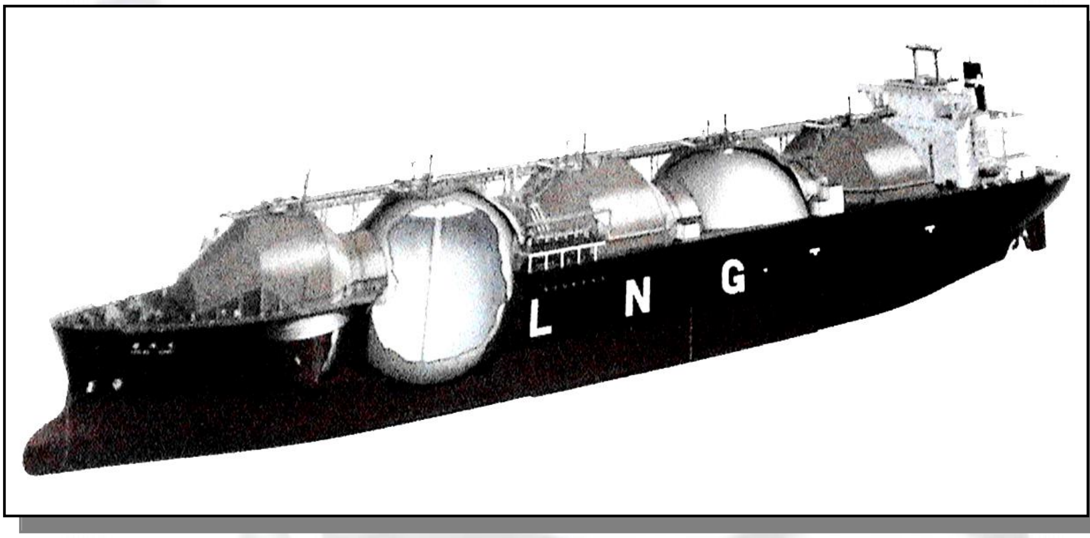

LNG OPERATIONS FOR ENGINE RATINGS

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I. INTRODUCTION

I.1 OUTLINE OF LNG

I.1.1 Definition of LNG

When natural gas is chilled to below it's boiling point of -162°C at atmospheric pressure, it condenses into a liquid about one six hundredth of gas in volume. This liquid is called LNG (Liquefied Natural Gas). The weight of this colorless, transparent liquid is about one half of water with the same volume.

a. **Composition of LNG**

Similarly to natural gas, LNG consists of several hydrocarbons of which methane is the main component. Other hydrocarbons making up this compound liquid are ethane, propane, butane, and pentane, plus nitrogen which is often found in natural gas is also dissolved into LNG. However, other useless components in natural gas such as H_2O, H_2S, CO_2, heavy hydrocarbons, etc., are removed in the liquefying process. Composition of each hydrocarbon contained in LNG dictates the actual density or specific gravity of LNG. The more the heavier hydrocarbons are present, the higher the density of LNG becomes and the greater its calorific value. As a difference between LNG and natural gas, it can be mentioned that the components of LNG change while in storage in a tank. This change is caused by the evaporation of light components such as methane and nitrogen, which takes place than that of heavier hydrocarbons. Thus, the concentration of heavier hydrocarbons increases while in a prolonged storage.

I.1.2 Characteristics of LNG

The following are enumerated as main properties of LNG and its characteristics in storage and transportation:

a. Cryogenic temperature of about -160°C LNG will require use of suitable materials for cryogenic temperature, consideration toward expansion and contraction due to the change in temperatures, structural design with due regard to thermal stress, effective heat-insulation system, precaution against damage caused by low temperature, etc.

b. Volumetric reduction to about one six hundredth of gas at the normal temperature due to liquefaction. This is advantageous to storage and transportation. Tank pressure will rise due to the boil-off (evaporation)
c. A liquid in the state of boiling point. When equilibrium between gas and liquid is destroyed by rise of temperature or fall of pressure, the liquid will immediately start boiling.
d. Density is about half, that of water. Inflammable, but combustion range of its vapour is narrow.
e. Volumetric percent LNG is present in air and forms an explosive mixed gas. In order to prevent such a formation, considerations are given to avoiding LNG corning into contact with air by for example, keeping the tank pressure slightly higher than the atmospheric.
f. Upon leaking into air, it rapidly evaporates and forms white vapour cloud by the condensation of moisture.
g. Colorless and odorless liquid.
h. Large latent heat of evaporation.
i. High volatility.
j. Low viscosity.
k. High dielectric power and extremely poor electric conductivity. It can easily be charged even by static electricity.
l. No causticity and no toxicity.
m. Almost no solubility in water.
n. Small surface tension.

II. LIQUIFIED NATURAL GAS CARRIER OUTLINE

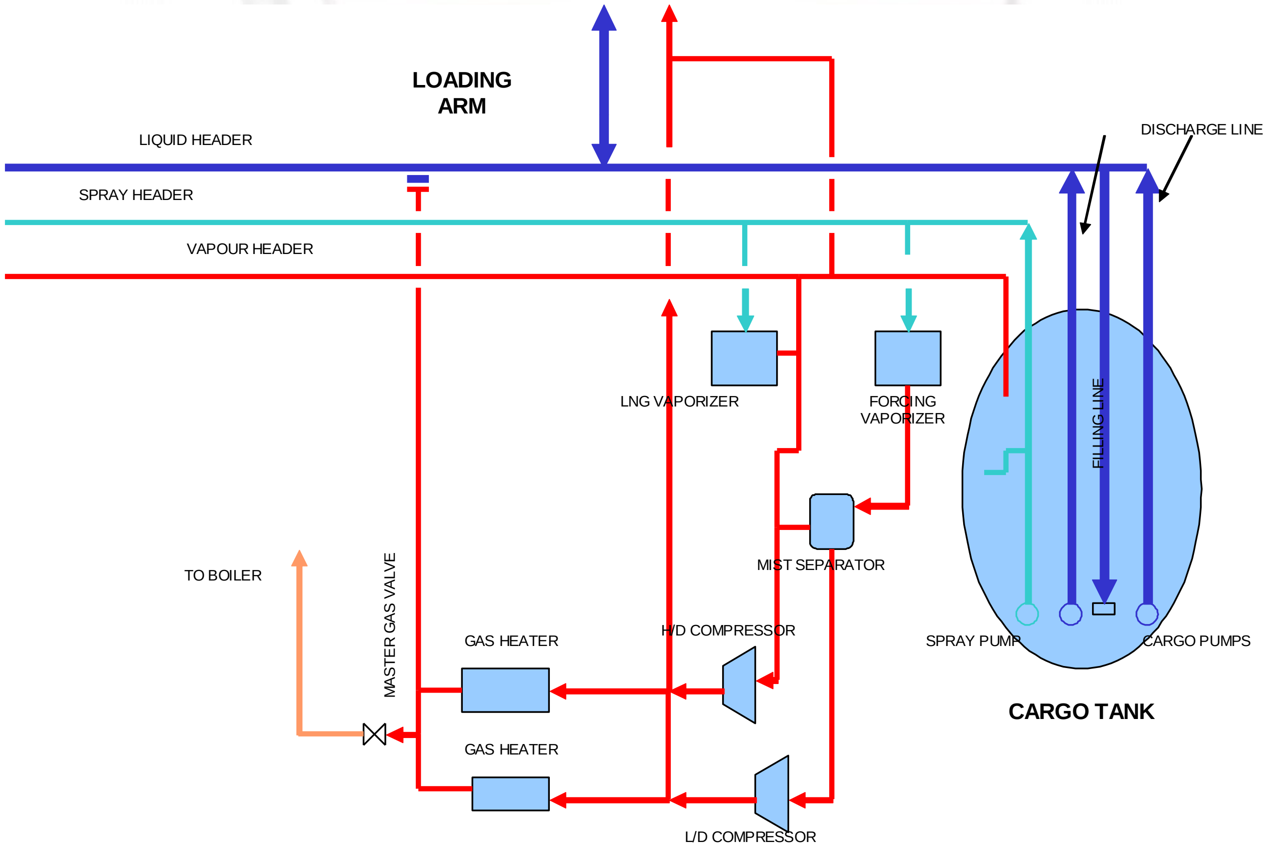
Liquefied natural gas or LNG is liquid with a boiling point close to -160^{0}C. This cryogenic LNG is loaded in a cargo tank lined with insulating aluminum alloy and other appropriate insulations such as balsa wood and polyurethane foam among others for insulation. Under the external heat, LNG in the tank is in the boiling state. This LNG easily vaporize in a slight difference of temperature producing boil off gas. Boil off gas produced at this point, by the external heat acting on the tank, increases tanks internal pressure. Consequently, the boiling point of LNG rises, causing the LNG temperature to rise also. In this condition, it is therefore necessary to maintain the LNG constant temperature of -160^{0}C by extracting the boil off gas to stabilize the tanks internal pressure and to avoid further vaporization of LNG.

The main machine used in loading, unloading and transportation of LNG cargo includes the cargo pumps, which is fitted two sets in each of the five cargo tanks and is used in discharging LNG from ship to receiving terminal or facilities.

The spray pump which is fitted in number 4 and 5 cargo tanks only and is used to cool down the cargo tanks and cargo lines prior to any cargo operations, and to extract cargo to be forcibly vaporize by the use of LNG vaporizer to meet the boiler fuel gas demand in case of gas combustion mode only.

The high duty compressor, which transports the boil off gas, generated during loading from ships cargo tanks to land in order to stabilize both the ship and terminal cargo tanks internal pressure and temperature.

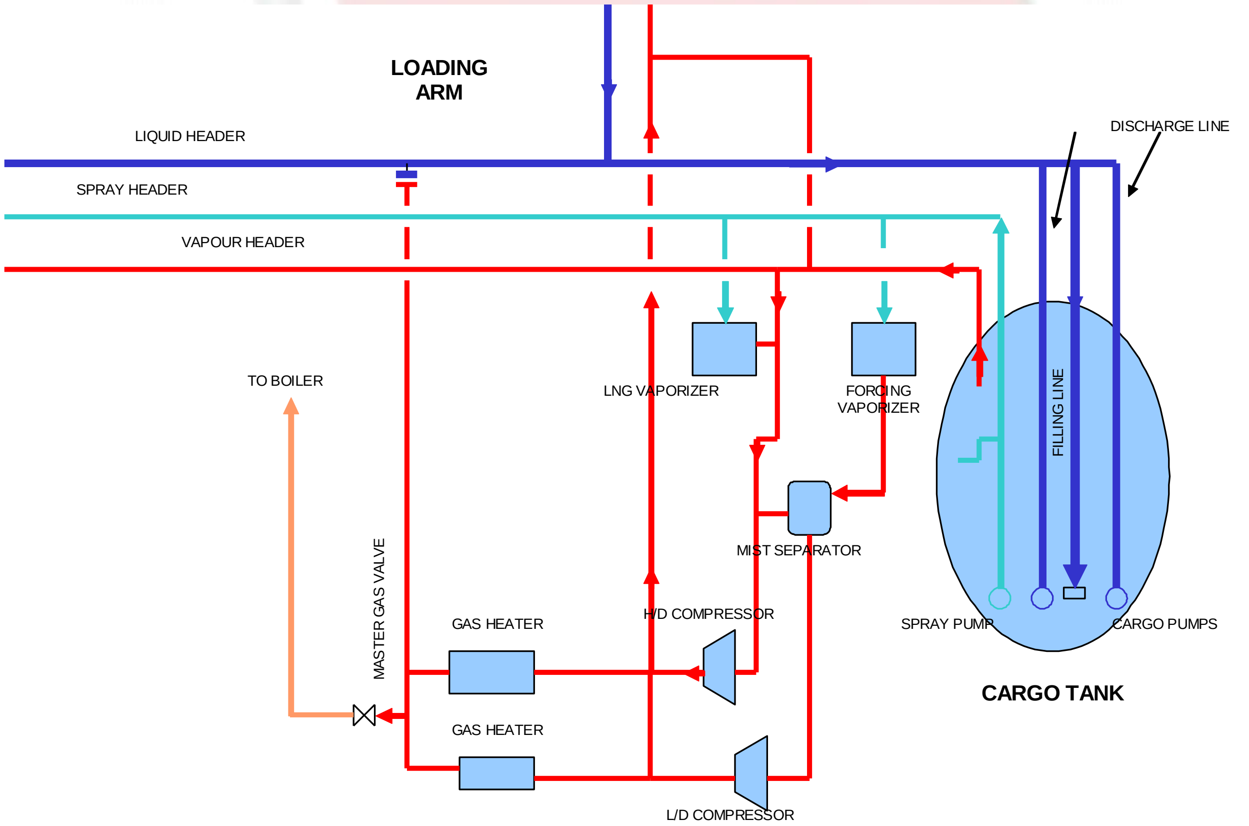
The LNG vaporizer, which forcibly vaporize the LNG necessary for boiler



LNG CARRIER OUTLINE

consumption. Any boil off gas during laden and ballast voyages is sent to the boiler and is used as fuel. The main machines, which allow the boil off gas to be sent into the boiler and used as fuel includes the mist separator, which prevents vapour, carry over to the low duty compressor. The low duty compressor, which compresses and pressurize the LNG into a preset temperature and pressure necessary for boiler combustion specification. The gas heater in which the gas is further heated from 30^0C-45^0C. The master gas valve, which acts as the gas supply root valve, which is activated by the tanks internal pressure. The gas nozzles which combust the gas. There are two kinds of gas nozzles. One is the outer mixing nozzle which is used in low combustion or when the boiler load is low. Moreover, the other is outer mixing nozzle which is used in high combustion or when the boiler load is high. The boiler hood exhaust fan which maintains the negative pressure inside the tubes duct of the gas line to contain and expel boil off gas to the atmosphere preventing the boil off gas to leak in the engine room thus reducing the risk of ignition and explosion in the engine room should the rapture of the gas line occurs

II.1 LOADING OPERATION

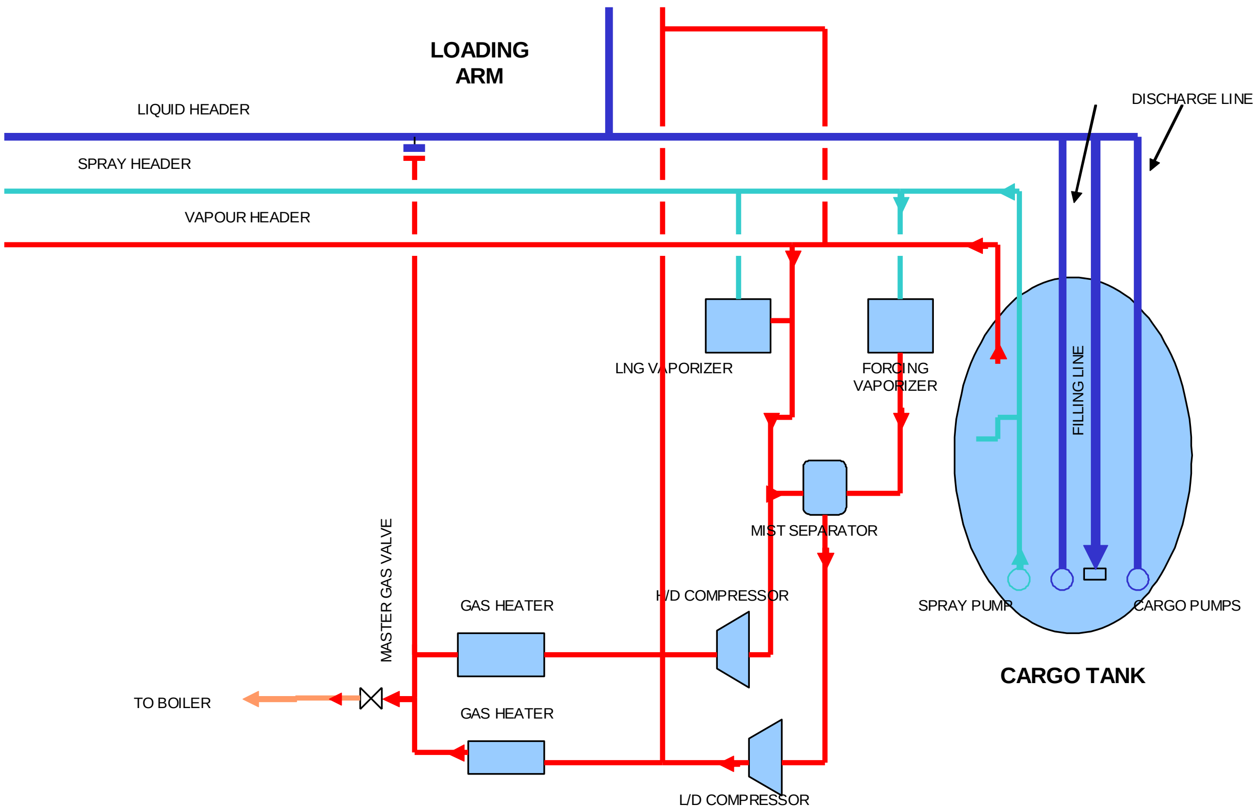


LOADING OPERATION

During loading operation, liquefied natural gas is loaded into the vessel through the liquid line or the liquid header and to the filling line. During loading, the LNG driven by a land base pump is feed into the cargo tanks. The LNG is first loaded in a slow rate. Inspects all lines, and if no abnormalities then increase gradually up to the normal rate. As loading commences, boil off gas is produced, due to LNG level rises causing the tank internal pressure to rise. Consequently, as loading proceeds, the H/D compressor is driven in order to

transfer the boil off gas, which causes the tank internal pressure to rise, back to land via the gas line or the vapour header. In this manner, the tanks internal pressure stabilizes even the liquid level continue to rise or loading proceeds because the boil off gas is returned to the terminal.
FIG. II-1

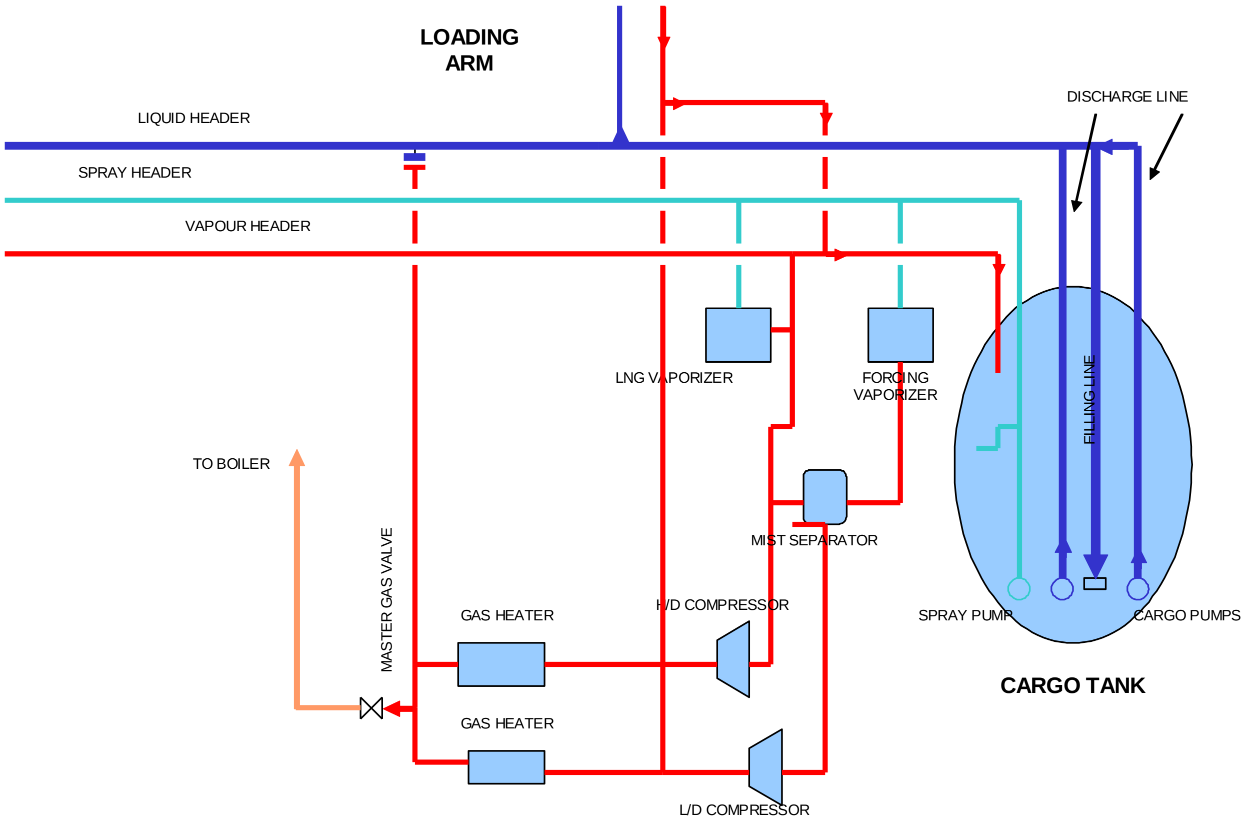
II.2 LADEN VOYAGE



LADEN VOYAGE

During laden voyage, the external heat and the vessels motion, causes the LNG to boil off and the cargo tank internal pressure to rise. As the pressure increases inside the cargo tank, the LNG temperature inside the cargo tank also rises. Consequently, the L/D compressor is driven in order to suck in the boil off gas inside the cargo tanks through the gas line. This low temperature gas is heated to 30 -45 degrees by the gas heater, send to the boiler through the master gas valve, and used as fuel. If during gas combustion, there is insufficient gas to operate the boiler, or the boiler gas demand is high, the LNG is forcibly gasified by the use of forcing vaporizer to compensate the boiler gas demand. In such case, the LNG driven by the spray pump, through the spray line, is send into the forcing vaporizer where the LNG is gasified. The forcing vaporizer further heats the liquid LNG in order to gasified. The gas produced from the forcing vaporizer is then feed to the boiler vie the low duty compressor to meet the boiler fuel gas demand.

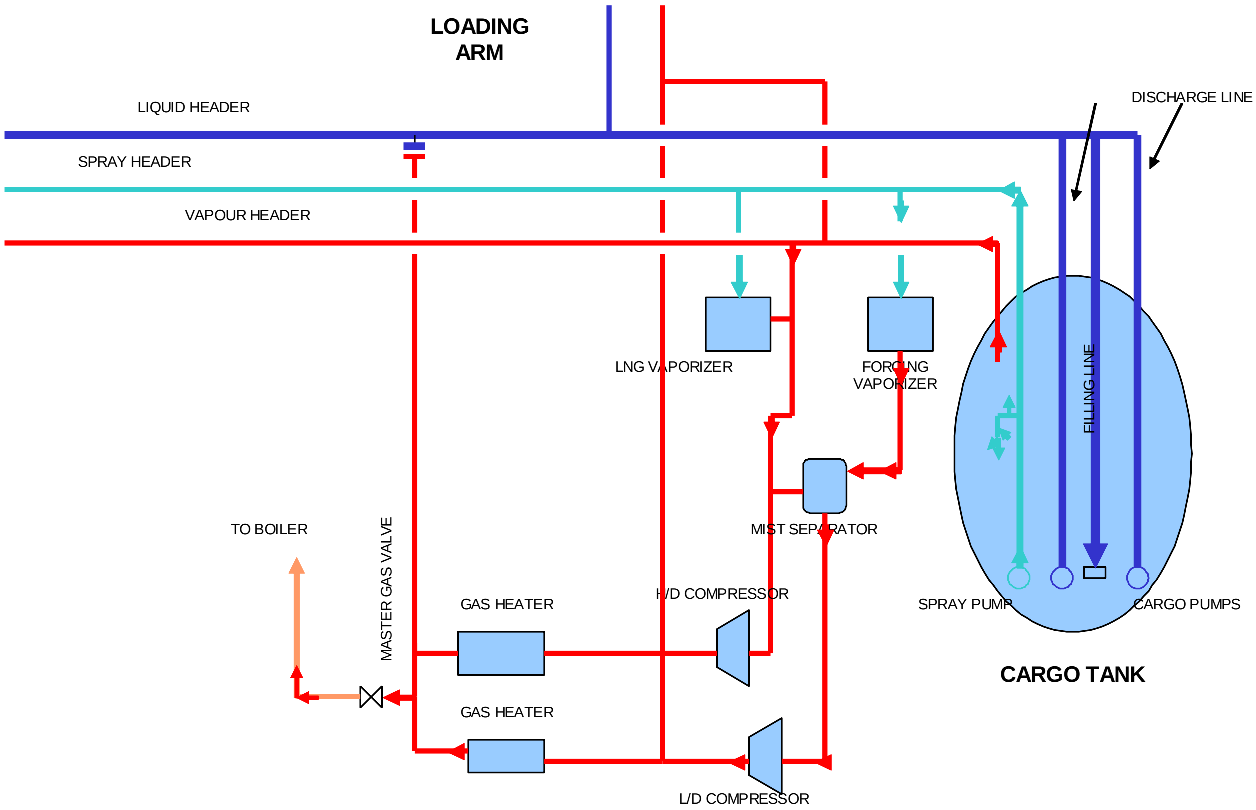
II.3 DISCHARGING OPERATION



DISCHARGING OPERATION

During discharging operation, the cargo pumps drive the LNG along the liquid line to land. At this point the cargo tank internal pressure falls, as the liquid LNG level drops. In order to maintain cargo tanks internal pressure during discharging, gas is send through the gas line from land by the use of RGB or return gas blower from the terminal.

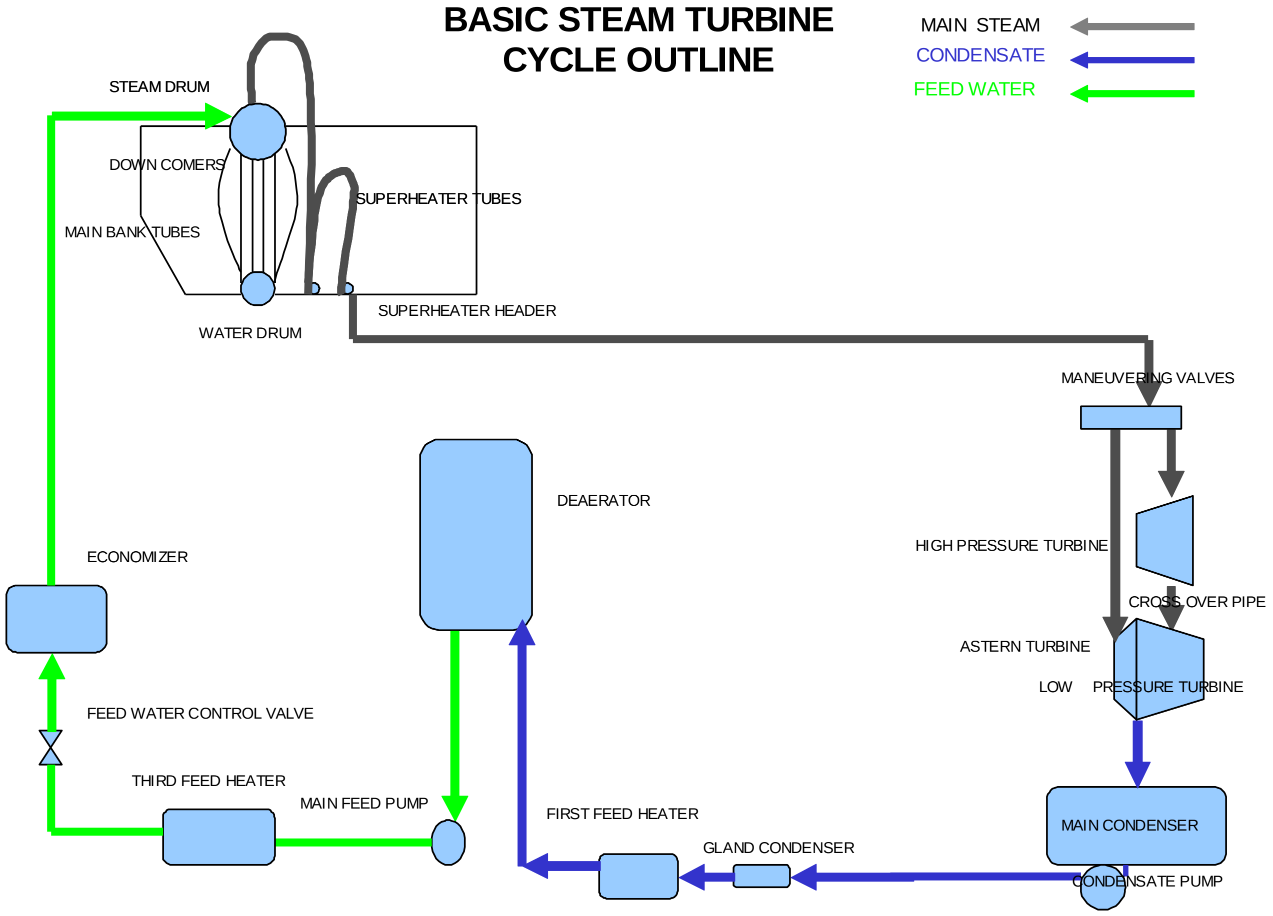
II.4 BALLAST VOYAGE



BALLAST VOYAGE

During ballast voyage, the cargo tank and ships tank is cooled down in preparation for loading. The LNG driven by the spray pump inside the cargo tank through the spray line, is sent into the spray nozzles, where it is sprayed thoroughly inside the cargo tank, up to the target equator temperature is achieved. As the LNG gasified when sprayed, heat is absorbed from the surroundings, cooling the interior of the cargo tank. As the cargo tank internal pressure rises when spraying commences, gas is sucked in by the L/D compressor through the gas line. This gas is send to the gas heater and once heated to 30-45 degrees is send to the boiler through the master gas valve where it is used as fuel. If during boil off gas combustion, there is insufficient gas to operate the boiler, or if the boiler gas demand is high, the LNG is forcibly gasified to compensate for the insufficient gas. By the use of spray pump through the spray line, the LNG is supplied to the forcing vaporizer, where the LNG is vaporized. Then to the mist separator where the vaporized LNG vapor is separated, to prevent carry over to the L/D compressor, then feed to the boiler as fuel.

III. BASIC STEAM TURBINE PLANT CYCLE OUTLINE

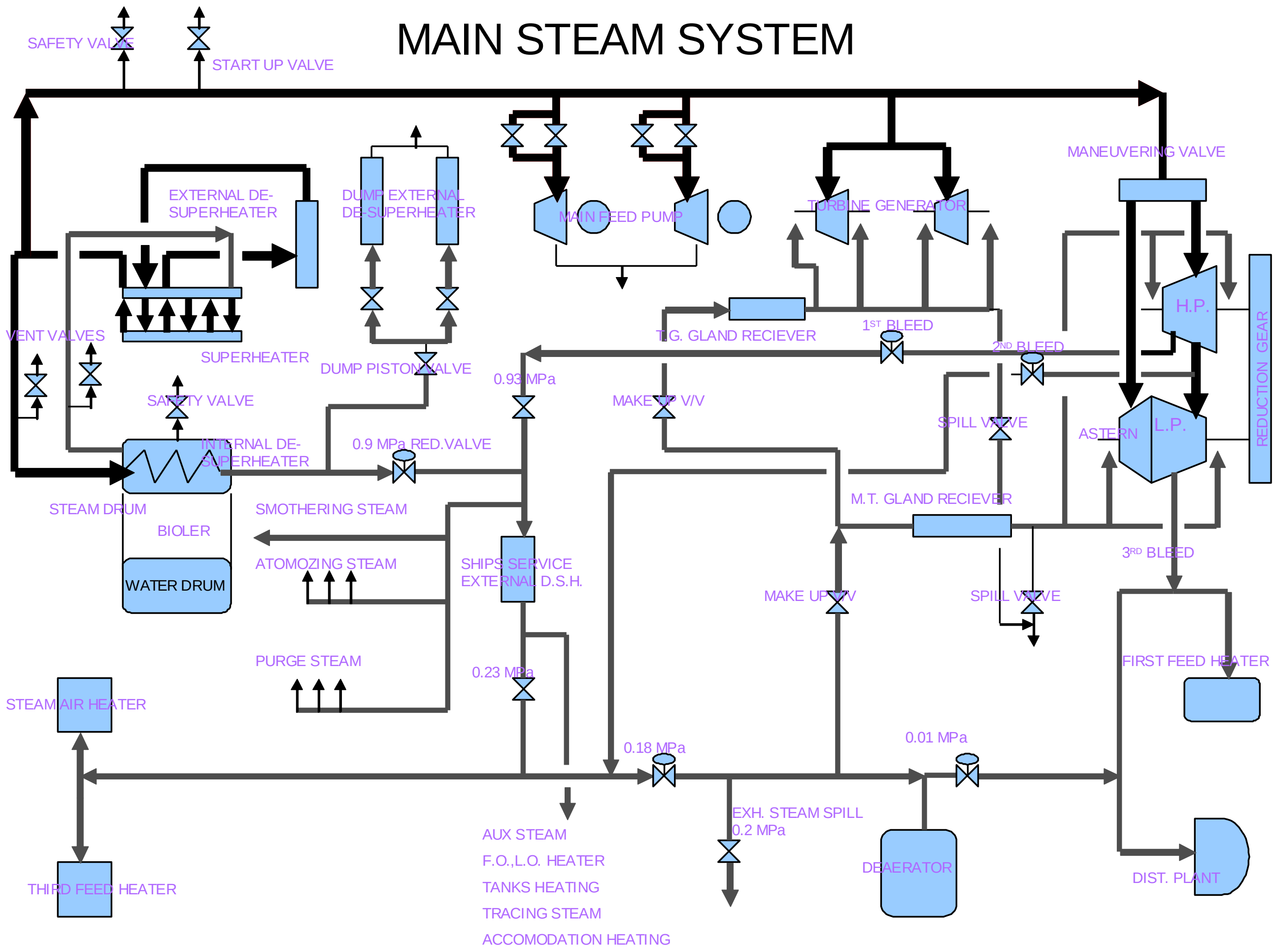


In order to make effective use of boil off gas from the cargo tank, the LNG carriers employs the steam turbine plant. The steam turbine uses the force or the energy of the steam to turn the turbine rotor and the propeller. Machines that make up the plant include the boiler, where the steam is produced. The steam turbine, which uses the energy of the steam to turn the propeller. The reduction gear, which reduces the high revolution of the turbine into the preset or designed revolution appropriate for the vessel. The condenser, which condenses the steam, used to turn the propeller ion order to utilize it again for steam generation. The de-aerator, which acts as the second stage heater, removes oxygen content of the water by de-aeration to prevent scaling of tubes, maintains the positive suction head of the feed pump for better plant efficiency. The feed water pump, which drives and pressurizes the feed water with minimal amount of oxygen from de-aerator to the boiler.

Water inside the boiler turns into steam, send to the main condenser after driving the steam turbine, becomes water once again, passes through the de-aerator and replenishes into the boiler.

Water inside the boiler is heated by the heat generated by the fuel combustion, turns into steam, and collects into the steam drum. In this state, the steam is referred to as saturated steam. All of the saturated steam is transported to the super heater, where it is further heated to become superheated steam hotter than the saturated steam. These high temperature high-pressure steams coming from the boiler, passes through the maneuvering valve, and send to the main turbine. Inside the turbine, the steam expands when passing through the nozzles, and increases its velocity energy. The steam impacts onto the moving blades to turn the rotor, where the rotary power is generated, through the action of the steam as it expands in between of the moving blades. Once the steam is spent inside the turbine, it is cooled by the main condenser and becomes condensate water. To exploit the thermal energy held by the steam inside the condenser, the condenser is maintained at a vacuum state by the vacuum pump. In this manner, the large heat drop from the steam inside the turbine improves the plants thermal efficiency. Condensate water inside the condenser is sucked in by the by the condensate water pump and send to the de-aerator. Inside the de-aerator, the condensate water is heated to saturation temperature, separating the oxygen dissolved in the condensate water. Feed water sucked in and pressurized by the feed water pump, is heated by the feed water heater, and re directed to the boiler.

III.1 MAIN STEAM SYSTEM



All saturated steam from the steam drum, is further heated by the super heater, turning into high temperature high-pressure super heated steam. Super heated steam goes from the 4th pass of the super heater, to the external de-super heater, and returns to the 5th pass. The external de- super heater adjusts the volume of water sprayed into the steam, and the steam temperature at the outlet of the super heater is adjusted to 525 degrees Celsius. The superheated steam is used in two ways; firstly, as superheated steam to drive the main turbine, the turbo generator and the feed water pump. Secondly, as de- super heated steam to heat the other installations. The warming up line which bypasses the motor valve to warm up the lines of the stand by feed water pump, and warm up the stand by feed water pump itself, is installed in the feed water pump steam inlet motor valve. A safety valve, which protects the boiler by releasing steam when the steam pressure rises too high, is installed in the steam drum and the outlet of the super heater. The safety valve pressure setting is higher in the steam drum than the super-heater outlet, this is due to the fact that if the safety valve of the steam drum is activated before the super-heater the volume of the steam flowing through the super-heater tubes decreases causing heat damage to the tubes.

Air vent valves are fitted into the steam drum and the internal de-super-heater inlet to extract air from the interior of the boiler when the plant up is carried out. A start up valve, which maintain the flow of steam inside the super-heater, is fitted onto the super-heater outlet in order to prevent heat damage to the super- heater tubes in times such as when the plant up is carried out or the boiler trips. Some of the super-heated steam flow to the internal de-super-heater installed on the steam drum in order to lower the temperature. The internal de-super-heater in the steam drum or water drum lowers the temperature of the super-heated steam by heat exchange between the super-heated steams with the boiler water. When the load of the main turbine rapidly drops or the processing of the boil off gas produces excess steam, the surplus steam travels from the de-superheated steam line through the dump valve to the condenser where it is finally cooled. As the in the inlet to the dump valve is extremely high compared to that of the outlet, there is possibility of steam leaking into the condenser when only one dump valve is on. For this reason, the piston is fitted to the inlet side of the dump valve.

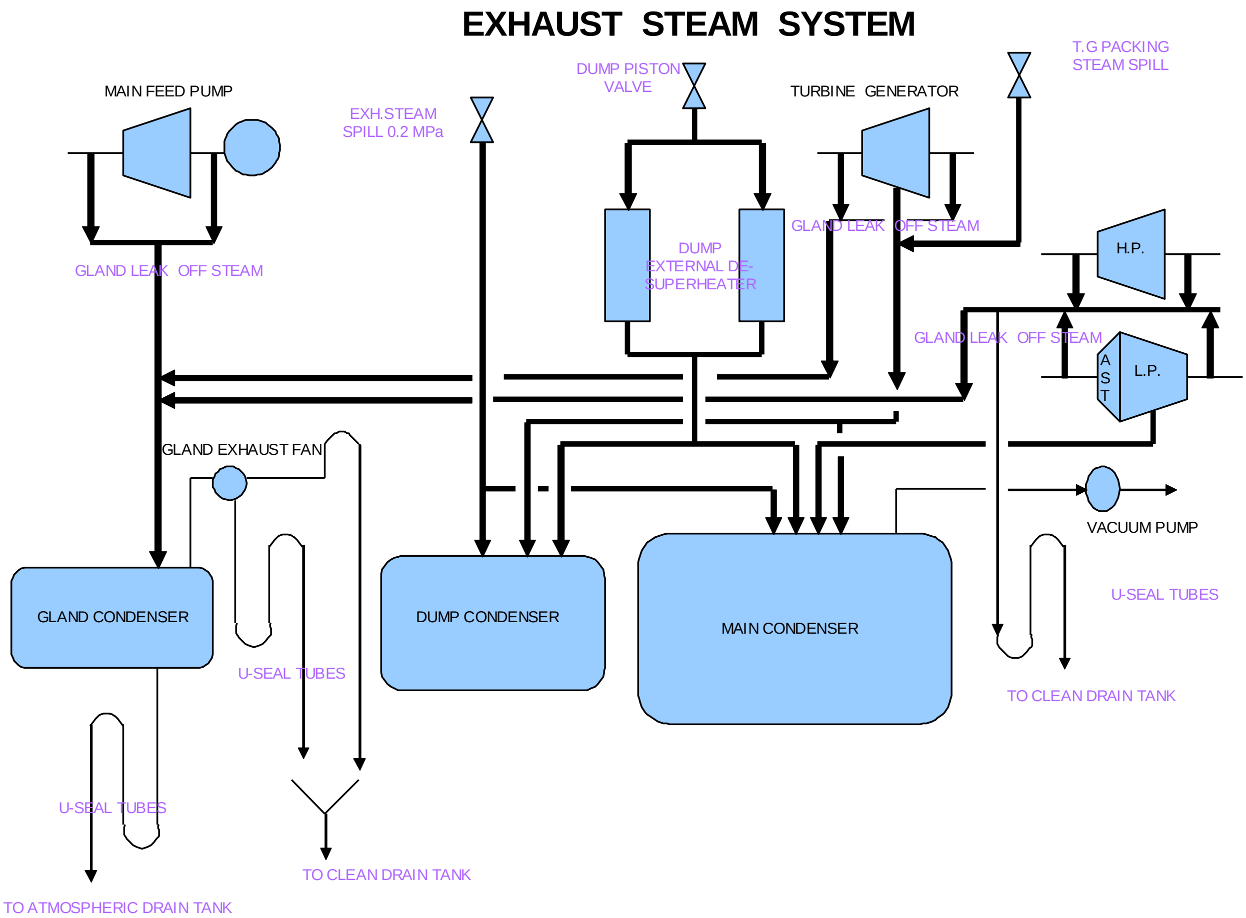
Furthermore, in order to prevent damage to the main condenser due to the high temperature steam the external de-super-heater is located at the outlet side of the dump valve. De-pressurized steam through a 0.9 MPa pressure reducing valve is supplied for the burners atomizing steam, purge steam and the extinguishing steam of the furnace. The temperature of the 0.9 MPa steam is lowered by the external de-super-heater, the steam is supplied as the heating steam for the fuel oil and lubricating oil further de-pressurized and then supply to other facilities. The heating steam of the steam air heater and the 3rd feed water heater is supplied from 0.23 MPa pressure reducing line. As the thermal energy held by the feed water pump exhaust steam is high, it is used as de-aerator heating steam and as packing steam. However, as there is global feed water pump exhaust steam when the boiler load is low 0.18 MPa steam which has been depressurized from 0.23 MPa line is supplied in order to compensate for this lack of heating steam to the S.A.H and 3rd heater.

Furthermore as there is a large amount of exhaust steam from the feed water pump when the boiler load is high causing the pressure to rise excessively in the 0.18 MPa line the steam is released into the main condenser or the dump condenser via 0.2 MPa exhaust steam spill valve.

Gland sealing steam is supplied to the main turbine and the turbo generator from the 0.18 MPa line. The distilling plant heating steam is supplied from the 0.01 MPa line. While at sea some of the main turbine steam is extracted for use as bleed steam to further improve the over-all efficiency of the plant.

The opening and shutting of the first and second piston bleed valve is controlled in accordance with the main turbine nozzle valves position or by the pressure of the bleed line when the main turbine load is high, the valves are open.

III.2 EXHAUST STEAM LINE



Exhaust steam from main turbine is condensed by the main condenser. The interior of the main condenser is maintained in a vacuum state by a vacuum pump. This increases the heat drop of the steam from the main turbine making it possible to convert the greater amount of thermal energy into a mechanical energy thereby increasing efficiency.

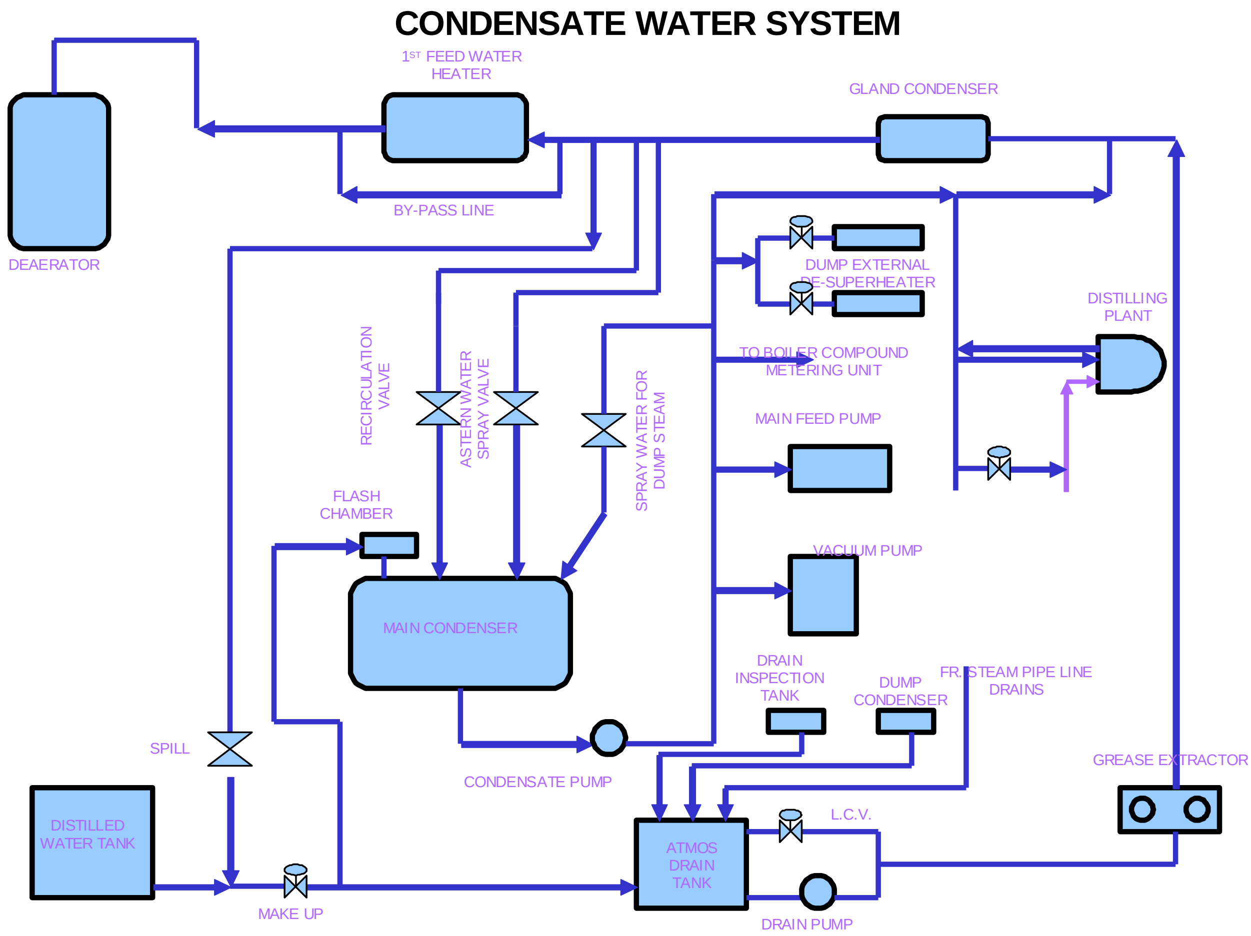
Exhaust steam from turbo the generator, dump steam and excess steam from the de-aerator heating steam line via 0.2 MPa exhaust steam spill valve or normally condensed by the main condenser. The steam lines of the above installation are designed to be exchanged to the dump condenser; however, as the interior of the dump condenser is not in a vacuum state, care must be taken when changing not to reduce the vacuum in the main condenser. The spill line of the turbo generator gland sealing steam is connected to the exhaust steam line of the turbo generator. Gland leak steam from the main turbine, turbo generator, and main feed water pump is condensed by the gland condenser. The gland condenser is maintained at a pressure slightly below atmospheric pressure by the gland exhaust fan casing is expelled through the u-seal. The u-seal maintains internal pressure of the fan and serves to remove any drains from the gland exhaust fan casing.

III.3 DRAIN SYSTEM

The drain system is describes by two types, the clean drain and the contaminated drain. The clean drains are those drains, which cannot be contaminated by oil. The contaminated drain on the other hand such as fuel tanks heating have a risk of oil contamination. The drain water level of the 3rd feed water heater is controlled by the LCV. The drain line of the 3rd feed water heater is automatically changes according to the load of the main turbine. When the main turbine load is high it changes to the de-aerator and when the main turbine load is low to the 1st feed water heater. The drain of the steam air heater of the boiler serves as the heat source of the 1st feed water heater. The water level of the 1st feed water drain is controlled by the level controlled valve, like the drain line of the 3rd feed water heater that of the 1st feed water heater is automatically change according to the load of the main turbine. With the high load it switches to the drain tank and when low to the flash chamber of the main condenser.

The flash chamber separates the turbine drain, leak steam into drain, and vapor thereby protecting the main condenser. Spill from the main turbine gland sealing steam, drain of distilling plant, heating steam line, and main turbine is sent to main condenser through the flash chamber. Drain from the steam line, is sent to the drain tank and re-used in order to heat the tank. Condensate water from the distilling plant heating steam is sent to the drain tank. Contaminated drain is cooled by the drain cooler, cleaned of oil by the de-oiler, and send to the drain tank through the inspection tank. An oil content monitor fitted by the outlet of the drain cooler checks if the drain is contaminated by oil. In order to maintain the internal pressure of the gland condenser, the condensate water inside the gland condenser is send to the drain tank through the u-seal.

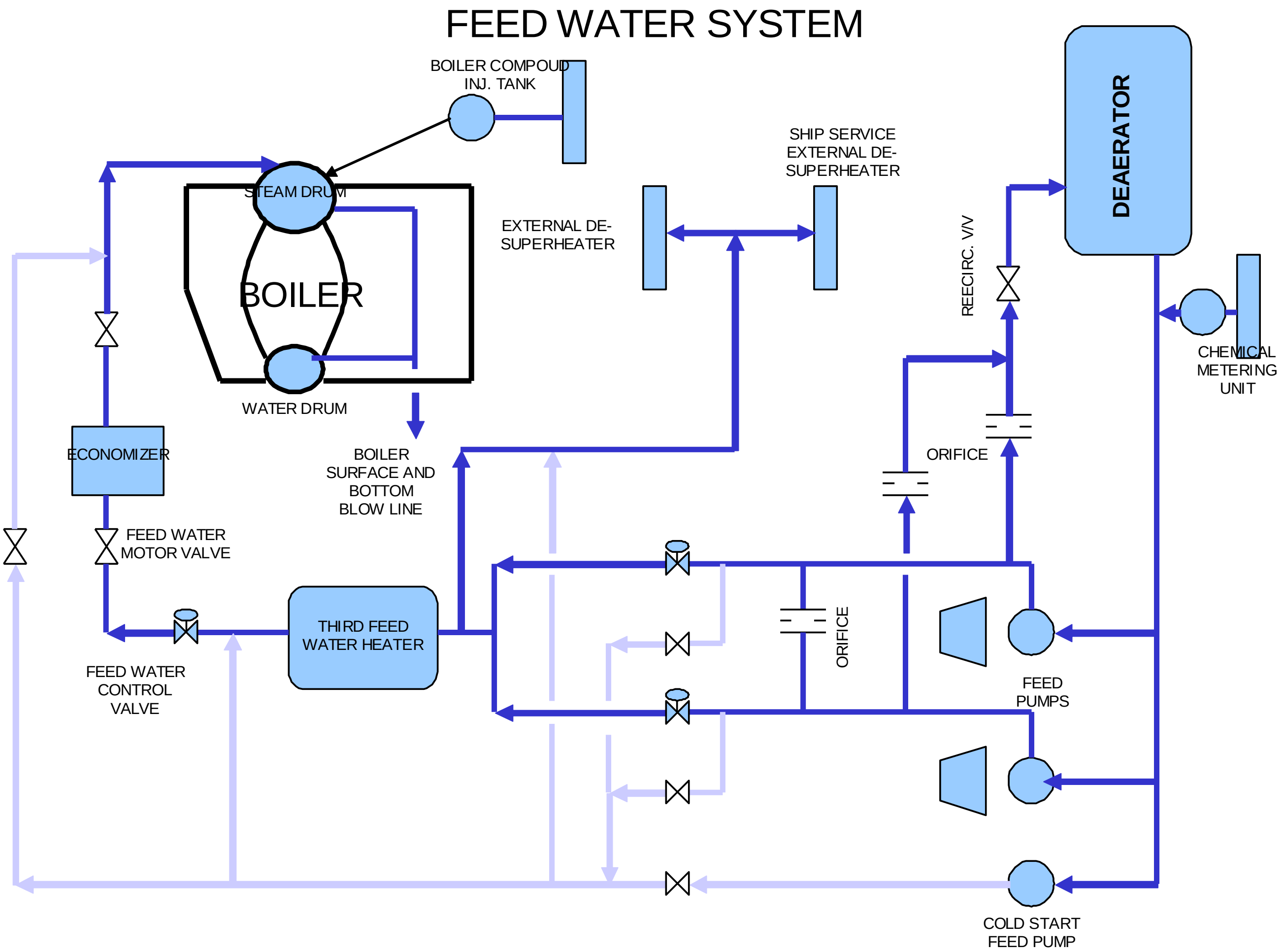
III.4 CONDENSATE WATER SYSTEM



Condensate water from the main condenser is sucked in and pressurized by the main condensate pump, heated by the gland condenser and the 1st feed water heater and finally sent to the de-aerator. Although the 1st feed water heater is fitted with the by-pass line, the gland condensate is not. The water level of the main condenser is controlled by the cavitations control of the condensate pump and the recirculation valve. The condensate water pump cavitations control exploits the changes in the discharge capacity of the pump generated by the cavitations. The discharge volume depends on the main condensers water level. As the water level on the main condenser drops, the pump suction head become smaller causing cavitations to occur in the impeller and the delivery volume to decrease. When the water level of the main condenser rises cavitations does not occur, the discharge power of the pump is restored and the discharge volume increases. When the level of the main condenser drops, the recirculation valve opens and circulates condensate water to the main condenser. In order to maintain the flow volume of the cooling water on the gland condenser, the recirculation valve is fitted in the outlet side of the gland condenser. To prevent the main condenser from overheating when processing dump steam in the main condenser, condensate water is sprayed into the main condenser and the external de-super-heater for dump steam. Similarly, as the temperature of the exhaust steam is high when the main turbine is driven astern condensate water is sprayed into the exhaust steam chamber of the astern turbine preventing the main condenser from overheating.

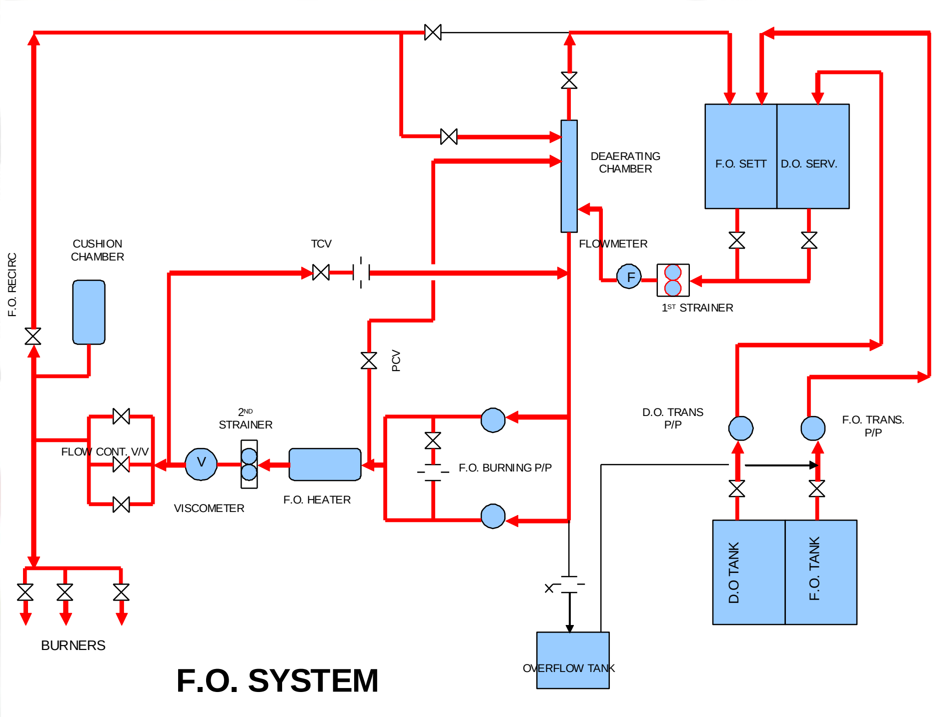
Furthermore the condensate line supplies condensate water to the vacuum pumps sealing water tank, the feed water pump as sealing water, the boiler compound tank and the chemical metering pump and the distilling plant as the cooling water. Condensate water from the dump condenser, drain from the drain inspection tank, and sealing water from the feed water pump collect in the drain tank has been suck-in through the drain pump and filtered by the grease extractor and flows to join the condensate line. The water level of the drain tank is controlled by the level control valve, which regulates the circulation volume to the tanks. Condensate water sent to the de-aerator is sprayed into the steam by the nozzle and heated to saturation temperature; this causes the drop of oxygen solubility separating the dissolved oxygen. The de-aerators water level is regulated by the make-up valve and the spill valve. When the de-aerator water level drops, the make-up valve opens distilled water from the distilled water tank replenishes the drain tanks causing the water level of the drain tank to rise. Consequently, the level control valve decreases the circulation volume causing the volume of the drain sent to the de-aerator to increase and the de-aerator water level to rise. As the de-aerator water level rises, the spill valve opens and the condensate water returns to the distilled water tank. In doing so, the volume of the condensate water sent to the de-aerator decreases and the water level drops. A make-up line is installed to fill the main condenser with distilled water when the plant is started up.

III.5 FEED WATER SYSTEM



Feed water de-aerated by the de-aerator, is sucked in and pressurized by the feed water pump, and normally heated by the third feed water heater. After which, is send to the feed water regulating valve. In order to preserve the suction head of the feed water pump, the de-aerator is positioned high to the engine room. The feed water-regulating valve is controlled by the boilers feed water control, to regulate the flow volume of the feed water. This volume regulated feed water is supplied to the boiler through the motor valve and the economizer. When the boiler water level rises too high, the motor valve is designed to cut off the feed water. The economizer uses the heat left in the boiler exhaust gas to heat the feed water. The third feed water heater can be by passed if some reason it fails to operate normally. If the feed water regulating valve or the economizer dysfunction for some reason, the auxiliary feed water line can be used instead. A recirculation valve is fitted to the feed water line in order to maintain the feed water pump minimum flow volume when the boiler load is low. A warming line is fitted to the outlet of the feed water pump in order to keep the standby feed water pump warm. Electric cold start feed water pump is used during the plant start up procedure to fill the boiler with water. Due to high pressure of the steam and the boilers external de super-heater and the de super-heater of the de superheated steam line, the spray water is supplied by the feed water line. There is a special fitted line which supplies the de-oxidant into the suction line of the feed water pump to remove any remaining oxygen from the de-aerator. Lines used for supplying boiler compound and blowing up boiler water are used to process the boiler water.

III.6 FUEL OIL SYSTEM

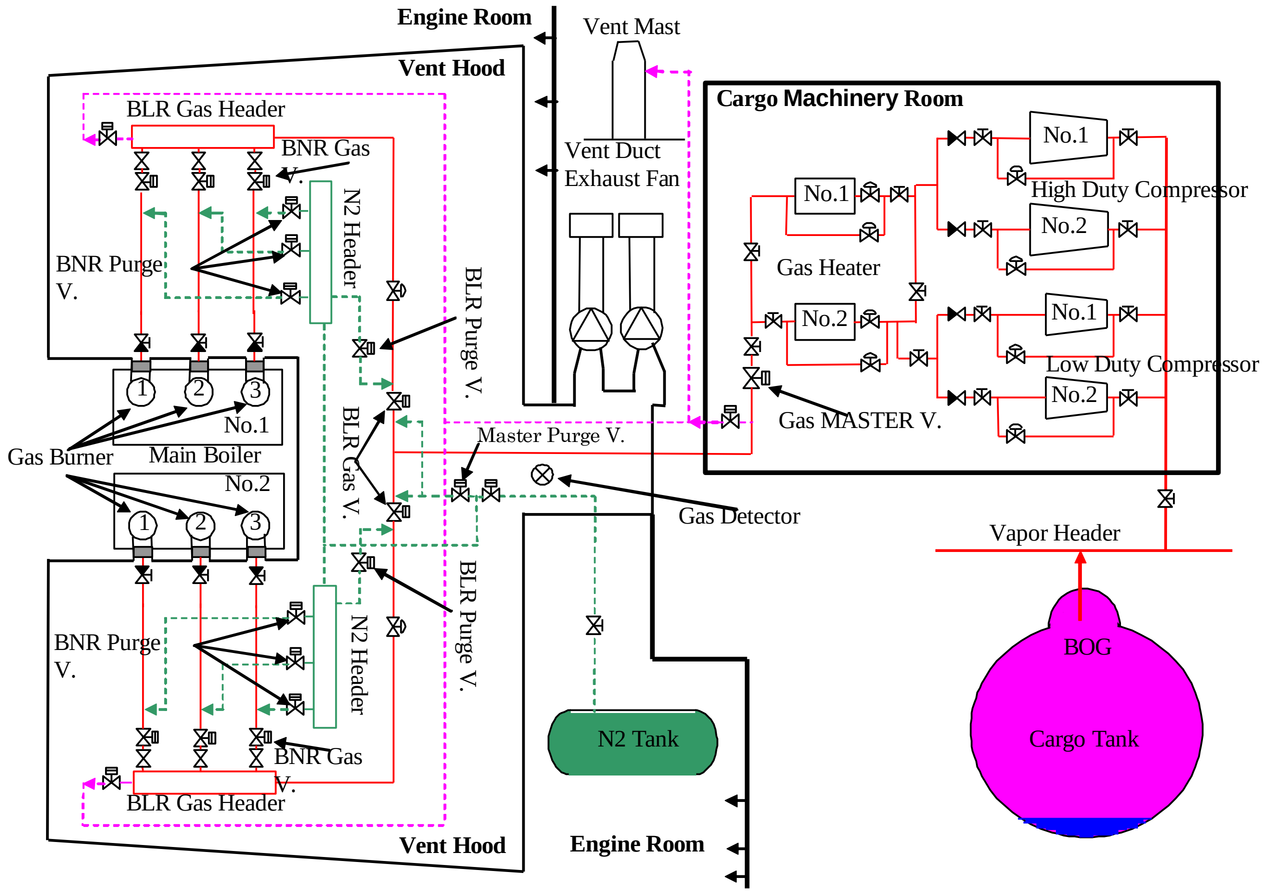


Fuel oil inside the return chamber is sucked in by the fuel oil burning pump, heated to the appropriate viscosity by the fuel oil heater, filtered by the second strainer and send to the fuel oil flow control valve. The fuel oil flow control valve regulates the fuel oil flow volume and is controlled by the boilers automatic combustion control. A minimum flow valve functions to stabilize the control of fuel oil when the valve opening is small, then the flow volume regulated fuel oil passe3s through the piston valve to supply to the fuel oil burner.

A cushion chamber is fitted onto the fuel oil header in order to absorbed the fluctuations in fuel oil pressure caused by increasing and decreasing the number of burners. As all fuel oil piston valve close up during gas combustion, the fuel oil is returned to the return chamber by the recirculation valve keeping the fuel oil temperature constant. The oil pressure in the fuel line is controlled by regulating the volume of fuel oil returned to the return chamber. A warming line, which circulates fuel oil, is fitted by the inlet of the fuel oil flow control valve to prevent the fuel oil from cooling when the volume is low. Air separated by the return chamber is send to the fuel oil settling tank. In order top, prevent leaking from the mechanical seal resulting from fuel oil sticking; an isolated valve, which lets the standby F.O. burning pump idle is fitted to the outlet side of the F.O. burning pump. When the return chamber drops, fuel oil is supplied by the fuel oil settling tank through the first strainer and the flow meter. When the fuel oil cannot be heated, diesel oil is supplied by the D.O. service tank. Replenishment of fuel oil to the F.O. settling tank and diesel oil to the D.O. service tank is carried out by each transfer pump.

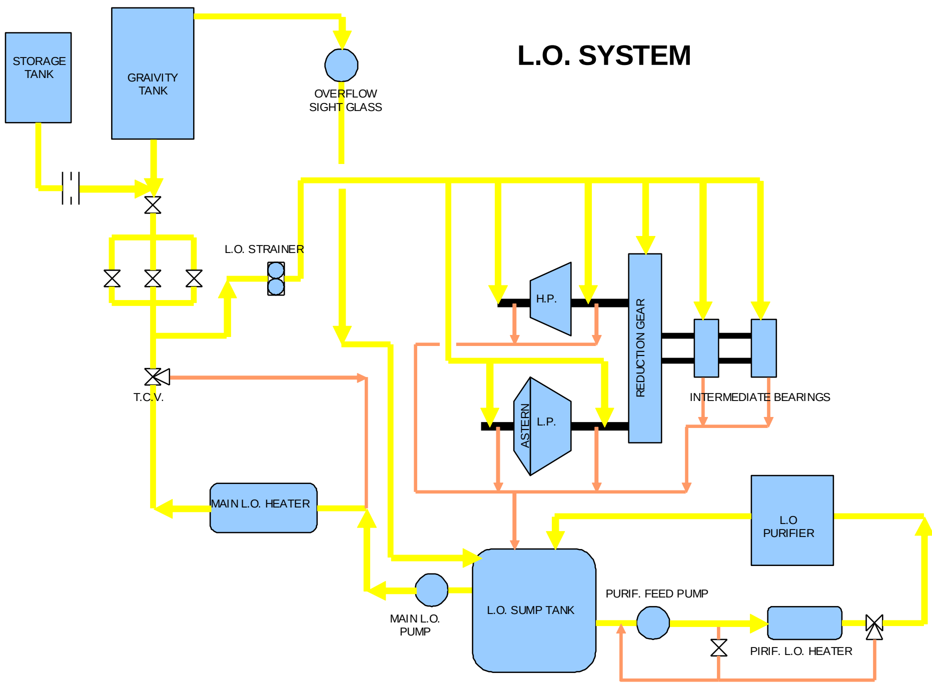
III.7 BOIL OFF GAS

FUEL GAS SYSTEM



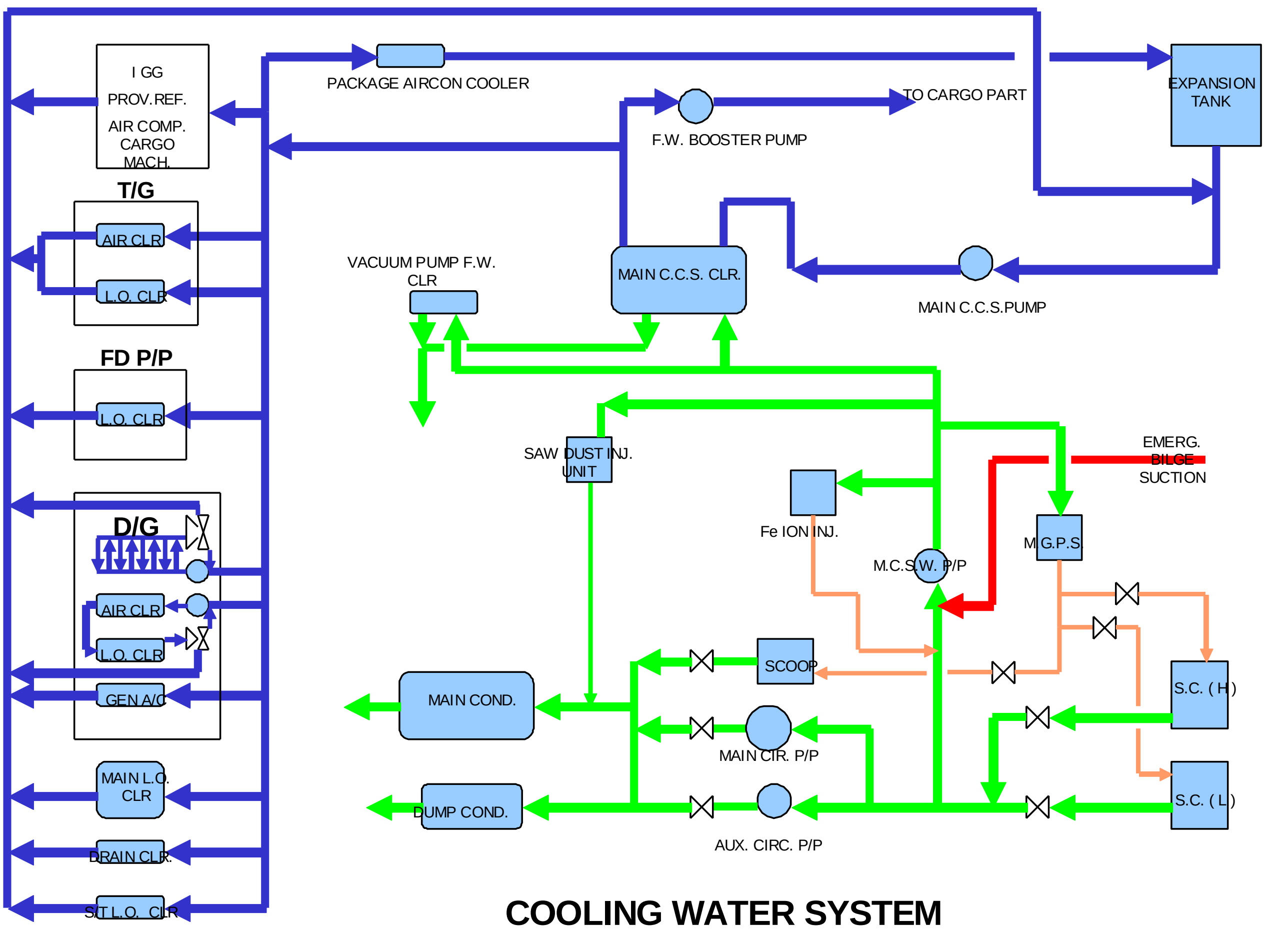
Boil off gas heated to 30-45 degrees Celsius in the cargo machinery room is send to the gas flow control valve as fuel gas through the master gas valve. The gas flow control valve controlled by the boiler automatic combustion control regulates the flow of the fuel gas. This volumetric controlled fuel gas passes to the piston valve supplying the gas burners. When the supply of fuel gas is stopped, the fuel gas line is purged with nitrogen gas. Purging the fuel gas remaining between the master gas valve and the gas flow control valve with nitrogen gas into the atmosphere is called master purge. Purging the fuel gas remaining between the gas flow control valve and the piston valve with nitrogen gas into the atmosphere is called boiler purge. Purging the fuel gas remaining at the outlet side of the piston valve into the boiler furnace with nitrogen gas is called burner purge. The fuel gas line inside the engine room and the fuel gas valve are surrounded by the duct and checks for leaks by the flammable gas detectors. The fuel gas line duct interior is kept in a constantly negative pressure state by the exhaust fan.

III.8 LUBRICATING OIL SYSTEM



Lubricating oil inside the lubricating oil sump tank is sucked in and pressurized by the electric main L.O. pump, cooled by the main L.O. cooler and once filtered by the strainer goes to supply the main turbine, reduction gear, and intermediate shaft bearings. The temperature of the lubricating oil is controlled by regulating the by pass volume with the temperature control valve situated at the outlet of the main L.O. cooler. Even if the main L.O. pump stops, there is a line that supplies lubricating oil from L.O. gravity tank using the force of gravity situated at the inlet of the strainer. While the main L.O. pump is in operation, some of the lubricating oil is supplied at all times to the L.O. gravity tank. Any oil that overflows from the L.O. gravity tank is supplied to the sump tank. Any overflow from the L.O. gravity tank while the main turbine is in operation, must be confirmed by the sight glass. In case the main L.O. pump stops and cannot be reactivated immediately, it is important to stop the main turbine idling before the L.O. gravity tank empties. However if the main turbine is not stopped in time, a specially fitted line supplies fresh oil from the lubricating oil storage tank. Care must be taken when fresh oil is supplied from the lubricating oil storage tank as the L.O. sump tank can sometimes overflow. Lubricating oil from the L.O. sump tank, is sucked in by the lubricating oil purifier feed pump, once heated by the purifier L.O. heater, purified by the purifier, it is then returned to the lubricating oil sump tank.

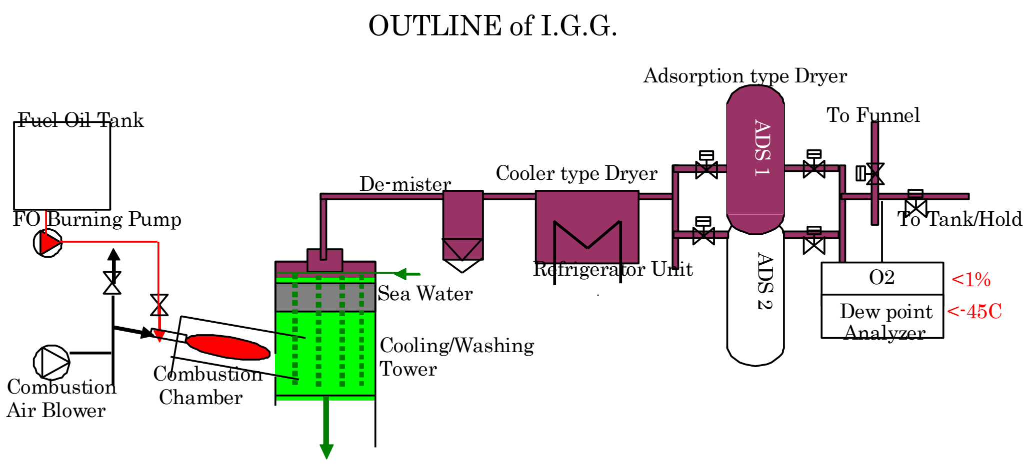
III.9 COOLING WATER SYSTEM



COOLING WATER SYSTEM

A fresh water central cooling system is employed to cool each heat exchanger. This cooling fresh water is circulated by the main central cooling fresh water pump. This cooling fresh water is cooled by sea water in the main cooling fresh water cooler and supplied to the turbo generator, lubricating oil cooler, and air cooler, the feed water pumps lubricating oil cooler, the diesel generators lubricating oil cooler and air cooler, the main lubricating oil cooler, the drain cooler, the stern tube lubricating oil cooler, and the air conditioner. Expansion caused by the rising temperature of cooling fresh water is managed by the expansion tank. The packaged air conditioner cooling fresh water is returned to the expansion tank. In order to supply the cargo machinery room and other isolated locations, the cooling fresh water I pressurized by the booster pump. Cooling seawater from the main condenser is supplied by the scoop, which exploits the speed of the vessel at sea. Nevertheless, as it cannot supply by the scoop when cruising at low speed or berthing, the main circulating pump is used instead. If the main circulating pump is not functional for any reasons, an auxiliary circulating pump is automatically started instead, to supply the cooling seawater. When using the dump condenser the auxiliary circulating pump supplies the cooling sea water. The sea chest can be changed remotely from the engine control room. The cooling seawater for the main cooling fresh water cooler and the vacuum pump fresh water cooler is supplied by the main cooling seawater pump. The vacuum pump sealing water cooler is cooled by the seawater, because when the sealing water temperature rises, the capacity of the vacuum pump drops and the main condenser vacuum lowers. A marine growth preventing system stops seashells, seaweeds, and other marine life from growing on the sea water lines. The MGPS injection inlet change together with that of the scoop, high sea chest, and low sea chest. A ferrous ion generator is installed to prevent corrosion and erosion of all cooling pipes except of that of the main condenser. As an emergency measure when seawater leaks through the holes of the main condenser cooling tubes, a tank is installed that injects sawdust.

IV. INERT GAS GENERATOR



The inert gas generator plant sends inert gas or dry air to cargo tanks and cargo holds. Dry air is supplied to cargo tank for aeration and hold drying. The plant consists of two air blowers, an inert gas generator, an inert gas refrigerating unit, and an inert gas dryer unit.

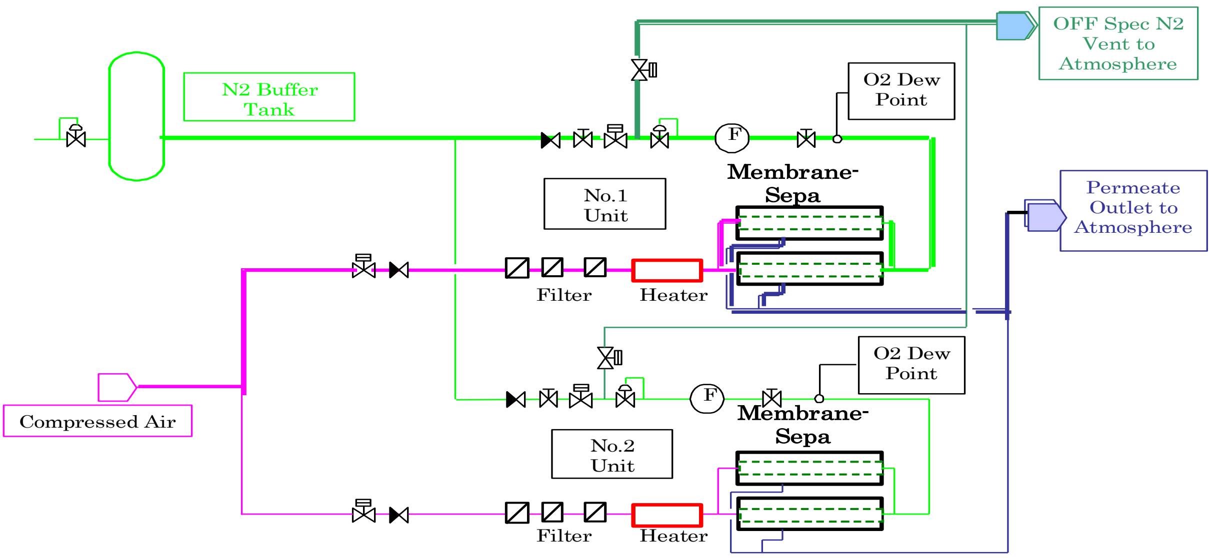
In the inert gas generator, fuel oil and air are burnt and inert gas is generated. Then a seawater shower cools the inert gas and washes out sulphur oxides, which are contained in the gas. The ballast pump supplies seawater to the inert gas generator. The IGG fuel oil pump supplies fuel oil from the IGG gas oil tank. The combustion air is supplied by roots type air blowers. The final discharge pressure of the dryer is maintained by the air blowers, and the pressure is controlled via pressure control valve.

The inert gas refrigerating unit cools the inert gas as the first step of drying. The inert gas refrigerating unit consists of a Freon compressor with capacity control, a Freon condenser, a Freon evaporator and a demister. A Freon evaporator is a shell and tube type cooler. Direct expanded Freon r-22 cools inert gas and condenses excess water in the inert gas.

The dryer unit absorbs water in the inert gas with activated alumina. The inert gas dryer unit has two dryer vessels. When one vessel is working, the other vessel is regenerating. The change over between working and regenerating is carried out automatically every 6 hours. In the regenerating phase, the vessel is heated by hot air for at least four hours, and then cooled.

The final discharge pressure of the inert gas plant is controlled by the pressure control valve to a preset value of 0.025 MPa. The oxygen content can be adjusted manually by opening or closing the valve on manual loading station on IGG system. Purging or discharging mode can be selected at the cargo control console. When oxygen content rise above the high level (1%), the discharge valve to the tank will close and the purge valve to atmosphere will open and the inert gas will blown off to the atmosphere. Dew point is measured continuously by the dew point analyzer. When the dew point rises above the high level (-45^{0}C) the inert gas is blown off too. When the dew point and oxygen content achieves normal level, the inert gas charge valve will open by manual.

V. NITROGEN GAS GENERATOR



Nitrogen gas generated by the nitrogen generator is used for cargo line purging, cargo compressor gland sealing, cargo tank insulation space inerting, vent riser fire extinguishing medium, and engine room gas line purging.

Ambient air is compressed by the ships service air compressor and the compressed air is supplied through the ships service air reservoir. Some condensate water is separated in the three separators and automatically drained out. Then the saturated air passes through the three filters. The filter removes oil, which are included in the supply air. The treated compressed air is heated by the electric heater before entering the membranes. The heated air then passes into the membranes then separated into two streams. One is nitrogen and the other is the remaining gases. In downstream of the membranes, the nitrogen passes through the flow indicator, the flow control valve, and the backpressure regulator and is led to the nitrogen buffer tank. The other gases are discharged to the atmosphere.

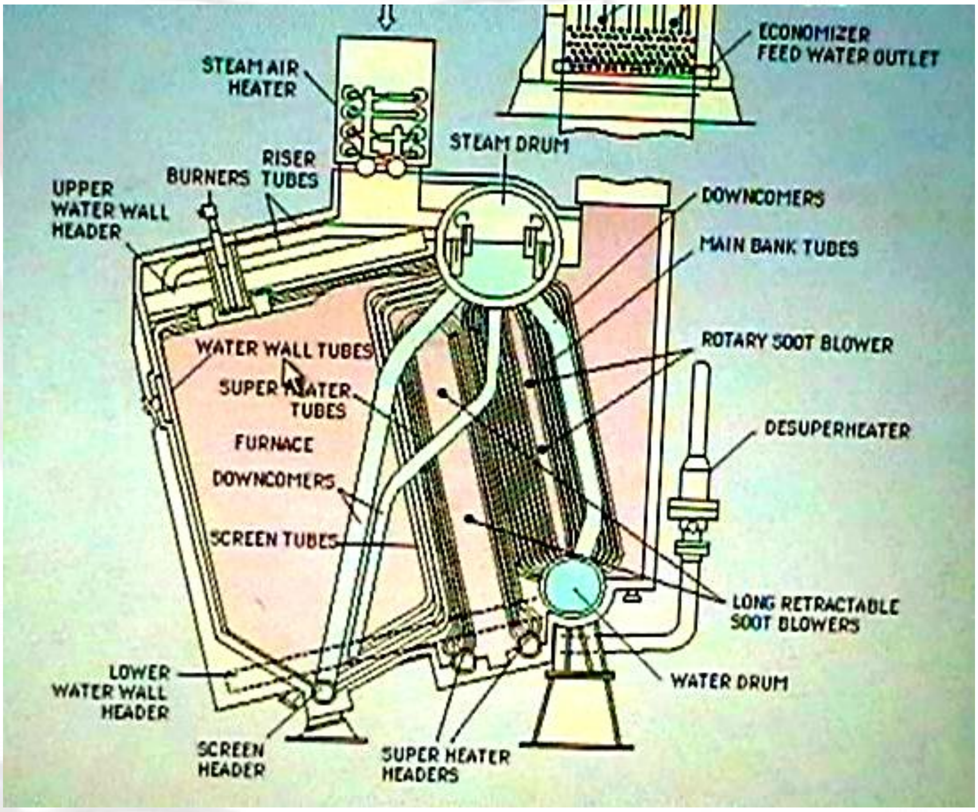
The nitrogen generator is started and stopped locally. Once the system is started from the local control panel, the feed air inlet valve is open/shut automatically in response to the pressure in the nitrogen buffer tank. (open: 300Kpa, shut 490KPa). When the plant is stopped, the generator inlet and outlet valves are closed and vent valves are opened. If the plant is stopped for several hours, the membranes become cold and will therefore not separate properly for about 15 minutes after start-up. The nitrogen gas can be supplied after about 15 minutes. Confirm that the oxygen content below 3.5% before supplying the nitrogen gas to various purpose.

VI. BOILER OVERVIEW

Boilers of LNG carrier are equipped with two drums water tube boilers. Positioned on the boilers upper region is the steam and on the lower the water drum and the screen header. The steam drum and the water drum is connected by the main bank tubes and down comers. The steam drum and screen header are connected by the screen tubes, water wall tubes, and down comers. The furnace is enclosed inside the water wall. The water wall tubes have vertically attached fins and welded together into a mono wall structure; this increases the air tightness of the furnace and negates the risk of leaking. Fire proof materials are no longer necessary allowing for simply casing structure.

A super-heater, which further heats the saturated steam coming from the steam drum, is fitted between the screen tubes and the main bank tubes, which are arranged in a reverse U configuration.

The economizer, which heats the feed water using the heat from the exhaust gas, is fitted from the boiler up take in order to boost the heat recovery ratio, the economizer tubes used a spiral fin tubes arranged in a staggered configuration.



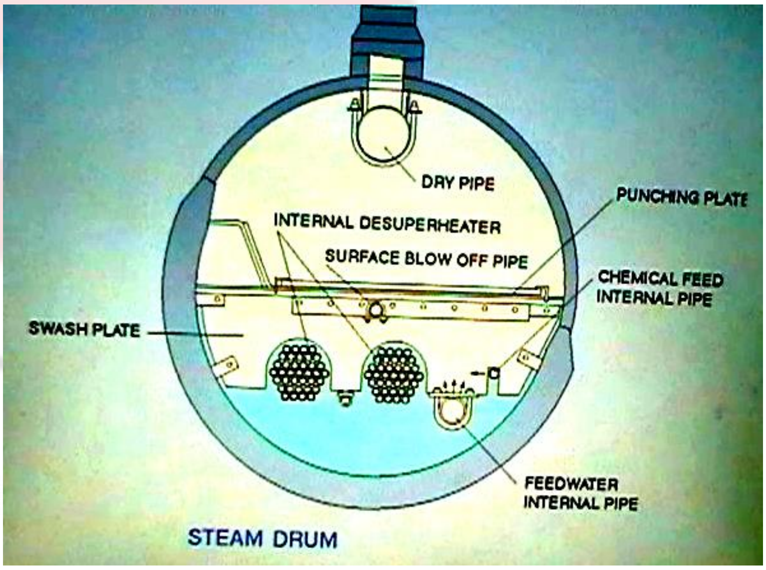
In order to equalize the combustion gas flow, maximize absorption ratio, maintain the distance necessary for combustion and to ensure complete combustion the burner is positioned to the ceiling of the boiler.

Air to be used for combustion is heated by the steam air heater and supplied to the furnace. Combustion gas passes through the screen tubes, super- heater tubes, main bank tubes and the economizer is finally expelled.

Soot blower is fitted in the super –heater tubes, main bank tubes, and economizer removes soot from the exterior of the tubes. The super-heater for which the high combustion gas passes using long retractable type soot blower whereas the main bank tubes and economizer uses rotary type soot blowers. Boiler water from the water drum, screen header, and lower water wall header is supplied through the down comers. When the boiler water inside the main bank tubes is heated by the combustion gas, steam bubbles produced and the boiler water is mixed with water and steam which is lighter than the boiler water inside the down comer heads up towards the steam drum and the boiler water in the down comer drops. This weight differential, which causes the boiler water to circulate, is called natural circulation.

The down comer is positioned in the exterior of the water wall thereby enhancing the circulation of the boiler water. The temperature of the superheated steam is controlled by regulating the amount of water sprayed into the external de-super-heater. The outside foundation under the water drum is fixed to the boiler seat; the other seats are sliding type, which expands and contracts with heat.

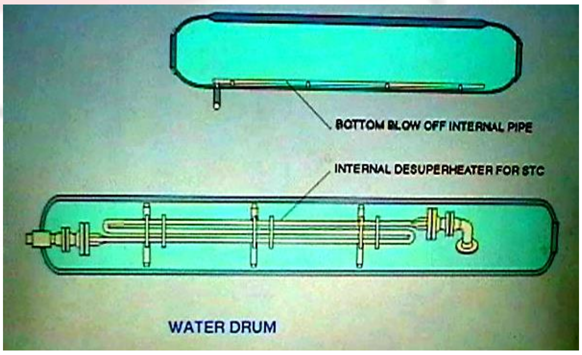
VI.1 STEAM DRUM



Installed on the interior of the steam drum is the feed water internal pipe, which evenly distributes feed water, supplied to the drum. The dry pipe, which enhances the separation of the steam to the water and evenly extracts steam from the steam drum. The swash plates, which reduce slashing of water due to the vessels pitching. The multi hole punching plate, which prevents air bubbles caused by boiler water frothing from flowing into the super-heater.

The surface blow off pipe, which blows off particles and oils from the water surface, and the chemical, feed internal pipes, which injects boiler compound into the steam drum. The swash plates are not fitted into the lower half of the steam drum in order not to impede the flow of boiler water to the down comers. Furthermore, on the lower half of the steam drum is the internal de-super-heater, which lowers the temperature of the super heated steam by heat exchange of the boiler water, and super- heated steam.

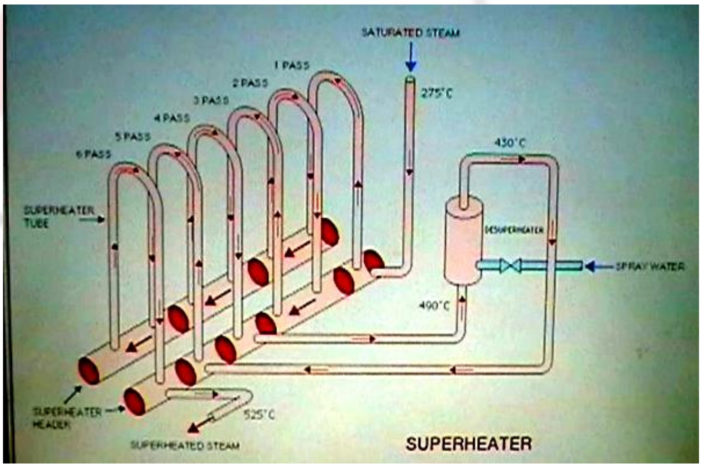
VI.2 WATER DRUM



A bottom blow off internal pipe inside the water drum functions to evenly blow off sediments from the bottom of the drum. When the boiler load is high the bottom blow functions does not operate due to the risk of boiler water circulation impeded. Some boilers are fitted with internal de-super-heater inside the water drum, which lowers the temperature of the super-heated-steam, by the heat exchange of the boiler inside the water drum to that of the super-heated-steam.

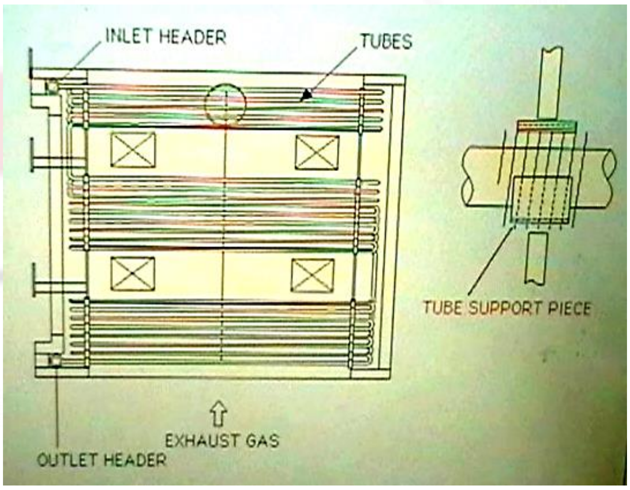
VI.3 SUPERHEATER

All saturated steam from the steam drum is send to the super-heater through the steam extraction internal pipe where it undergoes further heating to be transformed into super-heated steam hotter than the saturated steam. The super-heater steam is send to from the super-heater 4th path to the external de-super-heater where its temperature is controlled. The external de-super-heater lowers the temperature of the stem by spraying with condensate water and adjusts the temperature of the steam inside the outlet of the super-heater to a preset level by adjusting the amount of water sprayed. Super-heated steam controlled by the external de-super-heater returns to the super-heaters 5th path then to 6th path, from the 6th path it is then distributed to all parts.



VI.4 ECONOMIZER

The economizer fitted to the boiler up take functions to heat the feed water with the exhaust gas. Using the economizer makes it possible to improve the boiler efficiency retrieving the heat loss in the form of exhaust gas. The heat difference between the feed water and boiler water is reduced thereby lessening the effect of thermal stress inside the steam drum. Feed water is supplied to the upper inlet header, flows toward the upper steam side of the exhaust gas, absorbs the heat of the exhaust gas and goes toward the lower outlet header. The economizer tube is arranged with a spiral fins with a staggered configuration in order to increase its heating surface. In order to

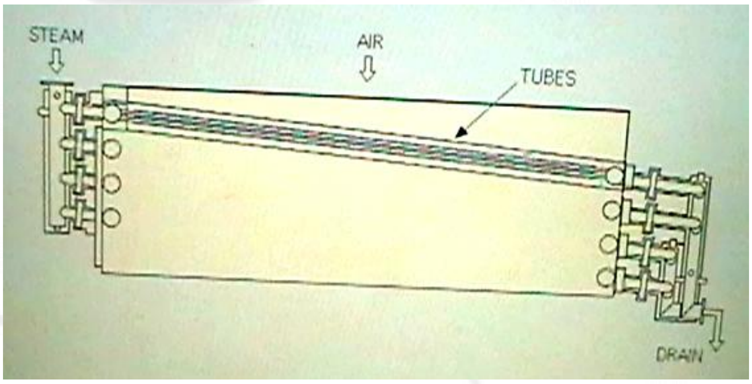


prevent damage to its fins even if the tube slides due to heat expansion, a tube support piece and collar is attached to the connection between where the tube penetrates the tubes sheets.

A rotary soot blower removes soot as thermal conductivity of the fin is impaired if covered with soot causing the temperature of the feed water supply to the boiler to drop when the temperature of the feed water supplied to the economizer is too low; the temperature of the pipe surfaces also drops. Sulfur acts with gas converts to sulfuric acid, which can cause corrosion. The temperature of the feed water in the economizer inlet must be therefore carefully monitored.

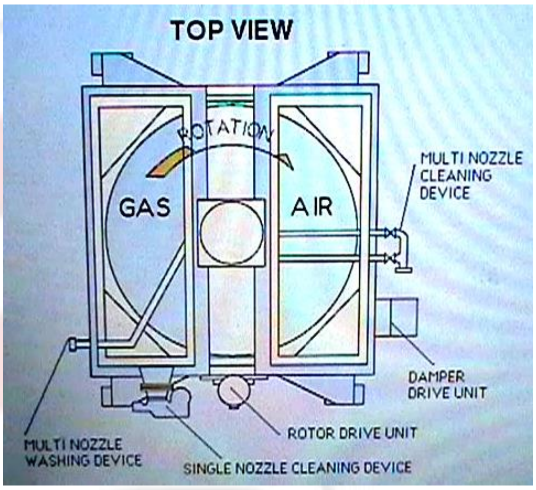
IV.5 AIR PREHEATERS

VI.5.1 STEAM AIR HEATER

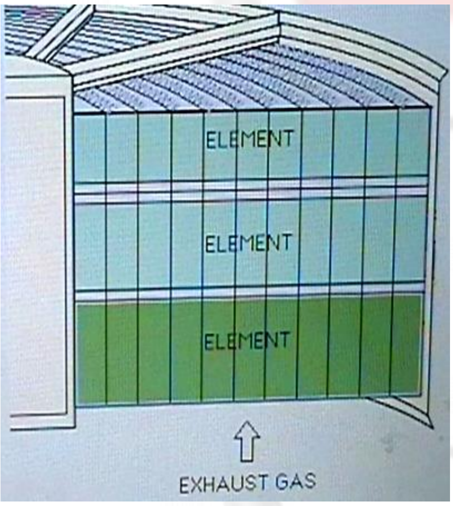


Complete combustion is achieved with the small amount of excess air, firing efficiency and firing feed is improved and large amount of fuel can be combusted. Furthermore the furnace interior which is high temperature increasing the amount of conductible heat. Some plants use a steam air heater but other plant uses a gas air heater. With the steam air heater the combusting, air is heated with the de-super-heated steam of the main turbine bleed steam. Heating steam is supplied to the steam inlet header is split up with other tubes with air and flows to the drain outlet header. Fins are attached to the steam air heater tubes in order to increase the heating surface. As the steam air heater does not use an exhaust gas there is no soot build up or corrosion to the heating tubes surfaces. The steam air heater can keep the temperature of the combusting air constant independent from the boiler load. The steam inlet valves must be open slowly before use, if open suddenly large amount of steam condensed and once with the risk of causing water hammering.

VI.5.2 GAS AIR HEATER



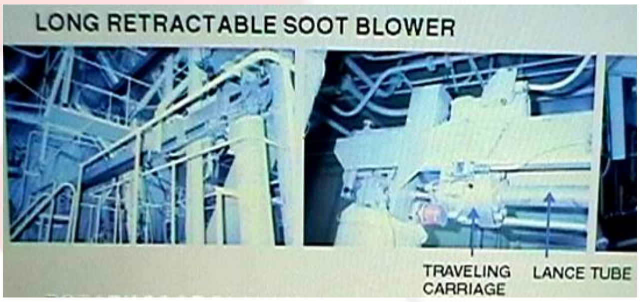
The gas air heater attached to outlet of the economizer uses exhaust to heat the combusting air. LNG carriers are equipped with regenerative ljungstrom air heaters. This gas air heater slowly rotates the rotor fitted with the heating elements by absorbing the heat from the exhaust gas and heating the air with this heat. As this method retrieves heat from the exhaust gas thereby increasing the overall efficiency of the boiler. Its disadvantage are that soot, ash and other corrosive matter built up easily to block the heating element and combusting air can leak into the exhaust gas side. The rotor is protected by the rotor support bearing on the lower end of the gas air heater; the center is maintained by the lower rotor guide bearing and is driven at a speed of 3-5 revolution per minute by the rotor drive unit. The rotor is usually driven by an electric motor but if the rotor stops due to some malfunctions it changes to a back-up air motor. In order to prevent soot built up in the element from firing, the rotor should be driven continuously and finally stops only once the element has cooled down sufficiently. The exhaust gas and air are separated by the rotor seal keeping the leakage of air to the exhaust gas side to minimum. There is a by-pass damper fitted to both gas side and airside while the exhaust gas side are operated manually, the airside is fitted with the drive unit for remote operation. When the boiler load is low, a drop of temperature of the element can cause corrosion. It is therefore necessary to open the by-pass damper on the airside thereby regulating the temperature of the element. To allow for easy exfoliation of soot during soot blow off, the by-pass damper on the other side is open and the temperature of element is increased.



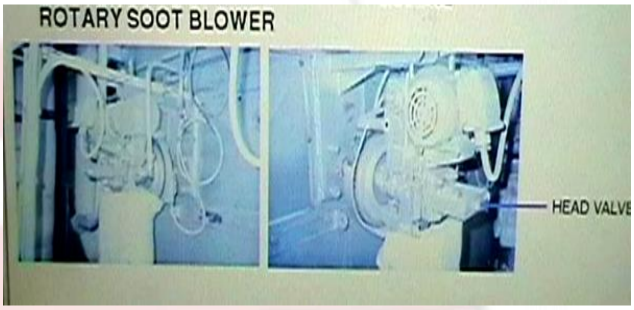
A swing type soot blower is fitted at the exhaust gas air heater. Element cleaning devices are positioned on the exhaust gas outlet and the air inlet side. The elements are divided into 12 parts with between 2 to 4 layers and are build into the rotor. In order to prevent corrosion, the element for the low temperature and mid temperature layers of the exhaust gas outlet side are treated with corrosion resistant enamel coating, while the element at the high temperature layers of exhaust gas inlet side are treated with corrosion resistant steel but not treated with an enamel coating.

VI.6 SOOT BLOWER

In order to prevent loss of thermal conductivity as a result of soot collecting into the tubes, the soot should be blown off regularly. If a wet steam is used during soot blowing, the soot is prone to building up on the tube surface making the removal of soot difficult, therefore the steam line needs to be drain sufficiently.



A long retractable soot blower is used to clean the super-heater, which come into contact with high temperature combustion gas. A lance tube fitted with a spray nozzle rotates as it moves in and out of the super-heater. The blow off steam is sprayed from two nozzles positioned on the top of the lance tube. The movement and rotating of the lance tube dislodge soot stocked to the tubes. A lance tubes is operated by a motor driven traveling carriage. The opening and shutting of the head valve, which supplies the blow steam, is operated by the link mechanism driven by the movement of the traveling carriage. As the lance tube is cooled by the steam during soot blow off operation, special care must be taken that the supply of steam is not cut-off as the lance tube can undergo heat bending making it difficult to retract. If motor that drives the traveling carriage breaks down, the operation can continue manually using a handle.



A rotary type soot blower are - used to clean the main bank tubes and the economizer. As multiple nozzle spray pipes rotate, blow off steam is ejected at a predetermined angle from the nozzles to dislodge soot stock on the tubes. The opening and shutting of the head valve supplying the blow steam is operated by the fear fitted cam. The spray pipe is operated by the motor driven reduction gear. If however the motor malfunctions, the spray pipe can be operated manually using a handle.

VI.7 COMBUSTION DEVICES

LNG carriers are equipped with so-called combination burners, comprising both of fuel oil and of gas burners fitted at the ceiling of the boiler. The number of burners differs from plant to plant.

Fuel gas is supplied to the gas burner from the gas line, which is surrounded by a duct through the valve. Fuel oil is supplied to fuel oil burners through the valve and cock. Atomizing steam, which helps to atomize the fuel oil, is also supplied to the fuel oil burners through the valve and cock.

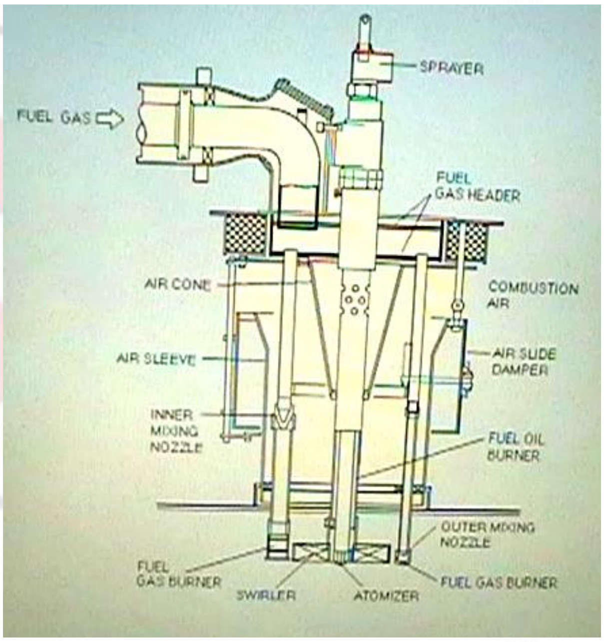
The burner is controlled by the burner management system or BMS automatically or manually. The BMS makes it possible to automatically operate the various combustion modes including the igniting and extinguishing the burners, changing the number of burners in operation and changing between fuel oil combustion, dual combustion and gas combustion.

The igniter used to ignite the fuel oil is controlled by the BMS during ignition. The igniter is controlled to move forward to the ignition position and after ignition returns automatically to its original position.

The BMS also controlled the opening and shutting down of air slide damper used to shut the combustion air.

VI.8 BURNER STRUCTURE

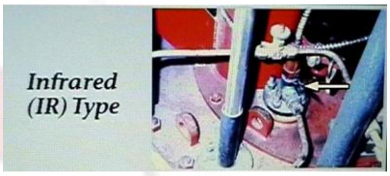
The combination burner is consist of central fuel oil burner surrounded by several gas burners. The fuel oil burners use a steam jet atomizer. Fuel oil supplied to the exterior of the atomizer is atomized by the atomizing steam supplied to the interior of the atomizer. When extinguishing the fuel oil burner, any remaining fuel from the pipe between the fuel oil cut-off valve and the atomizer is purge with steam. Furthermore, steam is supplied in order to cool the fuel oil burner during gas combustion. As there is no steam when the plant is first started up, compressed air is used instead of atomizing steam.

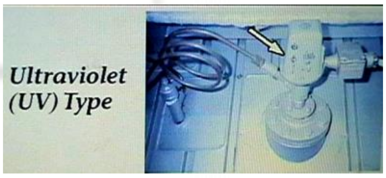


In order to ensure a stable combustion on the gas burner with either light or heavy loads, two types of nozzle is fitted inside the boiler, an inner mixing nozzles and outer mixing nozzles are positioned alternately around the F.O burner. The inner mixing nozzle allows a stable combustion with a light load, the outer mixing nozzle permits stable combustion with the heavy load.

Combusting air flows in traveling between the air sleeve and the air cone. When the burner is off the air slide damper is shut and the air is cut-off.

VI.9 FLAME EYE

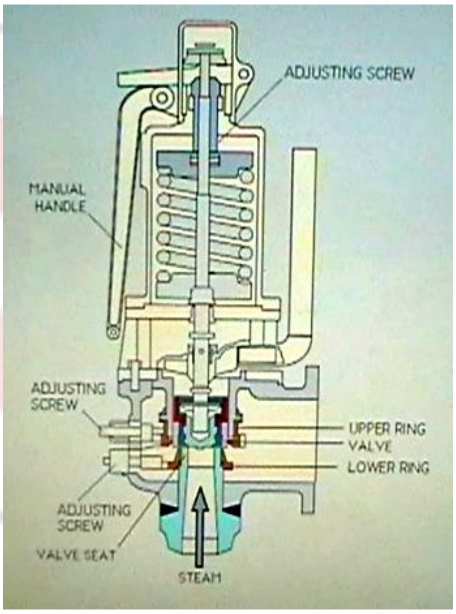




In cases, that burner flames fails, the fuel oil supply and fuel gas supply must be shut off, the flame eye detects any flame failure. Although there are several variety of flame eye used, the most common type that is used are ultraviolet and infrared flame eye, which is fitted in each burners.

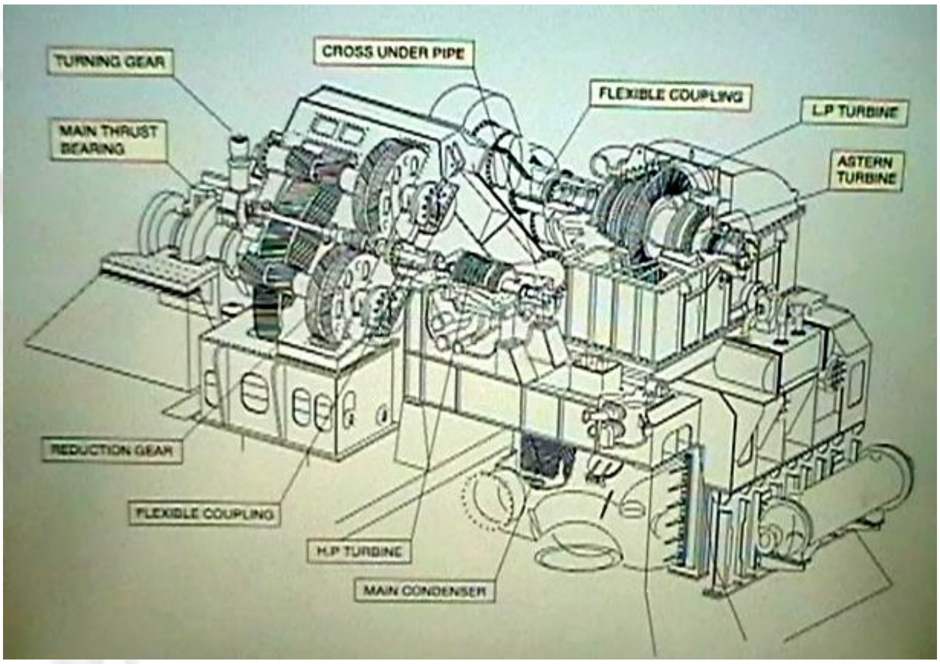
The infrared flame eye is fitted on the ceiling of the boiler and detects flame during F.O mode. The ultraviolet flame eye is positioned on the side of the boiler to detect flame during fuel gas mode. A seal air fan directs air to the flame eye to prevent the lens from soiling due to the combusting gas.

VI.10 SAFETY VALVES



When the pressure inside the boiler rises above the set value, the safety valve releases some of the steam to maintain safety inside the boiler. There are two safety valves on the steam drum and one on the super-heater outlet. The blow off pressure setting of the steam drum safety valve is higher than that of the super-heater outlet safety valve. This is because if the steam drum safety valve blow off first, the amount of steam flowing to the super-heater drops causing burn out to the super-heater tubes. A safety valve maybe activated manually by a special fitted handle or remotely by wire. Some of the safety valves have a powerful blow off despite the smallest of its diameter. This called a high lift safety valve. If the steam pressure inside the boiler exceed the set value the is lift up to eject steam. To set the safety valve pressure setting the force of the spring, which pushes the valve, is adjusted by the so-called adjusting screw. In cases where drain comes out from the safety valve drain pipes, a cause maybe attributed from a steam leaking from some part of the valve seat. This leakage can be corrected by opening it manually pushing the valve to the valve seat using the gag, which should stabilize the valve seat. Care should be taken not to damage the valve by pushing the gag too tightly. The valve uses thermal disc to prevent leakage due to heat whopping. The safety valve sometimes leaks as the blow off pressure approaches this can be adjusted by the lower ring. As the position of the lower ring rises approaching the valve, leaking steam acts on the valve lower surface to increase the force that pushes the valve. The valve opens by the pressure that started the leak. The upper ring is designed to regulate the safety valve shutting pressure after blow off and the amount of blow off steam. To increase the amount of shutting pressure after the blow off, the position of the upper ring must be raised. As the position of the upper ring lowers, the angle of the blow off steam faces downward as the force pushes the valve in reaction to strengthen the amount of steam blown off, increasing the shutting pressure after blow off. Safety valve chattering cause by the amount of blow off steam being too small can be corrected by increasing the amount of blow off with an adjustment of the upper ring.

VII. MAIN TURBINE OVERVIEW



The main turbine is two cylinders cross compound type consisting of a horizontally arranged H.P. turbine and L.P. turbine. The H.P. and L.P. turbine are connected with a steam pipe, a cross under pipe.

Ahead steam used in H.P. turbine is transferred along the steam cross under pipe and supplied to the aft side of the low-pressure turbine. The astern turbine, which is used in the astern operation, is fitted on the forward side of the low-pressure turbine of the same shaft. Astern steam is supplied to the astern turbine through the astern guard valve fitted at the fore side of the low-pressure turbine. The main condenser, which condenses the exhaust steam from the L.P. turbine and astern turbine, is fitted to the lower part of the fore side of the L.P. turbine. The H.P. and L.P. turbine are connected to the reduction gear by flexible coupling. Power generated by the turbine is transferred to the propeller by the reduction gear, thrust shaft, intermediate shaft, and the propeller shaft. Thrust force generated by the propeller shaft is supported by the main thrust bearing. The turning gear is fitted to the reduction gears aft side.

Depending on the state of the steam activated, steam turbine are categorized in three types; The impulse turbine, the reaction turbine, and the combination of the impulse and reaction turbine. Also depending upon the steam flow direction. The turbines are categorized into the axial flow turbine and the radial flow turbine.

The rotor of the impulse turbine is driven with the accelerated steam, which has expanded through the nozzles. The accelerated steam generates impulse power onto the rotors moving blades. Steam pressure in between the moving blades, is kept constant.

The rotor of the reaction turbine which is driven by the impulse power of the accelerated steam and the additional driving power of the reaction force generated by the steam expansion in between the moving blades.

The combination turbine is composed of different types of turbine such as the impulse turbine combined with the reaction turbine, or impulse turbine with various functions.

Impulse turbine can be categorized into various types including the single stage impulse turbine, the pressure compound impulse turbine, the velocity compound impulse turbine, and the pressure velocity compound impulse turbine.

The single stage impulse turbine, consist of the nozzles and the rotor with single wall of moving blades. The pressurized steam is expanded through the nozzles at the working pressure level at a single burst and generates impulse power to the moving blades.

The pressure velocity compound impulse turbine has nozzles and moving blades arranged alternately. The pressurized steam is expanded at multiple stages, and the thermal energy of the steam can be effectively transferred to a mechanical energy. The speed of the steam is increased by steam expanding through the nozzles and decreased as it impacts on the moving blades. The degree of change of the steam speed is virtually the same at every stage. As the steam expands in every nozzle, the steam pressure is decreased at every stage.

The velocity compound impulse turbine, consist of nozzles and rotor with double row of moving blades. After the steam is expanded onto the first row of moving blades, the direction of the steam is adjusted by the guide blades, and again generates impulse power to the second row of the moving blades. The speed of the steam is increased by the steam expansion through the nozzles and decreased by generating impulse power to the moving blades. The steam pressure is decreased by steam expansion through the nozzles and is kept constant in between the moving blades, and in between the guide blades.

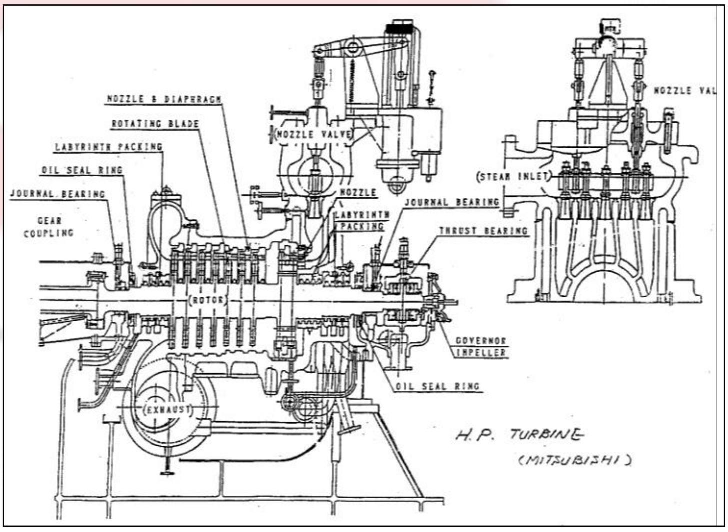
The pressure velocity compound impulse turbine consists of velocity compound impulse turbine arranged in series.

The reaction turbine had the guide blades and moving blades arranged alternately. The guide blades of the reaction turbine controls the steam flow direction and functions as a nozzles. The moving blades of the reaction turbine converts the velocity energy of the accelerated steam into the impulse power and also functions as nozzles. Steam pressure is reduced in between the guide blades and moving blades by steam expansion. The speed of the steam is increased in between the guide blades by steam expansion, and decreased due to generating of impulse power onto the moving blades. This cycle is repeated continuously.

A general configuration of steam turbine consist of nozzles or guide blades which converts thermal energy into velocity energy, moving blades which converts the steam velocity energy into rotary energy, the rotor to which the moving blades are attached, the shaft to which the rotor is mounted, casing which houses the rotor and bearing which supports the shaft.

VII.6 HIGH PRESSURE TURBINE

A high-pressure combination turbine consists of a velocity compound impulse turbine from the first stage and pressure compound impulse turbine from the second stage. By positioning the velocity, compound impulse turbine on the first stage it can markedly reduced the steam pressure and temperature allowing the turbine to be kept compact. Steam supplied to the high-pressure turbine worked at each stage from fore to aft and flows to the exhaust casing. Each stage is

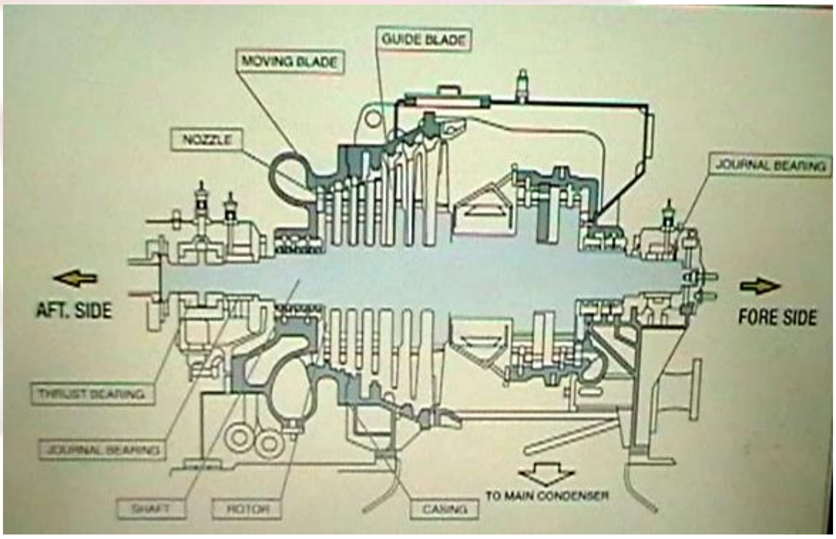


divided by the diaphragm to which the extension nozzles had been fitted. The rotors are supported by journal bearings positioned at both fore and aft sides. Thrust produced by the rotor while in operation is supported by the thrust bearing positioned at fore side. The high-pressure turbine casing is supported by the panting plate, which allows it to expand freely towards the fore side with the aft as a reference point. While in operation, the casing expands from the heat towards the fore side, however the rotor expand towards aft side with the thrust bearing positioned fore side as reference point effectively offsetting the amount of expansion which maintains appropriate clearance for all parts. Spring support type labyrinth packing is fitted at penetrating parts of the rotor and casing and all diaphragm, which prevents steam leaking out and air leaking in.

Gland sealing steam is feed into the second outermost pocket while the leaked steam and air goes from the outermost pocket to the gland condenser. Air escaping from the third outermost pocket of the fore side gland connected to the exhaust casing of the high pressure turbine is used to optimum effect by the low pressure turbine.

VII.7 LOW PRESSURE TURBINE

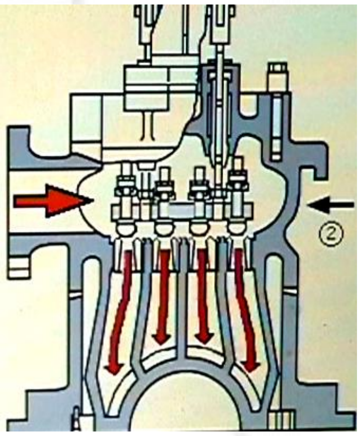
Spend steam from the high-pressure turbine is transferred to the cross under pipe and into the low-pressure turbine. This low-pressure combination turbine consists of a pressure compound impulse turbine to the fourth stage and after the fifth stage a reaction turbine. The steam flows towards fore side and the exhaust steam goes to the main condenser. A drain hole on the low pressure turbine drains out drain which can cause so called drain attack likely to occur as the steam become increasingly wet as it nears the final stage. Furthermore, in order to prevent damage from drain attack satellites are soldered to the rear of the steam inlet of the final stages of the moving blades.



The astern turbine in this case a velocity compound impulse turbine is fitted to the front side of the low-pressure turbine. Astern steam is supplied from the fore side goes to the main condenser. As the exhaust steam, temperature in astern condition is higher than that in ahead condition condensate water is sprayed onto the casing to prevent it from overheating. An exhaust guide in the exhaust casing prevents exhaust steam from generating impulse power onto the moving blades of the turbines not in operation.

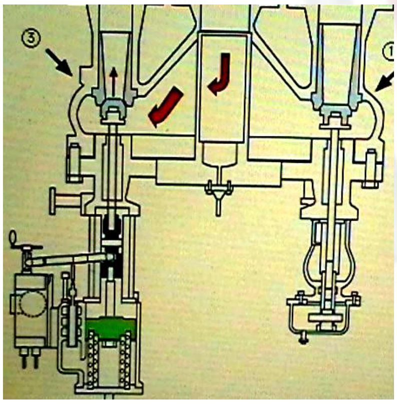
A sentinel valve positioned on the upper part of the casing, signals an alarm when the chamber pressure is higher than a pre setting value. The rotors are supported by journal bearings positioned at both fore side and aft side. Thrust produced by the rotor while in operation is supported by the thrust bearing positioned aft side. The fore side low pressure casing is fixed in position by the condenser with flange connection, while the aft side low-pressure turbine is supported by the panting plate. While in operation the casing expands from the heat towards aft side, however the rotors expand towards forward side with the thrust bearing positioned on the aft side as reference point, effectively offsetting the amount of expansion, which maintains the appropriate clearance of all parts. Spring support type labyrinth packing fitted at the penetrating part of the rotor and the casing and all diaphragms prevents steam from leaking out and air leaking in. Gland seal steam is feed into the second outmost pocket, while leak steam and air goes from outermost pocket to the gland condenser. Air escaping from the third outermost pocket of the aft side gland connected to the bleed line is used effectively.

VII.8 MANEUVERING DEVICE



Two devices regulates the speed of the steam turbine, the nozzle governing which regulates the amount of steam supplied and the throttling governing which regulates the pressure of the steam to be supplied.

The nozzle governing regulates the amount of steam supplied by opening and shutting the nozzle valves of each group, which are divided into groups on the first stage. The nozzle valve can be operated either the open and shut position or intermediate position. Although this is a kind of throttling governing stage, in this case it is generally called nozzle governing.

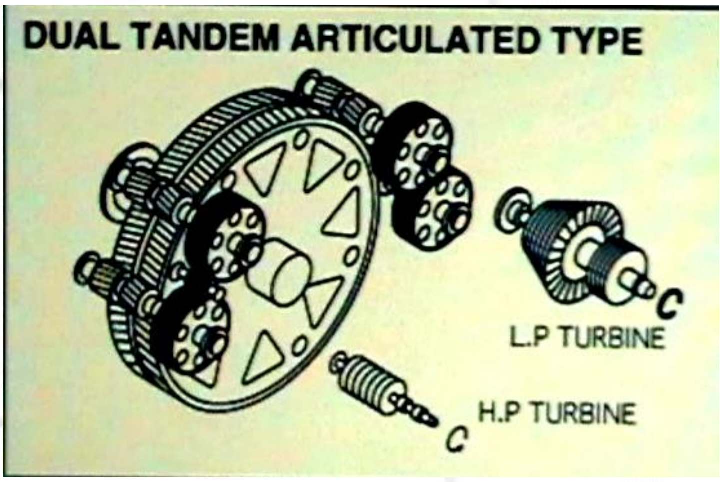


Throttling governing regulates the pressure of the steam to be supplied by adjustment of the steam flow with the maneuvering valve. When the steam pressure is reduced with the adjustment of the maneuvering valve the steam flow is also reduced.

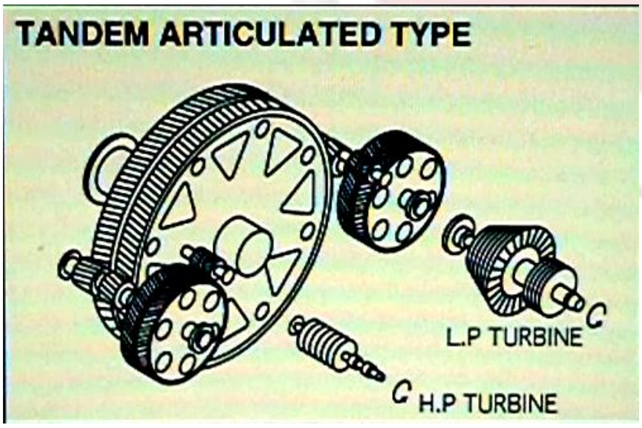
Ahead maneuvering is carried out by the adjustment of ahead nozzle valve and involves nozzle governing which regulates the steam flow rate supply to the high-pressure turbine. The ahead nozzle valve, which consists of several valves, is responsible for shutting off the steam supply to the nozzles.

Astern maneuvering is carried out by the astern maneuvering valve and involves throttle governing which regulates the steam pressure supplied to the astern turbine. The astern maneuvering valve is able to regulate the steam pressure by adjustment of the valve opening.

VII.9 REDUCTION GEAR



Using a high steam turbine makes it possible to reduce the size of the turbine. While maintaining a high out put, however the performance of the screw propeller proposition is reduced as a result of cavitations on the propeller blades at high rpm, therefore the reduction gear is fitted between the steam turbine and the propeller to reduce the rpm of the propeller to a level that maximizes the propeller efficiency. The rotors of both high pressure and low-pressure turbine are connected the reduction gear by flexible coupling. The flexible coupling transfers the power by a coupled mechanism, which consists of external gear fitted to the interior of the sleeve and gears fitted on both end of the claw piece. The reduction of the LNG carriers normally equipped with dual tandem articulated type or tandem articulated type mechanical reduction gears. This reduction gear reduces the rotating speed in stages with the combinations of the pinions and the gear wheel. Torque transmitted from the primary pinion to the primary wheel is transferred to the quill shaft via the flexible coupling. As one end of the quill

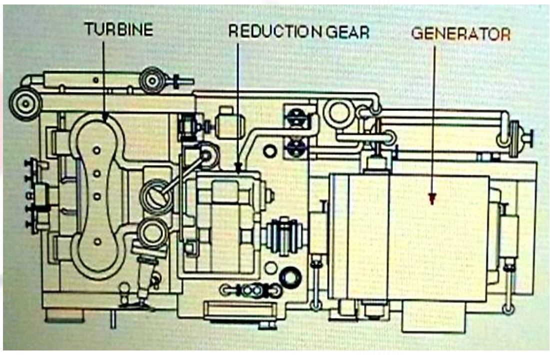


shaft is connected to the shaft of the secondary pinion by the flange, the torque is transferred to the secondary pinion and then to the secondary wheel. The reduction gear uses a double helical gear, as the double helical gear engages with the multiple gear teeth simultaneously the pressure of each tooth is minimal and it engages smoothly with the reduced noise. The flexible coupling, which connects the turbine rotor with the primary pinion of the reduction gear, absorbs any misalignment with the rotor and the primary pinions access and eccentricity caused by heat fluctuation. The quill shaft function to absorb any misalignment between the teeth of the primary wheel and the secondary pinion, and to prevent damage to the tooth surface from impacting. Lubricating oil is feed into the contact surface of the quill shafts teeth in order to reduce heat friction and prevents wear and tear.

VII.10 MAIN CONDENSER

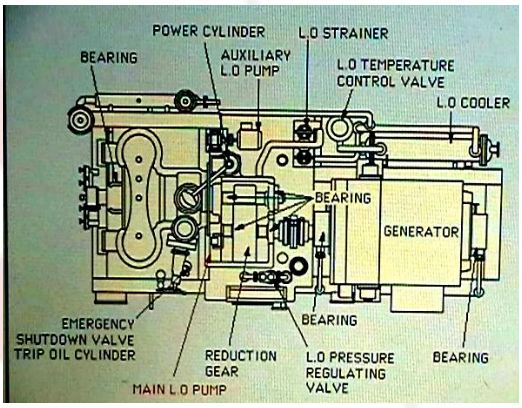
The main condenser cools the exhaust steam from the steam turbine reusing it as condensate water. The vacuum that resolves from the reduction in steam volume keeps the steam pressure at a low level. The vacuum inside the main condenser is almost the same as the saturated pressure caused the temperature at the cooling water outlet. The degree of this vacuum changes according to the temperature change of the cooling water. The main condenser uses a radial flow surface type device, which is positioned on the lower part of the low-pressure turbine and arranged at the right angle to the shaft of the main turbine. The flange of the main condenser upper half is directly bolted to the steam outlet flange of the low-pressure turbine, and suspended above the brace that supports the low-pressure turbine. Condensers fitted in this manner are called suspended condensers. A panting plate, which releases any related expansion in the direction of the shaft, is fitted to the fore side of the main condenser. Both ends of the titanium tubes are attached to the tube plates with the tube expander using the tube expansion method. The heat expansion difference between the water tube and the shell is absorbs by the diaphragm positioned on the shell. The interior of the water chamber is coated with neoprene lining and is fitted with an anti-corrosive plate, which prevent corrosion of the water chamber, the tube plates and the water tubes. While at sea cooling, seawater is supplied by the scoop and when the vessel is low or is birthing the water is supplied by the main circulating pump. Exhaust steam from the main turbine flows in from the exterior to the center of the water tubes. Water condensed on the surface of the water tubes drops from the exterior of the water tubes and down into the hot well at the lower part of the main condenser where it collects. When the condensate water drops, it is reheated to the saturated temperature by the exhaust steam outside the water tubes and deaerated. The vacuum pump extracts air and other incondensable gases from the air extraction box situated inside the main condenser. Excess steam is led to the main condenser through the dump steam pipe where it is cool down to become condensate water. In order to prevent the main condenser from overheating at this stage condensate water is sprayed into the main condenser.

VIII. TURBO GENERATOR OVERVIEW



The turbo generator comprises the following: The turbine, which converts the steam energy into rotary power. The reduction gear, which reduces the rpm of the turbine and the generator, which generates electricity.

The rotary power-generating turbine is made up of the turbine casing, nozzles, blades, and the rotor positioned inside the turbine casing. The steam, which drives the turbine, passes along the steam inlet pipe, emergency shutdown valve and the regulating valve, into the turbine where the steam is used and expelled from the turbine to the condenser and turn into condensate water. The turbine is controlled by the governor power cylinder and the regulating valve, which maintains a constant rpm. The governor situated on the turbine side of the reduction gear senses the rpm of the turbine. If the rpm reading has changed, it outputs a signal, which activates the regulating valve to reset the rpm to its original setting. The governor signal is relayed to the power cylinder where the regulating valve is activated by the oil pressure mechanism inside the power cylinder. This regulates the steam volume and controls the rpm.



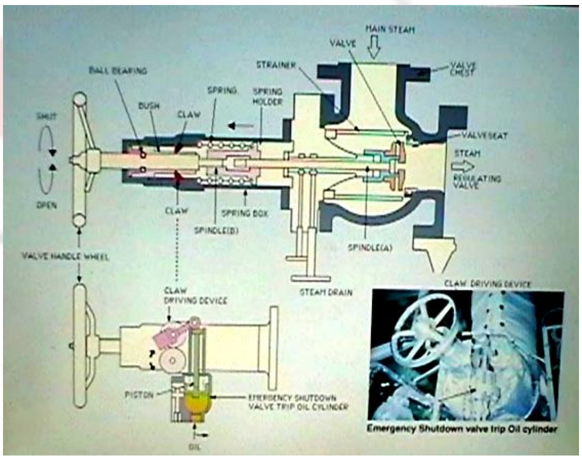
Gland packing prevents air sipping into or steam leaking from the gland located on both ends of the turbine casing. Steam for seal or packing steam is supplied to the gland. This packing steam is supplied by various devices including; the gland packing steam pressure controller, the gland packing steam receiver, the gland packing steam make up control valve, and the gland packing steam spill control valve.

The reduction gear functions to reduce the fast rotating 10036 rpm turbine to match the generators rpm preset to 1800 rpm. The pinion gear and wheel gear are positioned inside the reduction gear with the pinion gear is directly connected to the turbine rotor by the flange coupling. The wheel gear is connected to the generators rotor by the gear coupling, a type of flexible coupling. During normal operation, lubricating oil is supplied to the bearings and reduction gear by the main lube oil pump, which is driven by the shaft of reduction gears wheel gear. Lubricating oil is also used to operate a power piston for the regulating valve and the safety device. When stop or at low speed, the lubricating oil is supplied by the electric auxiliary lube oil pump. The turbo generator is shut down by the safety device in order to prevent damage to the turbo generator by automatically shutting down the emergency shut down and regulating valve under the following circumstances: When turbine over speeds, the lubricating oil pressure drops too low, the turbine rotor axial movement is abnormal, or when the turbine rotor vibrates excessively. The system is equipped with a manual trip device as well. The turning gear prevents rotor deformation caused by heat differential by rotating the rotor during the warming up and cooling down process, which helps to equalize the rotor head distribution. The turning gear is driven by an electric motor.

VIII.1 TRUBO GENERATOR CONSTRUCTION

Turbine casing is made up of upper and lower turbine casing separated at a horizontal joint. The emergency shut down, regulating and sentinel valves are positioned on the upper turbine casing. One side of the lower turbine casing is fixed to the lower reduction gear casing while the other side is protected by the panting plate via the bearing pedestals. This allows the casing to expand freely in the axial direction from the reduction gear side. Furthermore, the lower turbine casing is connected to the exhaust gas casing, which transports the exhaust gas to the condenser.

VIII.5 EMERGENCY SHUT DOWN VALVE

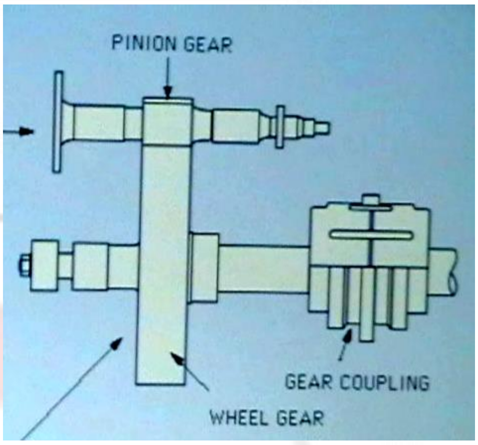


The emergency shut down valve positioned in the upper turbine casing comprises the following components:

The valve, strainer, spindle A, ring and spring holder, spindle B, bush, claw, ball bearing and the valve handle wheel. As the valve handle wheel is turned towards open the screw in spindle B, is screwed into the spring holder, pulling the spring holder into the left, finally the valves open. In this case, the counter reaction from the spring is absorbed by the ball bearing, bush, and claw. During malfunction, the emergency shut down valve trip oil cylinder. In emergencies, the steam is cut-off when the claw when the claw, which holds the bush, is unhooked by the emergency shut down valve oil cylinder, causing the valve to immediately shut off under the force of the spring.

As long no malfunction occurs in the turbine when emergency shut off valve is open, oil supplied to the emergency shut down valve trip oil cylinder to push up the piston. As a result, the claw hooks onto the bush thereby pulling the spring. If malfunction occurs, oil to the emergency shut down valve trip oil cylinder is cut off, causing the piston to immediately drop under the force of the spring and the claw to unhook, as the claw unhooks the valve is immediately shut off by the action of the spring. Once the emergency shut down valve is shut down, unless the handle is returned to fully closed position and the claw is hooked into the bush, the emergency shut down valve cannot be reopened.

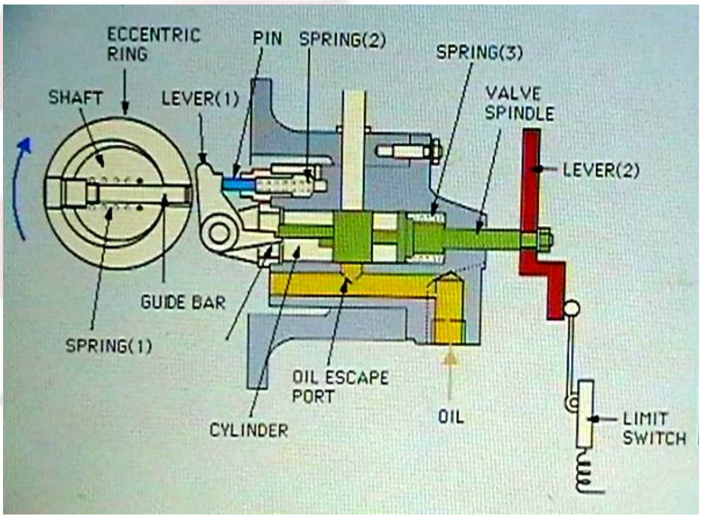
VIII.8 REDUCTION GEARS



The reduction gear made up of the single helical pinion gear and wheel gear, slows the rpm of the 10000 rpm turbine by approximately 5.6 times, to the preset 1800 rpm of the generator. The reduction gear casing is divided into a lower and upper part by the horizontal joint. The lower casing supports one end of the turbine casing. The pinion gear shaft and the turbine rotor are directly connected by the flange coupling. However, in other turbo generator types, they are connected by a quill shaft and a gear coupling, a type of a flexible coupling. This prevents accident occurring as a result of inters haft misalignment. Positioned on one end of the wheel gear is the driving gear, which drives the main L.O. pump, the governor, and the over speed trip device. The other end is connected to the generator rotor by the gear coupling, a type of a flexible coupling.

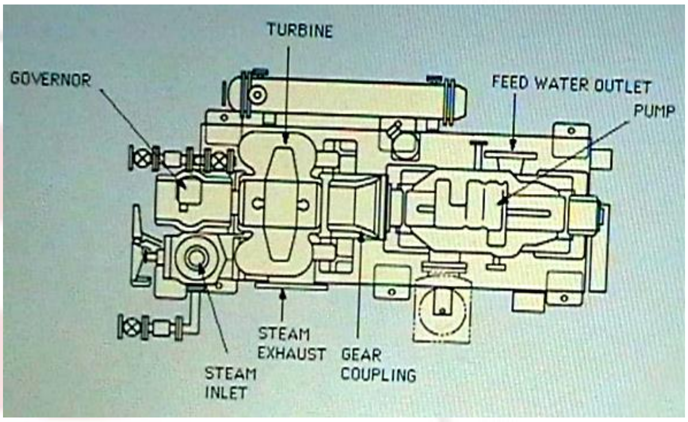
The gear coupling comprises the following components; the hub which has 82 outer teeth. The sleeve whose internal teeth are engaged with the hub. The reamer bolts connecting the sleeves. And the three keys connecting the sleeves, the wheel gear sides hub, and the generators sides hub. The power is transferred from the reduction gears wheel gear shaft, to the wheel gears side key, hub, sleeve and reamer bolts. And along the generator sides sleeve, hub, key, and generators rotor. In addition, turbine oil is contained inside the gear coupling.

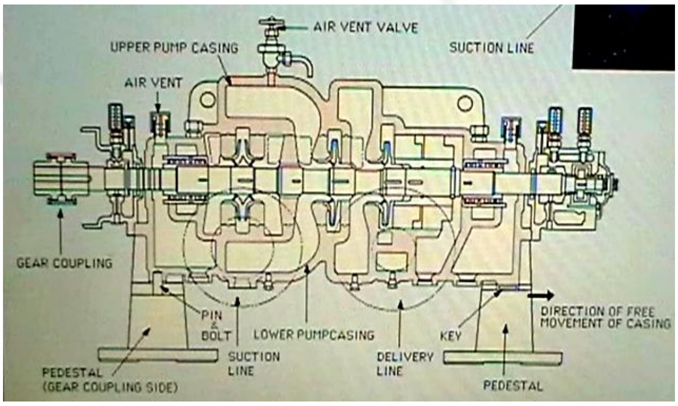
VIII.9 OVER SPEED TRIP DEVICE

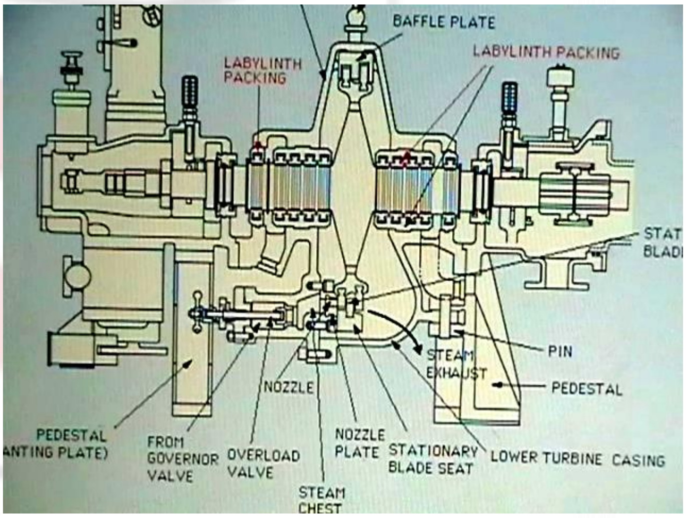


The components that make up the over speed trip device including the eccentric ring, spring 1 and the guide bar rotate together along with the shaft fitted to the reduction gear wheel shaft. Under normal circumstances, the valve spindle is locked by lever 1 and push right. Lever 2, which activates the limit switch, is attached to one end of the valve spindle. In this state the valve spindle blocks the oil escape port, opened by the cylinder and the oil is obstructed by the valve spindle, thereby maintaining the oil pressure in the oil line. When the turbine reaches 110 percent of rated rpm, the centrifugal force of the eccentric ring counter reacts the compressive force of spring 1, whereby the ring moves outward causing the lever 1 to collapse. As lever one collapses, it releases the valve spindle, which under the force of the spring 3 moves to the left freeing the oil escape port. As a result, the oil is released from the oil escape port and the oil line pressure falls causing the emergency shut down valve and the regulating valve to close. The limit switch is activated triggering the emergency shut down valve trip solenoid valve and the governor trip coil, in turn causing the emergency shut down valve and the regulating valve to close. Finally, the over speed trip device can be reset by manually releasing lever 2.

IX. MAIN FEED WATER PUMP



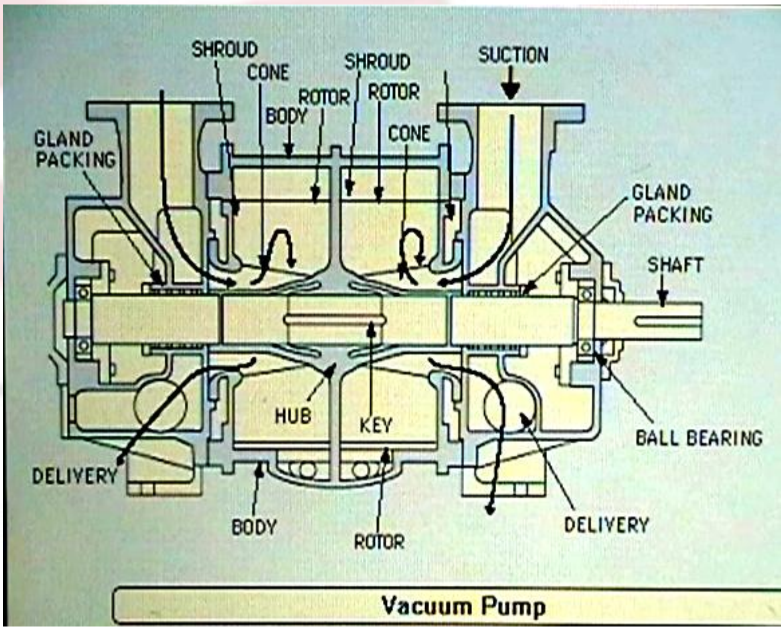




The main feed water pump consists of a turbine, which generates rotary power from steam energy, and the pump, which sucks in and pressurizes the feed water. Energy generated by the turbine is transferred to the pump via the gear coupling, a king of flexible coupling. Driving steam that goes to the turbine is supplied to the steam inlet valve and governor valve. After working with the turbine blades in the turbine casing, the steam is expelled from the exhaust valve. Condensate water is provided through the suction valve, and the feed water inlet strainer, to the pump, where it is pressurized and sends to the boiler. Furthermore, in order to prevent feed water leaking out, a stuffing box hermetically sealed with seal water, is fitted at a location where the pump shaft penetrates the pump casing. This main feed water pump controls the feed water delivery pressure. This delivery pressure is controlled by the feed water pressure transmitter, the feed water pressure controller, the governor, and the governor valve. Lubricating oil is supplied to the bearing and gear coupling by the main L.O. pump directly connected to the turbine. However, at a low rpm lubricating oil is supplied by the motor driven auxiliary L.O. pump. Safety devices fitted to the main feed pump, functions to prevent damage. Safety devices automatically stops the turbine in circumstances such as; over speeding, the lube oil pressure is too low, the turbine exhaust pressure is too high, and when the turbine rotor axial movement is abnormal. In addition, a hand trip device is also installed.

X. VACUUM PUMP

The vacuum and the main condenser of the steam turbine plant are generally maintained by either a Nash vacuum pump or the steam ejector.

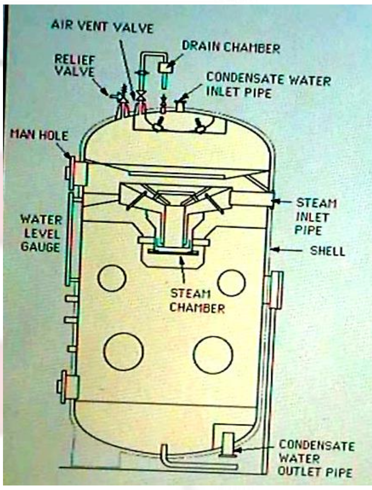


The Nash vacuum pump consists of the vacuum pump itself, the air ejector, water separator, and the seal water cooler. The rotor fitted with blades rotates inside the vacuum pump. Up to -79 kPa the air inside the main condenser is sucked in by vacuum pump, through the check valve and the air ejector. Air mixed with water ejected from the vacuum pump inters the water separator. Although air separated from the water separator is expelled into the atmosphere by the air outlet pipe, portion of air is used as the motive air that drives the air ejector. Water separated by the water separator is cooled by the seal water cooler and supplied back to the vacuum pump as seal water. When the main condenser vacuum falls below -97 kPa , motive air in the air ejector reaches acoustic velocity. The air ejector begins to operate sucking in air from inside the main condenser. Air from the air ejector is pressurized to atmospheric pressure by the vacuum pump and expelled into the water separator.

XI. DEAERATOR

The deaerator has three main functions. Firstly, the deaerator heats up the feed water with steam which improve the thermal efficiency of the turbine plant. Secondly, it eliminates and separates gases dissolved in the feed water, especially oxygen which can cause electrochemical corrosion in the boiler pipes, and various equipments. Thirdly, it prevents cavitations by securing the feed water pump suction head.

There are two main methods for oxygen separation and elimination. Firstly is the physical method, which is used in the deaerator. Secondly is the chemical method, which uses reducing agent such as sodium sulfide, hydrazine, or ion exchange resin.

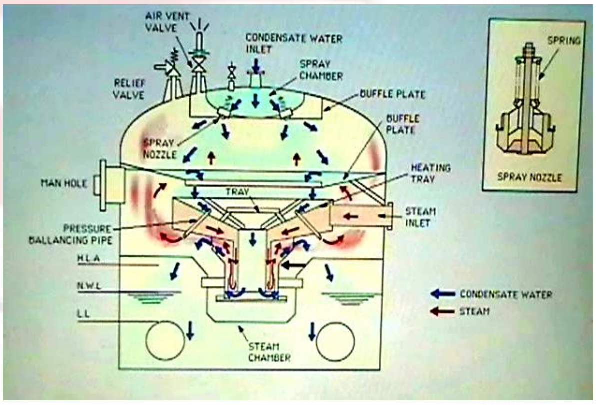


In physical method, it uses the principle of oxygen solubility in relation to water temperature. Oxygen solubility increases the colder the water and decreases the hotter the water. The deaerator is designed to take advantage of the special solubility characteristics by heating the feed water with steam, which efficiently separates and eliminates the oxygen content from the feed water.

XI.1 DEAERATOR CONSTRUCTION

The deaerator consists of the condensate water inlet pipe, the air vent pipe which expels separated air into the atmosphere. The drain chamber, which condenses and retrieves steam mixed in with the separated air. The relief valve, which reduces the pressure inside the deaerator when it exceeds the setting. Moreover, the steam inlet pipe through which the heating steam to heat the feed water comes through. On the mid level of the deaerator are the water level gauge and water level controller, which controls the water level of the deaerator. At the bottom end is the condensate water outlet pipe.

XI.2 INTERNAL STRUCTURE OF DEAERATOR



Condensate water transported by the condensate water pump and the drain pump inters into the spray chamber. Condensate water atomize by the spray nozzle is rapidly heated to near saturation temperature by the rising steam. This separates most of the air dissolves in the water droplets. This atomize condensate water temporarily collects in the baffle plates ready to flow downwards. The condensate water falls onto the steam-heated cone shaped heating plate and once heated in the surface of the plate collects into the steam chamber. The condensate water in the steam chamber is sucked in by the heating steam and forcibly ejected out from the steam chamber. Simultaneously, it mixes with the steam to form into fine water droplets to which the air is also completely separated. Separated air is expelled into the atmosphere through the air vent valve in the upper part of the deaerator.

XII. PLANT OPERATION PROCEUDRES

XII.1 TURBO GENERATOR STARTING PROCEDURE

Starting procedure of the turbo generator from a cold down stage.

1. After confirming and checking the level of the lubricating oil sump tank, start the auxiliary L.O. pump.
2. Start the turning motor to commence the turning of the rotor.
3. Supply cooling water to the L.O. cooler and air cooler.
4. Open slightly the drain valve of the gland seal steam receiver.
5. Raise the setting of the gland seal steam pressure controller from 0 to 5 MPa and confirm that the make up valve opens.
6. Open slightly the gland seal steam inlet valve. Once the drain has dry up open the valve slightly to full.
7. As the steam from the turbine gland comes out, open the gland leak off outlet valve.
8. Shut off the drain valve on the gland seal steam receiver.
9. Open the drain valve fitted at the inlet side of the main steam inlet valve to commence the line warming up process.
10. Open the drain inlet valve fitted on the inlet of the emergency shut off valve. Fully open the primary drain valve while opening the secondary one only slightly.
11. Once the drain from the main steam inlet valve has dry up, slightly open the main steam inlet valve.
12. Open the by pass valve fitted at the exhaust steam motor valve and establish exhaust steam line vacuum. Care must be given to open the by pass valve gradually to the fully open position, in order not to let the vacuum state of the main to drop.
13. Increase the setting on the gland steam pressure controller from 5 to 10 MPa.
14. Open up the exhaust steam motor valve and shut off the by pass valve. The exhaust steam motor valve is operated carefully by opening it gradually while observing the main condenser vacuum. Once the vacuum fluctuations settles down, open the exhaust motor valve to full.
15. Stop the turning motor and disengage the turning gear.
16. Gradually open to full the main steam inlet valve.

17. Slightly open the first stage drain valve.
18. Reset the emergency shut off valve and open it slightly. Carry out the warming operation of the turbo generator by rotating it at low rpm and check its condition during this operation.
19. Once the turbo generator has been warmed up, as long as there is no abnormalities on its components gradually open the emergency shut off valve and accelerate the turbo generator. During acceleration, be careful when approaching the critical speed by operating the turbo generator to swiftly pass the critical speed zone.
20. After the rpm rise to the rated rpm, and confirming that the governor is operating normally, open to full the emergency shut off valve.
21. In order to prevent the emergency shut off valve from sticking, due to heat expansion after it was fully open, the valve wheel must be turned back one half of the wheel revolution.
22. Shut the drain valves of the emergency shut off valves, main steam inlet valve, and the first stage drain valve.
23. Confirm that the auxiliary L.O. pump stops automatically once the pressure of the lubricating oil reaches the setting pressure.

Note: Procedures 1 to 3 is applicable only during cold starting. In actual operation starting procedure starts from item no. 4.

XII.2 TURBO GENERATOR STOPPING PROCEDURE

1. Open slightly the first stage drain valve.
2. Stop the supply of steam by either manually closing the emergency shut off valve, or by manually tripping the turbo generator to confirm that the shut off safety devices are operating normally.
3. Confirm the auxiliary L.O. pump automatically runs when the turbine rpm decelerates.
4. Shut off the main steam inlet valve.
5. Open the drain valve fitted on the emergency shut off valve, releasing the remaining pressure of the main steam line.
6. Lower the gland seal steam pressure controller setting from 10 to 5 MPa.
7. When the rpm drops to 100 rpm, shut off the exhaust steam motor valve.
8. After confirming, the rotor has stopped. Engaged the turning gear and start the turning motor.
9. Open the vacuum breaker valve. Once the vacuum in the exhaust gas line drops to atmospheric pressure, shut the gland seal steam inlet valve.
10. Lower the gland seal steam pressure controller setting from 5 to 0 MPa.
11. Shut the gland seal steam leak off outlet valve.

12. Shut the drain valves located on the first stage and inlet side of the emergency shut off valve.
13. When the casing temperature drops to the same temperature as in the engine room, stop the turning motor.
14. Stop the auxiliary L.O. pump
15. Cut the supply of cooling water going to the L.O. cooler and air cooler.

Note: Items 13 to 15 is only applicable when the turbo generator needs to be stopped for a long period such as major maintenance or dry-docking.

XII.3 PROCEDURE FOR LEAVING PORT

Port leaving procedure can only commenced after confirming the loading arm has been detached. Port leaving procedure involved 3 main stages; preparing the main engine, carrying out the try engine, and receiving the run up engine order.

While berthing, the main turbine should be kept rotating by the turning motor. In preparing the engine, the main turbine is warmed up until it ca be completely activated.

1. Shut off the ahead stop valve from 5mm opening.
2. Slowly open the warming up valve (main steam intermediate by pass valve) fitted to the boilers main steam intermediate valves to increase the pressure of the main steam line.
3. Once the main steam line pressure, reaches at approximately 5.8 MPa, full open the warming up valves of both boilers.
4. Open the main turbine main steam intermediate valves.
5. Shut off both boilers warming up valves.
6. Stop the main turbine rotating by the turning gear motor and disengage the turning gear.
7. Open the inlet and outlet valves of the astern water spray piston valve.
8. Start the control oil pump.
9. As the main turbine is still in the trip state, make sure it is reset.
10. Spin the turbine towards the astern side, by the astern maneuvering valve. At this point, the rpm of the propeller shaft must be less than 10 rpm. Furthermore, in order to prevent bending of the turbine rotor, care must be taken not to stop the rotor for more than 3 minutes.
11. Open gradually the ahead stop valve to fully open position.

12. Rotate the turbine rotor alternately towards the ahead and astern manually with the direct control switch until the main turbine steam inlet exceeds 350 degrees.
13. Carry out try engine operation at approximately 50 minutes before leaving port. Change the maneuvering mode from direct to lever maneuvering mode. After the try engine from engine control console, change location of control position to wheelhouse and carry out try engine.
14. When the standby engine is given, reactivate the hull s anti- corrosion system (CAPAC) which is stopped while berthing.
15. After the run up engine order has been given, accelerate the main turbine until it reaches its normal navigating speed. Main turbine acceleration is normally carried out automatically by the remote control devices, time delay schedule function.
16. Change the sea chest from high to low. At this point, the MGPS injection port change automatically as the sea chest is changed.
17. When the position of the maneuvering lever and ahead nozzle valve inter the normal zone, due to the acceleration of the main turbine, the plant zone automatically changes from the maneuvering to the normal mode.
18. During normal mode, shut off the astern guard valve.
19. When the rpm of the main shaft reaches to more than 50 rpm, the supply of cooling seawater to the main condenser, changes from the main circulating pump to the scoop system. Simultaneously, the MGPS injection inlet changes automatically.
20. The bleed valves open depending on the pressure of each bleed lines. Bleed valves are pressure controlled in accordance of the pressure setting of each bleed lines. As a result of bleed valve opening, the supply of steam to the de- superheated steam line commences.
21. Stop one of the turbo generators, to change the operation from parallel running to single operation.
22. Start up the distilling plant.
23. Carry out the boiler soot blow off.
24. After receiving permission from the gas part, change fuel mode to dual or gas mode.

XII.4 PORT ENTRY OPERATION

Port entry procedures are divided into three stages; prior to commencing deceleration of the main turbine, prior to stand by engine order is given, and after the finished with engine has been given.

Before commencement of the main turbine deceleration, various preparation must be carried out including;

1. Start and parallel run two turbo generators.
2. Stop distilling water plant.
3. Perform boiler soot blow off. Because boiler soot blow off is more effective when the boiler load is high, it is carried out before commencement of main turbine deceleration.
4. Before commencing the standby engine procedures, decelerate the main turbine.
5. Change over the sea chest.
6. Carry out astern test after completing deceleration.

When conducting the main turbine deceleration operation;

1. Change over the maneuvering control location to the engine control console in the engine control room. In order to prevent sudden load fluctuation, the turbine is usually decelerated at the rate of 1 revolution per minute.
2. When the position of the position of maneuvering lever and ahead nozzle valve into the maneuvering zone, along with the deceleration of the main turbine, the plant automatically changes from normal to maneuvering mode.
3. When the plant changes from normal to maneuvering mode, the first and second bleed valve shut. Consequently, the supply of bleed steam to the de- superheated steam line is cut off. Therefore, special attention must be given to the pressure fluctuation of the de- superheated steam line.
4. The astern guard valve on the astern maneuvering steam lines open.
5. When the boiler is burning gas, the fuel mode changes to dual mode.
6. When the shaft revolution drops to less than 48 rpm, the cooling sea water supply to the main condenser is process by the main circulating pump instead of by the scoop. At this point, the MGPS injection inlet changes automatically.

When the sea chest is changed from low to high, the MGPS injection inlet simultaneously changes.

After finished with engine order has been given, various necessary procedures must be carried out. The LNG carriers must comply with various restrictions while berthing.

1. The main turbine must be set to warming condition, and be rotated by the turning motor.
2. Change the maneuvering from lever maneuvering to direct maneuvering. As a result of this, the auto spinning stops.
3. Shut off the main steam intermediate valves for the main turbine.

4. Carry out hand spinning operation of the astern turbine in order to drain off the remaining steam. Shut the ahead stop valve.
5. Trip the main turbine manually with the hand trip.
6. Stop the control oil pump.
7. Shut of the astern water spray piston valve inlet and outlet valves.
8. Slowly open the warming up valve fitted at the boilers main steam intermediate valves.
9. Regulate the warming up valve opening in order to keep the pressure of the main steam line to 1 MPa.
10. Open the ahead stop valve 5mm. By performing these operations, the steam line from main steam intermediate valves to the ahead nozzle valve is warmed up.
11. After confirming the turbine rotor has stopped, engage the turning gear and commence turning the turbine rotor with the turning motor. Due to the risk of bending of the turbine rotor if stopped for a long period, while still being supplied by a gland seal steam, care must be taken not to stop the turning rotor for more than 3 minutes.
12. After receiving permission from the gas part, change the fuel mode from dual to F.O. mode, fuel oil combustion.

Other procedures include; regulating the MGPS flow volume, Stopping the hull anti- corrosive apparatus (CAPAC), and starting the turbo generator in preparation for loading or unloading.