limit (Diameter) mm
Roundness taper	0.01

To look for the oil clearance of crank pin, measure the inside diameter of crank pin metal. (Refer to 5.4.2(2).)

		Standard mm	Limit mm
Crank pin	Outside dia.	47.952-47.962	47.902
	Oil clearance	0.038-0.083	0.150
Crank journal	Outside dia.	49.952-49.962	49.902
	Oil clearance	0.038-0.068	0.150



- Dimension R and finishing precision of crankshaft journal and pin.

As for grinding processing of journal and pin, machine it by using the grinding wheel of the dimension R of below table.

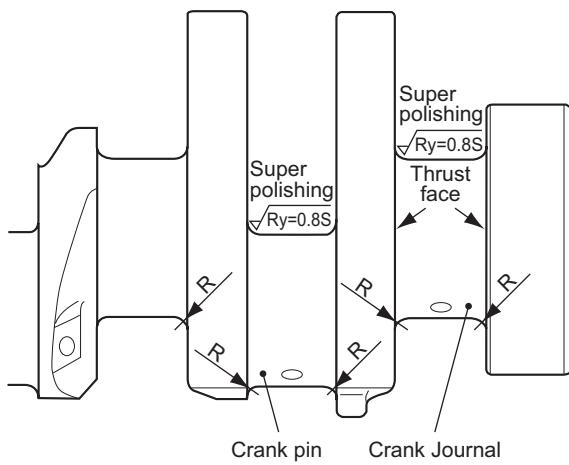
Surface finishing precision standard on journal and pin:

Ry = 0.8S super polishing

Surface finishing precision standard on the thrust side of crankshaft arm:

1.6 /
1.6 /

Finishing precision standard of dimension R (mm)
3.5 $^{+0.3}$ 0



NOTICE:

- If the oil clearance is excessive though the thickness of the journal and crankpin metals are normal or if partial uneven wear is observed, re-grind the crankshaft and use an oversized metals.
- If rust or surface roughening exists on the rear side of the metals, coat it with blue or minimum. Then assemble the crankpin metal to the connecting rod, and tighten the rod bolt to the specified torque to check the metal for contact. If the contact surface occupies 75% or more, the metal is normal. If the contact surface is insufficient, the metal interference is insufficient. Replace the metal with a new one.

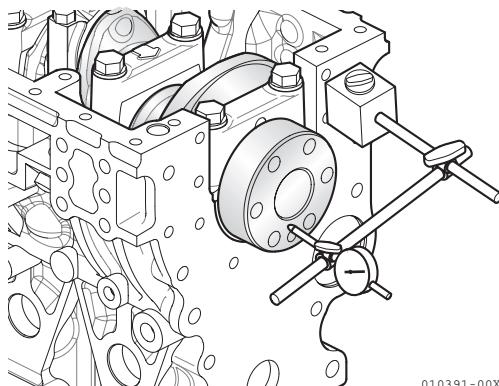
(4) Checking the side gap of a crankshaft

After assembling the crankshaft, tighten the main bearing cap to the specified torque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.

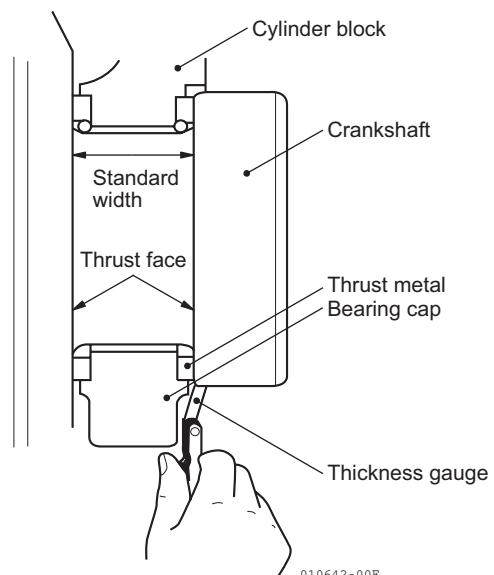
Replace the thrust bearing if it is worn beyond the limit.

	Standard	Limit
Crankshaft side gap	0.14-0.22	0.30

Other measurement method can also be effective. Insert the thickness gauge directly into the clearance between the thrust metal and crankshaft thrust face.



010391-00X



010642-00E

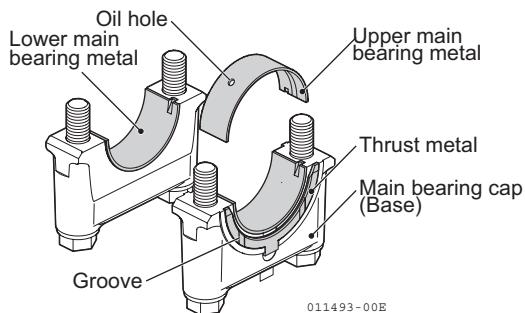
5.5.2 Main bearing

(1) Inspecting the main bearing

Check for flaking, seizure or burning of the contact surface and replace if necessary.

(2) Measuring the inner diameter of metal

Tighten the cap to the specified torque and measure the inner diameter of the metal.



mm

Inspection item	Standard	Limit
Crank journal (Selective pairing)	Journal outside diameter	49.952-49.962
	Metal inside diameter	51.000-51.010
	Metal thickness	1.995-2.010
	Clearance	0.038-0.068
mm		

Nm (kgf·m)

Tightening torque	96-100 (9.8-10.2)
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Note:

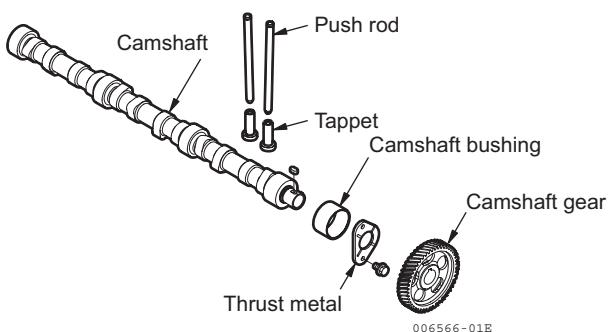
When assembling the bearing cap, keep the following in mind.

- 1) The lower metal (cap side) has no oil groove.
- 2) The upper metal (block side) has an oil groove.
- 3) Check the cylinder block alignment number.
- 4) The "FW" on the cap lies on the flywheel side.

5.6 Camshaft and tappets

5.6.1 Camshaft

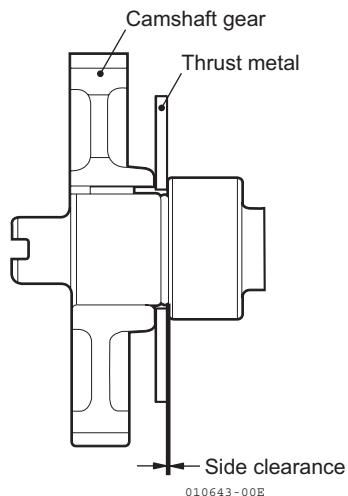
The camshaft is normalized and the cam and bearing surfaces are surface hardened and ground. The cams have a curve that minimized the repeated shocks on the valve seats and maximizes valve seat life.



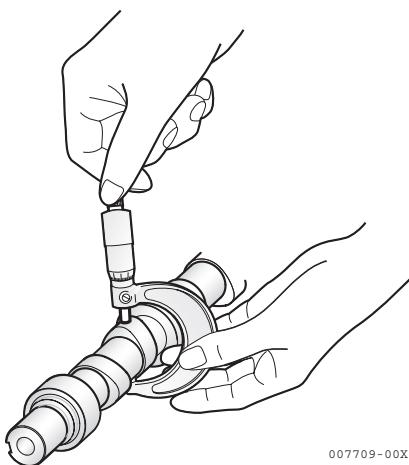
(1) Checking the camshaft side gap

Measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the thrust bearing.

	Standard	Limit
Camshaft side gap	0.05-0.20	0.35



(2) Measure the cam height, and replace the cam if it is worn beyond the limit.



		3JH4E/4JH4E		4JH4-TE/4JH4-HTE	
		Standard	Limit	Standard	Limit
Cam height	Intake	38.600-38.800	38.350	39.800-40.000	39.550
	Exhaust			37.800-38.000	37.550

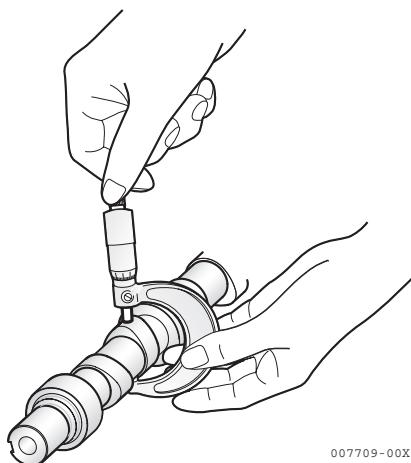
(3) Camshaft and bearing hole measurement

Measure the camshaft outside diameter with a micrometer. The oil clearance shall be calculated by subtracting the measured camshaft outside diameter from the inside diameter of the camshaft bearing or bushing. The camshaft bushing at gear case side is measured with a cylinder gage after insertion to the cylinder.

Replace if they exceed the limit or are damaged.

mm

Place	Item	Standard	Limit
Gear side (with metal)	Bushing I.D.	44.990-45.055	45.130
	Camshaft O.D.	44.925-44.950	44.890
	Oil clearance	0.040-0.130	0.240
Intermediate position (metal less)	Shaft hole I.D.	45.000-45.025	45.100
	Camshaft O.D.	44.910-44.935	44.875
	Oil clearance	0.065-0.115	0.225
Flywheel side (metal less)	Shaft hole I.D.	45.000-45.025	45.100
	Camshaft O.D.	44.925-44.950	44.890
	Oil clearance	0.050-0.100	0.210



007709-00X

(4) Bending of the camshaft

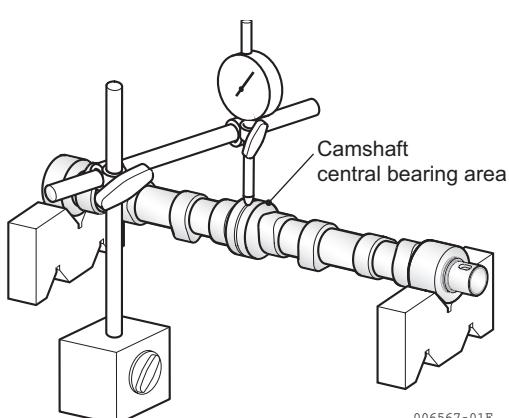
Support both ends of the camshaft with V-blocks, place a dial gauge at the central bearing areas and measure bending. Replace if excessive.

Note:

The reading on the dial gauge is divided by two to obtain the camshaft bend.

mm

	Standard	Limit
Camshaft bend	0.02 or less	0.05



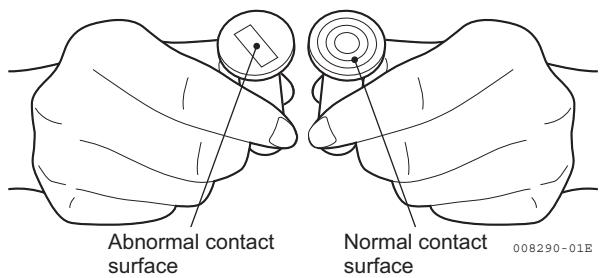
006567-01E

5.6.2 Tappets

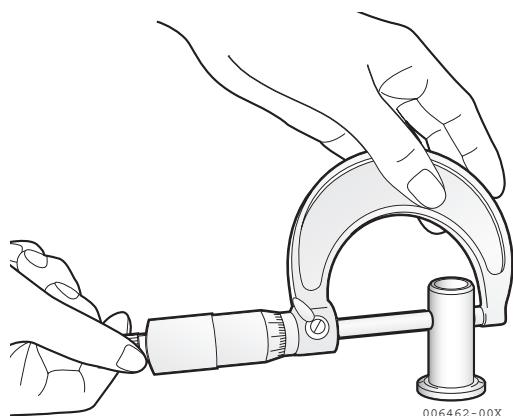
- (1) The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.

Note:

When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.



- (2) Measure the outer diameter of the tappet, and replace if worn beyond the limit.

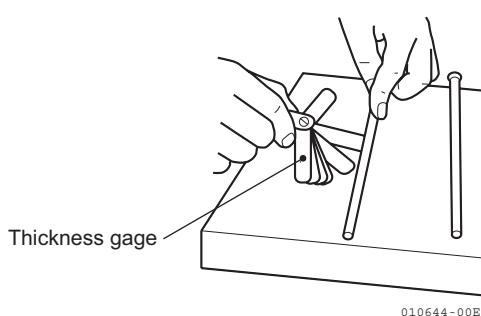


	3JH4E/4JH4E		4JH4-TE/4JH4-HTE	
	Standard	Limit	Standard	Limit
Tappet stem outside dia.	11.975~11.990	11.930	11.975~11.990	11.930
Tappet guide hole inside dia. (cylinder block)	12.000~12.018	12.045	12.000~12.025	12.052
Oil clearance	0.010~0.043	0.090	0.010~0.050	0.097

- (3) Measuring push rods.

Measure the length and bending of the push rods.

	Standard	Limit
Push rod length	178.25~178.75	-
Push rod bend	Less than 0.03	0.03
Push rod dia.	8.0	-



5.7 Timing gear

The timing gear is helical type for minimum noise and specially treated for high durability.

5.7.1 Inspecting the gears

- (1) Inspect the gears and replace if the teeth are damaged or worn.
- (2) Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

Note:

If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.

mm

	Standard	Limit
Backlash	0.07-0.15	0.17

(3) Idling gear

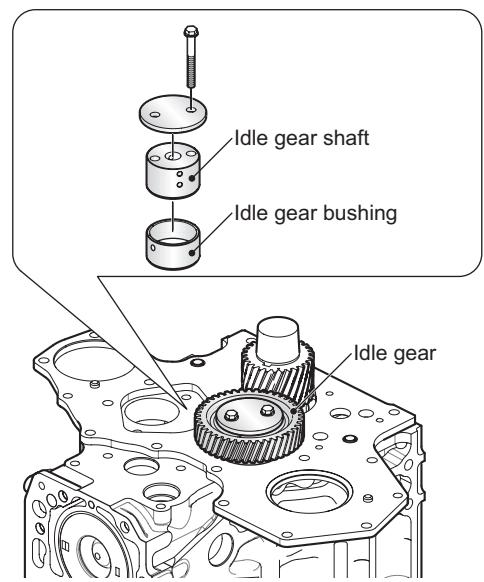
The bushing is pressure fitted into the idling gear.

Measure the bushing inner diameter and the outer diameter of the shaft, and replace the bushing or idling gear shaft if the oil clearance exceeds the wear limit.

A, B and C are inscribed on the end of the idling gear.

When assembling, these marks should align with those on the cylinder block.

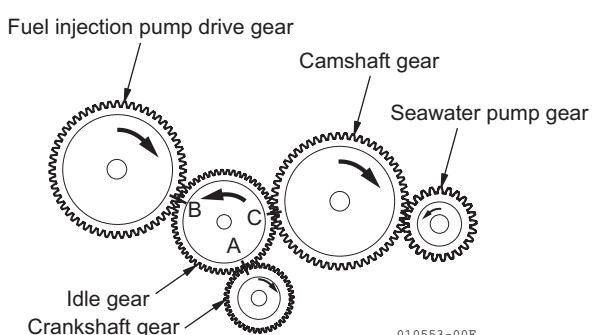
	Standard	Limit
Idle gear shaft dia.	45.950-45.975	45.880
Idle gear bushing inside dia.	46.000-46.025	46.075
Oil clearance	0.025-0.075	0.15



010552-00E

5.7.2 Gear timing marks

Match up the timing marks on each gear when assembling (A, B and C).



010553-00E

5.8 Flywheel and housing

The function of the flywheel is through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.

The flywheel is mounted and secured by 6 bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.

The fitting surface for the damper disc is on the crankshaft side of the flywheel. The rotation of the crankshaft is transmitted through this disc to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.

The flywheel's unbalanced force on the shaft center must be kept below the specified value for the crankshaft as the flywheel rotates with the crankshaft at high speed.

To achieve this, the balance is adjusted by drilling holes in the side of the flywheel, and the unbalanced momentum is adjusted by drilling holes in the circumference.

The ring gear is shrink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.

The stamped letter and line which show top dead center of each cylinder are positioned on the flywheel circumference, and by matching these marks with the arrow mark at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

5.8.1 Position of top dead center and fuel injection timing

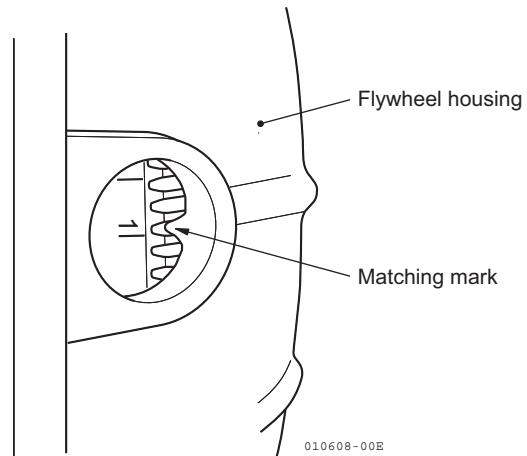
The marking is applied to the flywheel and flywheel housing to indicate the top dead center of this engine or the fuel injection timing angle.

(1) Marking

The marking is applied on the flywheel to show the crankshaft angle.

(2) Matching mark

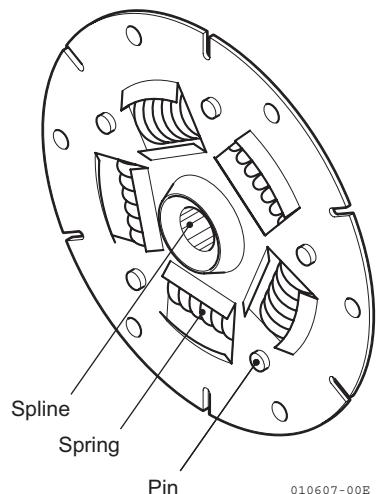
The matching mark is made at the hole of the flywheel housing.



5.8.2 Damper disc

When coupling a marine gear with an engine, a damper disk is used to absorb the torque fluctuations of the engine.

Refer to the marine gear service manual of the separate volume for the detail.

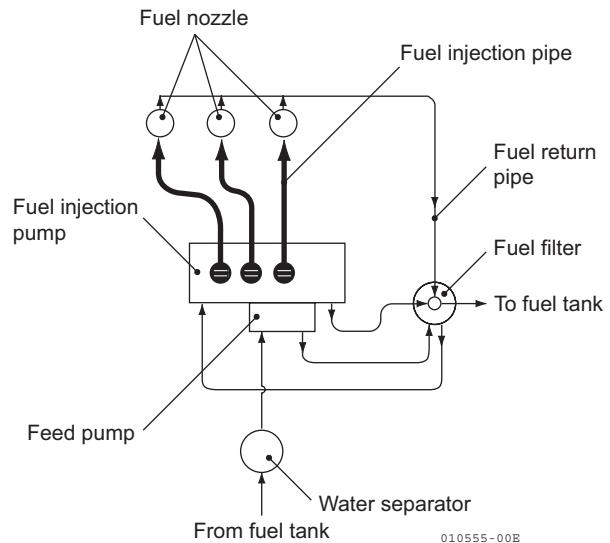


6. Fuel Injection equipment

6.1 Fuel Injection pump/governor for 3JH4E and 4JH4E

Refer to the JH3E manual of separate volume for the disassembly and assembly, adjustment procedure of a fuel injection pump.

6.1.1 Fuel system diagram



6.1.2 Fuel injection pump service data

(1) 3JH4E service date

Part code (Back No.)			-	729271-51450 (TM02)		
Adjustment SPEC			-	ENG SPEC	SERVICE STD	
Item	Fuel valve (Valve pressure)		-	VBG (220)	(170)	
	Nozzle type (ID mark)		-	159P185VAD1	DN-12SD12	
	Fuel injection pipe		mm	Ø 1.6 x 360	Ø2 x 600	
Injection adjustment	Starting	Pump speed N _s	min ⁻¹	200	200	
		Average injection volume Q _s	mm ³ /st	45 ± 5.0	50 ± 5.0	
	Rated load	Pump speed N _o	min ⁻¹	1500	1500	
		Injection volume Q _o	mm ³ /st	32.5 ± 0.75	56.5 ± 0.75	
		Nonuniformity	%	± 3	± 3	
	Torque rise	Pump speed N _T	min ⁻¹	-	-	
		Injection volume Q _T	mm ³ /st	-	-	
		Nonuniformity	%	-	-	
	Hi-idle	Pump speed N _{Hi}	min ⁻¹	1660 ⁺¹⁵ ₋₁₀	1660 ⁺¹⁵ ₋₁₀	
		Injection volume Q _{Hi}	mm ³ /st	6 - 7	18 - 19	
	Idle	Pump speed N _i	min ⁻¹	400	400	
		Q _i	mm ³ /st	6 - 7	7 - 8	
		Nonuniformity	%	± 15	± 15	
Plunger stroke			mm	8.0		
Plunger dia.			mm	8		
Suction volume of delivery valve			mm ³	36		
Pre-stroke			mm	3.0		
Top clearance			mm	0.5		
Governor spring	Spring constant		N/cm (kgf/cm)	2.76 (0.281)		
	Free length		mm	41		

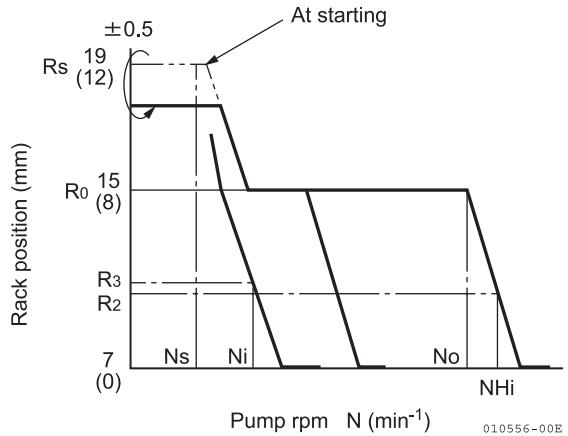
(2) 4JH4E service data

Part code (Back No.)			729670-51450 (SH79)		
Adjustment SPEC			ENGINE SPEC	SERVICE STD	
Item	Fuel valve (Valve pressure)		VBG (220)	(170)	
	Nozzle type (ID mark)		159P185VAD1	DN-12SD12	
	Fuel injection pipe	mm	Ø1.6 x 400	Ø2 x 600	
Injection adjustment	Starting	Pump speed N _s	(min ⁻¹)	200	
		Average injection volume Q _s	(mm ³ /st)	50	
	Rated load	Pump speed N _o	(min ⁻¹)	1500	
		Injection volume Q _o	(mm ³ /st)	33.1 ± 0.75	
		Variation	%	± 3	
	Torque rise	Pump speed N _T	(min ⁻¹)	-	
		Injection volume Q _T	(mm ³ /st)	-	
		Nonuniformity	%	-	
	Hi-idle	Pump speed N _{Hi}	(min ⁻¹)	1660 ⁺¹⁵ ₋₁₀	
		Injection volume Q _{Hi}	(mm ³ /st)	6 - 7	
	Idle	Pump speed N _i	(min ⁻¹)	400	
		Q _i	(mm ³ /st)	9 - 10	
		Nonuniformity	%	± 10	
Plunger stroke			(mm)	8.0	
Plunger dia.			(mm)	Ø8	
Suction volume of delivery valve			(mm ³)	36	
Pre-stroke			(mm)	3.0	
Top clearance			(mm)	0.5	
Governor spring	Spring constant		N/cm (kgf/cm)	2.76 (0.281)	
	Free length		(mm)	41	

(3) Adjusting fuel limit bolt at rated load

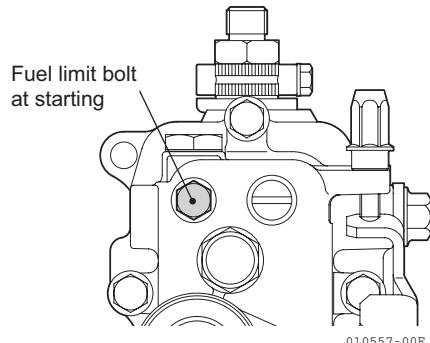
- 1) Adjust the fuel limit bolt to bring the rack position to the specified value (R_o) with the governor control lever towards the fuel increase position, while keeping the pump at rated speed N_o .
- 2) Measure fuel injection volume at rack position (R_o).
- 3) If the injection volume is at the specified value, tighten the fuel limit bolt lock nut at that position.

Note: The figure in the blank () is the indicator.



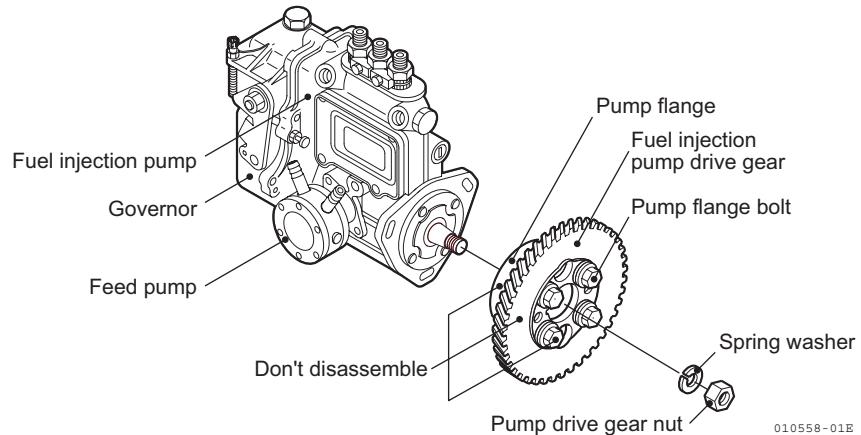
(4) Adjusting fuel limit bolt at starting

- 1) Adjust the fuel limit bolt at starting to bring the rack position to the specified value (R_s), while keeping the pump at starting speed N_s .
- 2) Measure fuel injection volume at starting position (R_s).
- 3) If the injection volume is at the specified value, tighten the fuel limit bolt lock nut at that position.

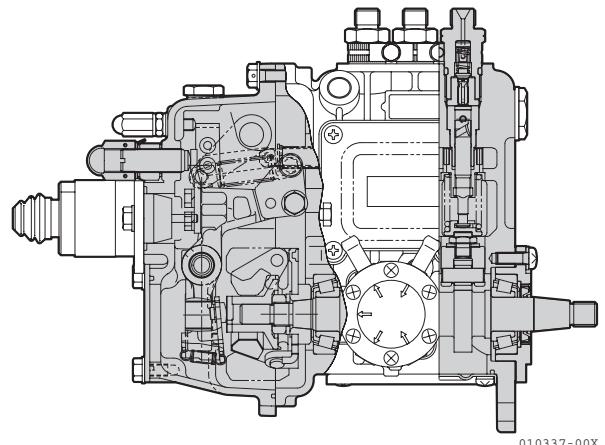


6.1.3 Fuel injection pump structure

(1) Component of fuel injection pump for 3JH4E



(2) Section of a fuel injection pump/ governor for 3JH4(B)(C)E



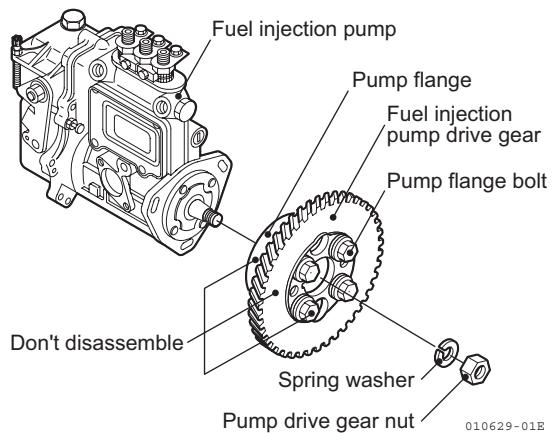
6.1.4 Removing a fuel injection pump

The procedure to remove a fuel injection pump from the gear case is shown.

[NOTICE]

Be sure to remove a flange and a fuel injection pump drive gear as a pair without loosening the flange bolts.

- 1) Remove fuel injection pipes, fuel pipes and a remote control wire. Block the entrance with tape so that trash may not enter the fuel injection pipes and the fuel injection pump.
- 2) Mark the position of the timing marks of a fuel pump and a gear case. Or, put a mark on the gear case at the position to agree the timing mark of a fuel pump.
- 3) Remove a pump cover from the gear case.
- 4) Give the marks on a fuel injection pump drive gear and a idle gear with paint or the line.
- 5) Loosen fuel injection pump installation nuts (three nuts).
- 6) Loosen a installation nut of a fuel injection pump drive gear.
- 7) Pull a fuel injection pump drive gear and a flange with a pair to your side by gear puller.
- 8) Remove a pump drive gear nut and a washer.
- 9) Remove a fuel injection pump. Leave the pump drive gear in the gear case.



6.1.5 Installing a fuel injection pump

[NOTICE]

- Use a new O-ring on the fuel pump flange and apply grease.
 - Confirm whether the marks of the pump drive gear and the idle gear is correct.
- 1) Turn a camshaft so that the key of the pump camshaft may almost agree in a position of the key groove of a pump drive gear.
 - 2) Insert a fuel injection pump into the installation hole of the gear case straight to prevent the damage of the O-ring. Insert a fuel pump while confirming whether the key of a camshaft and the key groove of a drive gear agree.
 - 3) Assemble a pump drive gear nut and a washer together temporarily.
 - 4) Turn a fuel injection pump to the position where the marks of the fuel injection pump and the gear case agrees.
 - 5) Fasten pump installation nuts (three nuts) on the fuel injection pump.
 - 6) Tighten the pump installation nut by the specified standard torque.

Tightening torque of the pump drive gear nut (without lube oil)

Tightening torque	Nm(kgf•m)
	78-88 (8-9)

6.1.6 Adjusting fuel injection timing

Refer to 2.2.6(1) in chapter 2.

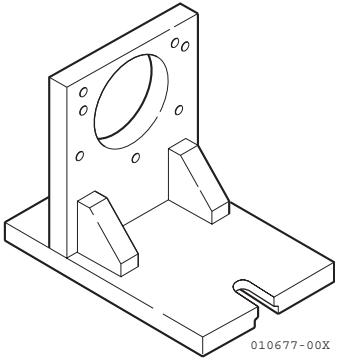
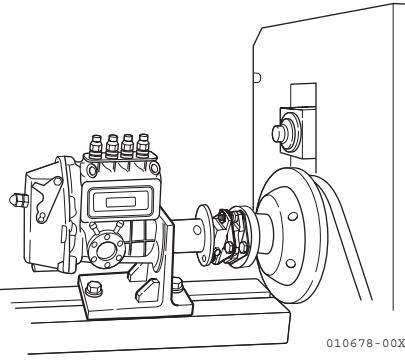
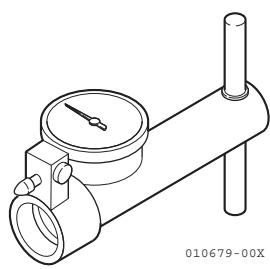
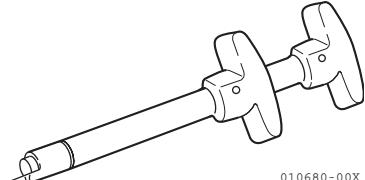
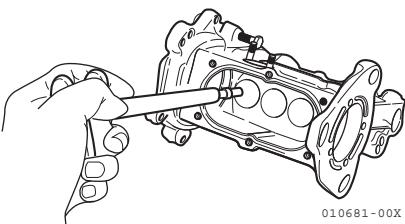
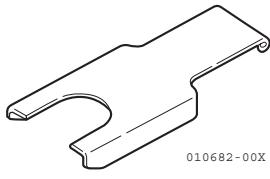
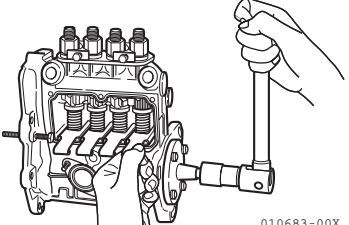
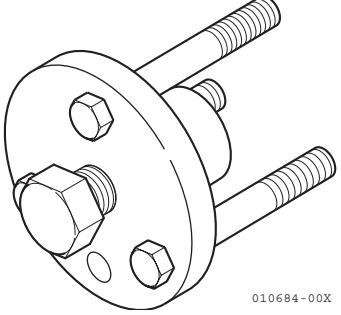
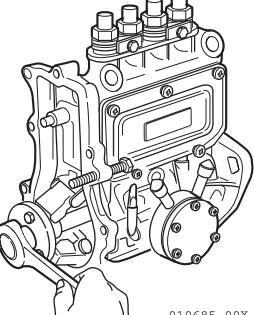
6.1.7 Troubleshooting of fuel injection pump

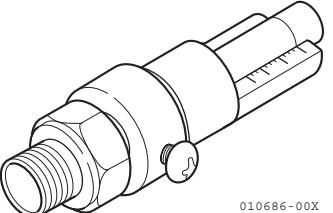
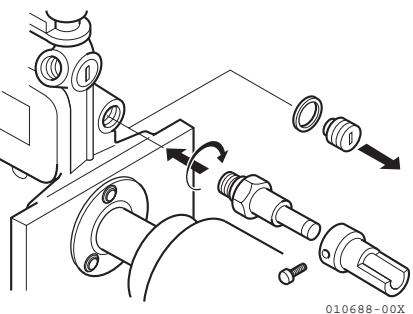
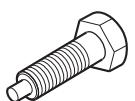
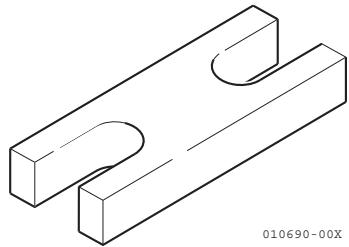
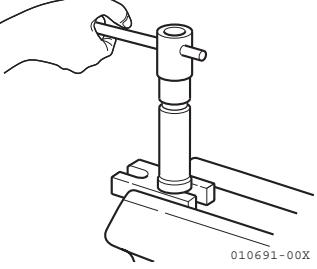
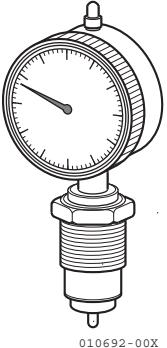
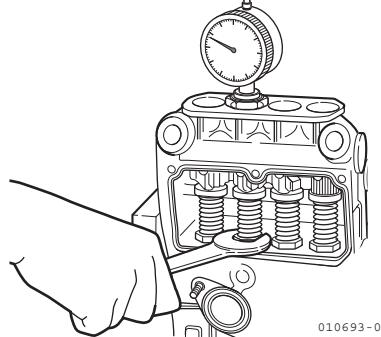
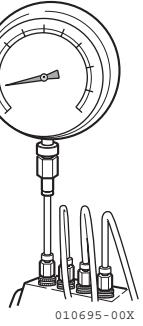
Complete repair means not only replacing defective parts, but finding and eliminating the cause of the trouble as well. The cause of the trouble may not necessarily be in the pump itself, but may be in the engine or the fuel system. If the pump is removed prematurely, the true cause of the trouble may never be known. Before removing the pump from the engine, at least go through the basic check points given here.

Basic checkpoints

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

6.1.8 Tools

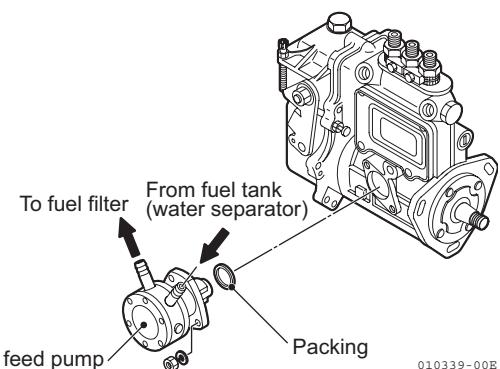
Name of tool	Shape and size	Application
Pump mounting scale for Yanmar tester 158090-51010 for Bosch (tester) 158090-51020	 010677-00X	 010678-00X
Measuring device (cam backlash) 158090-51050	 010679-00X	
Plunger insert 158090-51100	 010680-00X	 010681-00X
Tappet holder 158090-51200	 010682-00X	 010683-00X
Weight extractor 158090-51400	 010684-00X	 010685-00X

Name of tool	Shape and size	Application
Rack indicator 158090-51500	 010686-00X	 010688-00X
Rack lock screw 158090-51510	 010689-00X	
Dummy nut 158090-51520	 010687-00X	
Nozzle plate 158090-51700	 010690-00X	 010691-00X
Plunger gauge 121820-92540	 010692-00X	 010693-00X
Top clearance gauge 158090-51300	 010694-00X	 010695-00X

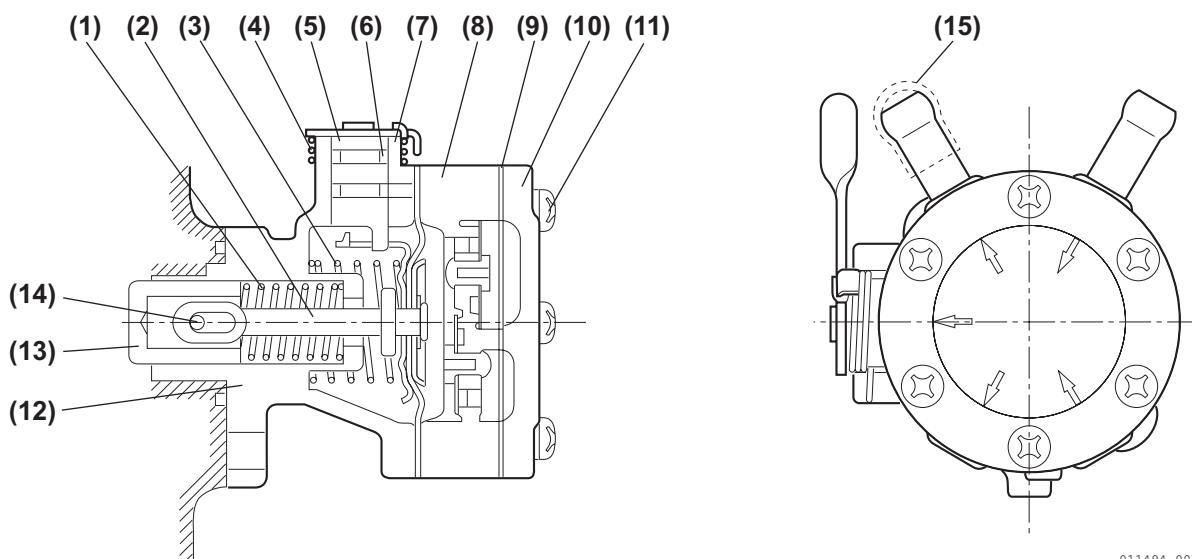
6.2 Fuel feed pump

The fuel feed pump pumps fuel from the fuel tank, passes it through the fuel filter element, and supplies it to the fuel injection pump.

The fuel feed pump is mounted on the side of this engine and is driven by the (eccentric) cam of the fuel pump camshaft. It is provided with a manual priming lever so that fuel can be supplied when the engine is stopped.



6.2.1 Construction of fuel feed pump



- | | | | |
|-------------------------|-----------------------|------------------|-------------|
| (1) Piston spring | (5) Lever assembly | (9) Packing | (13) Piston |
| (2) Diaphragm assembly | (6) O-ring | (10) Cover | (14) Pin |
| (3) Diaphragm spring | (7) Stop pin | (11) Small screw | (15) Cap |
| (4) Lever return spring | (8) Top body assembly | (12) Bottom body | |

6.2.2 Fuel feed pump specifications

Head	1m
Discharge volume	230 cm ³ /min at 1500 min ⁻¹ (cam), discharge pressure of 0.020 MPa (0.2 kgf/cm ²)
Closed off pressure	0.029 MPa (0.3 kgf/cm ²) or more at 400 min ⁻¹ (cam)

6.2.3 Disassembly and reassembly of fuel feed pump

(1) Disassembly

- 1) Remove the fuel feed pump mounting nut, and take the fuel feed pump off the fuel injection pump.
- 2) Clean the fuel feed pump assembly with fuel oil.
- 3) After checking the orientation of the arrow on the cover, make match marks on the upper body and cover, remove the small screw, and disassemble the cover, upper body and lower body.

(2) Reassembly

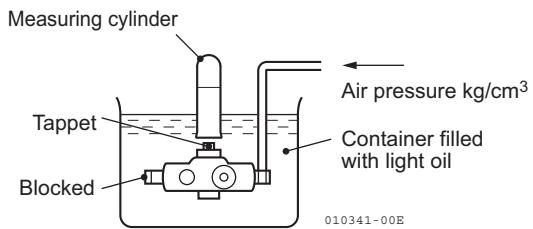
- 1) Clean all parts with fuel oil, inspect, and replace any defective parts.
- 2) Replace any packing on parts that have been disassembled.
- 3) Make sure that the intake valve and discharge valve on upper body are mounted in the proper direction , and that you don't forget the valve packing.
- 4) Assemble the diaphragm into the body, making sure the diaphragm mounting holes are lined up (do not force).
- 5) Align the match marks on the upper body of the pump and cover, and tighten the small screws evenly.

Nm(kgf·m)

Tightening torque	1.47-2.45 (0.15-0.25)
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6.2.4 Fuel feed pump inspection

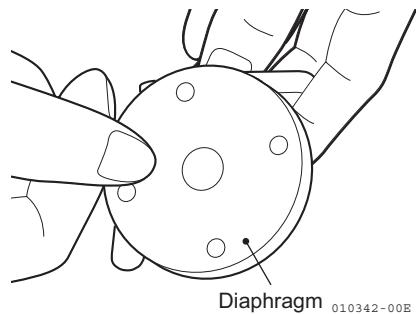
- (1) Place the fuel feed pump in kerosene, cover the discharge port with your finger, move the priming lever and check for air bubbles (Repair or replace any part which emits air bubbles).



- (2) Attach a vinyl hose to the fuel feed pump intake, keep the pump at the specified depth from the fuel oil surface, move the priming lever by hand and check for sudden spurts of fuel oil from the discharge port. If oil is not spurted out, inspect the diaphragm and diaphragm spring and repair/replace as necessary.

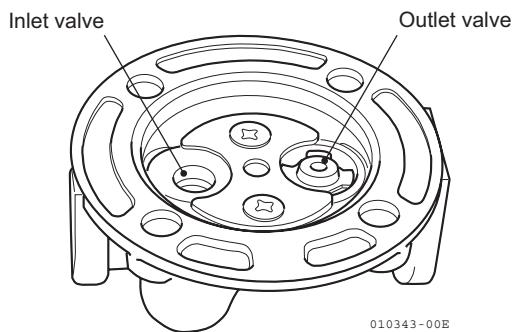
- (3) Diaphragm inspection

Parts of the diaphragm that are repeatedly burned will become thinner or deteriorate over a long period of time.
Check the diaphragm and replace if necessary.



- (4) Valve contact/mounting

Clean the valve seat and valve with air to remove any foreign matter.

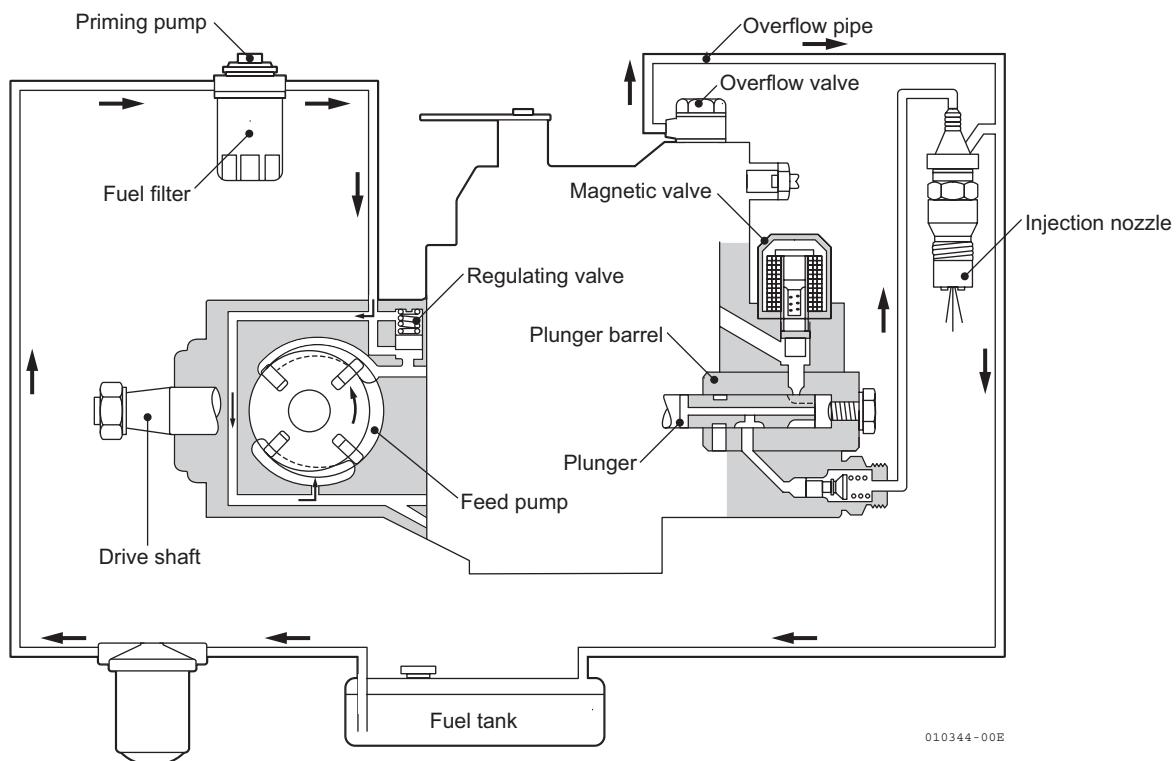


- (5) Inspect the diaphragm spring and piston spring for settling and the piston for wear, and replace as necessary.

Note: Replace parts as an assembly.

6.3 Fuel injection pump/ governor for 4JH4-TE and 4JH4-HTE

6.3.1 Fuel system diagram



6.3.2 Fuel injection pump structure

(1) Specification

The fuel injection pump is VE type (Bosh made).

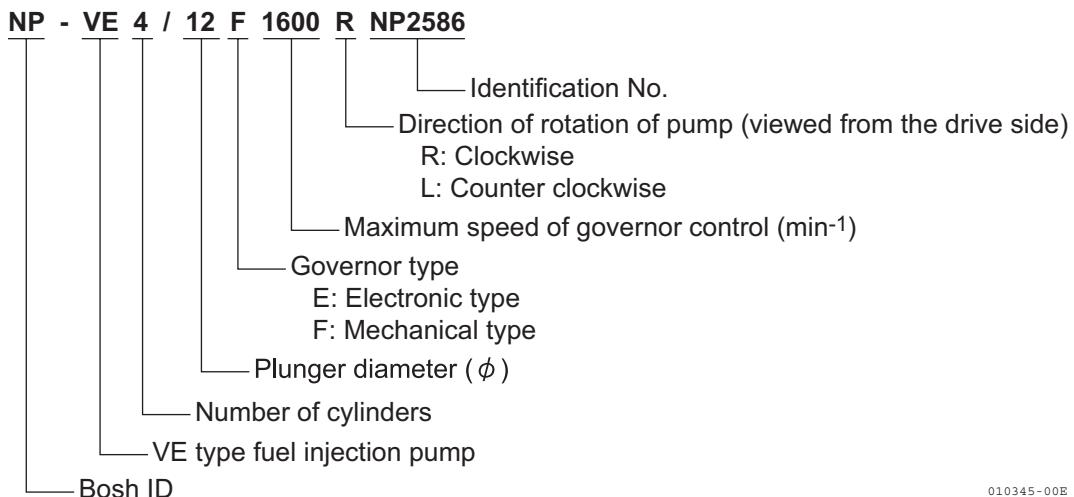
[NOTICE]

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

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

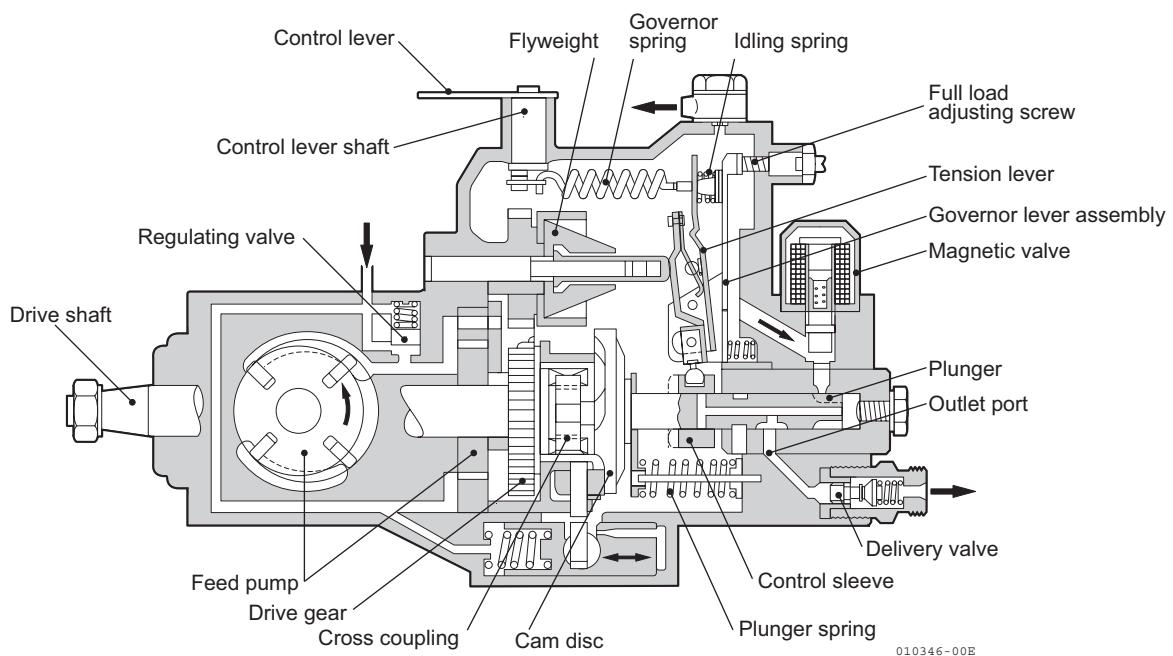
Model	VE4/12F	
Direction of rotation	Clockwise (viewed from the drive side)	
Plunger diameter	$\varnothing 12$ mm	
Governor type	All speed	
Fuel feed type	Vane	
Timer advancing angle	4JH4-TE 1.5°/1100 - 1600 min ⁻¹ (pump speed)	4JH4-HTE 2.6°/1200 - 1600 min ⁻¹ (pump speed)
Lubricating method	Fuel oil lubricating	
Fuel cut method	1) Magnetic valve (normal open) 2) With a manual stop lever	
Additional device	Boost compensator	

Model notation



010345-00E

(2) Structure and function



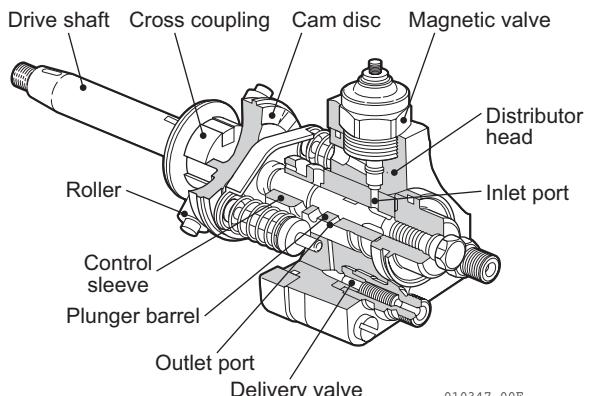
1) Plunger

- 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. The 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.



2) Governor

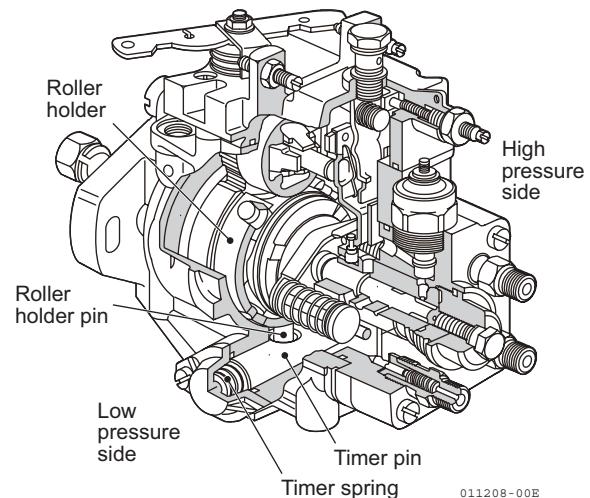
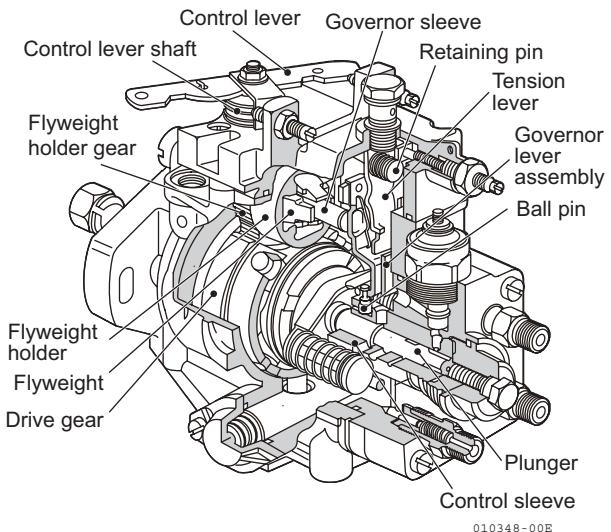
- a) The governor, which is located above the pump house, consists of a flyweight holder, governor lever assembly, etc. The flyweight holder holds four flyweights and governor sleeve and is supported by the governor shaft. The drive gear engages with the flyweight holder gear and speeds up the drive 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.
- b) The 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.

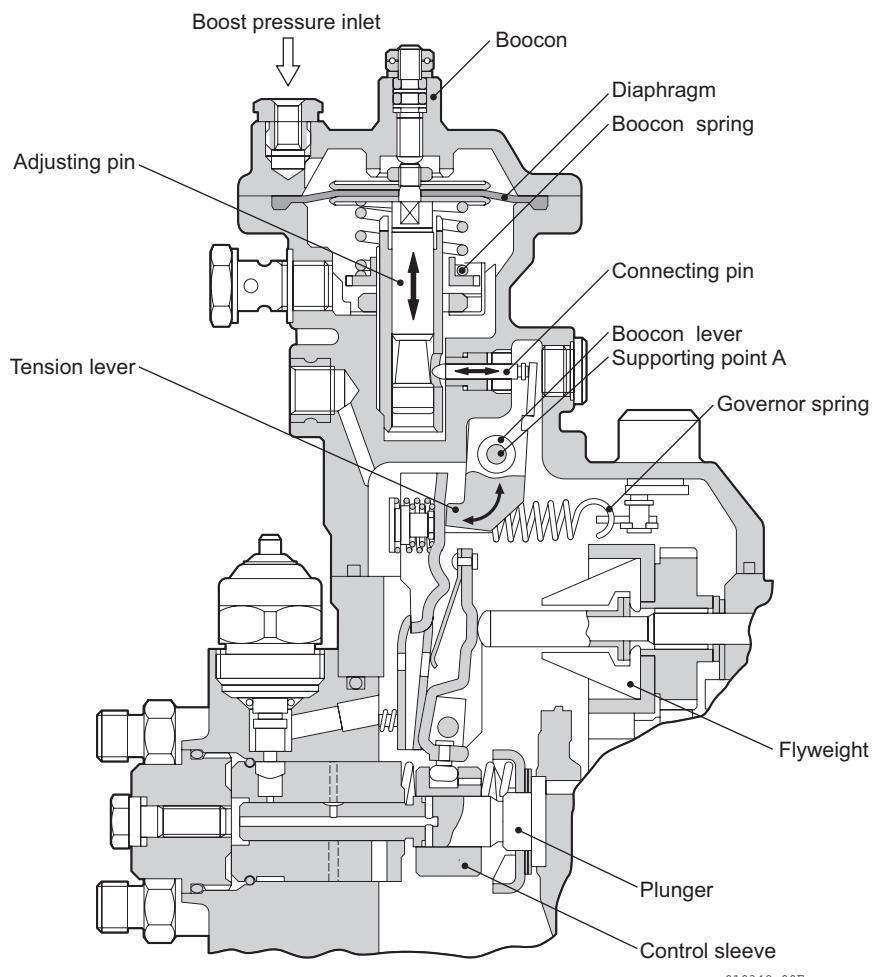
3) Timer

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.



4) Boost compensator



- 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:

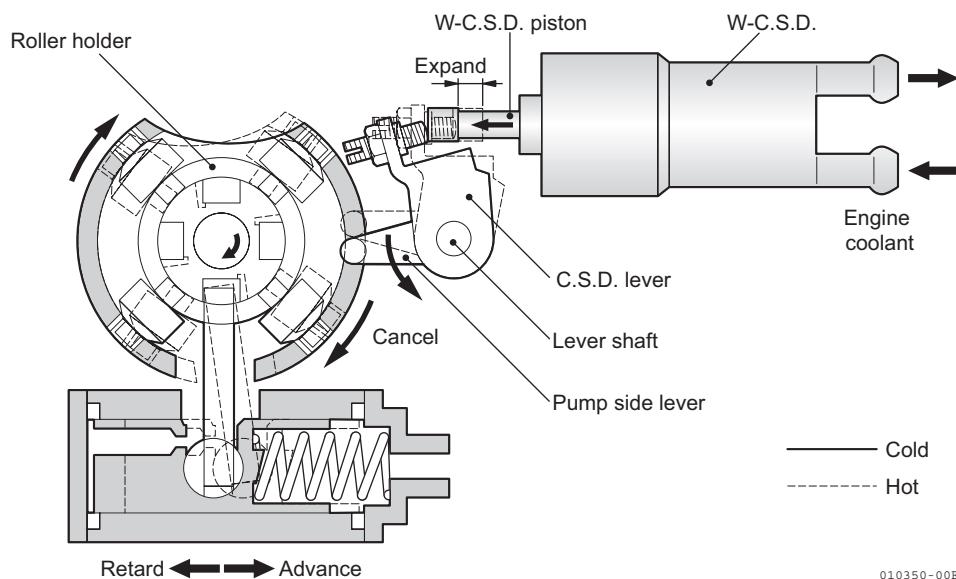
The description above is given based on the service manual issued by the Service Department of Bosch.

5) Wax type Cold Start Device (W-C.S.D.)

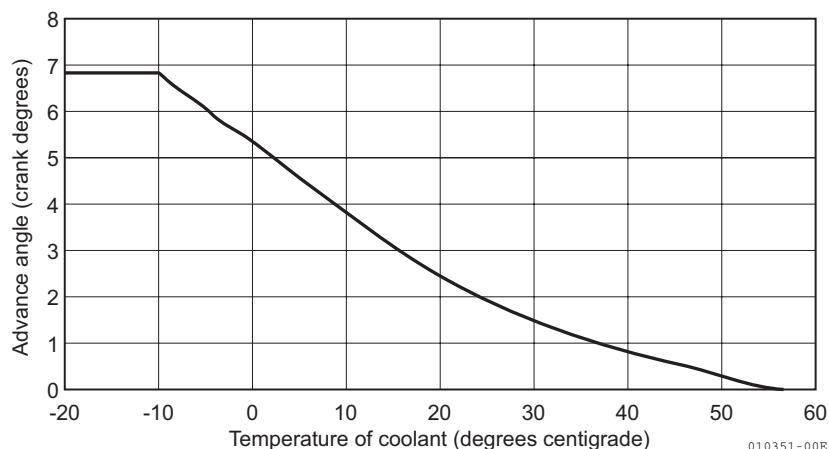
This device aids the easier start of engine by advancing the fuel injection timing, when the weather is cold.

The wax element is integrated into the body of W-C.S.D. The engine coolant is led to the wax element and flowing around it. The wax element is expanded by sensing the temperature of engine coolant and moves the W-C.S.D piston. The movement of W-C.S.D piston turns the pump side lever pin via lever shaft. This pin is connected to the roller holder against cam disc. The movement of W-C.S.D piston changes the fuel injection timing by changing the phase angle between cam disc and roller holder.

When the engine coolant is below - 10 degrees centigrade, the wax element becomes most shrunken state; the roller holder comes to the maximum advance angle position (6.8 degrees of crankshaft). When the engine coolant becomes warmer, the wax element expands gradually. The roller holder turns from maximum advance angle position to smaller advance angle position. When the temperature becomes over 56 degrees centigrade, the advance function of W-C.S.D is completely canceled. At standard engine operation state, temperature of engine coolant becomes over 56 degrees centigrade, and W-C.S.D never affects the exhaust emission.



W-C.S.D of 4JH4-TE/4JH4-HTE



6.3.3 Fuel injection pump service data

The expertise and facilities are necessary for the disassembly and adjustment of a fuel injection pump. Make a request to Bosch service shop for them.

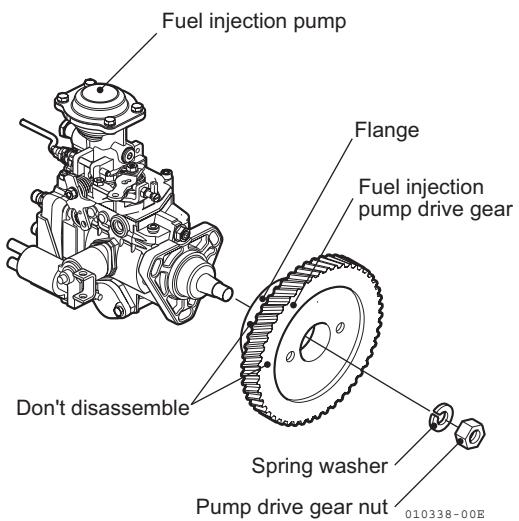
4JH4-TE and 4JH4-HTE

Adjustment conditions	Nozzle type	Bosh 105780-0060 (NP-DN0S1510)				
	Nozzle holder	105780-2150				
	Nozzle opening pressure	13.0 MPa				
	Fuel injection pipe (outside diameter x inside diameter-length)	$\varnothing 6 \times 2\text{-}450$ mm				
	Fuel oil feed pressure	20 kPa				
Engine model		4JH4-TE				
Adjustment value		Pump speed (min^{-1})	Boost pressure (kPa)	Injection quantity (mm^3/st)	Ununiformity (mm^3/st)	Lube oil temperature (°C)
Injection quantity and governor		600	0	(83.5)	-	50 ± 2
		800	40.0 ± 1.3	112 ± 2	-	50 ± 2
		900	66.7 ± 1.3	127.7 ± 2	10.5	50 ± 2
		1600	66.7 ± 1.3	(118.2 ± 6)	-	50 ± 2
		1800	66.7 ± 1.3	58.5 ± 5	-	50 ± 2
		400	0	8.5 ± 2.5	3.0	48 ± 2
		100	0	(134.2)	-	48 ± 2
Timer and pump room pressure		Pump speed (min^{-1})	Boost pressure (kPa)	Timer piston stroke (mm)	Pump room pressure (kPa)	Remarks
		1000	66.7 ± 1.3	0.5 or less	-	
		1500	66.7 ± 1.3	0.9 ± 0.4	520 ± 39	
		1600	66.7 ± 1.3	(1.0 ± 0.6)	-	
Cold advancer characteristics		Coolant temperature (°C)	Timer piston stroke (mm)			Remarks
		20	1.04 ± 0.6			
		-10	2.81 ± 0.8			
Engine model		4JH4-HTE				
Adjustment value		Pump speed (min^{-1})	Boost pressure (kPa)	Injection quantity (mm^3/st)	Ununiformity (mm^3/st)	Lube oil temperature (°C)
Injection quantity and governor		500	0	(43.1)	-	48 ± 2
		750	40.0 ± 1.3	91.2 ± 2	-	50 ± 2
		1100	80.0 ± 1.3	128.2 ± 2	10.5	50 ± 2
		1600	80.0 ± 1.3	(124.0 ± 6)	-	50 ± 2
		1750	80.0 ± 1.3	60.3 ± 5	-	50 ± 2
		380	0	8.0 ± 2.5	3.0	48 ± 2
		100	0	(110)	-	48 ± 2
Timer and pump room pressure		Pump speed (min^{-1})	Boost pressure (kPa)	Timer piston stroke (mm)	Pump room pressure (kPa)	Remarks
		1200	80.0 ± 1.3	0.5 or less	-	
		1500	80.0 ± 1.3	1.2 ± 0.4	569 ± 39	
		1600	80.0 ± 1.3	(2.1 ± 0.6)	-	
Cold advancer characteristics		Coolant temperature (°C)	Timer piston stroke (mm)			Remarks
		20	1.04 ± 0.6			
		-10	2.81 ± 0.8			

6.3.4 Removing a fuel injection pump

The procedure to remove only a fuel injection pump is shown.

- 1) Remove fuel injection pipes, fuel pipes and a remote control wire. After removing pipes, block the pipe inlet with tape so that trash may not enter the fuel injection pipes and the fuel injection pump.
- 2) Check the position of the timing marks of a VE pump and a VE pump bracket. If necessary, put a mark on the bracket at the position to agree the timing mark of the VE pump.
- 3) Remove a pump cover from the gear case.
- 4) Give the marks on a pump drive gear and a idle gear with paint or the like.
- 5) Loosen the fuel injection pump installation nuts (three nuts).
- 6) Loosen a installation nut of the pump drive gear.
- 7) Pull the pump drive gear to your side by gear puller.
- 8) Remove the pump drive gear nut and a washer.
- 9) Remove the VE pump and O-ring from the VE pump bracket. Leave the pump drive gear in the gear case.



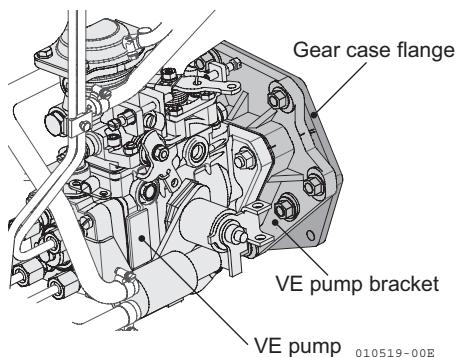
6.3.5 Installing a fuel injection pump

- 1) Confirm whether the marks of the pump drive gear and the idle gear agree.
- 2) Turn a pump camshaft so that the key of the camshaft may almost agree in a position of the key groove of the pump drive gear.
- 3) Insert the VE pump and O-ring into the installation hole of the VE pump bracket while confirming whether the key of the camshaft and the key groove of the drive gear agree.
Lightly tighten the 3 nuts for the VE pump.

Note:

- Replace the used O-ring with new one.
- Be careful not to scratch the O-ring.

- 4) Tighten the pump drive gear nut and the washer together temporarily.
- 5) Turn the VE pump to the position where the marks of the VE pump and the VE pump bracket agree.
- 6) Tighten the pump drive gear nut firmly by the specified standard torque.
Tightening torque of the pump drive gear nut
(apply lube oil)



Tightening torque	Nm (kgf·m)
-------------------	------------

59-69 (6.0-7.0)

- 7) Tighten the pump installation nuts (three nuts) firmly.
(After adjusting the injection timing, tighten the fuel injection pump)
- 8) Measure the backlash between the pump drive gear and idle gear.

mm

Backlash	0.07-0.15
----------	-----------

6.3.6 Adjusting fuel injection timing

Refer to 2.2.6(1) in chapter 2.

6.3.7 Troubleshooting of fuel injection pump

Complete repair means not only replacing defective parts, but finding and eliminating the cause of the trouble as well. The cause of the trouble may not necessarily be in the pump itself, but may be in the engine or the fuel system. If the pump is removed prematurely, the true cause of the trouble may never be known. Before removing the pump from the engine, at least go through the basic check points given here.

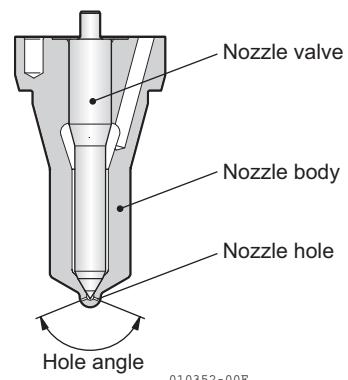
Basic checkpoints

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

Note:

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

6.4 Fuel injection nozzle

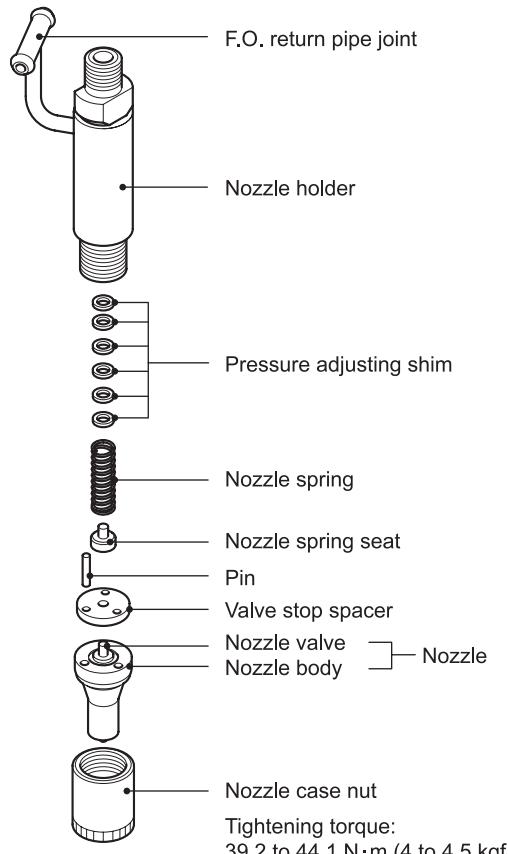


(1) Nozzle specifications

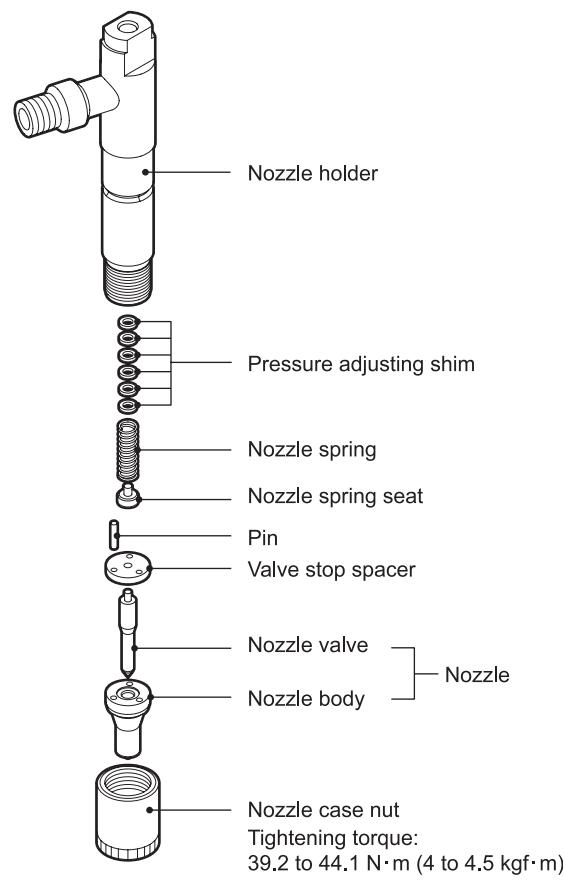
Item	3JH4E/4JH4E	4JH4-TE	4JH4-HTE
Nozzle type	YDLLA-P		
Hole angle	159	156	
Number of nozzle holes-hole diameter (mm)	5-ø0.18	6-ø0.16	6-ø0.18
Injection nozzle opening pressure MPa (kgf/cm ²)	21.1-22.1 (215-225)		
Nozzle stamp mark	159P185VAD1	156-P166VCC0	156P186VCC0

(2) Fuel injection nozzle structure

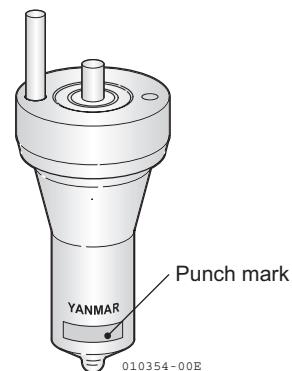
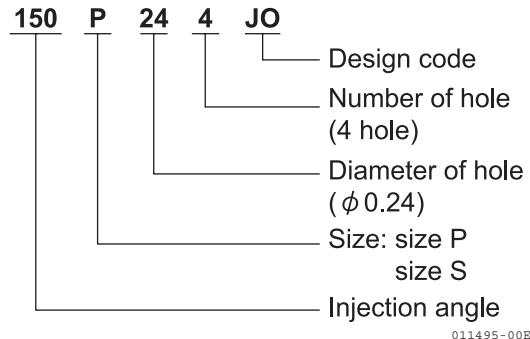
2-valve head (3JH4E and 4JH4E)



4-valve head (4JH4-TE and 4JH4-HTE)



(3) Nozzle stamp notation



(4) Adjustment of fuel injection nozzle and injection test

Refer to 2.2.6(2) for the procedure.

(5) Adjustment of fuel injection timing

Refer to 2.2.6(1) for the procedure.

(6) Removing the fuel injection nozzle from cylinder head

Refer to 4.3.1(18) for the procedure.

(7) Installing the fuel injection nozzle to cylinder head

Refer to 4.3.2(23) for the procedure.

6.5 Fuel Filter

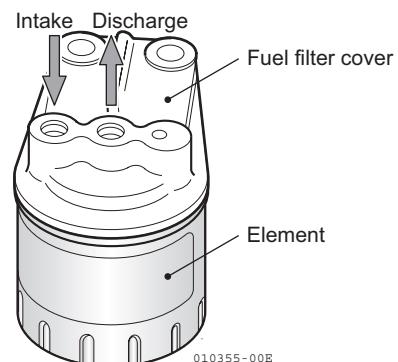
The fuel filter is installed between the fuel feed pump and fuel injection pump for 3JH4E and 4JH4E and between the fuel tank and fuel injection pump (feed pump) for 4JH4-TE and 4JH4-HTE. The fuel filter removes dirt/ foreign matter from the fuel pumped from the fuel tank.

The fuel filter element must be changed periodically. The fuel pumped by the fuel feed pump goes around the element, is fed through the pores in the filter and discharged from the center of the cover. Dirt and foreign matter in the fuel are deposited in the element.

6.5.1 Fuel filter for 3JH4E and 4JH4E

(1) Fuel filter specifications

Part No.	129470-55703
Filtering method	Filter paper
Filtering area	840cm ²
Maximum flow	1.5 L/min
Pressure loss	20mm Hg or less
Max. dia. or unfiltered particle	10μ



(2) Fuel filter inspection

The fuel strainer must be cleaned occasionally. If there is water or foreign matter in the strainer bowl, disassemble the strainer and wash with clean fuel oil to completely remove foreign matter. Replace the element every 250 hours of operation or every year, whichever comes first.

Replace the filter prior to this if the filter is very dirty, deformed or damaged.

6.5.2 Fuel filter for 4JH4-TE and 4JH4-HTE

(1) Fuel filter specifications

Item	Unit	Specifications
Part No.	-	129574-55820
Fuel filter	Filtration method	- Paper element
	Filtration area	m ² 0.24
	Filtration accuracy	μ 15
	Maximum flow	L/min 0.8
	Pressure loss	mm Hg 60 or less
Priming pump	Discharge	cm ³ /st 15
	Stroke	mm 8
Water separation	Maximum capacity	cm ³ 120

Note:

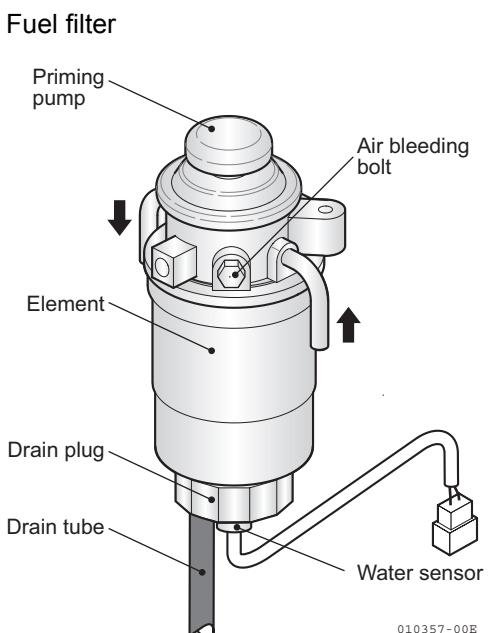
This fuel filter is equipped with water alarm sensor for water level.

The water alarm sensor is used for C type panel.

(2) Fuel filter inspection

The fuel strainer must be cleaned occasionally. If there is water or foreign matter in the strainer bowl, disassemble the strainer and wash with clean fuel oil to completely remove foreign matter. Replace the element every 250 hours of operation or every year, whichever comes first.

Replace the filter prior to this interval if the filter is very dirty, deformed or damaged.

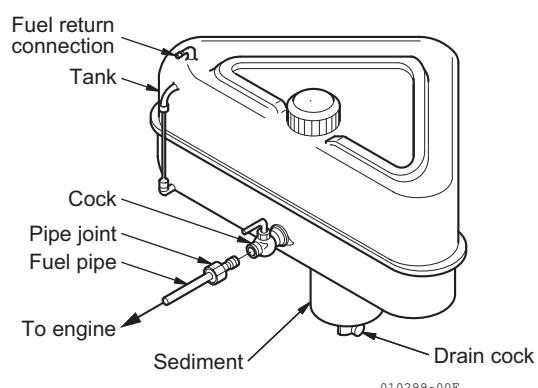


010357-00E

6.6 Fuel tank

A triangular 30 liter fuel tank with a 2000mm (78.74 in.) rubber fuel hose to fit all models is available as an option.

A fuel return connection is provided on top of the tank of which a rubber hose can be connected to return fuel from the fuel nozzles.



010299-00E

7. Intake and exhaust system

7.1 Intake system

7.1.1 3JH4E and 4JH4E

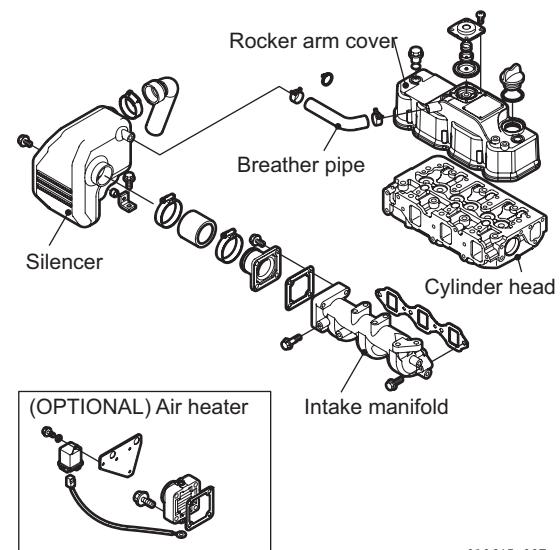
Air enters in the intake silencer mounted at the end of the intake manifold. It is fed to the intake manifold and then to each cylinder.

When the inside of the intake manifold becomes dirty, intake air resistance is increased and reduces engine power. Periodically check the inside of the intake manifold. In the same way, the intake air silencer should be checked for dirt periodically and cleaned.

When the intake manifold is being attached to the cylinder head, the attachment surfaces should be checked for dirt and cleaned. Care should also be taken to insure there is no air leakage.

Do not operate with the intake air silencer removed. Air heater is prepared for cold starting as an option.

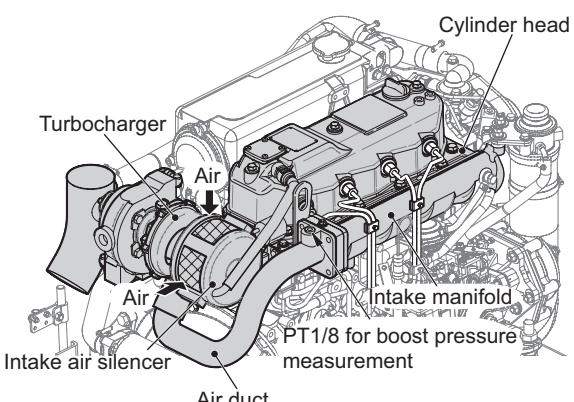
3JH4E



010645-00E

7.1.2 4JH4-TE

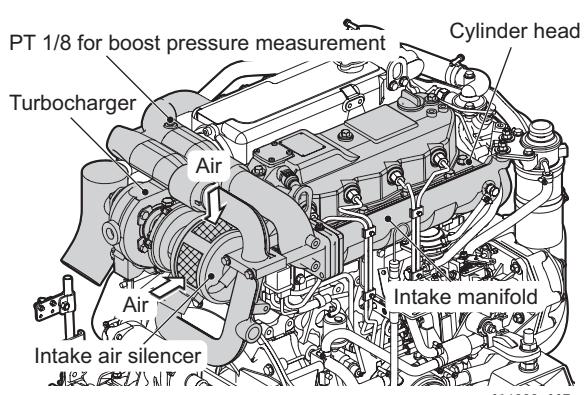
Air goes from the intake silencer to the turbocharger. Then it goes to the intake manifold through the air duct and is fed to each cylinder. Air heater is prepared for cold starting as an option.



010703-00E

7.1.3 4JH4-HTE

Air goes from the intake silencer to the turbocharger. Then it goes to the intercooler through the air duct and return to the intake manifold through the another air duct and is fed to each cylinder. Air heater is prepared for cold starting as an option.



014222-00E

7.1.4 Breather system (A reductor to intake air system of blowby gas)

Emitting blowby gas is harmful to natural environment. Therefore blowby gas reductor is adopted to 3JH4 and 4JH4 naturally-aspirated engines as breather system.

Some of the combustion gas passes through the clearance between cylinder and piston, and flows to the crankcase. This is said as blowby gas. While it passes into cylinder head and rocker arm cover, the blowby gas mixes with splash oil, and becomes oil mist-blownby gas. The gas passes through the baffle plate inside a rocker arm cover. And it passes through a diaphragm assy, and reaches a intake silencer. The gas is reduced in the combustion chamber.

Pressure inside a crankcase is controlled by the function of the diaphragm assy, and suitable amount of blowby gas is reduced in intake air system.

[Disassemble]

When a rocker arm cover is taken off, check whether oil or the like enter the diaphragm space from a small hole on the side of a diaphragm cover or not without disassembling the diaphragm.

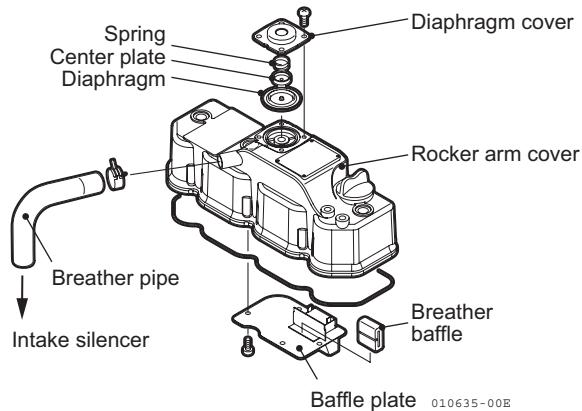
[NOTICE]

1) When a diaphragm is damaged, pressure control inside the crankcase becomes insufficient, and troubles occur. When the internal pressure of the crankcase decreases too much due to the damage of a spring, much blowby gas containing oil is reduced in intake air system, and it may cause the combustion defect by the early dirt of the intake valve or the urgent rotation of the engine by the oil burning.

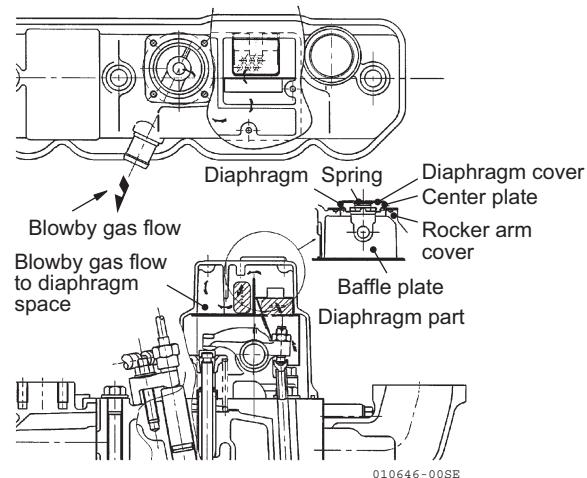
When pressure progresses in the crank case too much due to the wrong operation of the diaphragm and so on, it is considered that oil leakage from the joint of a oil pan, a oil seal and so on will occur. When a diaphragm is damaged, blowby is discharged from the breathing hole on the side of diaphragm cover, and not reduced in the intake manifold. Therefore, be careful of the diaphragm trouble.

2) At lubricating oil replacement or lube oil supply

The amount of lubricating oil isn't to be beyond the standard upper limit (in the engine horizontality, the upper limit mark of the dip stick). Since the blowby gas reductor is adopted, be careful that the amount of oil mist may be inducted in the combustion chamber and the oil hammer sometimes may occur, when the lubricating oil quantity is beyond the upper limit or an engine is operated beyond the allowable maximum angle of an engine.



Blowby gas flow



[Reassembly]

Replace the diaphragm with new one, when it is damaged.

7.1.5 Diaphragm assy inspection (only for 3JH4E and 4JH4E)

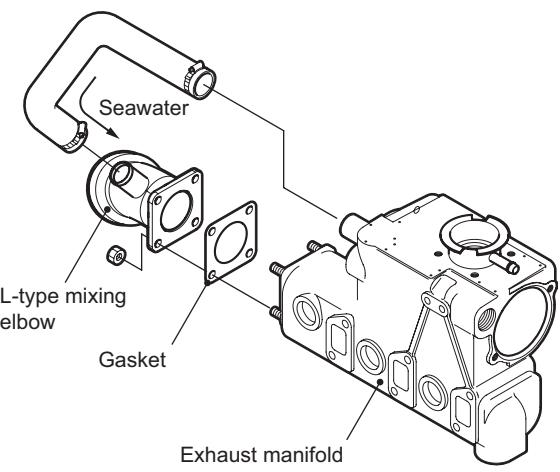
Refer to 2.2.6(5) for the inspection procedure.

7.2 Exhaust system

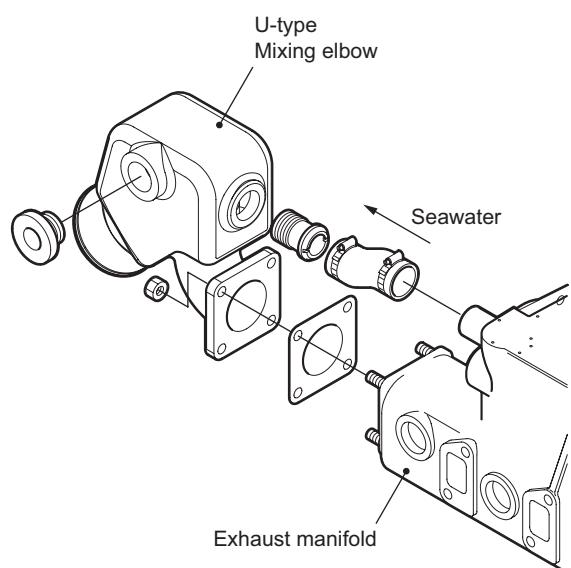
7.2.1 Exhaust system for 3JH4E and 4JH4E

Exhaust gas goes from the exhaust manifold to the mixing elbow and is discharged from ship along with seawater. There are two types of mixing elbows, the L-type and the U-type.

L-type

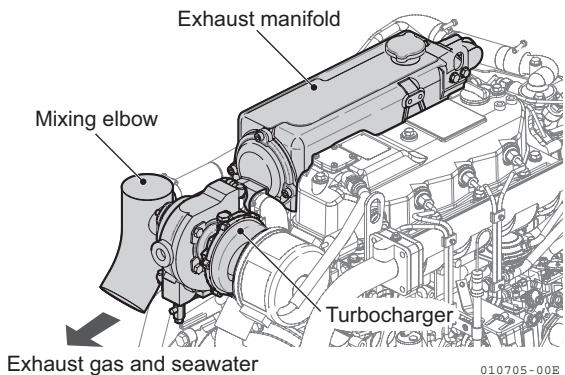


U-type



7.2.2 Exhaust system for 4JH4-TE and 4JH4-HTE

Exhaust gas goes from the exhaust manifold to the mixing elbow through the turbocharger, and is discharged from ship along with seawater. There are two types of mixing elbows, the L-type and the U-type.



7.2.3 Mixing elbow inspection

- (1) Clean dirt and scale out of the gas and coolant lines.
- (2) Repair crack or damage to welds, or replace.
- (3) Inspect the gasket packing and replace as necessary.

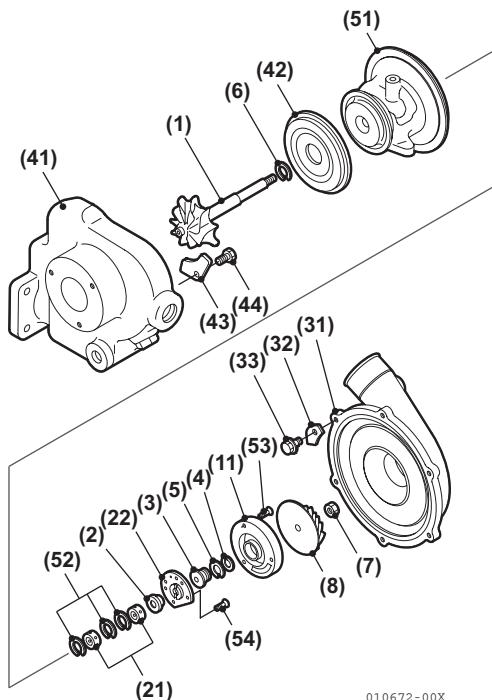
7.3 Turbocharger

(1) Particulars and structure

1) Specifications

Model	4JH4-TE	4JH4-HTE
	RHB52W (IHI)	RHB52W (IHI)
Spec. No.	7000VNHP12NFW	7000VHP15NFW
Turbine	Radial flow type	
Compressor	Centrifugal type	
Lubricating	Engine system oil	
Bearing	Fuel floating	
Cooling	Fresh water cooling	
Dry mass	3.6 kg (35.3)	

2) Components

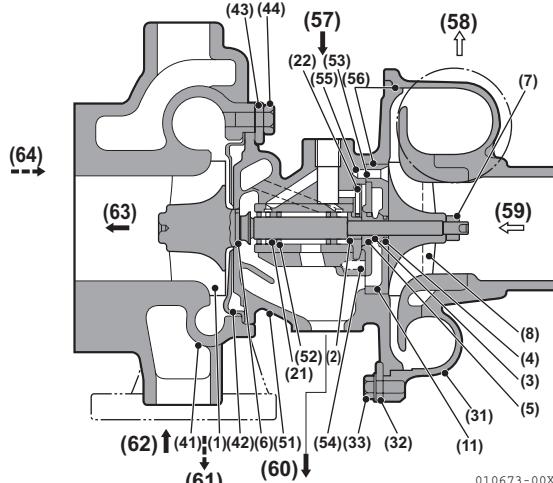


010672-00X

3) Sectional view and tightening torque

No.	Components	Q'ty	Tightening torque Kgf·cm (Ncm)
(1)	Turbine shaft	1	
(2)	Thrust bearing	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)
(51)	Bearing housing	1	
(52)	Retaining ring	3	
(53)	TORXT screw bolt	3	13±1 (128±10)
(54)	TORXT screw bolt	4	13±1 (128±10)
(55)	Locktite	-	
(56)	Liquid gasket	-	Three-bond 1207
(57)	Oil inlet		
(58)	Air outlet		
(59)	Air inlet		
(60)	Oil outlet		
(61)	Coolant outlet		
(62)	Gas inlet		
(63)	Gas outlet		
(64)	Coolant inlet		

The mark ● shows non-reusable part.



010673-00X

(2) Checking and servicing procedures

1) Service interval

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

2) Checking 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.

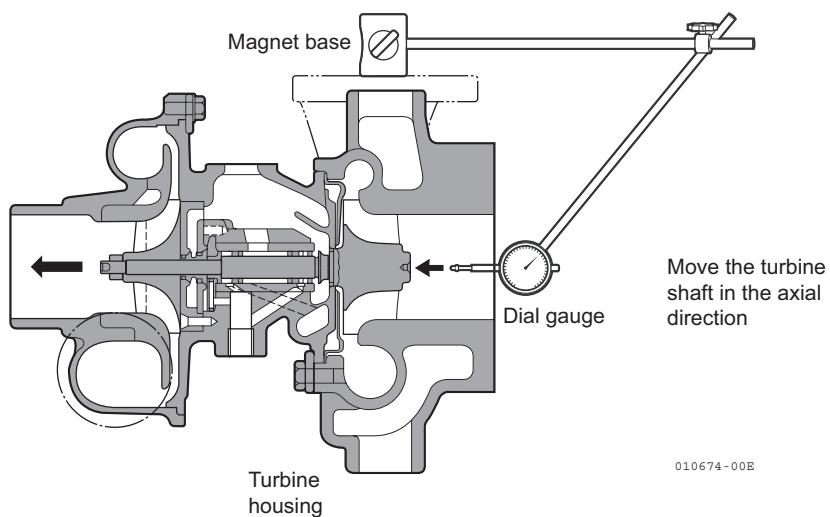
When the turbocharger is dismounted from the engine, be sure to block the oil inlet/outlet with gummed cloth tape.

- End play in the turbine shaft

End play

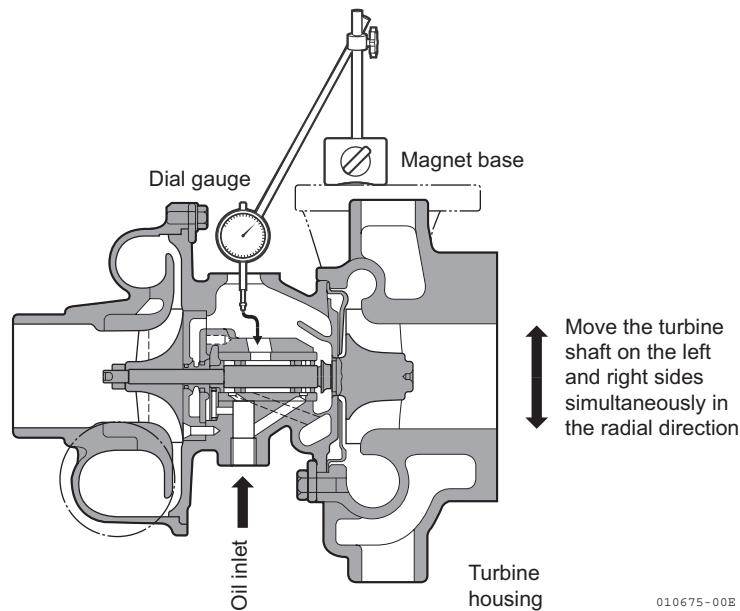
Service standard: 0.03 to 0.06 mm

Wear limit : 0.09 mm



010674-00E

- Radial play in the turbine shaft
Service standard: 0.08 to 0.06 mm
Wear limit : 0.17 mm

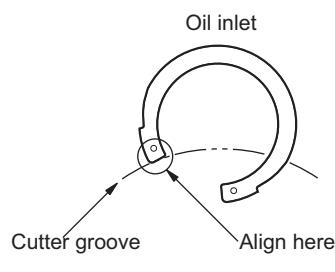


3) Cautions about assembly

a) Retaining ring

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

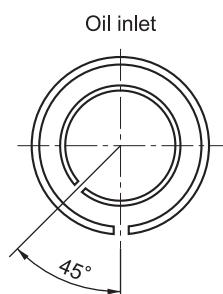
This is applied to one abutment only that is located nearest the turbine side.



Viewed from turbine side.

All except the above one.

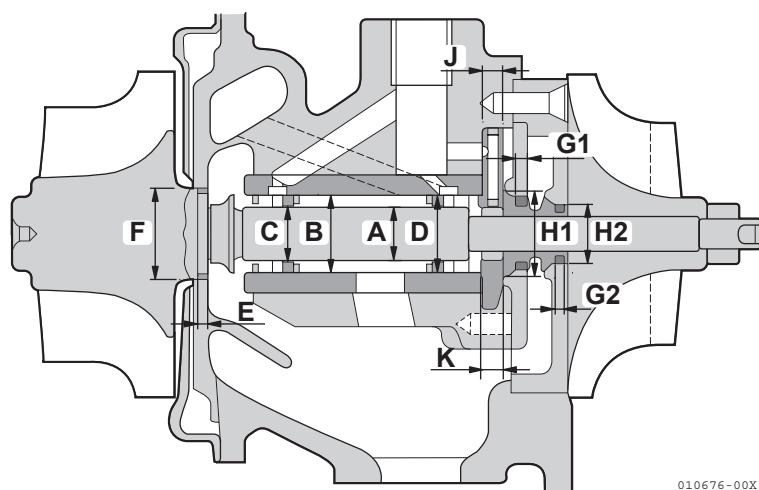
011209-00E



Viewed from the compressor side

011210-00E

4) Service standards



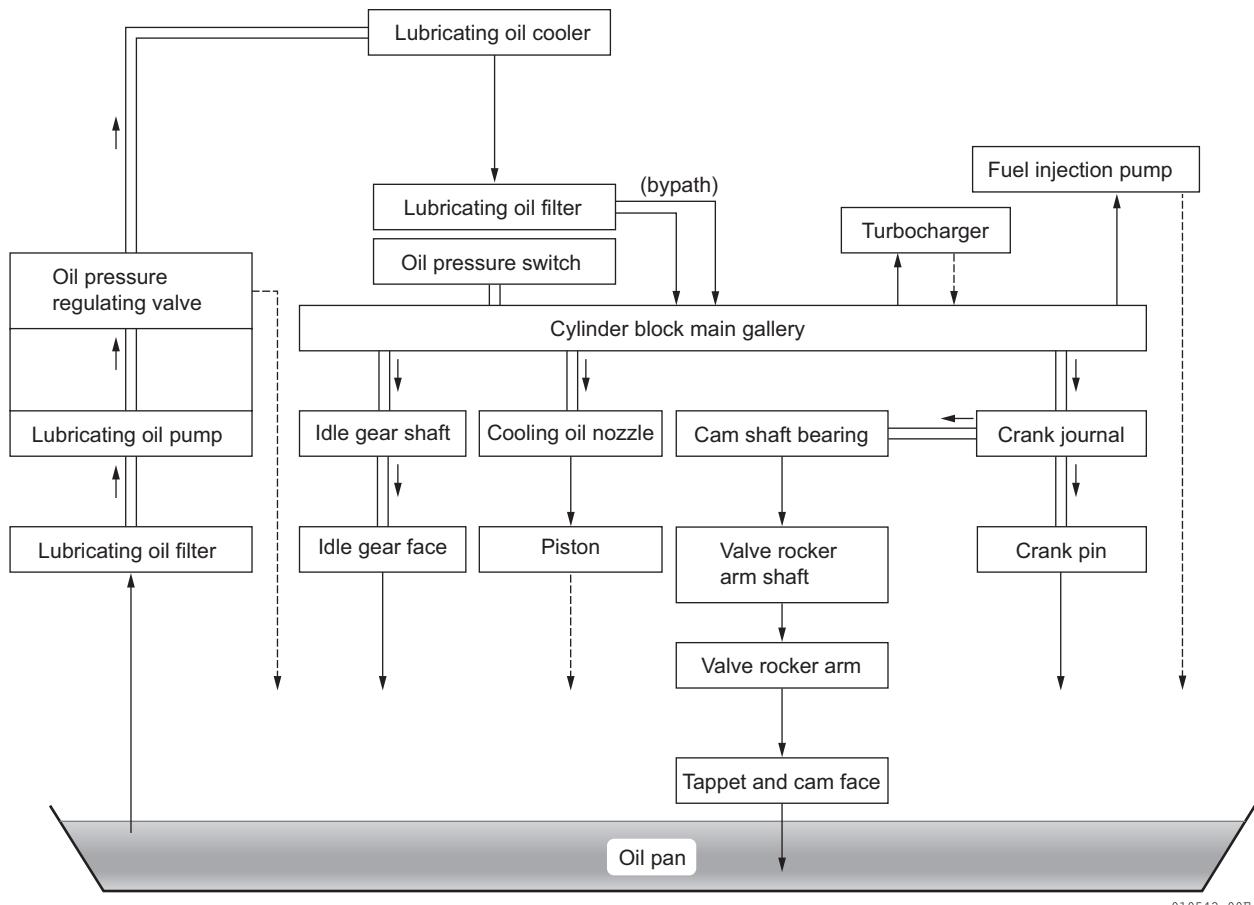
(Unit: mm)

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

8. Lubrication system

8.1 Lubrication system

The lube oil in the oil pan is pumped up through the intake filter and intake piping by the lube oil pump. The oil pressure is regulated by the oil pressure regulating valve equipped with the lube oil pump. The lube oil, which flows from the holes in the cylinder body to the lube oil cooler, is cooled and sent to the lube oil filter. After being filtered, it is fed to main gallery in the cylinder body. The lube oil, which flows in the main gallery, goes to the crankshaft journal, lubricates the crankshaft journal and crank pin, and a portion of the oil is fed to the camshaft bearings. Oil is sent from the camshaft bearings to the rocker arm shaft to lubricate the rocker arm and valves. Oil is also sent from the main gallery to the piston cooling nozzle to cool the piston. Oil for the fuel injection pump and turbocharger(4JH4-TE and 4JH4-HTE) is sent by pipes from the main gallery to those parts.



010542-00E

8.2 Lube oil pump

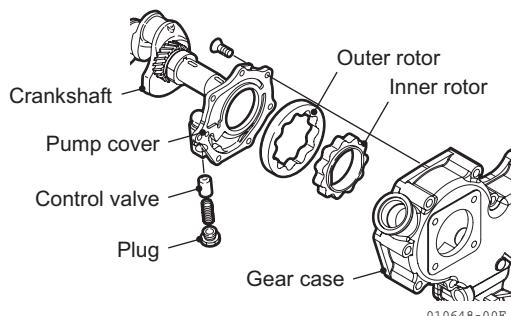
8.2.1 Lube oil pump construction

The trochoid type lube oil pump is mounted in the gear case, and the inner rotor is driven by the crankshaft.

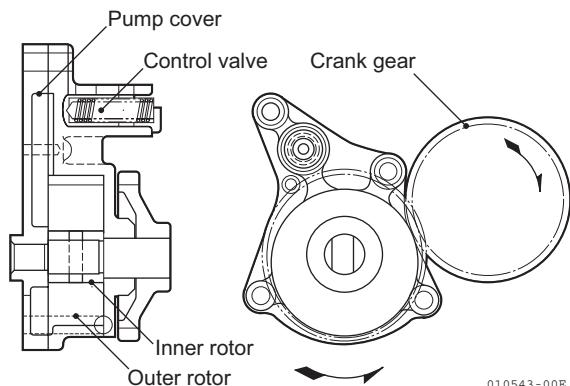
The lube oil flows from the intake filter mounted on the bottom of the cylinder block through the holes in the cylinder block and engine plate, and out from the holes in the engine plate and cylinder block to the discharge filter.

The lube oil pump is fitted with a control valve, which controls the discharge pressure.

3JH4E and 4JH4E



4JH4-TE and 4JH4-HTE



8.2.2 Specifications of lube oil pump

Lube oil pump specifications

		3JH4/4JH4E		4JH4-TE/4JH4-HTE	
Engine speed	min ⁻¹	3000	800	3200	800
Delivery quantity	(L/min)	≥17.5	≥8.0	≥17.5	≥8.0
Delivery pressure	MPa (kgf/cm ²)	0.39-0.54 (4.0-5.5)	≥0.06 (0.6)	0.28-0.45 (2.9-4.6)	≥0.06 (0.6)
Oil temp. (Oil pan)	(°C)	≤115	↔	↔	↔

8.2.3 Lube oil pump disassembly and reassembly

Disassembly

- (1) Remove the crankshaft pulley.
- (2) Remove the gear case from the gear case flange.
- (3) Remove the lube oil pump.

3JH4E and 4JH4E

Remove the pump cover from the gear case. Do not disassemble the inner/outer rotors, and check that the pump rotates smoothly.

4JH-TE and 4JH4-HTE

Remove the lube oil pump assembly from the gear case flange. Do not disassemble the inner/outer rotors, and check that the pump rotates smoothly.

- (4) The plug of the oil pressure control valve is coated with adhesive and screwed in, so it cannot be disassembled. These parts cannot be reused after disassembly. Replace it as an assembly if necessary.

Reassembly

[NOTICE]

Always check if the pump rotates smoothly after installation on the gear case.

Running the engine when the pump rotation is heavy may cause the pump to be burnt.

- (1) Apply lube oil to rotor (outer/inner) insertion part.
- (2) Mount the lube oil pump.

3JH4E and 4JH4E

Assemble the outer rotor so that the mark of the end face may come to a cover side when inserting it in the gear case.

4JH4-TE and 4JH4-HTE

Mount the lube oil pump assembly to the gear case flange.

- (3) Fasten the pump cover for 3JH4E and 4JH4E by the standard torque.

Tightening torque Nm (kgf·m)	6.9 ± 1.5 (0.7 ± 0.15)
---------------------------------	------------------------

- (4) When replacing the lube oil pump, replace the whole assy.

8.2.4 Lube oil pump inspection

The right figures show the examples of lube oil pump of 3JH4E and 4JH4E.

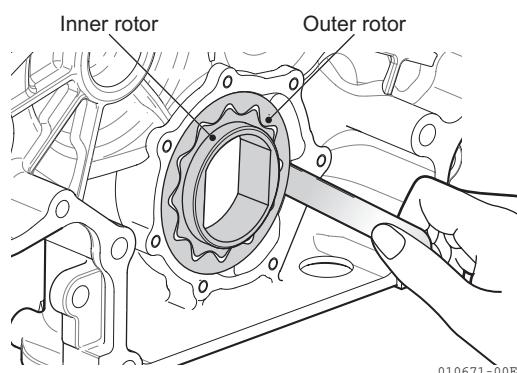
It is the same procedure for the 4JH4-TE and 4JH4-HTE lube oil pump as well.

(1) Outside clearance of outer rotor

Insert a gap gage between an outer rotor and a pump body, and measure the clearance.

Outside clearance mm

	Standard	Limit
3JH4E/4JH4E	0.12-0.21	0.30
4JH4-TE/4JH4-HTE	0.09-0.16	-



(2) Clearance between outer rotor and inner rotor

Insert a gap gage between an outer rotor and an inner rotor, and measure the clearance.

mm

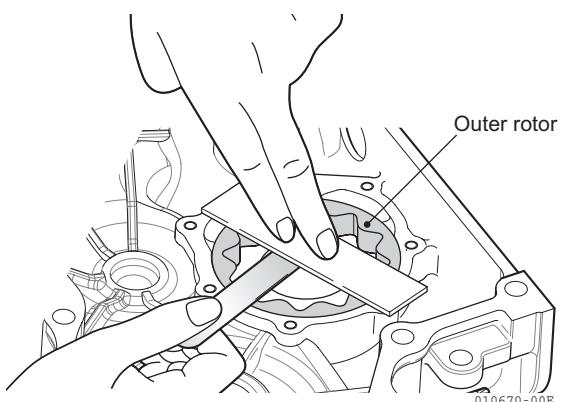
	Standard	Limit
3JH4E/4JH4E	-	0.16
4JH4-TE/4JH4-HTE	-	0.16

(3) Side clearance of outer rotor

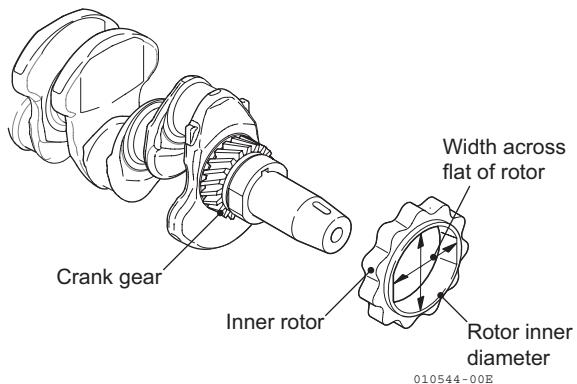
When measuring a side clearance, put a right-angle gage to the pump body, insert a gap gage and measure the clearance.

Side clearance mm

	Standard	Limit
3JH4E/4JH4E	0.02-0.07	0.12
4JH4-TE/4JH4-HTE	0.05-0.1	0.15



- (4) Inner rotor and gear boss clearance for
3JH4E and 4JH4E



Item	Part	Standard dimension (mm)	Standard clearance (mm)	Standard clearance limit (mm)
Inside clearance of inner rotor	Gear boss diameter	53.05-53.15	0.3-0.5	0.6
	Rotor inner diameter	53.45-53.55		
Width across flat clearance of inner rotor	Width across flat of gear boss	49.45-49.75	0.2-0.6	0.7
	Width across flat of rotor	49.95-50.05		

8.2.5 Oil pressure control valve construction

The oil pressure control valve attached with lube oil pump controls the oil pressure from the time the lube oil leaves the filter and is cooled in the lube oil cooler until just before it enters the cylinder body main gallery.

When the pressure of lube oil entering the cylinder body main gallery exceeds the standard, the control valve piston opens the bypass hole and lube oil flows back into the oil pan.

8.3 Lube oil filter

8.3.1 Lube oil filter construction

The lube oil filter is a full-flow paper element type and a cartridge type easy to remove.

It is mounted to the side of the cylinder body with the filter bracket.

To prevent seizure in the event of the filter clogging, a bypass circuit is provided in the oil filter. The bypass valve in the filter element opens when the difference in the pressure in front and behind the paper element reaches 0.08-0.12MPa (0.8-1.2kg/cm²). Then the lube oil will flow in the bypass circuit.

Engine model	Unit	3JH4E	4JH4E 4JH4-TE 4JH4-HTE
Part No.	-	119305-35150	129150-35152
Type	-	Full flow, paper element	
Filtration area	m ²	0.10	0.12
Discharge volume	l/min	30	30
Pressure loss	MPa (kgf/cm ²)	0.03-0.05 (0.3-0.5)	0.02-0.04 (0.2-0.4)
By-pass valve regulating pressure	MPa (kgf/cm ²)	0.08-0.12 (0.8-1.2)	0.08-0.12 (0.8-1.2)

8.3.2 Lube oil filter replacement

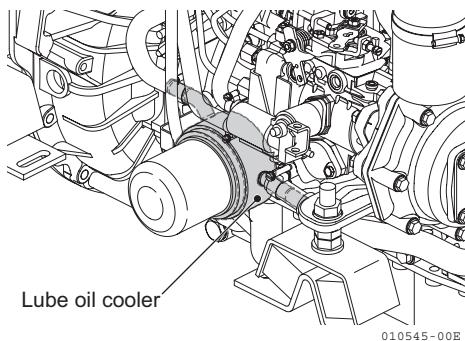
Refer to 2.2.2(2).

8.4 Lube oil cooler

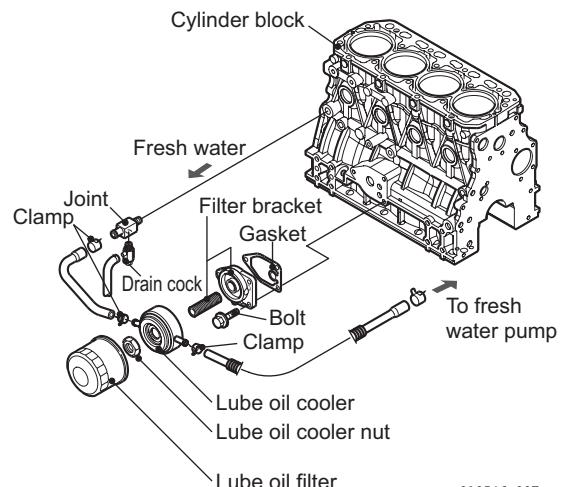
8.4.1 Lube oil cooler construction

The lube oil cooler is located between the lube oil filter and the filter bracket, which is mounted on the cylinder block.

The lube oil is cooled by fresh water.



4JH4-TE



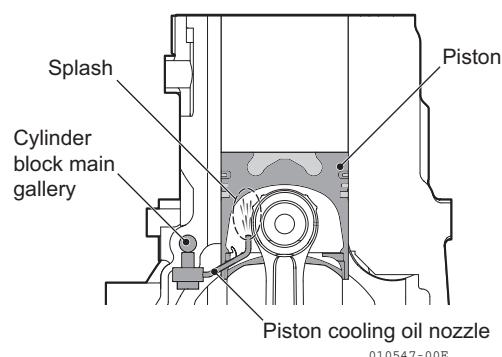
8.4.2 Inspecting the lube oil cooler

- (1) Clean the coolant path (fresh water) of the lube oil cooler to prevent the buildup of scale.
- (2) If the rubber hose connection or welds are corroded, repair or replace the cooler.
- (3) Apply the following water pressures to the fresh water path and lube oil path lines to check for any leakage. Repair or replace the cooler if there are any leaks.

	Test pressure
Lube oil circuit	0.98 MPa (9.6 kgf/cm ²)
Fresh water path	0.20 MPa (2.0 kgf/cm ²)

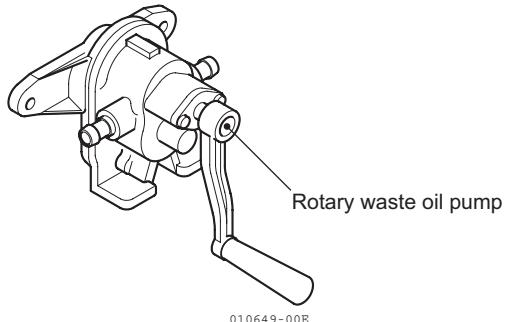
8.5 Piston cooling oil nozzle

- (1) Check the hole ($\varnothing 1.8\text{mm}$) in the nozzle end for dust or foreign matters.
- (2) Check the brazed portion of the copper tube for breakage due to vibration.



8.6 Rotary waste oil pump (Optional)

A rotary waste oil pump to pump out waste oil is available as an option.



Rotary waste oil pump

Delivery capacity per one revolution	0.057 L
Delivery pressure	0.15 MPa (1.5 kg/cm ²) or below
Suction head	less than 1m
Part No.	124413-39100

9. Coolant system

9.1 Coolant system

The coolant system is of the indirect seawater cooled, fresh water circulation type. The cylinders, cylinder heads and exhaust manifold are cooled with fresh water, and fresh water cooler (heat exchanger) uses seawater.

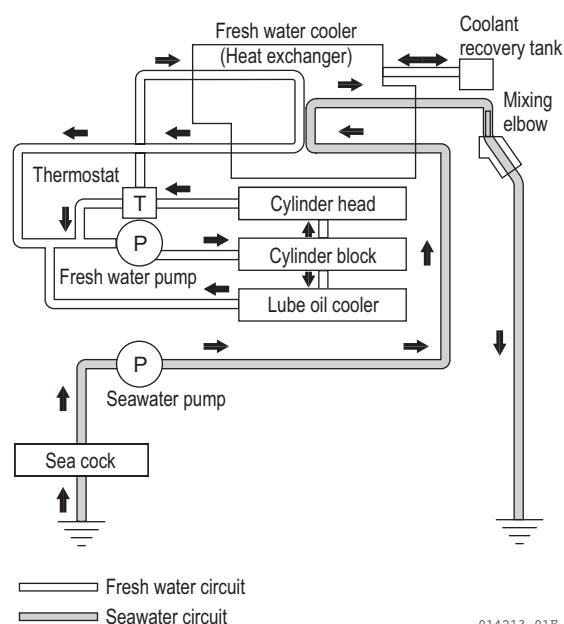
Seawater pumped from the sea by the seawater pump goes to the heat exchanger, where it cools the fresh water. Then it is sent to the mixing elbow and is discharged from the ship with the exhaust gas.

Fresh water is pumped by the fresh water pump to the cylinder jacket to cool the cylinders and the cylinder head.

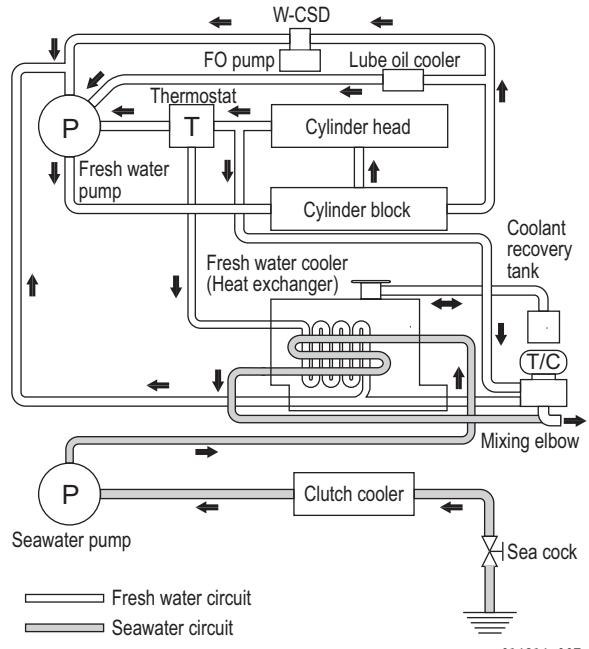
The thermostat is closed when the fresh water temperature is low just after the engine has started and is operating at low load, etc. Then the fresh water flows to the fresh water pump inlet, and is circulated inside the engine without passing through the heat exchanger.

When the temperature of the fresh water rises, the thermostat opens, the fresh water flows to the heat exchanger, and it is then cooled by the seawater in the cooler tubes. The temperature of the fresh water is thus kept within the constant temperature range by the thermostat.

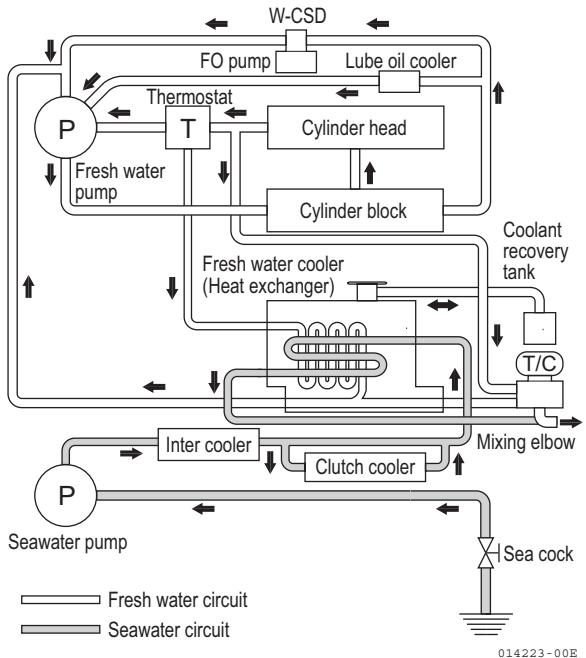
3JH4E and 4JH4E



4JH4-TE



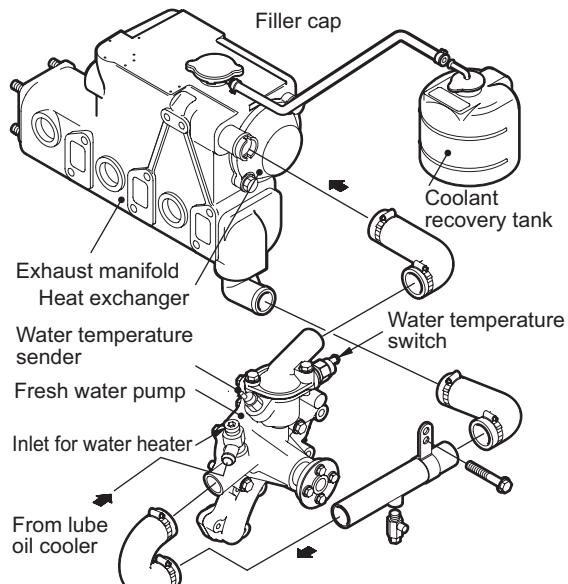
4JH4-HTE



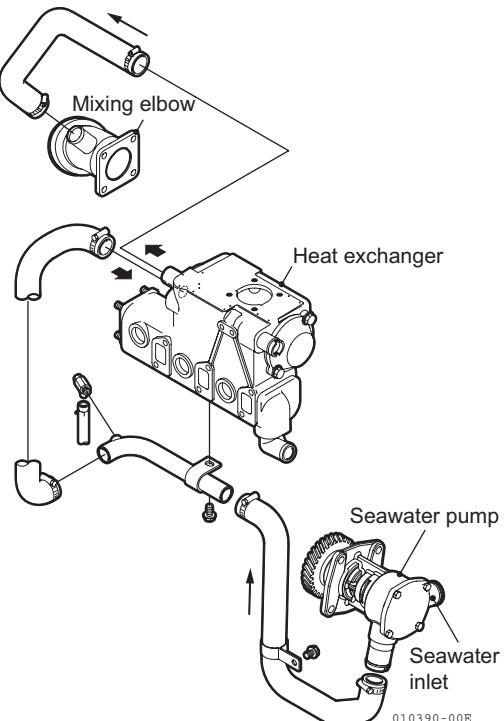
014223-00E

Example of coolant line for 3JH4E and 4JH4E

Fresh water line



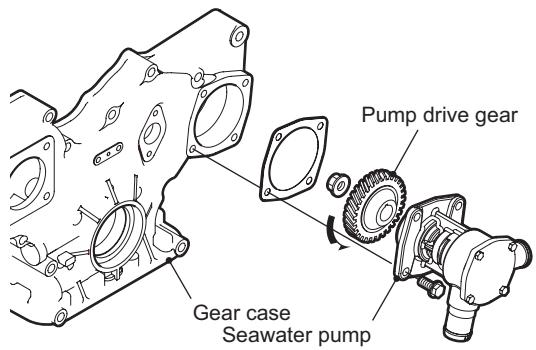
Seawater line



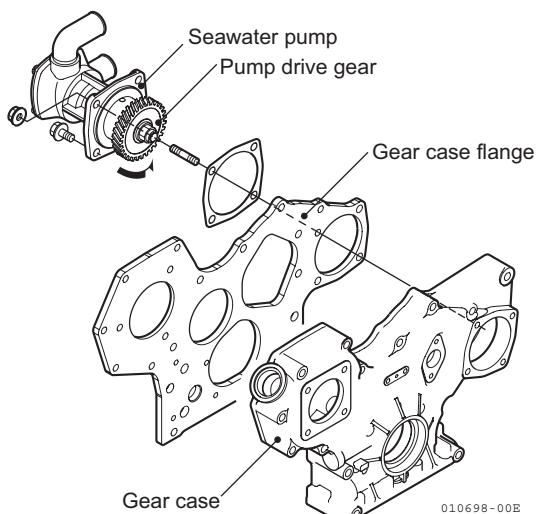
9.2 Seawater pump

The seawater pump is driven by a gear.

3JH4E and 4JH4E



4JH4-TE and 4JH4-HTE



9.2.1 Specifications of seawater pump

(1) Performance

Flow	Min. 3800 L/h at pin = -5 kPa (-0.05 bar) pout = 95 kPa (0.95 bar) n = 3250 min ⁻¹ after 1500 h duty
Self-priming ability	Max. 10 s at Suction head = 0.5 m length of pipe = 0.6 m n = 500 min ⁻¹
Tightness test	400 kPa (4 bar)

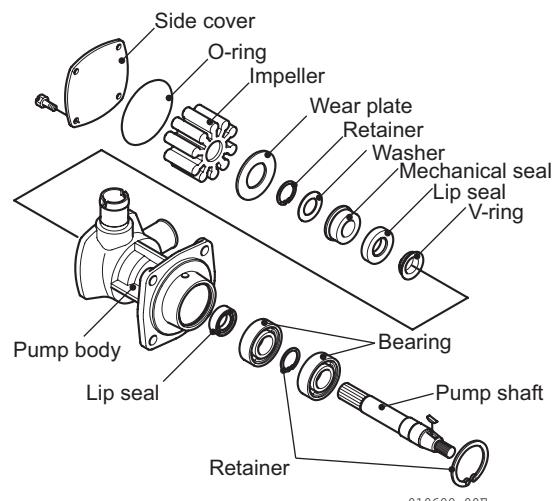
(2) Durability (reference data)

Impeller Flow drop	Min. 1500 h Max. 10% after 1000 h
Leakage from seals Mechanical seal, water Lip seal, oil	Max. 3 cm ³ /h 3000 h 3000 h
Cover, wear plate	Min. 3000 h
Other parts	Min. 6000 h

9.2.2 Seawater pump disassembly

(Refer to 2.2.4.(5).)

- (1) Remove the rubber hose from the seawater pump outlet and then the seawater pump assembly from the gear case (flange).
- (2) Remove the side cover and take out the O-ring, impeller and wear plate.
- (3) Remove the retainer, washer and mechanical seal.
- (4) Insert plier from the drive gear side and remove the retainer that holds the bearing.
- (5) Lightly tap the pump shaft from the impeller side and remove the pump shaft and bearings as a set.
- (6) Remove the lip seal and mechanical seal if necessary.



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9.2.3 Seawater pump Inspection

(Refer to 2.2.4(5).)

- (1) Inspect the rubber impeller, checking for splitting around the outside, damage or cracks, and replace if necessary.
- (2) Inspect the mechanical seal and replace if the spring is damaged, or the seal is corroded. Also replace the mechanical seal if there is considerable coolant leakage during operation.

Coolant leakage	less than 3 cm ³ /h
-----------------	--------------------------------

- (3) Make sure the ball bearings rotate smoothly. Replace if there is excessive play.

9.2.4 Seawater pump reassembly

- (1) When replacing the mechanical seal, coat the No.1101 oil seal and pressure-fit. Coat the sliding surface with a good quality silicon oil, taking sufficient care not to cause any scratches.
- (2) When replacing the lip seal, coat with grease and insert.
- (3) Mount the pump shaft, ball bearing and gear assembly to the pump body and fit the retainer.

Note:

Coat the shaft with grease.

- (4) After inserting the mechanical seal retainer and washer, mount the wear plate and impeller.
- (5) Mount the O-ring and side cover.

Note:

Replace the O-ring with new one.

9.3 Fresh water pump

9.3.1 Fresh water pump construction

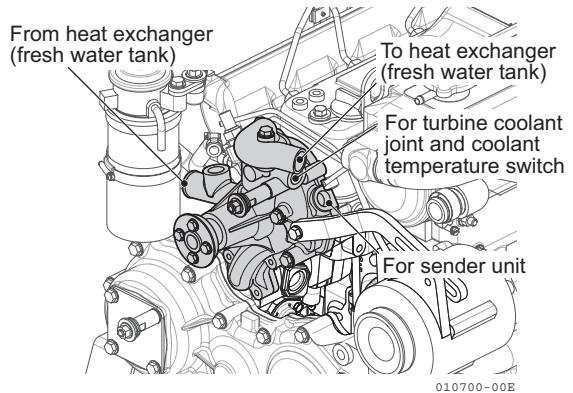
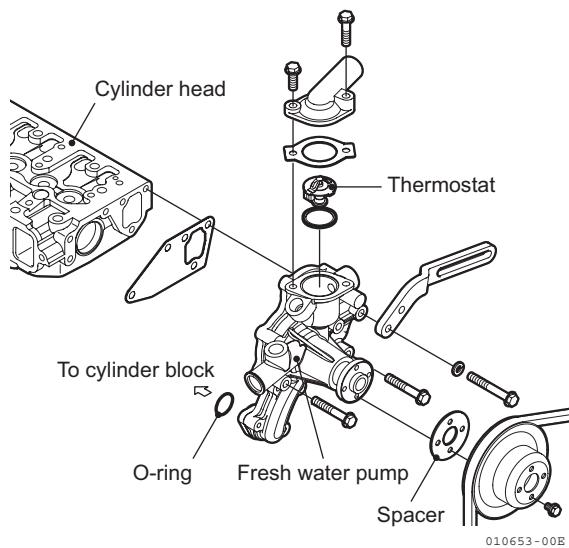
The fresh water pump is of the centrifugal (volute) type, and circulates water from the fresh water tank to the cylinders and cylinder head.

The fresh water pump consists of the pump body, impeller, pump shaft, bearing unit and mechanical seal. The V pulley on the end of the pump shaft is driven by a V belt from the crankshaft.

The bearing unit assembled in the pump shaft uses grease lubricated ball bearings and cannot be disassembled.

The totally enclosed mechanical seal spring presses the impeller seal mounted on the impeller side away from the pump body side. This prevents water from leaking along the pump shaft.

As the impeller and pulley flanges are press fit assembled, they cannot be disassembled.



9.3.2 Specifications of fresh water pump

Model	3JH4E 4JH4E	4JH4-TE 4JH4-HTE
Pulley ratio (crank shaft/pump shaft)	$\varnothing 134/\varnothing 120$	
Delivery capacity (at fuel stop power)	55 L/min or more	54 L/min or more
Total head	4m	

9.3.3 Fresh water pump disassembly

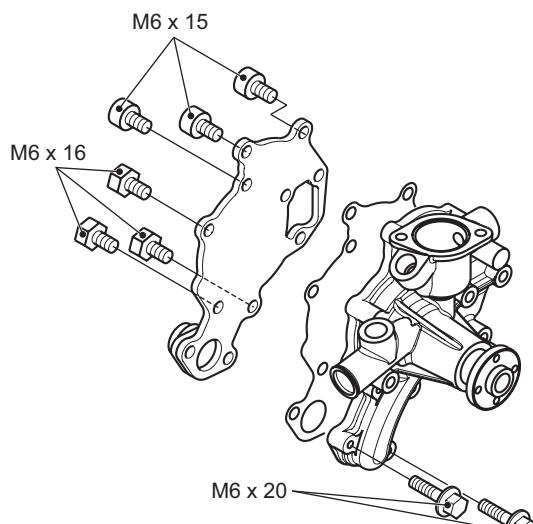
- (1) Do not disassemble the fresh water pump. It is difficult to disassemble and, once disassembled, even more difficult to reassemble. Replace the pump as an assembly in the event of trouble.
- (2) When removing the fresh water pump as an assembly from the cylinder block and cylinder head, replace the O-ring at the cylinder block inlet.
- (3) When installing the pump assembly to the cylinder block, tighten the 2 bolts (M6 x 20) at the cylinder block inlet to the specified torque.

Tightening torque (M6 x 20)	8.82-10.8 Nm (90-110 kgf•cm)
--------------------------------	---------------------------------

Note:

When disassembling the fresh water pump and reassembling the pump cover, tighten the M6 bolts to the specified torque.

M6 x 15	9.3-11.3 Nm (95-115kgf•cm)
M6 x 16	8.82-10.8 Nm (90-110 kgf•cm)



9.3.4 Fresh water pump inspection

(1) Bearing unit inspection

Rotate the impeller smoothly. If the rotation is not smooth or abnormal noise is heard due to excessive bearing play or contact with other parts, replace the pump as an assembly.

(2) Impeller inspection

Check the impeller blade, and replace if damaged or corroded, or if the impeller blade is worn due to contact with pump body.

(3) Check the holes in the fresh water and bypass lines, clean out any dirt or other foreign matter and repair as necessary.

(4) Replace the pump as an assembly if there is excessive water leakage due to mechanical seal or impeller seal wear or damage.

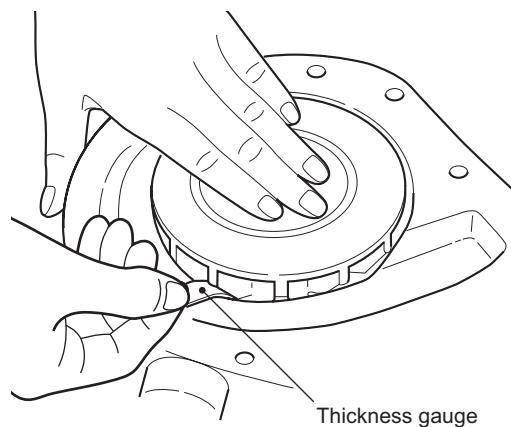
(5) Inspect the fresh water pump body and flange, clean off scale and rust, and replace if corroded.

(6) Measure the clearance between the Impeller and the pump body, by pushing the impeller all the way towards the body, and inserting a thickness gauge diagonally between the impeller and the body.

Measure the clearance between the impeller and the plate (pump body bracket) by placing a straight-edge against the end of the pump body and inserting a thickness gauge between the impeller and the straight-edge.

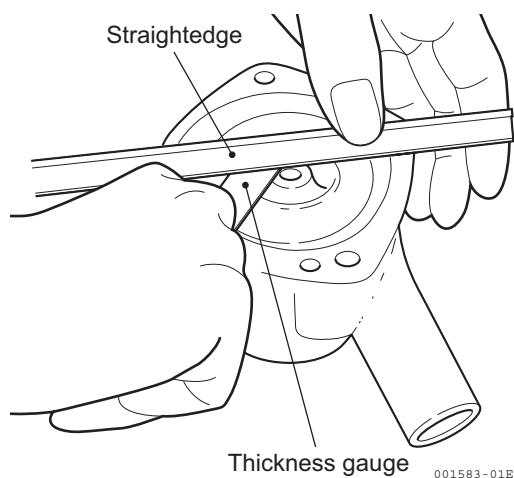
9. Coolant system

Measuring clearance between impeller and pump body.



Measuring clearance between impeller and pump body bracket.

	Standard	Limit
Clearance between impeller and body	0.3-1.1	1.5
Clearance between impeller and plate	15	-



9.4 Heat exchanger

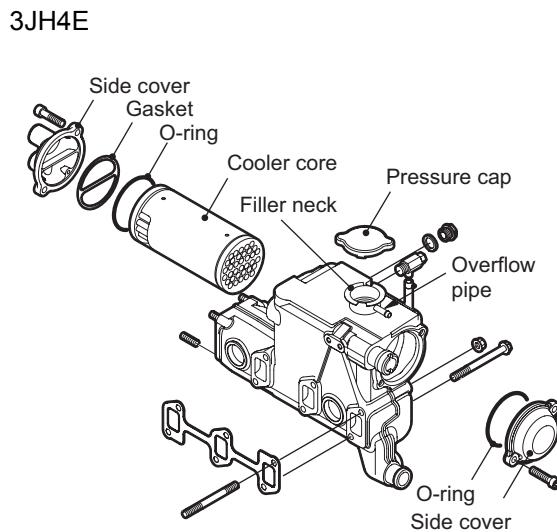
9.4.1 Heat exchanger construction

The heat exchanger cools the hot fresh water, that has cooled the inside of the engine, with seawater. The cooler core consists of many small diameter tubes, baffle plates and tube cover.

The seawater flows through the maze formed by the baffle plates.

There is a reservoir below the cooler core, which serves as the fresh water tank. There is an exhaust gas passageway in the reservoir, which forms a water cooled exhaust manifold.

The pressure cap (filler cap) on top of the heat exchanger has a pressure valve, which lets off steam through the overflow pipe when pressure in the fresh water system exceeds the specified value. It also takes in air from the overflow pipe when pressure in the fresh water system drops below the normal value.



9.4.2 Specifications of heat exchanger

Model	Unit	3JH4E	4JH4E	4JH4E-TE/4JH4E-HTE
Tube diameter	mm	$\varnothing 6/\varnothing 5 \times 54$	$\varnothing 6/\varnothing 5 \times 54$	$\varnothing 6/\varnothing 5 \times 121$
Tube surface area	m^2	0.193	0.347	0.853
Fresh water flow	L/hr	3300	3300	3250
Seawater flow	L/hr	3080	3080	3300
Fresh water velocity	m/s	0.99	0.91	0.82
Seawater velocity	m/s	1.61	1.61	1.08

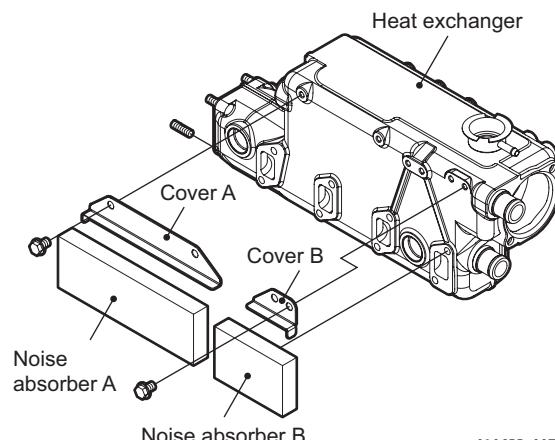
9.4.3 Disassembly and reassembly of the heat exchanger

- (1) Remove the heat exchanger from the cylinder head. The noise absorber A and B are installed between the heat exchanger and cylinder head for 4JH4E/4JH4-TE/4JH4-HTE engines. Replace if the absorber deteriorates.

Note:

- 1) Be careful not to get hurt with the cover A or B.
- 2) Be careful not to pour lube oil on the noise absorbers.

4JH4E



- (2) Remove the covers on both sides and take out the cooler core and O-ring(s).

Note:

Replace the O-ring(s) when you have removed the cooler core.

9.4.4 Heat exchanger inspection

Refer to 2.2.6(4).

9.5 Pressure cap and coolant recovery tank

9.5.1 Pressure cap construction

The pressure cap mounted on the fresh water filler neck incorporates a pressure control valve. The cap is mounted on the filler neck cam by placing it on the rocking tab and rotating. The top seal of the cap seals the top of the filler neck, and the pressure valve seals the lock seat.

9.5.2 Pressure cap pressure control

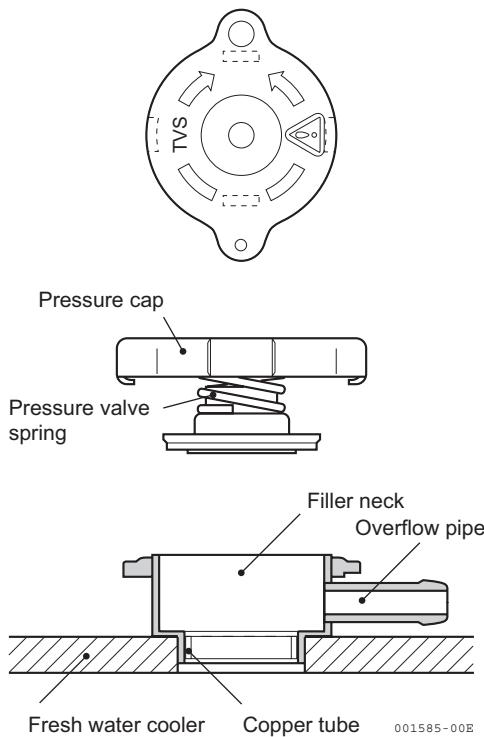
The pressure valve and vacuum seal both seal the valve seat when the pressure in the fresh water system is within the specified value of 0.9 kg/cm^2 . This seals the fresh water system.

When the pressure within the fresh water system exceeds the specified value, the pressure valve opens, and steam is discharged through the overflow pipe. When the fresh water is cooled and the pressure within the fresh water system drops below the normal value, atmospheric pressure opens the vacuum valve, and air is drawn in through the overflow pipe.

The coolant recovery tank (which will be described later), keeps the water level from dropping due to discharge of steam when the pressure valve opens.

Action of pressure control valve

Pressure valve	Open at 82-109 kPa ($0.84-1.11 \text{ kgf/cm}^2$, 0.82-1.09 bar)
Vacuum valve	Open at 8 kPa (0.08 kgf/cm^2 , 0.08 bar) or below

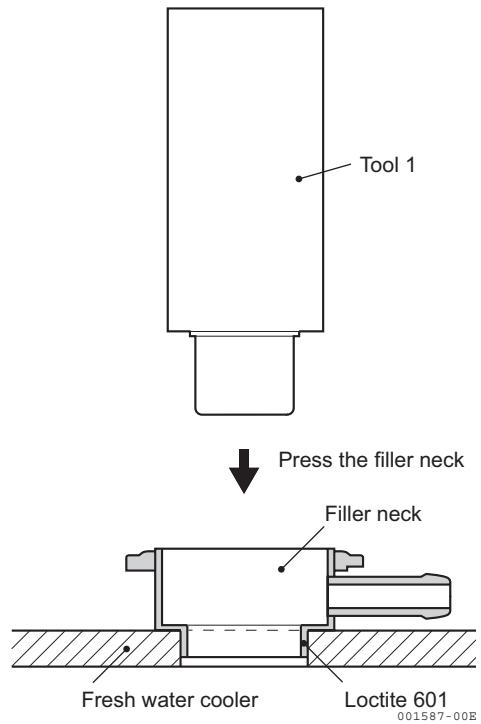
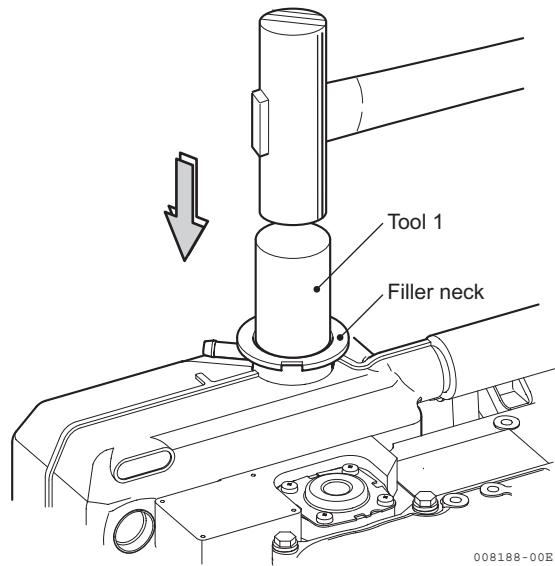


9.5.3 Pressure cap inspection

Refer to 2.2.6(4).

9.5.4 Replacing filler neck

- 1) Take out the copper tube inside the filler neck with striking a circumference with a driver and so on. When the filler neck is removed, remove it with being careful not to damage the fresh water cooler, and scrap it.
- 2) Clean both the new filler neck and the insertion part of fresh water cooler. Apply T7471 type activator or equivalent on both the surfaces and let it evaporate.
- 3) Apply Loctite 603 (improved 601) glue or equivalent on filler neck outside contour and press the filler neck into the fresh water cooler with the special tool.



- 4) To fix the filler neck on the fresh water cooler, press the small copper tube inside the filler neck with the special tool.

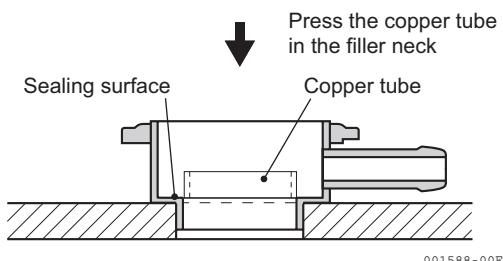
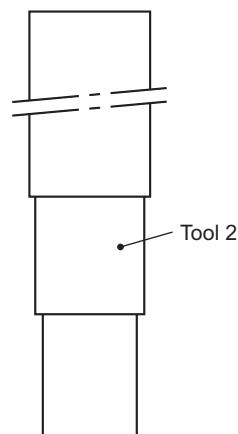
Note:

The top of this tube should be under the sealing surface of the filler neck for the pressure cap.

- 5) Fit the pressure cap on the filler neck.

Filler neck Part No.	Copper tube Part No.
129673-44110	129673-44150

Refer to 4.2.2 for tool 1 and tool 2.



9.5.5 Function of the coolant recovery tank

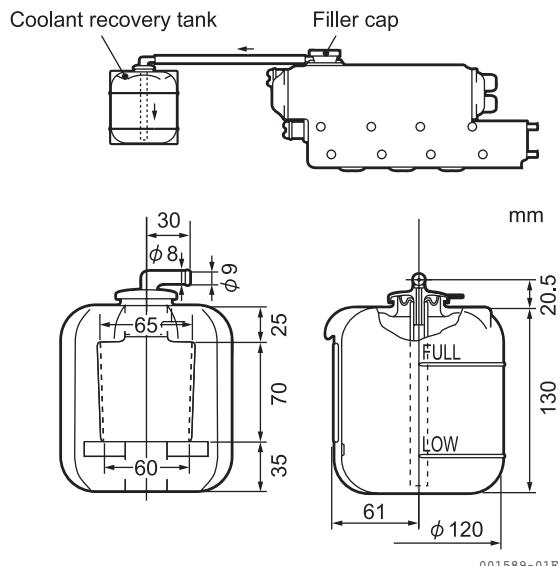
The pressure valve opens to discharge steam when the steam pressure in the fresh water tank exceeds 82-109 kPa (0.84-1.11 kgf/cm²).

This consumes water. The coolant recovery tank maintains the water level by preventing this discharge of water.

The steam discharged into the coolant recovery tank condenses into water, and the water level in the tank rises.

When the pressure in the fresh water system drops below the normal value, the water in the coolant recovery tank is sucked back into the fresh water tank to raise the water back to its original level.

The coolant recovery tank facilitates long hours of operation without water replacement and eliminates the possibility of burns when the steam is ejected from the filler neck because the pressure cap does not need to be removed.



9.5.6 Specifications of coolant recovery tank

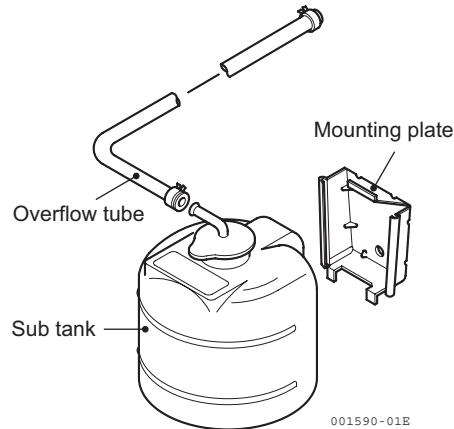
Capacity of coolant recovery tank	Overall capacity	1.3 L
	Full-scale position	0.8 L
	Low-scale position	0.2 L

9.5.7 Mounting the coolant recovery tank

- (1) The coolant recovery tank is mounted at approximately the same height as the heat exchanger (fresh water tank).
(allowable difference in height : 300 mm (11.8110 in.) or less)
- (2) The overflow pipe should be less than 1000 mm (39.3701 in) long, and mounted so that it does not sag or bend.

Note:

Make sure that the overflow pipe of the coolant recovery tank is not submerged in bilge. If the overflow pipe is submerged in bilge, water in the bilge will be siphoned into the fresh water tank when the wafer is being cooled.



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9.5.8 Precautions on usage of the coolant recovery tank

- (1) Check the coolant recovery tank when the engine is cool and refill with fresh water as necessary to bring the water level between the low and full marks.
- (2) Check the overflow pipe and replace if bent or cracked. Clean out the pipe if it is clogged up.

9.6 Thermostat

9.6.1 Functioning of thermostat

The thermostat opens and closes a valve according to changes in the temperature of the fresh water inside the engine, controlling the volume of water flowing to the heat exchanger from the cylinder head, and in turn maintaining the temperature of the fresh water in the engine at a constant level.

The thermostat is bottom bypass type. It is located in a position connected with the cylinder head outlet line at the top of the top of fresh water pump unit.

When the fresh water temperature exceeds the above temperature, the thermostat opens, and a portion of the water is sent to the heat exchanger and cooled by seawater, the other portion going from the bypass line to the fresh water pump intake.

The bypass line is closed off as the thermostat valve opens and is completely closed when the fresh water temperature reaches 81.5°C (valve lifts 4 mm (0.1575 in)), sending all of the water to the heat exchanger.

9.6.2 Thermostat construction

The thermostat used in this engine is of the wax pellet type, with a solid wax pellet located in a small chamber.

When the temperature of the coolant rises, the wax melts and increases in volume. This expansion and contraction is used to open and close the valve.

9.6.3 Characteristics of thermostat

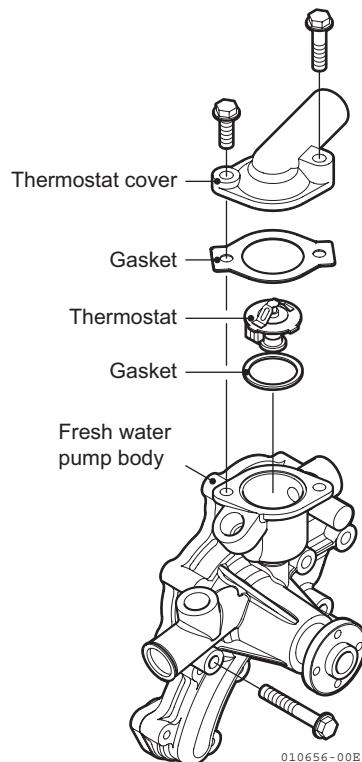
Opening temperature	75-78°C
Full open temperature	90°C
Valve lift at full open	8 mm
Bypass valve lift	3.7 mm
Bypass valve close temperature	81.5°C

9.6.4 Thermostat inspection

Remove the thermostat cover on top of the fresh water pump and take out the thermostat. Clean off scale and rust and inspect, and replace if the characteristics (performance) have changed, or if the spring is broken, deformed or corroded.

9.6.5 Testing the thermostat

Refer to 2.5 in chapter 2.



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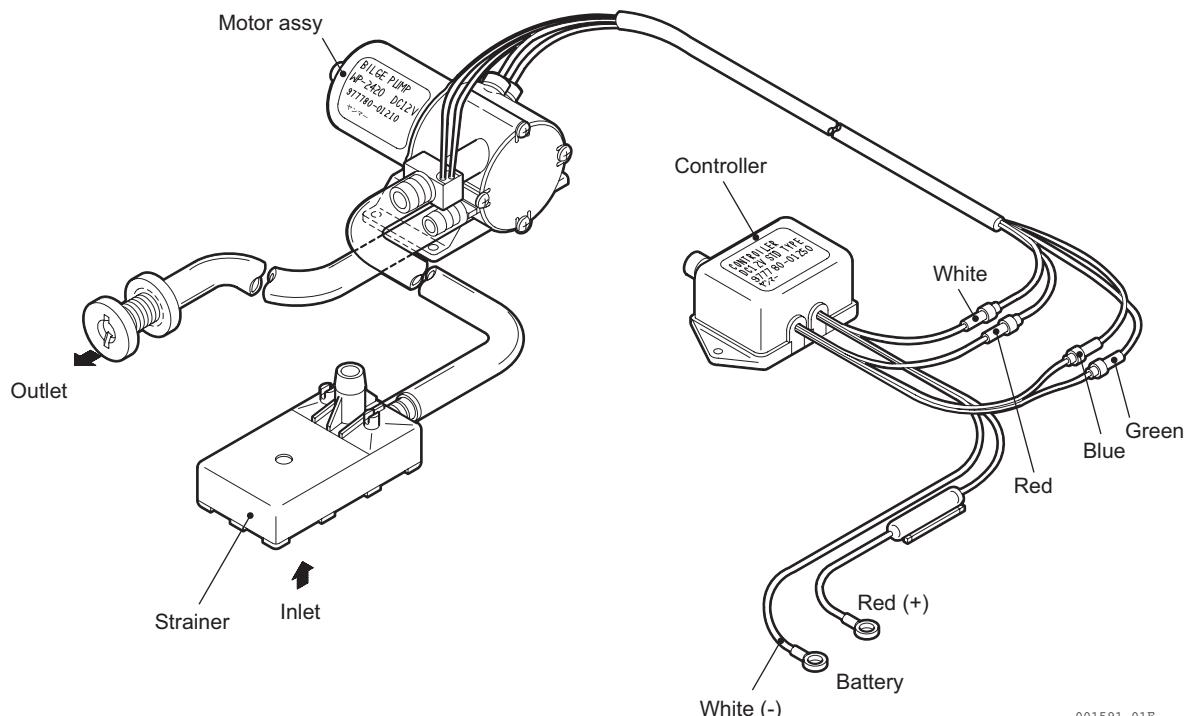
9.7 Bilge pump and bilge strainer (Optional)

9.7.1 Introduction

(1) General Introduction

Name	Bilge pump
Time	10 minutes
Rotation direction	Right (viewed from the impeller side)
Weight	Pump 1.4 kg
Negative pressure detector	Diaphragm type
Temperature	-30°C-80°C

(2) Exterior



001591-01E

Pump dimensions

Length	225 mm
Yoke diameter	Ø61
Assembly hole diameter	Ø5.3
Assembly pitch	50 x 90 mm

9.7.2 Description

(1) Characteristics

- 1) Discharge at lift : 0 m discharge capacity : 20 liters/min. or greater.
- 2) Automatic feeding height : 1 m or greater
(Limit for automatic feeding height: new pump with inside parts wet, approx. 2 m)
- 3) Automatic feeding time : 2-5 seconds.
(Limit for automatic feeding time: new pump with inside parts wet, approx. 1 second.)
- 4) Automatic stopping : Air intake causes negative pressure triggering automatic stopping.

(2) Insulation

- 1) Insulation resistance: 500V with a megatester when the difference between the continuity point and the body is $1M\Omega$ or greater.
- 2) Insulation proof stress: AC50 between the continuity point and the body, or 60hz 500V for 1 minute when impressed current leakage is 10 mA or lower.

(3) Durability

Rated voltage when there is 3% salt water 60L + engine oil 3%, and operation is at 1800 cycles and there are no difficulties.

(4) Vibration proof

Amplitude 0.51 mm (one side of the amplitude)
Vibration frequency 10-55 Hz
Sweep time 90 seconds.
Direction of vibration each direction 4 hours
No difficulties after test period

9.7.3 Cautions

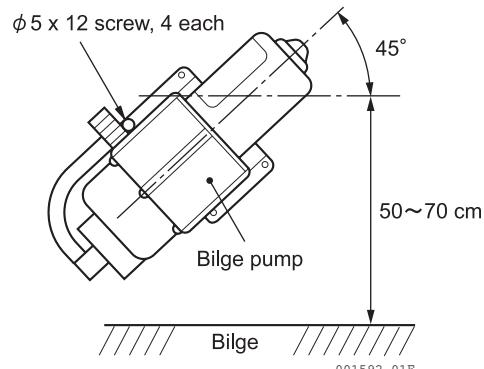
- (1) Attach at a position higher than the bilge water away from rain or other water, and 50-70 cm above the bottom of the boat.
- (2) Never run the pump dry. Be sure that the strainer is inserted in the drain water before pushing the switch. If no water is being drawn up after a period of 10 seconds or more, prime the pump. (Do not run the pump for longer than 10 seconds when no water is being drawn up.)
- (3) When the pump has not been used for a long period of time, the inside of the pump will be dry and drawing ability will be lowered. Before reusing, clean the inside of the pump or prime it to insure that it is wet, and check to be sure that the pump is then operating correctly.
- (4) When charging the diesel engine oil, wait a period of 30 minutes or longer from the time of stopping (oil temperature 20-70°C). Refrain from operation when the oil temperature is below 15°C, or above 50°C.
- (5) When the bilge inside the pump or hose freezes, completely melt the water with a steaming towel before beginning operation. When the temperature inside the pump is low, it will take a longer amount of time for the pump to drain off the bilge.
- (6) The impeller replacement kit includes one impeller and 3 washers for adjusting the side gap. If after replacing the impeller the pump does not drain, place side gap adjustment washers underneath the bottom plate to adjust. Select the number of washers used in accordance with the following. (When the pump is draining, the electric current load is about 5A. When there are too many washers, the electric current value will be too great and will blow a fuse.)
- (7) The pump cannot be used to drain off rain water or large amounts of flood water. The pump can be run continuously for a period of 10 minutes. After this time it must shut off for a period of 2 hours before reusing.
- (8) Do not use the pump for showering.
If the pump outlet is deformed for showering, the increase in water pressure will increase the load on the motor and cause motor seizure.
- (9) Fix the strainer so that it well not turn upside down or on its side.
- (10) When sludge has built up in the bilge to be drained, position the strainer about 20 mm above the sludge. When the pump is stopped, be sure there is no sludge remaining inside the pump.
- (11) The specific gravity for the battery fluid is 1.25 or more.

9.7.4 Assembly procedure

When bilge is being used, assemble in accordance with the following.

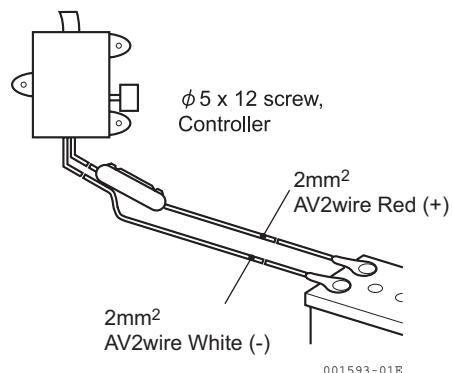
(1) Assembling the bilge pump

- Select a dry place above the bilge water level.
- Select the location for the bilge pump taking into consideration the length of the switch cable (approx. 3 m) and its attachment point, and the position of the battery.
- Position at a 45° angle as shown in the illustration with the nozzle facing up, and 50-70 cm from the bottom of the boat.



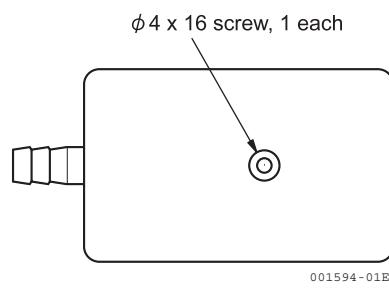
(2) Assembling the switch

- Attach in a place to insure easy operation away from rainwater.
- Connect the terminal to the battery.
(When the cord will not reach the battery, an extension of no greater than 3 m length suitable for AV3mm² can be attached.)



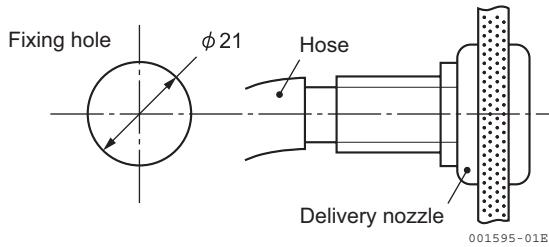
(3) Positioning the strainer

- Attach at the place where the greatest amount of water is collected when the boat is stopped.
- It is best to place the strainer as close to the bilge pump as possible. Cut the 3 m hose to a length of 1.2 m-1.8 m and attach allowing plenty of give.
- Check the strainer during a test operation before screwing firmly into place.
(When the strainer is screwed in, be especially careful not to damage the bottom of the boat.)
- The strainer contains a weight, and can be used with the weight in place.
- Always keep the strainer clean.



(4) Attaching the delivery nozzle (outlet)

- Make a fixing hole of Ø21 or less for attaching the nozzle. The hose attached at the nozzle should be 1.8 m or less and should reach without any strain, therefore care should be taken in deciding on the best position.
- Fix the nozzle (outlet) in place and attach on the discharge side of the pump.



(5) Attaching the hose

- Attach the hose from the strainer to the pump inlet.
- Attach the delivery nozzle hose to the pump outlet.
- Make the hose as short as possible and avoid sharp bends.

(6) Test operation

- Collect water in the bottom of the boat, and check for any problems with the hose or siring. After doing this, connect the battery.
- Turn on the pump switch, and check to see that water is being taken in and discharged properly. The pump will stop automatically when there is no water left.
- If the inside of the pump is dry, or if the water is not being drawn up initially after a period of 10 seconds, lift the strainer above the water surface and stop the pump. Prime the pump before starting it up again.

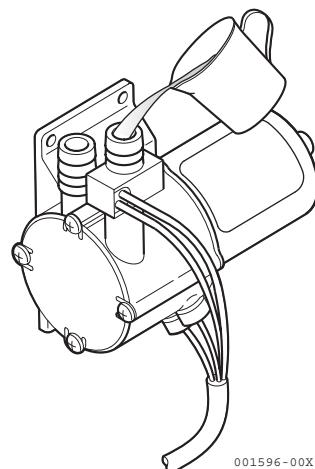
(7) Fixing the strainer

- After the test operation, fix the strainer into place with screws.
(Be careful not to damage the bottom of the boat with the screws.)

9.7.5 Cautions for assembling

Observe the following cautions for handling.

- Do not use gasoline or solvents.
1) gasoline 2) ester 3) benzol 4) battery fluid
5) liquids at 70°C or greater or engine oil
- Never run when there is no water in the bilge.
Check to be sure that the strainer is in the water before turning on the switch.
- Keep the cord terminal away from the water.
Water inside the motor or switch may lead to damage. When the insulation around the cord is damaged, water can seep in to the wires; thus, care should be taken not to scratch or nick the cord.
- When the pump has not been used for a long period of time, the inside of the pump will be dry and it may not operate properly at first. If after 10 seconds the pump is not working, turn off the switch and prime the pump before trying again.
(Never run the pump dry for period of greater than 10 seconds.)



- Replace the diesel engine oil only after the engine has been stopped for a period of 30 minutes (oil temp. 20-70°C). Whenever possible refrain from operation when the oil temperature is below 15°C or above 50°C.
- Bilge water left in the hose or inside the pump can freeze, and care should be taken to see that any excess bilge is completely discharged. If bilge water should freeze, and care should be taken to see that any excess bilge is completely discharged. If bilge water should freeze inside the hose or pump, it should be completely melted before starting up the pump. When the temperature inside the pump is low, it will take a longer time for the pump to operate. (0°C, 5-10 seconds.)
- Keep the pump in a dry place away from rain or other water.
- Use the regulation hose; do not use thin vinyl hose or hose which is not heat-resistant.
- The pump cannot be used to drain off rainwater or large quantities of flood water. This pump can be operated continuously for a period of 10 minutes.

- Do not use the pump for showering.
If the pump outlet is deformed for showering, the increase in water pressure will increase the load on the motor and cause motor seizure.
- When sludge has built up in the bilge to be drained, position the strainer about 20 cm above the sludge. When the pump is stopped, be sure there is sludge remaining inside the pump housing.
- The specific gravity for the battery fluid is 1.25.
- Refer to your local dealer for impeller replacement.

The local dealer will perform the following.

The impeller replacement kit includes one impeller and 3 films for adjusting the side gap. If after replacing the impeller the pump does not drain, place side gap adjustment washers underneath the bottom plate to adjust. Select the number of films used in accordance with the following. (When the pump is draining, the electric current load is about 10A for 12V and 5A for 24V. The pump operates efficiently at these electric current loads.)

Steps for replacement

- 1) Remove the impeller plate by taking out the M4 screws and opening the top of the diaphragm switch.
(Screw lock has been applied to the screw, and a dryer should be used to heat the screw before removing it.)
- 2) Clean the inside of the pump.
- 3) Grease the plate, impeller, and film for side gap adjustment, and then reassemble the pump by inserting first the film plate and then the impeller.

9.7.6 Troubleshooting

Refer to the following countermeasures for difficulties that arise.

Problem	Cause	Countermeasure
1. Pump does not turn	Faulty wiring	Check the wiring between the motor and battery.
	Faulty battery	Check to see if the specific gravity of the battery fluid is greater than 1.25. Recharge or replace the battery.
	Faulty starter switch	Consult your local dealer.
	Faulty pump	Consult your local dealer.
2. Pump turns but does not draw up water.	Draws up air.	Check hose connections. Retighten pump screws.
	Low voltage in battery.	Check to see if the specific gravity of the battery fluid is greater than 1.25. Recharge or replace the battery.
	The distance between the pump and the surface of the water is too great.	Lower the pump. (Position the pump so that it is closer to the surface of the water.)
	The pump is too high.	Lower the pump. (Position the pump so that it is 50-70 cm above the bottom of the boat.)
	Pump intake is weak.	If intake is still faulty after priming, consult your local dealer.
3. Pump turns, but the amount of discharge is low.	Clogged strainer	Clean strainer.
	Hose is broken or damaged.	Check for damage and repair. If incorrect hose has been used, replace with the regulation type of hose.
4. Water leakage from pump	Water leakage from packing	Retighten pump screws.
	Faulty pump seal	Consult your local dealer.
5. Pump draws up bilge, but motor stops when hand is removed from starter switch.	Faulty diaphragm switch	Check for loose wiring in diaphragm switch and correct.
	Damaged diaphragm switch	Consult your local dealer.
6. Motor does not stop, when there is no bilge water left	Clogged strainer or hose	Clean strainer or hose.
	Damaged diaphragm switch	Check for continuity of diaphragm switch terminal. Consult your local dealer if there is continuity.

10. Reduction and reversing gear

The specifications of marine gears are explained in this manual.

Refer to the service manuals of the existing JH3 series engines and the marine gear service manual for inspection, disassembly and reassembly procedures. Also refer to the service manual of the sail drive.

10.1 Specifications of 3JH4E marine gears

Model		KM35P		KM35A	
For engine models		3JH4E		3JH4BE	
Clutch		Constant mesh gear with servo cone clutch (wet type)			
Reduction ratio	Forward	2.36	2.61	2.33	2.64
	Reverse	3.16	3.16	3.04	3.04
Propeller shaft speed (at continuous power, Forward) min ⁻¹		1232	1114	1246	1103
Direction of rotation	Input shaft		Counter-clockwise, viewed from stern		
	Output shaft	Forward	Clockwise, viewed from stern		
		Reverse	Counter-clockwise, viewed from stern		
Remote control	Control head		Single lever control		
	Cable		Morse. 33-C (cable travel 76.2 mm)		
	Clamp		YANMAR made. standard accessory		
	Cable connector		YANMAR made. standard accessory		
Output shaft coupling	Outer diameter		100 mm		
	Pitch circle diameter		78 mm		
	Connecting bolt holes		4-10.5 mm		
Position of shift lever, viewed from stern		Left side		Right side	
Lubricating oil		API CC class, SAE 20/30			
Lubricating oil capacity		0.5 liters		0.65 liters	
Dry mass		12 kg		13 kg	

10.2 Specifications of 4JH4E and marine gears

Model			KM35P		KM35A2		KM4A1				
For engine models			4JH4E		4JH4BE		4JH4B4E				
Clutch			Constant mesh gear with servo cone clutch (wet type)								
Reduction ratio	Forward		2.36	2.61	2.33	2.64	1.47	2.14	2.63	3.30	
	Reverse		3.16	3.16	3.06	3.06	1.47	2.14	2.63	3.30	
Propeller shaft min ⁻¹ (Forward/ Reverse)			1232 /921	1114/ 921	1246 /950	1103 /950	1983 /1983	1360 /1360	1106 /1106	882 /882	
Direction of rotation	Input shaft		Counter-clockwise, viewed from stern								
	Output shaft	Forward	Clockwise, viewed from stern								
		Reverse	Counter-clockwise, viewed from stern								
Remote control	Control head		Single lever control								
	Cable		Morse. 33-C (cable travel 76.2mm)								
	Clamp		YANMAR made. standard accessory								
	Cable connector		YANMAR made. standard accessory								
Output shaft coupling	Outer diameter		100mm			120mm					
	Pitch circle diameter		78mm			100mm					
	Connecting bolt holes		4-10.5mm			4-10.5mm					
Position of shift lever, viewed from stern			Left side		Right side						
Lubricating oil			API CC class, SAE 20/30								
Lubricating oil capacity			0.5 liters		0.65 liters		1.3 liters				
Dry mass			12kg		13kg		27.5kg				

Model			ZF30M												
For engine models			4JH4FE												
Clutch			Wet type multi-disc, mechanically operated												
Reduction ratio	Forward		2.15			2.70									
	Reverse		2.64			2.64									
Propeller shaft min ⁻¹ (Forward/ Reverse)			1353 /1103			1078 /1103									
Direction of rotation	Input shaft		Counter-clockwise as viewed from stern												
	Output shaft	Forward	Clockwise as viewed from stern												
		Reverse	Counter-clockwise as viewed from stern												
Remote control	Control head		Single lever control												
	Cable		Morse. 33-C (cable travel 76.2mm)												
	Clamp		Option												
	Cable connector		Standard												
Output shaft coupling	Outer diameter		102mm												
	Pitch circle diameter		82.5mm												
	Connecting bolt holes		4-10.5mm												
Position of shift lever, viewed from stern			Right side												
Lubricating oil			ATF												
Lubricating oil capacity			1.1 liters												
Dry mass			27.5kg												

10.3 Specifications of 4JH4-TE and 4JH4-HTE marine gears

Model			ZF30M		KM4A2					
For engine models			4JH4-TFE 4JH4-HTFE		4JH4-TBE 4JH4-HTBE					
Clutch			Mechanical wet multiple disk clutch			Mechanical cone clutch				
Reduction ratio	Forward		2.15	2.70	1.47	2.14	2.63			
	Reverse		2.64	2.64	1.47	2.14	2.63			
Propeller shaft min ⁻¹ (Forward/ Reverse)			1444 /1176	1150 /1176	2115 /2113	1451 /1450	1180 /1179			
Direction of rotation	Input shaft		Counter-clockwise, viewed from stern							
	Output shaft	Forward	Clockwise viewed from stern		Bi-rotation					
		Reverse	Counter-clockwise viewed from stern		Bi-rotation					
Remote control	Control head		Single lever control							
	Cable		Morse. 33-C (cable travel 76.2mm)							
	Clamp		YANMAR made. standard accessory							
	Cable connector		YANMAR made. standard accessory							
Output shaft coupling	Outer diameter		102mm		120mm					
	Pitch circle diameter		82.5mm		100mm					
	Connecting bolt holes		4-11.5mm		4-10.5mm					
Position of shift lever, viewed from stern			Right side		Right side					
Lubricating oil			ATF		API CD or higher, SAE 20/30					
Lubricating oil capacity (total)	L (quart)		1.1(1.2)		2.0(2.1)					
Lubricating oil capacity (effect)	L (quart)		0.2(0.2)		0.2(0.2)					
Dry mass			27.5 kg		30 kg					

Model		KMH4A		ZF25A			
For engine models		4JH4-THE 4JH4-HTHE		4JH4-TIE 4JH4-HTIE			
Clutch		Hydraulic wet multiple disk clutch					
Reduction ratio	Forward	2.04	2.45	1.93	2.48		
	Reverse	2.04	2.45	1.93	2.48		
Propeller shaft min ⁻¹ (Forward/ Reverse)		1520 /1520	1263 /1263	1607 /1607	1250 /1250		
Direction of rotation	Input shaft		Counter-clockwise, viewed from stern				
	Output shaft	Forward	Bi-rotation				
		Reverse	Bi-rotation				
Remote control	Control head		Single lever control				
	Cable		Morse. 33-C (cable travel 76.2mm)				
	Clamp		YANMAR made. standard accessory				
	Cable connector		YANMAR made. standard accessory				
Output shaft coupling	Outer diameter		120mm	101.6 mm			
	Pitch circle diameter		100mm	82.6 mm			
	Connecting bolt holes		4-10.5mm	4-11.5mm			
Position of shift lever, viewed from stern			Left side	Left side			
Lubricating oil			API CD or higher, SAE 20/30	ATF			
Lubricating oil capacity (total)		L (quart)	2.0(2.1)	1.8(1.9)			
Lubricating oil capacity (effect)		L (quart)	0.2(0.2)	-			
Dry mass			30 kg	42 kg			

11. Remote control system (Optional)

11.1 Remote control system

11.1.1 Construction of remote control system

The remote control permits one handed control of the engine speed changing from forward to reverse, and stopping.

Fittings which allow for easy connection of the remote control cables with the fuel injection pump and transmission are provided with the remote control set.

The use of Morse remote control cables, clamps and a remote control head, are also provided for the device to stop the engine is electric and will be explained under the section on electrical equipment.

11.1.2 Remote control device components

	Morse description
Remote control head	Morse MT3 top mounting single lever Morse MN side mounting single lever
Remote control cable	Morse 33C x 4m Morse 33C x 7m
Engine stop cable	Yanmar 4m Yanmar 7m

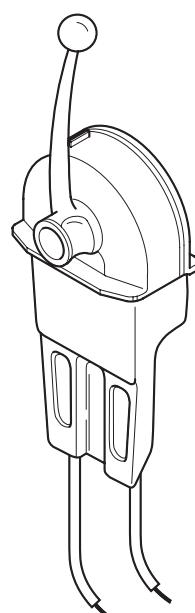
(1) Remote control handle

The model MT-3 remote control has been designed so that operation of the clutch (shift) and governor (throttle) can be effected with one lever.

Two cables are required for the MT-2 single, one for the clutch and the other for the governor.

When warming up the engine, to freely control the governor separately from the clutch put the lever in-neutral, the central position, and pull the knob in the center of the control lever. When the lever is returned to the neutral position, the knob automatically returns to its original position, and the clutch is free. The governor can then be freely operated.

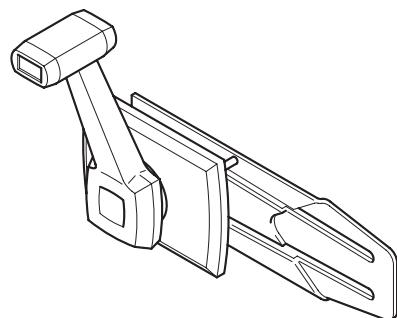
MT-3 Type



010657-00X

The MN type controller has been designed so that operation of the clutch and throttle can be effected with one lever. When the button next to the control lever is pulled out with the lever in the central position, it holds the clutch in the neutral position so that the throttle can be opened all the way and warm up the engine. When the engine is warmed up, return the handle to the central position and push the button back in. Control of the clutch and throttle is thus effected with one handle.

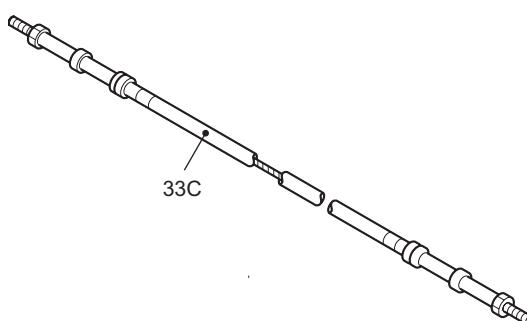
MN Type



010658-00X

(2) Remote control cable

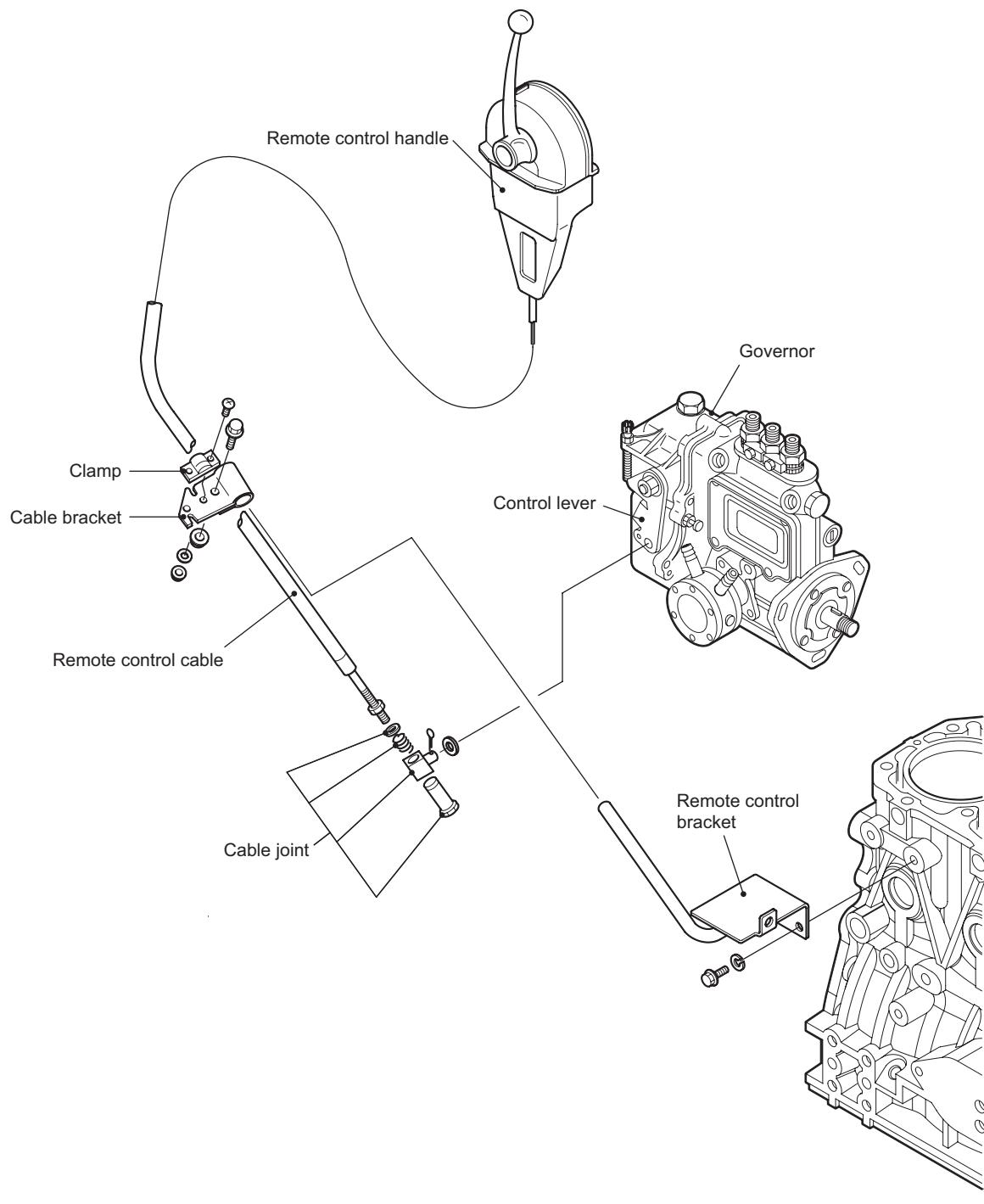
Use only Super Responsive Morse Control Cables. These are designed specifically for use with Morse control heads. This engineered system of Morse cables, control head and engine connection kits ensures dependable, smooth operation with an absolute minimum of backlash.



010659-00X

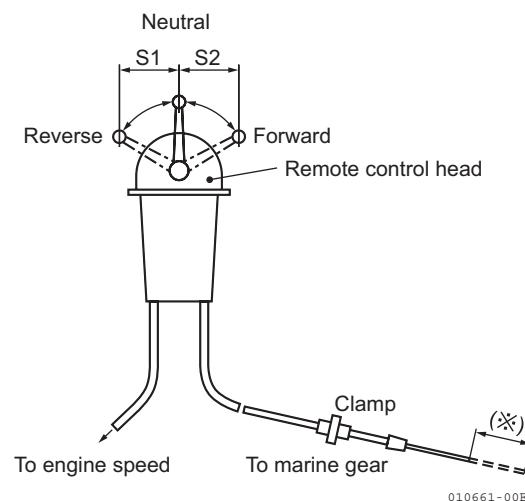
11.2 Remote control installation

(1) Speed control

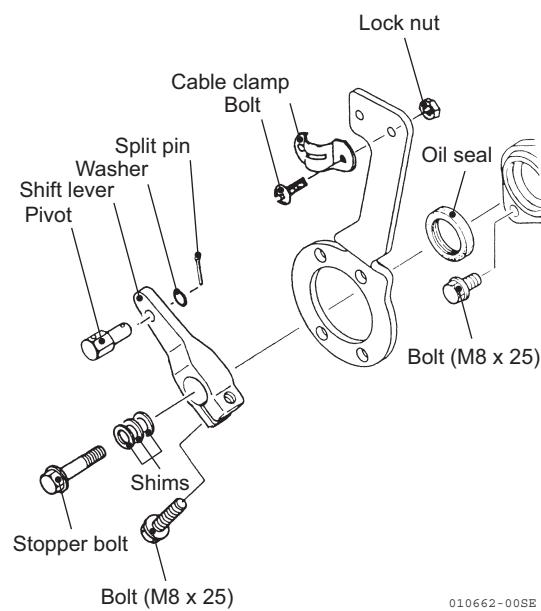


(2) Clutch control

Note: (※) Cable shift travel
 S1 = More than 36 mm (1.42")
 S2 = More than 36 mm (1.42")



KM35P marine gear

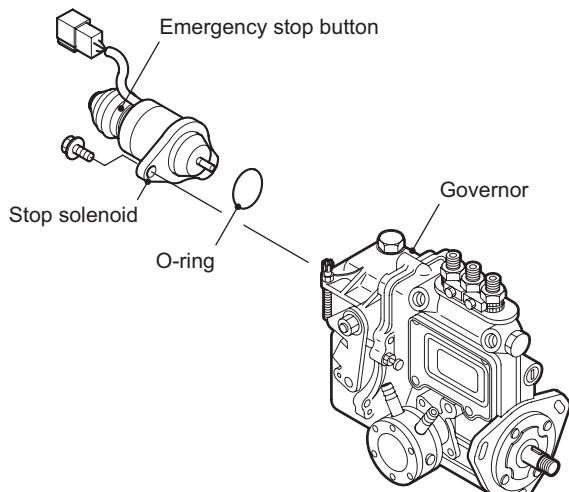


(3) Engine stop

Usually, to stop the engine, the stop button of an instrument panel is pushed, and the engine is stopped.

Emergency stop for 3JH4E and 4JH4E

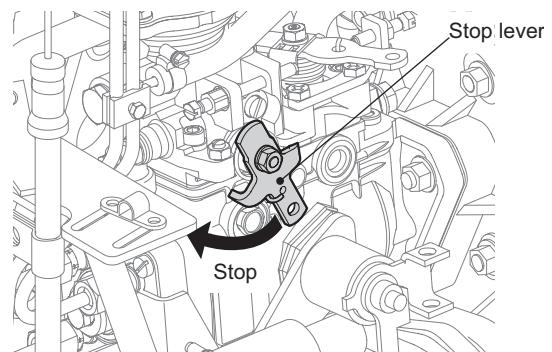
When the engine can't be stopped by the stop button on the panel, the emergency stop button behind the stop solenoid equipped with the governor can be pushed, and the engine is stopped.



010663-00E

Emergency stop for 4JH4-TE and 4JH4-HTE

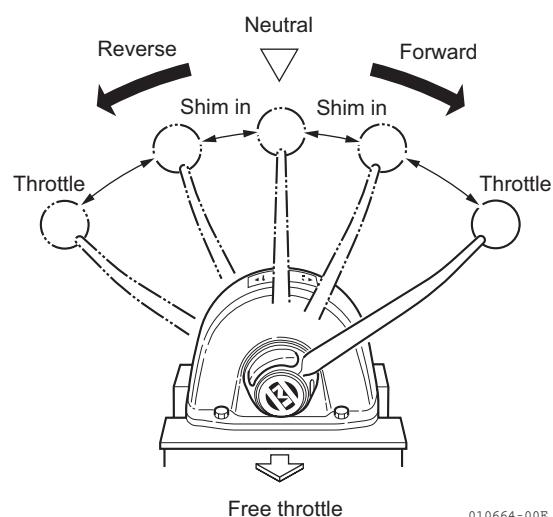
When the engine can't be stopped by the stop button on the panel, stop the engine by moving the stop lever equipped with the governor to the left by hand.



008405-01E

11.3 Remote control inspection

- (1) When the control lever movement does not coincide with operation of the engine, check the cable end stop nut to see whether or not it is loose, and readjust/retighten when necessary.



- (2) Too many bends (turns) in the cable or bends at too extreme and angle will make it difficult to turn the handle. Reroute the cable to reduce the number of bends or enlarge the bending radius as much as possible (to 200 mm or more).
- (3) Check for loose cable bracket/clamp bolts or nuts and retighten as necessary.
- (4) Check cable connection screw heads, cable sleeves and other metal parts for rust or corrosion. Clean off minor rust and wax or grease the parts. Replace if the parts are heavily rusted or corroded.

11.4 Remote control adjustment

(1) Shift lever adjustment

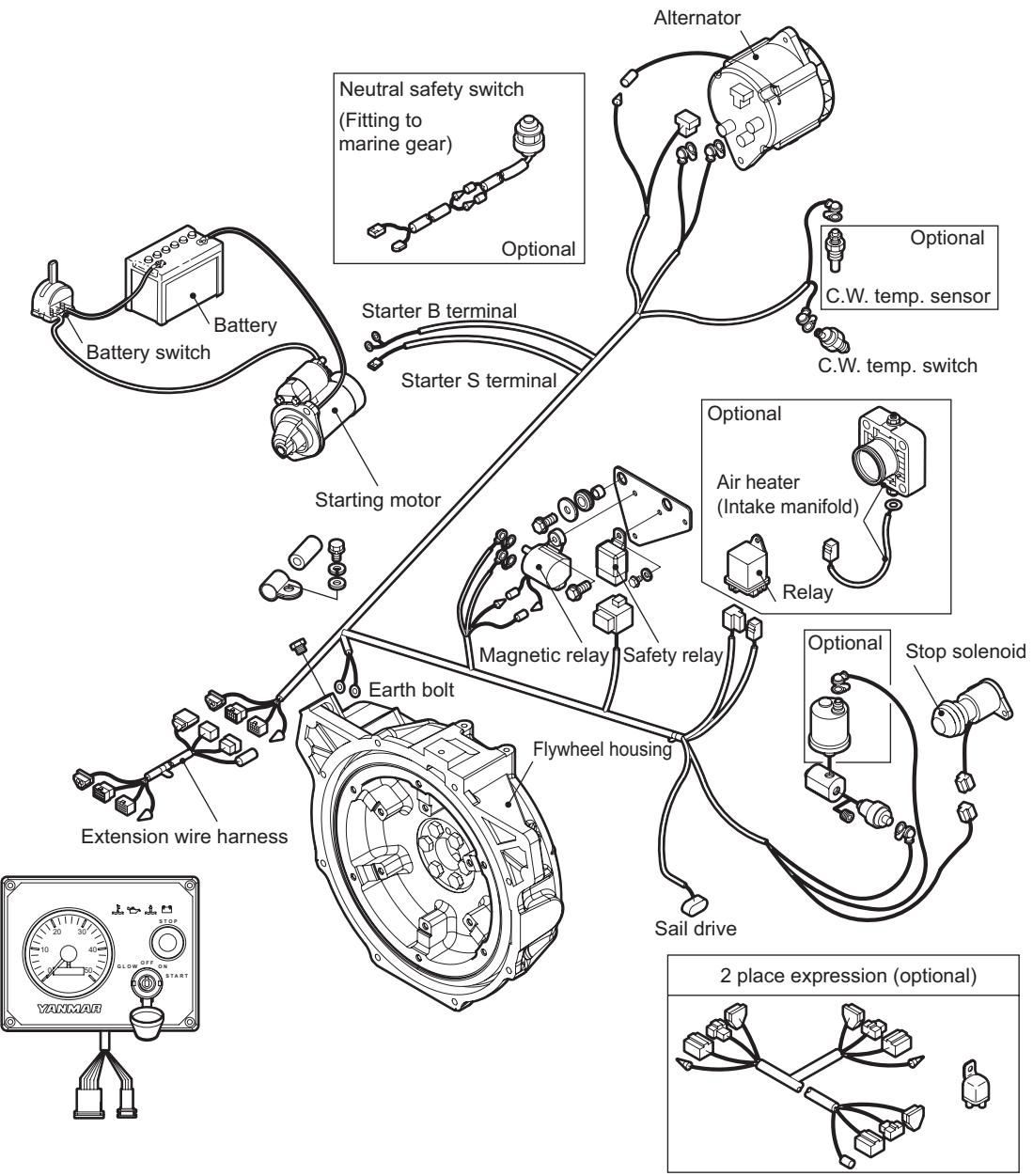
Move the control lever several times. The movement of the clutch lever on the marine gear (forward, neutral and reverse) must coincide with the forward, neutral and reverse on the control lever. If they do not coincide, adjust the fittings as necessary (first engine side, then controller side).

(2) Throttle lever adjustment

Move the control lever all the way to full throttle several times, and then return. The throttle lever on the engine (governor) must lightly push against the idle switch when it is returned. If it is properly adjusted, the knob can be easily pulled out when the lever is in the neutral position, and will automatically return when the control lever is brought back to the neutral position. If the control lever presses too hard against the knob, it may not return automatically, in which case the cable end must be adjusted (first engine side, then controller side). The knob cannot be pulled out when the lever is not in the neutral (central) position.

12. Electrical system

12.1 Electrical system

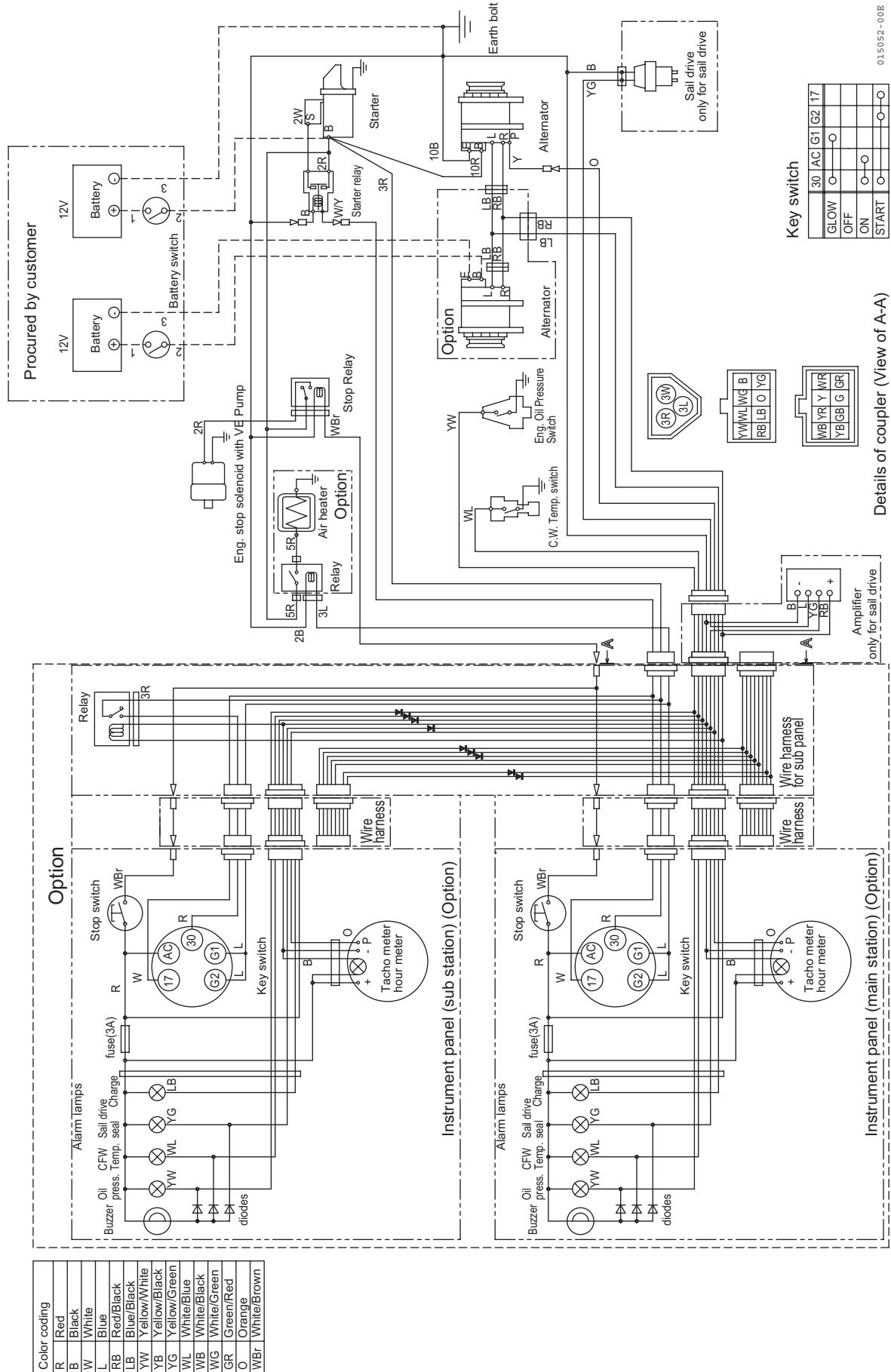


010665-00E

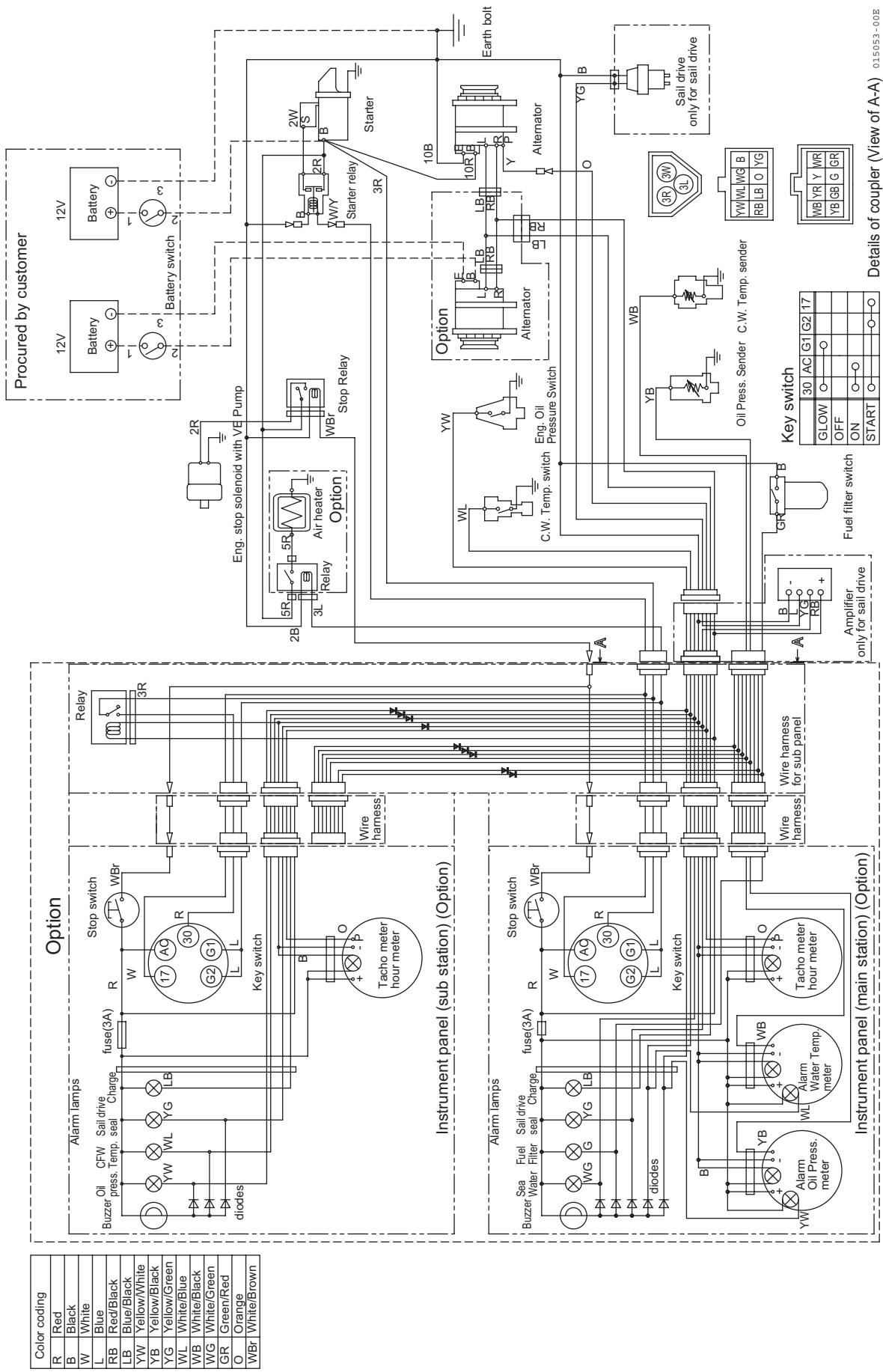
Note: This figure shows an example of 3JH4E and 4JH4E electric system.

12.1.1 Wiring diagram

(1) For B-type instrument panel



(2) For C-type instrument panel



12.2 Battery

Refer to 2.2.3(2) for electrolyte level and battery charge.

Also refer to the service manual of the previous model 3/4JH3E series for other data regarding battery.

(1) Battery capacity

Since the battery has a minimum capacity of 12V, 80AH, it can be used for 80-120AH.

Battery capacity (5 hours rating)	12V-80AH or more (type 120D31R equivalent)
--------------------------------------	---

(2) Battery cable

Wiring must be performed with the specified electric wire. Thick, short wiring should be used to connect the battery to the starter. Using wire other than that specified may cause troubles.

The overall length of the wire between the battery (+) terminal and the starter (B) terminal, and between the battery (-) terminal and the engine earth terminal, should be determined according to the following table.

Voltage system	Allowable wiring voltage drop	Conductor cross-section area	a + b + c allowable length
12V	0.2V or less/100A	20mm ²	Up to 2.5m
		40mm ²	Up to 5m

Note: Excessive resistance in the key switch circuit (between the battery and start [S] terminals) can cause improper pinion engagement. To prevent this, follow the wiring diagram carefully.

12.3 Starting motor

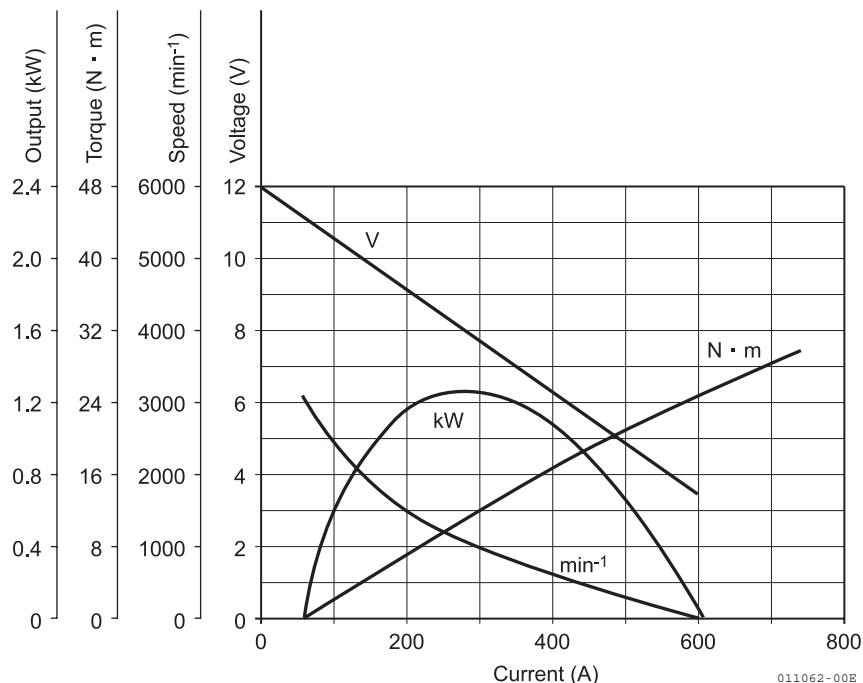
A starting motor turns the ring gear installed on a engine flywheel by the pinion while overcoming resistance such as the compression pressure and the friction loss of the engine and makes the engine start.

12.3.1 Specifications

YANMAR Part No.	129608-77010	
HITACHI model No.	S114-817A	
Nominal power (kW)	1.4	
Nominal voltage (V)	12	
Rating (second)	30	
Direction of rotation (Looking from the pinion side)	Clockwise	
Number of pinion teeth	11	
Weight (kg)	3.0	
No load	Terminal voltage (V) Electric current (A) Revolutions (min^{-1})	11 90 (MAX) 2,700 (MIN)
Load	Terminal voltage (V) Electric current (A) Torque (N·m) Revolutions (min^{-1})	8.4 250 8.3 (MIN) 1,000 (MIN)

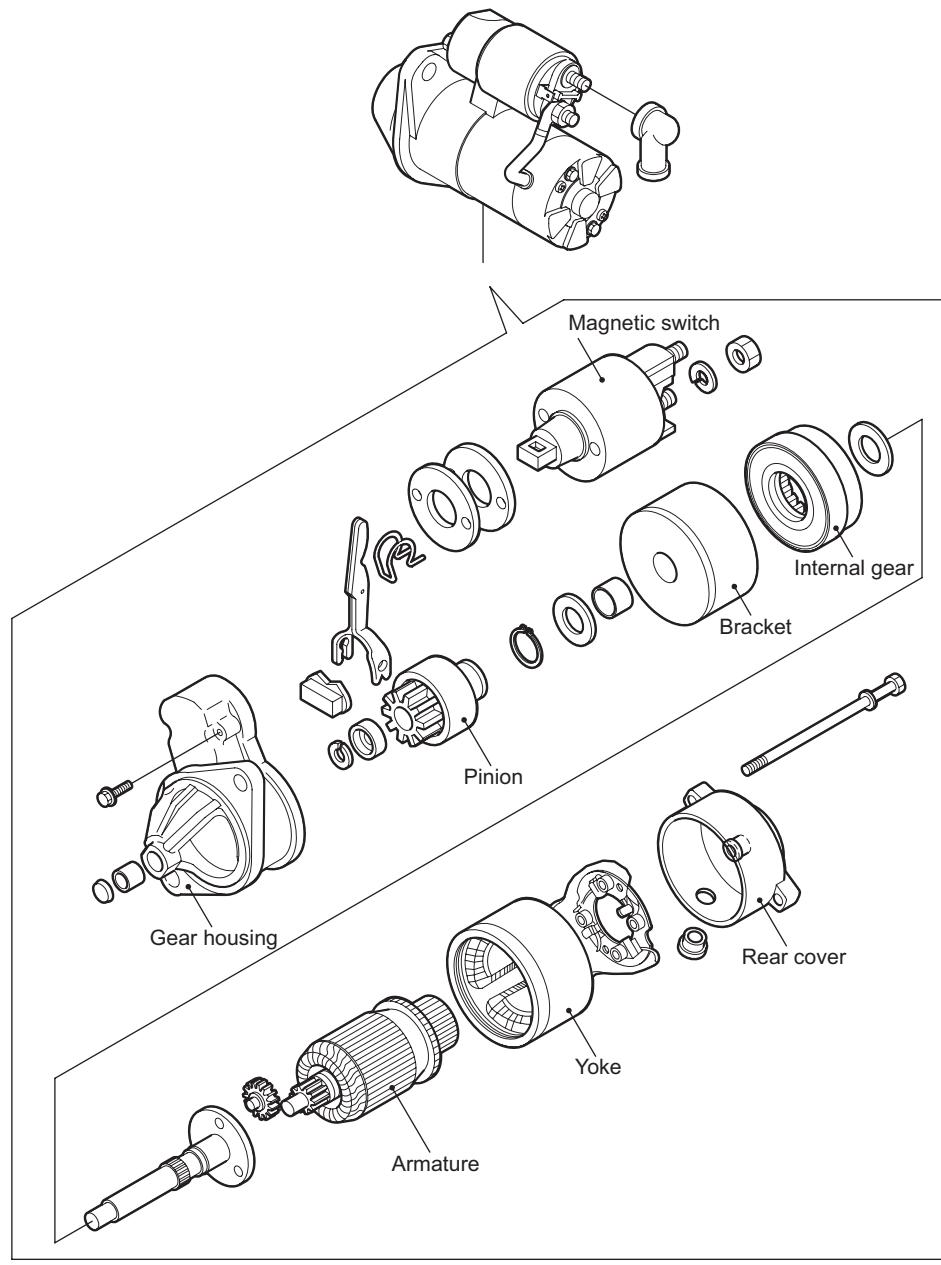
12.3.2 Characteristics

Standard Performance 12V 1.4kW



12.3.3 Structure

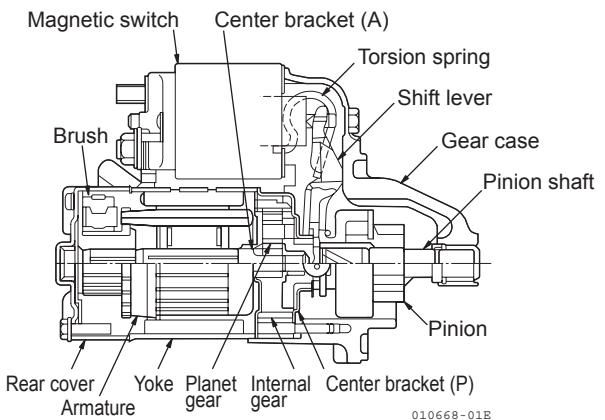
(1) Disassembly drawing



011063-00E

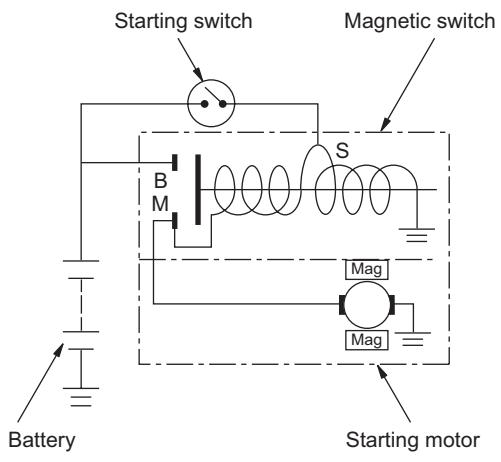
(2) Structure

When the starting switch is turned on, a magnet switch takes a voltage, and a pinion projects. The pinion engages with the ring gear of a engine, and the engine is started.



12.3.4 Wiring diameter of a starting motor

- 1) When a starting switch is turned on, a magnet switch is charged, and a moving core is absorbed, and a pinion clutch is moved forward through a lever, and the pinion engages with a ring gear.
- 2) When the pinion engages the ring gear, because a main contact point is closed and the main electric current flows and a pull coil is short-circuited by the main contact point and it stops being charged with electricity, the pinion is kept at the position by a holding coil during the start.
- 3) When the starting switch is turned off, the main contact point becomes open, and the pinion clutch is returned to the stop position by a return spring.



12.4 Alternator 12V/60A (Optional)

The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-pulley at the end of the crankshaft by a V belt.

The type of alternator used in this engine is ideal for high speed engines with a wide range of engine speeds. It contains diodes that convert AC to DC, and an IC regulator that keeps the generated voltage constant even when the engine speed changes.

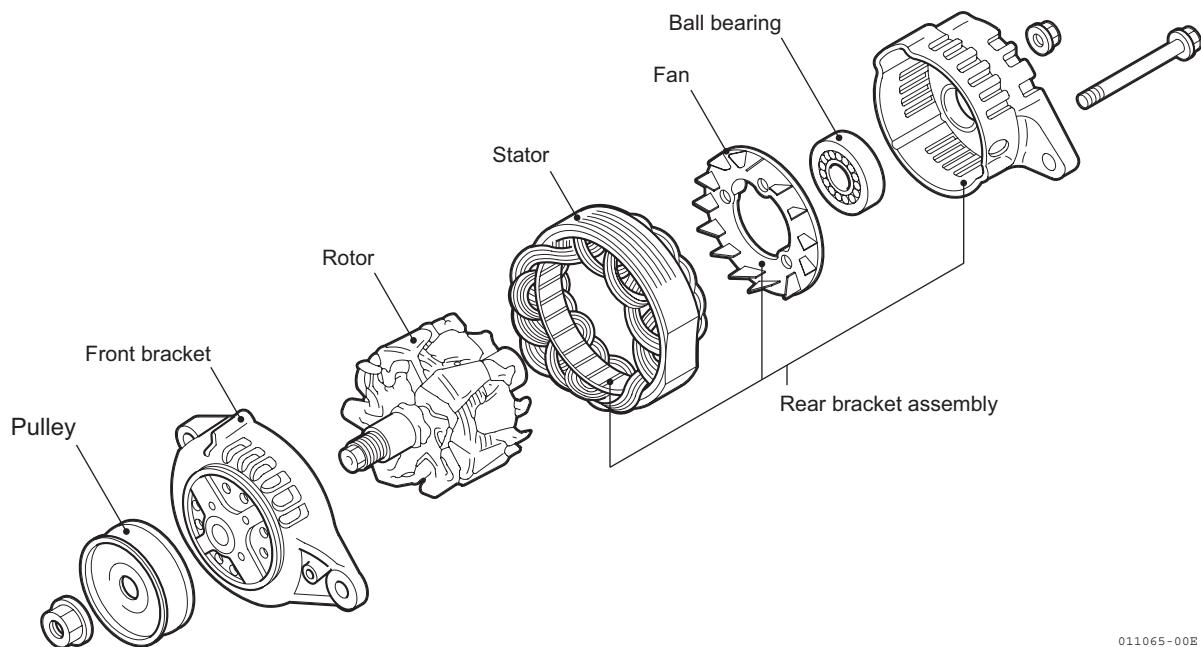
12.4.1 Specifications

Yanmar code	128271-77200
Model of alternator	LR160-741 (HITACHI)
Model of IC regulator	SA-A (HITACHI)
Battery voltage	12V
Nominal output	12V/60A
Earth polarity	Negative earth
Direction of rotation (viewed from pulley end)	Clockwise
Weight	4.2 kg
Rated speed	5000 min ⁻¹
Operating speed	1,050-18,000 min ⁻¹
Speed for 13.5V at 20°C	1,050 min ⁻¹ or less
Output current for 13.5V	56A or more/ 5000 min ⁻¹
Regulated voltage	14.4±0.3V (at 20°C, voltage gradient, -0.01V/°C)

12.4.2 Structure

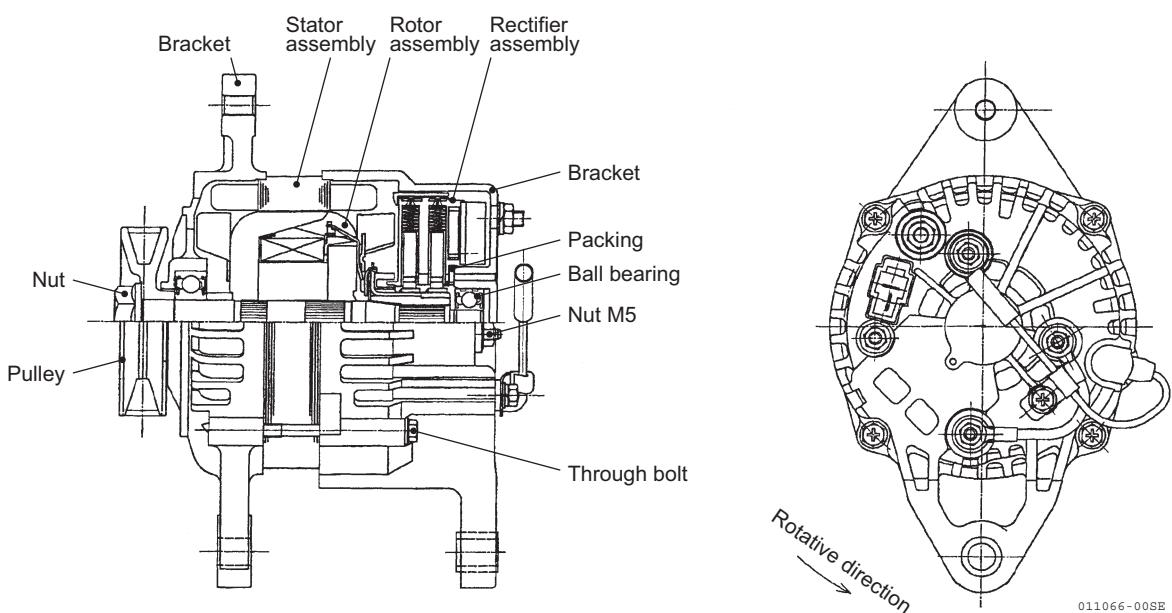
(1) Disassembly drawing

12V60A alternator



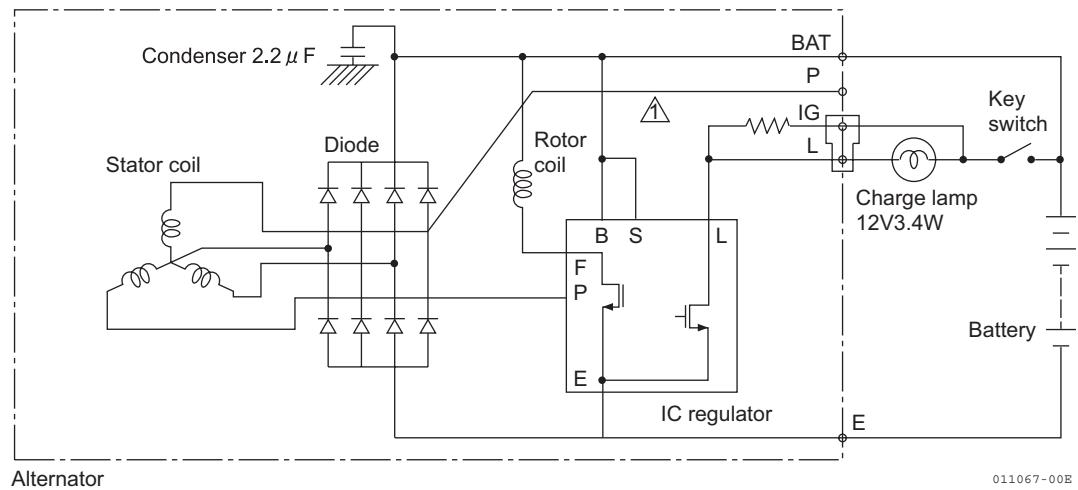
011065-00E

(2) Structure



011066-00SE

12.4.3 Wiring diagram

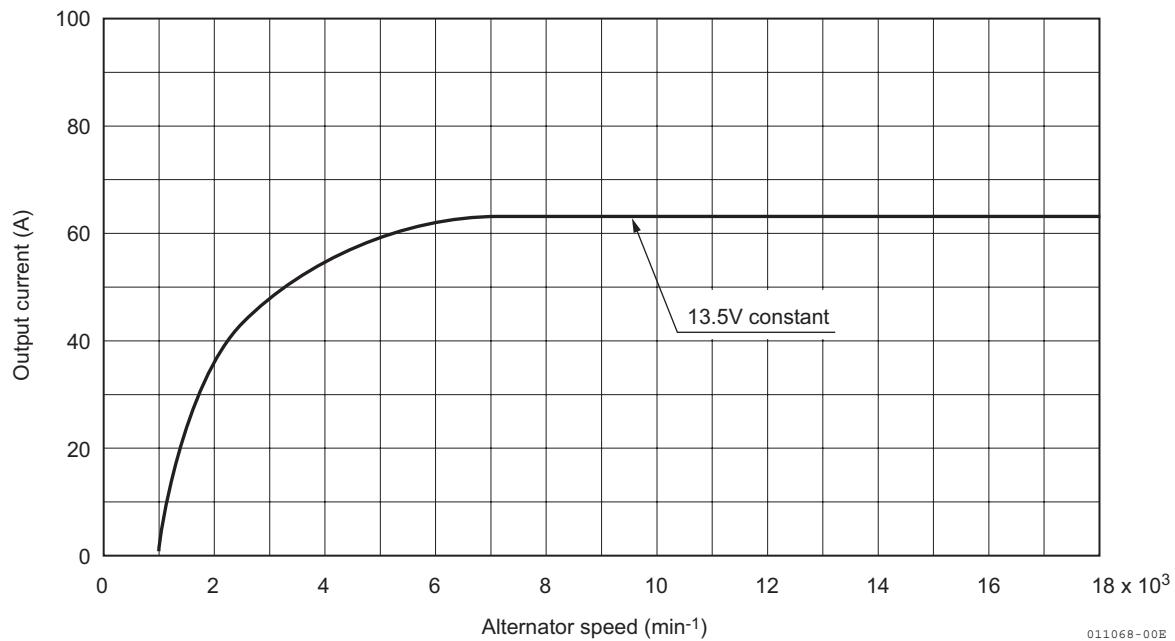


[NOTICE]

- 1) Don't do mis-connecting and short-circuit of each terminal.
- 2) Don't remove a battery terminal and a B terminal when rotating.
- 3) Shut out a battery switch during the alternator stop.

12.4.4 Standard output characteristics

The standard output characteristics of this alternator are shown as the below figure.



12.4.5 Inspection

(1) V belt inspection

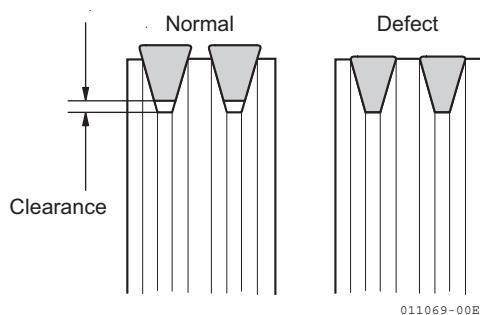
- 1) Inspect the matter whether there are not crack, stickiness and wear on the belt visually.
Check that a belt doesn't touch the bottom part of the pulley groove. If necessary, replace the V belt set.
- 2) V belt tension:
(Refer to 2.2.2.(4) in Chapter 2.)

(2) Visual check of wiring and check of unusual sound

- 1) Confirm whether wiring is right or there is no looseness of the terminal part.
- 2) Confirm that there is no unusual sound from the alternator during the engine operation.

(3) Inspection of charge lamp circuit

- 1) Move a start switch to the position of on.
Confirm lighting of the charge lamp.
- 2) Start an engine, and confirm the lights-out of the lamp. Repair a charge lamp circuit when a lamp doesn't work.



011069-00E

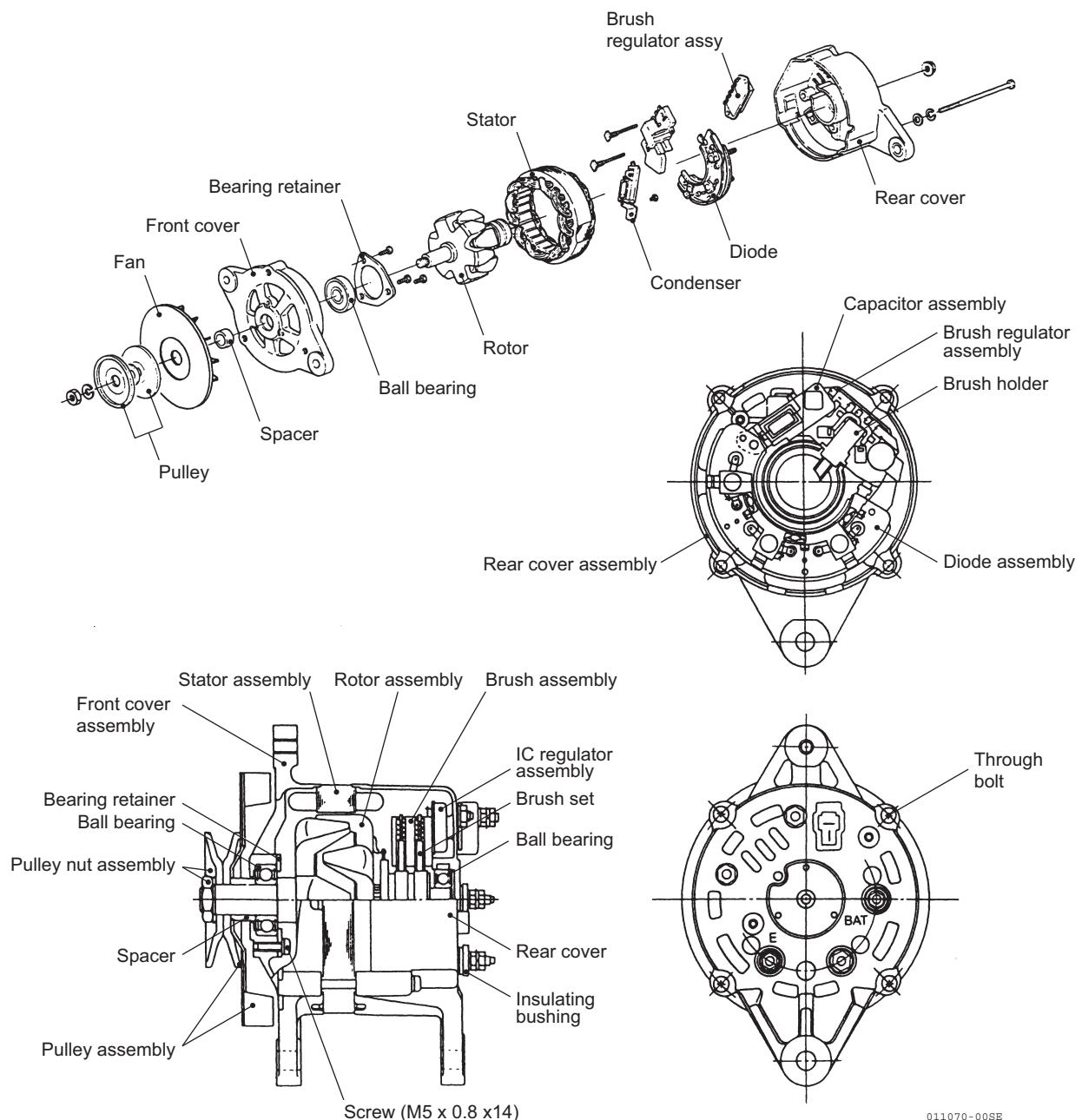
12.5 Alternator 12V/80A (Standard)

12.5.1 Specifications

Yanmar code	119573-77201
Model of alternator	LR180-03C (HITACHI)
Model of IC regulator	TR1Z-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/80A
Earth polarity	Negative earth
Direction of rotation (viewed from pulley end)	Clockwise
Weight	5.4 kg
Rated speed	5,000 min ⁻¹
Operating speed	1,200-9,000 min ⁻¹
Speed for 13.5V at 20°C	1,200 min ⁻¹ or less
Output current for 13.5V	75A or more/ 5,000 min ⁻¹
Regulated voltage	14.5±0.3V (at 20°C, voltage gradient, -0.01V/°C)

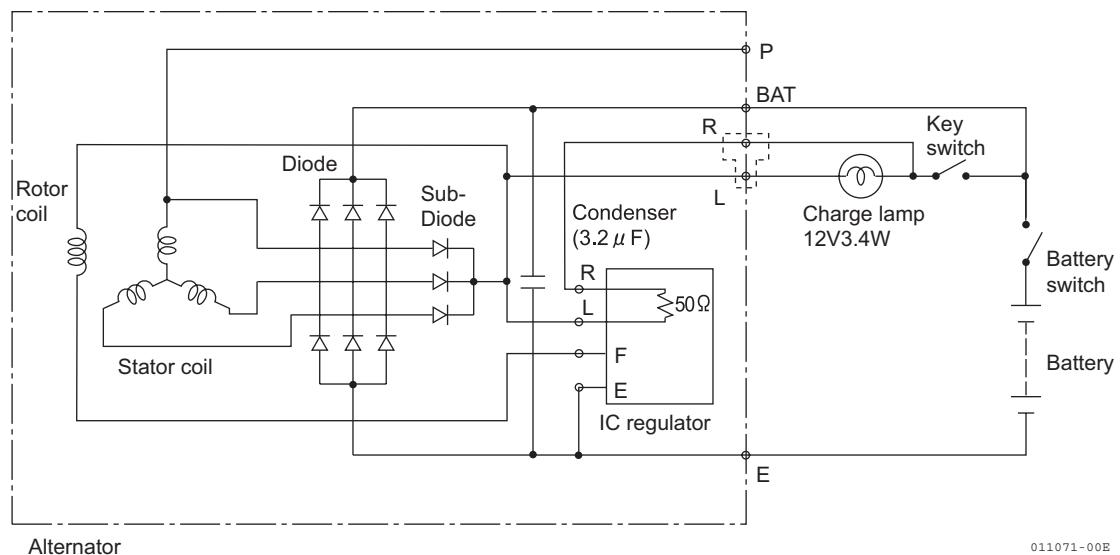
12.5.2 Structure

Disassembly drawing and structure



011070-00SE

12.5.3 Wiring diagram

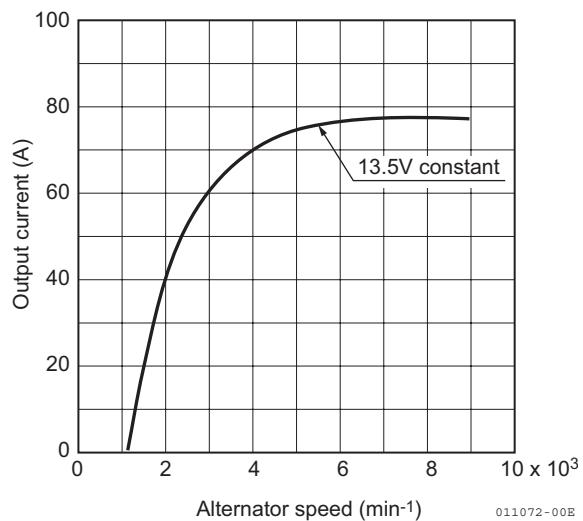


[NOTICE]

- 1) Don't do mis-connecting and short-circuit of each terminal.
- 2) Don't remove a battery terminal and a B terminal when rotating.
- 3) Shut out a battery switch during the alternator stop.

12.5.4 Standard output characteristics

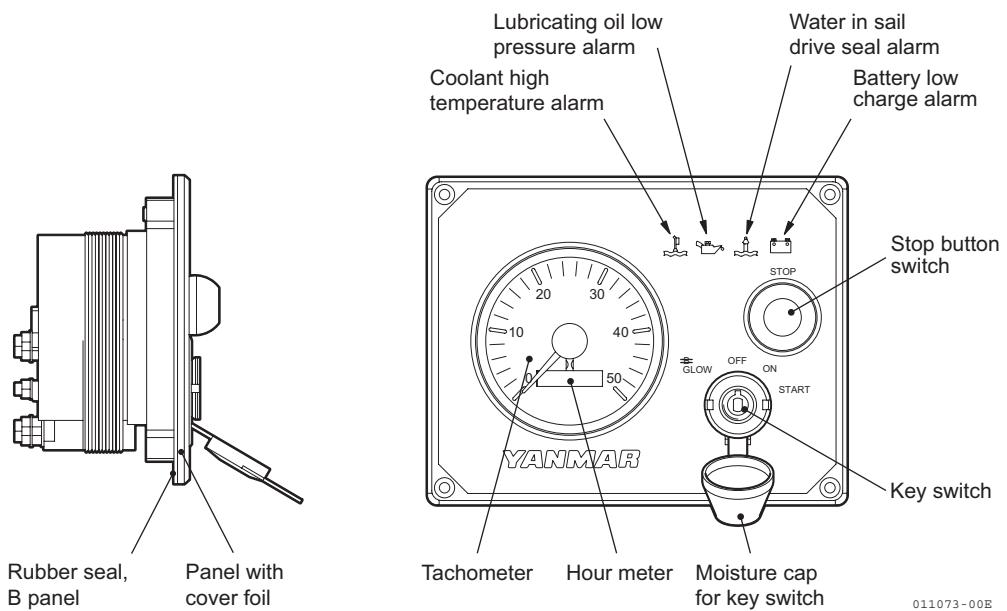
The standard output characteristics of this alternator are shown as the below figure.



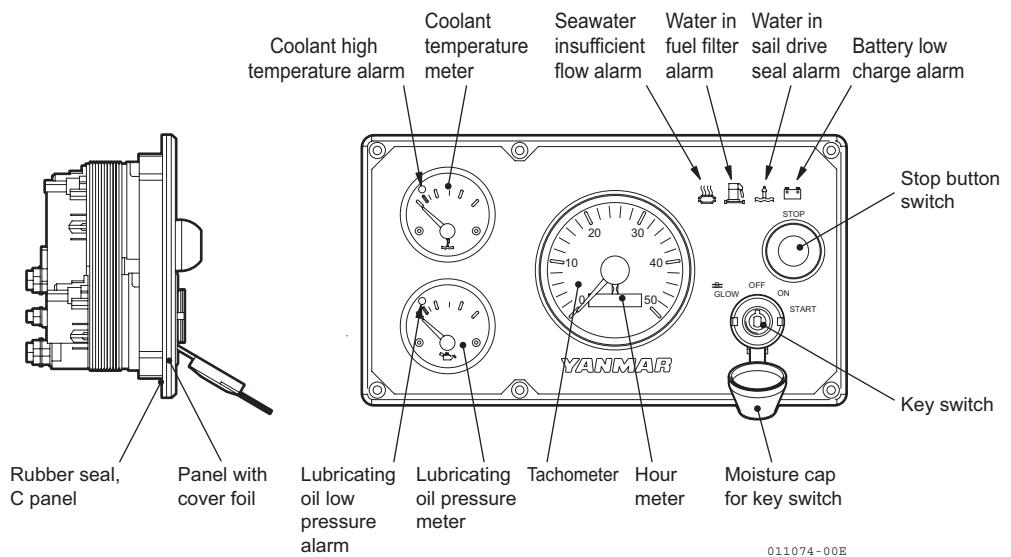
12.6 Instrument panel

The new type instrument panels are applied for JH4E series engines. The features are compactness, waterproof and independence from pulse by ring gear teeth number.
The engine speed with new panel is activated by alternator P terminal pulse.

12.6.1 B-type instrument panel (Selectable optional)



12.6.2 C-type instrument panel (Selectable optional)

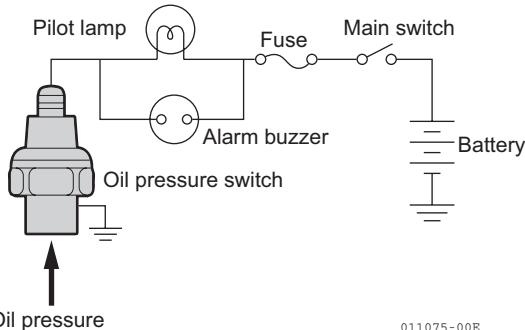


12.7 Warning devices

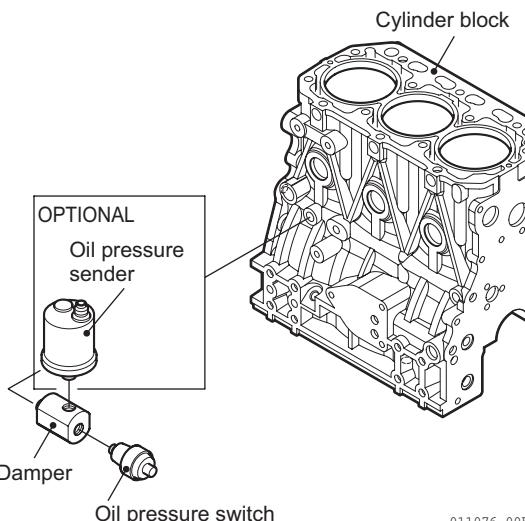
12.7.1 Oil pressure alarm

If the engine oil pressure is below 0.01-0.03 MPa (0.1-0.3 kgf/cm², 1.42-4.26 lb/in.²), with the main switch in the ON position, the contacts of the oil pressure switch are closed by a spring and the lamp is illuminated through the lamp → oil pressure switch → ground circuit system. If the oil pressure is normal, the switch contacts are opened by the lubricating oil pressure and the lamp remains off.

Oil pressure alarm circuit

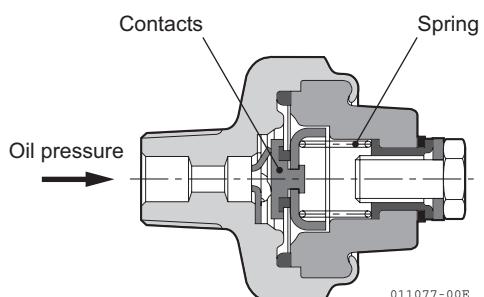


011075-00E



011076-00E

Oil pressure switch



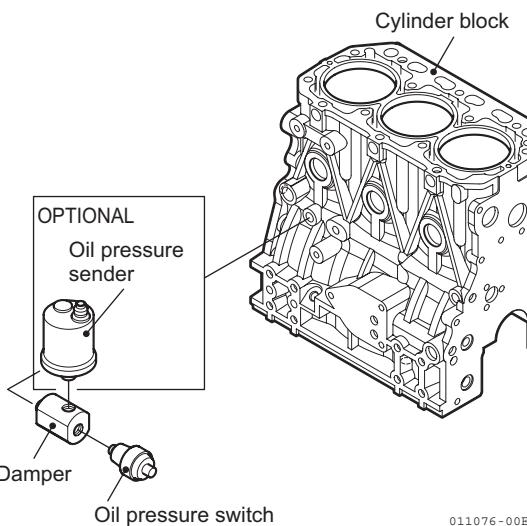
011077-00E

Inspection

Problem	Inspection Item	Inspection method	Corrective action
Lamp not illuminated when main switch set to ON.	1. Oil pressure lamp blown out.	(1) Visual inspection. (2) Lamp not illuminated even when main switch set to ON position and terminals of oil pressure switch grounded.	Replace lamp.
	2. Operation of oil pressure switch.	Lamp illuminated when checked as described in (2) above.	Replace oil pressure switch.
Lamp not extinguished while engine running.	1. Oil level low.	Stop engine and check oil level with dipstick.	Add oil.
	2. Oil pressure low.	Measure oil pressure.	Repair bearing wear and adjust regulator valve.
	3. Oil pressure faulty.	Switch faulty if abnormal at (1) and (2) above.	Replace oil pressure switch.
	4. Wiring between lamp and oil pressure switch faulty.	Cut the wiring between the lamp and switch and wire with separate wire.	Repair wiring harness.

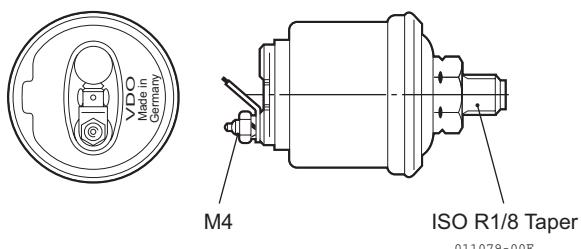
12.7.2 Sender unit for lube oil pressure gauge

The sender unit for the lube oil pressure gauge has a mounting seat for mounting on the lube oil filter bracket. Oil pressure is measured when the oil enters into the main gallery after being fed from the lube oil cooler and passing through the oil pressure control valve. Be sure to mount a damper when mounting the oil pressure sender unit.



Lube oil pressure sender unit

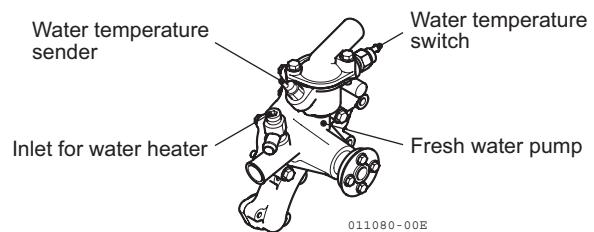
Part code No.	119773-91650
Type	Resistance switch
Rated voltage	DC 12V
Max. operating pressure	0.98 MPa (10 kgf/cm ²)



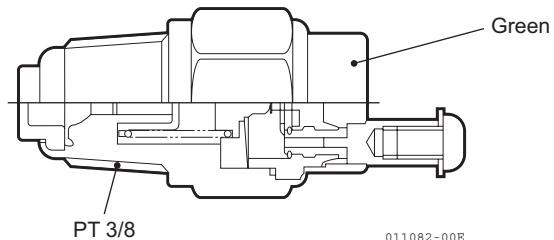
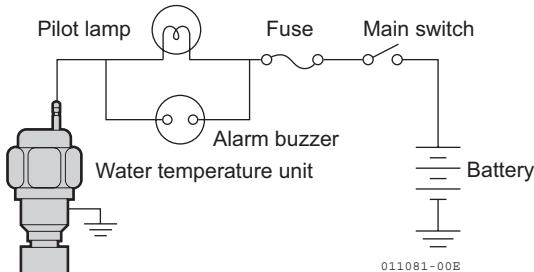
12.7.3 Coolant temperature alarm

A water temperature lamp and water temperature gauge, backed up by an alarm in the instrument panel, are used to monitor the temperature of the engine coolant. A high thermal expansion material is set on the end of the water temperature unit. When the coolant temperature reaches a specified high temperature, the contacts are closed, and an alarm lamp and buzzer are activated at the instrument panel.

Operating temperature	ON	97-103 deg. C
Electric capacity		DC 12V, 1A
Response time		within 60 sec.
Indication color		Black
Tightening torque		23.5-31.4 Nm (2.40-3.20 kgf-m)



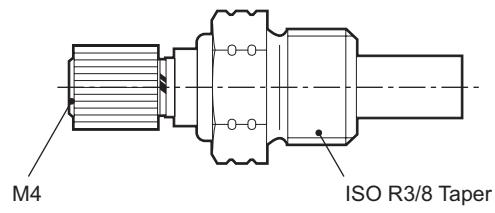
Water temperature alarm circuit



12.7.4 Sender unit for the coolant temperature gauge

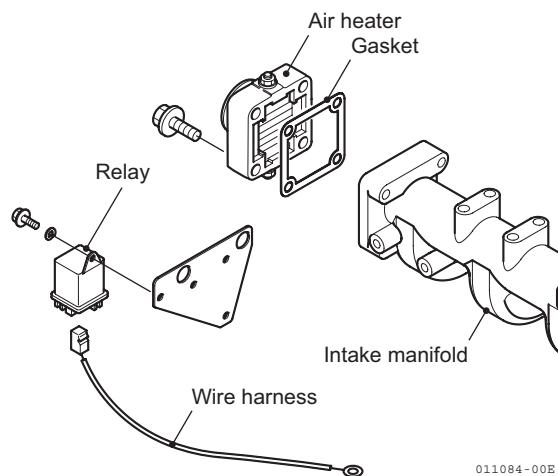
The water temperature sender unit has a mounting seat for mounting on the fresh water pump unit. Water temperature is measured when the coolant flows into the thermostat housing after leaving the cylinder head.

Part code No.	119773-91700
Type	Thermistor switch
Rated voltage	12V



12.8 Air heater (Optional)

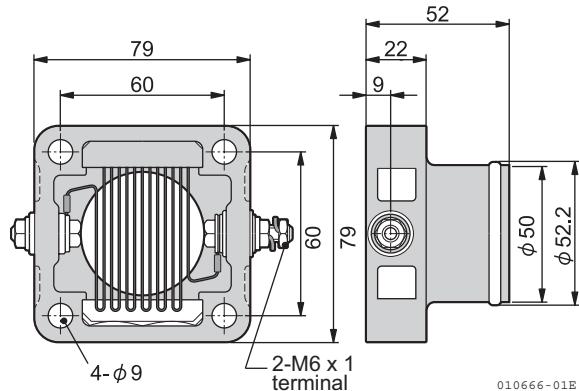
An air heater is available for warming intake air when starting in a cold weather. The air heater is mounted to the intake manifold. The device is operated by the glow switch on the instrument panel.



011084-00E

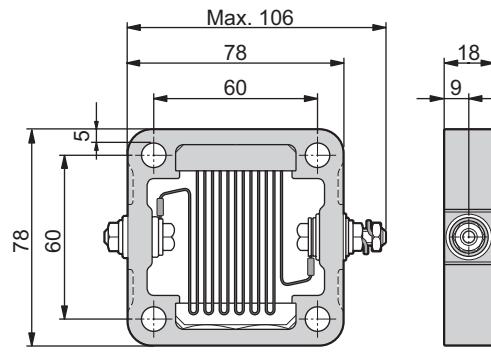
	3JH4E/4JH4E	4JH4-TE/4JH4-HTE
Part No.	129120-77501	129100-77500
Rated output	390W	
Rated current	35.5A	
Rated voltage	DC11V	

3JH4E and 4JH4E



010666-01E

4JH4-TE and 4JH4-HTE

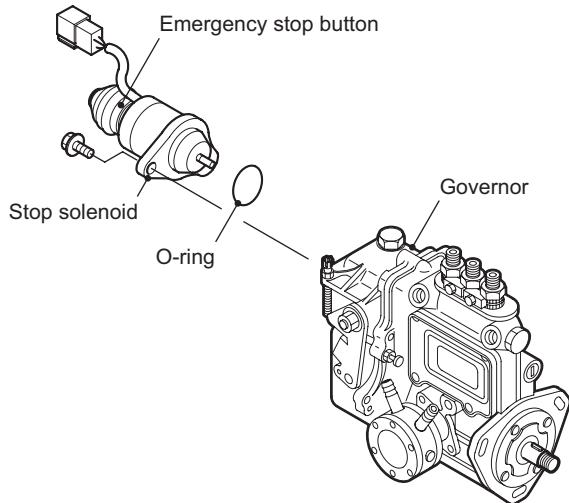


010667-01X

12.9 Electric engine stopping device

The electric engine stop device is fitted to the governor. The device is operated by the stop switch on the instrument panel.

Electric emergency stop for 3JH4E and 4JH4E
The emergency stop button is integrated with the solenoid. When pushing the stop button in a time of emergency, the engine will shut down.



010663-00E

13. Service standards

13.1 Engine tuning

No.	Inspection item			Standard	Limit	Reference page	
1	Intake/exhaust valve clearance mm			0.15-0.25	-	2.2.2(5)	
2	V-belt tension at 98N (10kgf) mm	Between alternator and F.W. pump	Used part	8-10	-	2.2.2(4)	
			New part	6-8	-		
3	Fuel injection pressure MPa (kgf/cm ²)			21.1-22.1 (215-225)	-	2.2.6(2)	
4	Compression pressure (at 250 min ⁻¹)		3JH4E 4JH4E 4JH4-TE	3.4±0.1 (35±1)	-	3.4	
	MPa (kgf/cm ²)		4JH4-HTE	3.2±0.1 (32±1)	-		
5	Coolant capacity (Liter)	3JH4E		4.5	-	2.2.1(5)	
		4JH4E		6.0	-		
		4JH4-TE/ 4JH4-HTE		7.2	-		
		Coolant recovery tank		0.8	-		
6				Total	Effective	2.2.1.(3)	
	Lube oil capacity of 3JH4E (Liter)	Engine (with KM35P, at rake angle 8 degrees)		5.0±0.3	1.1		
		Engine (with KM35A/ SD40, at rake angle 0 degree)		5.5±0.3	1.2		
		Marine gear	KM35P	0.5	-		
			KM35A	0.65	-		
	Lube oil capacity of 4JH4E (Liter)	Engine (with KM35P/ ZF30M, at rake angle 8 degrees)		5.0±0.3	1.2		
		Engine (with KM35A2/ KM4A1/ SD40, at rake angle 0 degree)		5.0±0.3	1.4		
		Marine gear	KM35P	0.5	-		
			KM35A, KM35A2	0.65	-		
			ZF30M	1.1	-		
		KM4A1	1.3	-	-		

13. Service standards

No.	Inspection item		Standard	Limit	Reference page
6	Lube oil capacity of 4JH4-TE/ 4JH4-HTE (Liter)		Total	Effective	2.2.1.(3)
			Engine (with ZF30M, at rake angle 7 degrees)	5.7±0.3	
			Engine (with KMH4A/ KM4A2/ ZF25A/ SD50, at rake angle 0 degrees)	6.9±0.3	
			ZF30M	1.1	
	Marine gear	KMH4A	2.0		
		KM4A2	2.0		
		ZF25A	1.8		
		SD50-4T (only for 4JH4-TE)	2.2		
			0.1		
7	Lubricating oil pressure MPa (kgf/cm ²)	3JH4E/ 4JH4E		0.39-0.54 (4.0-5.5)	0.06(0.6) or above
		4JH4-TE/ 4JH4-HTE		0.28-0.45 (2.9-4.6)	
8	Oil pressure switch operating pressure MPa (kgf/cm ²)		0.02±0.01 (0.2±0.1)	-	12.7.1
9	Thermostat		valve opening temperature deg. C	Full opening lift (mm) (temperature)	2.5
			75.0-78.0	8 or above (90 deg.C)	
10	Thermo switch actuating temperature (deg. C)	ON		97-103	2.4.2
		OFF		90 or more	
11	Top clearance		0.68-0.80	-	5.2.6

13.2 Engine body

13.2.1 Cylinder head

(1) Cylinder head

Inspection item			Standard	Limit	Reference page
Combustion surface distortion			mm	0.05 or less	0.15
Valve sink	mm	Intake Exhaust	0.30-0.50	0.8	5.2.3(3)
Valve seat	Seat angle	deg.	Intake	120	-
			Exhaust	90	-

(2) Intake/exhaust valve and guide

	Inspection item			Standard	Limit	Reference page		
3JH4E 4JH4E	Intake	Guide inside diameter		8.010-8.025	8.10	5.2.3		
		Valve stem outside diameter		7.955-7.975	7.90			
		Clearance		0.035-0.070	0.18			
	Exhaust	Guide inside diameter		8.015-8.030	8.10			
		Valve stem outside diameter		7.955-7.970	7.90			
		Clearance		0.045-0.075	0.18			
	Valve guide projection from cylinder head			14.7-15.0	-	5.2.3(4)		
	Valve guide driving-in method			Cold-fitted	-			
4JH4-TE 4JH4-HTE	Intake	Guide inside diameter		6.000-6.015	6.1	5.2.3		
		Valve stem outside diameter		5.960-5.975	5.90			
		Clearance		0.025-0.055	0.16			
	Exhaust	Guide inside diameter		6.000-6.015	6.1			
		Valve stem outside diameter		5.945-5.960	5.90			
		Clearance		0.040-0.070	0.18			
	Valve guide projection from cylinder head			8.2-8.5	-	5.2.3(4)		
	Valve guide driving-in method			Cold-fitted	-			

(3) Valve spring

mm

	Inspection item	Standard	Limit	Reference page
Free length	3JH4E/ 4JH4E	44.4	43.0	5.2.4(1)
	4JH4-TE/ 4JH4-HTE	37.4	36.9	
Inclination		-	1.1	

13. Service standards

(4) Rocker arm and shaft

mm

Inspection item	Standard	Limit	Reference page
Arm shaft hole diameter	16.000-16.020	16.090	5.2.7(1)
Shaft outside diameter	15.966-15.984	15.955	
Clearance	0.016-0.054	0.140	

(5) Push rod

mm

Inspection item	Standard	Limit	Reference page
Bend	Less than 0.03	0.03	5.6.2(3)

13.2.2 Camshaft and gear train

(1) Camshaft

				mm
Inspection item		Standard	Limit	Reference page
Side gap		0.05-0.20	0.35	5.6.1(1)
Bending (1/2 the dial gage reading)		0.02 or less	0.05	5.6.1(4)
Cam height		3JH4E/ 4JH4E 4JH4-TE/ 4JH4-HTE	38.600-38.800 39.800-40.000	38.350 39.550
Shaft outside diameter / Metal inside diameter				
Gear side	Bushing inside diameter	44.990-45.055	45.130	5.6.1(3)
	Camshaft outside diameter	44.925-44.950	44.890	
	Clearance	0.040-0.130	0.240	
Intermediate	Bushing inside diameter	45.000-45.025	45.100	
	Camshaft outside diameter	44.910-44.935	44.875	
	Clearance	0.065-0.115	0.225	
Flywheel side	Bushing inside diameter	45.000-45.025	45.100	
	Camshaft outside diameter	44.925-44.950	44.890	
	Clearance	0.050-0.100	0.210	

(2) Idle gear shaft and bushing

				mm
Inspection item		Standard	Limit	Reference page
Shaft outside diameter		45.950-45.975	45.880	5.7.1(3)
Bushing inside diameter		46.000-46.025	46.075	
Clearance		0.025-0.075	0.150	

(3) Backlash of each gear

				mm
Inspection item		Standard	Limit	Reference page
Crank gear, cam gear, idle gear, fuel injection pump gear and seawater pump gear		0.07-0.15	0.17	5.7.1(2)

13.2.3 Cylinder block

(1) Cylinder block

mm

Inspection item		Standard	Limit	Reference page
Cylinder inside diameter	3JH4E/ 4JH4E	88.000-88.030	88.200	5.1.5
	4JH4-TE/ 4JH4-HTE	84.000-84.030	84.200	
Cylinder bore	Roundness	0.01 or less	0.03	
	Inclination			

(2) Crankshaft

mm

Inspection item		Standard	Limit	Reference page
Bending (1/2 the dial gauge reading)		-	0.02	5.5.1(2)
Crank pin	Pin outside diameter	47.952-47.962	47.902	5.4.2(2) 5.5.1(3) 5.5.2(2)
	Metal inside diameter	48.000-48.026	-	
	Metal thickness	1.492-1.500	-	
	Clearance	0.038-0.083	0.150	
Crank journal (Selective pairing)	Journal outside diameter	49.952-49.962	49.902	
	Metal inside diameter	51.000-51.010	-	
	Metal thickness	1.995-2.010	-	
	Clearance	0.038-0.068	0.150	

(3) Thrust bearing

mm

Inspection item	Standard	Limit	Reference page
Crankshaft side gap	0.14-0.22	0.30	5.5.1(4)

(4) Piston and ring

1) Piston

mm

Inspection item	Standard	Limit	Reference page
Piston outside diameter (Measure in the direction vertical to the piston pin.)	3JH4E 4JH4E 4JH4-TE/ 4JH4-HTE	87.950-87.960 87.935-87.945 83.930-83.940	87.900 87.885 83.880
Clearance between piston and cylinder	3JH4E	0.045-0.075	-
	4JH4E	0.06-0.090	-
	4JH4-TE/ 4JH4-HTE	0.065-0.095	-
Piston diameter measure position (Upward from the bottom end of the piston)		22	-
3JH4E 4JH4E	Piston pin hole inside diameter	26.000-26.009	26.020
	Piston pin outside diameter	25.995-26.000	25.965
	Clearance between piston pin and hole	0.000-0.014	0.074
4JH4-TE 4JH4-HTE	Piston pin hole inside diameter	28.000-28.009	28.020
	Piston pin outside diameter	27.995-28.000	27.965
	Clearance between piston pin and hole	0-0.014	0.074

5.3.1(2)

5.3.2

13. Service standards

2) Piston ring

mm

Inspection item		Standard	limit	Reference page
3JH4E 4JH4E	Top ring	Ring groove width	2.060-2.075	2.170
		Ring width	1.970-1.990	1.950
		Side clearance	0.070-0.105	0.200
		End clearance (gap)	0.200-0.400	0.490
	Second ring	Ring groove width	2.025-2.040	2.140
		Ring width	1.970-1.990	1.950
		Side clearance	0.035-0.070	0.190
		End clearance (gap)	0.200-0.400	0.490
	Oil ring	Ring groove width	4.015-4.030	4.130
		Ring width	3.970-3.990	3.950
		Side clearance	0.025-0.060	0.180
		End clearance (gap)	0.200-0.400	0.490
4JH4-TE 4JH4-HTE	Top ring	Ring groove width	2.060-2.080	2.180
		Ring width	1.970-1.990	1.950
		Side gap	(half-keystone)	-
		End clearance (gap)	0.200-0.400	0.490
	Second ring	Ring groove width	2.050-2.065	2.170
		Ring width	1.970-1.990	1.950
		Side clearance	0.060-0.095	0.220
		End clearance (gap)	0.200-0.400	0.490
	Oil ring	Ring groove width	4.020-4.035	4.135
		Ring width	3.970-3.990	3.950
		Side clearance	0.030-0.065	0.180
		End clearance (gap)	0.200-0.400	0.490

(5) Connecting rod

1) Rod big end

mm

Inspection item	Standard	Limit	Reference page
Side clearance	0.20-0.40	0.55	5.4.1(2)

2) Rod small end

mm

Item		Standard	Limit	Reference page
3JH4E 4JH4E	Piston pin bushing inside diameter	26.025-26.038	26.068	5.3.2 5.4.3(1)
	Piston pin outside diameter	25.995-26.000	25.965	
	Clearance	0.025-0.043	0.101	
4JH4-TE 4JH4-HTE	Piston pin bushing inside diameter	28.025-28.038	28.068	5.4.3(1)
	Piston pin outside diameter	27.995-28.000	27.965	
	Clearance	0.025-0.043	0.101	

(6) Tappet

mm

Inspection item		Standard	Limit	Reference page
3JH4E 4JH4E	Tappet guide hole inside diameter	12.000-12.018	12.045	5.6.2(2)
	Tappet stem outside diameter	11.975-11.990	11.930	
	Clearance	0.010-0.043	0.090	
4JH4-TE 4JH4-HTE	Tappet guide hole inside diameter	12.000-12.025	12.052	5.6.2(2)
	Tappet stem outside diameter	11.975-11.990	11.930	
	Clearance	0.010-0.050	0.097	

13.3 Lubricating oil system (Trochoid pump)

(1) Outside clearance of outer rotor

mm

Standard	Limit	Reference page
0.12-0.21	0.30	8.2.4(1)

(2) Tip clearance between outer rotor and inner rotor

mm

Standard	Limit	Reference page
-	0.16	8.2.4(2)

(3) Side clearance of outer rotor

mm

Standard	Limit	Reference page
0.02-0.07	0.12	8.2.4(3)

(4) Inside clearance of inner rotor

mm

Item	Parts	Standard	Standard	Limit	Reference page
Inside clearance of inner rotor	Gear boss diameter	53.05-53.15	0.3-0.5	0.6	8.2.4(4)
	Rotor diameter	53.45-53.55			
Width across flat clearance of inner rotor	Width across flat of gear boss	49.45-49.75	0.2-0.6	0.7	
	Width across flat of rotor	49.95-50.05			

14. Tightening torque for bolts and nuts

14.1 Main bolt and nut

No.	Name	Thread diameter x pitch (mm)	Lubricating oil application (thread portion, and seat surface)	Torque Nm (kgf-m)
1	Head bolt	M10 x 1.25	Coat with lube oil	85.2-91.2 (8.69-9.30)
2	Rod bolt	M9 x 1.0	Coat with lube oil	44.1-49.1 (4.50-5.01)
3	Flywheel bolt	M10 x 1.25	Coat with lube oil	83.3-88.3 (8.49-9.00)
4	Metal cap bolt	M12 x 1.5	Coat with lube oil	96-100 (9.79-10.2)
5	Crankshaft pulley bolt (FC300 pulley)	M14 x 1.5	Coat with lube oil	83.2-93.2 (8.48-9.50)
6	Nozzle retainer bolt	M8 x 1.25	No lube oil	24.4-28.4 (2.49-2.90)
7	Fuel injection pump gear nut	3/4JH4E	No lube oil	78-88 (8-9)
		4JH4-TE 4JH4-HTE	M14 x 1.5 Coat with lube oil	59-69 (6-7)
8	Fuel injection pipe joint nut	M12 x 1.5	No lube oil	29.4-34.4 (3.00-3.51)
9	Heat exchanger set bolt	M8 x 1.25	No lube oil	34.2-40.2 (3.49-4.10)
10	Starter relay terminal nut (Magnetic relay)	M6 x 1.0	No lube oil	3.0-4.2 (0.31-0.43)

14.2 Standard bolts and nuts (without lube oil)

Nm (kgf-m)			
Name	Screw dia. x pitch (mm)	Tightening torque	Remarks
Hexagon bolt with a "7" head and hexagon nut. ("7" mark means JIS strength classification "7T".)	M6 x 1	9.8-11.8 (1.0-1.2)	Apply 80% torque when tightening to aluminum alloy.
	M8 x 1.25	22.5-28.5 (2.3-2.9)	
	M10 x 1.5	44-54 (4.5-5.5)	
	M12 x 1.75	78.2-98.2 (8.0-10.0)	Apply 60% torque to 4T bolts and lock nuts. (4T bolt has no mark on the head.)
PT plug (Taper plug)	1/8	9.8 (1.0)	
	1/4	19.6 (2.0)	
	3/8	29.4 (3.0)	
	1/2	58.8 (6.0)	
Pipe joint bolt	M8	12.7-16.7 (1.3-1.7)	
	M10	19.5-25.5 (2.0-2.6)	
	M12	24.4-34.4 (2.5-3.5)	
	M14	39.1-49.1 (4.0-5.0)	
	M16	48.9-58.9 (5.0-6.0)	

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