Water Cooling Systems

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Water Cooling Systems

1. General

Pipe systems vary considerably from plant to plant. The following schematic pipe diagrams are included here, for guidance, to illustrate the essential principles of the circuits and their correlation.
For a specific plant, the correct details must be found in the piping diagrams supplied by the shipyard.

2. Seawater Cooling System

Plate 70901

Seawater is drawn up through the sea connection (1) by the seawater pump (2).
From the pump, the water-flow is divided into three separate branches:

a) through the adjustable valve (3) direct to the main engine scavenge air cooler(s).

b) through the non-return valve (5) to the auxiliary engines

c) through the adjustable valve (3) to the lub. oil cooler and jacket water cooler, which are connected in series.

Other branches may be installed in parallel with branch c):

- Water supply to PTO/RCF lube oil cooler (if installed).
- Water supply to camshaft lube oil cooler (only engines without Uni-Lube system).

The sea water from the above-mentioned branches is later mixed again, and then continues to the thermostatically controlled 3-way regulating valve (6) at the seawater overboard valve (7).

Regulating valve (6) is controlled by the sensor (8) which is located in the seawater inlet pipe. The thermostat is adjusted so that the water temperature at the pump inlet is kept above 10°C, in order to prevent the lub. oil from becoming too viscous on the cold cooling surfaces *(see also 'Alarm Limits', Chapter 701).*

If the seawater inlet temperature drops below the set level, then regulating valve (6) opens for the return flow to the seawater pump suction piping.

3. Jacket Water Cooling System

Plates 70902, 70904

The jacket water is circulated through the cooler and the main engine cylinders by the jacket water pump (1). The thermostatically controlled regulating valve (2), at the outlet from the cooler, mixes cooled and uncooled jacket water in such proportions that the temperature of the *outlet water from the main engine is maintained at about 80-85°C. See Chapter 701, Pos. 387.*

Regulating valve (2) is controlled by the sensor (3), which is located in the cooling water outlet of the main engine.

In order to avoid increased cylinder wear it is important to maintain the cooling water outlet temperature at 80–85°C.

A lower temperature may cause condensation of sulphuric acid on the cylinder walls.

An integrated loop in the auxiliary engines ensures a constant temperature of 80°C at the outlets from the auxiliary engines.

To prevent air accumulation in the cooling water system, a deaerating tank (4) (cyclone tank) has been inserted in the piping. The expansion tank (5) takes up the difference in the water volume at changes of temperature.

Also an alarm device is installed to give off alarm, in case of excessive air/steam formation in the system. *See Chapter 701, Pos. 395.*

Pressure gauges are installed to enable checking of the pressure difference across the engine. *See Chapter 701, Pos. 390.*

Operation in Port
Plate 70902

The main engine is preheated by utilising hot water from the auxiliary engine(s). This preheating is activated by closing valves (6) and opening valves (7).

Activating valves (6) and (7) will change the direction of flow, and the water will now be circulated by the auxiliary engine-driven pumps.

From the auxiliary engines, the water flows directly to the main engine jacket outlet. When the water leaves the main engine, through the jacket inlet, it flows to the thermostatically controlled 3-way valve (2).

In this operating mode, the temperature sensor (3) for valve (2) measures in a non-flow, low temperature piping. Valve (2) will consequently be set to lead the cooling water to the jacket water cooler (8), and further on to the auxiliary engine-driven pumps.

The integrated loop in the auxiliary engines will ensure a constant temperature of 80°C at the auxiliary engine outlet, thus preheating the main engine.

Auxiliary engines in stand-by are automatically preheated by hot water entering through valves F3 and leaving through valves F1.

4. Central Cooling System

Plate 70903

In the *central cooling water system*, the central cooling water pump (3) circulates the low-temperature freshwater (central cooling water) in a cooling circuit: in parallel through the scavenge air cooler(s), through the lub. oil cooler and jacket water cooler, the two last mentioned connected in series, and through the auxiliary engines.

The temperature in the low temperature part of the system is monitored by the thermostatically controlled regulating valve (4). Adjust the regulating valve so that the min. temperature at inlet to the air cooler, the oil cooler, and the auxiliary engines is above 10°C.

Regarding main and auxiliary jacket cooling water systems, *see previous section 3, 'Jacket Water Cooling System'.*

Operation in Port
Plate 70903

The main engine is preheated by utilising hot water from the auxiliary engine(s). This preheating is activated by closing valves (6) and opening valves (7).

Activating valves (6) and (7) will change the direction of flow, and the water will now be circulated by the smaller port service central water pump.

From the auxiliary engines, the water flows directly to the main engine jacket outlet. When the water leaves the main engine, through the jacket inlet, it flows to the thermostatically controlled 3-way valve of the jacket water cooler.

In this operating mode, the temperature sensor for the thermostatically controlled 3-way valve measures in a non-flow, low temperature piping. The valve will consequently be set to make the cooling water by-pass the jacket water cooler and return to the port service pump.

The integrated loop in the auxiliary engines will ensure a constant temperature of 80°C at the auxiliary engine outlet, thus preheating the main engine.

Auxiliary engines in stand-by are automatically preheated by hot water entering through valves F3 and leaving through valves G1.

5. Preheating during Standstill

Preheat the engine in accordance with Chapter 703, Item 7, 'Operations AFTER Arrival in Port'.

Preheat by means of:

- A built-in preheater, *see also Plate 70904.*

  The capacity of the preheater pump should correspond to about 10% of the capacity of the jacket water main pump.

  The pressure drop across the preheater should be approx. 0.2 bar.

  The preheater pump and the main pump should be electrically interlocked to avoid the risk of simultaneous operation.

- Cooling water from the auxiliary engines, *see Item 3, 'Operation in Port'.*

6. Jacket Water Cooling Failure

It is assumed that the temperature rise is not caused by defective measuring equipment or thermostatic valve. These components should be checked regularly to ensure correct functioning.

If the cooling water temperature, for a single cylinder or for the entire engine, rises to **90–100°C**, follow this procedure:

Open the test cocks on the cylinder outlets.

Is water coming out?

YES

- Close the test cocks.
- Re-establish the cooling water supply at once, or stop the engine for trouble-shooting.

NO

The cooling space is not completely filled with water. This results in local overheating, and hence the formation of steam.

- Close the test cocks.
- Stop the engine.
- Close the outlet valve on the overheated cylinder.
- Open the indicator cocks.
- Keep the auxiliary blowers and lub. oil pumps running.
- Turn the piston of the cylinder concerned to BDC to slowly cool down the overheated area via the air flow through the cylinder and indicator cock.
- Leave the engine to cool.
  This prevents extra shock heat stresses in cylinder liner, cover and exhaust valve housing, if the water should return too suddenly.
- After 15 minutes, open the outlet valves a little so that the water can rise slowly in the cooling jackets. Check the level at the test cocks.
- Find and remedy the cause of the cooling failure.
- Check for proper inclination of the freshwater outlet pipe, and for proper deaeration from the forward end of the engine.
- Make a scavenge port inspection to ensure that no internal leakage has occurred. *See also Chapter 707, 'Cylinder Condition'.*

Note: Slow-turn the engine with open indicator cocks before starting the engine.

Cooling Water Treatment

1. Reducing Service Difficulties

To reduce service difficulties to a minimum, we strongly recommend:

- effective protection against corrosion of the cooling water system by adding a chemical **corrosion inhibitor**. *See Item 1.2.*
- using the correct **cooling water quality**. *See Item 1.3.*
- effective **venting** of the system. *See Item 1.4.*
- Checking the system and water during service. *See Item 2.*
- Using the correct cleaning and inhibiting procedure. *See Items 3 and 4.*

1.1 Types of Damage

If the above-mentioned precautions are not taken, the following types of damage may occur:

- corrosion, which removes material from the attacked surface by a chemical process.
- corrosion fatigue, which may develop into cracks because of simultaneous corrosion and dynamic stresses.
- cavitation, which removes material because of local steam formation and subsequent condensation in the cooling water, due to high water velocity or vibrations.
- scale formation, which reduces the heat transfer, mostly due to lime deposits.

Corrosion and cavitation may reduce the lifetime and safety factors of the parts concerned. Deposits will impair the heat transfer and may result in thermal overload of the components to be cooled.

1.2 Corrosion Inhibitors

Various types of inhibitors are available but, generally, only nitrite-borate based inhibitors are recommended.

A number of products marketed by major companies are specified in the table on Page 709.10. The relevant dosages are also mentioned, and we recommend that these directions are strictly observed.

Cooling water treatment using inhibiting oils is not recommended, as such treatment involves the risk of uncontrolled deposits being formed on exposed surfaces, and furthermore represents an environmental problem.

Note: The legislation for disposal of waste water, incl. cooling water, prohibits the use of chromate for cooling water treatment.
Chromate inhibitors **must not** be used in plants connected to a freshwater generator.

1.3 Cooling Water Quality

It is important to use the correct cooling water quality. We recommend to use deionized or distilled water (for example produced in the freshwater generator) as cooling water.

This prevents, to a wide extent, the formation of lime stone on cylinder liners and in cylinder covers, which would impair the heat transfer, and result in unacceptably high material temperatures.

Before use, check that the following values are not exceeded:

- Hardness: max. 10° dH (=10 ppm CaO)
- pH : 6.5-8.0 (at 20°C)
- Chloride : 50 ppm (50 mg/litre)
- Sulphate : 50 ppm (50 mg/litre)
- Silicate : 25 ppm (25 mg/litre)

Check that there is no content of:
- Sulphide
- Chlorine
- Ammonia

80

Note: Softening of the water does not reduce its sulphate and chloride contents.

If deionized or distilled water cannot be obtained, normal drinking water can be used in exceptional cases.

Rain water, etc. **must not** be used, as it can be heavily contaminated.

1.4 Venting

The system is fitted with a deaerating tank with alarm and with venting pipes which lead to the expansion tank.
See 'Jacket Water Cooling System', earlier in this Chapter.

2. Checking the System and Water during Service

Check the cooling water system and the water at the intervals given below:

We recommend to keep a record of all tests, to follow the condition and trend of the cooling water.

2.1 Regularly

Whenever practical, check the cooling water system for sludge or deposits.
See also Item 2.5, 'Every four-five years and after long time out of operation'.

Check at the cooling pipes, cooling bores, at the top of the cylinder and cover and exhaust valve bottom piece.

Sludge and deposits can be due to:

- contaminated cooling water system,
- zinc galvanized coatings in the cooling water system.

  Experience has shown that zinc galvanized coatings in the freshwater cooling system are often very susceptible to corrosion, which results in heavy sludge formation, even if the cooling system is correctly inhibited.

  In addition, the initial descaling with acid will, to a great extent, remove any galvanized coating. Therefore, generally, we advise against the use of galvanized piping in the freshwater cooling system.

2.2 Once a Week

Take a water sample from the system during running.
Take the sample from the circulating system, i.e. **not** from the expansion tank or the pipes leading to the tank.

Check the condition of the cooling water.
Test kits are normally available from the inhibitor supplier.

Check:

- Inhibitor concentration.
  The concentration of inhibitor **must not** fall below the value recommended by the supplier, as this will increase the risk of corrosion.
  When the supplier specifies a concentration range, we recommend to maintain the concentration in the upper end.
- pH-value.
  Should be within 8.5-10 at 20°C.
  A decrease of the pH-value (or an increase of the sulphate content, if measured) can indicate exhaust gas contamination (leakage).
  pH can be increased by adding inhibitor, however, if large quantities are necessary, we recommend to change the water.
- Chloride content.
  Should not exceed 50 ppm (mg/litre).
  In exceptional cases, a maximum of 100 ppm can be accepted, however, the upper limit specified by the inhibitor supplier must be adhered to.
  An increase of the chlorine content can indicate salt water ingress.
  Trace and repair any leakages at the first opportunity.

Note: If out-of-specification results are found, repeat the tests more frequently.

2.3 Every Third Month

Take a water sample from the system during running, as described in Item 2.2, 'Once a week'.

Send the sample for laboratory analysis, in particular to ascertain the content of:
- inhibitor
- sulphate
- iron
- total salinity.

2.4 Once a Year

Empty, flush and refill the cooling water system.

Add the inhibitor.
See also Item 4.5, 'Adding the inhibitor', further on.

2.5 Every Four-Five Years and after Long Time Out of Operation

Based on the regular checks, *see Item 2.1*, clean the cooling water system for oil-sludge, rust and lime.
Refill and add the inhibitor.
See Items 3 and 4 further on.

2.6 Water Losses and Overhauling

Replace evaporated cooling water with non-inhibited water.

Replace water from leakages with inhibited water.

After overhauling, e.g. of individual cylinders, add a new portion of inhibitor immediately after completing the job.

Check the inhibitor concentration any time a substantial amount of cooling water is changed or added.

3. Cleaning and Inhibiting

3.1 General

Carry out cleaning before inhibiting the cooling water system for the first time.
This ensures uniform inhibitor protection of the surfaces and improves the heat transfer.

During service, carry out cleaning and inhibiting every 4-5 years and after long time out of operation, *see also Item 2.5.*

Cleaning comprises degreasing to remove oil sludge and descaling to remove rust and lime deposits.

3.2 Cleaning Agents

Special ready-mixed cleaning agents can be obtained from companies specialising in cooling water treatment, and from the supplier of inhibitors.
See the table on Page 709.10.

These companies offer treatment, assistance and cooling water analysis.

We point out that the directions given by the supplier should always be closely followed.

The cleaning agents **must not** be able to damage packings, seals, etc. It must also be ensured that the cleaning agents are compatible with all parts of the cooling system to avoid any damage.

The cleaning agents should not be directly admixed, but should be dissolved in water and then added to the cooling water system.

For degreasing, agents emulsified in water, as well as slightly alkaline agents, can be used.
Note: Ready-mixed agents which involve the risk of fire obviously must not be used.

For descaling, agents based on amino-sulphonic acid, citric acid and tartaric acid are especially recommended.
Note: Use only inhibited acidic cleaning agents.

These acids are usually obtainable as solid substances, which are easily soluble in water, and do not emit poisonous vapours.

3.3 Inhibitors

See Item 1.2, 'Corrosion Inhibitors', earlier in this Chapter.

4. Cleaning and Inhibiting Procedure

4.1 General

Note: The engine must be at a standstill during the cleaning procedure to avoid overheating during draining.

Normally, cleaning can be carried out without any dismantling of the engine.

Since cleaning can cause leaks to become apparent (in poorly assembled joints or partly defective gaskets), inspection should be carried out during the cleaning process.

4.2 Degreasing

Note: Be careful. Use protective spectacles and gloves.

Prepare for degreasing

Does the cooling water contain inhibitor?
YES
Drain the system. Fill up with clean tap water. Follow the procedure below.
NO
Follow the procedure below.

Heat the water to 60°C and circulate it continuously.

Drain to lowest water level in the expansion tank sight glass.

Add the degreasing agent

Add the degreasing agent, preferably at the suction side of the running jacket water pump.
Use the amount of agent specified by the supplier.

Drain again to the lowest level in the expansion tank if the cooling water system is filled-up, before all agent is applied.

Circulate the solution

Circulate the agent for the period specified by the supplier.
Check and repair any leaks.

Drain and flush the system

Drain the system completely.
This will also flush out any oil or grease settled in the expansion tank.

Fill up with clean tap water.

Circulate the water for two hours.

Drain the system completely.

Proceed to the descaling procedure, *see Item 4.3*

4.3 Descaling

On completing the degreasing procedure, *see Item 4.2,* apply this descaling procedure.

Note: Be careful. Use protective spectacles and gloves.

Note: To avoid polluting the sea water with acid, it is recommended, if possible, to collect all the drained water that contains acid in a tank where it can be neutralised, for example by means of soda, before being led overboard.

Prepare for descaling

Fill up with clean tap water.

Heat the water to a maximum of 70°C, and circulate it continuously.

Note: Some ready-mixed cleaning agents are specified to be used at a lower temperature. This maximum temperature must be adhered to.

Add the acid solution

Dissolve the necessary dosage of acid compound in a clean iron drum, half filled with hot water. Stir vigorously, e.g. using a steam hose.

For engines that were treated before the sea trials, the lowest dosage recommended by the supplier will normally be sufficient.

For untreated engines, a higher dosage – depending on the condition of the cooling system – will normally be necessary.

The solubility of acids in water is often limited. This can necessitate descaling in two stages, with a new solution and clean water.
Normally, the supplier specifies the maximum solubility.

Fill the drum completely with hot water while continuing to stir.

Slowly add the acid compound at the suction side of the jacket water cooling pump.

Drain some water from the system, if necessary.

Circulate the acid solution

Keep the temperature of the water at the prescribed preheating temperature, and circulate it constantly.

The duration of the treatment will depend on the degree of fouling.

Normally, for engines that were treated before the sea trials, the shortest time recommended by the supplier will be sufficient.

For untreated engines, a longer time must be reckoned with.

Check every hour, for example with pH-paper, that the acid has not been neutralised.

A number of descaling preparations contain colour indicators which show the state of the solution.

If the acid content is exhausted, a new admixture dosage can be added, in which case the weakest recommended concentration should be used.

Neutralise any acid residues

After completing the descaling, drain the system and flush with water.

The flushing is necessary to remove any debris that may have formed during the cleaning.

Continue the flushing until the water is neutral (pH approx. 7).

Acid residues can be neutralised with clean tap water containing 10 kg soda per ton of water. As an alternative to soda, sodium carbonate or sodium phosphate can be used in the same concentration.

Circulate the mixture for 30 minutes.

Drain and flush the system.

Continue to flush until the water is neutral (pH approx. 7).

Note !
Check the acid content of the system oil directly after the descaling, and again 24 hours later. *See Chapter 708, 'Maintenance of the Circulating Oil', Items 4.5 and 5.*

4.4 Filling up with Water

To prevent the formation of rust on the cleaned surfaces, fill up with water immediately after the cleaning.

Fill up, with deionizer or distilled water, to the *lowest* level in the expansion tank.
See also Item 1.3 'Cooling water quality'.

4.5 Adding the Inhibitor

On account of the lack of hardness, the deionized or distilled water is relatively corrosive.

Add the corrosion inhibitor immediately after filling up.

Weigh out the quantity of inhibitors specified by the supplier, *see the table on Page 709.10.*

We recommend to use the maximum amount specified by the makers.

Dissolve the inhibitor in hot deionized or distilled water, using a *clean* iron drum.

Add the solution at the suction side of the running jacket water cooling pump or at another place where flow is ensured.

A liquid inhibitor may be entered directly into the system by equipment supplied by the maker. Follow the maker's instructions.

Fill up to *normal* water level, using deionized or distilled water.

Circulate the cooling water for not less than 24 hours. This ensures the forming of a stable protection of the cooling surfaces.

Check the cooling water with a test kit (available from the inhibitor supplier) to ensure that an adequate inhibitor concentration has been obtained.
See also Item 2.2 Once a Week, 'Check: Inhibition concentration', earlier in this Chapter.

5. Central Cooling System, Cleaning and Inhibiting

It is important for the proper functioning of this system to remove existing deposits of lime, rust and/or oil sludge in order to minimise the risk of blocking the coolers, and to ensure a good heat transfer. Subsequent inhibiting shall, of course, be carried out.

For central cooling water systems, which are arranged with separate high and low temperature freshwater circuits, the careful, regular checks which are necessary for the jacket cooling water (= high temperature freshwater circuit) are not necessary for the low temperature freshwater circuit.

Nitrite-borate Corrosion Inhibitors for Fresh Cooling Water Treatment

Company	Name of Inhibitor	Delivery Form	Maker's min. Recommended Dosage (*)
Castrol Ltd. Swindon Wiltshire, England	Castrol Solvex WT4 Castrol Solvex WT2	Powder Liquid	3 kg / 1000 l 20 l / 1000 l
Drew Ameriod Marine Boonton, N.J./USA	DEWT NC Liquidewt Maxiguard	Powder Liquid Liquid	3.2 kg / 1000 l 8 l / 1000 l 16 l / 1000 l
Nalfloc Ltd. Northwich, Cheshire, England	NALFLEET 9-121 NALFLEET 9-108	Powder Liquid	2.5 kg / 1000 l 2.25 l / 1000 l
Rohm & Haas (ex Duolite) Paris, France	RD11 DIA PROSIM RD25 DIA PROSIM	Powder Liquid	3 kg / 1000 l 50 l / 1000 l
Unitor Rochem Marine Chemicals Oslo, Norway	Dieselguard NB Rocor NB Liquid	Powder Liquid	3 kg / 1000 l 10 l / 1000 l
Vecom Maassluis, Holland	CWT Diesel QC2	Liquid	12 l / 1000 l
FAMM, Houston, USA	Havoline XLI Havoline XLC	Liquid	15 l / 1000 l

Generally we recommend 2000-2500 ppm Nitrite.

(*) Initial dosage may be larger.

The list is for guidance only and must not be considered complete. We undertake no responsibility for difficulties that might be caused by these or other water inhibitors/chemicals.

The suppliers are listed in alphabetical order.

Suitable cleaners can normally also be supplied by these firms.

Seawater Cooling System
Main and Auxiliary Engines

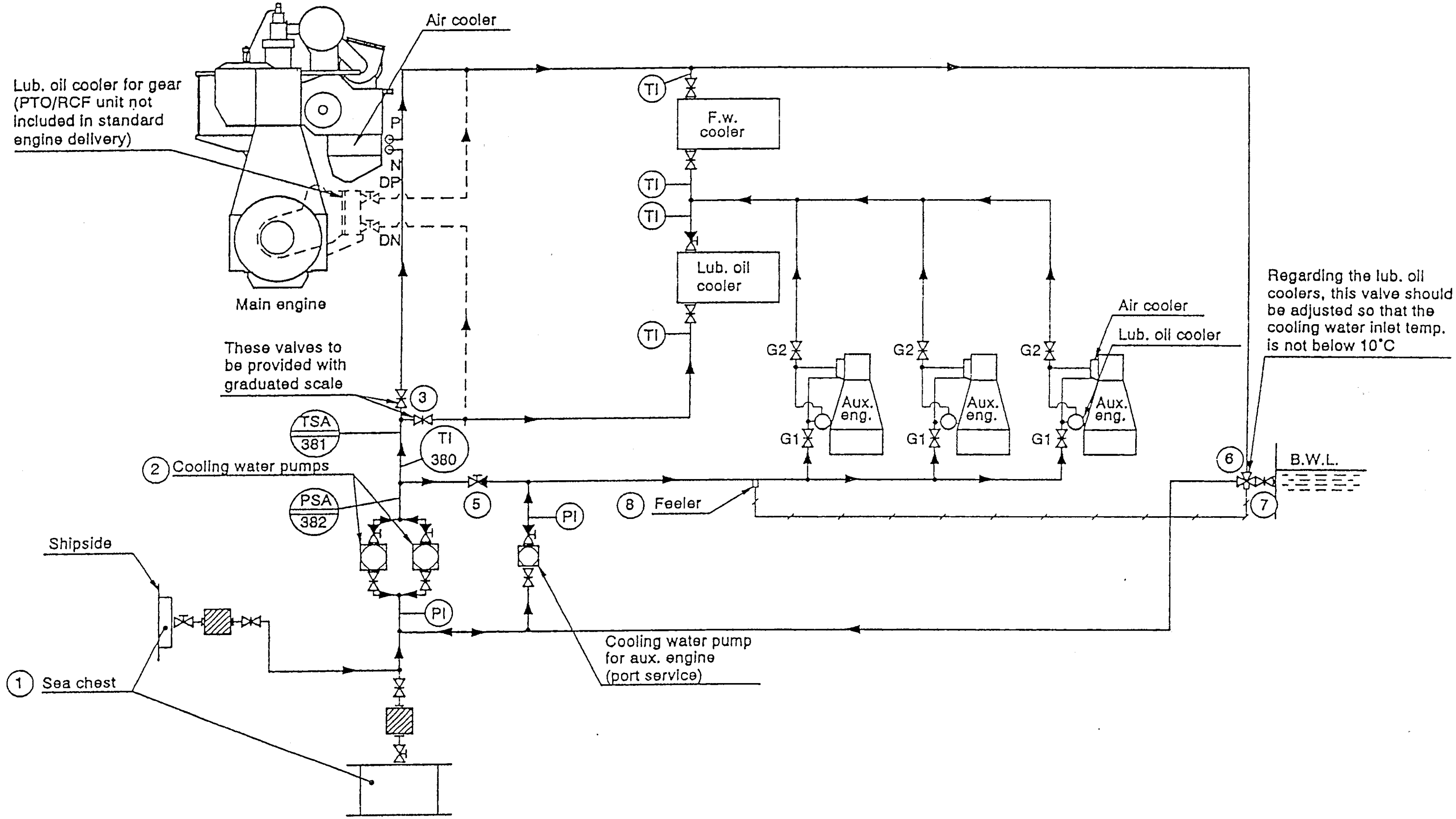
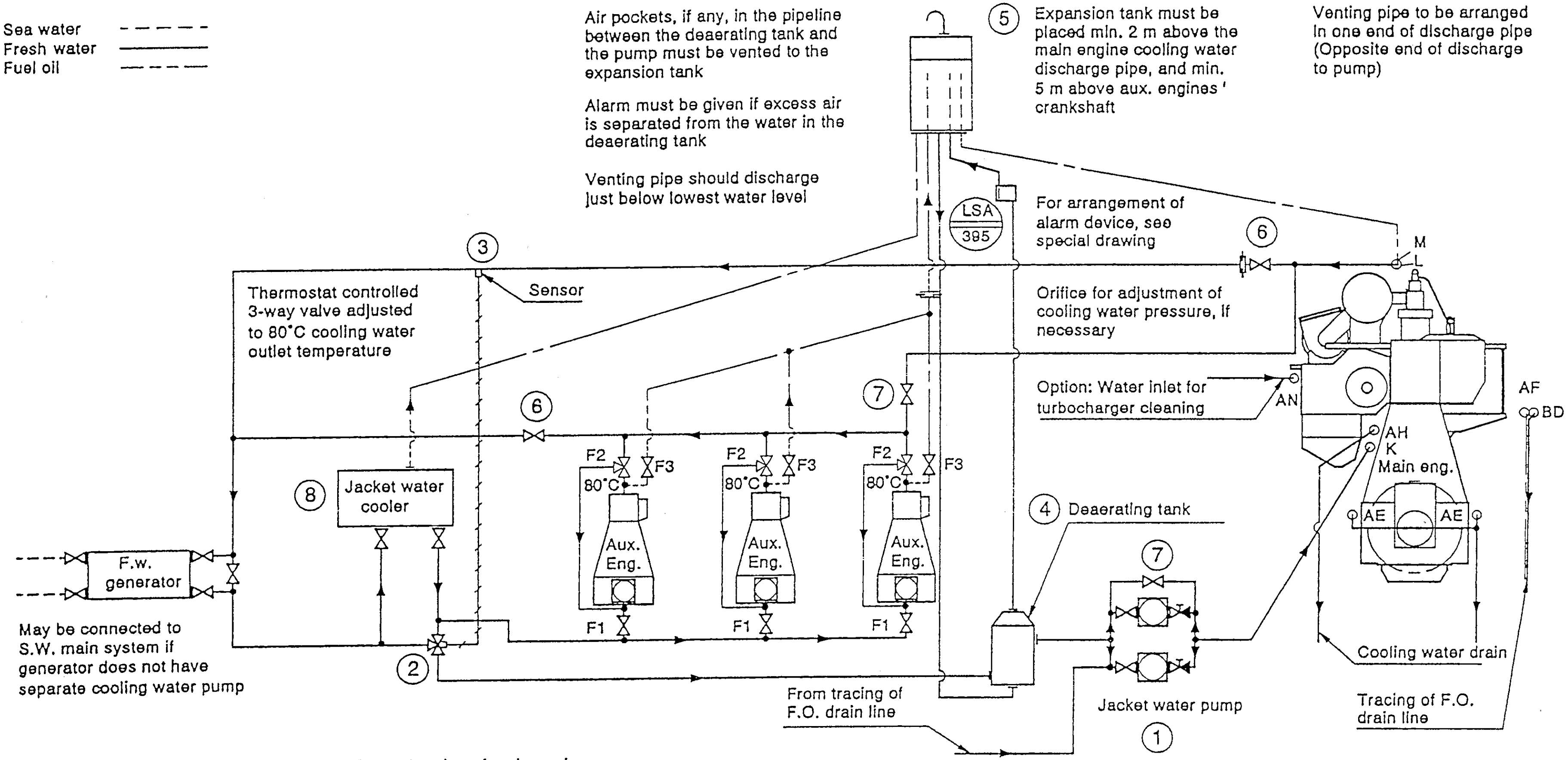


Plate 70901-40D

Plate 70902-40D Jacket Cooling Water System
Main and Auxiliary Engines

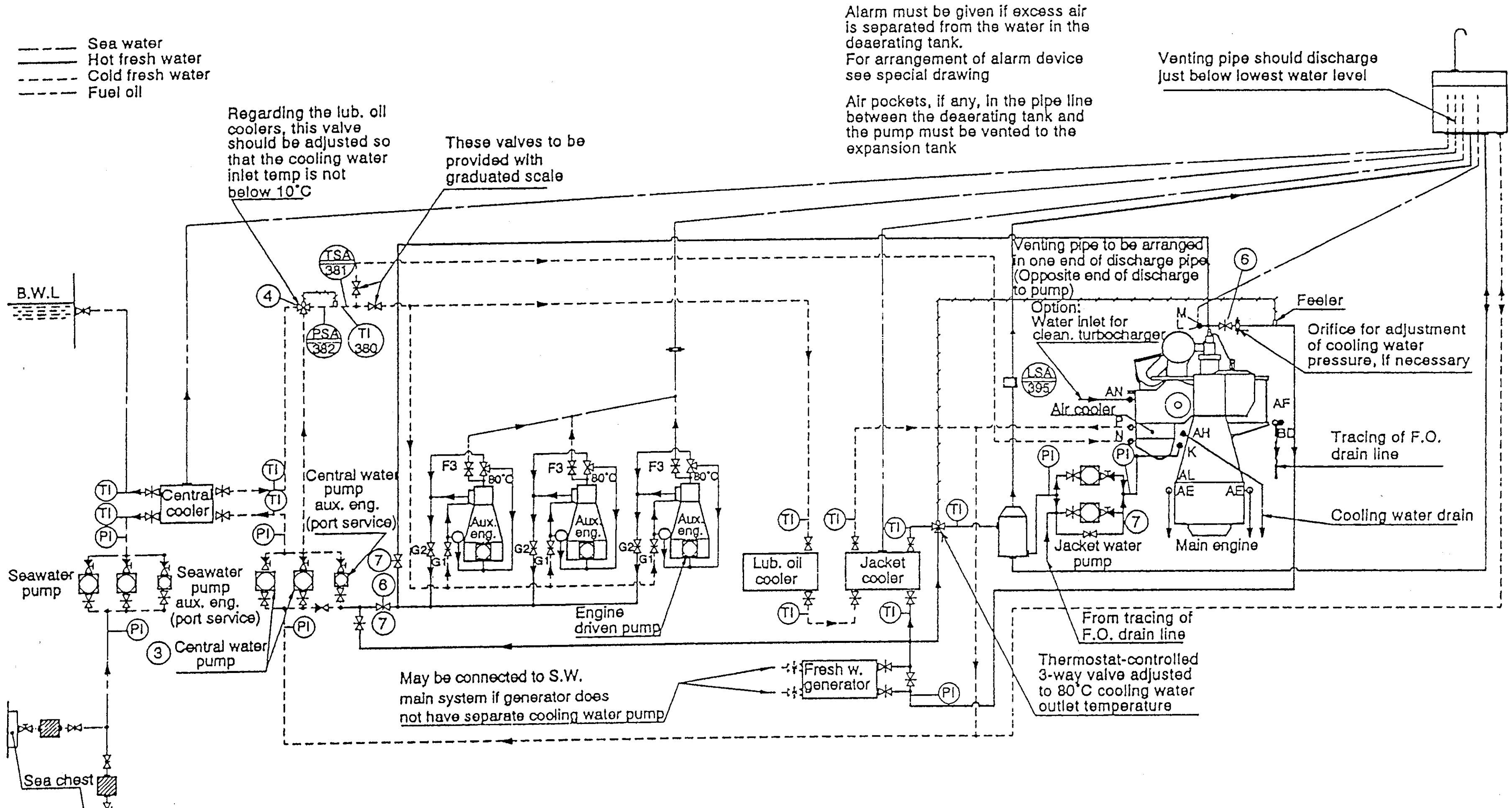


For preheating of main engine

6 Open at sea
Closed in port

7 Closed at sea
Open in port

When preheating a stopped aux. engine from running aux. engine, hot cooling water will be led into stopped engine at "F3" and out at "F1"



For preheating of main engine

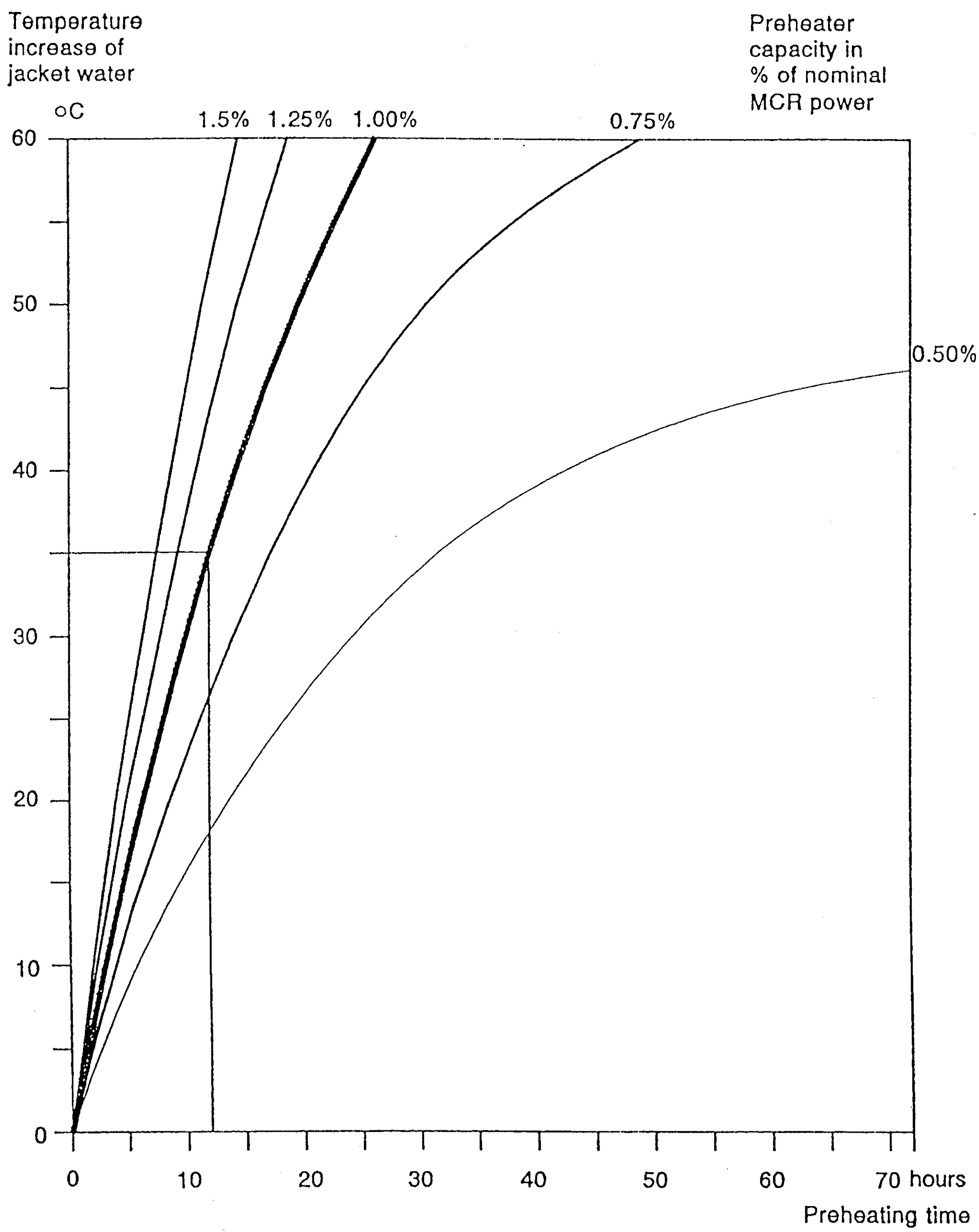
(6) Open at sea
Closed in port

(7) Closed at sea
Open in port

When preheating a stopped aux. engine from running aux. engine, hot cooling water will be led into stopped engine at "F3" and out at "G1"

Central Cooling System
Main and Auxiliary Engines

Plate 70903-40D



Preheating of Jacket Cooling Water

If the cooling water is heated by means of a preheater installed in the freshwater system, the curves above can be used.

The curves are drawn on the basis that, at the start of preheating, the engine and engine-room temperatures are equal.

Example:

A freshwater preheater, with a heating capacity equal to 1% of nominal MCR engine shaft output, is able to heat the engine 35°C (from 15°C to 50°C) in the course of 12 hours.

Cooling water preheating during standstill is described in Chapter 703, Item 7, 'Operations AFTER Arrival in Port'.