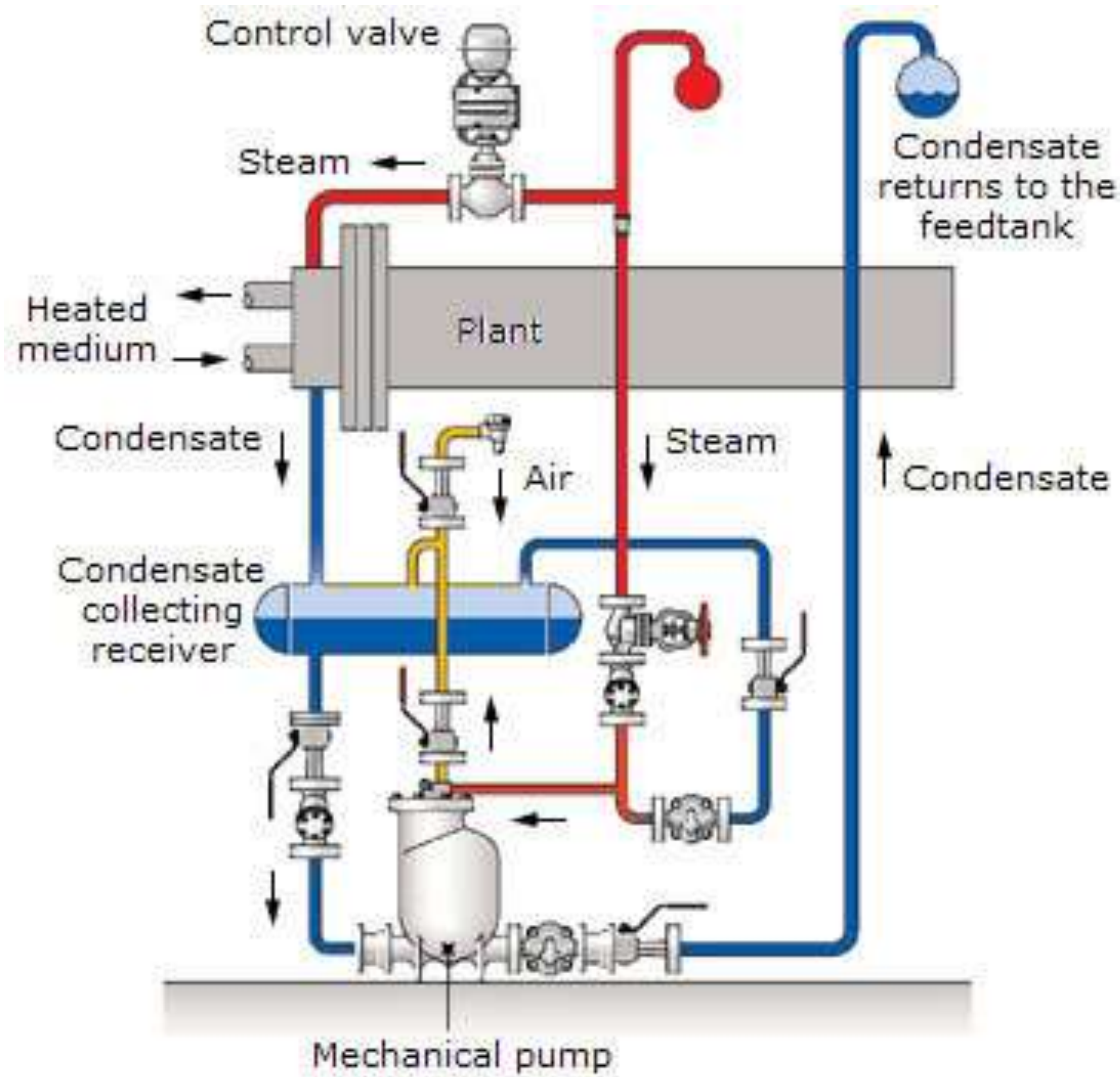
MAM 1

UNIT 1

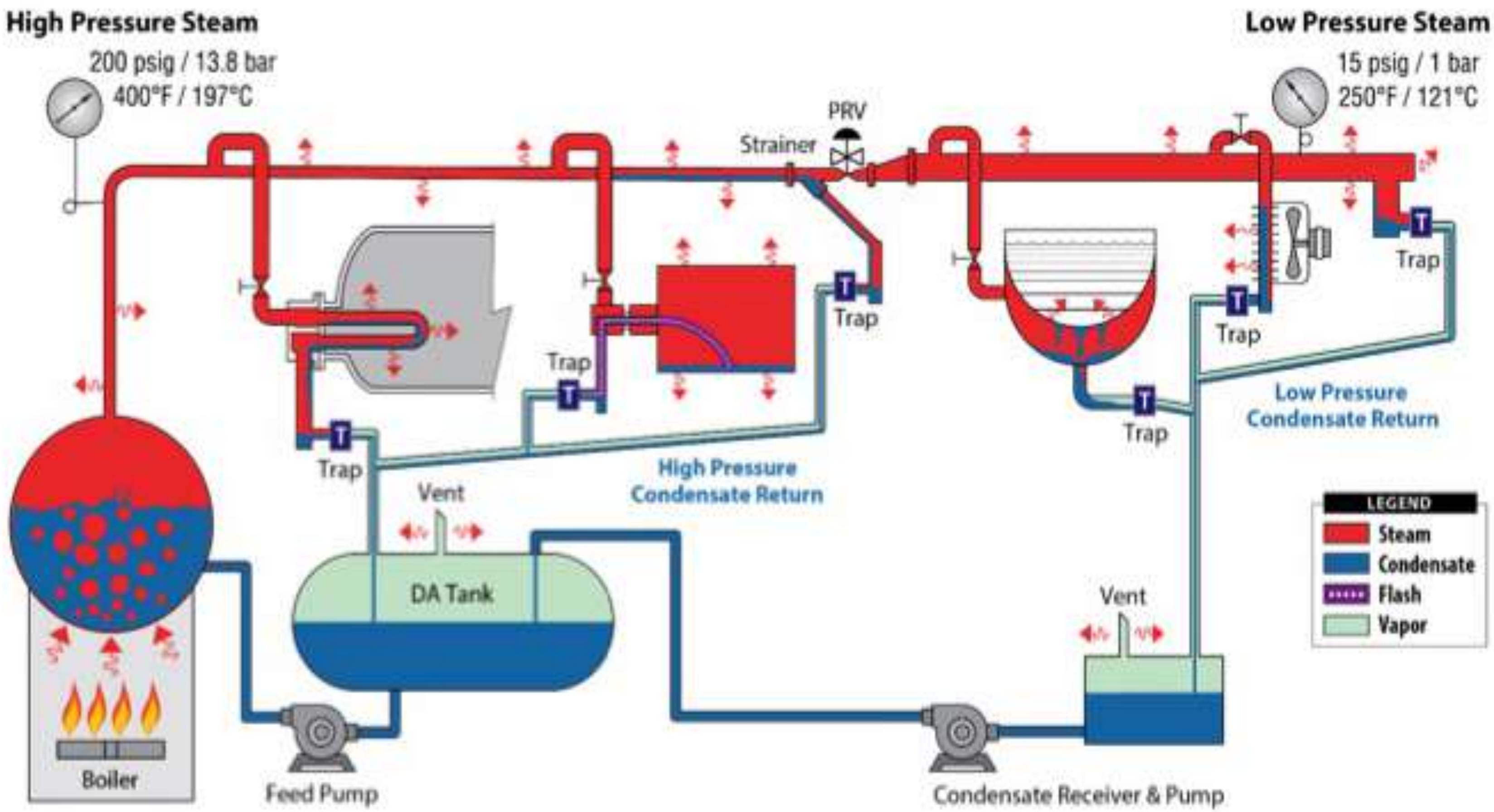
TOPIC TO BE COVERED IN UNIT 1

- LAY OUT OF THE MACHINERY IN THE SHIP
- STEAM CONDENSATE SYSTEM
- WHATER HAMMERING
- BILGE AND BALLAST PIPELINE SYSTEM
- FUEL OIL BUNKERING AND TRANSFER SYSTEM
- BUNKERING PROCEDURE
- PRECAUTIONS TO BE TAKEN DURING BUNKERING
- FUEL OIL SERVICE SYSTEM
- LUBRICATING OIL SERVICE SYSTEM
- ENGINE COOLING SYSTEM
- CENTRAL COOLING SYSTEM
- CENTRAL PRIMING SYSTEM
- DOMESTIC FRESHWATER AND SEA WATER HYDROPHORE SYSTEM
- DOMESTIC DRINKING WATER SYSTEM
- FIRE MAIN SYSTEM

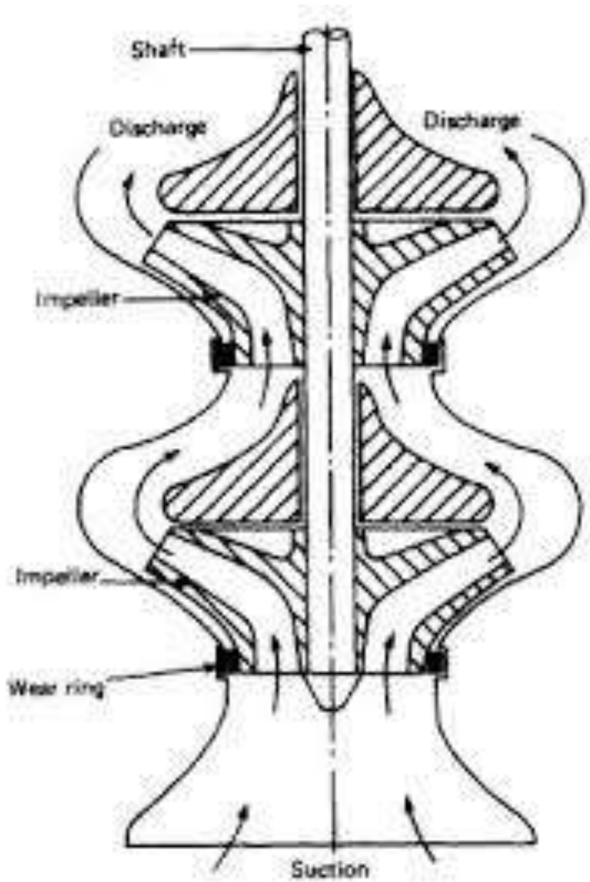
STEAM CONDENSATE SYSTEM



STEAM CONDENSATE SYSTEM



PUMP USED IN MARINE BOILERS



MULTISTAGE CENTRIFUGAL PUMP IS USED AS FEED WATER PUMP IN THE BOILER FED WATER SYSTEM

- **HIGH DISCHARGE**
- **HIGH PRESSURE**

WATER HAMMERING

- **Water hammer** is a pressure surge or wave caused when a fluid (usually a liquid but sometimes also a gas) in motion is forced to stop or change direction suddenly (momentum change). As soon as steam leaves the **boiler**, it starts losing heat. As a result, steam stats condensing inside the **pipe** work.
- Formation of water hammer
- Formation of water hammer can be understood very well from the diagrams below.

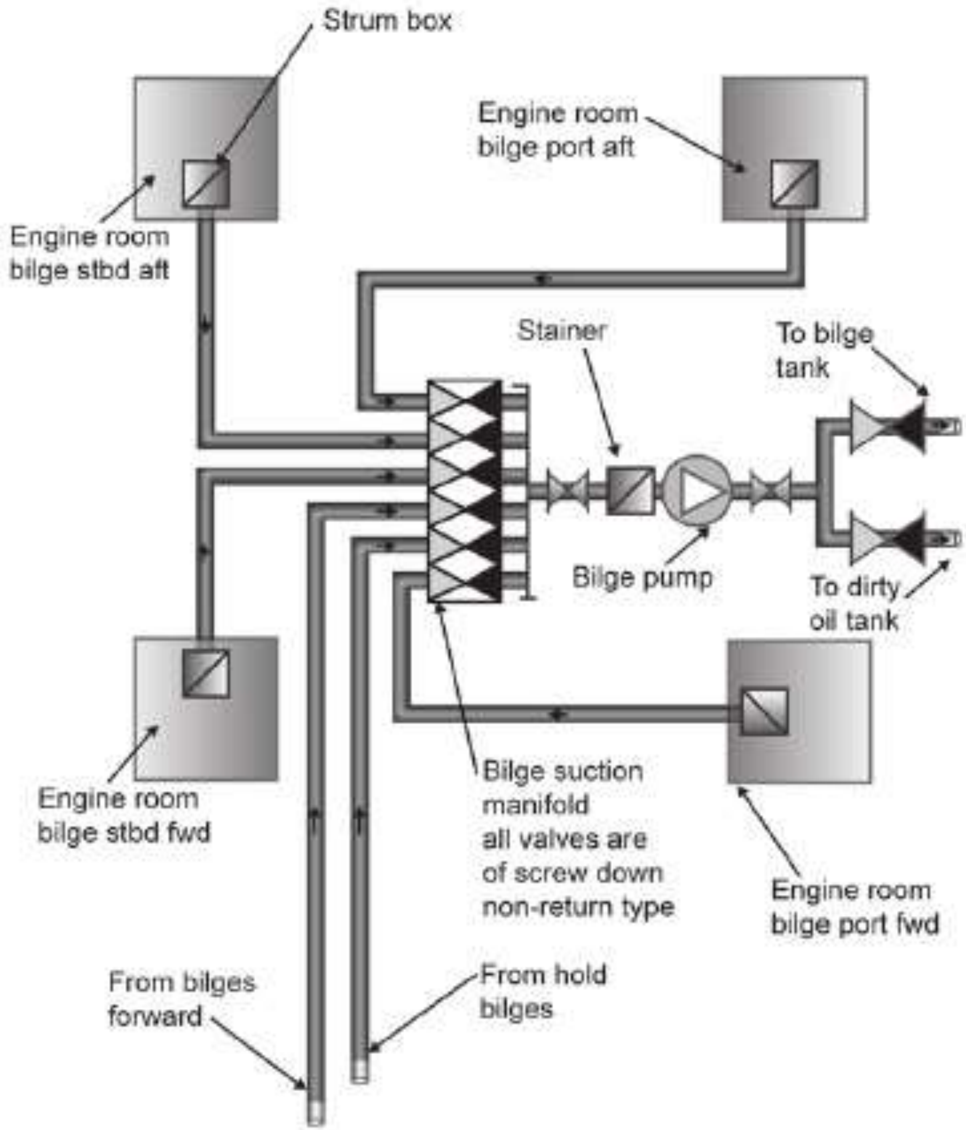
FORMATION OF WATER HAMMER

- After condensate is formed, the flow inside the pipe has two components, steam and the condensate. The flow velocity of steam is much higher than that of the condensate.
- During such dual phase flow, the heavy condensate which flows at the bottom of the pipe is pulled by high speed steam.
- This results in formation of water slug which is much denser than steam travelling with the velocity of steam.
- When this slug is stopped by any abruption like a bend or equipment, the kinetic energy of the slug will be suddenly converted into pressure energy which will create a shock wave in the entire pipework.
- The pipework will keep on vibrating until this energy is dissipated in the structure.

THE IMPACT OF WATER HAMMER

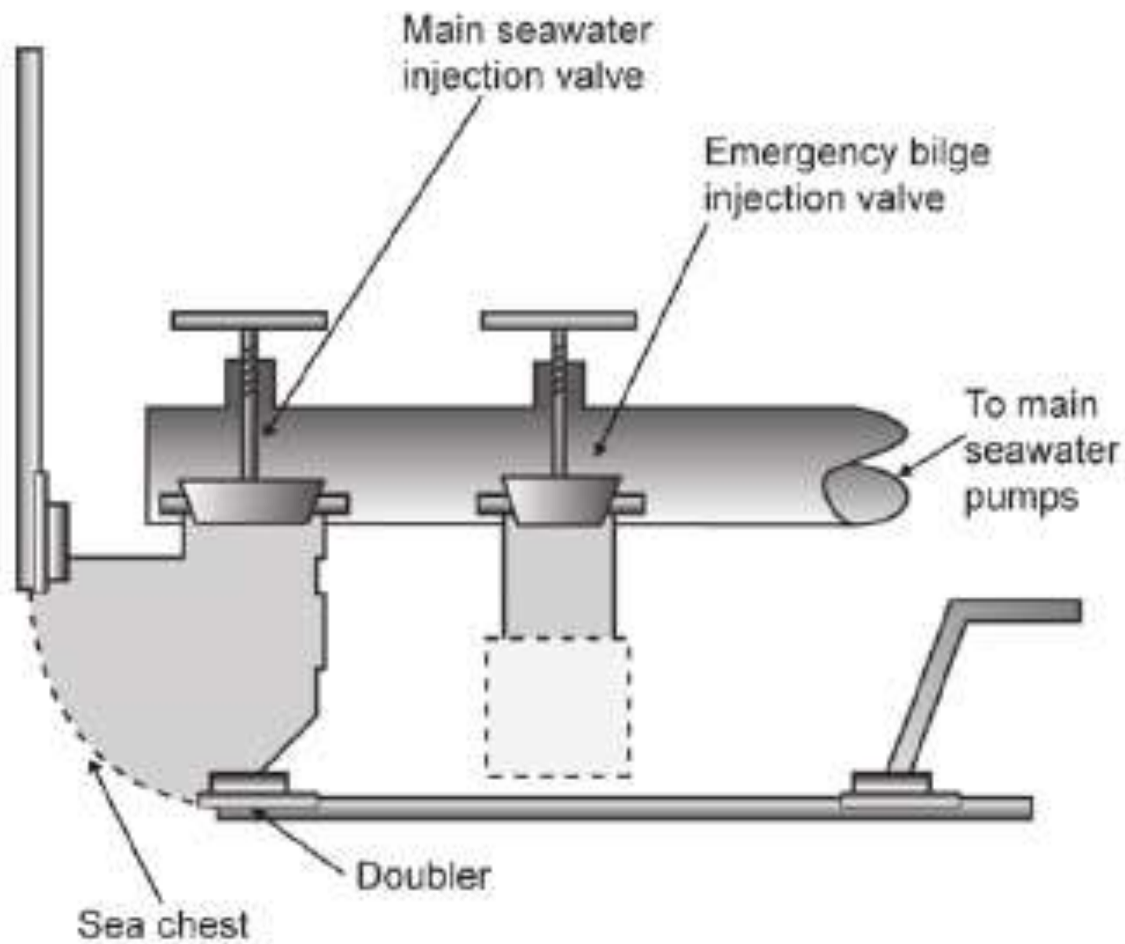
- Recommended velocity of saturated steam in pipe network = 20-35 m/s
- Recommended velocity of water in pipe network= 2-3m/s
- In case of water hammers, condensate is dragged by steam and hence, the water slug travels with velocity equal to that of steam which is around ten times more than the ideal water velocity. As a result, the total pressure impact exerted by water hammer is very high.
- Best practices to avoid water hammer
- Though water hammer cannot be completely eliminated from steam systems, it can certainly be avoided. There are certain best practices, which when followed, ensure least chances of occurrence of water hammer. Some of these practices are-
- Steam lines should always be installed with a gradual slope (gradient) in direction of flow.
- Installing steam traps at regular intervals and also at the low points. This ensures removal of condensate from the steam system as soon as it is formed.
- Sagging of pipes should be avoided by providing proper support. Sagging pipes can form pool of condensate in the pipe work, increasing the chances of water hammer.
- Operators should be trained to open isolation valve slowly during the start-up modes.
- Drain pockets should be properly sized to ensure that condensate just not jumps over it. Instead, the drain pockets should be sized enough so that all the condensate reaches the trap.
- Reducers- Eccentric reducers should be used against concentric reducers

BILGE SYSTEM

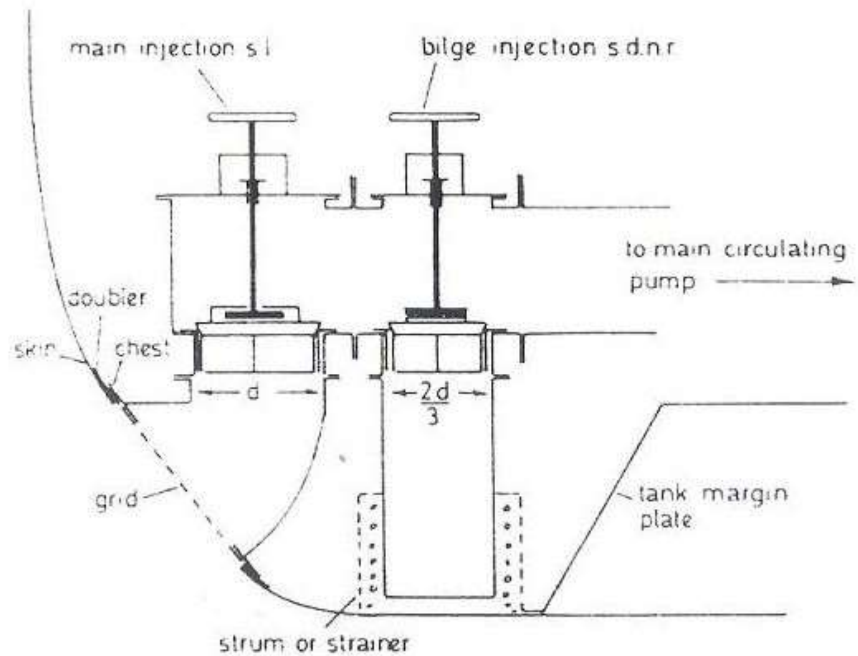


BILGE SYSTEM IN SHIP

BILGE SYSTEM

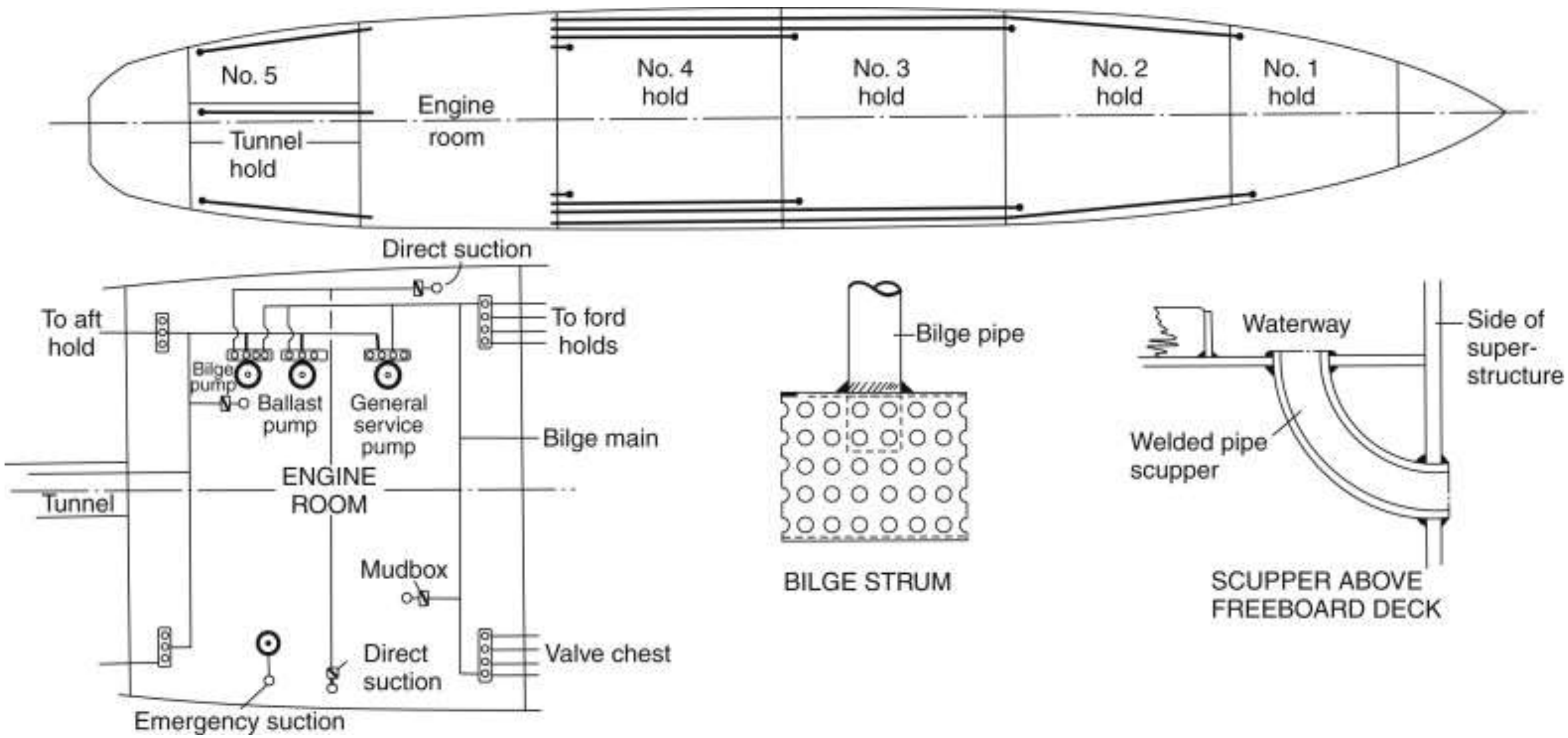


BILGE INJECTION SYSTEM

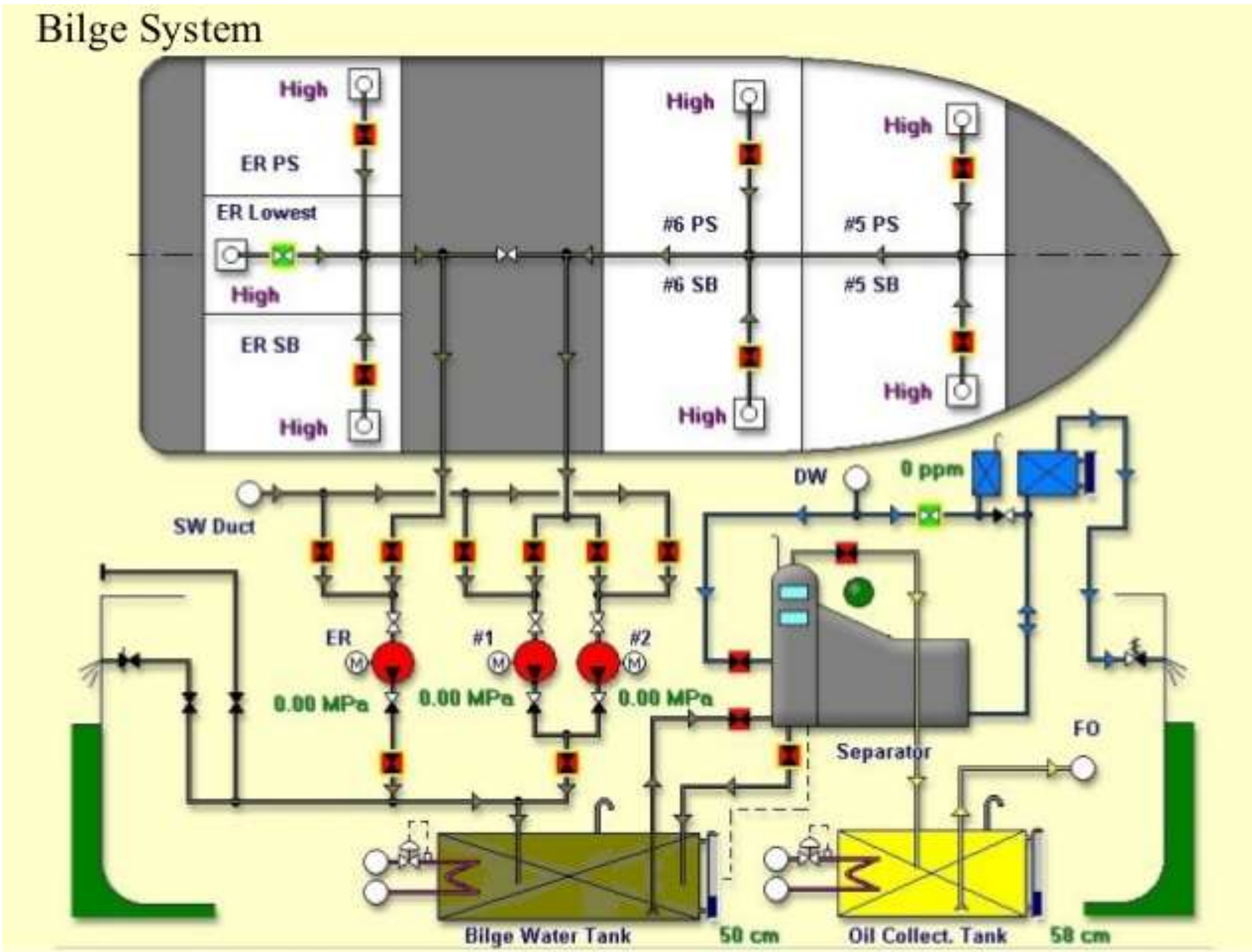


THE DIAMETER OF THE MAIN INJECTION SYSTEM IS REPRESENTED AS D; WHERE THE BILGE INJECTION SDNR VALVE SUCTION PIPELINE DIAMENTER RANGES FROM 2D/3

BILGE SYSTEM OF SHIP



BILGE SYSTEM IN SHIP



BALLASTING AND DE-BALLASTING

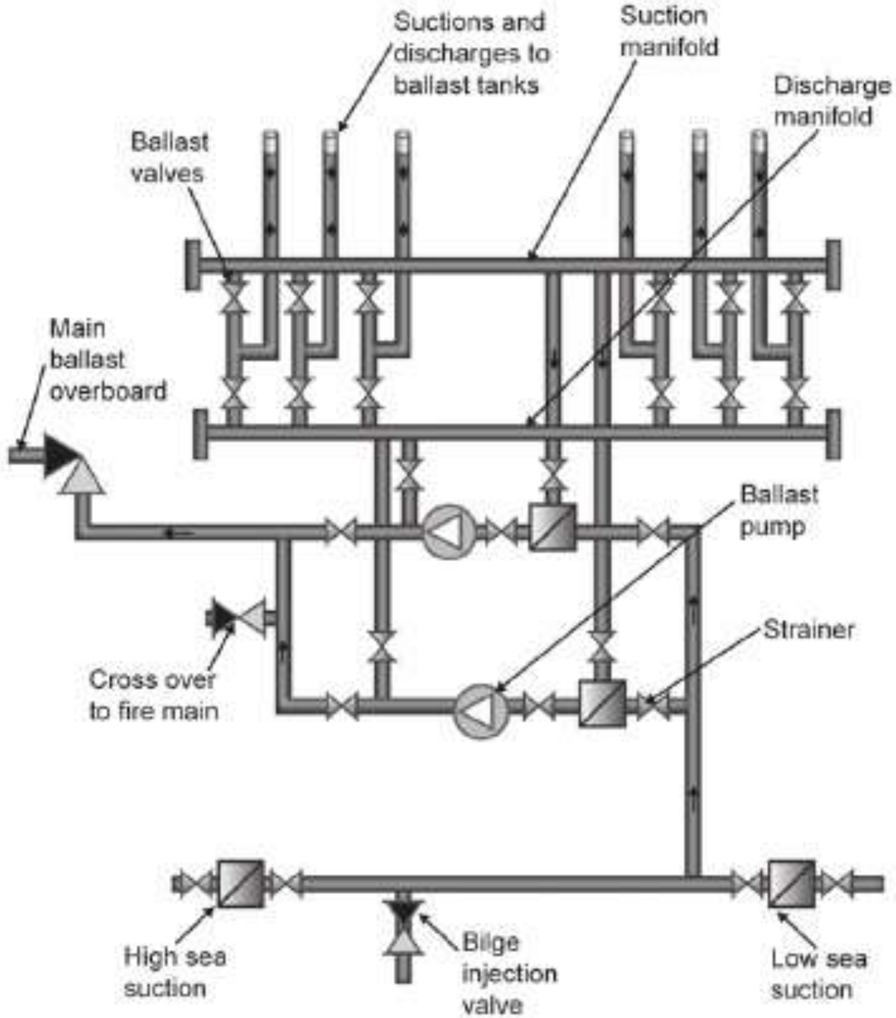
- Ballasting or de-ballasting is a process by which sea water is taken in and out of the ship when the ship is at the port or at the sea. The sea water carried by the ship is known as ballast water.
- Ballast or ballast water is sea water carried by a vessel in its ballast tanks to ensure its trim, stability and structural integrity. Ballast tanks are constructed in ships with piping system and high capacity ballast pumps to carry out the operation.

DE BALLASTING OF SHIP

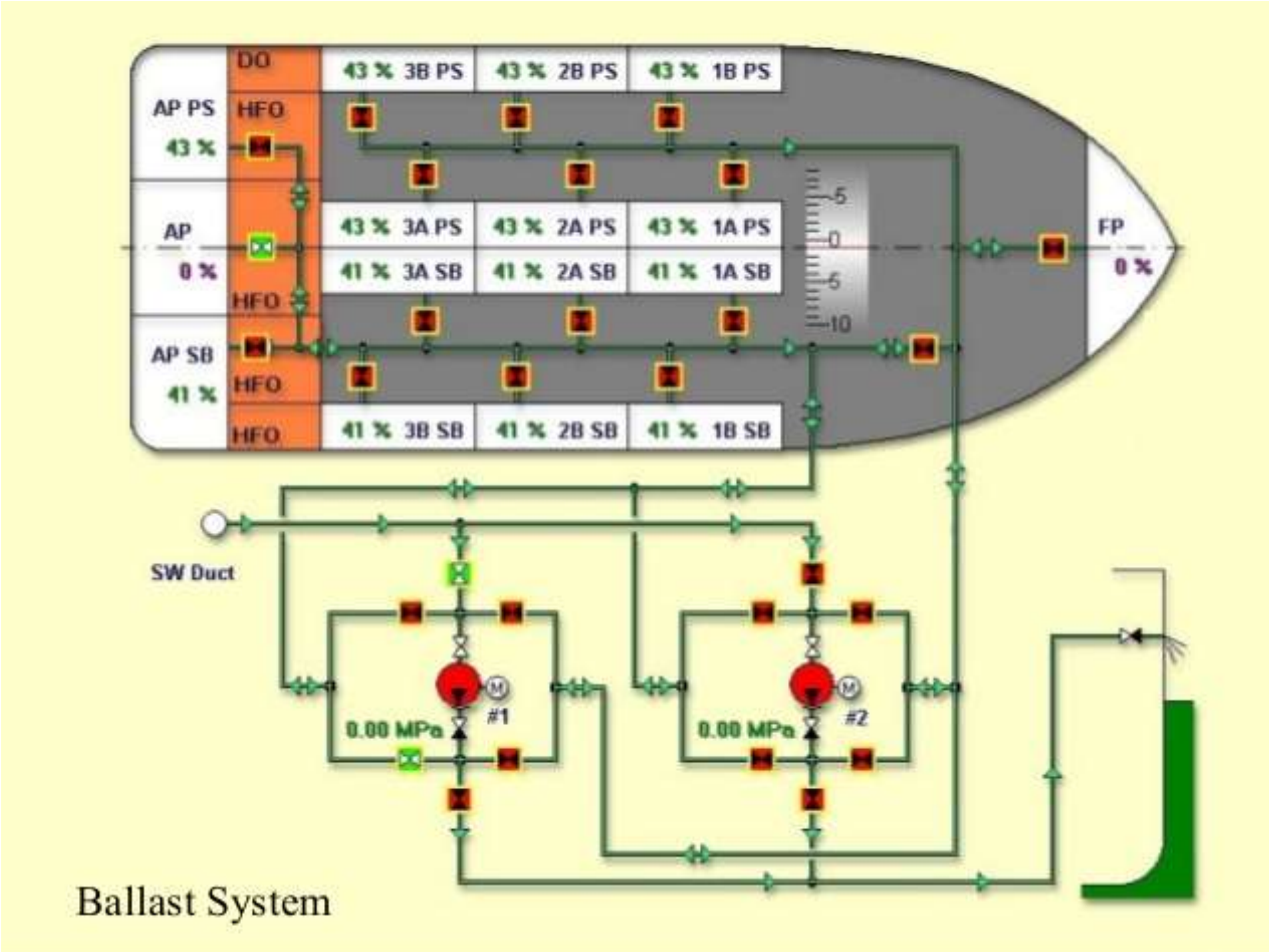
BALLASTING AND DE BALLASTING

- When no cargo is carried by the ship, the later becomes light in weight, which can affect its stability. For this reason, ballast water is taken in dedicated tanks in the ship to stabilize it. Tanks are filled with ballast water with the help of high capacity ballast pumps and this process is known as Ballasting**.**
- However, when the ship is filled with cargo, the stability of the ship is maintained by the weight of the cargo itself and thus there is no requirement of ballast water. The process of taking out ballast water from the ballast tanks to make them empty is known as de-ballasting**.**

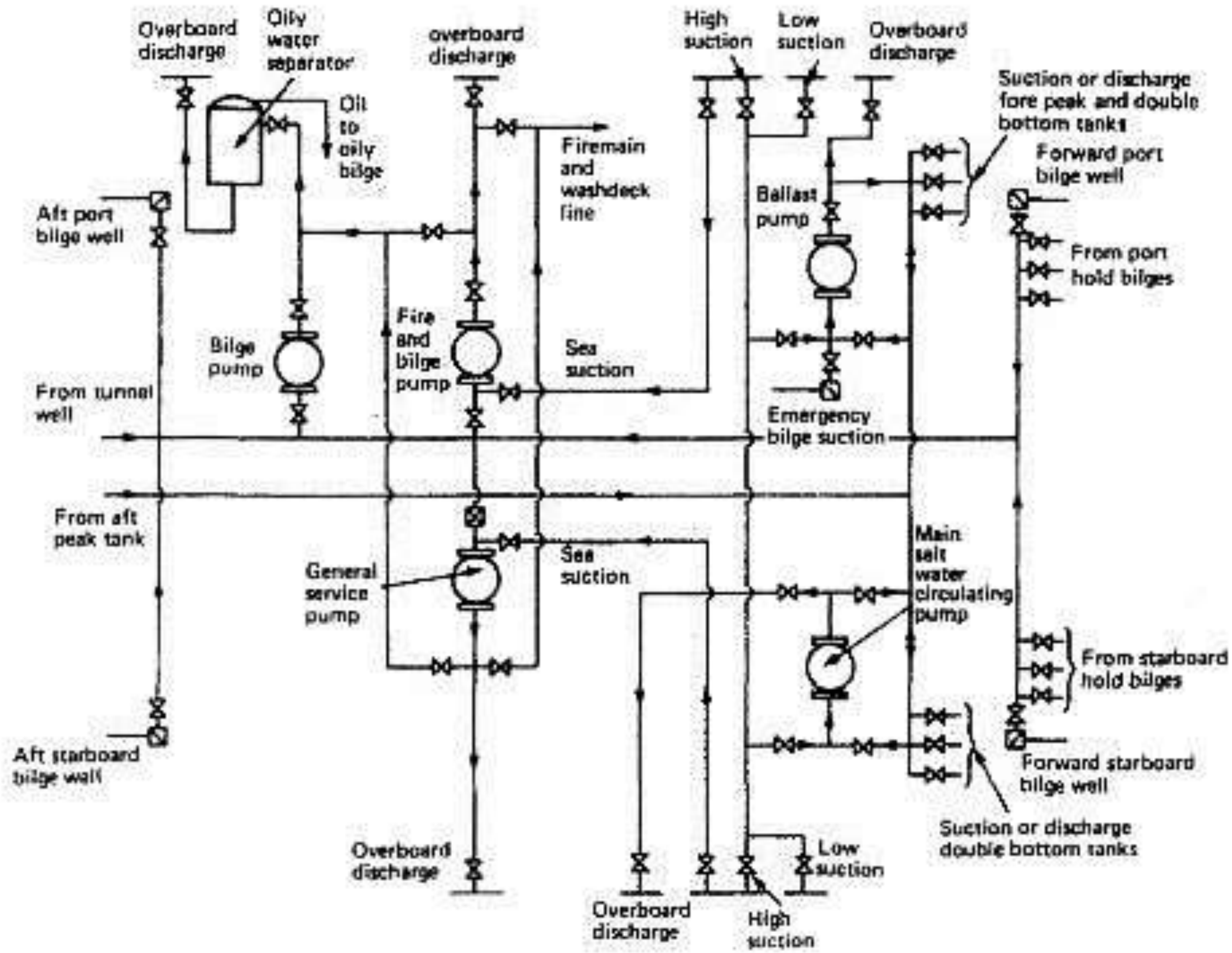
BALLAST SYSTEM



BALLAST SYSTEM IN SHIP



Ballast system



BUNKERING

- **Bunkering**
- The word “Bunker” is used to define an area to store and safeguard personnel and supplies (such as fuel, ammunition, food etc.). It was derived from a Scottish word “Bunk” which means a reserved seat or bench.
- In the shipping industry, the word bunker is used for fuel and lube oils, which are stored on a ship and used for machinery operation only. If a vessel is carrying marine fuel or lube oil to discharge it to another port, it will not be called “bunker”. If the vessel or truck is carrying it to transfer to another ship for using in its machinery, it will be termed as “bunker” and the operation performed to transport the oil is known as “bunkering”.

Types of Bunker Fuel:

- When the ship receives any kind of oil for using it in its machinery it is called a bunker fuel or bunker oil. Following are different types of bunkers which are supplied to a commercial or passenger vessel:
- – Heavy fuel oil bunker
- – Diesel oil bunker
- – Marine Gas oil bunker
- – Lube oil bunker
- – LNG fuel bunker

- The bunker fuel can be supplied to a cargo ship in different ways.
- The mode or method may vary depending upon the grade or type of fuel being delivered to the vessel.
- There can be different types of bunkering facilities which supply the required marine fuel or lube oil to the ship.
- A small barge or ship carrying bunker fuel can be used to transfer marine fuel oil (such as heavy fuel oil) to the vessel.
- If the quantity of oil is less (e.g. lube oil or MGO, LNG etc.), it can be supplied to the vessel using trucks.

BUNKERING OPERATION PROCEDURE

The bunkering procedure on a ship can be divided into three important stages:

- **Preparation**– Preparing for the bunkering operation which will involve the readiness of bunkering equipment, storage tanks and bunkering safety
- **Perform**– Performing the bunkering operation in real time as per the pre-decided procedure and receiving the marine fuel according to the bunker plan
- **Wrap-up**– Wrapping up the bunkering operation with utmost safety and ensuring the correct amount and quality of bunker fuel has been received onboard from the bunkering facilities (bunker ship or shore truck etc.)

Before Bunkering Operation

1. The chief engineer should calculate and check which bunker oil tanks are to be filled after he/she receives confirmation from the shore office about the amount of fuel to be accepted.
2. It might be required to empty some tanks and transfer the oil from one tank to other. This is required to prevent the mixing of two oils and prevent incompatibility between the previous oil and the new oil.
3. The sounding of other fuel storage tank (not be used in bunkering operation) should also be taken to keep a record of fuel already present onboard. This will help the ship's officer in case any valve is leaking, and the bunker oil is being transferred to the unwanted tank.
4. A meeting should be held between the members that will take part in the bunkering process, and they should be explained about the following:-
   - Which tanks are to be filled
   - Sequence order of tanks to be filled
   - How much bunker oil is to be taken
   - Bunkering safety procedures

Emergency procedure in case oil spill occurs

Responsibilities of each officer are explained

5. Sounding is taken before bunkering and record is made
6. A checklist is to be filled so that nothing is missed
7. All deck scuppers and save all trays are plugged
8. An overflow tank is provided in the engine room which is connected to the bunker tank and bunker line. Ensure the overflow tank is kept empty to transfer excess fuel from the bunker tanks
9. Adequate lighting at the bunker and sounding position are to be provided
10. No smoking notice should be positioned near the bunkering station

11. Onboard communication, signs, and signals to stop the operation between the people involved in bunkering are to be understood by all the crew involved in the operation.
12. Red flag/light is presented on the masthead
13. Opposite side bunker manifold valves are closed and appropriately blanked
14. Vessel draught and trim is recorded before bunkering
15. All equipment in SOPEP(shipboard oil pollution emergency plan) locker are checked and kept near the bunkering station
16. When bunker ship or barge is secured to the ship side, the person in charge on the barge is also explained about the bunker plan
17. Bunker supplier's paperwork is checked for the oil's grade and the density if they are as per the specification
18. The pumping rate of the bunker fuel is agreed with the bunker barge/ bunker truck

Related Reading: What is Cappuccino Bunker Effect On Ships?

19. The hose is then connected to the manifold. The condition of the hose must be checked properly by the ship staff and if it is not satisfactory, same to be notified to the chief engineer
20. Most of the bunker supplier send there crew to connect the bunker oil pipeline coming from bunker ship/ barge. The ship staff must recheck the flange connection to eliminate the doubt of any leakage
21. Once the connection is made, the chief engineer will ensure all the line valves which will lead the bunker fuel to the selected bunker tanks are open, keeping the main manifold valve shut
22. Proper communication between the barge and the ship is to be established23. Sign and signals are to be followed as discussed in case of communication during an emergency
24. Most bunkering facilities (ship/ barge/ terminal/ truck etc.) provide an emergency stop switch which controls the bunkering supply pump. Ensure to check its working before commencing the operation
25. Once all the checks are done, the manifold valve is open for bunkering

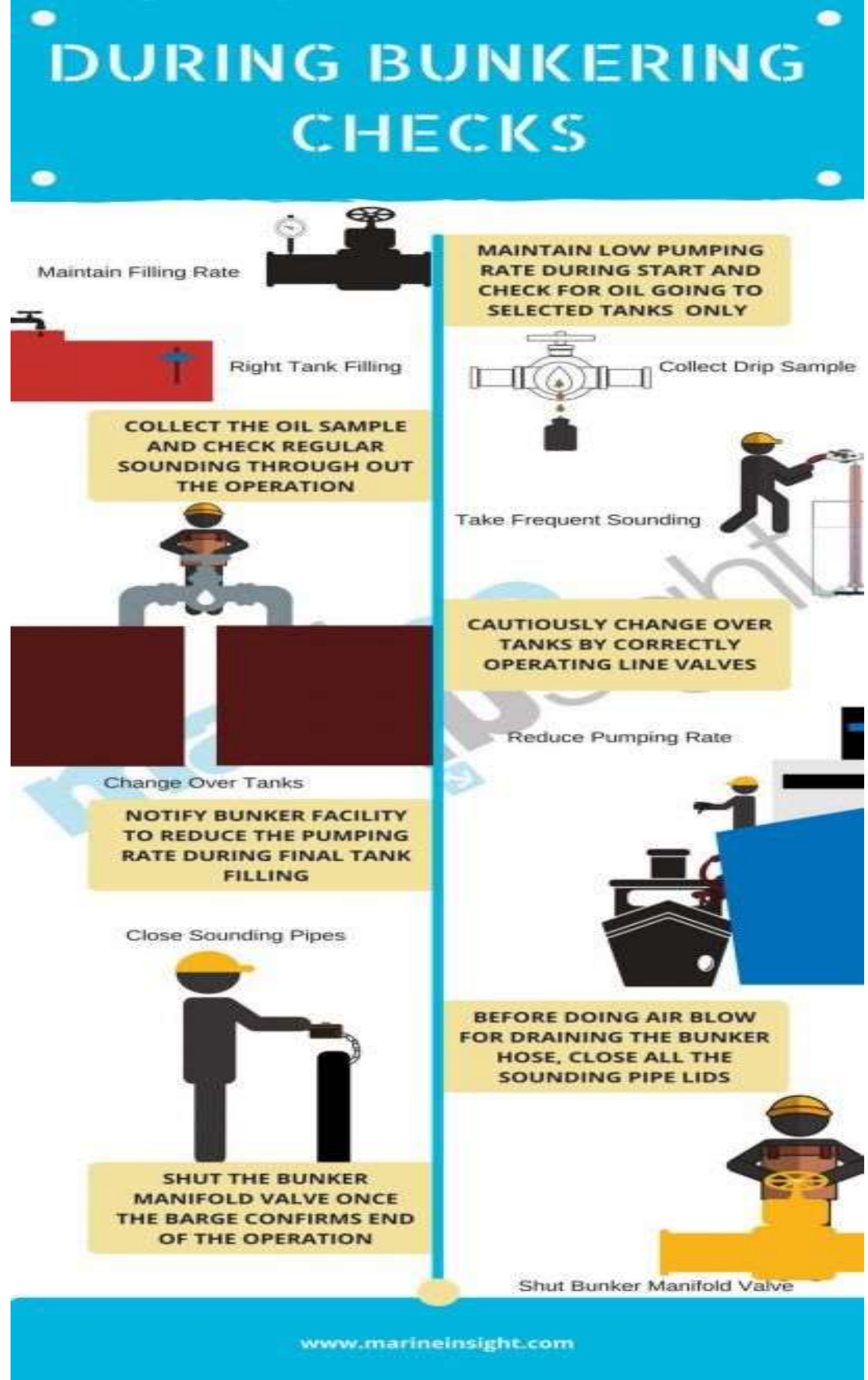
DURING BUNKERING

1. During the start of the bunker, the pumping rate is kept low; this is done to check that the oil is coming to the tank to which the valve is opened
2. The ship staff must track the sounding of selected bunkering tank and other tanks which are not involved in the operation to ensure oil is only going to the selected tank
3. After confirming the oil is coming to the proper tank, the pumping rate is increased as agreed before
4. Generally, only one tank filling is preferred because gauging of more than one tank at a time increases the chances of overflow
5. The max allowable to which tank is filled is 90 %, and when the tank level reaches about to maximum level, the barge is told to pump at low pumping rate to top up the tank, and then the valve of other tank is opened
6. During bunkering, sounding is taken regularly and the frequency of sounding is more when the tank is near to full. Many vessels have tank gauges which show tank level in the control room, but this is only to be relied upon if the system is working correctly.

Related Read: How and Why to Take Manual Sounding On Ship?

7. The temperature of the bunker oil is also to be checked; generally, the barge or supplier will provide the bunker temperature. Temperature is a critical parameter, especially for bunker fuel such as heavy fuel oil, and any deviation in the provided temperature value may lead to a shortfall in bunker supply
8. A continuous sample is taken during bunkering with the help of sampling cock at the manifold
9. The crew needs to switch (open and close the valves) the internal storage tanks to accommodate the quantity of the bunker oil being supplied. Utmost precaution needs to be taken when opening the other
10. storage tank valve and closing the valve of the tank which is reaching the maximum fill limit.


BEFORE BUNKERING CHECKS
BUNKER SHIP/ BARGE IS SECURELY MOORED TO THE SHIP AND MEANS OF ACCESS IS RIGGED
Bunker Barge Moored
Scupper Plugged
ARRANGE SOPEP EQUIPMENT AND PLUG SCUPPERS / SAVEALL TRAYS
SOPEP Arranged
Drip Tray Plugged
Communication Established
ESTABLISH COMMUNICATION WITH BUNKER SHIP/ BARGE AND FIX EMERGENCY SIGNALS
Emergency Signals Discussed
Connection Checked
CHECK THE SUPPLY CONNECTION AND PASTE DISPLAY SIGNS AND RELEVANT INFO
No Smoking Sign
Check Frequent Sounding
CHECK THE SOUNDING IN THE SUPPLIERS TANK AND LINE THE SHIP'S TANK VALVES TO RECEIVE BUNKER OIL
Line Tank Valves
FILL ALL RELEVANT CHECKLISTS AND TAKE SIGN OF MASTER, AND BUNKER SHIP INCHARGE
Follow and Fill Checklists
www.marineinsight.com


DURING BUNKERING CHECKS
Maintain Filling Rate
MAINTAIN LOW PUMPING RATE DURING START AND CHECK FOR OIL GOING TO SELECTED TANKS ONLY
Right Tank Filling
Collect Drip Sample
COLLECT THE OIL SAMPLE AND CHECK REGULAR SOUNDING THROUGH OUT THE OPERATION
Take Frequent Sounding
CAUTIOUSLY CHANGE OVER TANKS BY CORRECTLY OPERATING LINE VALVES
Reduce Pumping Rate
Change Over Tanks
NOTIFY BUNKER FACILITY TO REDUCE THE PUMPING RATE DURING FINAL TANK FILLING
Close Sounding Pipes
BEFORE DOING AIR BLOW FOR DRAINING THE BUNKER HOSE, CLOSE ALL THE SOUNDING PIPE LIDS
SHUT THE BUNKER MANIFOLD VALVE ONCE THE BARGE CONFIRMS END OF THE OPERATION
Shut Bunker Manifold Valve
www.marineinsight.com

AFTER BUNKERING

1. Once the bunker is finished, it is a general practice to air blow the bunkering supply line for discharging all the oil trapped in the pipelines. At this stage, ensure all sounding pipe caps are closed and keep a watch on those storage tank vents which are at its maximum limit.
2. Avoid opening the bunkering supply line connecting between bunker ship and receiving manifold. In case of any discrepancy, the supplier may agree to compensate the shortfall and may resume bunkering operation

Related Reading: 13 Malpractices In Bunkering Operations Seafarers Should Be Aware Of

3. Draught and trim of the ship is checked
4. Take sounding of all the tanks bunkered
5. The volume bunkered should be corrected for trim, heel and temperature correction
6. In general, for each degree of increase in temperature the density should be reduced by 0.64 kg/m3.

Related Read: 3 Important Calculations Every Marine Engineer Must Know

7. Four samples are taken during bunkering. One is kept onboard, one for the bunker ship or barge, one for analysis, one for port state or IMO
8. The chief engineer will sign the bunker receipt (BDN) and the amount of bunker received
9. If there is any shortfall of bunker received the chief engineer can issue a note of protest against the barge/supplier (in case the deficit is not agreed by the bunker supplier)
10. After everything is settled, the hose connection is removed
11. The sample is sent for laboratory analysis
12. The chief engineer will make the entry of the operation in oil record book along with received BDN

12. The new bunker should not be used until the report from the lab

THINGS TO BE DONE AFTER BUNKERING

Unit -4

MARINE AUXILIARY MACHINERY

TOPICS TO BE COVERED

- PRINCIPLE OF SURFACE HET TRANSFR
- SHELL & TUBE HEAT EXCHANGER
- PLATE TYPE HEAT EXCHNGER
- HEATER & COOLER
- L.O COOLER, FRESHWATER COOLER, M.E. AIR COOLER
- F.W HEATER
- CONDENSOR & EVAPORATOR
- DISTILLATION PROCESS
- SCALING PROBLEM AND METHODS TO AVOID
- METHODS OF DISTILLATION
- PRINCIPLE BEHIND HIGH EFF. DISTILLATION PLANT
- LPVE
- FLASH EVAPORATOR
- MULTIPLE EFFECT EVAPORATOR
- SALT WATER LEAK DETECTION- SALINOMETER
- R.O DISTILLATION PROCESS

PRINCIPLE OF SURFACE HEAT TRANSFER

Conduction: This is the transfer of heat through a solid. For example, heat generated inside an enclosure is transferred to the outer surface by means of conduction.

Convection: Convection is the transfer of heat from a surface by means of a fluid such as air. Natural convection occurs as air is heated: it expands, rises, and is replaced by cooler air. The amount of convection may be increased by using a fan to increase the flow of air.

Radiation*:* This is a process where energy is radiated through the air by means of electromagnetic radiation. Although effective for high temperature sources such as the sun, it’s less effective at ambient temperatures on earth.

Evaporation: The latent heat of a fluid can be used to transfer heat by absorbing the energy required to evaporate that fluid. The heat absorbed is released by allowing the fluid to condense outside the enclosure.

Passive Cooling

- Passive cooling, the reliance on natural conduction, convection and radiation, is suitable for lightly loaded enclosures that have relatively large surface areas and good ventilation. The ambient air temperature must be lower than the enclosure temperature. This method is not suitable for temperature-sensitive components in high ambient temperatures.

Forced Ventilation

- The effectiveness of convection can be increased by the use of fans that increase the flow of air through the enclosure. Cool air is drawn into the bottom of the enclosure and hot air discharged at the top. Fans should be fitted with filters to limit the ingress of dirt that could harm components. To ensure the electrical components do not get too hot, the ambient temperature must be well below the maximum desired enclosure temperature.

Heat Pipe Technology

- Heat pipes, first developed in the 1960s, are an almost energy-free method of enclosure cooling. A heat pipe consists of an evacuated copper tube partially filled with a fluid such as alcohol or water. Due to the low pressure, the fluid at the bottom of the pipe boils when it absorbs heat from the air inside an enclosure. The vapour rises to the top of the tube, where it is cooled by the air outside the enclosure and condenses. The condensed fluid then returns to the bottom of the tube and the cycle repeats.

Enclosure Air Conditioning

- Air conditioning also utilizes evaporation, but in a slightly different way. A refrigerant liquid, under pressure, is passed through an expansion device. The drop in pressure causes the liquid to evaporate in the air conditioner's evaporator coil and absorb heat, cooling the air inside an enclosure. The hot gas is then compressed and passed through a condenser coil, where the gas liquefies, giving up its heat to the air outside the enclosure. An enclosure air conditioner represents an extremely effective method of cooling an enclosure and will work efficiently even if the ambient temperature is much higher than the enclosure's air temperature.

WHERE ARE WE USING THE HEAT EXCHANGER ON BOARD SHIP

- PROPULSION PLANT
- MAIN ENGINE COOLERS AND HEATERS
- EVAPORATOR SYSTEM
- AC AND REFRIGIRATION SYSTEM
- AIR STARTING SYSATEM & FUEL INJCTION SYSTEM
- STEERING COOLEING AND HEATING SYSTEM
- DOMESTIC FRESHWATER HEATER SYSTEM
- BOILER EVAPORATION SYSTEM AND DISTILLATE SYSTEM IN SHIP
- HYDRAULIC SYSTEM IN SHIP
- BOILER CONDENSOR AND PREHEATER SYSTEM
- CENTRAL COOLING SYSTEM
- TANK HEATING SYSTEM

COOLING SYSTEM

- **Sea Water cooling system:** Sea water is directly used in the machinery systems as a cooling media for heat exchangers.

- **Freshwater or central cooling system:** Fresh water is used in a closed circuit to cool down the engine room machinery. The fresh water returning from the heat exchanger after cooling the machinery is further cooled by sea water in a sea-water cooler.

WHY HEAT EXCHANGER ?

- The machinery systems fitted on board ships are designed to work with maximum efficiency and run for long hours. The most common and maximum energy loss from machinery is in the form of heat energy.
- This loss of heat energy has to be reduced or carried away by a cooling media, such as central cooling water system, to avoid malfunctioning or breakdown of the machinery.

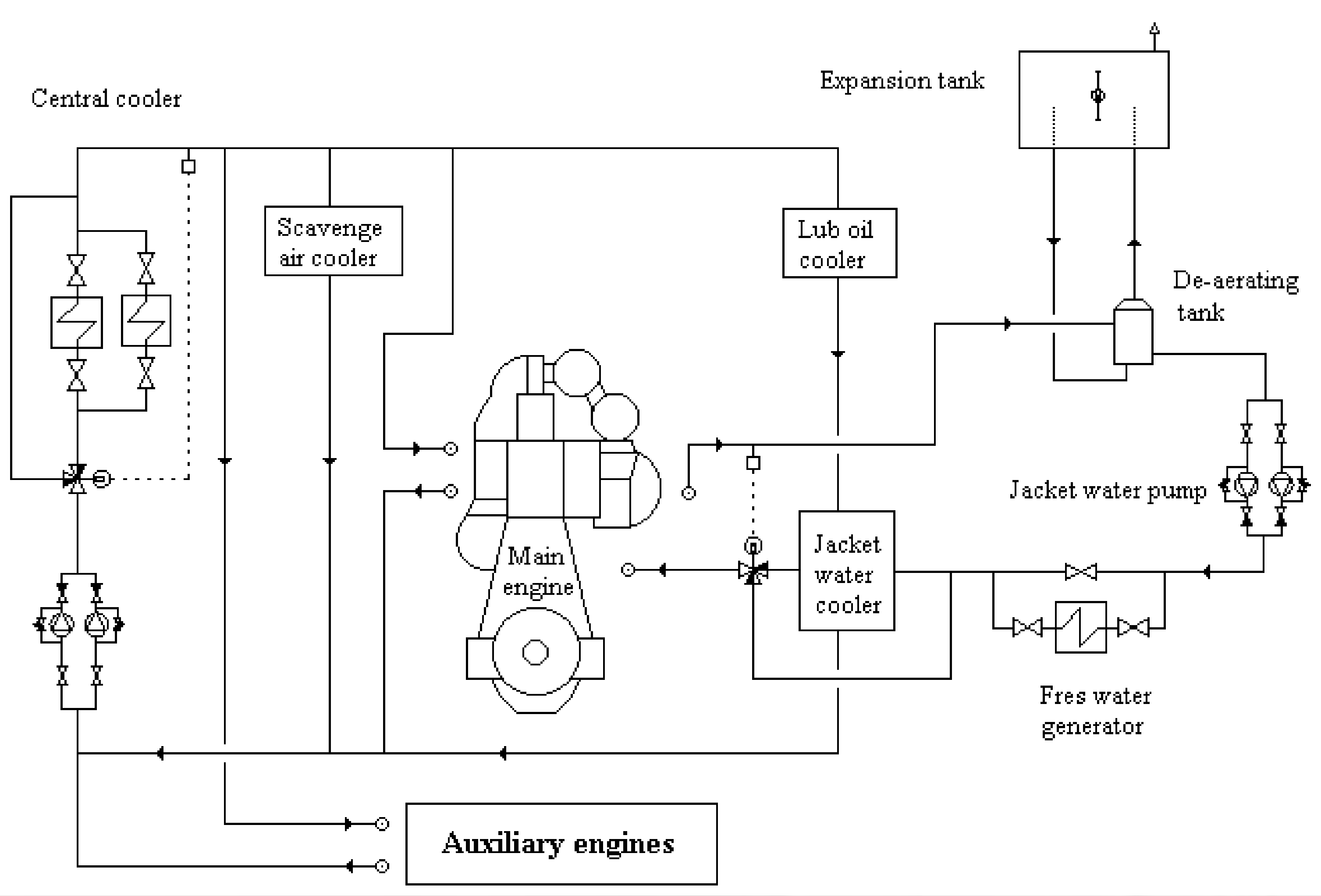
COOLING OF MAIN ENGINE

- Cooling enables the engine metals to retain their mechanical properties.
- The usual coolant used is fresh water: sea water is not used directly as a coolant because of its corrosive action.
- Lubricating oil is sometimes used for piston cooling since leaks into the crankcase would not cause problems. As a result of its lower specific heat however about twice the quantity of oil compared to water would be required.

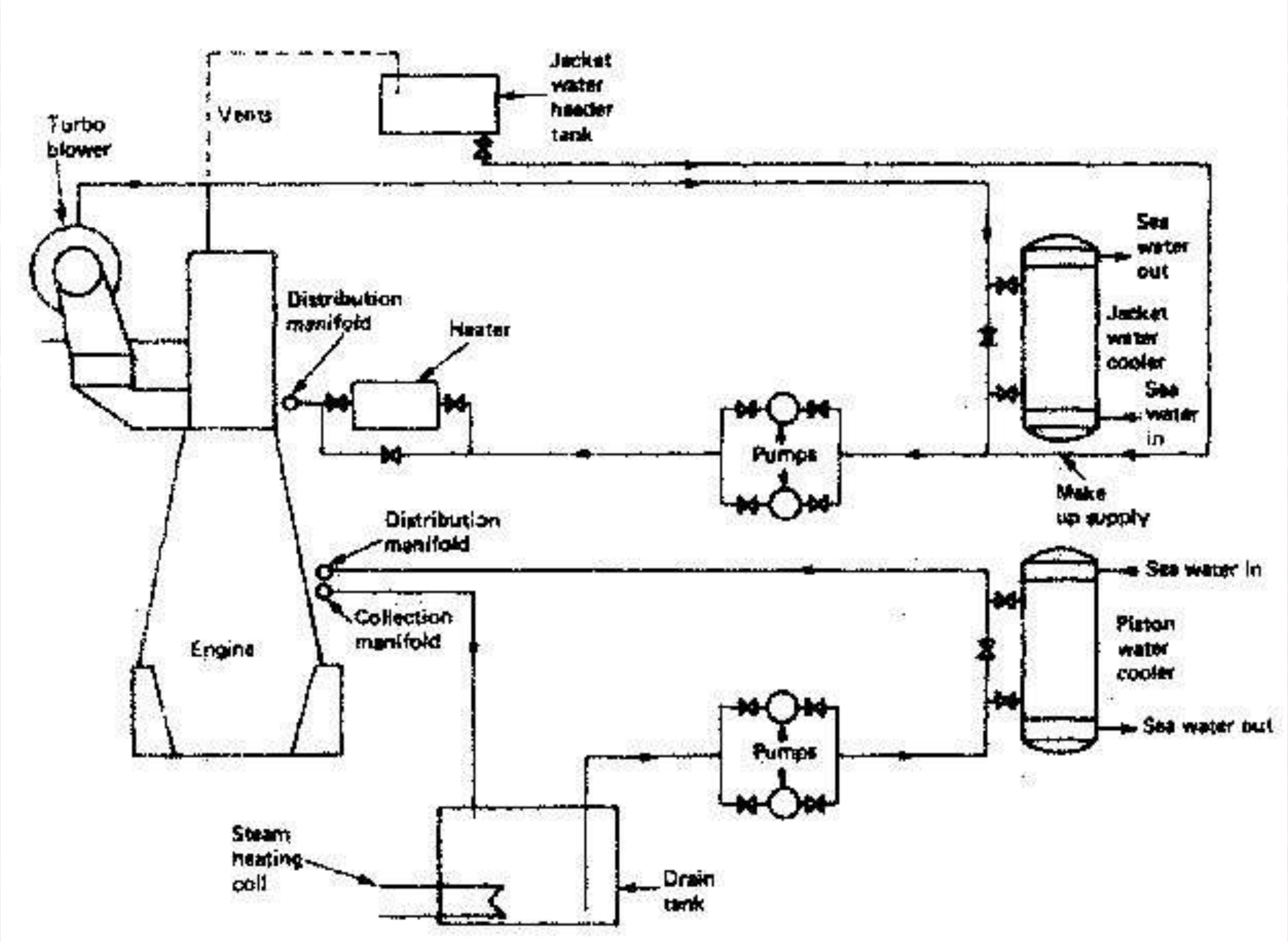
  Water carried in pipes is used to cool machinery.
- The main engine is cooled by two separate but linked systems: an open system (sea-to-sea) in which water is taken from and returned to the sea (seawater cooling), and a closed system where freshwater is circulated around an engine casing (freshwater cooling).
- Freshwater is used to cool machinery directly, whereas seawater is used to cool freshwater passing through a heat exchanger.

- The particular feature of an engine cooling system is continuous fluid flow.
- Fluid in motion causes abrasive corrosion and erosion. To reduce the effects of turbulent flows, seawater systems incorporate large diameter mild steel pipes, the ends of which open to the sea through sea chests where gate valves are fitted.
- If a seawater cooling pipe bursts, both suction and discharge valves will have to be closed to prevent engine room flooding.
- In order to make sure the valves operate correctly when you need them to, open and close them at regular, say monthly, intervals. Seawater pipes are usually mild steel, but galvanised steel, copper or copper alloy are also used.
- Freshwater cooling pipes are generally made of mild steel.

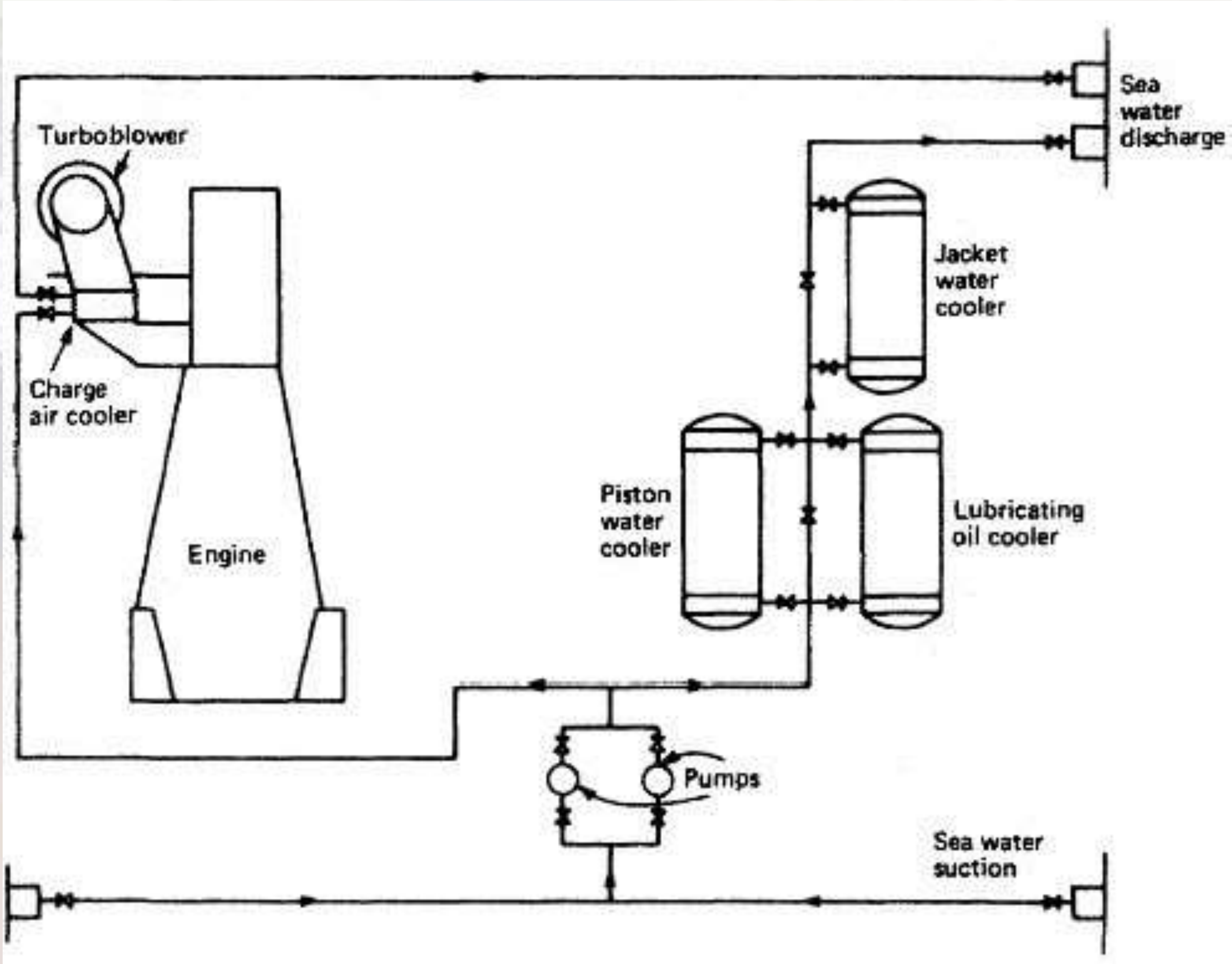
MAIN ENGINE COOLING SYSTEM



FRESH WATER COOLING SYSTEM



SEA WATER COOLING SYSTEM



EXPANSION TANK

- The loss in the closed circuit of the central cooling fresh water system is continuously compensated by the expansion tank which also absorbs the increase in pressure due to thermal expansion.

TEMPERATURE CONTROL VALVES

- The heat absorbed by the H.T circuit is transferred to L.T circuit at temperature control valve junction.
- The outlet temperature of the main engine cooling water is kept constant at 85-95 by means of temperature control valves by mixing water from the two central cooling system i.e. LT system into the HT system.

WHAT ARE THE TYPES OF COOLING SYSTEM

Low-temperature circuit

The low-temperature circuit is used for low-temperature zone machinery and this circuit is directly connected to the main sea water central cooler; hence its temperature is lower than that of high temperature (H.T circuit). The L.T circuit comprises of all auxiliary systems.

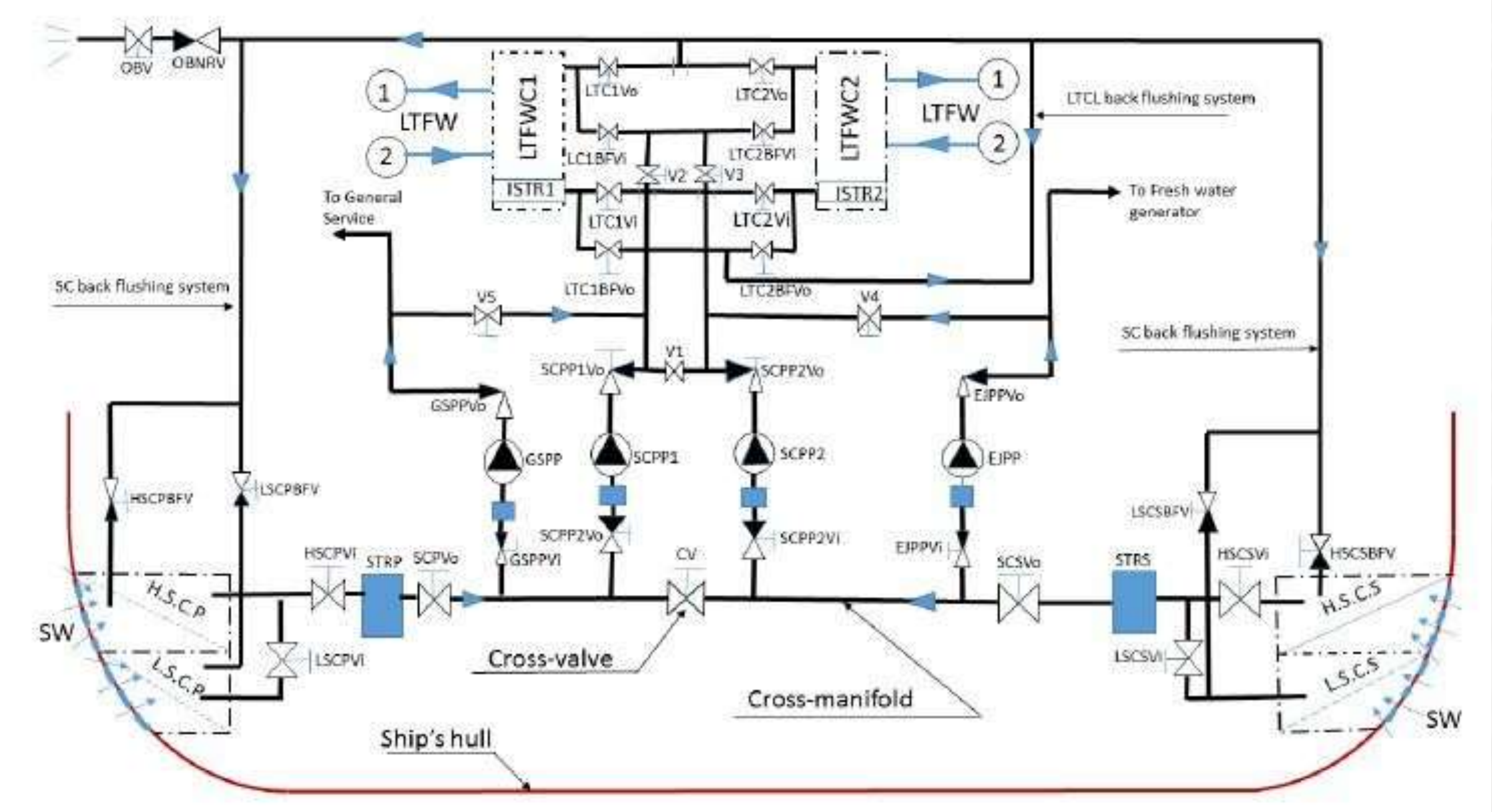
- The total quantity of low-temperature or L.T fresh water in the system is maintained in balance with the H.T. fresh water cooling system by an expansion tank which is common to both systems.
- The expansion tank used for these circuits is filled and makeup from the hydrophore system or from the distilled water tank using the F.W. refilling pump.

High-temperature circuit

- The H.T circuit in the central cooling system mainly comprises of jacket water system of the main engine where the temperature is quite high. The H.T water temperature is maintained by low-temperature fresh water and the system normally comprises of jacket water system of the main engine, FW generator, DG during standby condition, Lube oil filter for stuffing box drain tank.
- The HT cooling water system is circulated by electrical cooling water pumps, one in service and one standby.
- During standby, the DG is kept warm by the circulating system from the DG in service.

When ME is stopped, it is kept warm by HT cooling water from DG. If this is insufficient, the water may be heated by steam heated FW heater.

CENTRAL COOLING SYSTEM



POINTS TO REMEMBER

- The cooling water in the system to be treated with chemicals
- The makeup of central cooling system normally takes place from FW expansion tank, which is filled with drinking and wash water system, or, from the distilled water tank using the FW refilling pump
- If it is necessary to refill the system with a larger amount of water, this shall be supplied from the distilled water tank by the FW refilling pump via the LT system connection
- During overhaul/repair of the main engine, which requires FW cooling water inlet and outlet valves to be closed, the FW cooling pump and high-temperature circulation must be stopped and air to control valve must be closed
- In standby condition, the transfer of surplus heat from diesel generators can be used for FW generator service. In the feed water inlet to the FW generator evaporating section the high load orifice is to be replaced with the low load orifice, see maker's instruction.
- The circulating rate will depend on sea water temperature, engine load, the pressure drop across pumps and required heat removal from the system. The circulating rate can be adjusted by operating one or more pumps
- Generally, two fresh water pumps are installed and one complete spare pump is stored close to the working pumps area for quick installation in case one of the working pumps should fail
- The central coolers in the fresh water system are generally of plate type with plates of titanium material
- In the case of manual cleaning, the F.W. inlet and outlet valves shall be closed. In the case of chemical cleaning of S.W. side the F.W. side may be kept open.

CENTRAL COOLING SYSTEM

ADVANTAGES OF CENTRAL COOLING SYSTEM

- **Low maintenance cost:** As the system runs with fresh water, the cleaning, maintenance and component replacement reduces.
- **Less corrosion:** Since the sea water system is only in the central part, the corrosion of pipes and valves decreases.
- **The Higher speed of fluid hence better heat exchange:** Higher speed is possible in the fresh water system which results in reduced piping and low installation cost.
- **Use of cheaper materials:** Since the corrosion factor decreases, expensive materials are not required for valves and pipelines.
- **Constant temperature level maintained:** Since the temperature controlled is irrespective of sea water temperature, stable temperature is maintained which helps in reducing machinery wear down.
- **Less wear of engine parts:** Less wear of cylinder liner as the jacket is maintained warm avoiding cold corrosion.
- **Ideal for unmanned engine room:** The greater reliability and temperature controlling of the system offered by the central cooling system makes it an ideal choice for unmanned engine room

DISADVANTAGES OF THE CENTRAL COOLING SYSTEM

- High installation cost
- Limitation of low temperature

CONTROL OF TEMERATURE IN HEAT EXCHANGER

- TO BYPASS A PORTION OR ALL OF THE FLUID FLOW
- TO BYPASS OR LIMIT THE A SEA WATER FLOW
- TO CONTROL SEAWATER TEMPERATURE BY SPILLING PART OF SEAWATER DISCHARGE BACK IN TO PUMP SUCTION

HEAT EXCHANGER

- Different types of heat exchangers are used on board a ship.
- The type of heat exchanger used for a particular usage depends on the application and requirement.
- Almost all the systems on-board ship depends on heat exchanger where the fluid is either cooled or heated.

Shell and Tube Type Heat Exchanger

- This is the most popular type design with a shell accompanying several tubes and the flow of liquid to be cooled is mainly through tubes, whereas the secondary liquid flows over the tube inside the shell.
- Shell and tube type heat exchanger is extremely economical to install and easy to clean; however, the frequency of maintenance is higher than other types.
- In this heat exchanger, the complete shell is fitted with a tube stack or commonly known as the shell.
- There are two end plates which are sealed on both the sides of the shell and a provision is made at one end to cater for the expansion.
- The cooling liquid passes through the tubes which are sealed on either end into the tube plate.
- The tubes are secured in the tube plate by bell mouthing and expansion.

- The shell is enclosed with water chambers which surround the tube plates completely. The coolers could either be single pass or double pass exhibiting the flow of cooling liquid.
- Gaskets are fitted between the tube plates and the shell; similarly, between the tube plate and the end cover to cater to the leakages from the cooler.
- The other side of the tube plate, which is not fixed is free to move and has seals on either side of a safety expansion ring.
- The cooling liquid or the liquid to be cooled could then leak out and will hence be visible preventing any intermixing or contamination.
- The main engine cooling freshwater cooler and the main engine lube oil cooler have conventionally been circulated with seawater, which apparently passes through the tubes of the cooler.

- The shell, on the contrary, is in contact with the liquid being cooled, mainly lub.
- oil or distilled freshwater with corrosion-inhibiting chemicals which are added directly to the expansion tanks to keep a think protective layer inside the pipelines, thus preventing corrosion.

Rocor NB liquid

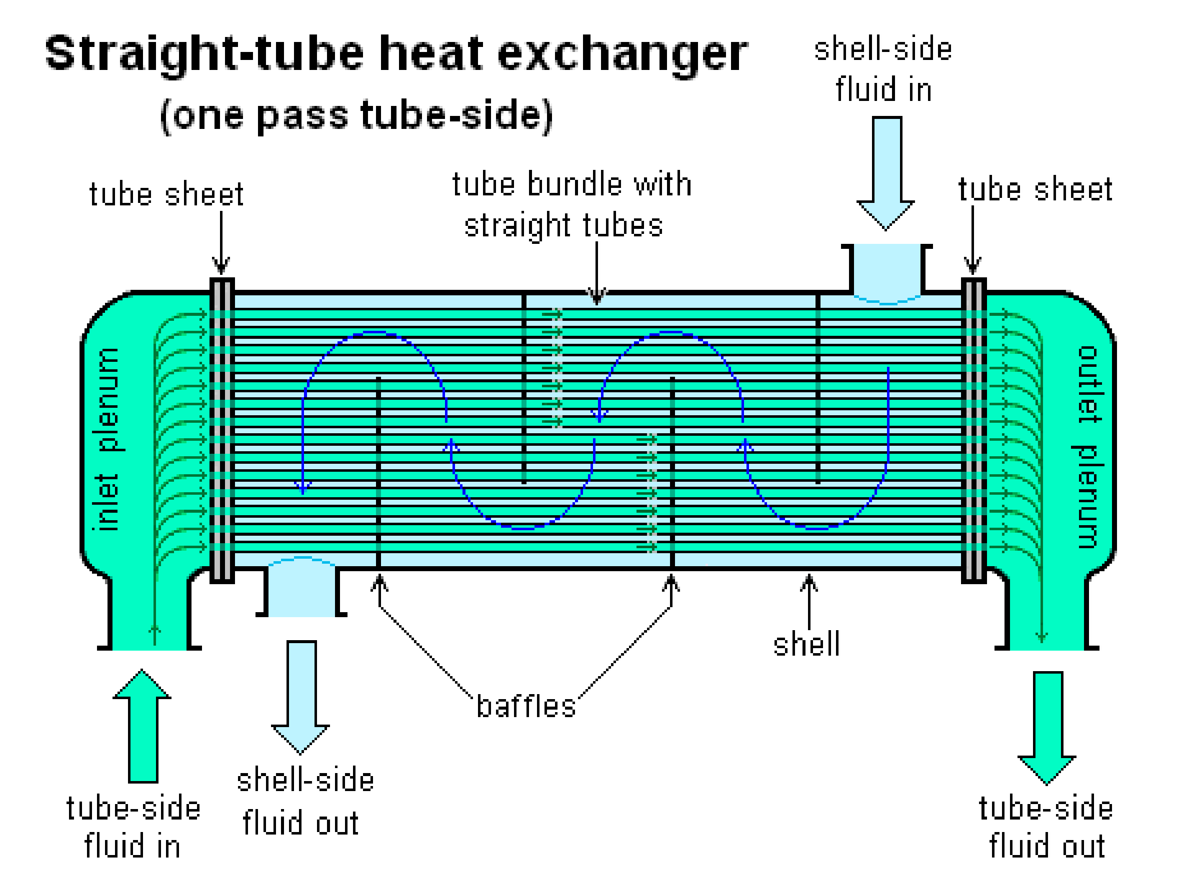
which is generally used for corrosion inhibition. The shell could be of cast iron or steel.

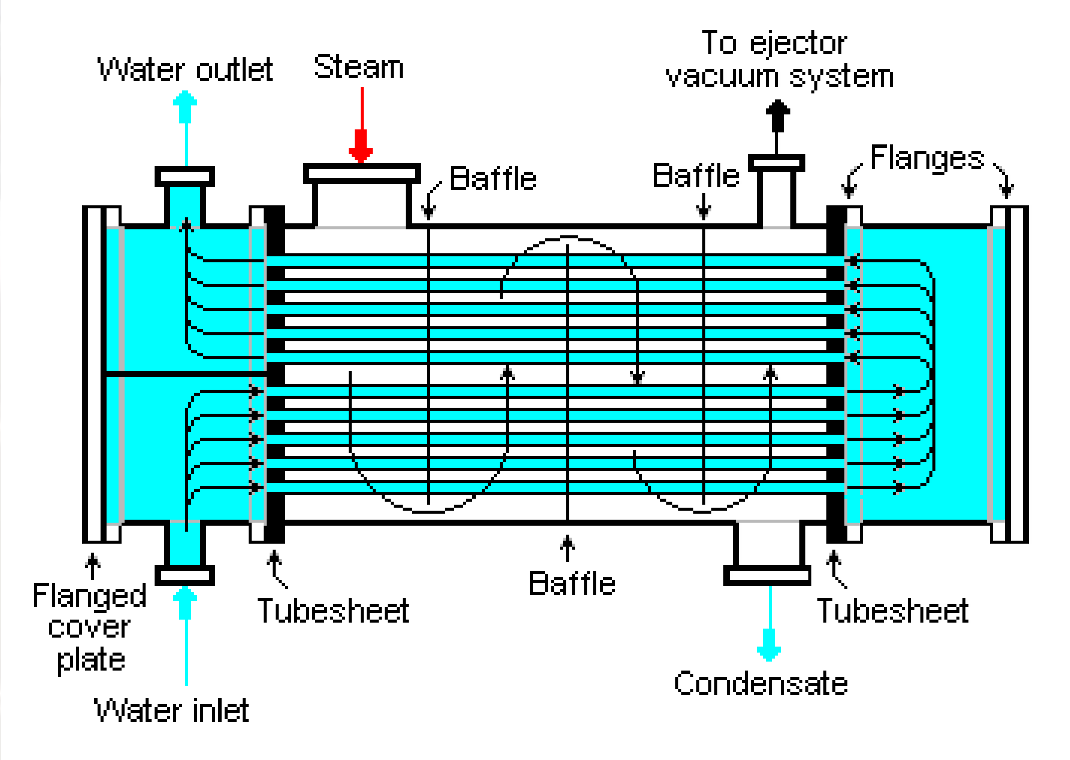
- It is recommended that the coolers are installed vertically to ensure the automatic venting of the air from the system, as the airlock causes excessive overheating and will reduce the effective cooling surface area of the liquid being cooled.
- Baffles are fitted on the tube bundle which lead the liquid to be cooled up and down, thus increasing the effective surface area of cooling.
- They also support the tubes, providing strength and rigidity to the bundle.
- Aluminium brass is generally used for the construction of the tubes which is 76% copper; 22% zinc and 2% aluminium.
- Sacrificial anodes are used in the seawater side for corrosion prevention as they corrode first and prevent the material with seawater being the electrolyte.
- The tubes could fail prematurely as the water could be polluted in coastal areas or because of excessive turbulence due to seawater flow rates. The water impinges at a high velocity and hence could fail the tubes.
- Thus, the velocity of seawater should be kept below 2.5 m/s in case of aluminium brass. A little turbulence is required which eventually reduces the silting and settlement in the tubes.

WITH RESPECT TO FLOW FO THE FLUID

- **Opposite Flow** : Primary medium (to be cooled) and secondary medium (which is cooling the primary medium) enters in the heat exchanger in the opposite direction to each other.
- **Cross flow** : Primary and secondary medium enters in an exchanger perpendicular to each other.
- **Parallel flow** : Primary and secondary medium both enter the heat exchanger parallel to each other.

SHEEL AND TUBE HEAT EXCHANGER





OPERATION OF SHELL & TUBE TYPE COOLER

- A leak test of the piping is supposed to be carried out before the shell and tube type cooler is used for the actual operation.
- The cooling liquid and the liquid to be cooled should be circulated, flushed and checked for leakages.
- It is generally advised to run clean cooling fluid in the tubes during the initial phase of circulation as the debris can erode the protective layer in the tubes.
- The seawater inlet and outlet valves are kept fully open generally but the liquid to be cooled could be bypassed if needed by a three-way temperature control valve.
- Vents are provided on either side of the medium, mainly the cooling liquid and the liquid to be cooled.
- The vents should be opened first after the initial circulation of fluids or after maintenance to purge off the air which could increase the temperature difference considerably.
- Drain plugs are mounted in the coolers at the lowest points so as to drain the cooler completely while maintenance. Single-pass, vertically mounted coolers will ensure automatic venting but with the horizontally mounted coolers the inlet cooling water branch should be faced downwards and the outlet water should be faced upwards for automatic venting of the air.

TUBE PLATES

- Naval brass tube plates are used with aluminium bass tubes. Tube stacks are made up to have a fixed tube plate at one end and a tube plate at the other end which is free to move with the expansion of the tubes. Other materials found in service are gunmetal, aluminium bronze and sometimes special alloys.

TUBE STACK

- The tube stack is fitted with alternate disc and ring baffles. The fixed end tube stack is sandwiched between the casing and the water box.
- If the joints leak at the other end the special ‘tell-tale’ ring will allow the liquids to escape without mixing. The joint rings are of synthetic rubber.

WATER BOXES & COVERS

- Easily removable covers on water boxes permit repairs and cleaning to be carried out.
- The covers and water boxes are commonly of cast iron or fabricated from mild steel.
- Where they have been coated with rubber or a bitumestic type coating, the iron or steel has been protected but has provided no protection for tubes and tube plate.
- Uncoated ferrous (iron) materials in water boxes provided a protective film on the tubes as the unprotected iron itself corrodes, products of corrosion coating the tubes. The iron also gives some measure of cathodic protection.

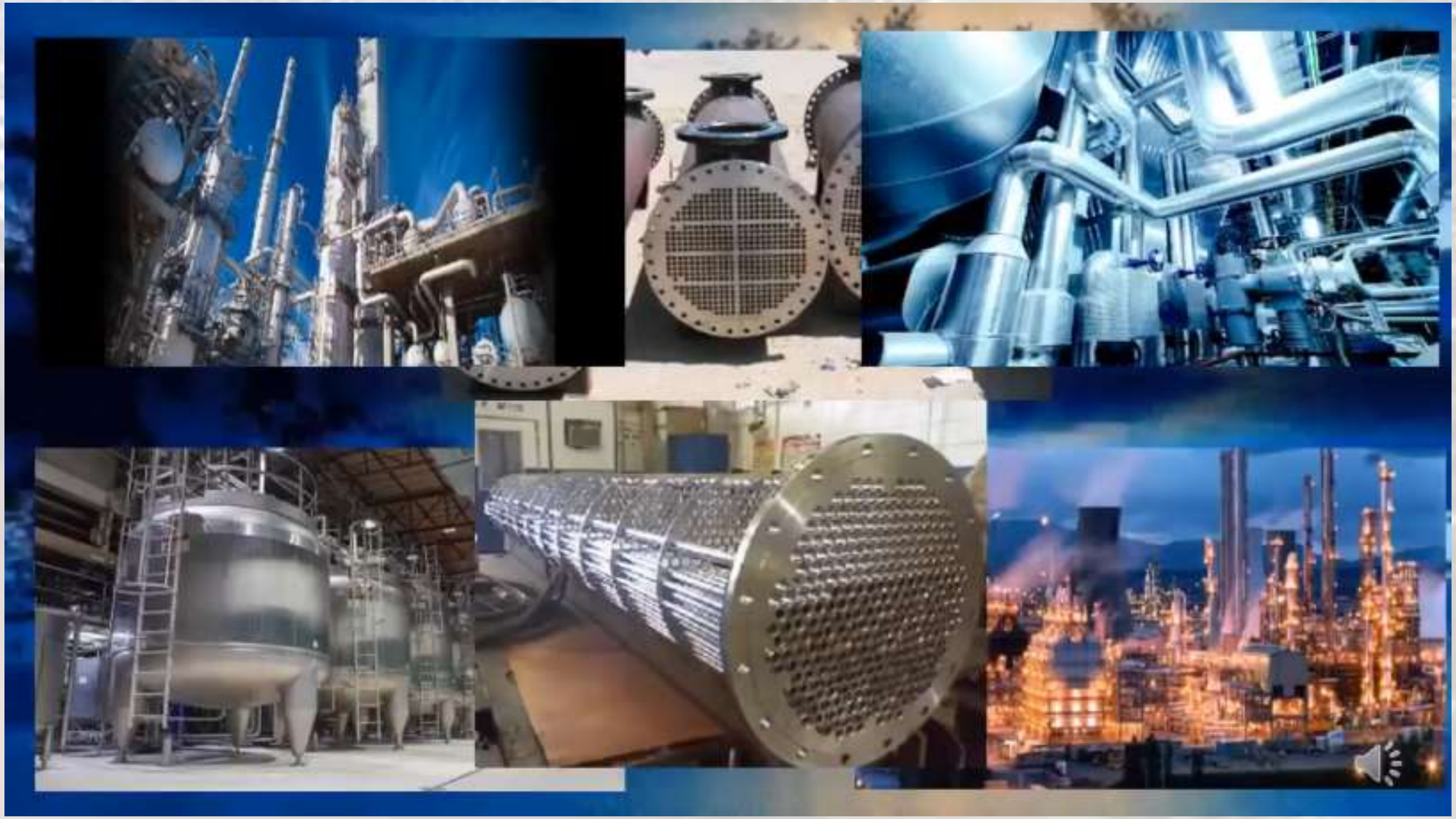
SHELL

- The shell or cylinder is fabricated or cast. It is in contact with the liquid being cooled. This may be oil, with which there is no corrosion problem, or water, which is normally inhibited against corrosion. The material is not critical (provided it is not reactive with any inhibiting chemicals) because it is not in contact with seawater.

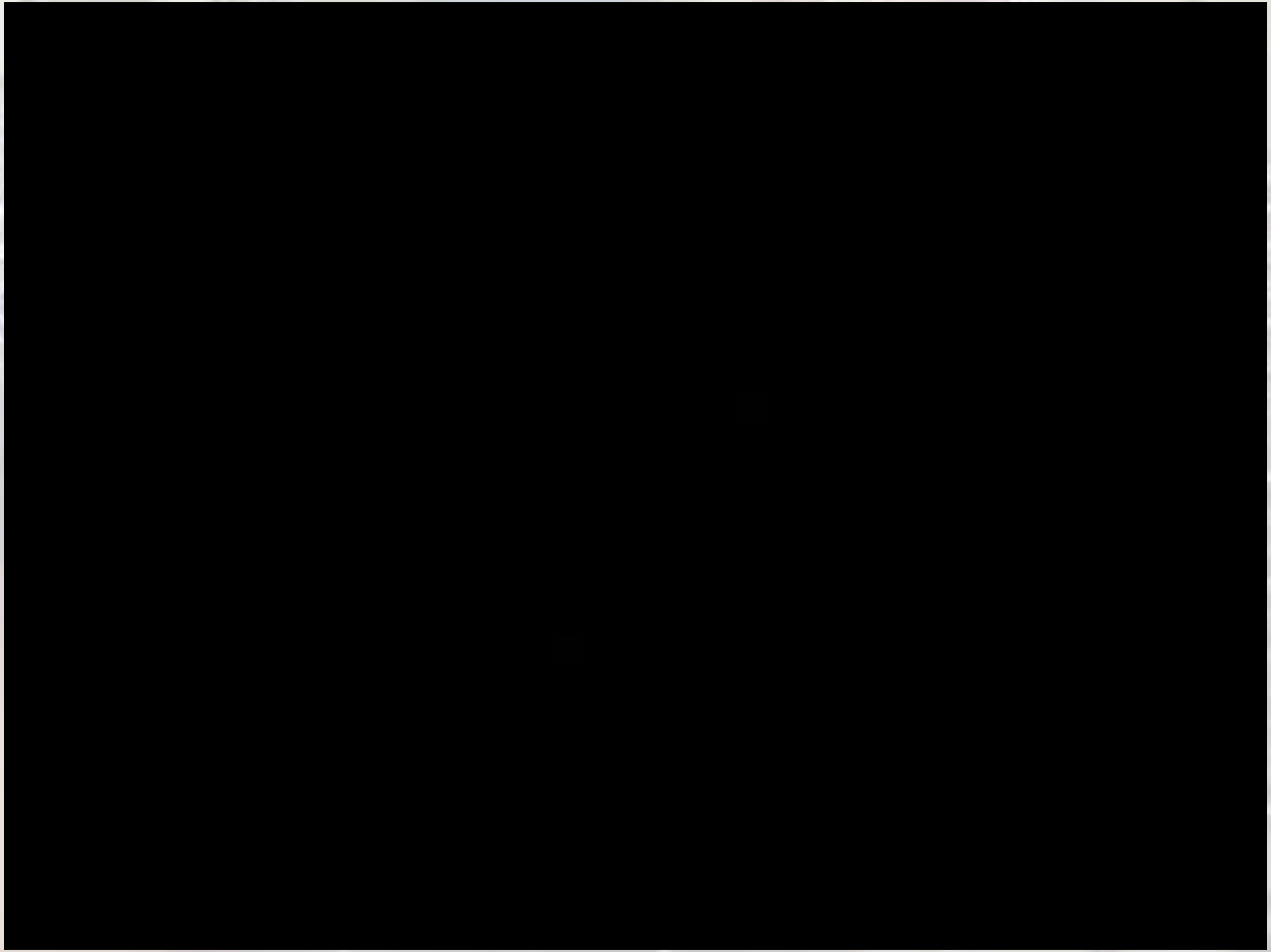
What is the purpose of baffle plate in coolers ?

- To support the tube stack.
- To guide the flow of fluid
- To increase cooling surface area
- To minimize the tube vibration

Types of SHELL AND TYPE HEAT ECHANGER



Working of shell and tube heat exchanger



Maintenance in shell and type heat exchanger

Methods of marine heat exchanger maintenance

- If the deposits on the heat exchanger are not so hard, then they can be removed using a wire brush.

•If the deposits are stubborn, chemical cleaning should be used by emersion of the part in chemical solution.

•Depending on the type of the heat exchanger, there are tools provided by the manufacturers for the cleaning purpose. For e.g. there are special tools for cleaning shell and tube type heat exchangers.

•Once the cleaning is done, the heat exchanger must be flushed with fresh water to remove any remaining chemical or dirt from the surface.

•In sea water cooled heat exchanger, anodes are fitted on the cover to prevent it from galvanic corrosion. Anodes must be checked and changed if required.

•Always renew the cover gasket if it is damaged during opening of heat exchanger.

•In oil coolers and heaters, fouling can take place on the outside of the tubes as well. This can be removed by chemical flushing.

How leaks are detected?

- If it’s a shell and tube type heat exchanger, leaks can be detected by following the procedure below:
- Isolating the heat exchanger from the system and draining the sea water
- Removing the end covers or headers to expose the tubes or plates
- If the surface is clean and dry, inspection of the liquid flow is made from around the tube ends and through the perforations.
- However, in large coolers it is difficult to get the coolers extremely dry to visualize any perforation.
- In such cases special fluorescent dye is added to the shell side of the cooler.
- The dye glows when an ultraviolet light is shone on the tube, revealing the tube leaks.

Adv & dis Adv of shell and tube

Advantages	Disadvantages
• Less expensive as compared to Plate type coolers • Can be used in systems with higher operating temperatures and pressures • Pressure drop across a tube cooler is less • Tube leaks are easily located and plugged since pressure test is comparatively easy • Tubular coolers in refrigeration system can act as receiver also. • Using sacrificial anodes protects the whole cooling system against corrosion • Tube coolers may be preferred for lubricating oil cooling because of the pressure differential	• Heat transfer efficiency is less compared to plate type cooler • Cleaning and maintenance is difficult since a tube cooler requires enough clearance at one end to remove the tube nest • Capacity of tube cooler cannot be increased. • Requires more space in comparison to plate coolers

Plate type heat exchanger

Plate type heat exchanger

- This type of heat exchanger is designed with multiple parallel sets of plates which are being compressed to form the cooler unit, allowing fluid to pass between lines on the plate to the outlet holes. Furthermore, the exchanger gasket is placed on both side ends of the plate, which separates both substances from mixing up.

Use of Plate type heat exchanger

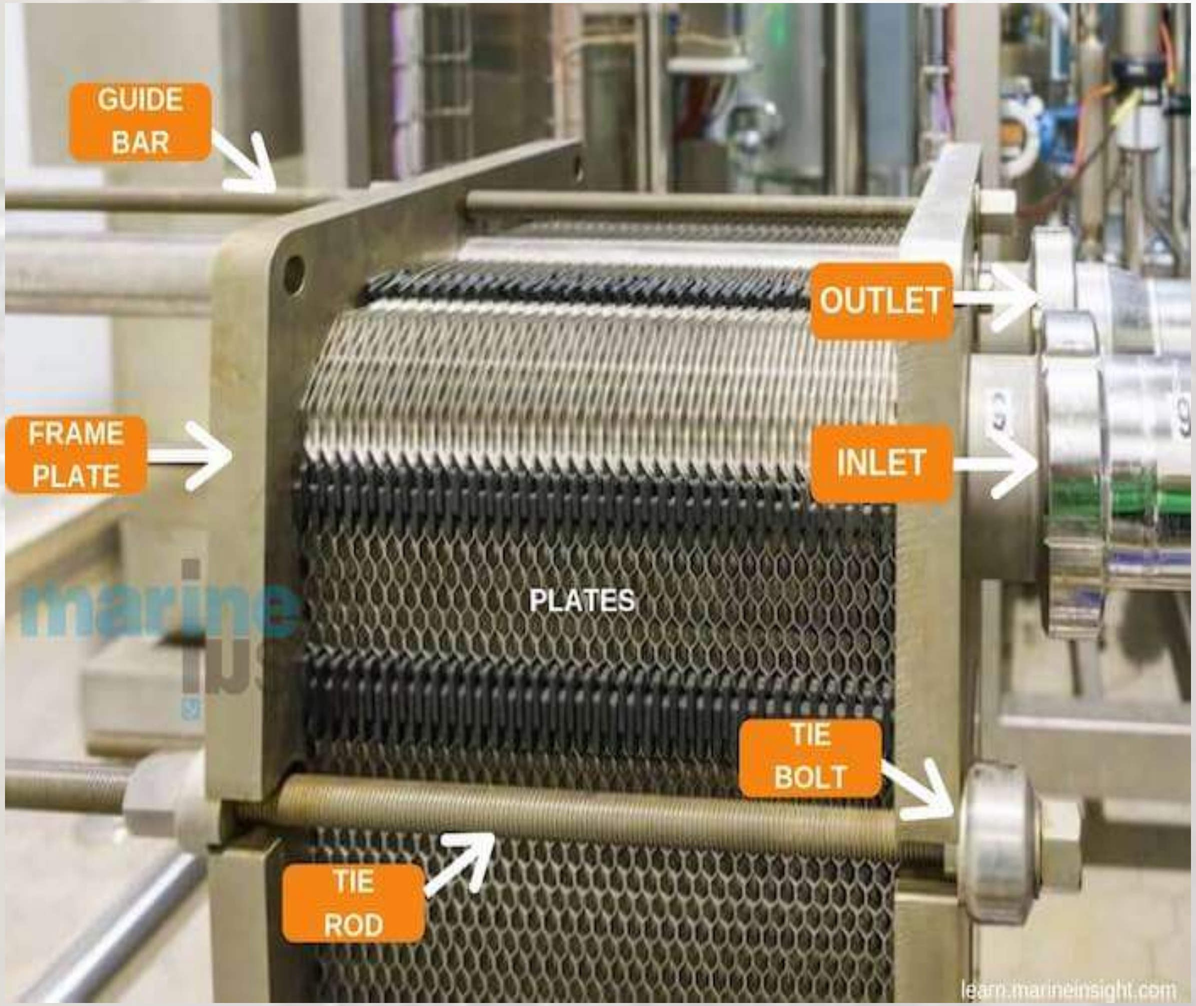
- Plate type heat exchanger is mostly used for lube oil and engine jacket water cooling. From my experience, the plate type seems to be the best exchanger in the terms of cooling effect and/or easy maintenance. In the terms of cleaning, it seems difficult and takes time.

PLATE TYPE HEAT EXCHANGER

- Plate type exchanger consists of thin corrugated plates joined parallel together, creating a cavity for fluid flow inside it. Alternate sides of the plate carry two different fluids, between which, heat transfer is carried out.
- Installation of this type of heat exchanger is expensive than shell and tube type, but the maintenance cost is much lower.
- The efficiency of plate type is higher than shell and tube type for the same size of the unit and can withstand high pressure.
- The plate type coolers can be opened up easily for cleaning and are thus convenient to install and clean as minimum space is required for their installation.
- They're highly efficient than the shell and tube type coolers of the same size and the same capacity.
- They are made up of similar metal plates which have a patterned corrugation and are sealed from each other by nitrile rubber joints.

- The first and last plates also called as innermost and the outermost plates are held together by the frames on either side and further set in place by the tie bolts.
- Four branch pipes on the pressure plate, align with ports in the plates through which two fluids pass.
- Seals around the ports are so arranged that one fluid flows in alternate passages between plates and usually in opposite direction.
- The plate corrugations promote turbulence in the flow of both fluids and so encourage efficient heat transfer.
- Turbulence, as opposed to smooth flow, causes more liquid to pass between the plates and to come into contact with them.
- It also breaks up the boundary layer of liquid which tends to adhere to the metal and act as a heat barrier when the flow is slow.
- The corrugations make the plates stiff so permitting the use of thin material.
- They additionally increase the plate area as well.
- Both of these factors contribute to heat exchange efficiency.

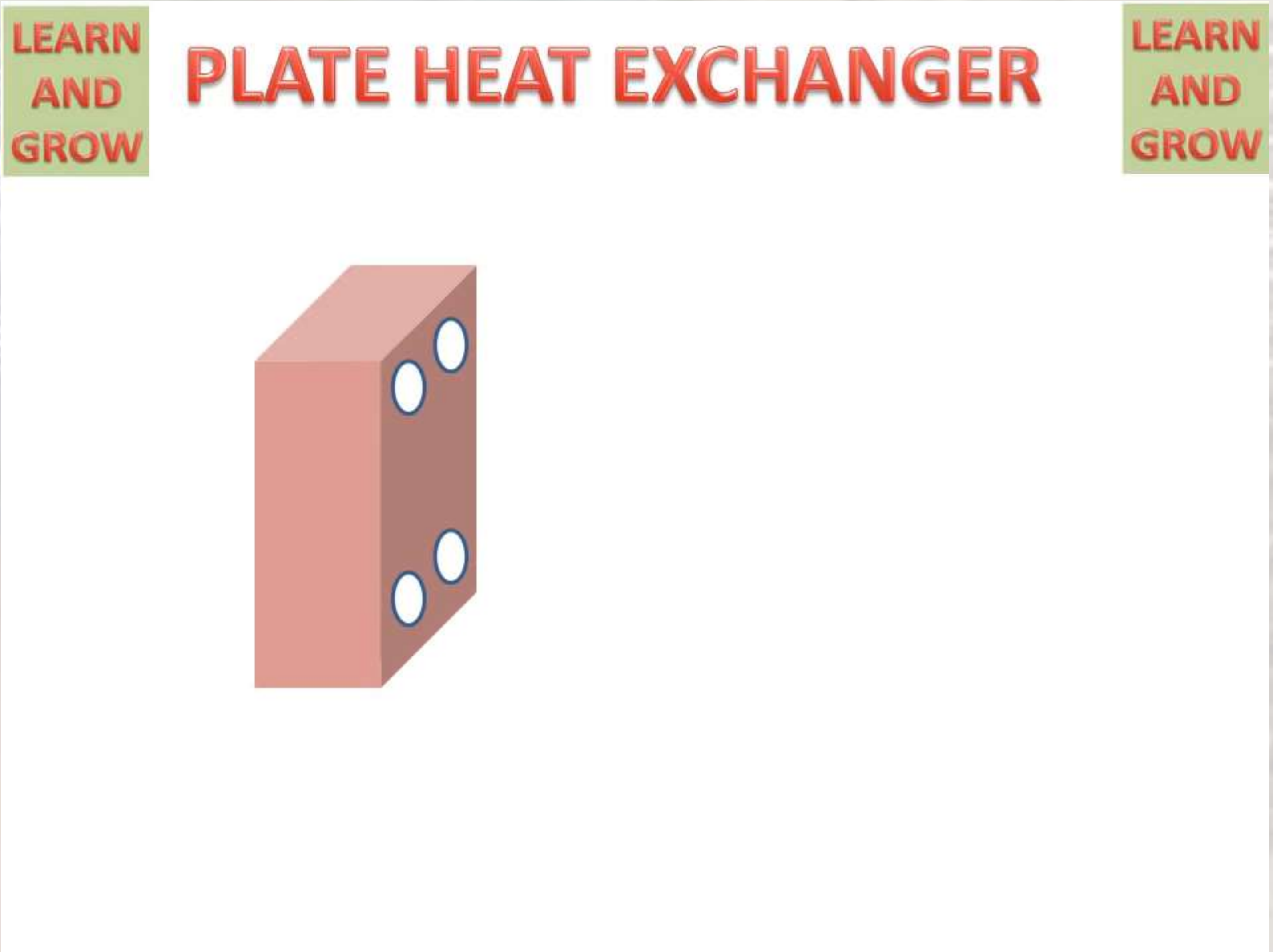
- Excessive turbulence can cause the erosion of the plate material and hence moderate flow rates must be incorporated.
- Titanium plates though expensive are generally used as they have the best resistance to corrosion and erosion.
- The rubber seals between the plates are bonded to the plate surfaces by the special adhesives and removed by acetone, if available.
- The rubber seals are not suitable for extremely high temperatures as they lose their elasticity and harden becoming brittle and eventually break when the cooler is opened up for cleaning and inspection.
- The rubber joints get squeezed properly when they're tightened by the clamping bolts and hence provide a good sealing therein.



- The length of the tie bolts should be measured correctly before opening the plate type cooler for maintenance and inspection as over-tightening the plates can bend them completely and render them useless and could be expensive.
- Under tightening can cause the plates to leak.
- Thus, the tie bolts should be tightened with the correct torque as mentioned in the instruction manual.
- Plate type coolers are very expensive because of the titanium plates but their low maintenance and the low operation cost outweigh them being so expensive.

PLATE TYPE HEAT EXCHANGER

OPERATION OF PLATE TYPE HEAT EXCHANGER



Maintenance in plate type heat exchanger

- In plate type heat exchangers, the stack of plates is removed to expose the surface.
- The plate surface is then cleaned with brush or by the methods suggested by the manufacturer. (Sharp tools should be avoided).
- Cleaning should be done in such a way that it does not damage the plate seals. However, if a replacement of the seal is necessary, it must be done before putting the plates back.
- While tightening the plates together, care must be taken for even tightening of all the exchanger studs and bolts or else leak will occur.
- Excessive corrosion of the heat exchanger surface can also lead to perforation of the surface, resulting in mixing of one liquid with another.
- Minor leakage detection is not easy especially when the header tanks are automatically toped or if there is no proper manual record maintained.
- However, major leakages can be easily detected as a result of sudden loss of lubricating oil or jacket water.
- Low level alarms are also useful in detecting major leaks.
- Another way to prevent mixing of two liquids because of perforation is by keeping the sea water at a pressure lower than the jacket water or any other liquid used. This reduces the risk of sea water entering into other mediums.

Adv and dis Adv of plate type heat exchanger

Advantages	Disadvantages
Simple and Compact in size Heat transfer efficiency is more Can be easily cleaned No extra space is required for dismantling Capacity can be increased by introducing plates in pairs Leaking plates can be removed in pairs, if necessary without replacement Maintenance is simple Turbulent flow help to reduce deposits which would interfere with heat transfer	Initial cost is high since Titanium plates are expensive Finding leakage is difficult since pressure test is not as ease as tube coolers Bonding material between plates limits operating temperature of the cooler Pressure drop caused by plate cooler is higher than tube cooler Careful dismantling and assembling to be done Over tightening of the clamping bolts result in increased pressure drop across the cooler Joints may be deteriorated according to the operating conditions Since Titanium is a noble metal, other parts of the cooling system are susceptible to corrosion

Effective

- Relating both exchangers, to my own opinion and statistics, the plate type heat exchanger is more effective and durability. But its durability and effectiveness depend on how it’s been managed.
- The shell and tube heat exchanger has it advantages too, which includes; easy to clean tubes, difficult to mix up except if the tubes leaks. While plate type can mix up easily if the gaskets are not placed very well.

LUBRICATING OIL COOLER

LUBRICATING OIL COOLER

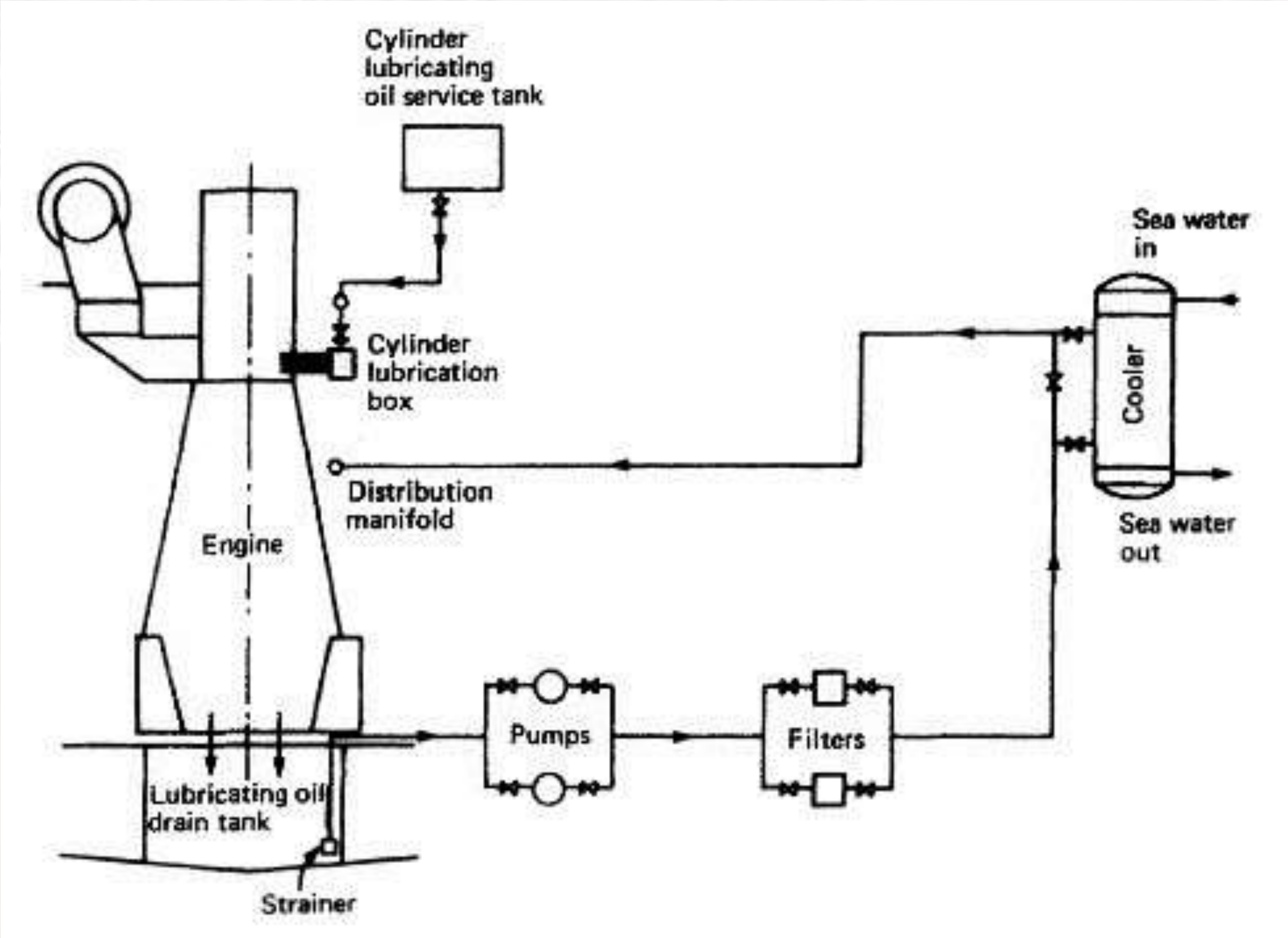
Function of lubrication:

- The lubrication system of an engine provides a supply of lubricating oil to the various moving parts in the engine.
- Its main function is to enable the formation of a film of oil between the moving parts, which reduces friction and wear.
- The lubricating oil is also used as a cleaner and in some engines as a coolant.

Main engine lubricating oil system

- This system supplies lubricating oil to the engine bearings, and cooling oil to the pistons.
- Lubricating oil is pumped from ME LO Circulating Tank, placed in the double bottom beneath the engine, by means of the ME LO Pump, to the ME LO Cooler, a thermostatic valve, and through a full-flow filter, to the engine, where it is distributed to the various branch pipes.
- Pumps and fine filters are arranged in duplicate, with one as a standby.
- From the engine, the oil collects in the oil pan, from where it is drained to the ME LO Circulating Tank for reuse.
- A centrifuge is arranged for cleaning the lubricating oil in the system and the clean oil can be provided from a storage tank.

LUB OIL CIRCUIT DIAGRAM



Cylinder lubrication

- Cylinder oil is pumped from Cylinder Oil Storage Tank to the Cylinder Oil Service Tank, placed min. 3000mm above the cylinder lubricators.
- The cylinder lubricators are mounted on the roller guide housing, and are interconnected with drive shafts. Each cylinder liner has a number of lubricating orifices, through which the cylinder oil is introduced into the cylinders via non-return valves.

  Large slow-speed diesel engines are provided with a separate lubrication system for the cylinder liners.
- Oil is injected between the liner and the piston by mechanical lubricators which supply their individual cylinder, A special type of oil is used which is not recovered.
- As well as lubricating, it assists in forming a gas seal and contains additives which clean the cylinder liner.

LUBRICATING OIL SUMP LEVEL

- The level of lubricating oil indicated in the sump when the main engine is running must be sufficient to prevent vortexing and ingress of air which can lead to bearing damage.

  The sump level is to be according to manufacturers/shipbuilders instructions .
- The 'Sump Quantity' is always maintained at the same safe operating level and is given in litres.
- It is essential that the figures are mathematically steady and correct from month-to-month, taking into account consumption, losses and refills and reported .

  The 'Sump Quantity' is calculated with the engine stopped, but the lubricating oil pump in operation, thus keeping the system oil in circulation.

  Sufficient reserve quantities of lubricating oil must always be held, i.e. to completely fill the main sump and sufficient quantities of other lubes must be held to cover the intended voyage plus 20%.
- Lubricating oils are a major expenditure item, therefore, all purchasing must be pre-planned with the aim of buying the maximum amounts from the cheapest supply sources which are primarily the US, Europe and Singapore.
- Lub oil requisitions should be sent to the office at least 10 days before the intended port of purchase and clearly indicate if the vessel requires supply in bulk or in drums.

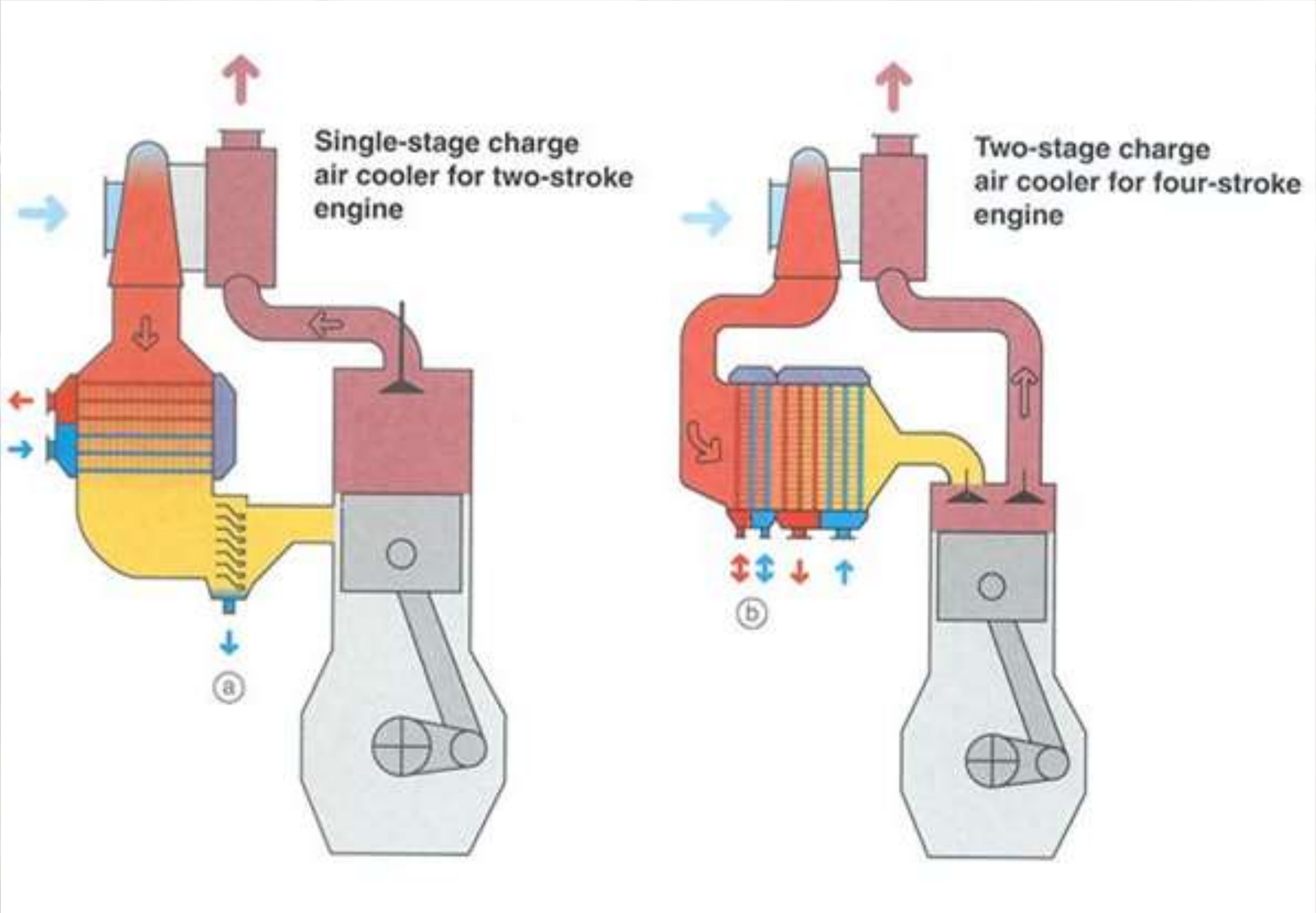
MAIN ENGINE AIR COOLER

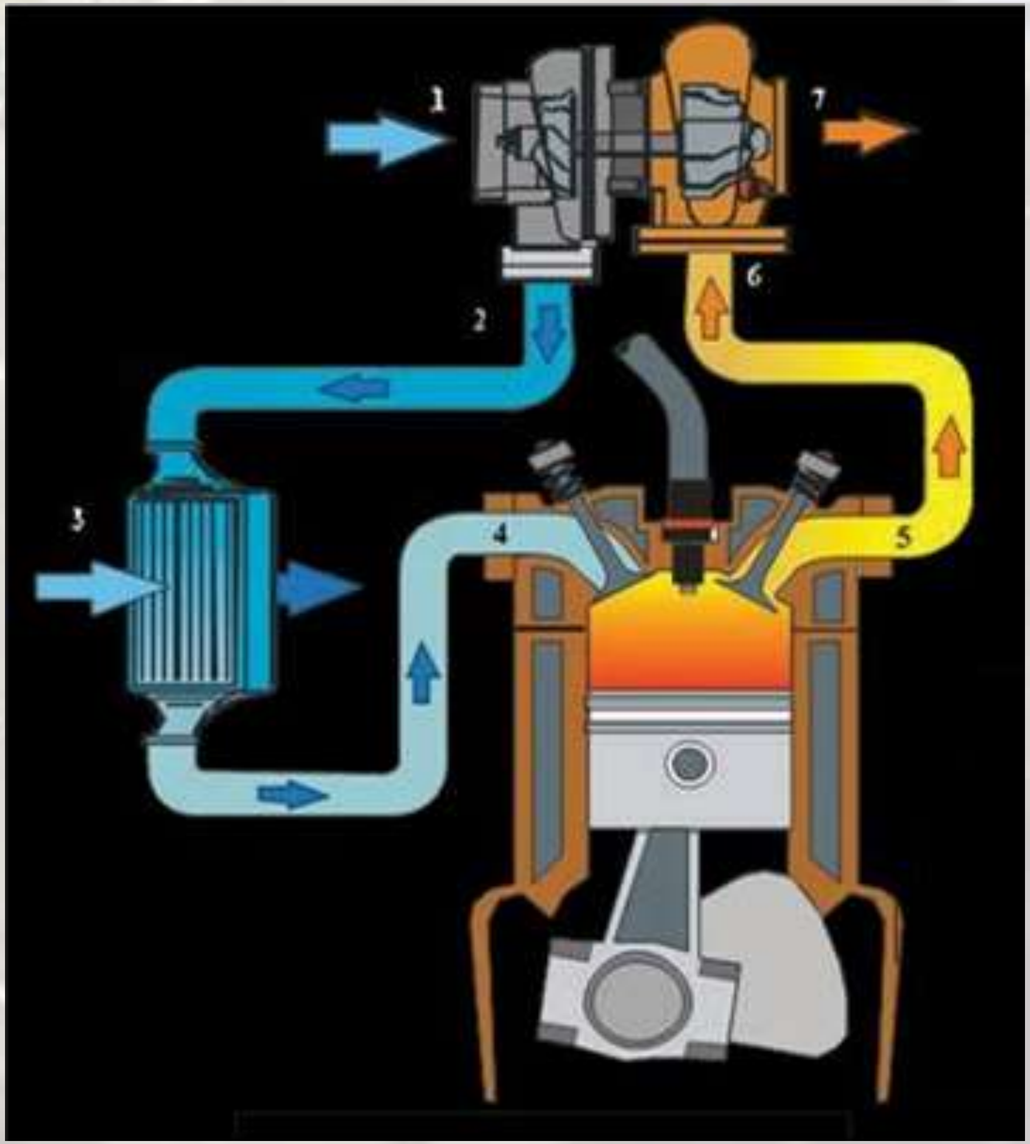
- A charge air cooler is used to cool engine air after it has passed through a turbocharger, but before it enters the engine. This is their main function. The idea is to return the air to a lower temperature, for the optimum power from the combustion process within the engine.
- More specifically, it is a heat exchange device used on turbocharged and supercharged (forced induction) internal combustion engines to improve their volumetric efficiency by increasing intake air-charge density through isochoric cooling. A decrease in air intake temperature provides a denser intake charge to the engine and allows more air and fuel to be combusted per engine cycle, increasing the output of the engine.
- The charge air cooler is designed to cool the charged air from something in the region of 180°C to 220°C, down to around 40°C. It achieves this by using cooling water.
- Charge air coolers range in size depending on the engine. The smallest are most often referred to as intercoolers and are attached to automobile or truck engines. The largest are often used on huge marine diesel engines or in power plants. They can weigh several tonnes in these circumstances.
- Most are still associated with diesel engines, but Vestas aircoil manufactures specialist air coolers for gas engines too.
- The first marine diesel engine charge air cooler was built by Vestas aircoil A/S in 1956. Look at our history here.
- The phrase “charge air cooler” is an all-encompassing term, meaning that it cools the turbo’s charged air before it is routed into the engine.

LOCATION OF LARGE AIR COOLER IN MDE

- Charge air coolers are located between the turbocharger compressor side outlet and the engine inlet manifold or scavenge manifold.
- The location of the charge air cooler between turbocharger and entry to engine should be such that the temperature of the charge air at the outlet of charge air cooler should not be increased before its entry to the engine cylinder due to the heated condition of the engine room.
- To avoid this, the air cooler should be located as close to the engine cylinder as possible.
- Also, the air duct between the charge air cooler and the engine inlet manifold should be insulated to avoid increase in the temperature of the air.

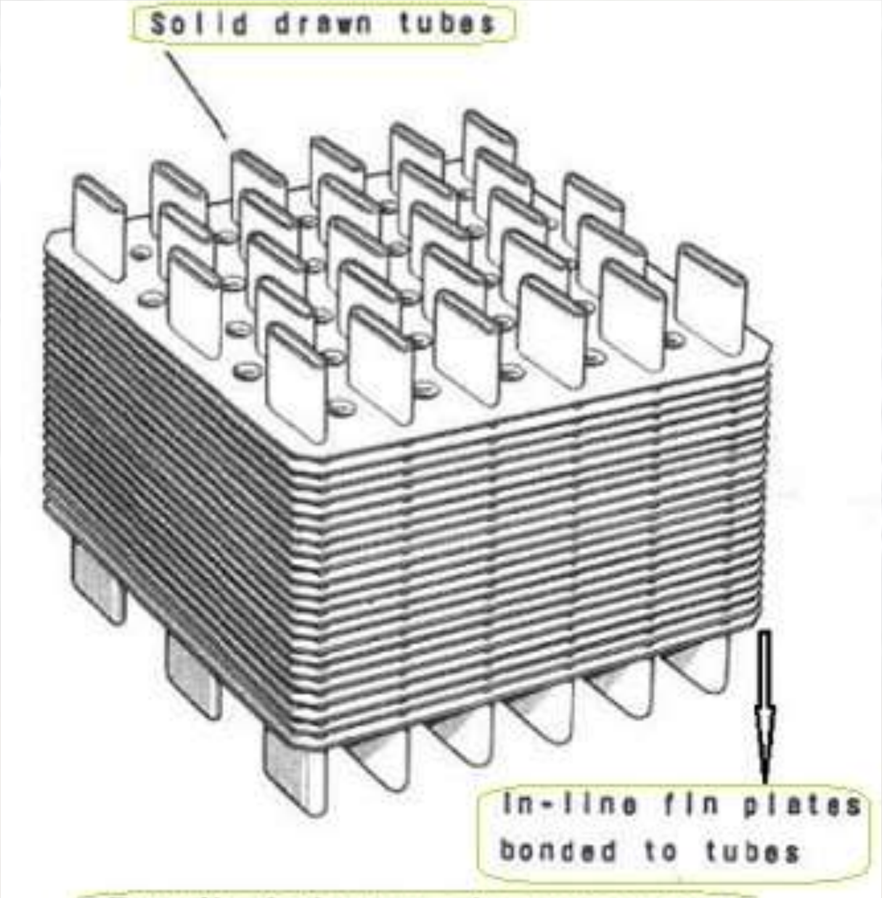
LOCATION OF MAIN ENGINE AIR COOLER





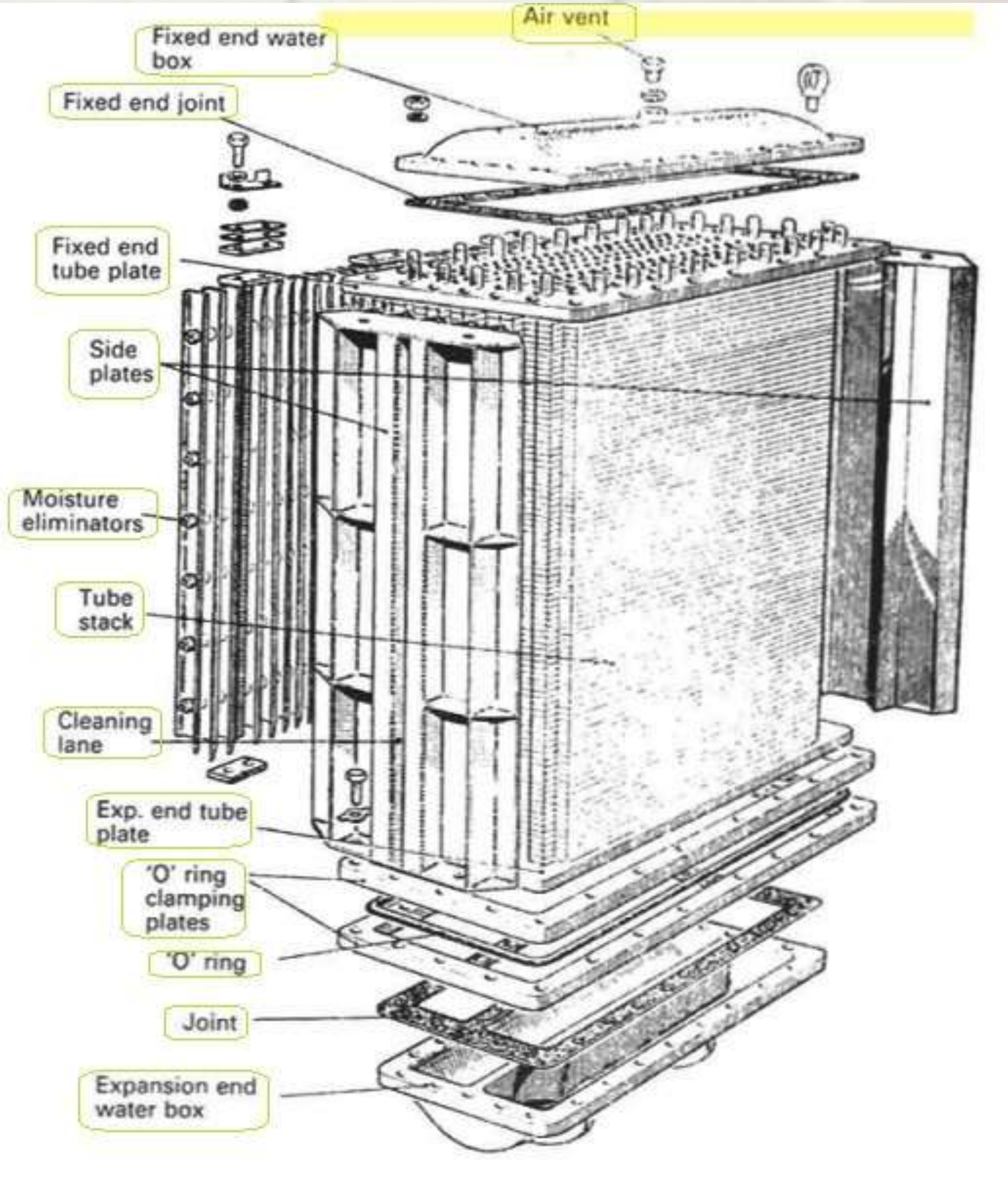
CONSTRUCTION OF ME AIR COOLER

AIR COOLER ON MDE



Detail of charge air cooler tube

- The charge air coolers fitted to reduce the temperature of air after the turbo-charger and before entry to the diesel engine cylinder, are provided with fins on the heat transfer surfaces to compensate for the relatively poor heat transfer properties of air.
- Solid drawn tubes with a semi-flattened cross section, have been favoured
- These are threaded through the thin copper fin plates and bonded to them with solder for maximum heat transfer



- Tube ends are fixed into the tube plates by being expanded and soldered.
- Cooling of the air results in precipitation of moisture which is removed by water eliminators fitted at the air outlet side.
- A change of direction is used in some air coolers to assist water removal.
- Condensate is removed by a drain connection beneath the moisture eliminators.

MAIN ENGINE AIR COOLER AND ITS EFFECT

- When the air cooler becomes fouled, less heat will be transferred from the air to the cooling water (usually fresh water).
- This is indicated by the changes in the air temperature and cooling water temperature and a pressure drop in the air passing through the air cooler.
- To measure this pressure drop, a manometer is connected between the charge air cooler inlet and outlet.
- The amount of pressure drop will depend upon the degree and nature of the fouling.

Indications of Air Side Fouling:

- Increase of air pressure drop across the charge air cooler.
- Decrease of air temperature difference across air cooler.
- Rise in scavenge air temperature.
- Rise in exhaust gas temperature from all cylinders.

Indications of cooling water side fouling:

- Rise in scavenge air temperature.
- Decrease in the difference of the air temperature across the air cooler.
- Decrease in the temperature of the cooling water across the cooler if fouling is on the tubes.
- Increase in exhaust gas temperature from all cylinders.
- Increase in the temperature of the cooling water due to fouling or chocking material in tubes that reduce the amount of cooling water flow.

Methods of air side cleaning:

- Fins in the air side can be cleaned by using compressed air at Low pressure.
- The air side can be cleaned by dipping the air cooler in a chemical bath for a certain period of time. This will remove all deposits on the air side.
- Another method of cleaning the air side is by using the jet of water at Low pressure.
- Note: Usage of very high pressure may lead to bending of fins and thus causing permanent damage to the air cooler.

Methods of Fresh water side cleaning:

- For soft deposits on the water side, dip the cooler in a chemical bath. After a certain period of time, take the cooler out and then clean with water at some temperature higher than ambient. It is always preferred to circulate water using wilden pump and drums.
- For hard deposits use a long drill bit to drill the hard deposits on the tubes. Note this requires a specialist to drill the hard deposits because small mistakes in drilling may damage the tubes.

MAIN ENIGINE AIR COOLER MAINTENANCE

How do you know air cooler leakage ?

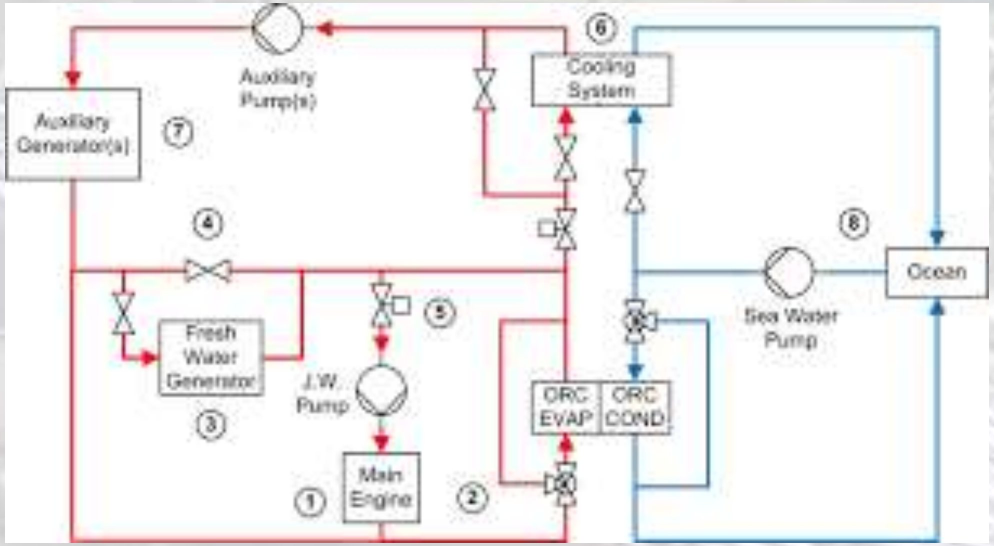
- Check water level insight glass fitted at cooler drain pipe.
- Drain the cooler / taste the water
- If the water continuous comes out, the cooler is leakage. Also in the funnel white & dense smoke.
- Then the engine should be stopped with permission from bridge.
- Normal leaking tubes can be stopped by plugging.
- Then the engine is put back normal running.

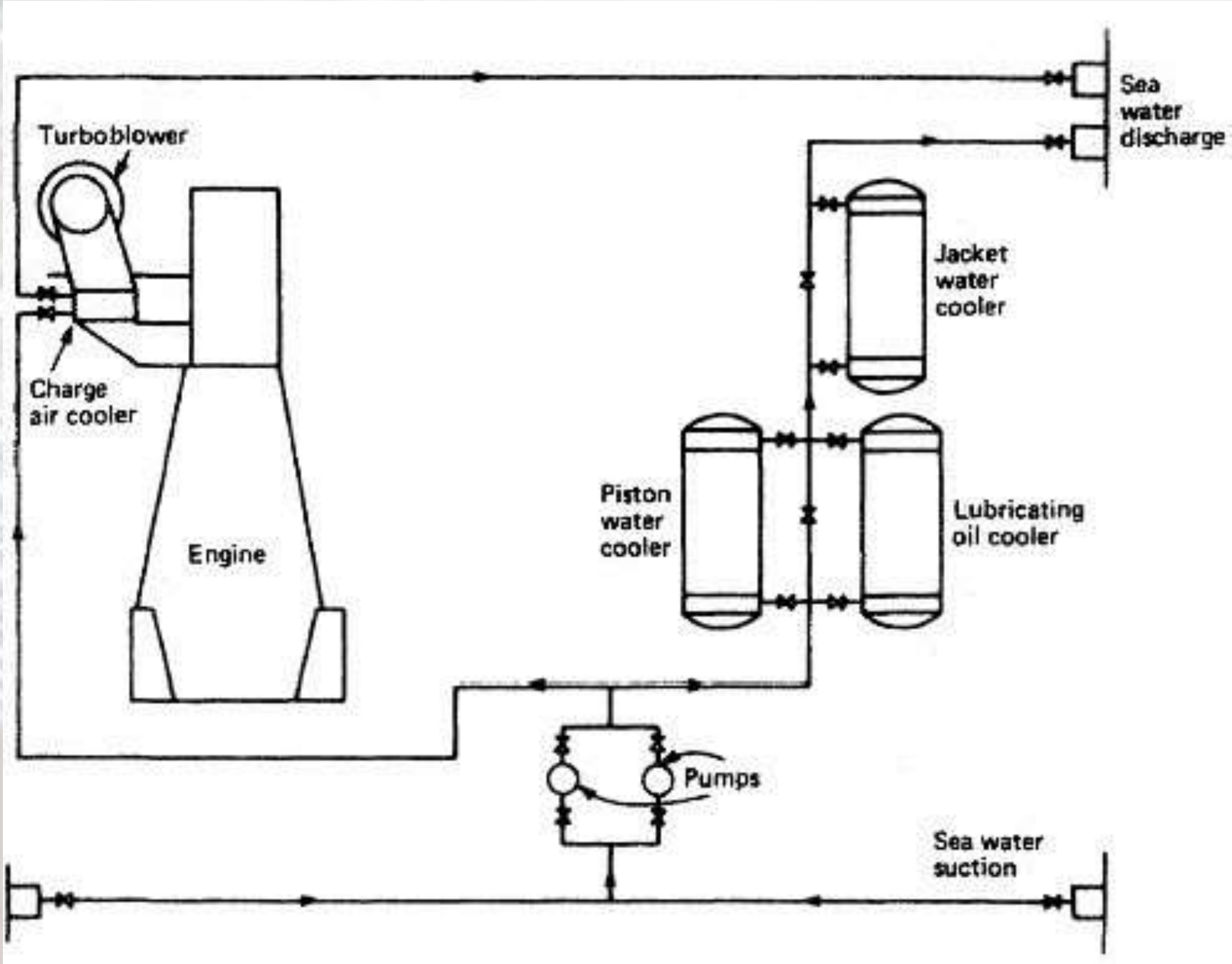
MAIN ENIGINE AIR COOLER MAINTENANCE

How to check cooler efficiency ?

- Check sea water in/out temperature difference. Less difference means poor efficiency of cooler (must be high)
- Check coolant medium in / out temperature (Difference temperature: should be low)
- Feel over cooler shell, upper hot, middle warm, down cool is normal.
- Check pump and by pass valve.

FRESH WATER COOLER circuit





FRESH WATER COOLER SYSTEM

- It is divided into two separate systems: one for cooling the cylinder jackets, cylinder heads and turbo-blowers; the other for piston cooling.
- The cylinder jacket cooling water after leaving the engine passes to a sea-water-circulated cooler and then into the jacket-water circulating pumps.
- It is then pumped around the cylinder jackets, cylinder heads and turbo-blowers. A header tank allows for expansion and water make-up in the system.
- Vents are led from the engine to the header tank for the release of air from the cooling water.
- A heater in the circuit facilitates warming of the engine prior to starting by circulating hot water.
- **The piston cooling system employs similar components, except that a drain tank is used instead of a header tank and the vents are then led to high points in the machinery space. A separate piston cooling system is used to limit any contamination from piston cooling glands to the piston cooling system only.**

FRESH WATER GENERATOR

- Fresh water production from sea water for domestic and auxiliary purposes is an essential requirement aboard ships. A considerable amount of fresh water is consumed in a ship.
- The crew consumes an average **100 liter/head/day**. In a steam ship (a ship whose main propulsion unit is steam turbine or a ship which is a large tanker having steam turbine driven cargo oil pumps) the consumption for the boiler can be as high as 30 tonnes/day.
- Sufficient potable water may be taken on in port to meet crew and passenger requirement.
- But the quality of this water will be too poor for use in water tube boilers and for filling expansion tanks.
- It is common practice to take on only a minimum supply of potable water and make up the rest by distillation of sea water.
- The stowage space that would have been used for fresh water can hence be utilized for fuel or extra space made available for cargo when fresh water generator is installed on a ship.
- It is statutory requirement to have a distillation plant for emergency use if otherwise ship has carried sufficient potable water.
- The equipment used on board for the production of freshwater from seawater is known as fresh water generator.

TYPES OF FRESH WATER GENERATOR

Various types of fresh water generators used on board ships are mainly:

- **Submerged tube type fresh water generator**
- **Plate type fresh water generator, and**
- **Reverse osmosis plant**
- Whatever type of plant is used, essential requirement of any fresh water generator is that it should produce fresh water as economically as possible.

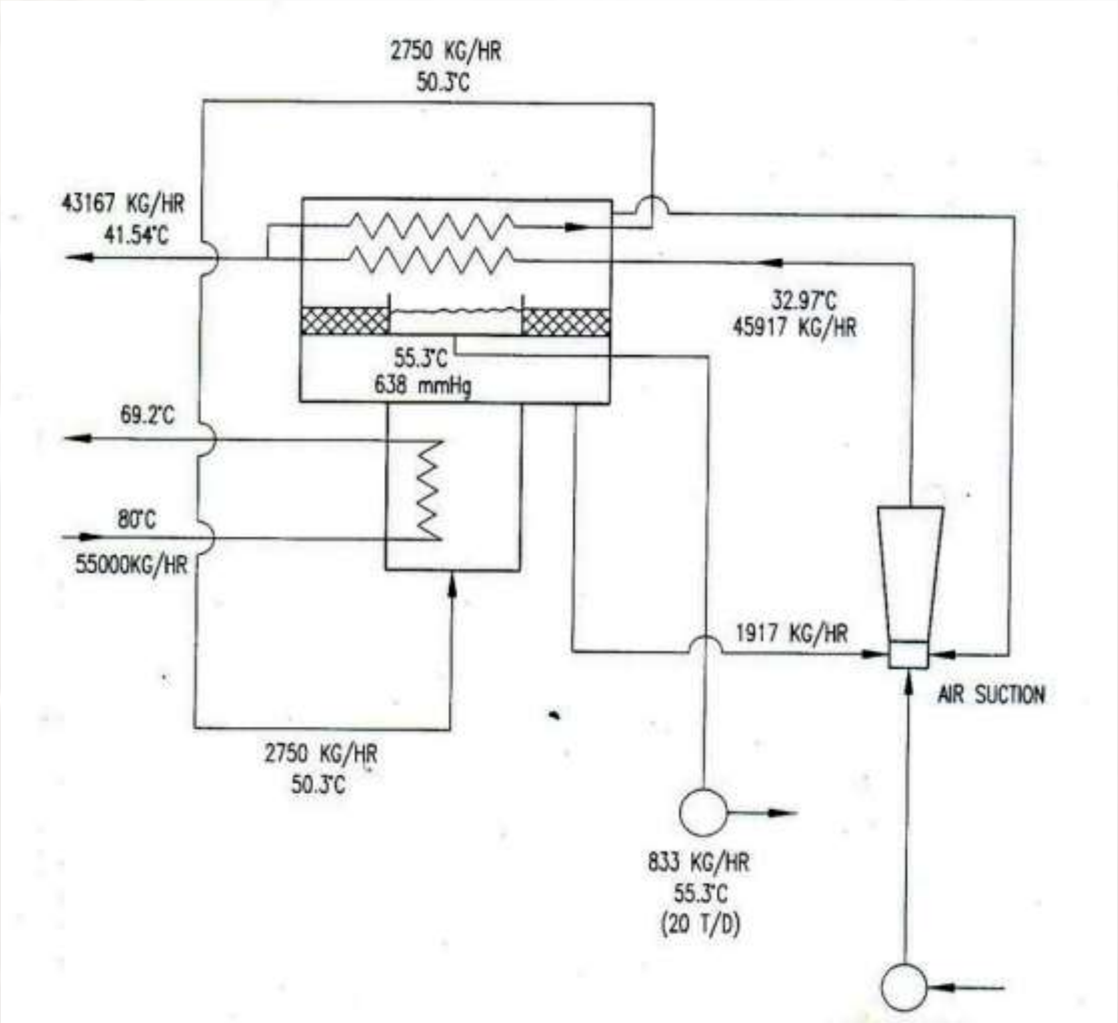
Submerged Tube Type Fresh Water Generator

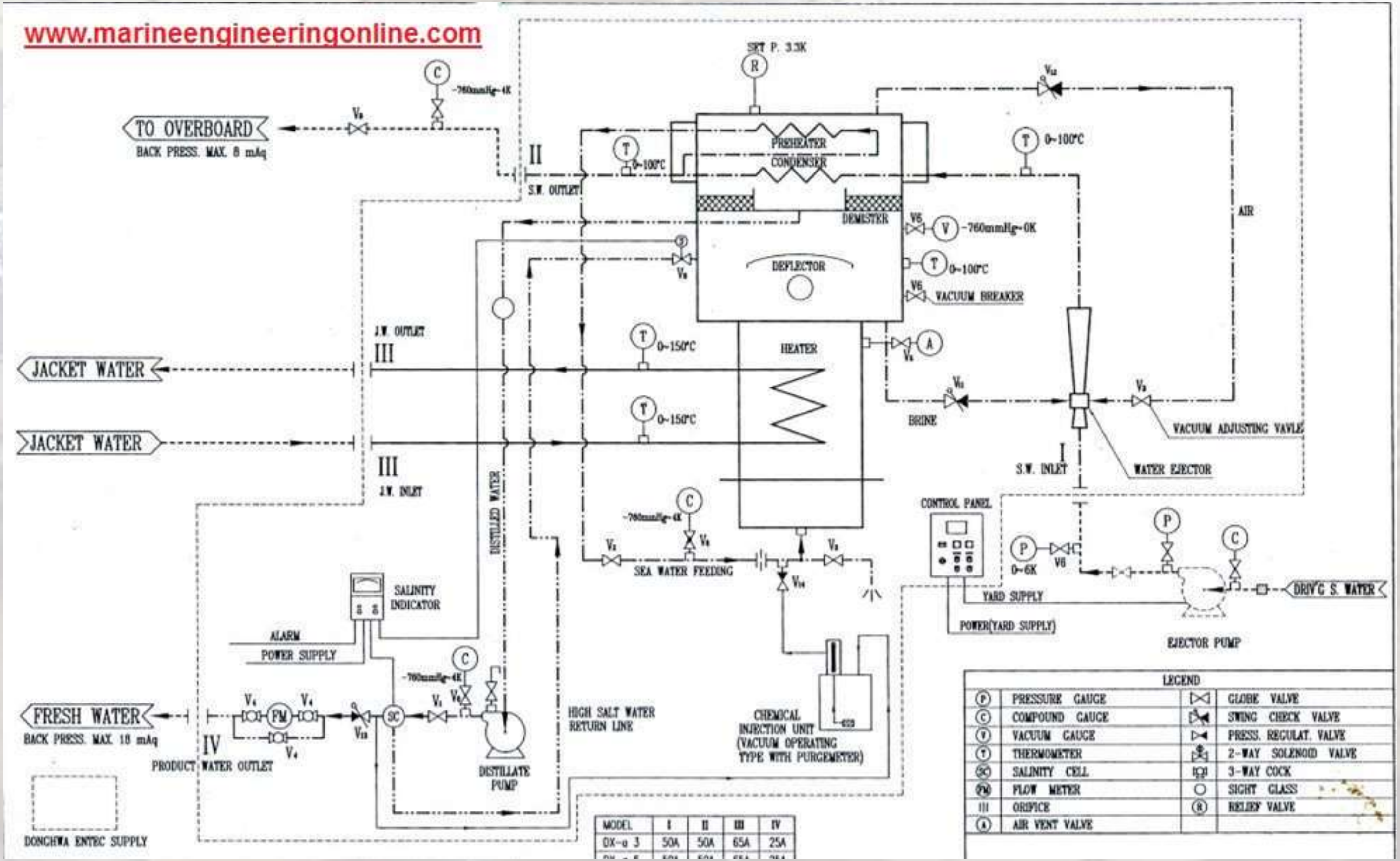
- The shell and tube freshwater generator consist of heat exchanger, separator shell and condenser. In addition to this water ejector, ejector pump, distillate pump, salinity indicator, demister or mesh separator, solenoid valve and water flow meter are also fitted as accessories.

Fresh Water Generator Working Principle

- Basic principle of all low pressure freshwater generator is that, boiling point of water can be reduced by reducing the pressure of the atmosphere surrounding it.
- By maintaining a low pressure, water can be boiled at low temperatures say 50 degree Celsius.
- The source of heat for the fresh water generator could be waste heat rejected by main engine jacket cooling water.
- Hence using energy from a heating coil, and by reducing pressure in the evaporator shell, boiling can takes place at about 40 to 60 degree Celsius.
- This type of single effect plant is designed to give better economy than obsolete Boiling Evaporators.

- The submerged tube type fresh water generator explained below uses the heat from main engine jacket cooling water to produce drinkable water by evaporating seawater due to the high vacuum, which enables the feed water to evaporate at a comparative low temperature.
- Steam can also be used as a heat source instead of main engine jacket cooling water.
- This type of fresh water generator is based on two sets of shell and tube heat exchangers, one acting as evaporator or heater and other as condenser.
- The combined air/brine ejector creates evaporator chamber vacuum condition by driving sea water pass through air/brine ejector, and sea water supplied by the ejector pump to be delivered to ejector for taking out the brine (concentrated seawater) and air.

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TO OVERBOARD
BACK PRESS. MAX. 8 mAq
-760mmHg-4K
SET P. 3.3K
II
S.W. OUTLET
0~100°C
PREHEATER
CONDENSER
DEMISTER
-760mmHg-0K
DEFLECTOR
0~100°C
VACUUM BREAKER
AIR
HEATER
J.W. OUTLET
III
JACKET WATER
0~150°C
JACKET WATER
0~150°C
III
J.W. INLET
BRINE
VACUUM ADJUSTING VAVLE
WATER EJECTOR
I
S.W. INLET
DISTILLED WATER
-760mmHg-4K
SEA WATER FEEDING
CONTROL PANEL
0~6K
YARD SUPPLY
POWER(YARD SUPPLY)
DRIV'G S. WATER
EJECTOR PUMP
SALINITY INDICATOR
ALARM
POWER SUPPLY
-760mmHg-4K
FRESH WATER
BACK PRESS. MAX. 18 mAq
IV
PRODUCT WATER OUTLET
DISTILLATE PUMP
HIGH SALT WATER RETURN LINE
CHEMICAL INJECTION UNIT (VACUUM OPERATING TYPE WITH PURGEMETER)
DONGHWA ENTEC SUPPLY
MODEL | I | II | III | IV
DX-α 3 | 50A | 50A | 65A | 25A
LEGEND
Ⓟ PRESSURE GAUGE
Ⓒ COMPOUND GAUGE
Ⓥ VACUUM GAUGE
Ⓣ THERMOMETER
ⓈⒸ SALINITY CELL
ⒻⓂ FLOW METER
ORIFICE
Ⓐ AIR VENT VALVE
GLOBE VALVE
SWING CHECK VALVE
PRESS. REGULAT. VALVE
2-WAY SOLENOID VALVE
3-WAY COCK
SIGHT GLASS
Ⓡ RELIEF VALVE

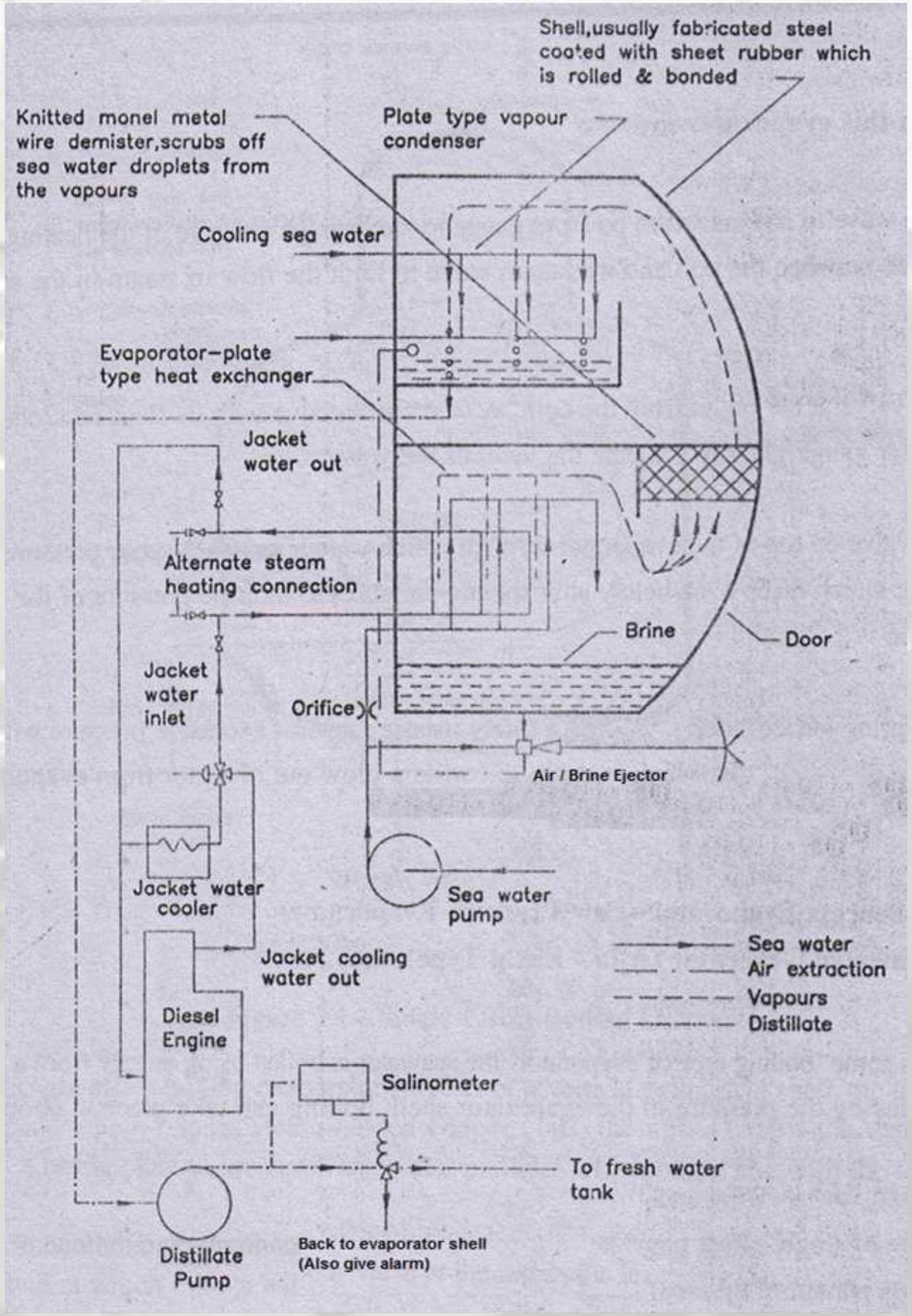
- The distilled water is then taken out by integral freshwater pump (distillate pump) and controlled by salinometer and solenoid valve.
- If the salt content of produced water is high, solenoid valve diverts the freshwater to the shell side of freshwater generator, and issues an alarm signal. In order to get better suction head, distillate pump is placed at the lowest possible location in the fresh water generator plant.
- This is because the fresh water generator shell is at a lower pressure. Distillate pump get maximum net positive suction head with the height of liquid column in the suction line.
- Thermometers are installed for control of seawater to the condenser and jacket cooling water to the evaporator.
- These thermometers permit control of both heating and cooling of these units.
- The salinometer or salinity indicator is connected to remote alarm so that very high salinity is immediately registered at the engine control room of the ship.

Plate Type Fresh Water Generator

- Working principle of plate type fresh water generator is same as that of submerged tube type.
- Only difference is the type of heat exchangers used. Here plate type heat exchangers are used for condenser and evaporator unit.
- Heat from the diesel engine cooling water is used to evaporate a small fraction of the seawater feed in the plate type freshwater generator or evaporator.
- Unevaporated water is discharged as brine (by combined air /brine ejector).
- The evaporated water passes through the demister to the plate type vapour condenser.
- Here, after condensation it is discharged to fresh water storage tank by fresh water distillate pump.
- During entire operation the feed rate to the evaporator is fixed by the orifice plate at the feed inlet to evaporator.

PLATE TYPE FRESH WATER GENERATOR

- In the event of salinity of fresh water exceeding a predetermined value (maximum usually 10 ppm) the solenoid controlled dump valve diverts the flow back to the shell.
- This prevent contamination of the made water. Excess salinity could be used by many factors include leakage of seawater at condenser or priming of evaporator or malfunctioning of demister, or many other reasons.
- What cannot be condensed at the condenser are called ‘incondensable gases’ like air and these gases are continuously ejected out by air/brine ejector.
- This way the shell of fresh water generator is maintained at high vacuum, a must requirement to boil water at low temperatures.



Materials of Construction for Fresh Water Generator

- The **shell** is usually **fabricated steel** (or non-ferrous metal like **cupro-nickels**) which has been shot blasted then coated with some form of protective.
- One type of **coating is sheet rubber** which is rolled and bonded to the plate then hardened afterwards by heat treatment. The important points about protective coatings are:
  - They must be inert and prevent corrosion.
  - They must resist the effect of acid cleaning and water treatment chemicals
  - They must have a good bond with the metal
- Heat exchangers use aluminium brass tubes and muntz netal tube plate in the case of tube type fresh water generator. For plate type, titanium plates are used for condenser and evaporator. Demister is made of layered knitted wire of monel metal.

OPERATION OF FWG

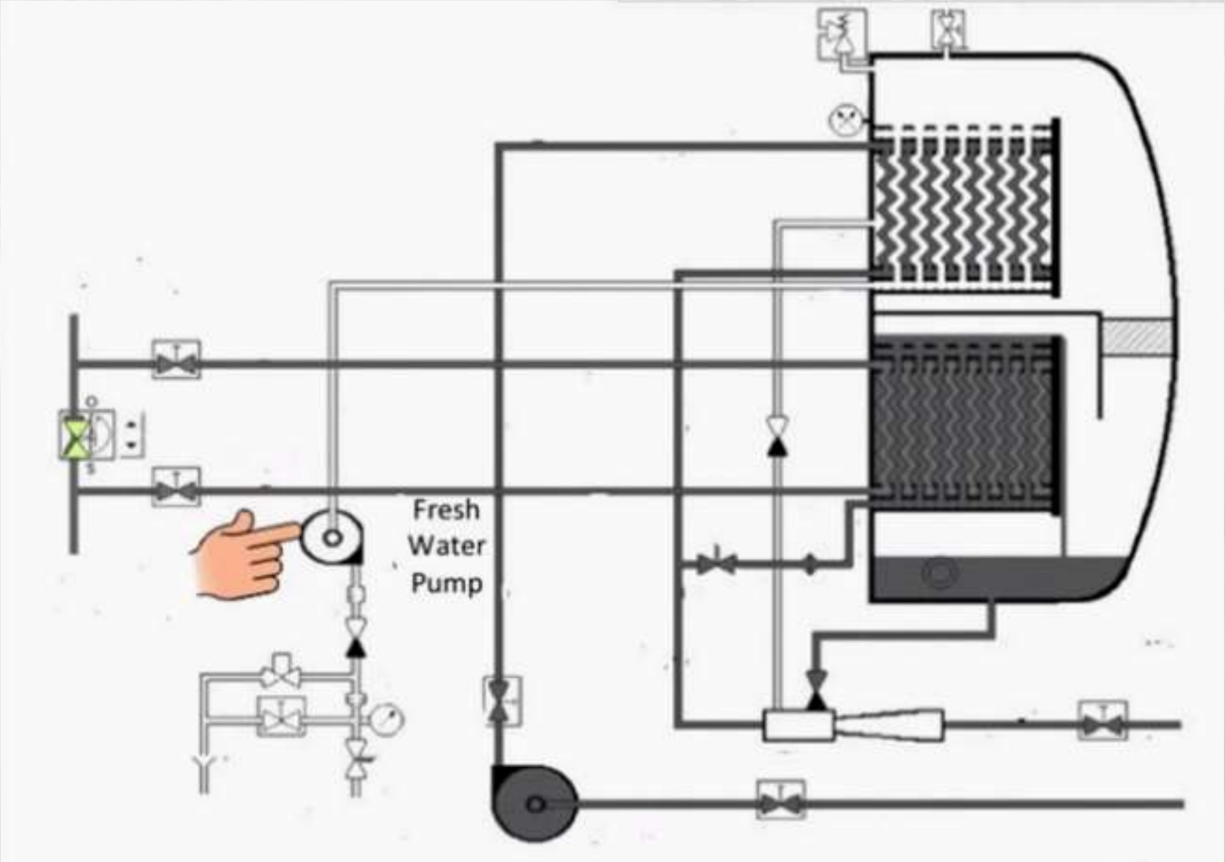
Extreme care must be taken during the operation of fresh water generator on-board ships. Operate all the valves gradually. Sudden opening and closing of valves may result in thermal shock to the main engine. Also make sure that distillate pump never runs dry.

- Fresh water Generator Starting Procedure
- Make sure seawater ejector pump suction, discharge and overboard valves are open. Start the ejector pump. Seawater pressure at the air ejector must be 3 bar or more.
- Wait for vacuum to build up inside fresh water generator shell. (About 92 % vacuum).
- Open the feed water valve to feed seawater to the evaporator. Adjust the feed water pressure. Normally marking is provided on the pressure gauge for desired feed water pressure.
- Open main engine jacket cooling water inlet and outlet to the evaporator gradually.
- Open the air vent clock at the top of the evaporator to make sure the evaporator is filled with jacket cooling water. Air must be purged out if any.
- Switch on the salinity alarm panel for measuring purity of the freshwater produced.
- There will be a sight glass provided at the suction line for the distillate pump. Make sure condensed water is coming to the suction line. Now start the distillate pump and open discharge valve to lead generated water to specified storage tanks.
- Do checks While Running Fresh water Generator
- Through the sight glass provided in the evaporator shell, observe flashing of water.
- Also check for the brine level inside. It should not be too high or too low.
- Shell temperature must be around 50 deg cel.
- Make sure shell vacuum is more than 90% from the vacuum gauge.
- Check seawater inlet and outlet temperature to the condenser.
- Ensure seawater pressure at air ejector inlet more than 3 bars.
- Check for distillate pump pressure and water flow meter.
- Check salinity of fresh water produced.
- Check level and flow of dosing chemical.
- Check ampere of ejector pump and distillate pump motor

STOPPING PROCEDURE FO THE FWG

1.Close the jacket water inlet valves. Generally inlet is closed first and then the outlet valve.
2.Close the valve for feed water treatment.
3.Stop fresh water pump.
4.Switch off the salinometer.
5.Stop sea water pump (also known as ejector pump).
6.Open vacuum valve.
7.Close sea water suction valve and overboard valve.

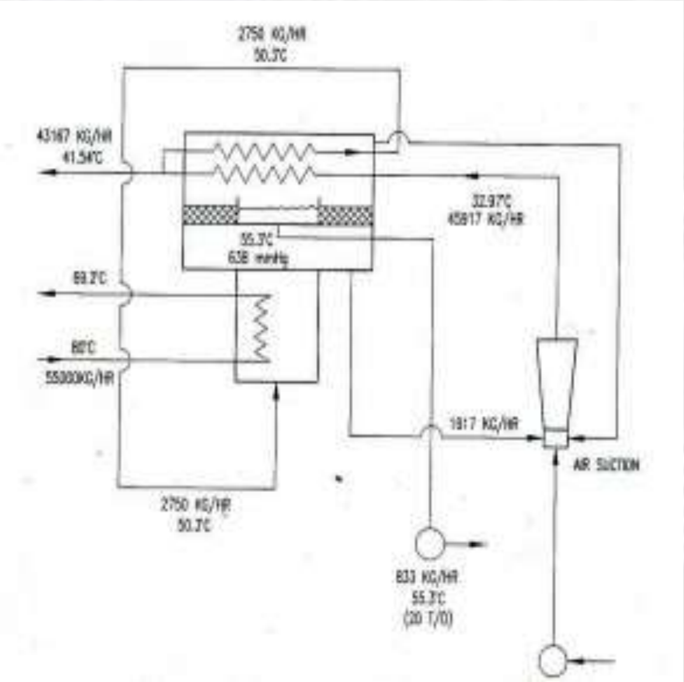
This is generally not required as they are non-return valves. However, in case of valve leaking or damage, these valves are to be closed without fail.



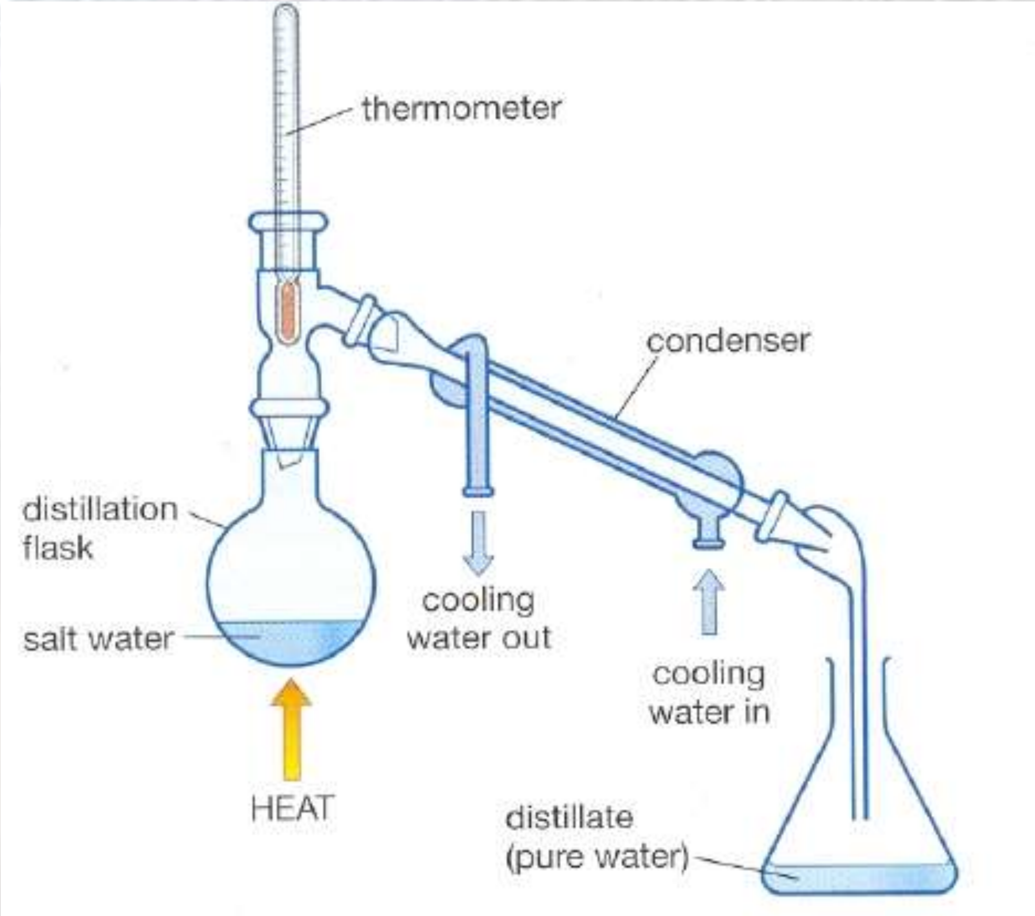
Precautions for Operation of Fresh water Generator

- Seawater pressure at the inlet of air ejector must be 3 bar or more.
- The pressure at ejector outlet should not exceed 0.8 bar.
- Never start fresh water generator distillate pump in dry condition.
- Operate jacket cooling water valves to the fresh water generator gradually to avoid thermal shock to the main engine.
- Feed water to be supplied for a few minutes to cool down the evaporator before stopping.
- Never open the drain valve of evaporator before opening vacuum breaker. Otherwise atmospheric pressure causes seawater inside to hit the deflector.

SHELL AND TUBE FRESH WATER GENERATOR



FRESH WATER DISTILLATION ON BOARD A SHIP : PRINCIPLE OPERATION



- **Desalination** (also known as **desalinization** or **desalting**) is the process of removing salt from water.
- A desalination device essentially separates seawater (saline water) into 2 streams: one with low concentration of dissolved salts (the fresh water stream) and the other containing the remaining dissolved salts (the concentrated or brine stream).

Thermal Processes

3 types are discussed here:

(1) Multi-Stage Flash (MSF) Distillation
(2) Multiple-Effect Distillation (MED)
(3) Vapour-Compression (VC) Distillation

WHAT DOES SEA WATER HAVE?

- Seawater is pure water plus dissolved solids and gases.
- A 1-kg sample of saltwater typically contains 35-g of dissolved compounds, including inorganic salts, organic compounds from living organisms, and dissolved gasses.
- The solid substances are known as 'salts' and their total amount in the water is referred to by a term known as salinity (expressed as parts per thousand).
- Oceanic salinities generally range from 34 to 37 parts per thousand; or 34,000 - 37,000 ppm. [For comparison, the salt content of fresh water is less than 1,000 ppm].

SHELL AND TUBE FRESH WATER GENERATOR

WORKING

- The freshwater generator uses the heat from main engine jacket cooling water to produce drinkable water by evaporating seawater due to the high vacuum, which enables the feed water to evaporate at a comparative low temperature. Steam can also be used as a heat source instead of main engine jacket cooling water.
- The freshwater generator is based on two sets of shell and tube heat exchangers, one acting as evaporator or heater and other as condenser.
- The water ejector creates evaporator chamber vacuum condition by driving sea water pass through water ejector, and sea water supplied by the ejector pump to be delivered to ejector for taking out the brine (concentrated seawater) and air.
- While entering to the evaporator chamber, feed water evaporates due to vacuum condition. The water spray and droplets are partly removed from the vapour by the deflector mounted on top of the evaporator and partly by a build in demister. The separated water droplets fall back into the brine, which is extracted by the water ejector.
- The desalted vapour, which passes through the demister, will be sucked into vapour chamber where it will be condensed by means of incoming cold seawater.
- The distilled water is then taken out by integral freshwater pump (distillate pump) and controlled by salinometer and solenoid valve. If the salt content of produced water is high, solenoid valve diverts the freshwater to the shell side of freshwater generator, and issues an alarm signal.
- Thermometers are installed for control of seawater to the condenser and jacket cooling water to the evaporator. These thermometers permit control of both heating and cooling of these units.
- The salinometer or salinity indicator is connected to remote alarm so that very high salinity is immediately registered at the engine control room of the ship.

Working Principle with Saturated Steam Heating

- In addition to engine jacket cooling water heating, saturated live steam can alternatively be used as heating medium for the shell and tube freshwater generator.
- The saturated live steam is being delivered to the heat exchanger of the freshwater generator through a steam injector.
- This steam injector works as a circulating pump and heat up the circulated freshwater or steam condensate, which comes from the outlet branch of the heat exchanger.
- The heat exchanger of the freshwater generator is filled with clean freshwater or steam condensate by starting the steam heating process.
- The produced steam condensate from supplied live saturated steam escapes from the socket in the vertical safety blow off pipe.
- This condensate is led back to the boiler feed water hot well or cascade tank.

What are the causes of loss of vacuum in fresh water generator ?

- Failure of ejector pump
- Failure of ejector nozzle (fouling, erosion)
- Malfunction of check valve (at ejector nozzle)
- Defective vacuum breaker
- Any air leakage into the system (At joint)

What will happen when vacuum reach 100% in fresh water generator ?

- Increase the salinity because of agitation. At that time boiling rate is very high.
- To control this condition, open the vacuum breaker to maintain 93% vacuum.

Why fresh water generator is fitted on ships ?

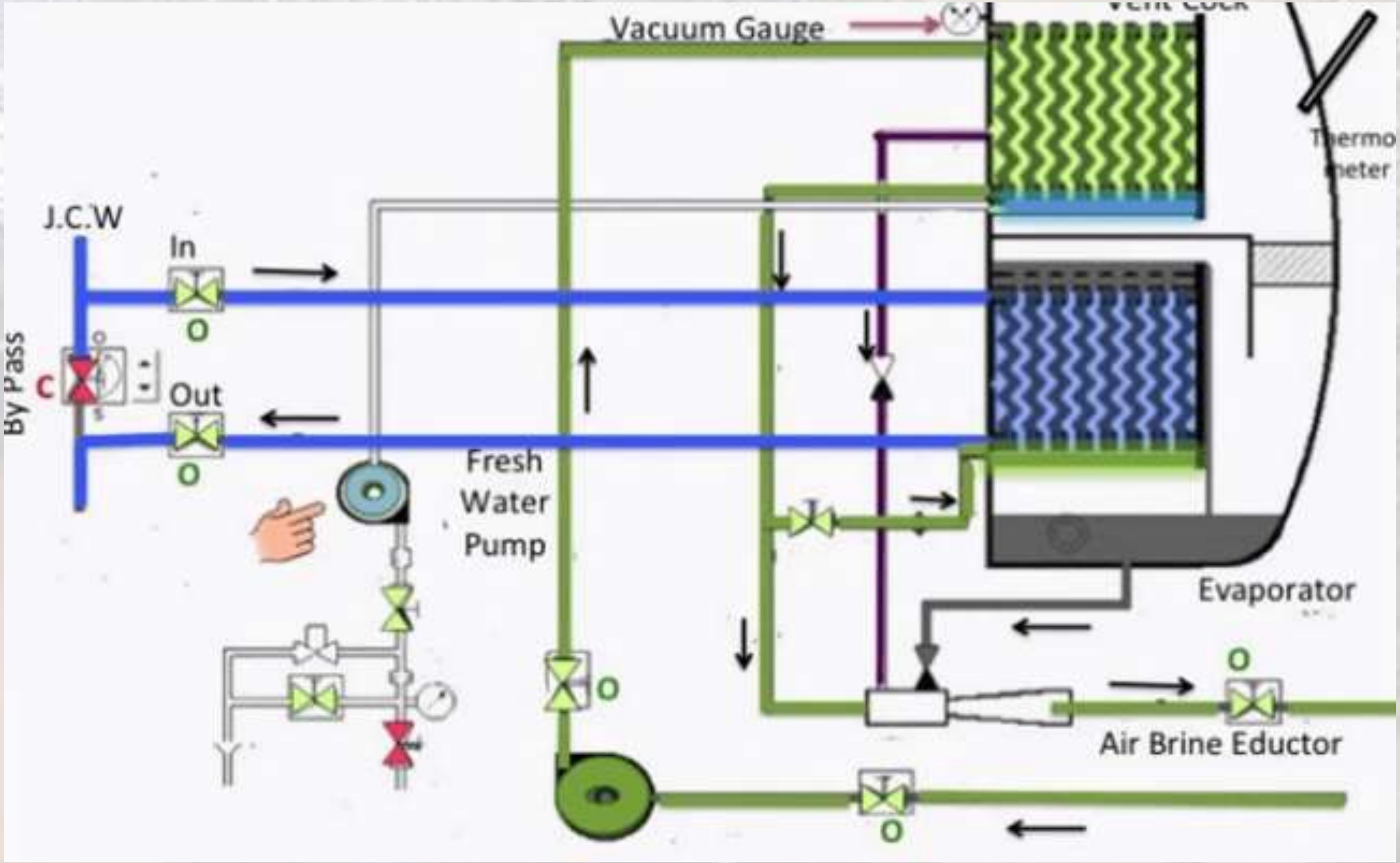
- To produce the high purity distilled water from sea water
- To provide make up water for boiler and portable water for drinking and domestic use. So can save cost.
- What are the treatments for drinking purposes ?
- Chlorination.
- Ultra violet light sterilization.
- Liberation of silver ions to the water.

LOW PRESSURE EVAPORATION (FWG) OR VACCUM OPERATION

Evaporation is a unit operation that consists of concentrating a solution by eliminating the solvent by boiling.

In this case, it is performed at a pressure lower than atmospheric pressure. Thus, the boiling temperature is much lower than that at atmospheric pressure, thereby resulting in notable energy savings.

HOW LOW PRESSURE IS CREATED IN FWG? BRINE EDUCTOR



R.O PLANT

What is meant by Osmosis ?

- When different concentration solutions are separated by a semi-permeable membrane, water from less concentrated solution pass to the other solution through the membrane to equalize the concentration of the two solution.
- It create hydraulic pressure gradient across the membrane as the volume and level of weaker solution fall and those of the stronger solution rise.

What is meant by Reverse Osmosis ?

- The pressure greater than the osmotic pressure is applied to the side of higher concentration solution, the osmosis process is reversed.
- Water from the stronger solution is forced back through the semi-permeable membrane to dilute the initially weak solution on the other side and further increase the concentration of the strong solution.
- The total pressure required for this process consists of the osmotic pressure (between 4 bar for brackish water up to 28 bar for sea water) plus the system pressure losses and net driving pressures (around 25 bar).

What are the semi permeable membranes used on ships ?

- Hollow fine fiber (aromatic polyamide or cellulose acetate spurn to form hollow fiber)
- Spirally wound (cellulose acetate for backish water and polymide or polysulphonate for sea water)

REVERSE OSMOSIS

- The diffusion of water through a selectively permeable membrane is called osmosis.
- This allows only certain particles to go through including water and leaving behind the solutes including salt and other contaminants. In the process of reverse osmosis, thin film composite membranes (TFC or TFM) are used.
- These are semipermeable membranes manufactured principally for use in water purification or desalination systems.
- They also have use in chemical applications such as batteries and fuel cells.
- Membranes used in reverse osmosis are, in general, made out of polyamide, chosen primarily for its permeability to water and relative Impermeability to various dissolved impurities including salt ions and other small molecules that cannot be filtered.
- Another example of a semipermeable membrane is dialysis tubing.

Stages of Filtration

- The modern RO system is a unit consisting of a sediment pre-filter to remove particulates, turbidity, sand and rust; an activated carbon pre-filter to remove the chlorine, pesticides, herbicides, disinfectants, and VOCs which might otherwise damage the reverse osmosis membrane; the reverse-osmosis membrane which removes virtually everything such as heavy metals, lead, salt, chromium and dissolved solids; a storage tank, and an activated-carbon post filter. The carbon post filter or polishing filter is necessitated by the demineralized, slightly acidic RO water attacking the rubber inside the storage tank, dissolving some of the rubber. This can be avoided by remineralizing the water prior to storage. This remineralization technology is found in the patented Artesian Full Contact system.
- **Sediment Stage**: removes rough particles, sand and rust.
- **Carbon stage**: removes chlorine and chemicals which would otherwise damage the TFC reverse osmosis membrane. Multiple carbon stages my be necessary at this point depending on the carbon quality and contact time.
- **Reverse osmosis stage**: removes dissolved solids nd virtually everything larger than the water molecule itself. This is where the bulk of the purification is accomplished.
- **Remineralization Stage**: water purified by reverse osmosis is highly pure and slightly acidic. The Tap Master Artesian Full Contact remineralizes with calcium and magnesium to balance the pH, improve the taste and introduce healthy minerals. Learn more about Alkaline Water.

Storage tank

- **Optional or application specific water treatment stage(s)**: UV filter to destroy microorganisms, nitrate/arsenic/fluoride/deionization selective filters to remove whatever small amount remains of these contaminants.
- **Final Carbon stage**: also known as a "polishing" filter this carbon filter removes any tastes or odors the acidic RO water has "picked up" from the storage tank. In other words the acidic water produced from systems without the Artesian Full Contact technology will dissolve some of the rubber in the storage tank which the final carbon filter then removes.

Types of Reverse Osmosis Membranes

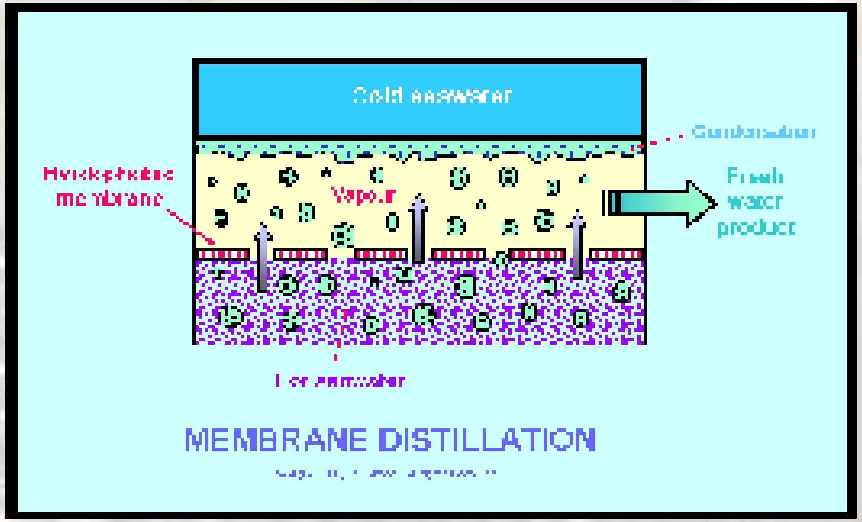
- Two common types of household RO membranes are the Thin Film Composite (TFC or TFM) membrane and the Cellulose Triacetate (CTA) membrane.
- The main differences between the two types are filtration ability and chlorine tolerance. The CTA membrane is chlorine tolerant, but is more susceptible to fouling from bacteria, and it only rejects 93% of standard contaminants.
- The TFC/TFM membranes reject 98% of standard contaminants on average, are less susceptible to organic fouling, but it can only treat chlorine free water.
- Carbon pre-treatment filters must be used with a TFC/TFM membrane when purifying chlorinated municipal water supplies.
- Brackish water, saline water, and brine water membranes are available for marine, industrial, and municipal desalinization projects.

REVERSE OSMOSIS PURITY

- Reverse osmosis removes salt and most other dissolved inorganic material present in the water, and for that reason, reverse osmosis water filters are usually used in places where the drinking water is brackish (salty), contains nitrates, radio nucliatides, heavy metals or other dissolved minerals which are difficult to remove by other methods.
- Using a quality carbon filter to remove any organic materials and chemicals that get through the sediment pre-filter, in conjunction with RO produces water with a purity that approaches distilled water is important for any house water filtration system.
- Microscopic parasites (including viruses) are usually removed by RO units, but any defect or micro-tear in the membrane will allow these organisms to pass into the 'clean" water.
- This is why RO systems are not rated to remove microorganisms except when an Ultraviolet Light filter is incorporated into the system, such as in the case of the UV

MEMBRANE PROCESSES

- The membrane process is, appropriately, known as membrane distillation.



Membrane Distillation

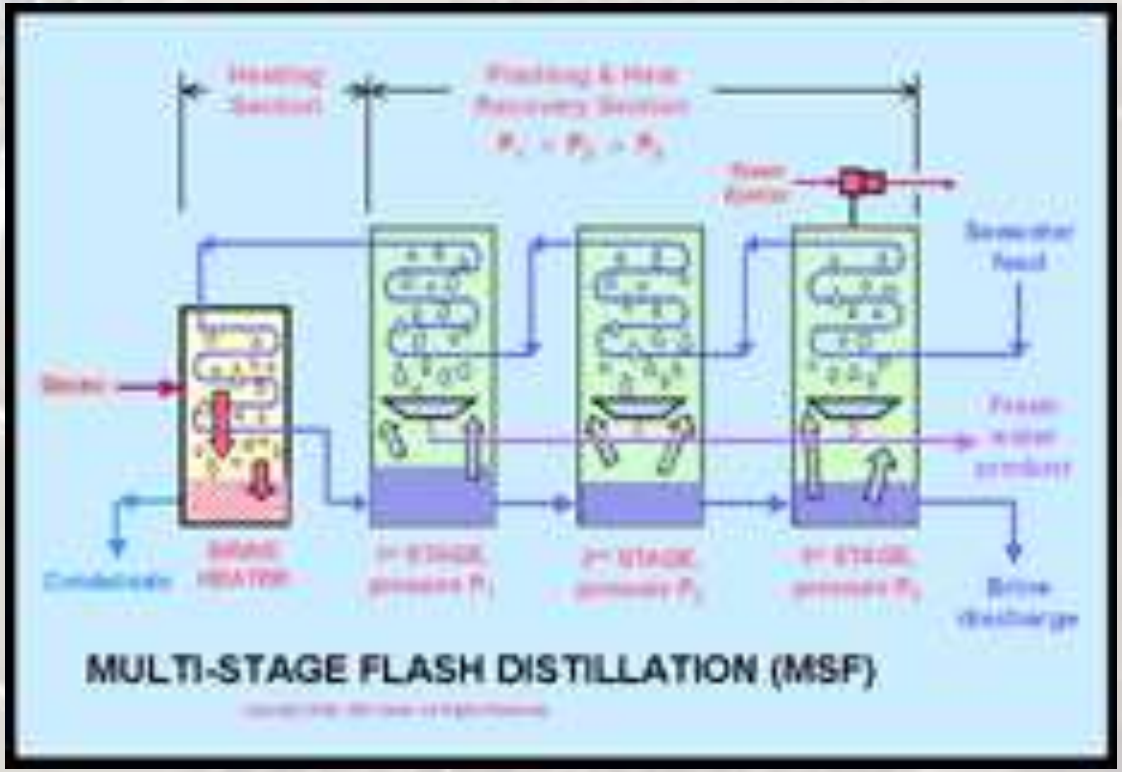
- This process uses a special membrane to bring out the water vapour generated from hot seawater, condensing and collecting it as fresh water.
- The membrane used is a porous, hydrophobic membrane, meaning that only water vapour can pass through it, but droplets of water cannot.
- By passing hot water through one side of the membrane, only the water vapour generated from the seawater passes through.
- When the water reach the other side of the membrane where cold seawater is flowing, it condenses into water droplets, producing fresh water.

MULTI-STAGE FLASH DISTILLATION

Seawater enters the Brine Heater in a bank of tubes, where steam is condensing on the outside.

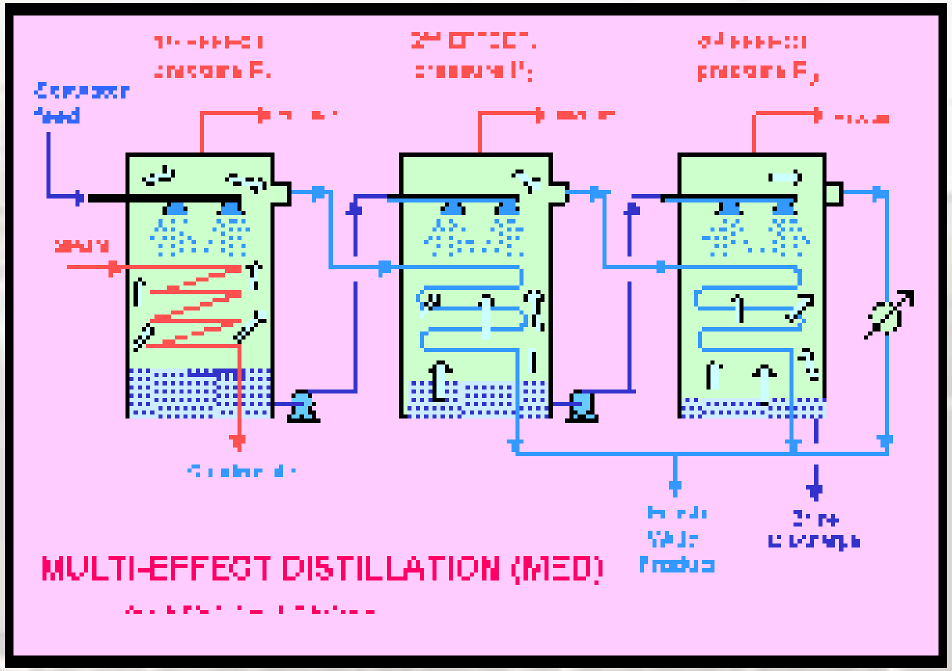
- The heated seawater flows to the first stage, where it flashes upon entry. During flashing, some of the water vapor (steam) is removed from seawater.
- The flashed vapor is then condensed on the outside of the tubes carrying seawater feed to the brine heater.

- The condensed steam is withdrawn as fresh water.
- The unflashed portion of seawater now contains more salts, and is send to the second stage for further flashing. The second stage is operated at a pressure lower than the first stage in order to lower the boiling point of seawater.
- At the second stage, more water vapor (steam) is flashed off, and is again recovered as fresh water by condensing on the tubes carry seawater feed to the first stage.
- The remaining seawater is then send to the third stage, at a lower pressure than the second stage, for more separation.
- Multi-stage flash distillation plants built commercially has capacities ranging from 4,000 to 30,000 m^3/day, and usually operates at the top feed temperature (after the brine heater) of 90 - 120 ^oC. A typical MSF plant can contain from 4 to about 40 stages, with each successive stage operating at a lower pressure and temperature than the previous one.
- This allows the reduction of boiling point of the seawater as it gets more concentrated in going down the stages. Multiple boiling is thus possible without the supply additional heat after the brine heater.



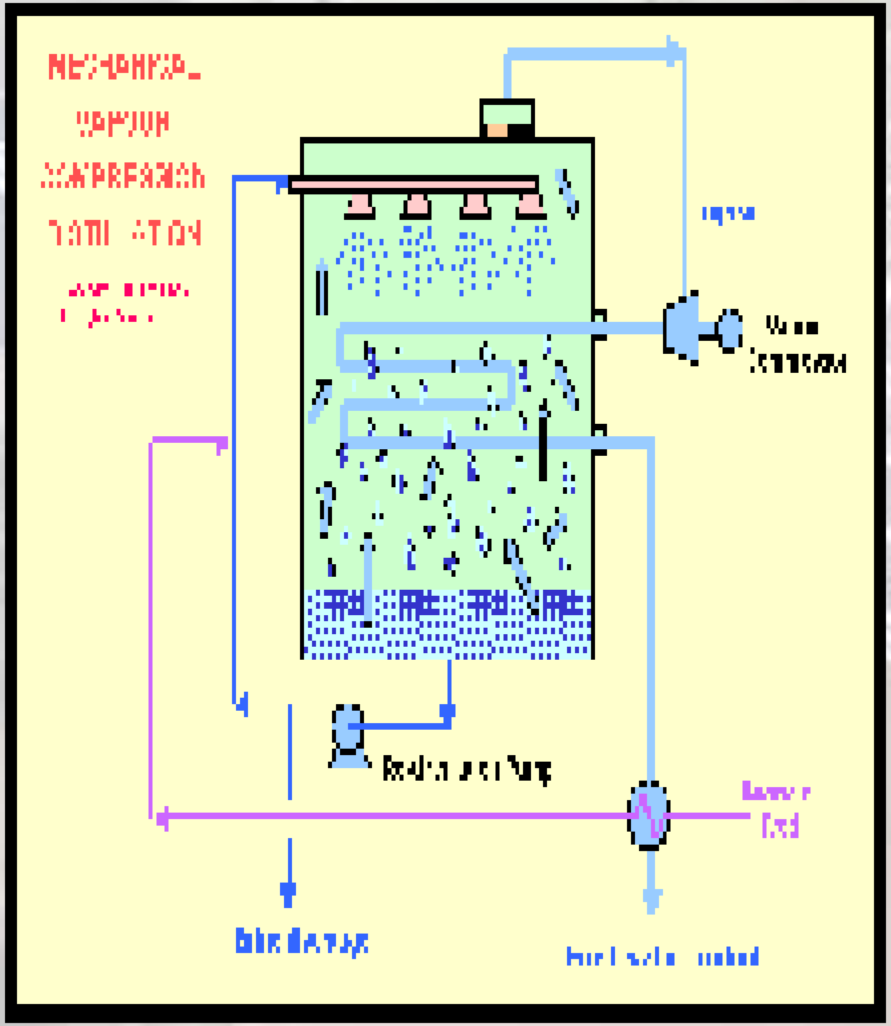
MULTI-STAGE FLASH DISTILLATION (MSF)

Multiple-Effect Distillation



- Like the MSF distillation, separation takes place in a series of vessels (known as effects), each operating at a lower pressure.
- In the MED plant, the seawater entering the first effect is sprayed onto the surface of a bank of tubes inside which steam in flowing.
- Refer to the Figure below. A portion of the water is evaporated off the surface, and the rest of the seawater is collected at the bottom of the first effect.
- Steam condenses in the tubes and is withdrawn for recovery.
- The evaporated hot water vapor acts as a heat source for the second effect. It now flows into a bank of tubes on the second effect.
- Seawater from the first effect is pumped to the second effect and is sprayed over the tubes carrying the vapor from the first effect.
- Further evaporation occurs on the tubes surfaces, while the rest of the seawater is collected at the bottom of the second effect. At the same time, the vapor condensed inside the tubes and is withdrawn as fresh water from the second effect.
- Vapor produced from evaporation in the second effect is likewise routed to the third effect, where it is used to separate the seawater from the second effect. Up to 8 or 16 effects can be used in this way.
- MED plants typically are built in units of 2,000 to 10,000 m^3/day capacity, with a top temperature (first effect) of about 70 $^{\circ}$C. It is not as widely used as the MSF method.

Vapour Compression (VC) Distillation



- In this method, a mechanical compressor or a steam jet is used to condense the water vapor to provide the heat required to vaporize the incoming feed seawater.
- The compressor withdraws vapor from the vessel, creating a low pressure condition.
- The vapor gains heat by being compressed by the compressor.
- The hot, compressed vapor is returned to the vessel in a bank of tubes where seawater is being sprayed onto the outside surface of the tubes.
- Water vapor evaporates from seawater, and the vapor in the tubes condenses.
- The remaining seawater that is not evaporated is collected at the bottom of the vessel and is re-circulated using a pump.
- The evaporated water vapor is drawn off by the compressor, while the condensed vapor in the tubes is withdrawn as fresh water product.
- This process is usually used for small to medium production. Typical capacity is in the 20 - 2,000 m^3/day range.

Scale formation

How to Minimize Scale Formation?

- Scale formation in fresh water generator can be controlled and minimized by continuous chemical treatment.
- **Polysulphate compounds (like sodium polysulphate) with anti foam** is preferred by marine engineers and is extensively used on ships.
- These chemicals minimize calcium carbonate scale formation and possibility of foaming. the compound is non toxic, no-acidic, and can be used in fresh water generator producing water for drinking purposes.
- If would be continuously fed into the feed line using a metering pump or by gravity.
- Amount of chemical to be dosed depends on the capacity of fresh water produced. Important thing is that this chemical is effective only on low pressure fresh water generators.
- The sea water temperature to be less than 90 degrees. Fresh water generator chemical treatment to be religiously carried out to maintain its performance.

How scale formation occurs in FWG

The performance of fresh water generator reduces with the formation of scales because of reduction in heat transfer efficiency.

Three scales which are normally found in fresh water generators are:

✓ Calcium Carbonate, $CaCO_3$

✓ Magnesium Hydroxide, $Mg(OH)_2$

✓ Calcium Sulphate, $CaSO_4$

- Calcium carbonate and magnesium hydroxide scale formation mainly depends on the temperature of operation. Calcium sulphate scale formation depends mainly on the density of the evaporator contents or brine. The reaction takes place when sea water heated are:

$$\mathbf{Ca(HCO_3)_2 \longrightarrow Ca + 2HCO_3}$$

$$\mathbf{2HCO_3 \longrightarrow CO_3 + H_2O + CO_2}$$

- If heated up to approx. 80 degree Celsius

$$\mathbf{CO_3 + Ca \longrightarrow CaCO_3}$$

- If heated above 80 degree Celsius

$$\mathbf{CO_3 + H_2O \longrightarrow HCO_3 + OH}$$

$$\mathbf{Mg + 2OH \longrightarrow Mg(OH)_2}$$

- Hence if the sea water in the fresh water generator is heated to a temperature below 80 degree Celsius, calcium carbonate scale predominates. If sea water is heated above 80 degree Celsius, magnesium hydroxide scale is deposited.
- If the density of evaporator contents is in excess of 96000 ppm, calcium sulphate scales are formed. But fresh water generator brine density is normally 80000 ppm and less. Hence scale formation due to calcium sulphate is not a problem.
- Hence it is recommended to operate fresh water generator at its rated capacity, not more. More production of water than rated capacity means higher concentration of brine and more scale formation. Similarly higher shell temperatures result in formation of hard scales which will be difficult to remove. All these together will reduce the plant efficiency drastically.

LOSS OF VACCUM IN FWG

What happens if Loss of Vacuum or Over-pressure of Shell?

- The shell pressure of the fresh water generator rises and rate of freshwater produced reduces. The reasons are:
- Air leaks into the evaporator shell in large quantities and air ejector cannot cope.
- The cooling water flow through the condenser is reduced or cooling water temperature is high. This cause saturation temperature and hence saturation pressure within the condenser to rise.
- Malfunctioning of the air ejector.
- Flow rate of the heating medium increased and excess water vapour produced. Since this excess vapours cannot be condensed, shell pressure increases or vacuum falls.

SALT WATER CARRY OVER

- Salt water may be carried over in large quantities during operation of the freshwater generator. This is called priming. General reasons of the priming are:
- Level of salt water inside the shell is high. When water level is high agitation due to boiling occurs and salt water may carry over along with the vapours.
- When the salt water brine density is too high, agitation of salt water occurs which results in priming.
- Increased evaporation rate.

GRADUAL INCREASE IN LEVEL OF BRINE

- For the satisfactory operation of the freshwater generator, a constant level of brine to be maintained in the shell.
- Brine is the concentrated sea water after liberation of water vapours. This brine is gradually extracted from the shell.
- Usually this is achieved by the combined air-brine ejector. It extracts air as well as brine from the shell.
- Any fault in the ejector or brine extraction pump (in some models) cause increase in the brine level.

INCREASE IN SALINITY OF FRESHWATER

Possible causes are:

- Brine level inside shell too high.
- Leaking condenser tubes or plates.
- Operation of evaporator near shore with contaminated feed water.
- Shell temperature and pressure too low.
- Increased solubility of CO2 generated from the salt water due to reduced sea water temperature. This dissolved CO2 makes water acidic and conductivity of water increases. Hence salinometer shows increased salinity, which is a measure of conductivity ans not presence of salt.

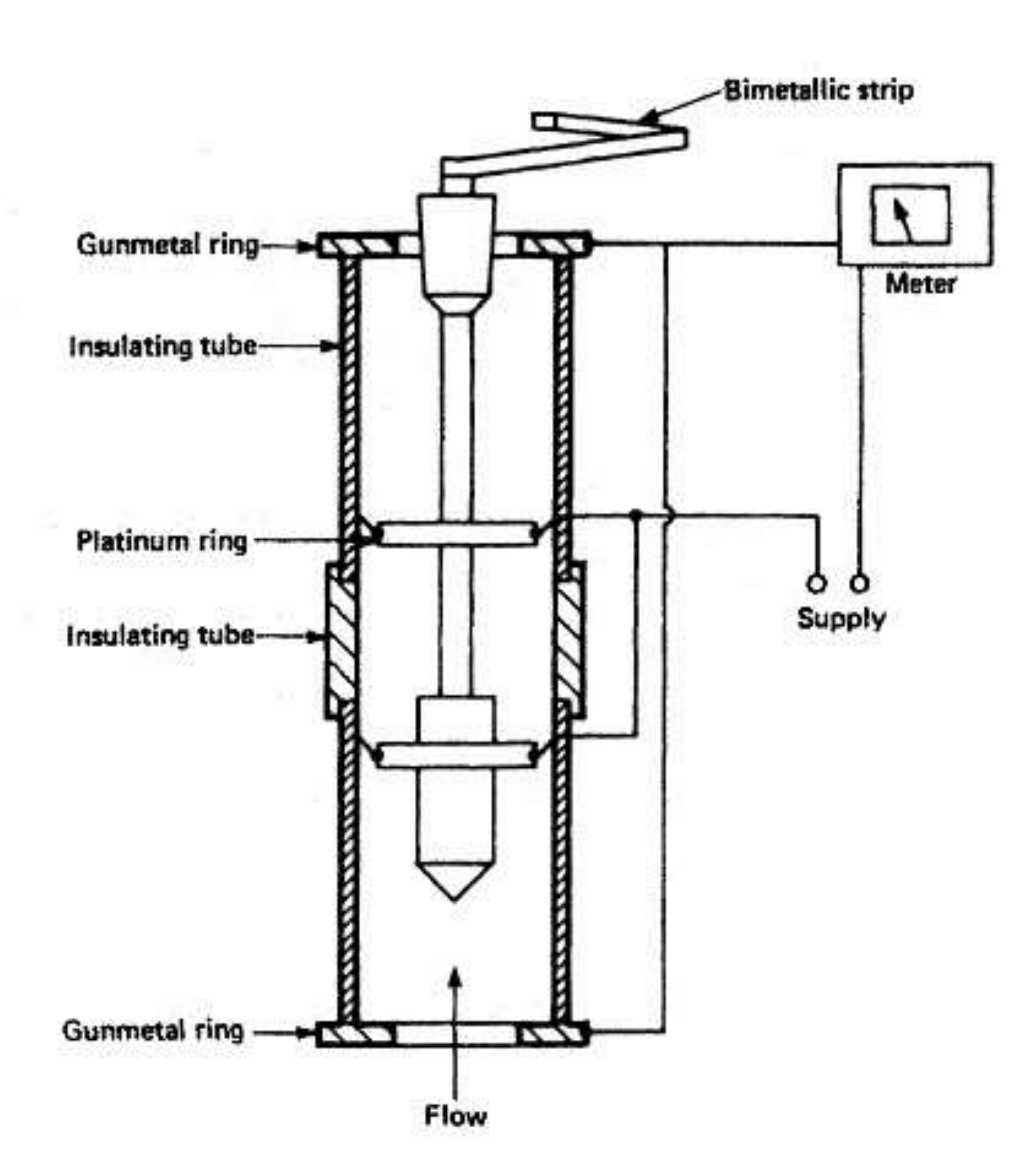
DRINKING WATER TREATMENT

- Chlorination.
- Ultra violet light sterilization.
- Liberation of silver ions to the water.

SALINOMETER

How to determine water purity ?

- Water purity, in terms of the absence of salts, is essential where it is to be used as boiler feed.
- Pure water has a high resistance to the flow of electricity whereas salt water has a high electrical conductivity.
- A measure of conductivity, in Siemens, is a measure of purity.
- The salinity measuring unit (shown in Figure) uses two small cells each containing a platinum and a gunmetal electrode.
- The liquid sample passes through the two cells and any current flow as a result of conductance is measured.
- Since conductivity rises with temperature a compensating resistor is incorporated in the measuring circuit.
- The insulating plunger varies the water flow in order to correct values to 20 degree C for a convenient measuring unit, the micro Siemens/cm3 or dionic unit.
- A de-gassifier should be fitted upstream of this unit to remove dissolved carbon dioxide which will cause errors in measurement.



FRESHWATER TREATMENT

- Several methods are used to sterilize water on ships. If ultra violet sterilizer and automatic chlorinator system are used, they should be in proper working condition. Moreover, a full flow silver ion system can also be used for the same.
- Fresh water storage tanks should be prevented from getting contaminated by taking every step possible. The following steps must be taken without fail.
- If possible, drinking and washing water should be kept in a separate tank, which is isolated from the system supplying fresh water to jacket water, oil purifiers etc.
- In case such arrangement is not possible, a non return valve or an air break in the pipe work should be fitted to prevent any back contamination.
- Fresh water storage tanks should be inspected at regular intervals of time and proper maintenance should also be carried out.
- They must be inspected every 12 months and refilled with sterilized water following cleaning with a 50 PPM chlorine solution.
- Fresh water tanks should not be located near any of the oil tanks
- Fore peak tanks which are susceptible to damage, or aft peak tanks which are too difficult to clean should not be used for fresh water storage

- The storage tanks should be designed in such a way that easy drainage and cleaning is possible.
- Tanks should be pressure tested every 10 years to ensure that there is no seepage of any kind.
- Manholes should be made of adequate size and must be raised above the deck level
- Pipes which have the same quality of water should be allowed to pass through the tanks
- Goose necks should be properly designed to prevent ingress of sea water
- Proper coatings as suggested by the manufacturers should be applied inside the tanks
- Contamination of fresh water mainly occurs in the distribution system and therefore suitable filtration system (filters and strainers) is a must.
- Water treatment equipment, neutralizers, softeners etc. should also be used to improve the quality of water.
- Hot water line in the fresh water generator should be properly insulated especially when it runs adjacent to the cold water line. Moreover, special care should be taken while choosing material used for the joints.
- The fresh water distribution system should be a part of the planned maintenance system on ships.
- Chlorinators should be raised to 70^{o}C before opening for inspection to kill any type of bacteria colonies. Moreover, opportunity should be taken at refits to flush the system with 50 PPM chlorine solution. Shower heads and taps should be cleaned in a similar solution every 3 months.
- Chemicals approved and suggested by the manufactures must only be used to prevent any kind of toxicity entering the fresh water.
- Antifouling equipment of the approved type should be used if required.