CHAPTER 8

FRESH WATER COOLING SYSTEM

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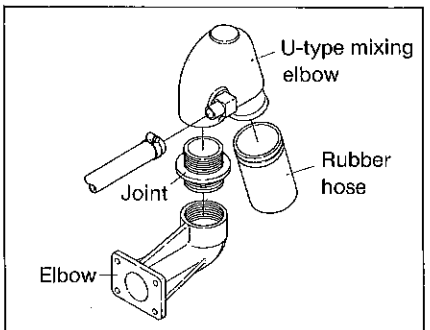
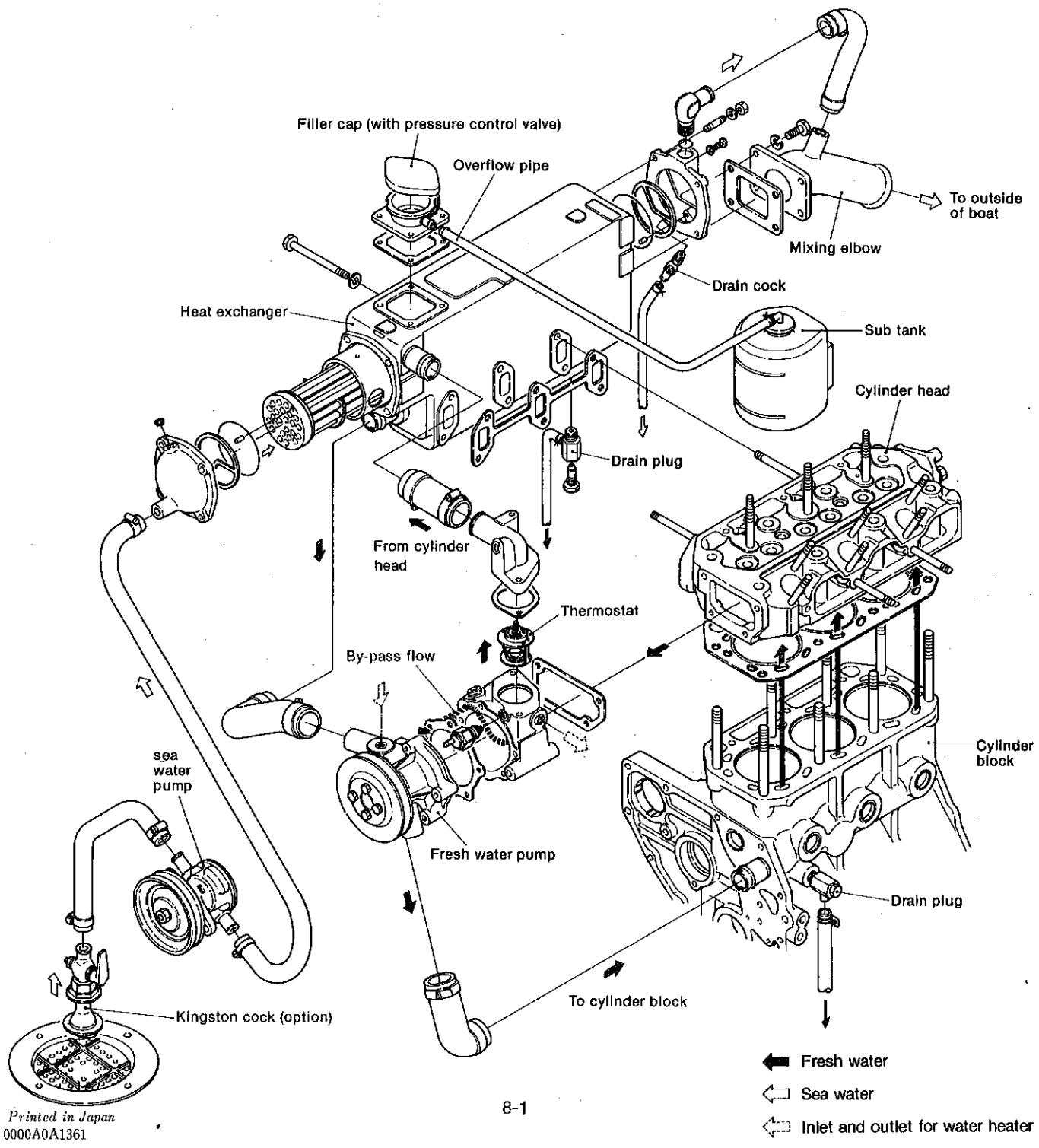
1. Cooling System

1-1. System Diagrams

Models 2GM20F, 3GM30F and 3HM35F are constructed from different parts but use the same water flow. The illustration below is of model 3HM35F.



U-type mixing elbow for option [except 1GM10(C)]



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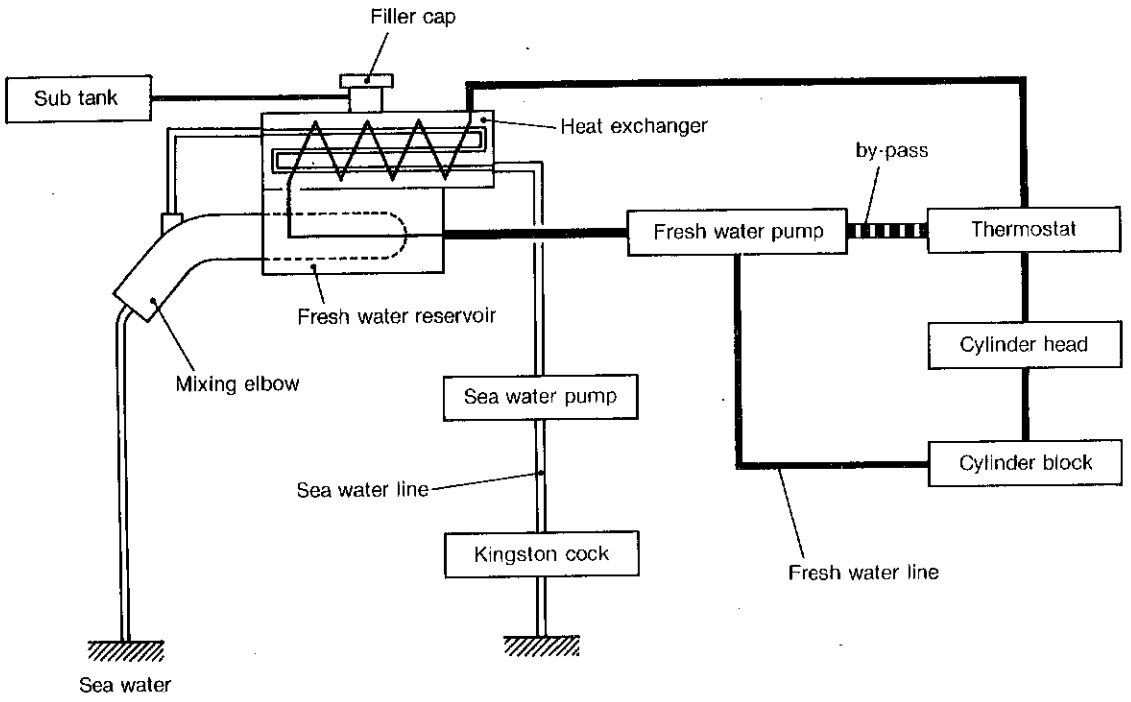
1-2. Cooling system diagram



1-3. Cooling system configuration

With fresh water cooled engines, fresh water from the heat exchanger is circulated around the cylinder block and cylinder head. The fresh water itself is cooled by sea water. The fresh water pump forces the fresh water through the cylinder block and cylinder head cooling passages and back to the heat exchanger. The fresh water is kept in constant circulation.

The thermostat is installed at the cylinder head cooling water outlet (fresh water pump mounting bracket). As the thermostat is closed while the fresh water temperature is low—directly after engine starting or when the engine load is light—fresh water flows through the by-pass passage to the suction side of the fresh water pump, and circulates inside the engine without passing through the heat exchanger.

As the fresh water temperature rises the thermostat is opened and fresh water flows into the heat exchanger. The fresh water is cooled in the heat exchanger by sea water in the tube, so the fresh water temperature is always kept at the proper level by the thermostat.

Sea water is delivered by the sea water pump and fed through tubes located inside the cooling pipe to cool the fresh water.

Sea water flows from the heat exchanger into the mixing elbow, and is discharged with the exhaust gas.

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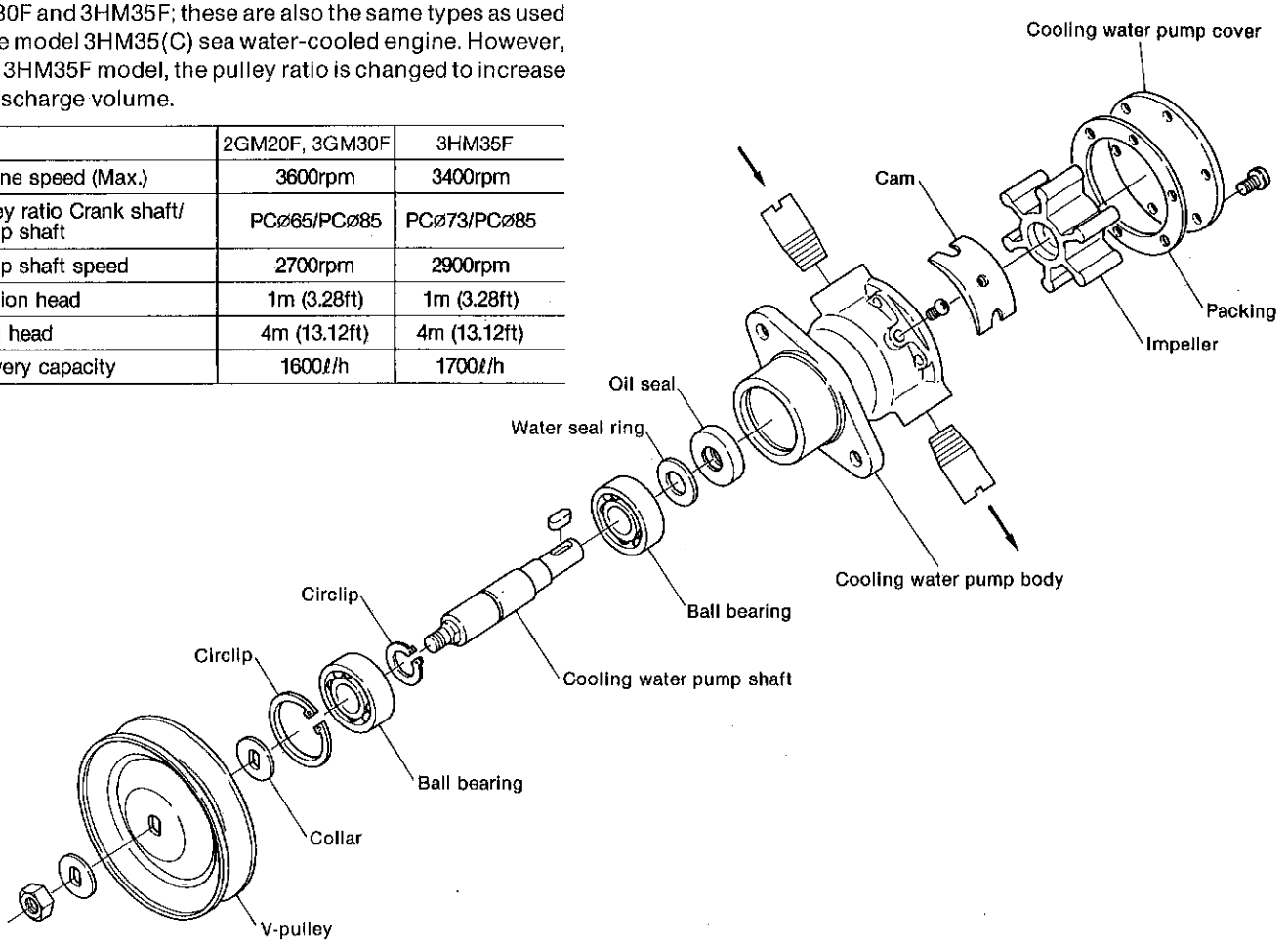
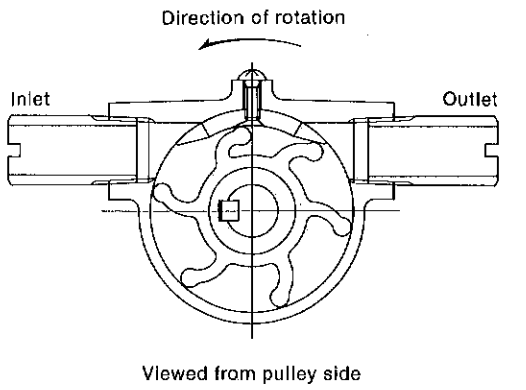
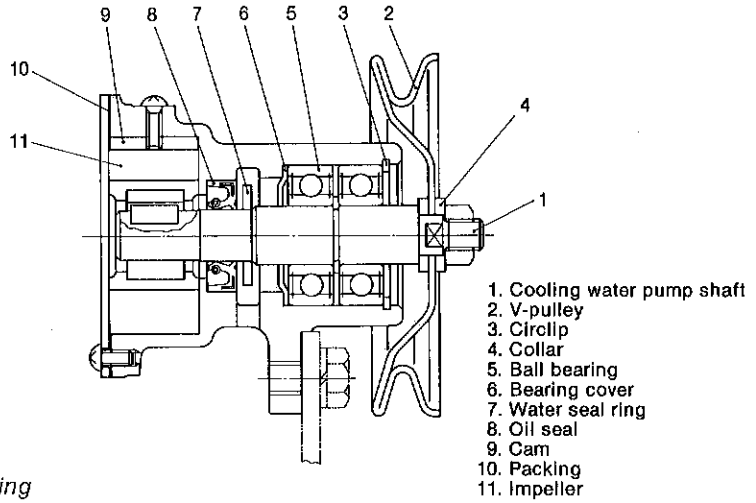
2. Sea Water Pump

The sea water pump used for the fresh water-cooled engine is the rubber impeller pump; it is the same type as used for the sea water-cooled engine.
The same sea water pumps are used for models 2GM20F, 3GM30F and 3HM35F; these are also the same types as used for the model 3HM35(C) sea water-cooled engine. However, in the 3HM35F model, the pulley ratio is changed to increase the discharge volume.

	2GM20F, 3GM30F	3HM35F
Engine speed (Max.)	3600rpm	3400rpm
Pulley ratio Crank shaft/ Pump shaft	PCø65/PCø85	PCø73/PCø85
Pump shaft speed	2700rpm	2900rpm
Suction head	1m (3.28ft)	1m (3.28ft)
Total head	4m (13.12ft)	4m (13.12ft)
Delivery capacity	1600ℓ/h	1700ℓ/h







1. Cooling water pump shaft
2. V-pulley
3. Circlip
4. Collar
5. Ball bearing
6. Bearing cover
7. Water seal ring
8. Oil seal
9. Cam
10. Packing
11. Impeller

NOTE: For details on disassembly and reassembly, handling precautions and inspection, refer to "Chapter 7, Section 2. Water pump (P.7-5)".

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3. Fresh Water Pump

3-1. Pump construction

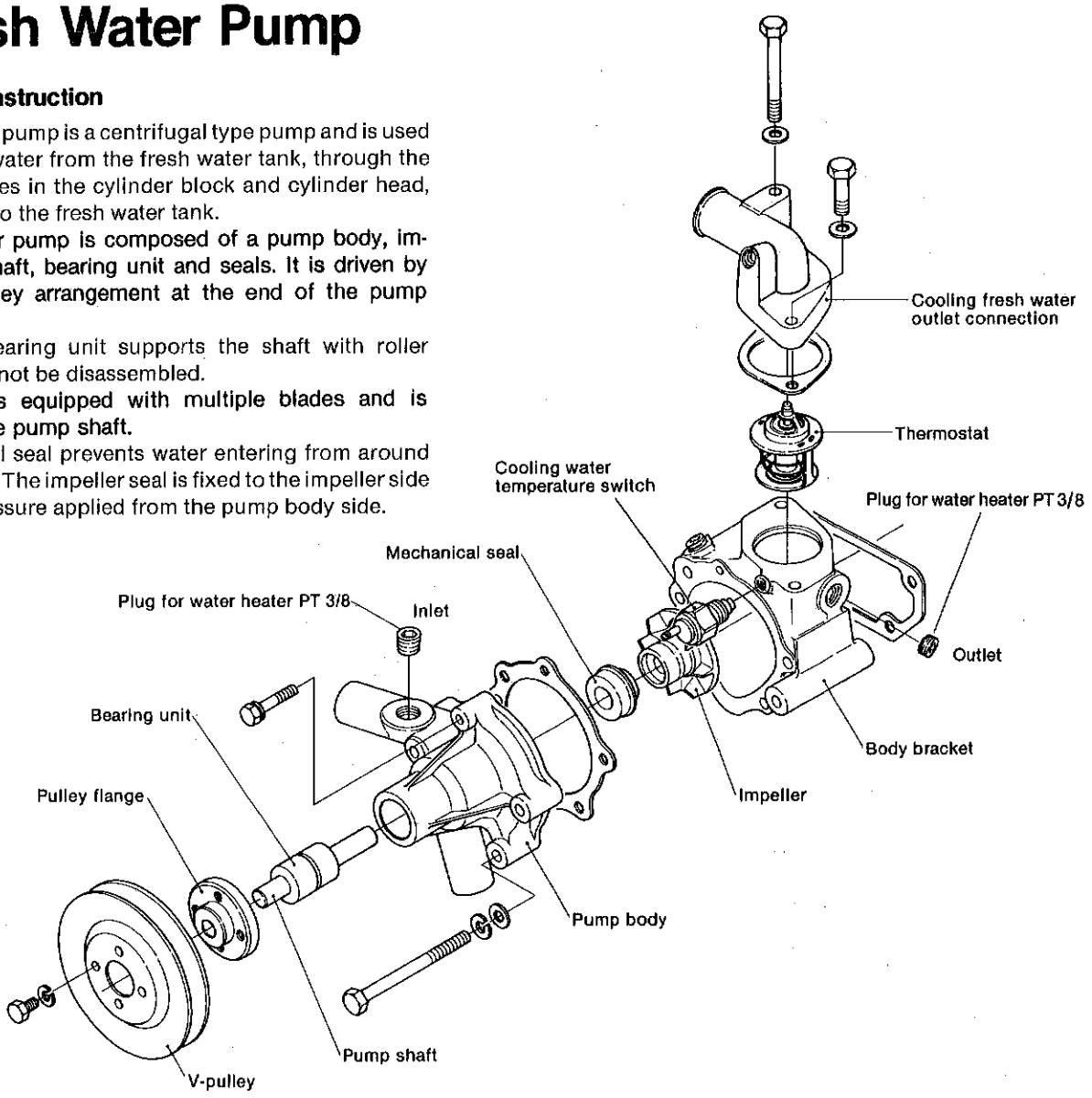
The fresh water pump is a centrifugal type pump and is used to move fresh water from the fresh water tank, through the cooling passages in the cylinder block and cylinder head, and then back to the fresh water tank.

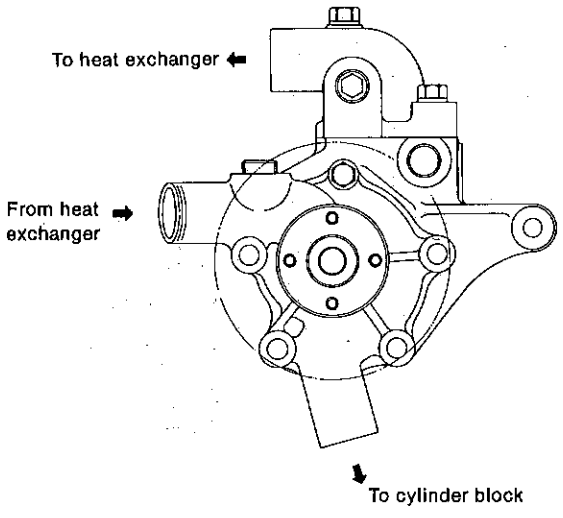
The fresh water pump is composed of a pump body, impeller, pump shaft, bearing unit and seals. It is driven by a belt and pulley arrangement at the end of the pump shaft.

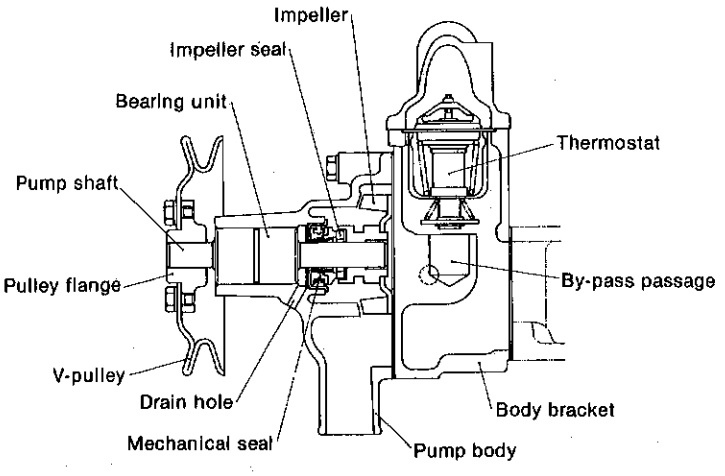
The packed bearing unit supports the shaft with roller bearings. It cannot be disassembled.

The impeller is equipped with multiple blades and is mounted on the pump shaft.

The mechanical seal prevents water entering from around the pump shaft. The impeller seal is fixed to the impeller side with spring pressure applied from the pump body side.







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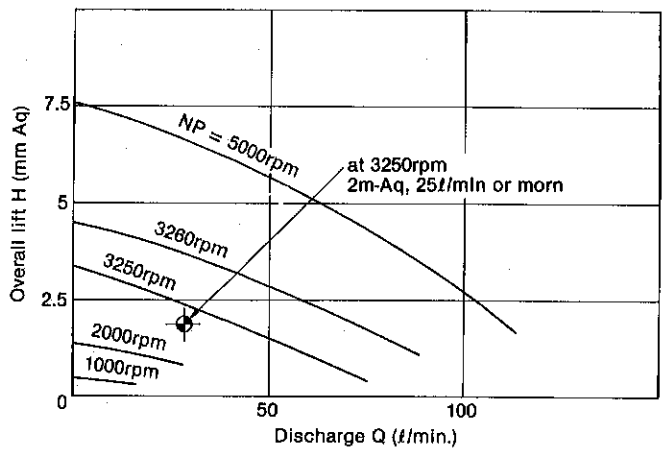
3-2. Pump capacity and characteristic

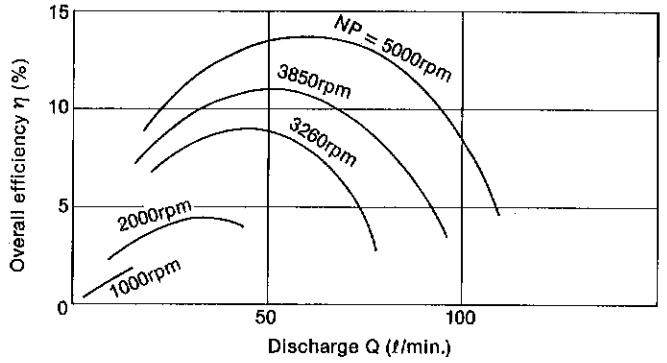
	2GM20F,3GM30F	3HM35F
Crank shaft speed	3600rpm	3400rpm
Pulley ratio Crankshaft/ Pump shaft	PCø127/PCø103	PCø138/PCø103
Pump shaft speed	4400rpm	4500rpm
Delivery capacity	4000ℓ/h	4200ℓ/h
Total head	3m (9.84ft)	3m (9.84ft)

NOTE: The same type of fresh water pump is used for models 2GM20F, 3GM30F and 3HM35F.

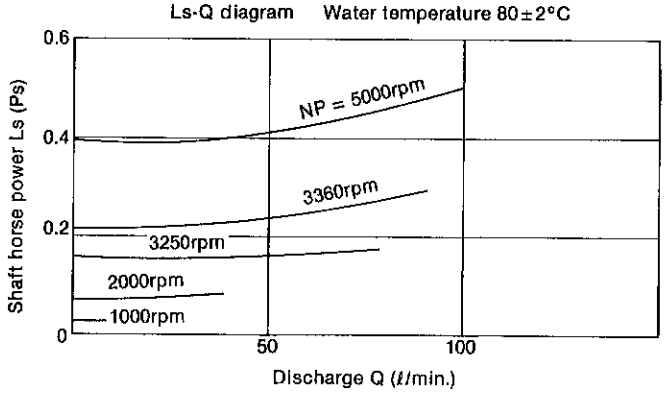
H-Q diagram Water temperature 80±2°C



η-Q diagram Water temperature 80±2°C



Ls-Q diagram Water temperature 80±2°C

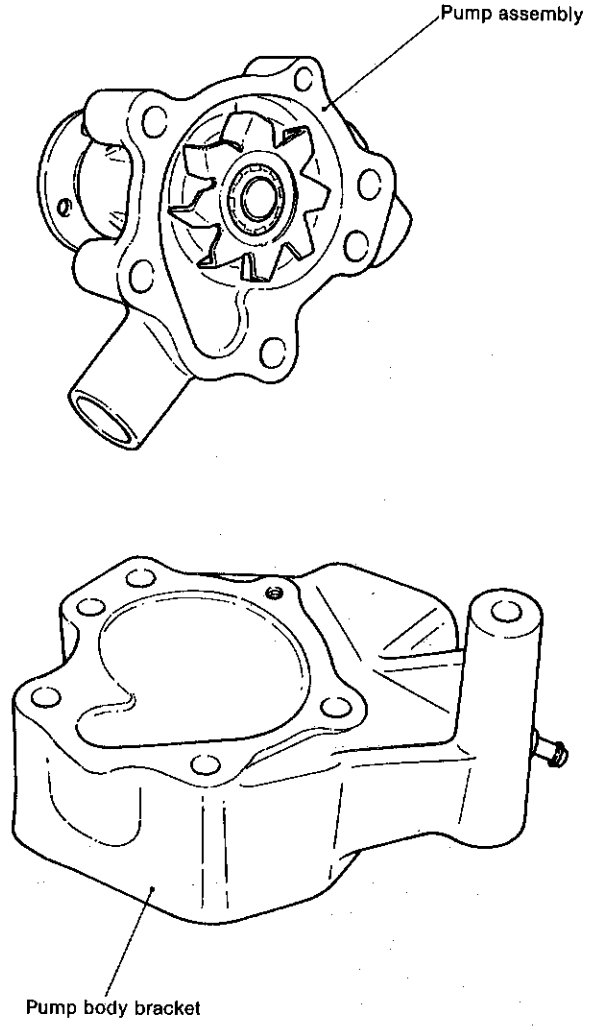


3-3. Pump disassembly

Disassembly of the fresh water pump is difficult and should not be attempted. Faulty units should be replaced. The pump assembly should not be disassembled from the pump body brackets, unless absolutely necessary.

kg•cm (ft•lb)

Tightening torque for pump setting bolts	40—80 (2.89 ~ 5.79)



3-4. Inspection and measurement

(1) Confirm smooth rotation by rotating the impeller by hand.
When the rotation is not smooth, due to bearing play or friction, or abnormal noise is heard, replace the entire pump assembly.

(2) Impeller inspection
Check impeller for damage, corrosion and water. Replace if required.

(3) Check the holes drilled in the cooling water passage or by-pass passage, and clean or unblock where necessary.

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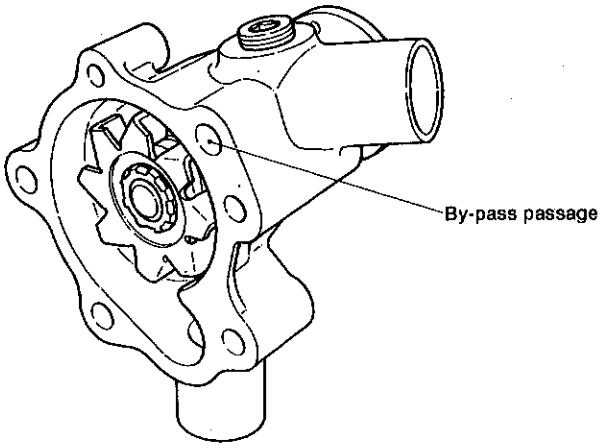
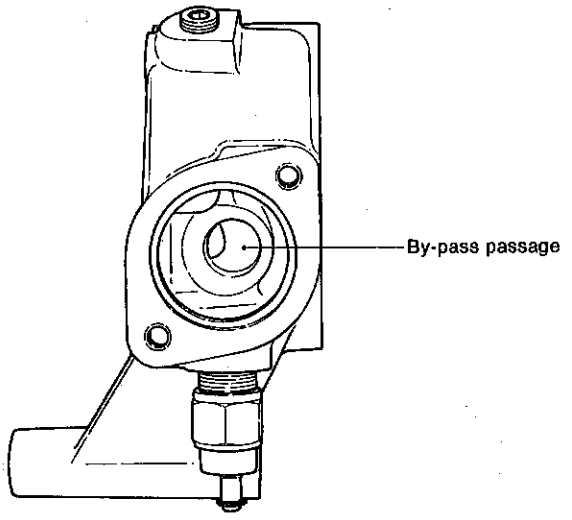
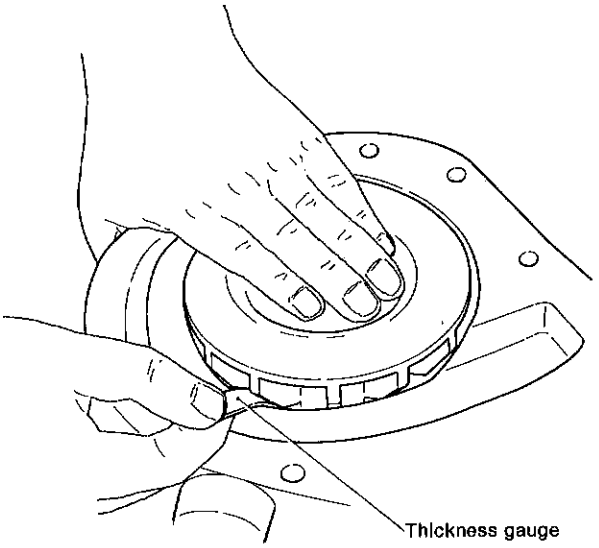
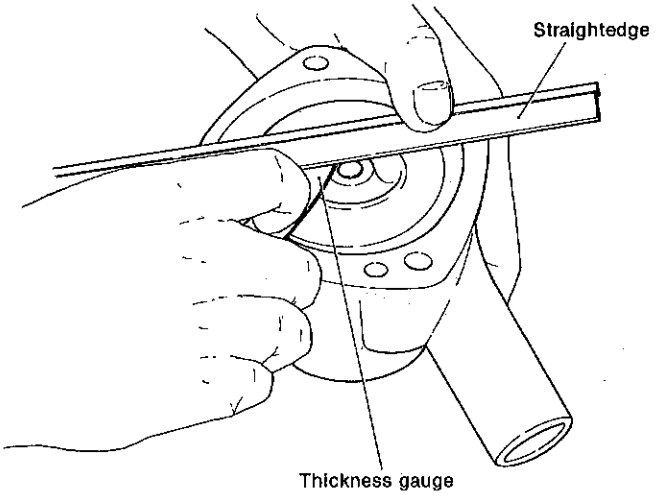




Measuring clearance between impeller and pump body



Measuring clearance between impeller and pump body bracket



(4) Where water leakage is heavy, due to wear or a damaged mechanical seal and impeller seal, replace the pump assembly with a new one.

(5) Pump body and pump bracket inspection
Clean deposits and rust from body and bracket. Replace if heavily worn or corroded.

(6) Impeller clearances.

mm (in)

	Maintenance standard
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)
Clearance between impeller and bracket	0.5 (0.0197)

To measure clearance between impeller and body, insert a thickness gauge between the two parts at an oblique angle between the two parts.

To measure clearance between impeller and bracket, place a straightedge on the pump body surface and insert a thickness gauge between the straightedge and impeller.

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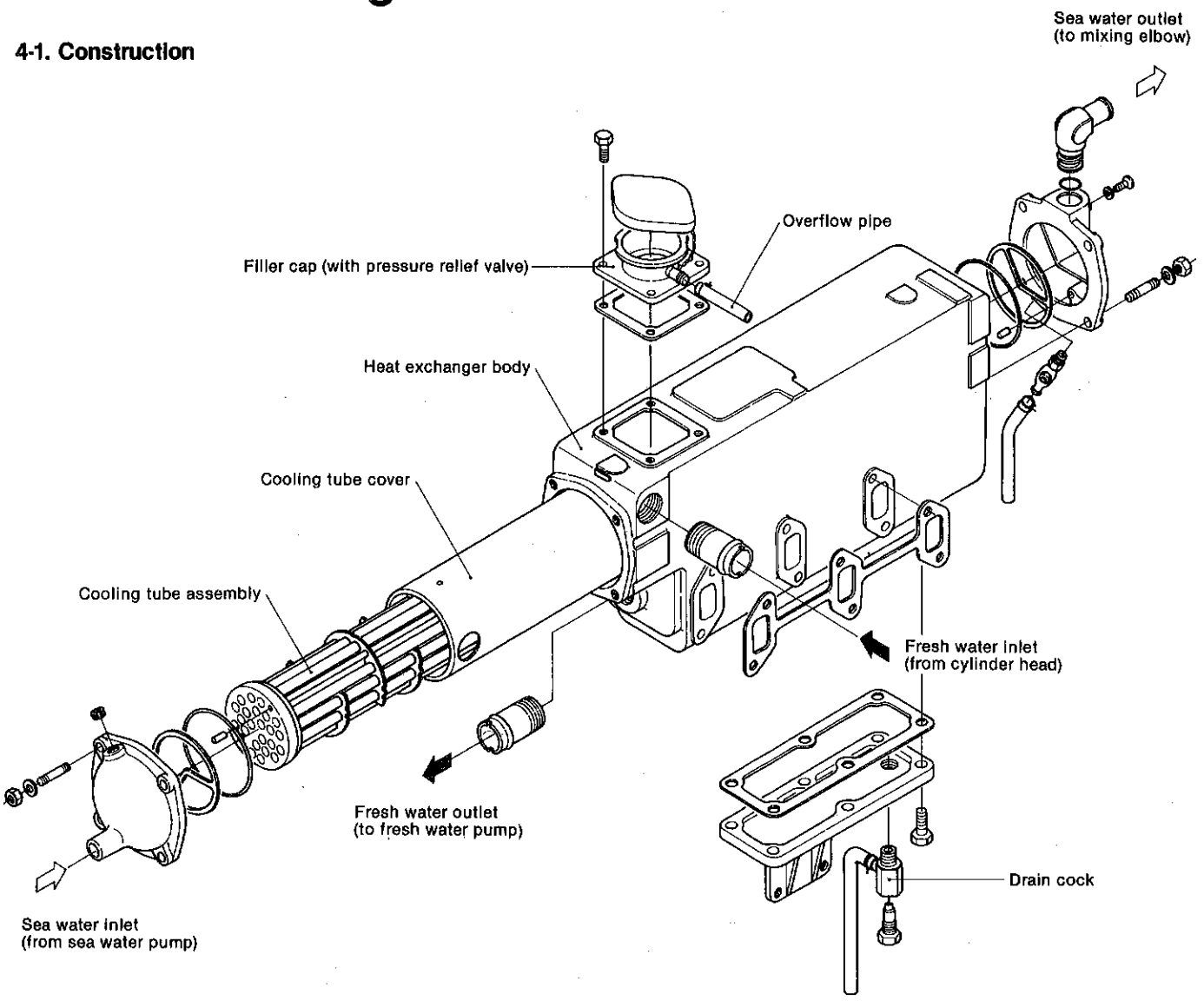
4. Heat Exchanger

4-1. Construction



The heat exchanger uses sea water to cool the fresh water, which has reached a high temperature, while being circulated in the cylinder block.

The heat exchanger is a cooling tube which consists of 24 slender tubes and baffle plates, and a cooling tube cover. Sea water passes through the slender tubes, and fresh water passes through the flow path formed between the tubes and baffle plates inside the cooling tube cover.

The lower part of the heat exchanger stores the fresh water, acting as a fresh water tank. An exhaust gas passage, leading out of the storage position, is integrated with the water-cooled exhaust manifold.

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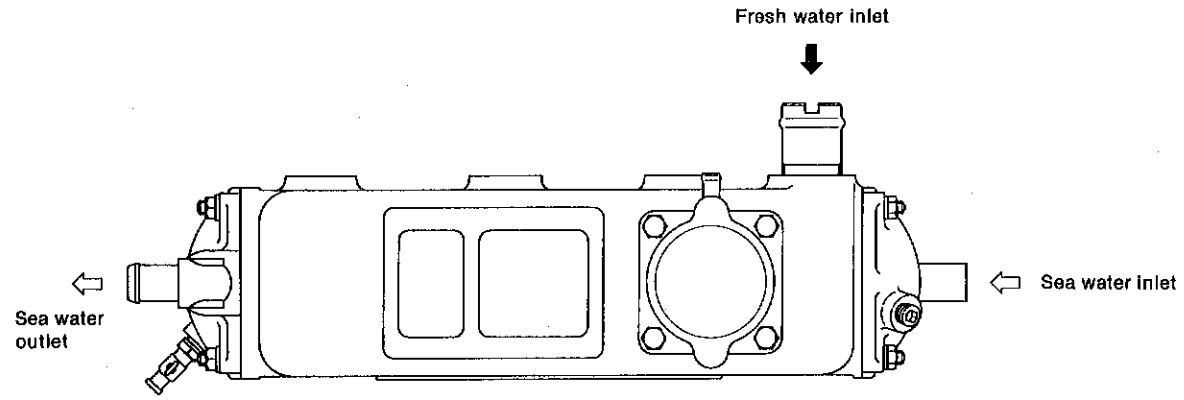
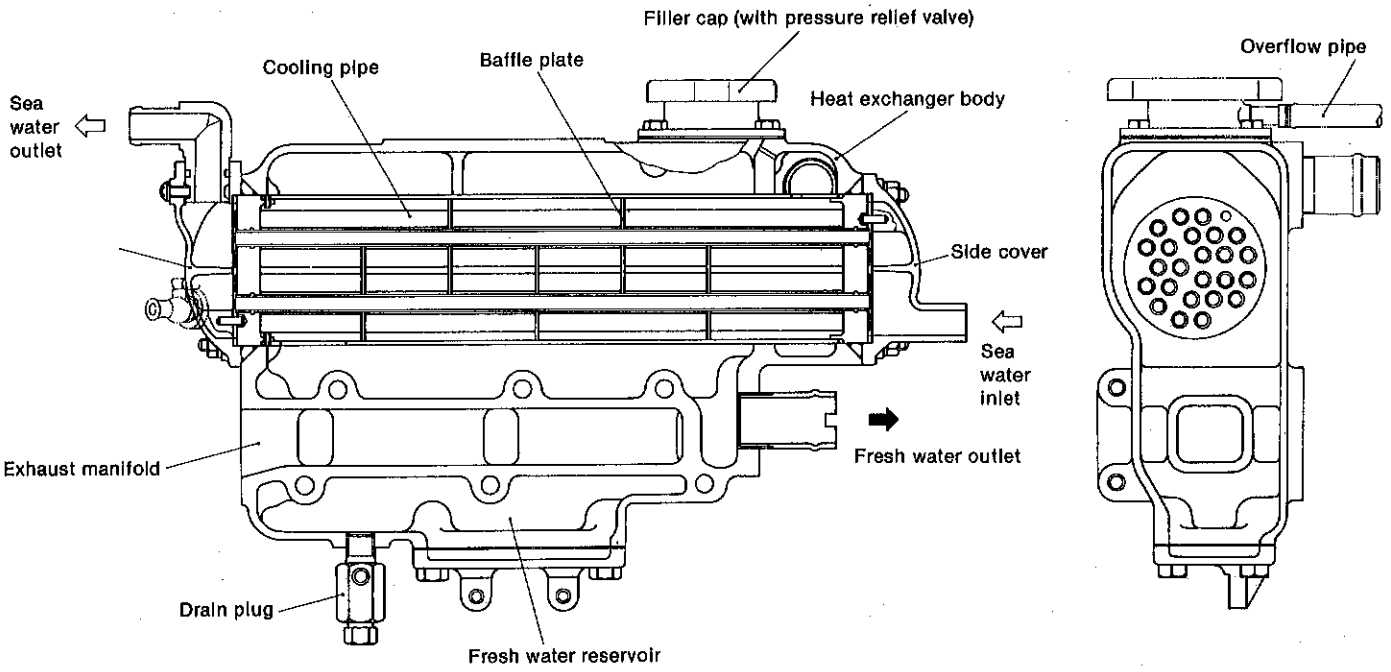
The filler cap on top of the heat exchanger is equipped with a pressure relief valve. When pressure exceeds the specified limit, this valve opens to release pressure through the overflow pipe.

On the other hand, when the cooling system pressure becomes negative in relation to the atmospheric pressure, air enters from the overflow pipe.





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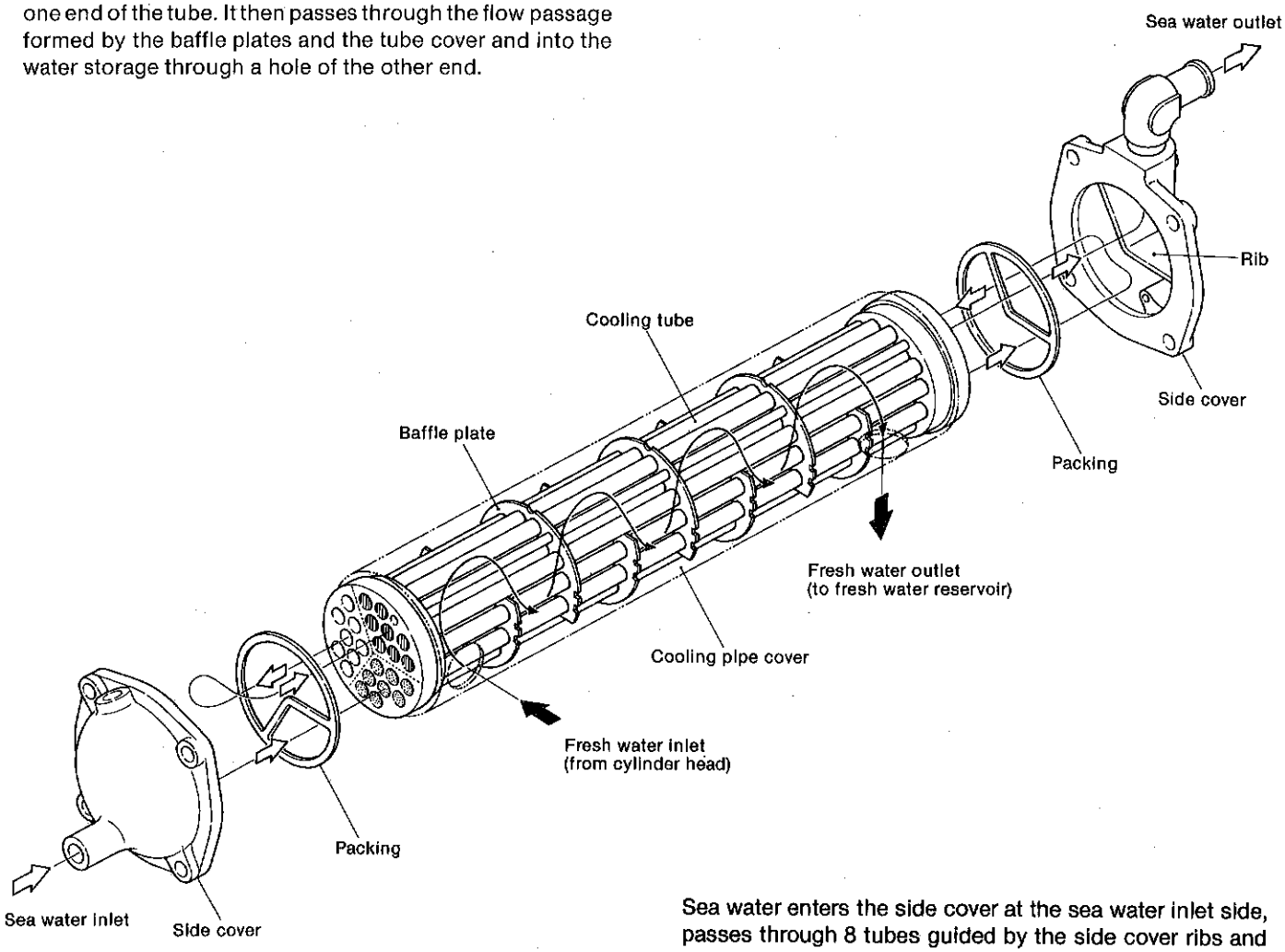
4-2. Water flow in water cooling tube

Fresh water enters the cooling tube from a hole drilled at one end of the tube. It then passes through the flow passage formed by the baffle plates and the tube cover and into the water storage through a hole of the other end.



Sea water enters the side cover at the sea water inlet side, passes through 8 tubes guided by the side cover ribs and then leaves the side cover at the sea water outlet side. Here it passes through another 8 tubes guided by the side cover ribs, and returns to the side cover at the inlet side.
At the inlet side, it is guided by the remaining 8 tubes as at the outlet side, and then flows out to the mixing elbow from the outlet connection via the side cover at the outlet side.

4-3. Specifications

Model of engine		2GM20F	3GM30F	3HM35F
Output (DIN 6270 B rating)	HP/rpm	18/3600	27/3600	34/3400
Pipe dia. X pieces	mm	ø6/ø8 × 24	ø6/ø8 × 24	ø6/ø8 × 24
Radiation area	m^2	0.119	0.163	0.208
Radiation area/HP	m^2/HP	0.0066	0.0060	0.0061
Fresh water capacity	ℓ (cu. in)	2.9 (177.0)	3.4 (207.5)	4.9 (299.0)

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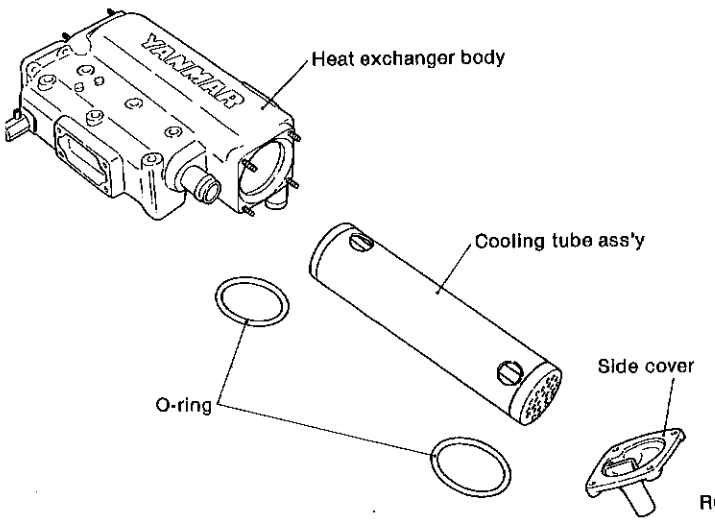
4-4. Disassembly

(1) Remove the side covers and pull out the cooling pipe and rubber packings.

NOTE: After the cooling pipe is removed, always replace the rubber packings on both side covers.

(2) Remove filler cap and port.

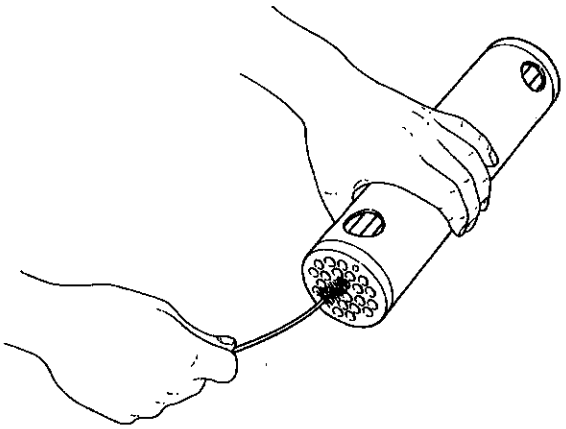
(3) Remove lower cover and packing.



4-5. Inspection and cleaning

4-5.1 Cooling pipe

(1) Inspect for dirt and deposits in the tubes. Clean as required.



(2) Inspect caulked portions of tubes and flanges for damage. Repair or replace as required.

(3) Inspect the cooling pipe and tubes for leaks. Repair as required.

(4) Check for clogged water passages. Clean as required.

4-5.2 Heat exchanger body

(1) Check for dirt and corrosion build-up inside body and on side covers. Replace if corroded, broken or otherwise damaged.

(2) Check joints at sea water inlet and outlet ports and fresh water inlet and outlet ports. Retighten any loose screws and clean pipes as required.

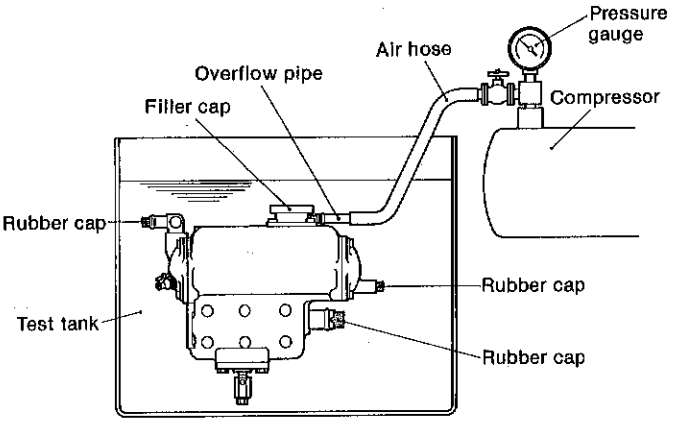
(3) Check drain cock for clogging. If clogged, clean or repair as required. Retighten screws if necessary.

(4) For inspection of filler cap, anticorrosion zinc, and thermostat, see below.

4-5.3 Leakage test

(1) Test with compressed air and test tank. Seal fresh and sea water ports with rubber caps and immerse tank in a test tank filled with water. Inject compressed air through the overflow pipe and check for air bubbles.

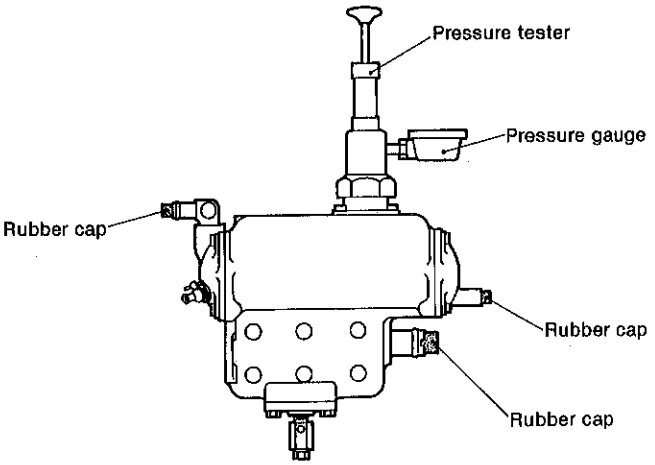
NOTE: Air pressure should be 0.5 ~ 2.0kg/cm² (7.11 ~ 28.45 lb/in²).



Leakage test using compressed air and test tank

(2) Test using pressure tester

Seal fresh and sea water ports with rubber caps and fill the tank completely with water. Replace the filter cap with a pressure tester and pressurize the tank. If there is a leak, the tank cannot be pressurized or it will only be able to retain pressure for a short time.



Leakage test using a pressure tester

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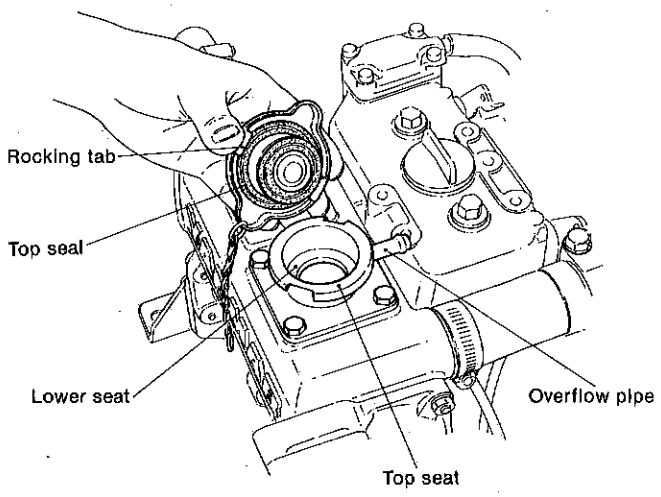
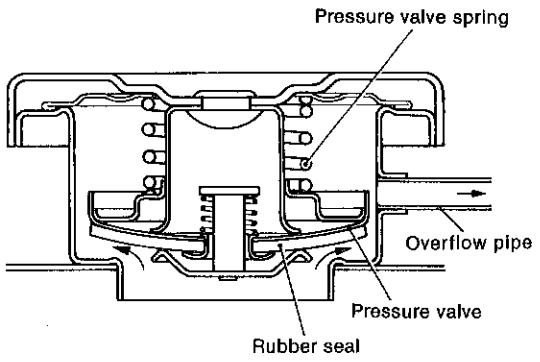
5. Filler Cap and Subtank

5-1. Filler cap construction

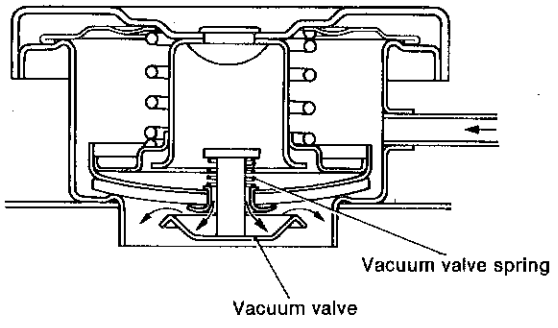
The filler cap is placed on the fresh water inlet port and is equipped with a pressure control valve.
To attach, place the rocking tab (extension on the attachment section) on the flyneck cam. Then, turn and tighten.
The top seal touches the flyneck tap seat while the pressure valve touches the lower seat.



5-2. Filler cap pressure control



Pressure valve operation



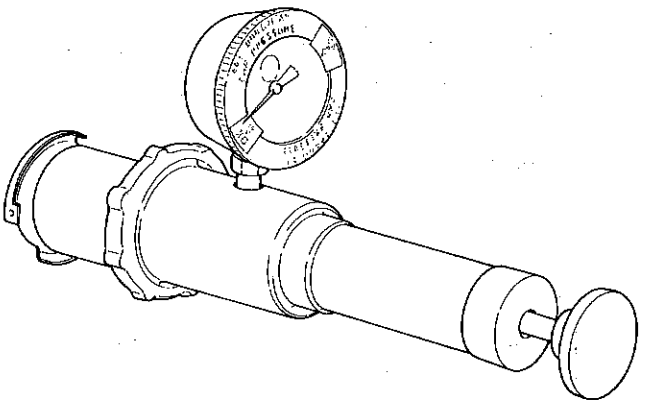
Vacuum valve operation

When the cooling system pressure is within the specified range 0.9kg/cm^2 (12.80 lb/in^2), the pressure valve and vacuum valve are tightly closed on their valve seats. When pressure rises, the pressure valve opens and vapor is discharged from the overflow pipe. When the water cools down and the pressure in the system is lower than atmospheric pressure, the vacuum valve opens and air enters the system through the overflow pipe.
To prevent the pressure valve from opening and resulting water loss, the cooling system can be equipped with a subtank, described below.
Action of Pressure control Valve

Pressure Valve	Opens at 0.9 kg/cm^{2}G (12.80 lb/in^2)
Vacuum Valve	Opens at 0.05 kg/cm^{2}G (0.71 lb/in^2) or below

5-3. Filler cap inspection

(1) Remove all deposits and rust, check for damage and wear on the seat contacting surfaces, and check spring for proper functioning. Repair or replace as required.
(2) Tester inspection
Attach adaptor and filler cap to tester.
Increase pressure and if pressure remains constant for six seconds, the cap is normal. If pressure does not increase or does not remain constant for six seconds, check for defects. Repair or replace as required.



5-4. Subtank function

When the cooling system pressure rises above 0.9kg/cm^2 (12.80 lb/in^2.), the pressure valve opens and vapor is released, reducing the amount of water in the cooling system. The subtank collects this vapor where it condenses. Then, when cooling system pressure falls below atmospheric pressure, the water in the subtank is siphoned back to the main tank.
Use of a subtank is highly recommended, since this allows the engine to be run for longer periods between water replenishment, and the need to open the filler cap is eliminated, thereby removing one possible cause of accidents.

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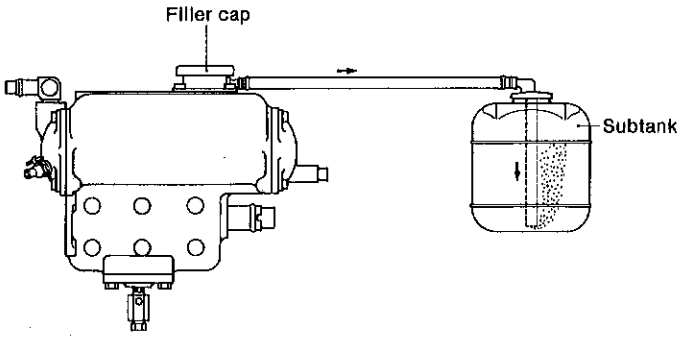
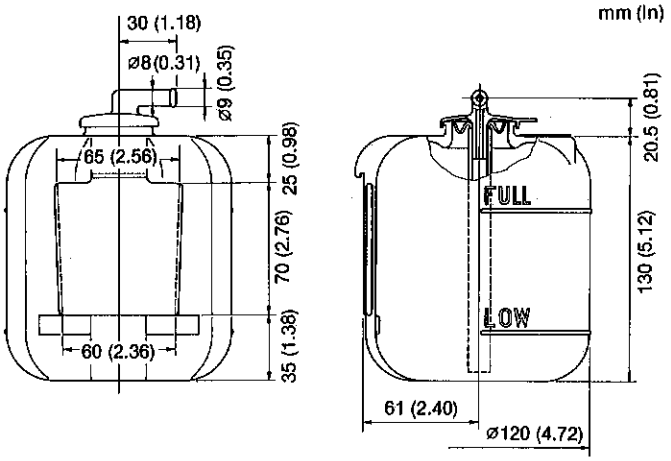
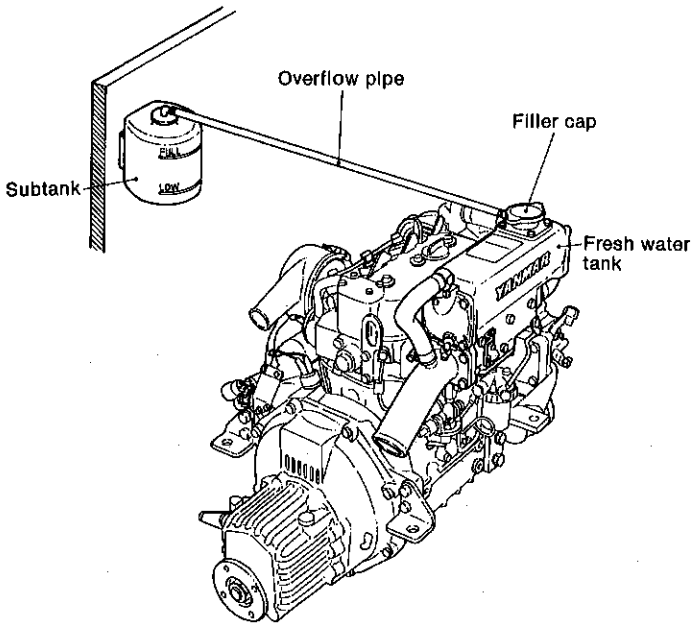


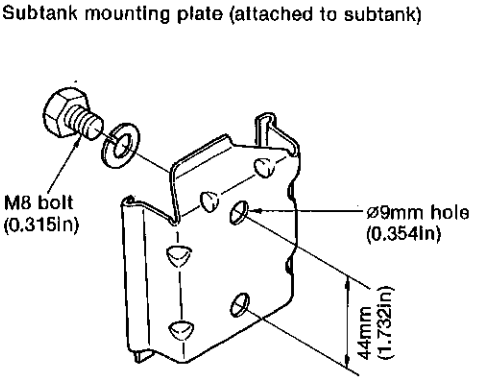


ℓ (cu. In)

Subtank capacity	Over all capacity	1.25 (76.28)
	Full scale position Low scale position	about 0.8 (48.82) about 0.2 (12.20)
Part No.	120445-44530	

5-5. Installation of subtank





(1) Mount the subtank at the same height as the fresh water tank.
(2) Ensure that the length of the overflow pipe is no more than 1m (39.37 in.), and that it does not break.

NOTE: If a subtank is not used, be careful not to immerse the overflow pipe in the bilge, since this can cause bilge water to be siphoned into the cooling system.

5-6. Maintenance during use

(1) Check that when the cooling water is cold the level is within the specified range.
(2) Check that the overflow pipe is not broken, and also that the holes are not blocked up.

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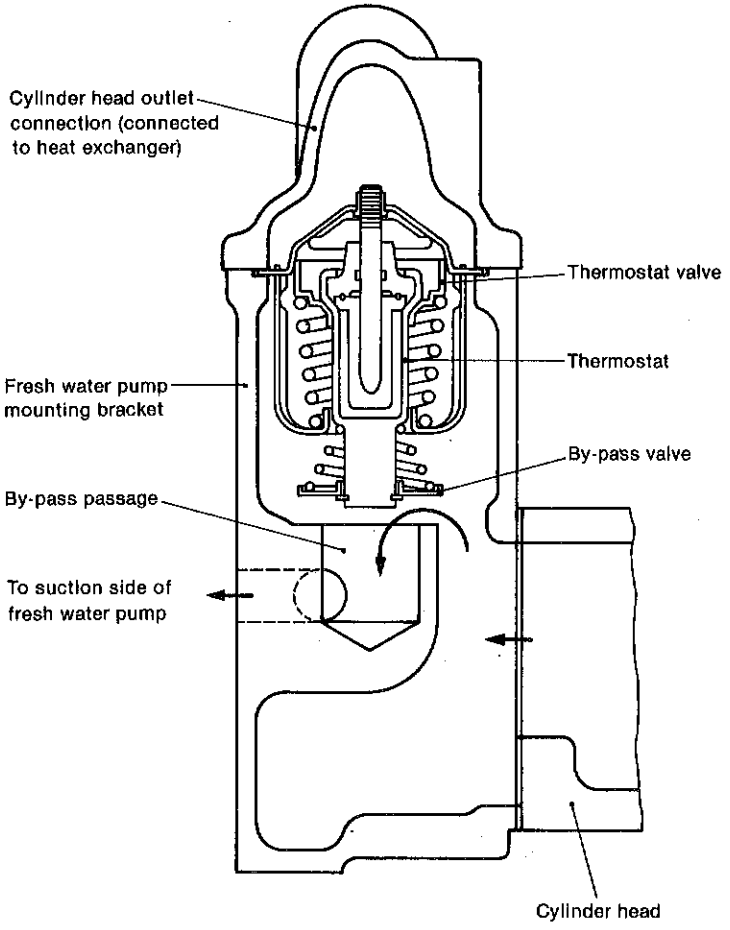
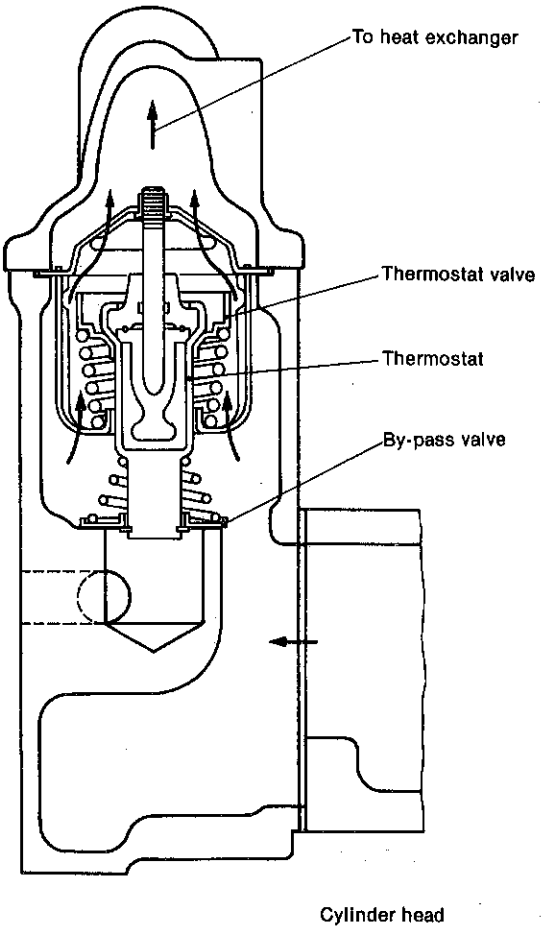
6. Thermostat

6-1. Operation



When valve is closed (by-pass passage is opened)



When valve is opened (by-pass passage is closed)

The thermostat opens and closes the by-pass valve and thermostat valve according to the temperature changes of the fresh water in the engine, adjusts the flow of fresh water to the heat exchanger and keeps the fresh water temperature in the engine at the correct level.

The thermostat in the fresh water-cooled engine is a bottom-by-pass type, as shown in the figure, and is installed inside the fresh water pump bracket which combines with the cylinder head cooling water outlet passage.

The thermostat valve is closed while the fresh water temperature is low, and fresh water is fed to the fresh water pump inlet through the drilled hole in the by-pass passage, to be circulated inside the engine.

When the fresh water temperature rises over the valve opening temperature, the thermostat valve opens, and fresh water is fed to the heat exchanger and where it is cooled and then fed to the fresh water pump. With the thermostat valve open, the by-pass passage is throttled. The by-pass passage is completely closed as the temperature rises.

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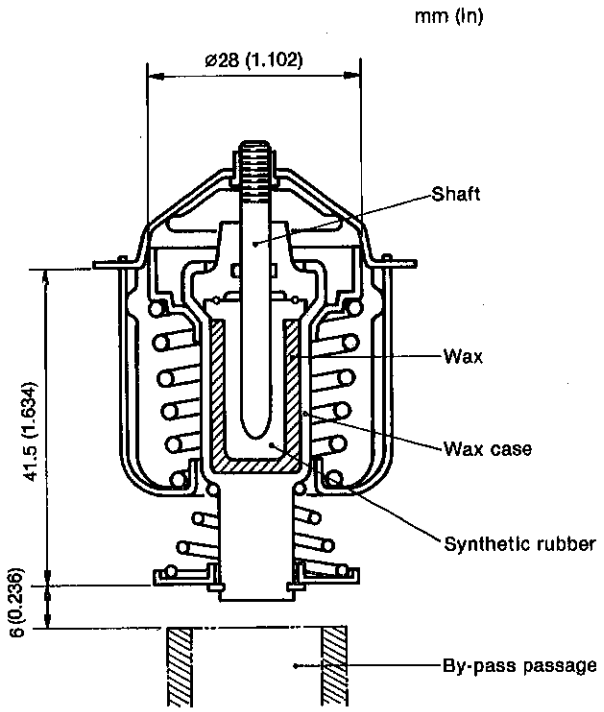
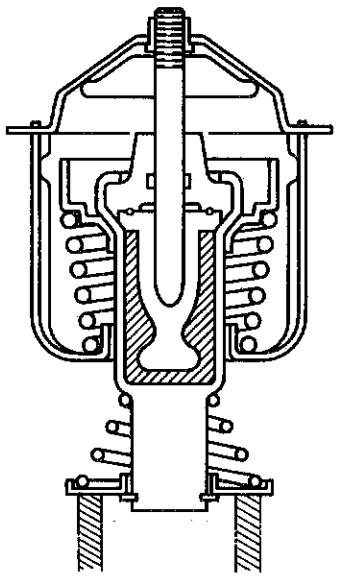
6-2. Construction

A wax-pellet type thermostat is used for this engine. The "wax-pellet" type is the description given to a quantity of wax in the shape of a small pellet. When the temperature of the cooling water rises, the wax melts and its volume expands. The valve is opened or closed by these variations in volume.



When valve is closed

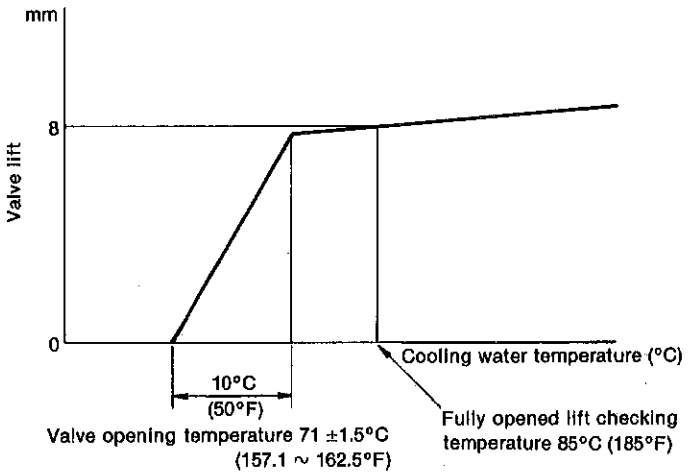


When valve is opened

Thermostat operating temperature °C (°F)

Opening temperature	71° (159.8)
Full open temperature (Temperature corresponding to 8mm or more valve lift)	85° (185)

Characteristic of Thermostat



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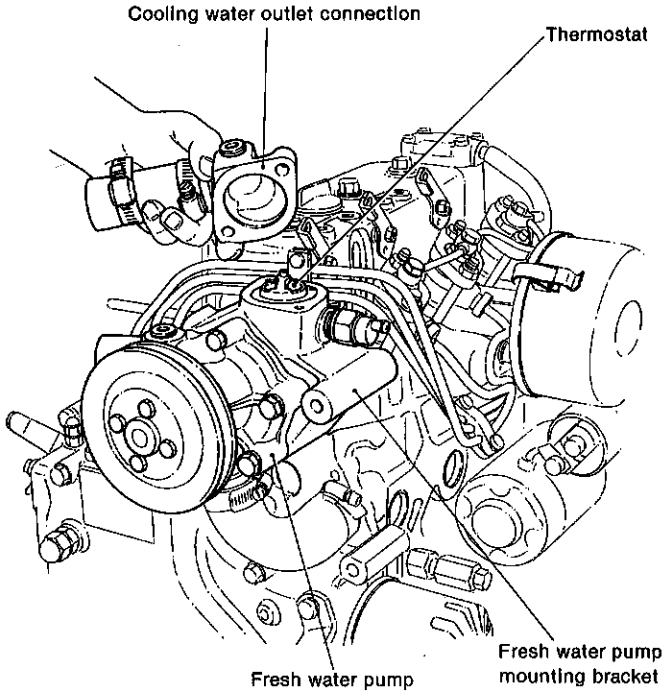
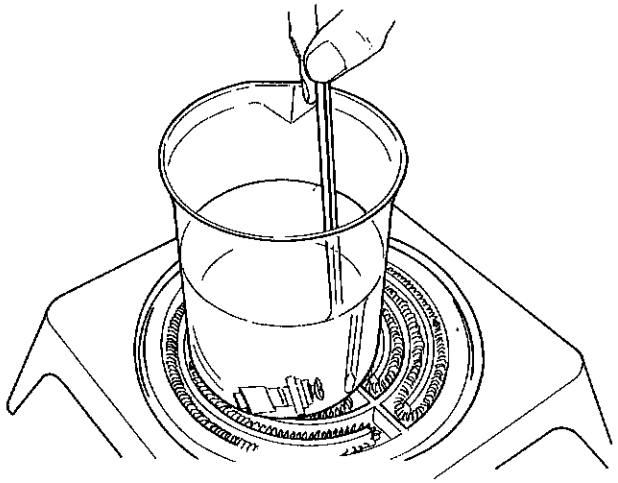
6-3. Inspection

(1) Remove the cooling water outlet connection at the top of the fresh water pump mounting bracket and take out the thermostat.
Remove all deposits and rust, check functioning and inspect parts. Replace if performance has deteriorated or if the spring or other parts are excessively corroded, deformed or otherwise unsuitable.



(2) Testing the thermostat
Place the thermostat in a container filled with water. Heat the container with an electric heater. If the thermostat valve begins to open when the water temperature reaches about 71°C and becomes fully open at 85°C, the thermostat may be considered all right. If its behaviour differs much from the above, or if it is found to be broken, replace it.



(3) In general, inspect the thermostat after every 500 hours of operation. However, always inspect it when the cooling water temperature has risen abnormally and when white smoke is emitted for a long period of time after the engine starts.
(4) Replace the thermostat when it has been in use for a year, or after every 2000 hours of operation.

Part No. code of thermostat	121750-49800

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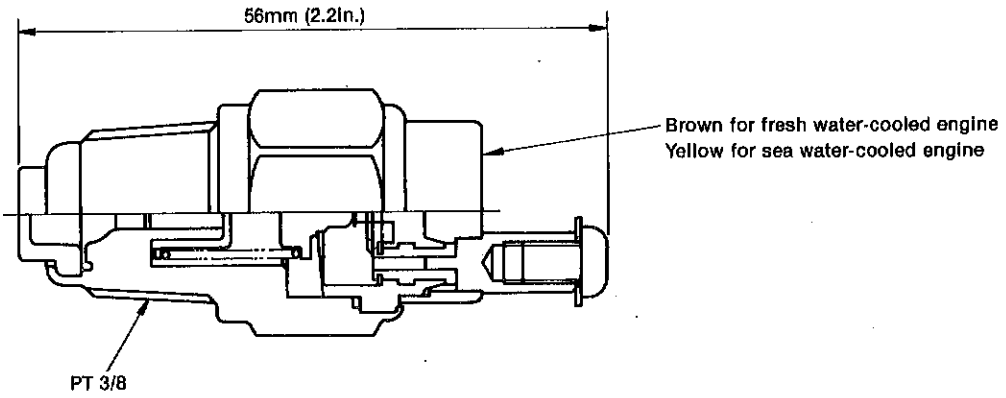
7. Cooling Water Temperature Switch

The cooling water temperature switch is identical to that for the sea water-cooled engine in shape and dimension, but care must be taken when parts are replaced as the operating temperature is different.
This can be checked by the seal color.



Operating temperature		Current capacity	Response time	Indication color	Parts code
ON	OFF				
95°C(202~193°F)	88°C(187°F) or higher	DC 12V 1A	Within 60 sec.	Green	127610-91350

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8. Precautions

8-1. Ventilator

The surface temperature of fresh water cooled engines is higher than sea water cooled engines. Therefore, if the engine room is not well ventilated, engine room temperatures can rise to a point where they will adversely influence engine performance.

8-2. Cooling water

(1) Fresh water

Use clean soft water as cooling water. Hard water will cause calcium build-up, poor heat transmission and a drop in the cooling affect, resulting in overheating.

(2) Fresh water tank capacity

ℓ (cu. in)

Model	Capacity
2GM20F	2.9 (177.0)
3GM30F	3.4 (207.5)
3HM35F	4.9 (299.0)

Remove the cap from the fresh water cooler, and check the water level. If the water level is below the top of the cooling pipe, add clean soft water up to the iron plate at the bottom of the filler.

If water is added up to the mouth of the fresh water tank, about 50cc of water will overflow from the filler immediately after the engine is started. This is normal, and is caused by the increase in the volume of the water as its temperature rises. If the water filler cap is removed after the engine has been stopped and allowed to cool, the water level will be 2—3cm from the top of the filler. This is also normal, and is caused by the overflow of the unnecessary water as the temperature of the water rises.

(3) Cooling water (fresh water) level check

Check the level of the cooling water (fresh water) before daily operation. A low cooling water level can cause insufficient pump discharge and the accumulation of scale in the heat exchanger.

(4) Cooling water leakage check during operation

Although checking for water and oil leakage during operation is generally necessary, check for fresh water leakage with special care.

Fresh water leakage is directly related to seizing of the engine.

(5) Fresh water replacement

Replace water every 500 hours. Always use an anti-rust agent.

To drain the water, open the cooling water drain cock and remove the water filler cap. If the filler cap is not removed, a vacuum will be created in the water jacket and not all the water will be drained.

(6) Removing the filler cap

Do not attempt to remove the water filler cap at the top of the fresh water tank while the engine is running, or while the engine is still hot after it has been stopped; steam will escape and may cause serious injury. If removal of the filler cap is unavoidable, place a piece of cloth over the cap and turn the cap slowly, making sure you are in a safe position even if steam escapes.

8-3. Antifreeze

(1) Use permanent type antifreeze in the winter. Freezing of the fresh water will damage the heat exchanger, cylinder head and water jacket.

(2) Antifreeze use

1) Before adding antifreeze, clean the cooling system and check for leaks.

2) Select mixing ratio according to the following table.

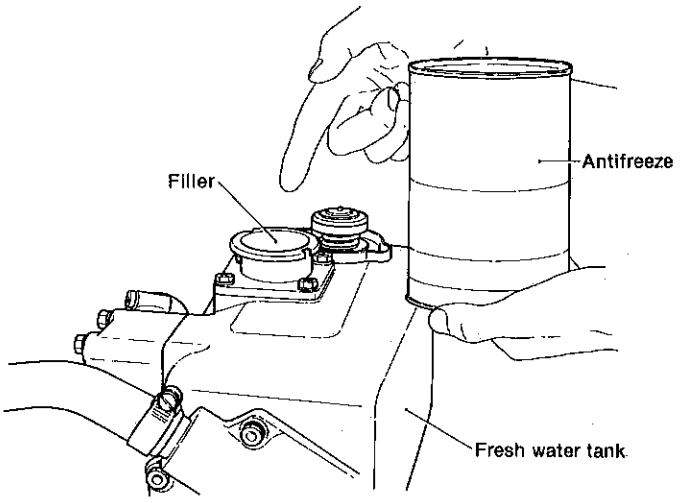
ℓ (cu. in)

Temperature	−5°C	−10°C	−15°C	−20°C	−25°C	−30°C
Mixing ratio	12%	22%	29%	35%	40%	44%
2GM20F	0.35 21.40	0.64 39.10	0.84 51.30	1.02 62.20	1.16 70.80	1.28 78.10
3GM30F	0.41 25.00	0.75 45.80	0.99 60.40	1.19 72.60	1.36 83.00	1.50 91.50
3HM35F	0.59 36.00	1.08 65.90	1.42 86.70	1.72 105.00	1.96 119.60	2.21 129.40

NOTE: The temperature selected in the above table should be 5°C lower than the lowest expected temperature in the area.

NOTE: Check the mixing ratio carefully, especially when using premixed coolant.

3) Tighten the drain cock and fill the cooling system. Then, run the engine for approx. 5 to 30 minutes to make sure the solution is well mixed.



NOTE: Some antifreeze solutions will corrode aluminum. Check carefully before use.

NOTE: When antifreeze protection is no longer necessary, drain water, flush cooling system and refill with fresh water.

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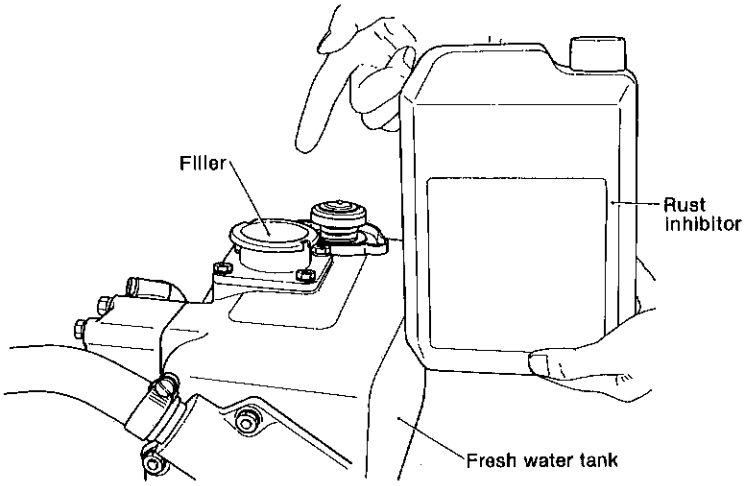
8-4. Rust inhibitor

When the fresh water is changed, a rust inhibitor must be added to the new water to prevent rusting.

Rust inhibitor : Fresh water = 1 : 10

Flush cooling system with fresh water, fill with proper rust inhibitor and then top-up cooling system with fresh water.



8-5. Idling the engine when stopping

Always idle the engine for ten minutes immediately after starting and prior to stopping. Be sure to idle the engine adequately, especially before stopping. Stop the engine only after its temperature has dropped sufficiently. If the engine is stopped while hot, the hot fresh water will cause the temperature of the water in the heat exchanger pipe to rise, causing a build-up of calcium deposits in the pipe and a drop in the cooling affect.

8-6. Cleaning the heat exchanger tube

If the heat exchanger tube through which the fresh water flows becomes extremely dirty, the cooling effect will deteriorate.

If the C.W. warning lamp lights periodically when the engine is run at the rated output, clean the tube in the fresh water tank with a cleaning agent and then flush the accumulated scale produced by cooling the fresh water from the tube.

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