MARITIME E-TRAINING, INC.

UPGRADING TRAINING FOR OILERS & WIPERS

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

1. Course Introduction

This Course covers the mandatory requirements for knowledge, understanding and proficiencies for Upgrade Training for Oiler and Wiper. Upon successful completion of this Course, trainees shall be expected to have gained the minimum knowledge, understanding and proficiencies needed to carry out and undertake the tasks given on board a ship.

1. Engine Room Machineries Operating Principles

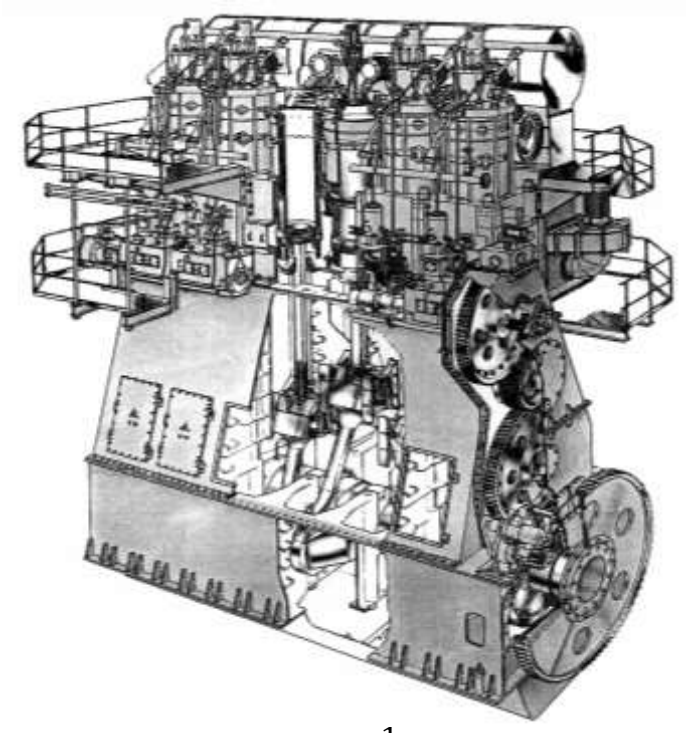
2.1. Positive Work Attitude / Work Ethics

2.2. Marine Diesel Engine

Main Propulsion Engine -These are engines which are directly responsible in propelling or moving the ship forward or astern. Usually they are located in the ship's Engine room.

Auxiliary Engines -These engines are smaller engines which give additional power to the ship.

Diesel Engine Propulsion -This type of propulsion utilizes diesel engine as a prime mover. Its layout or arrangement depending on the number of prime mover connected to the propulsion shaft. In case there are two prime movers, one is installed at the port side and the other one at the starboard of the engine room. Each prime mover either drives an individual shaft or both will be driving a single shaft. The most common arrangement is one large engine at the center of the engine room driving one propulsion shaft as illustrated by the drawing.



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Classification of Diesel Engine

In order to understand a diesel engine better, it is necessary to know its classification. It is classified as follows:

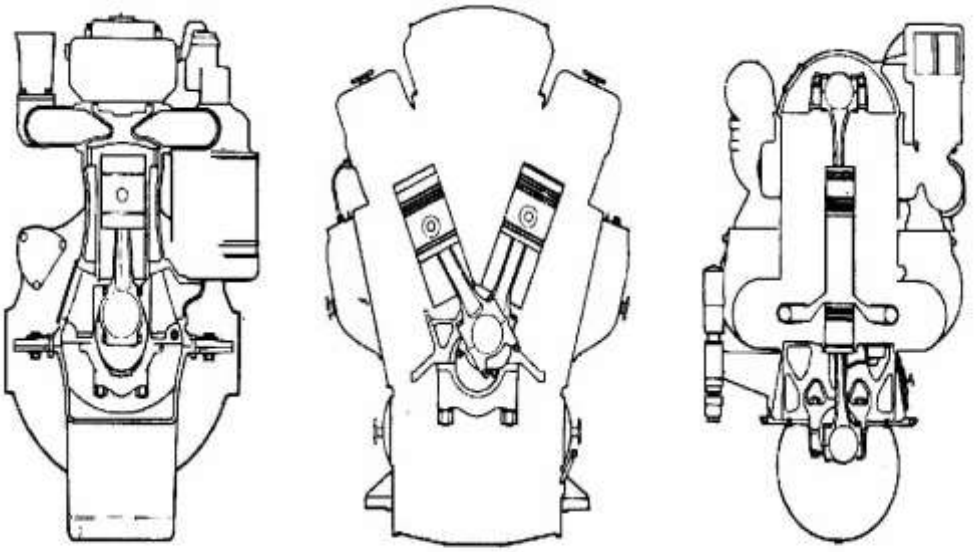
According to cylinder arrangement

- In-line cylinder engine -an engine is said to be in-line cylinder engine when their cylinders are arranged in vertical position parallel from each other. Large diesel engines are usually of this type.

- Vee-type diesel engine -engines are said to be of this ~e when their cylinders are arranged to form a letter "W", two connecting rods connected to one crankpin in a crankshaft. This type is common to medium size diesel engine.

- Opposed Piston Engine -engines of this type has two pistons working in one cylinder. These two pistons compress the air by meeting at the center of the cylinder. After the combustion they move outward to deliver the power.

- Radial Engines -an engine is said to be radial engine when four cylinders are arranged surrounding the crankshaft. Four connecting rods are connected in one crankpin in the crankshaft. This type is common to small high speed engine.



COMMON ENGINE CYLINDER ARRANGEMENTS

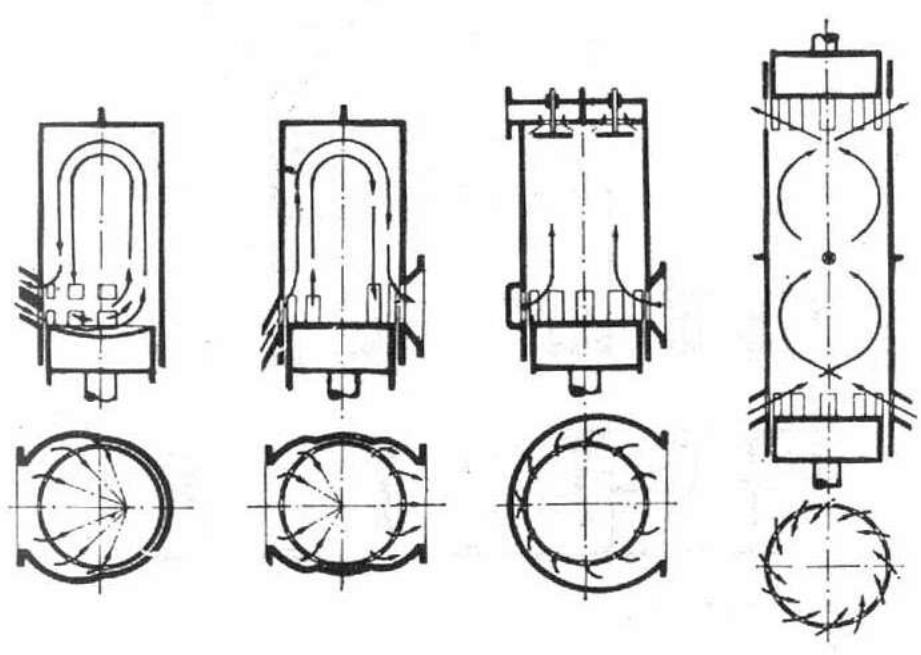
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

According to Piston Action

- Single Acting Engine -an engine that produces power at one side of the cylinder.
- Double Acting Engine -an engine that produces power on both side of the cylinder alternately giving twice the number of power strokes than the single acting engine.

According to Method of Charging

- Natural Aspirated -the fresh air charged in the cylinder is drawn in the vacuum created when the piston moves away from the combustion space.
- Supercharged -the charged is admitted in to the cylinder at higher than atmospheric pressure. This high air pressure is produced by a pump or blower.



(a) loop scavenging
(b) cross scavenging
(c) uniflow scavenging with exhaust valves
(d) uniflow scavenging opposed pistons

Scavenging methods of low-speed engines

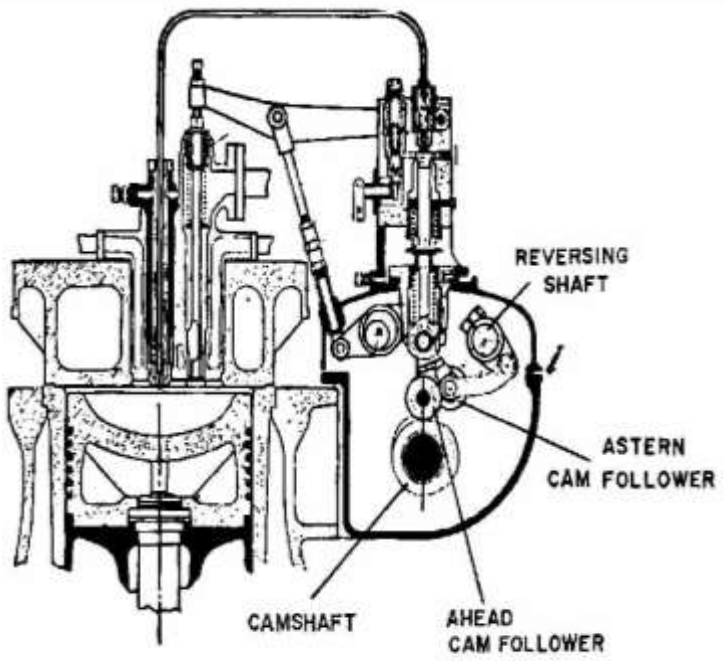
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

According to Engine Speed

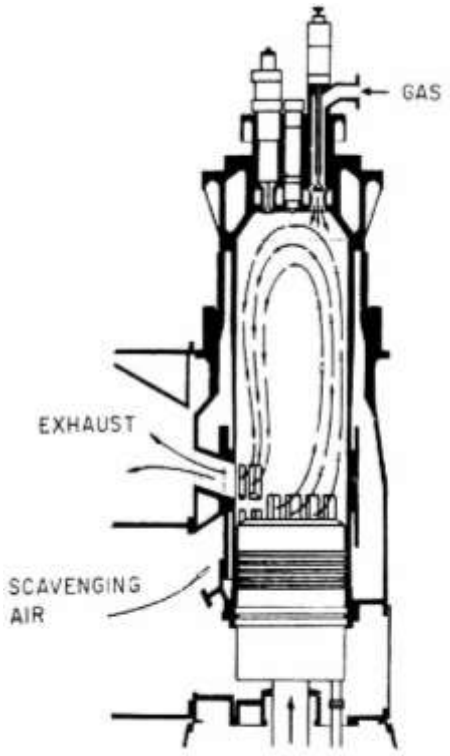
- Slow Speed Engine -an engine is considered a slow speed engine when it's revolution ranges from 0-300 RPM
- Medium Speed Engine -revolution ranges from 300 -1000 rpm.
- High Speed Engine -an engine ranging from 1000 rpm and above.

According to Method of Injection

- Air injection -in the original low speed engines, the fuel is injected in to the cylinder by a blast of compressed air
- Mechanized -at present mechanized injection is being used for all types and sizes of diesel engine.



Mechanized Injection



Gas injection for a dual-fuel engine

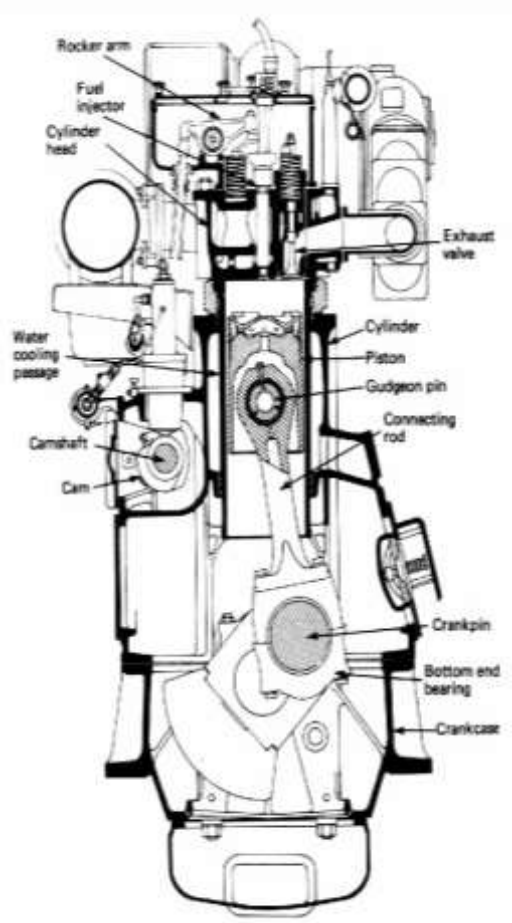
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

According to Operating Cycle

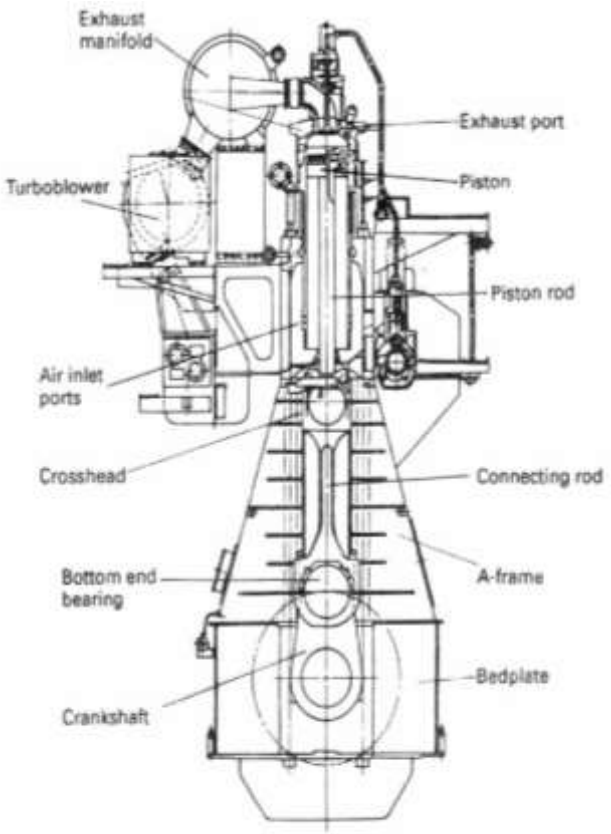
- Two Stroke Cycle Engine - an engine is said to be a two stroke cycle engine if two strokes of the piston or one revolution of the crankshaft to complete a working cycle.

- Four Stroke Cycle Engine - four strokes of the piston or two revolutions of the crankshaft to complete a working cycle.

- Stroke is the movement of the piston from bottom dead center (BDC) to top dead center (TDC), Cycle-a sequence of events which recur regularly and in the same order.

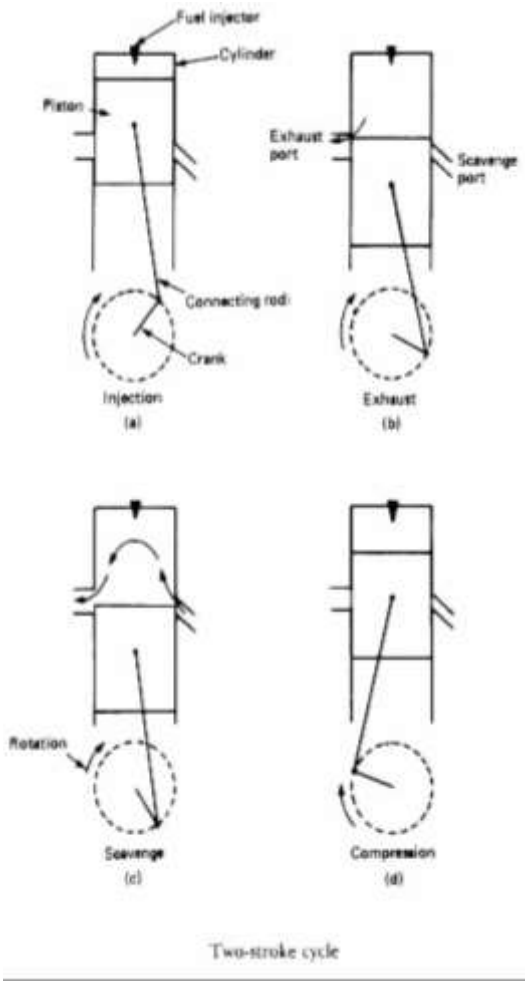


Cross-section of a four-stroke diesel engine

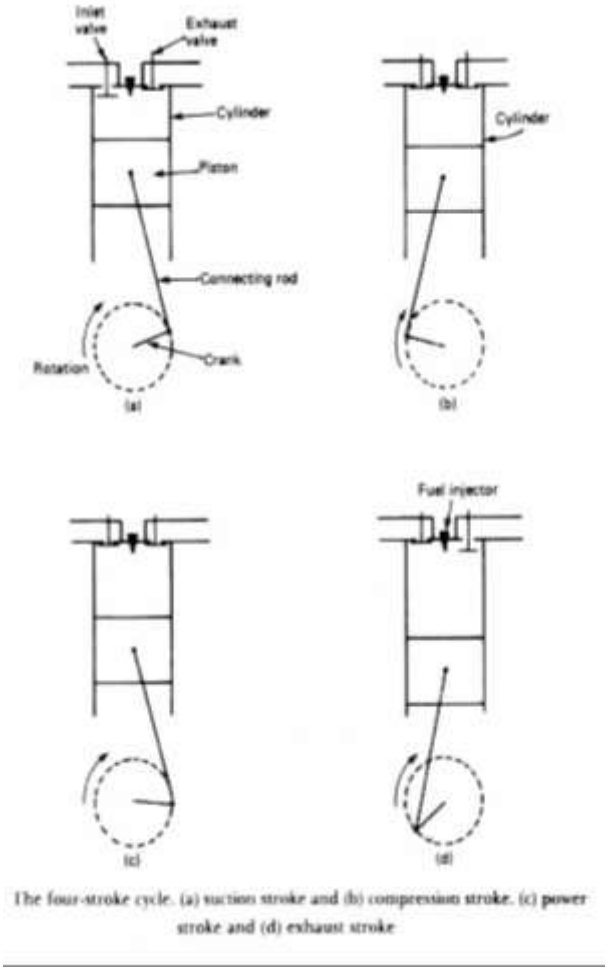


Cross-section of a two-stroke diesel engine

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



Two-stroke cycle



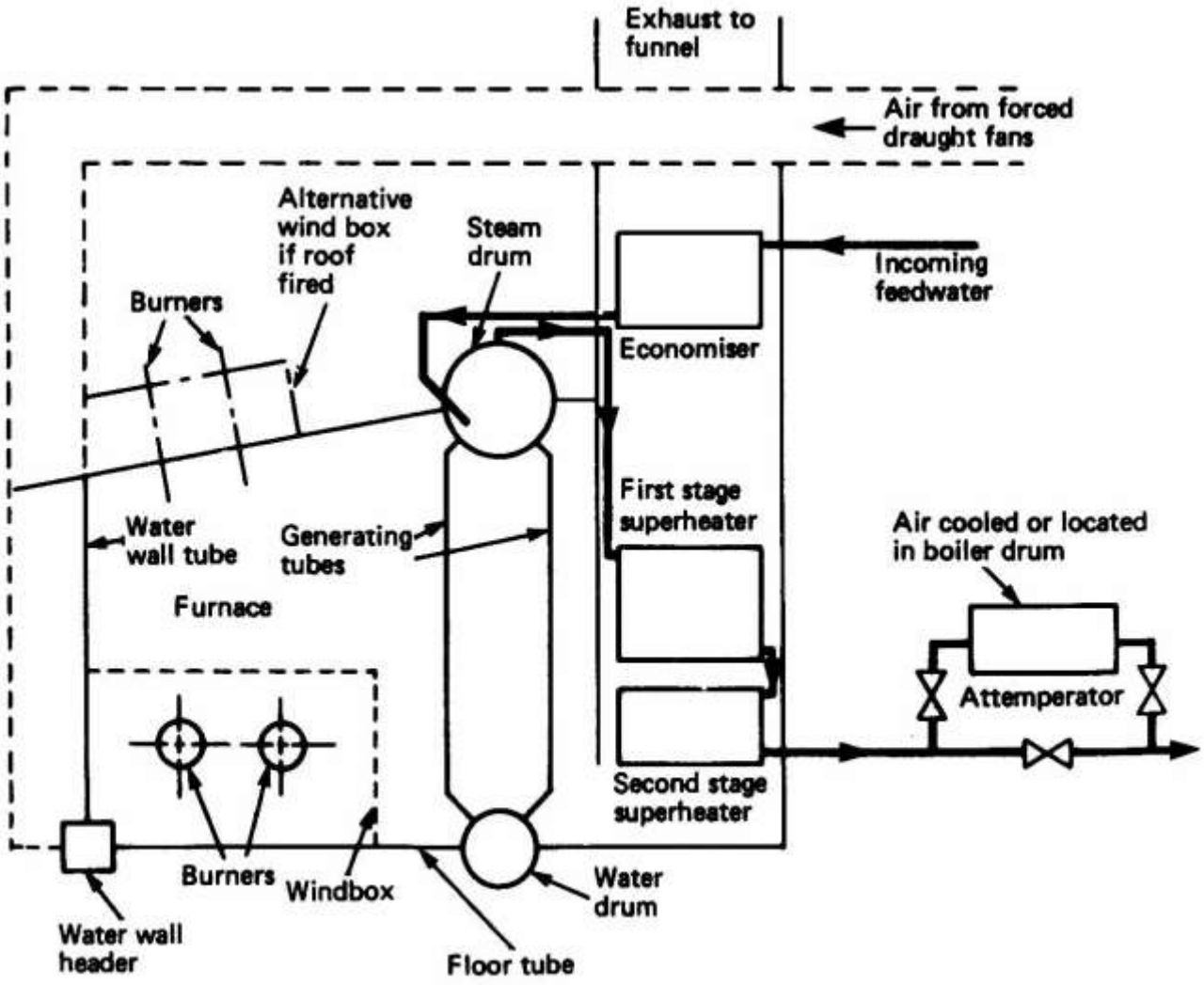
The four-stroke cycle. (a) suction stroke and (b) compression stroke. (c) power stroke and (d) exhaust stroke

2.3. Boiler

The most important single piece of equipment in any steam power plant is the boiler. Without the boiler, there naturally would be no means to transfer the energy in fuel to useful work output. Similarly, an efficient or poorly operated boiler will upset the smoothness of running of the best designed engine or turbine.

Boilers of a sort have been in existence since man first discovers the use of fire. However, until the advent of the first steam engine, there was little need for an efficient steam generator. Since the days of Newcomen and Watt, the development of engines and boilers have proceeded side by side with an improvement in one demanding, or following, an improvement in the other.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

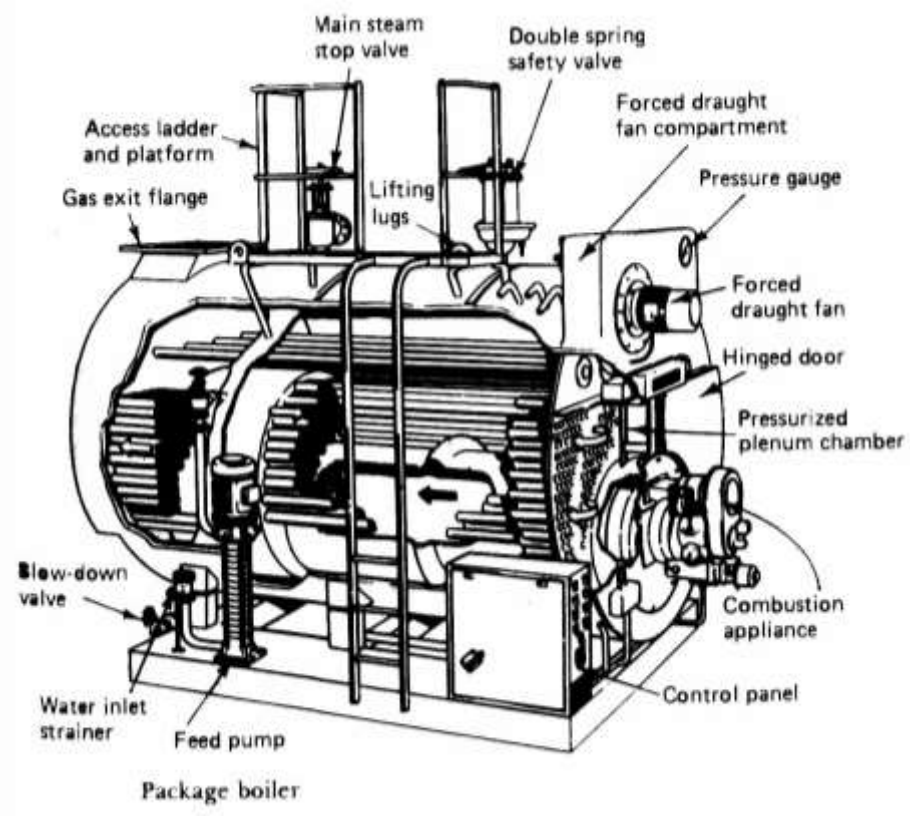


Simplified boiler arrangement

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Two Types of Boiler

a. Fire Tube Boiler -this type of boiler is still in use today in low pressure heating plants and on many merchant vessels. The essential characteristic of a fire-tube boiler is that the products of combustion pass through the inside of the tubes, with the outside of the tubes being surrounded by water. In marine usage, there have been essentially three types of fire-the boilers namely, the scotch boiler, the leg type boiler, and the vertical boiler. The scotch boiler is by far the most commonly used fire-tube boiler in marine work, and detailed description is illustrated below.

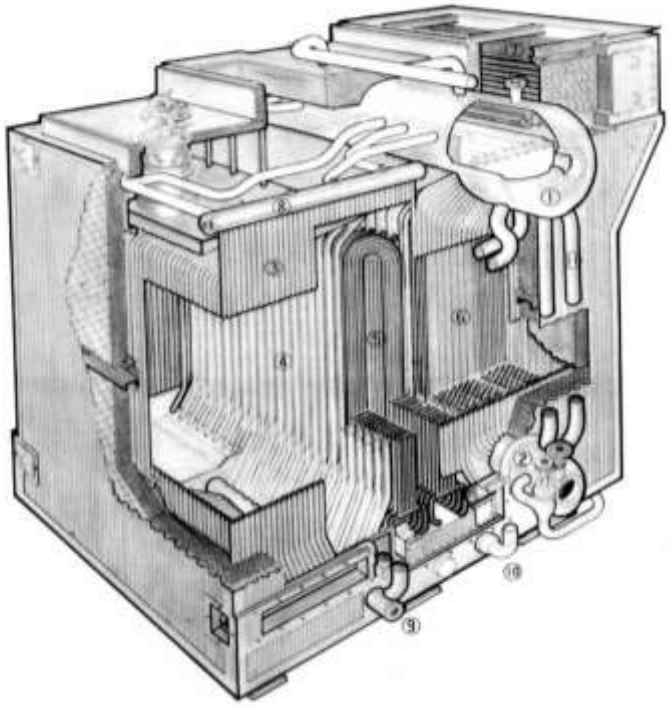


Package boiler

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

b. Water Tube Boiler -with the development of electrical generators by Thomas Edison in the latter half of the nineteenth century, a demand was created for a more efficient drive that would produce electrical power economically. This demand called for the efficient production of higher-pressure steam. Answering this need was the water tube boiler, in which as essential characteristics, water is contained within the tubes with products of combustion passing around the outside of the tubes. The water tube boiler has answered the need to such an extent that all large shore side power plants and all American ocean going steam vessels of recent construction use the water-tube boiler to the practical exclusion of fire tube boilers.

▼ Internal Construction of UM-Boiler



(1) Steam drum
(2) Water drum
(3) Water wall
(4) Screen tube
(5) Superheater
(6) Generating tube bank
(7) High level economizer
(8) Water wall header
(9) Furnace bottom header
(10) Superheater header
(11) Down comer

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

List of Boiler Mountings and Respective Functions

- Safety valve protects the shell o drum against excessive pressure.
- Main steam stop valve allows steam to leave the boiler to go into the main steam line, and from there, to the main engine or turbine
- Auxiliary steam stop valve allows steam to leave the boiler to pass into the auxiliary steam line, and from there, to pumps, generators, and other auxiliaries.
- Water column provides a stilling space so that its water level will not be greatly affected by pitching and rolling of the ship. Water in the column is cooler than that in the boiler shell or drum. Thus, no actual boiling takes place in the column, and the water level is more easily detected.
- Gauge glass attached to the water column or to the drum and indicates the level of the water in the boiler.
- Try cocks attached to the shell or to the water column, and are used to prove the reading indicated by the gauge glass.
- Surface blow valve allows light impurities, such as oil or grease, to be blown off from the surface of the water in the boiler
- Bottom blow valve allows sediment to be blown off from the bottom of the boiler.
- Salinometer cock allows a sample of water to be drawn off from the boiler so that the density of the water may be measured.
- Main feed water stop valve permits or prevents entrance of the feed water into boiler from the main feed water line.
- Auxiliary feed water stop valve has the same function as the main feed water stop valve, but is located in the auxiliary feed water line.
- Main feed water check valve regulates the flow of water in to the boiler from the main feed line and prevents water in the boiler from backing up in the main feed line in event of failure of the main feed water pump.
- Auxiliary feed water check valve has the same function as the main feed water check valve, but is placed in the auxiliary feed water pump.
- Air vent allows air to be released from the boiler prior to cutting in the boiler on the line and to break the vacuum when the boiler is being emptied.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

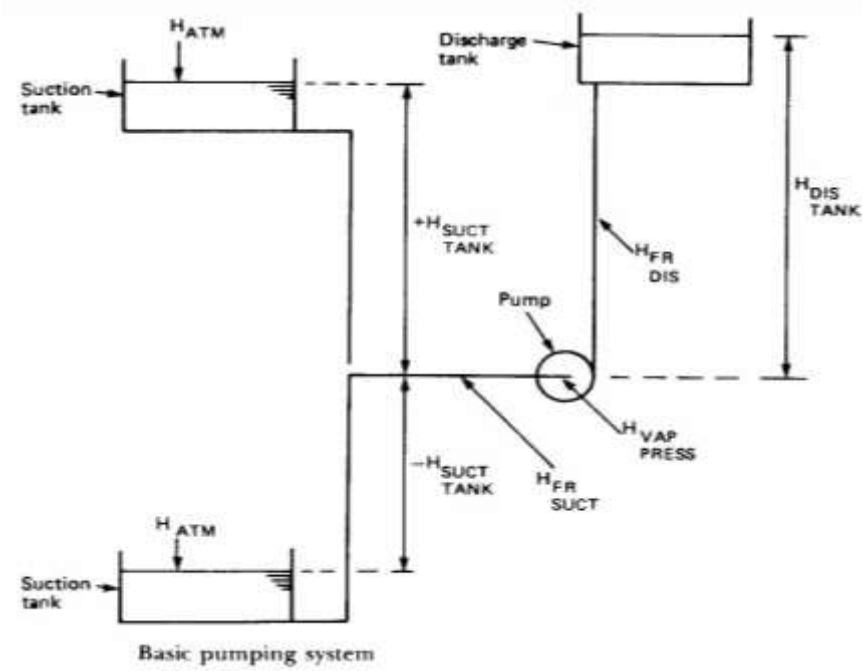
- Whistle valve furnishes steam for the ship's whistle.
- Pressure gauge indicates pressure being carried in the boiler.
- Belly plug fitted on scotch boilers for the purpose of allowing water to drain from the boilers in to the bilges.
- Hydrokinetic valve found only on scotch boilers, and supplies steam to the hydrokinetic, which is used to speed up circulation and cause even heating of the boiler when the latter is started up from cold. The mountings listed above, with the exception of the belly plug and hydrokinetic are found on both scotch and water tube boilers.

2.4. Pumps

A pump is a device which adds to the energy of a liquid or gas causing an increase in its pressure and perhaps a movement of the fluids. A simple pumping system is shown schematically in the figure below. The basic system consists of a suction branch, a pump and a discharge branch.

Pump Theory

The pump only adds to the energy of the system. The energy required to bring the fluid to the pump is an external one and in most practical conditions is provided by atmospheric pressure. When liquid is forced through the pump outlet it causes a partial vacuum at the inlet. Atmospheric pressure then pushes on the liquid into the pump inlet. At the outlet of the pump the fluid flows and the resistance of the fluid to flow causes pressure to develop.



Basic pumping system

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Types of Pumps:

Pumps constitute by far the most numerous units of auxiliary machinery aboard ship. Included among the types are centrifugal pumps, propeller pumps, reciprocating pumps, positive displacement rotary pumps, jet pumps and eductors, and air ejectors.

a. Reciprocating Pumps

The reciprocating pumps move water or other liquid by means of a piston or plunger which reciprocates (goes back and forth or up and down) within a cylinder. Reciprocating pumps are classified as:

- Direct acting or indirect acting
- Simplex (single) or duplex (double)
- Single-acting or double-acting r;"
- High pressure or I QW pressure
- Vertical or horizontal

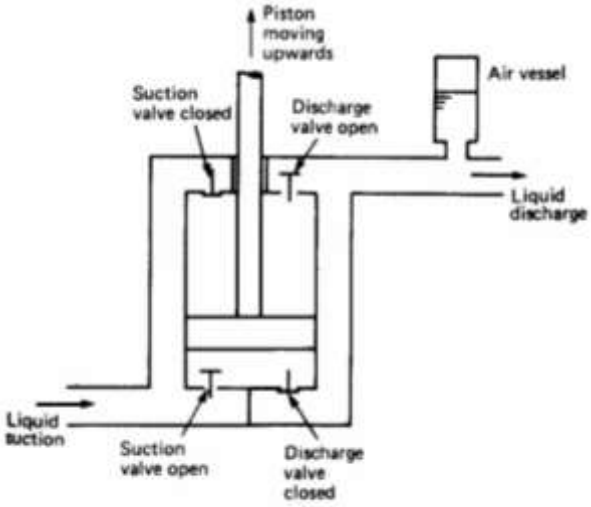
The reciprocating pump shown in figure below is a direct-acting, simplex, double-acting, high-pressure, vertical pump. Now let's see what all these terms mean, with the reference to the pump illustrated.

The pump is DIRECT -ACTING because the pump rod is a direct extension of the piston rod; and, therefore, the piston in the power end is directly connected to the plunger in the liquid end. Most reciprocating used in ships are direct-acting. An INDIRECT -ACTING pump may be driven by means of a beam or a linkage which is connected to and motivated by the steam piston rod of a separate reciprocating engine; or it may be driven crank-and connecting rod mechanism which is operated by a steam turbine or an electric motor. An indirect-acting pump might appear to have only one end-that is, the pump end. However, don't forget that this pump, like others, must have a power end as well. The separate engine, turbine or motor which drives the pump is the actual power end of the pump.

The pump shown in figure called a SINGLE or SIMPLEX pump because it has only one liquid cylinder. Simplex pumps may be either direct-acting or indirect-acting A DOUBLE OR t) EJPLEX pump is an assembly of two single pumps, placed side by side on the same foundation; the two steam cylinders are cast in a single block, and the two liquid cylinders are cast in another block. Duplex reciprocating pumps are seldom found in modern vessels, but are commonly used in older ships.

In a SINGLE-ACTING pump, the liquid is draw into the liquid cylinder on the first or SUCTION STROKE and is forced out of the cylinder on the return or DISCHARGE STROKE. In a DOUBLE- ACTING pump, each stroke serves both to draw in liquid and to discharge liquid. As one end of the cylinder is filled, the other end is emptied, on the return stroke, the end which was just emptied is filled and the end which was just filled is emptied. The pump shown in figure 8-2 is double-acting, as are most of the reciprocating pumps used aboard ships.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

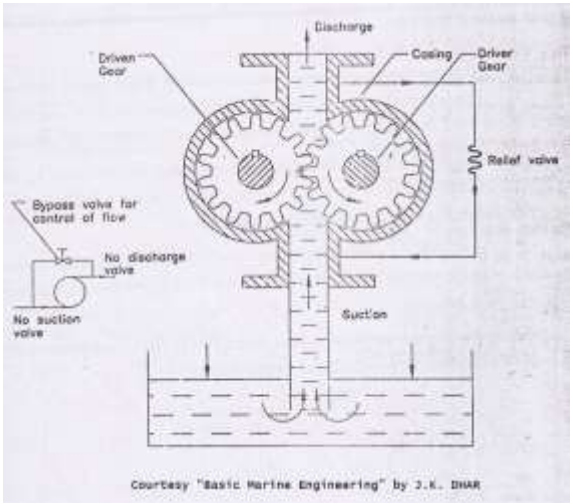


Diagrammatic reciprocating displacement pump

b. Rotary Pumps

All rotary pumps work by means of rotating parts which trap the liquid at the suction side and force it through the discharge outlet. Gears, screws, lobes, vanes, and cam-and plunger arrangements are commonly used as the rotating elements in rotary pumps. Rotary pumps, like reciprocating pumps, operate on the positive displacement principle that is each rotation or each stroke delivers a definite quantity of liquid.

Rotary pumps are particularly useful for pumping oil and other heavy, viscous liquids. In the fire room this type of pump is used for fuel oil-service, fuel oil transfer, and lubricating oil service. Rotary pumps are also used for non-viscous liquids, such as water or gasoline, where the pumping problem involves a high suction lift.



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

c. Centrifugal Pumps:

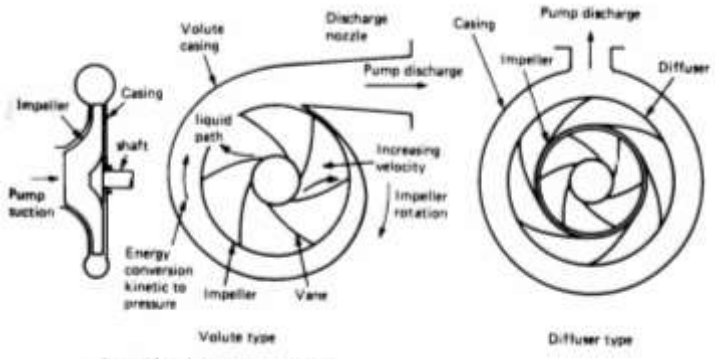
The Centrifugal Pump utilizes the throwing force *of* a rapidly revolving IMPELLER. The liquid is pulled in at the center or EYE *of* the impeller and is discharged at the outer rim of the impeller.

By the time the liquid teaches the outer rim *of* the impeller, it has acquired a considerable velocity. The liquid is then slowed down by being led through a volute or through a series *of* diffusing passages. As the velocity of the liquid decreases, its pressure increases and, thus its kinetic energy is converted into potential energy.

There are many different types *of* centrifugal pumps, the two which you are most likely to see on board ship are the volute pump and the volute turbine pump. The VOLUTE PUMP as shown in the figure below, in this pump, the impeller discharges into a volute-that is, a gradually widening channel in the pump casing. As the liquid passes through the volute and into the discharge nozzle, a great part *of* its kinetic energy is converted into potential energy.

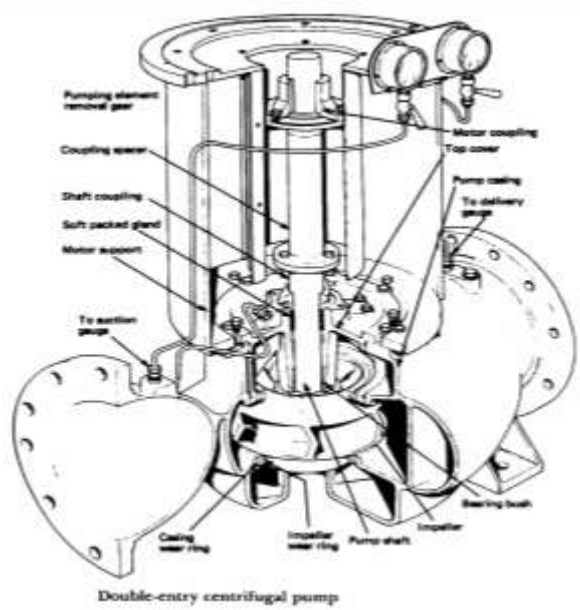
In the Volate Turbine Pump shown below, the liquid leaving the impeller is first slowed down by the stationary diffuser vanes which surround the impeller. The liquid is forced through gradually widening passages in the diffuser ring (not shown) and into the volute. Since both the diffuser vanes and the volute Centrifugal pumps may be classified in several ways. For example, they may be either SINGLE-STAGE or MULTISTAGE. A single stage pump has only one impeller. A multistage pump has two or more impellers housed together in one casing; as a rule, each impeller acts separately, discharging to the suction *of* the next-stage impeller. Centrifugal pumps are also classified as HORIZONTAL or VERTICAL; depending upon the position *of* the pump shaft. The impellers used on centrifugal pumps may be classified as SINGLE-SUCTION or DOUBLE SUCTION. The single-suction impeller allows liquid to enter the eye from one direction only; the double-suction type allows the liquid to enter the eye from two directions.

Impellers are also classified as CLOSED or OPEN. Closed impellers have side walls which extend from the eye to the outer edge *of* the vane tips; open impellers do not have these side walls.



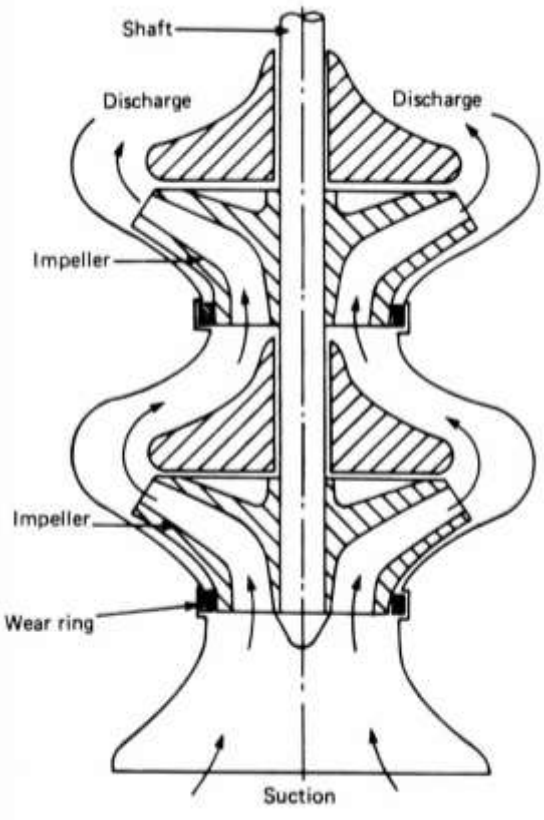
Centrifugal pump operation

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



Double-entry centrifugal pump

Multi-stage centrifugal pump



Note only two stages are shown

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

2.5. Centrifugal Separators

Centrifugal separation means a separating operation by means of centrifugal force for thickening of solid particles suspending in liquid (solid-liquid), separation of water particles (liquid-liquid) or simultaneous removal of water and solid particles dispersing in oil (solid-heavy liquid-light liquid) etc.

If centrifugal force which is several thousand times larger than gravity is used in these operations, it will greatly accelerate separation.

Namely, taking example *of* removal of solid particles in liquid, one sedimentation centrifuge has sufficiently a capacity equivalent to that of a settling basin whose area shall be several hundred meters square. While, taking another example of removal of water particles in oil the difference of specific gravity between oil and water is extremely small and it is not rare that the value is less than 0.05. In this case, separation is only possible by powerful centrifugal force.

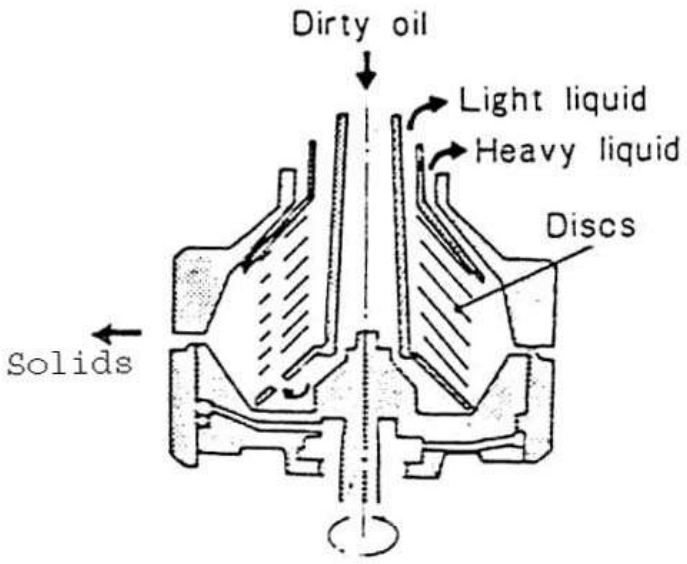
As mentioned above, sedimentation centrifuge has great characteristics which cannot be gained sedimentation.

Kinds of Sedimentation Centrifuge

Sedimentation centrifuge performs separation by means of density difference and in case there is density difference of about 3% separation will be easily performed. But in case of solid-liquid separation, if the amount of solids is more than 1 % in volume, batch system centrifuge can be hardly applicable to industrial purposes. In that case centrifuge 'with a structure of discharging solid particles shall be applied.

a. Disc-Type

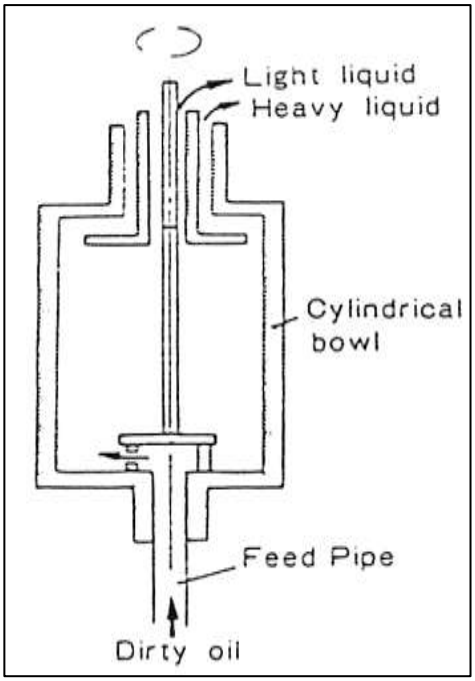
Disc type centrifuge has discs in the shape of truncated cone in the bowl and performs sedimentation separation in the narrow spaces between discs.



Therefore the structure of disc type centrifuge is rather more complicated that of cylindrical bowl type and its number of revolutions of bowl is about 4,000-10,000 rpm. However, centrifugal sedimentation area of discs type is far larger than that of cylindrical bowl type. This type is mainly used for the separation of "liquid-liquid", 'solid- liquid", having small content of solids or "solid-liquid-liquid" containing much solid particles.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

b. Cylindrical Bowl Type



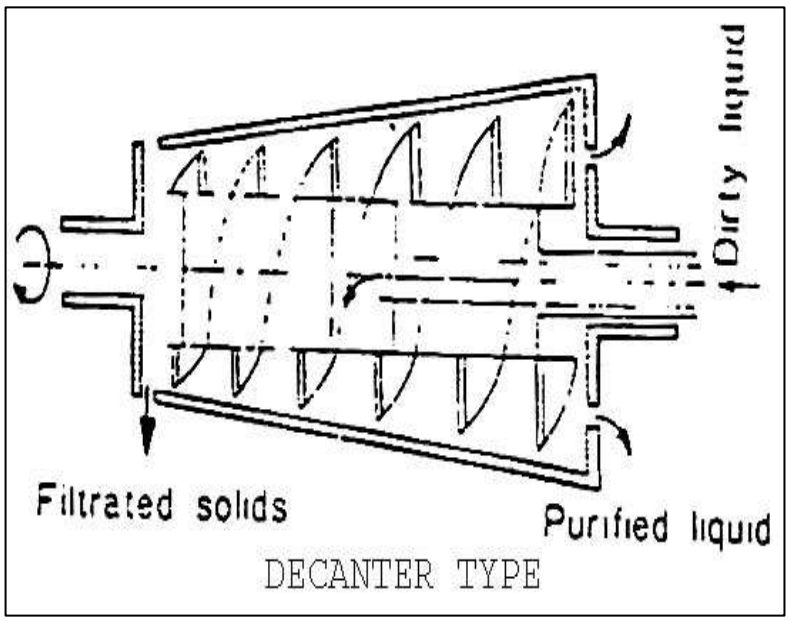
Cylindrical bowl type has larger centrifugal effect and is used for separation of "liquid- liquid" or "solid-liquid"

Accordingly, it has rather larger number of revolutions of about 10,000 -20,000 rpm, but centrifugal sedimentation area of this type of centrifuge is small because of the restriction in size from its structure.

Though the structure is very simple, it is necessary to remove sludge by stopping the operation.

c. Decanter Type

Decanter type centrifuge is used for the separation of "solid-liquid" having large density difference and much content of solid particles. Clarifier of this type such a structure as disc type centrifuge without discs and is designed that solid particles may be settled and accumulated inside the bowl.



In case of sufficient purification cannot be performed in using only this type of centrifuge, it may be used for pre-treatment in combination with disc type or cylindrical bowl type centrifuge. Centrifuge of this type, both conical and cylindrical type are capable of continuous taking out of sediment solid particles after dehydrating them to a certain extent. As for the structure, for the purpose of transporting solid particles, they are equipped in the conical or cylindrical bowl with screw conveyor rotating at the speed little different from bowl. Accordingly, they are called as screw type decanter centrifuge too.

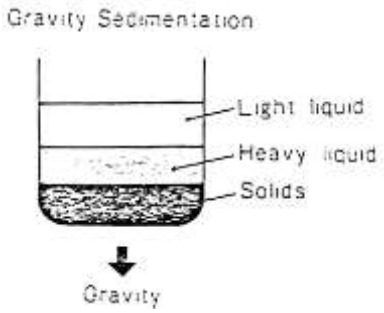
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

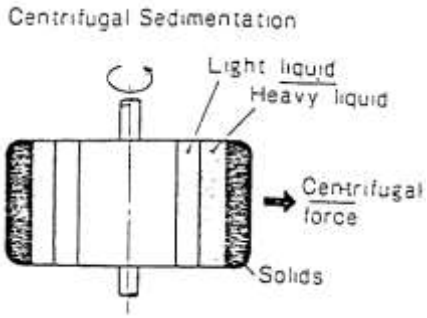
Principle of Operation

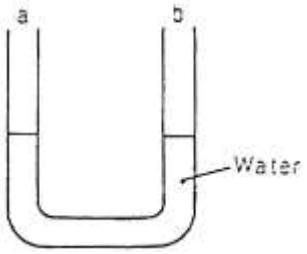
Centrifuge (Centrifugal Separator) performs separation by sedimentation in centrifugal field. Figure-A shows gravity sedimentation under static condition, which is substituted for centrifugal sedimentation as shown in Figure B (shows transparency).

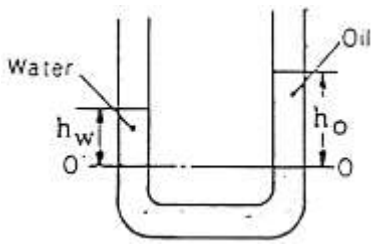
Both centrifugal and gravity sedimentation perform separation by means of specific gravity difference between mixed liquids, using centrifugal force for the former and gravity for the latter.

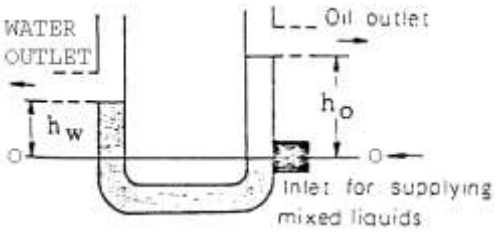
In case of centrifugal sedimentation, as the centrifugal force acting upon is several thousand times as large as gravity, its separation rate and purification effect are far bigger than those of gravity sedimentation.









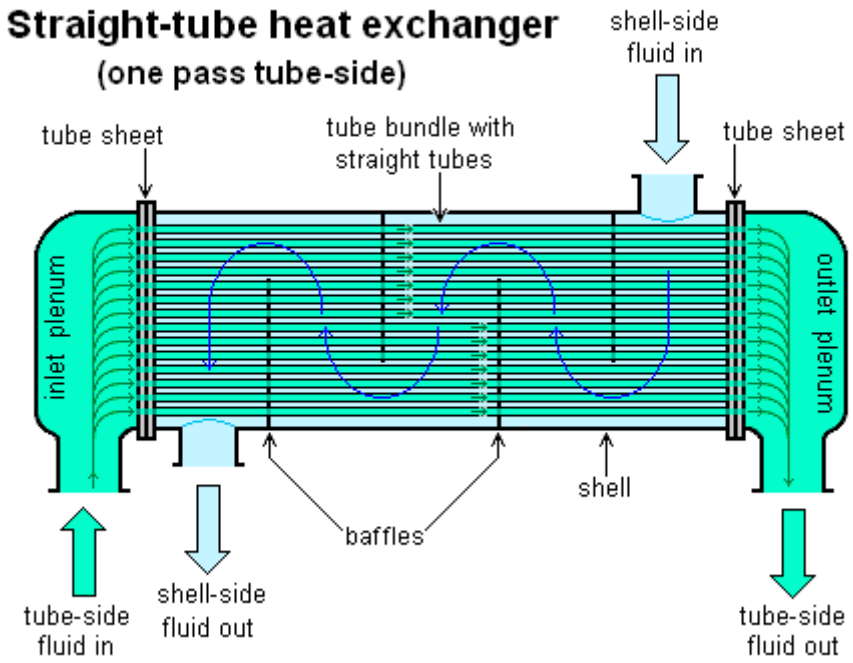


Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

2.6. Heat Exchangers

A heat exchanger is a device that allows heat from a fluid (a liquid or a gas) to pass to a second fluid (another liquid or gas) without the two fluids having to mix together or come into direct contact. If that's not completely clear, consider this. In theory, we could get the heat from the gas jets just by throwing cold water onto them, but then the flames would go out! The essential principle of a heat exchanger is that it transfers the heat without transferring the fluid that carries the heat.

Shell and Tube Heat Exchanger



Shell and tube heat exchangers consist of series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required. A set of tubes is called the tube bundle and can be made up of several types of tubes: plain, longitudinally finned, etc. Shell and tube heat exchangers are typically used for high-pressure applications (with pressures greater than 30 bar and temperatures greater than 260 °C). This is because the shell and tube heat exchangers are robust due to their shape

Plate heat exchangers

Another type of heat exchanger is the plate heat exchanger. These exchangers are composed of many thin, slightly separated plates that have very large surface areas and small fluid flow passages

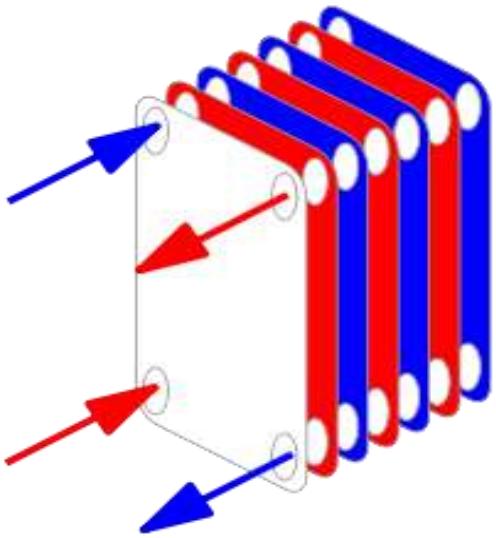
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

for heat transfer. Advances in gasket and brazing technology have made the plate-type heat exchanger increasingly practical.

When used in open loops, these heat exchangers are normally of the gasket type to allow periodic disassembly, cleaning, and inspection. There are many types of permanently bonded plate heat exchangers, such as dip-brazed, vacuum-brazed, and welded plate varieties, and they are often specified for closed-loop applications such as refrigeration.

Plate heat exchangers also differ in the types of plates that are used, and in the configurations of those plates. Some plates may be stamped with "chevron", dimpled, or other patterns, where others may have machined fins and/or grooves.

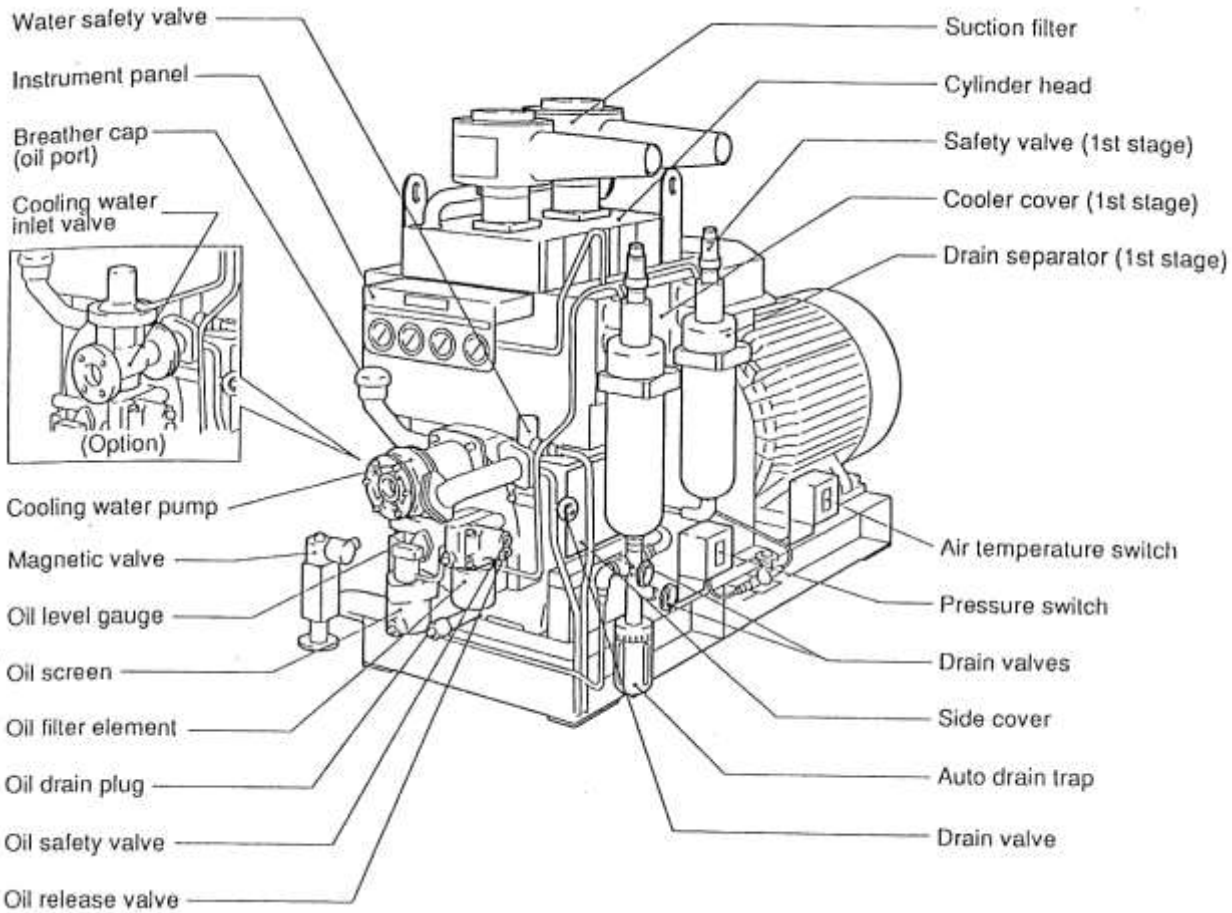
When compared to shell and tube exchangers, the stacked-plate arrangement typically has lower volume and cost. Another difference between the two is that plate exchangers typically serve low to medium pressure fluids, compared to medium and high pressures of shell and tube. A third and important difference is that plate exchangers employ more countercurrent flow rather than cross current flow, which allows lower approach temperature differences, high temperature changes, and increased efficiencies.



2.7. Main Air Compressors

There are a number of variations in the design and construction of air compressors. The construction and principles of operation of some of the most common types of air compressors, used on ships, will be discussed in this chapter.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



Air Compressor produces pressurized air by decreasing the volume of air and in turn increasing its pressure. Different types of air compressors are used according to the usage

Uses of Air Compressor on Ship

On board a ship, compressed air is used for several purposes. On the basis of application, different air compressors are kept for a particular usage. Normally, air compressors on board ships are:

- main air compressor
- topping up compressor
- deck air compressor
- Emergency air compressor

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Common Classification

Air compressors are classified in various ways. A compressor may be single acing or doubt acting, single stage or multistage, and horizontal, angle or vertical. A compressor maybe designed so that only one stage of compression takes place within one compressing element, or so that more than one stage takes place within one compressing element. In general, compressors are classified according to the type of compressing element, the source of driving power, the method by which the driving unit is connected to the compressor, and the pressure developed.

a. Types of compressing element -Air compressor elements may be of the centrifugal, rotary, or reciprocating types. Most of the compressors used have reciprocating elements. In this type of compressor the air is compressed in one more cylinders, very much like the compression, which takes place in an internal combustion engine.

b. Sources of power -Compressors are driven by electric motors, internal combustion engines, steam engines, steam turbines, or reciprocating steam engines. Most of the air compressors in ship service are driven by electric motors

c. Drive connections -The driving unit may be connected to the compressor by one of several methods. When the compressor and the driving unit are mounted on the same shaft, they are close coupled. Close coupling is often used for small capacity compressors that driven by electric motors. Flexible couplings are used to join the driving unit to the compressor where the speed of the compressor and the speed of the driving unit can be the same V -belt drives are commonly used with small, low pressure, motor driven compressors, and with some medium pressure compressors. In a few installations, a rigid coupling is used between the compressor and the motor. In a steam turbine drive, compressors are usually driven through reduction gears.

d. Pressure classification -Compressors are classified as low pressure, medium pressure, or high pressure. Low-pressure compressors are those which have a discharge pressure of 150 psi or less. Medium pressure compressors are those, which have a discharge pressure of 151 psi to 1000 psi. Compressors, which have a discharge pressure above 1000 psi, are classified as high pressure.

Operating Cycle of Reciprocating Air Compressors

Reciprocating air compressors are usually similar in design and operation. The following discussion relates to the operating cycle during one stage 'of compression in a single-stage, single acting compressor.

The cycle of operation or compression cycle within an air compressor cylinder includes two strokes of the piston; a suction stroke and a compression stroke. The suction stroke begins when the piston moves away from the TOP DEAD CENTER (TDC). The air under pressure in the clearance space (above the piston) expands rapidly until the pressure falls below the pressure on the opposite side of

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

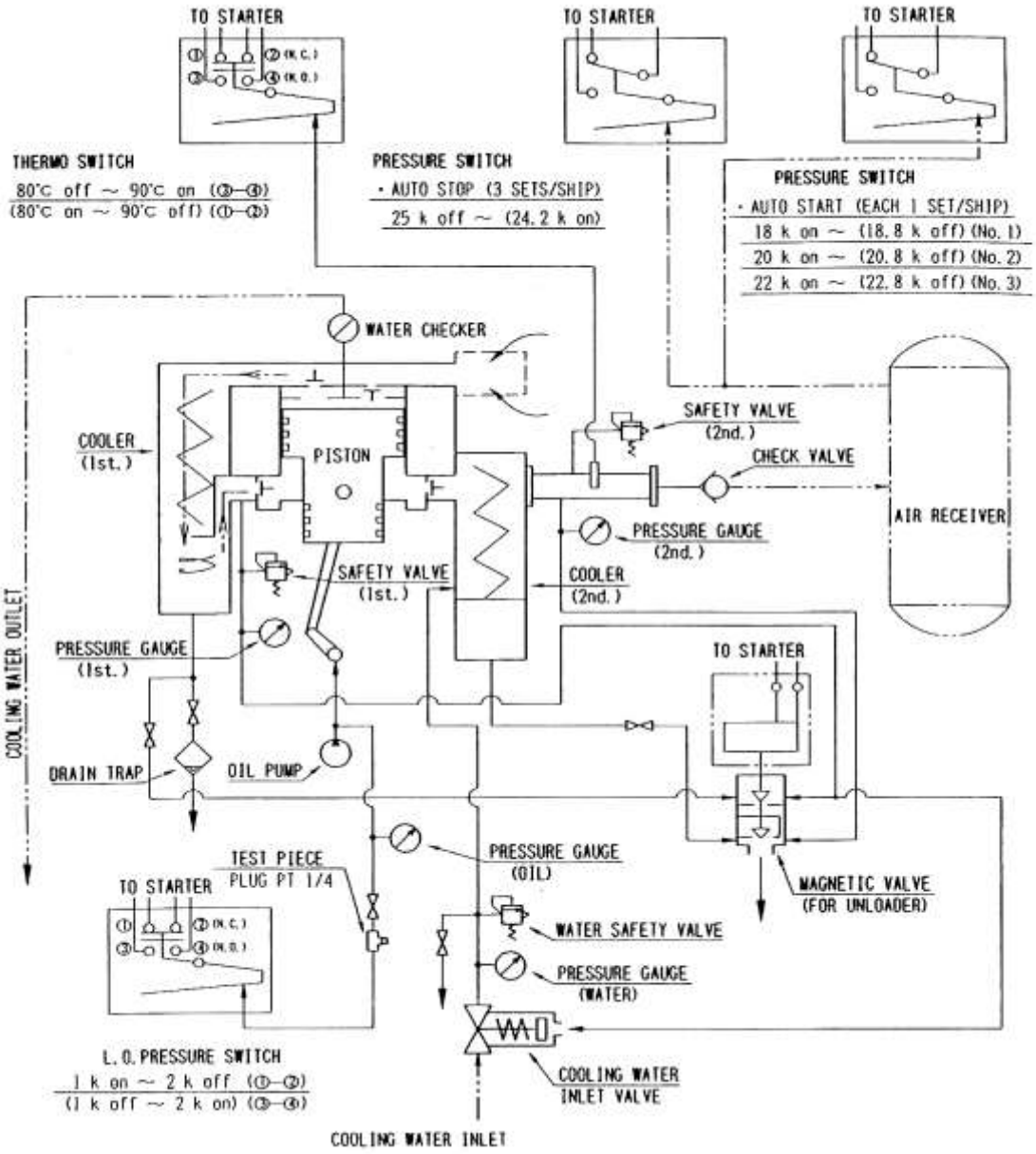
the inlet valve. At this point, the difference in pressure causes the inlet valve to open; and air is admitted to the cylinder until the piston reaches BOTTOM DEAD CENTER (BDC)

The compression stroke starts as the piston moves away from the BDC; compression of the air begins. When the pressure in the cylinder equals the pressure on the opposite side of the air inlet valves, the inlet valve closes. Air is increasingly compress as the piston moves towards TDC, until the pressure in the cylinder becomes great enough to force the discharge valve open against the discharge line pressure and the pressure of the valve springs. (The discharge valve opens a few degrees before the piston reaches the TDC). During the balance of the compression stroke, the air which has been compressed in the cylinder is discharged, at an almost constant pressure, through the open discharge valve.

The basic operating cycle just described is repeated a number of times in double-acting compressors and in other stages of multistage compressors. In a double-acting compressor, each stroke of the piston is a suction stroke in relation to one end of the cylinder, and a compression stroke in relation to the other end of the cylinder. In a double-acting compressor, therefore two basic compression cycles are always in process when the compressor is operating; but each cycle, considered separately, is simply one suction stroke and one compression stroke.

In the multistage compressors, the basic compression cycle must occur at least once for each stage of compression. If the compressor is designed with two compressing elements for the first (low pressure) stage, two compression elements will be in process in the first stage at the same time. If the compressor is designed so the two stages of compression occur at the same time. In each stage, the air is compressed to the designed working pressure to that particular stage and is then discharged to the stage having the next highest working pressure, with the last stage discharging to the receiver.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



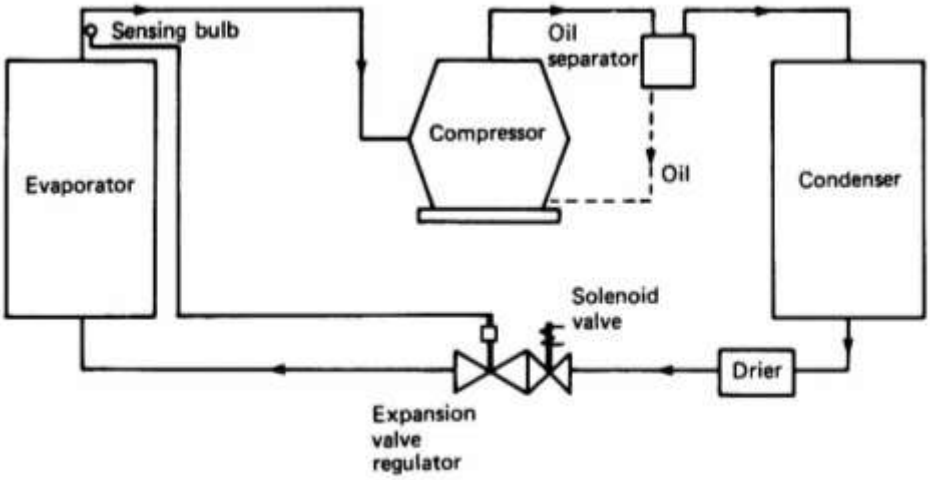
2.8. Refrigeration System

Refrigeration is a process that involves the removal of heat from an area which is desired to be kept cool, and the rejection of that heat to an area whose temperature remains practically constant. In a marine refrigerating plant, the area desired to be kept cool may be the icebox where the ship's provision are stored, or cargo holds in which perishable cargo is transported. The heat that is removed from this space is rejected to the sea.

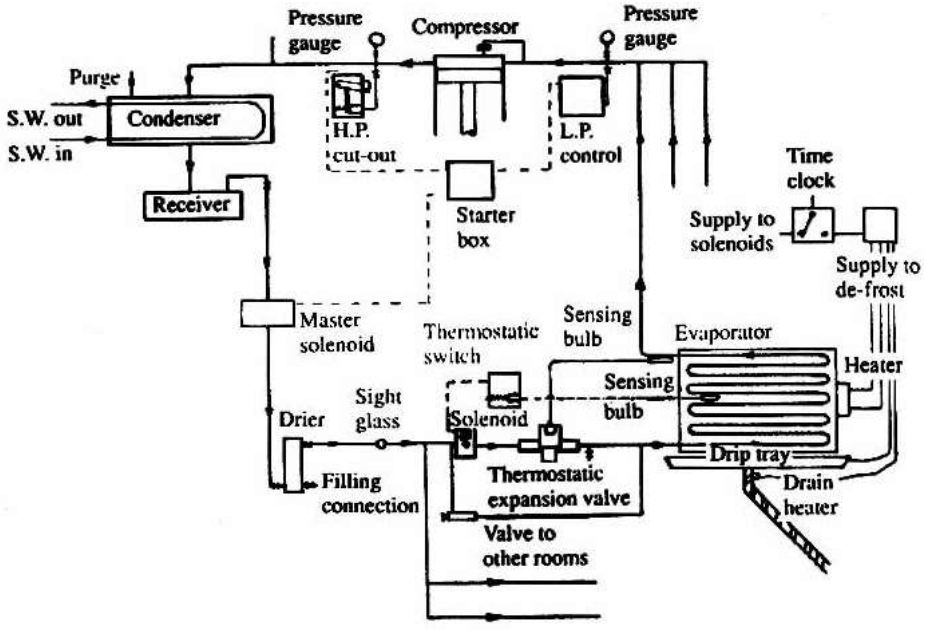
In the past, refrigeration was accomplished by natural methods that is, ice was taken on board ship and the melting of ice removed heat from the food chests in which the ice was stored. Today, however, all modem refrigeration is of the mechanical variety. A mechanical refrigeration system is one in which

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

the transfer of heat is made to take place by mechanically circulating the working fluid (known as a refrigerant) through the system. Mechanical refrigeration is either of the two types -adsorption or compression. The first type is best exemplified by the familiar Electrolux household refrigerator, but this type is seldom used on merchant vessels by far the greatest number of marine refrigeration plants employ the compression system.



Vapour compression cycle



Automatic Freon system

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

2.9. Waste Oil Incinerator

Incinerator is a machinery which burns waste generated on the ship, such as oil from oily water separator, sludge from purifiers, oily rags, and galley waste. Some special design of incinerator are capable of burning plastic.

Maintenance and checks for incinerators:

1. Igniter cleaning
2. Burner inspection and cleaning
3. Furnace cleaning and inspection of refractories
4. Checking and regular maintenance of fans
5. Oil filter cleaning
6. Greasing

Safety devices for Incinerator

- The incinerator should have a flame safeguard control consisting of a flame sensing element and associated equipment for shut-down of the unit in the event of ignition failure and flame failure during the firing cycle.
- A combustion temperature controller, with a sensor placed in the combustion chamber, should be provided that will shut down the burner if the combustion chamber temperature exceeds the maximum temperature.
- A flue gas temperature controller, with a sensor placed in the flue gas duct, should be provided that will shut down the burner if the flue gas temperature exceeds the pre-set temperature.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

3. Basic Lubrication

3.1. Basic Lubrication Principles

In internal combustion engines or any machinery that involves moving parts, it needs lubrication for the basic reason that it will avoid wear and tear in between moving parts. In shipping where the size of the engines is huge, lubrication requirements are specific and much important. On board ship mainly lubrication is needed for main engines in large scale.

One basic function which we all know is that lubricants tend to form a film between the two moving parts and provided a slippery surface on which metal parts can move or revolve smoothly. So, thus we are avoiding the metal to contact and stop wear and tear between parts. The followings are the function of lubricants:

1. First of all it forms a medium between the two surfaces and thus avoids any metal to metal contact. It reduces static and dynamic friction, and reduces the wear and tear between the parts.

2. A lubricant also helps to remove to the heat from the bearing which is developed to the high speed of moving parts. So, we are getting a cooling effect also and that is the reason why lubricants are designed to withstand high temperatures.

3. To protect the metal from getting corroded, lubricants avoid any type of corrosion taking place in the combustion chamber of the engine. Also it protects the engine from cold corrosion. During combustion and engine being in motion, lots of carbon deposits are accumulated at the end of the moving surfaces. Lubricants have detergency quality and they tend to wash away these carbon deposits and thus avoid deposition of carbon particle locally.

   It dampens the load acting on the bearings and also reduced noise that is caused when two surfaces are moving against each other.

4. Another unique function of lubricants is that they act as a sealant and avoid blow by gases being passed from the scavenge space to the crankcase space. They take up the high stresses when the load on the engine increases. So these were some of the functions of lubricants in engine lubrication.

Handling, storing and dispensing marine lubricants

In order to ensure that lubricants and greases can deliver their maximum performance they must be stored and handled correctly, both shore-side and on-board vessels. Poor handling, storing and dispensing methods can cause the products to deteriorate or become contaminated, which can result in machinery damage and potentially avoidable maintenance issues. Problems can arise due to:

- Container damage

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

- Water contamination from rain, seawater or condensation
- Dirty dispensing equipment
- Exposure to dust and dirt
- Mixing different brands or types of lubricant
- Exposure to excessive heat or cold
- Products exceeding their shelf life

Best practice guidelines

Handling Drums and pails should only be moved using the correct lifting equipment to avoid container damage, drops and spills. Containers should only be filled in clean conditions.

Storage Use a cool, dry, indoor storage area for lubricants and greases, avoiding environments that can reach extreme temperatures. The ideal storage range is 5-50o C but users should contact their manufacturers' representatives for specific product recommendations. Drums and pails must be securely tied and properly labelled and checked regularly for any signs of leakage.

Dispensing Use the first-in, first-out storage principle; check container labels to ensure the oldest products get used first. Clean drums and pails before opening and use clean dispensing equipment. Do not mix products and always replace lids and bungs properly after opening.

Nowadays however we have a choice of two main types of lube oil;

Types of Lubrication

Mineral Lubricants - these are obtained from the processing of crude oil.

Synthetic Oils - a relatively new innovation involving the use of polyglycols or esters.

Properties of Lubricating Oils

Viscosity

- It is a measure of internal resistance to flow between liquid layers.
- Viscosity of lube oil reduces when temperature rises and vice versa.

Viscosity index

- It is the rate of change of viscosity of an oil with respect to change in temperature.
- An oil with low viscosity index has greater change of viscosity with change in temperature.
- An oil with high viscosity index has very little change of viscosity with change in temperature, which is a desirable property for lubricating oil.
- Hydraulic oils should have high viscosity index for faster response of the system.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Pour point

- It is the lowest temperature below which an oil will stop flow.
- Pour point indicates that oil is suitable for cold weather or not.

Flash point

- It is the lowest temperature at which the oil will give off a sufficient inflammable vapour to produce a momentary flash when a small flame is brought into the surface of the oil.

Why flash point is important?

- Fuel oil flash point is to be high because if it is low, there would be a possibility of fire in storage.
- Engine crankcase lubricating oil flash point should be as high as possible to prevent crankcase explosion.

Total Acid Number (TAN) and Total Base Number (TBN)

- The ability of an oil to react with a base reagent which indicates the acidity is expressed as TAN.
- The ability of an oil to react with acidic reagent which indicate the alkalinity is expressed as TBN.

What type of engine are using high TBN and why?

- If blow pass occur in a trunk type engine using heavy fuel oil, incomplete combustion products reach directly into the crankcase and may cause the contamination of lube oil with acid. Thus in this type of engine to neutralize the acid contamination must be used high TBN oil.

Detergency and Dispersancy

A chemical additive called detergent which has a property of preventing the deposition of carbon deposits and wash away with the lube oil.

Dispersant additive is added to divide the larger size deposits into tiny particles to be carried in a colloidal suspension evenly throughout the bulk of oil, which can be removed while filtration of the oil.

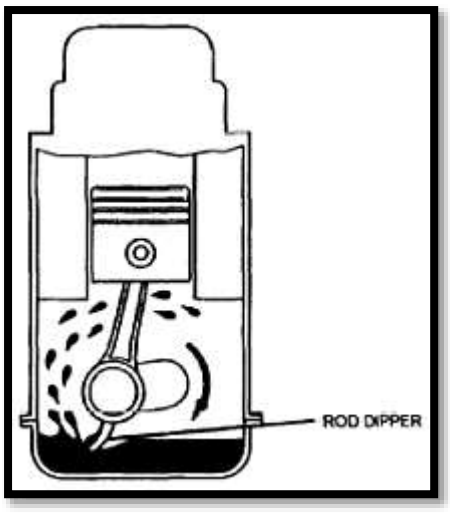
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

3.2 Lubricating Oil Application

Splash Lubrication

In the splash lubricating system, oil is splashed up from the oil pan or oil trays in the lower part of the crankcase. The oil is thrown upward as droplets or fine mist and provides adequate lubrication to valve mechanisms, piston pins, cylinder walls, and piston rings.

In the engine, dippers on the connecting-rod bearing caps enter the oil pan with each crankshaft revolution to produce the oil splash. A passage is drilled in each connecting rod from the dipper to the bearing to ensure lubrication.



Combination Splash and Force Feed

In a combination splash and force feed, oil is delivered to some parts by means of splashing and other parts through oil passages under pressure from the oil pump.

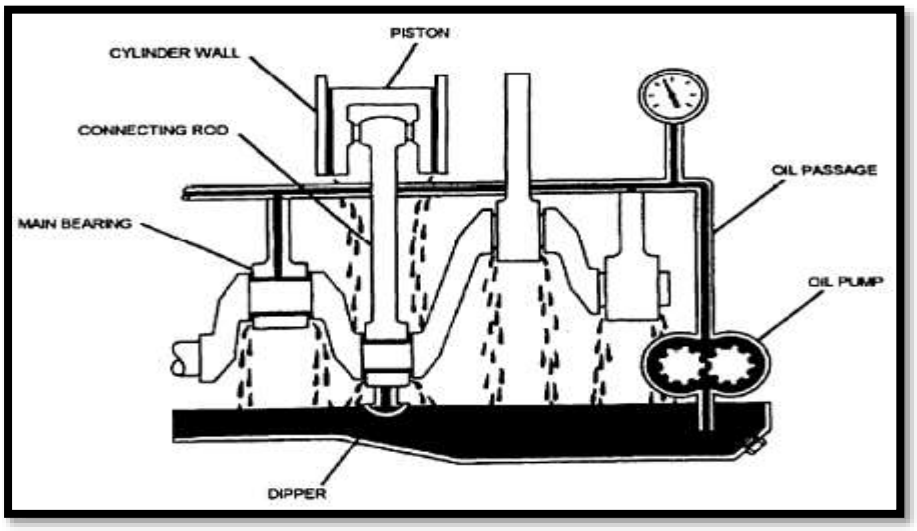
The oil from the pump enters the oil galleries. From the oil galleries, it flows to the main bearings and camshaft bearings. The main bearings have oil-feed holes or grooves that feed oil into drilled passages in the crankshaft. The oil flows through these passages to the connecting rod bearings. From there, on some engines, it flows through holes drilled in the connecting rods to the piston-pin bearings.

Cylinder walls are lubricated by splashing oil thrown off from the connecting-rod bearings. Some engines use small troughs under each connecting rod that are kept full by small nozzles which deliver oil under pressure from the oil pump. These oil nozzles deliver an increasingly heavy stream as speed increases.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

At very high speeds these oil streams are powerful enough to strike the dippers directly. This causes a much heavier splash so that adequate lubrication of the pistons and the connecting-rod bearings is provided at higher speeds.

If a combination system is used on an overhead valve engine, the upper valve train is lubricated by pressure from the pump.



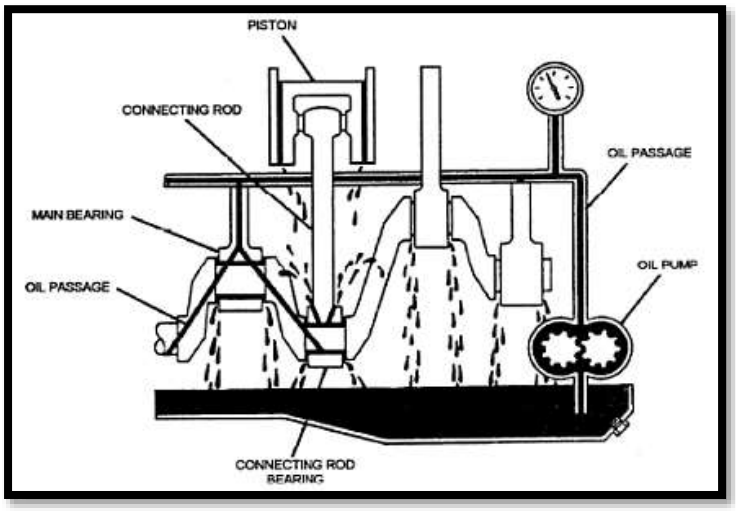
Force Feed

A somewhat more complete pressurization of lubrication is achieved in the force-feed lubrication system. Oil is forced by the oil pump from the crankcase to the main bearings and the camshaft bearings. Unlike the combination system the connecting-rod bearings are also fed oil under pressure from the pump.

Oil passages are drilled in the crankshaft to lead oil to the connecting-rodbearings. The passages deliver oil from the main bearing journals to the rod bearing journals. In some engines, these opening are holes that line up once for every crankshaft revolution. In other engines, there are annular grooves in the main bearings through which oil can feed constantly into the hole in the crankshaft.

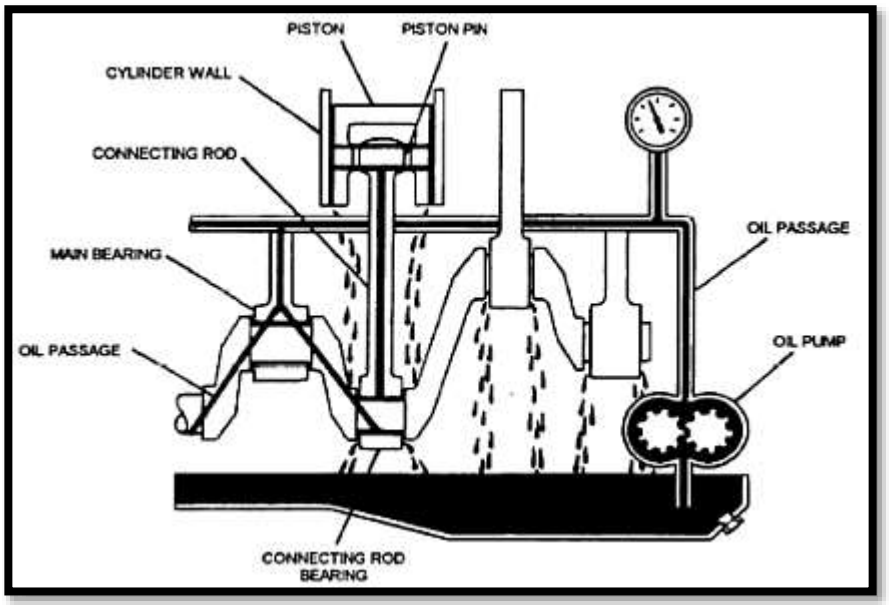
The pressurized oil that lubricates the connecting-rod bearings goes on to lubricate the pistons and walls by squirting out through strategically drilled holes. This lubrication system is used in virtually all engines that are equipped with semifloating piston pins.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



Full Force Feed

In a full force-feed lubrication system, the main bearings, rod bearings, camshaft bearings, and the complete valve mechanism are lubricated by oil under pressure. In addition, the full force-feed lubrication system provides lubrication under pressure to the pistons and the piston pins. This is accomplished by holes drilled the length of the connecting rod, creating an oil passage from the connecting rod bearing to the piston pin bearing. This passage not only feeds the piston pin bearings but also provides lubrication for the pistons and cylinder walls. This system is used in virtually all engines that are equipped with full-floating piston pins.

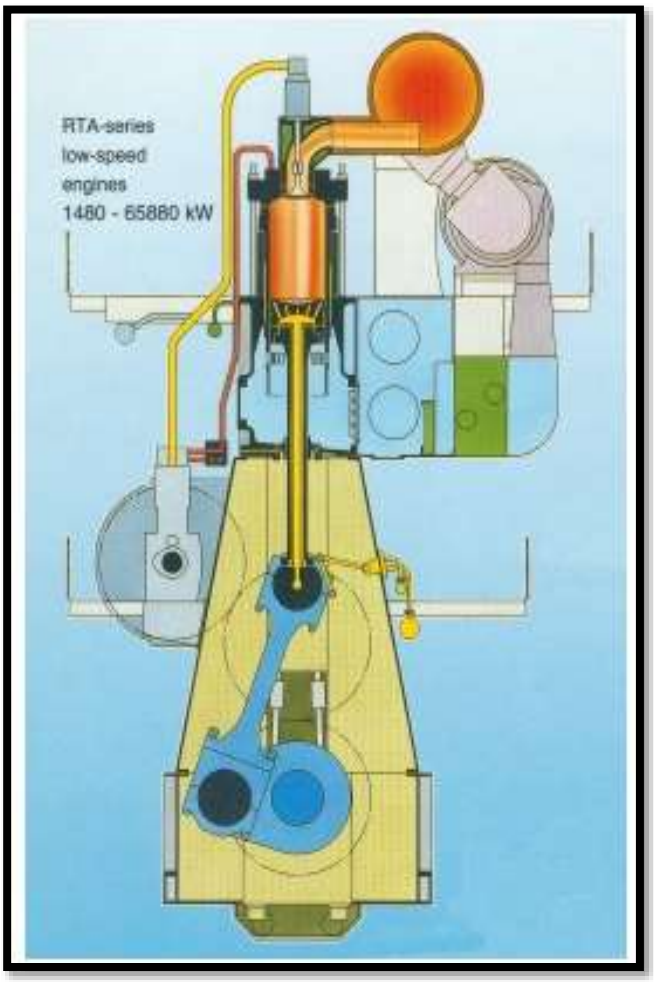


Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

3.3 Machinery Lubrication

3.3.1 Main Engine Lubrication

On a two stroke crosshead engine lubricating oil is supplied to the main bearings and camshaft and camshaft drive. A separate supply is led via a swinging arm or a telescopic pipe to the crosshead where some of it is diverted to cool the piston (travelling up and back through the piston rod), whilst some is used to lubricate the crosshead and guides, and the rest led down a drilling in the connecting rod to the bottom end or crankpin bearing. Oil is also used to operate the hydraulic exhaust valves.



On some engines, the oil supply to the crosshead bearing is boosted in pressure to about 12 bar by a second set of pumps. This oil is also used to operate the hydraulic reversing gear for the engine.

The cylinder liners on a two stroke engine are lubricated using separate injection pumps which use a different specification of oil. The oil which is led to drillings in the liner is able to deal with the acids produced by the burning of high sulphur fuels.

3.3.2 Auxiliary Machinery

On a medium speed 4 stroke engine the oil is supplied to the main bearings through drillings in the engine frame to the crankshaft main bearings. Drillings in the crankshaft then take the oil to the crankpin or bottom end bearings. The oil is then led up the connecting rod to the piston or gudgeon pin and from there to the piston cooling before returning to the crankcase.
Oil is also supplied to lubricate the rocker gear operating the inlet and exhaust valves, and to the camshaft and camshaft drive.

The oil then drains from the crankcase into the drain tank or sump.

The oil in the drain tank is being constantly circulated through a centrifugal purifier. This is to remove any water and products of combustion plus any foreign particles which may be in the oil.

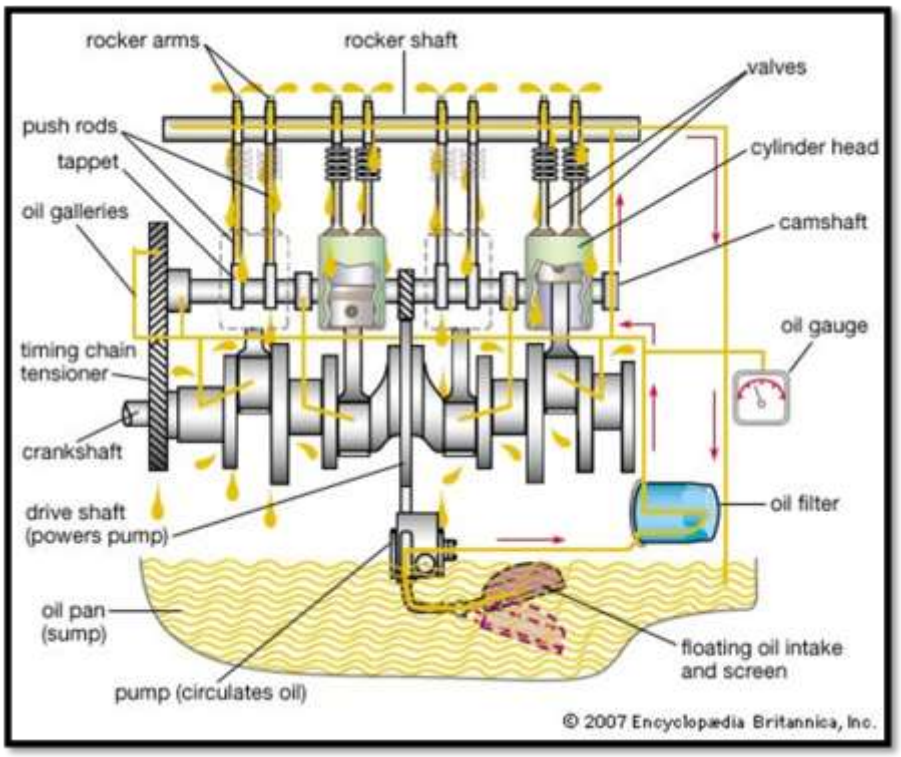
The cylinder liner must be lubricated as well. This is so there will be a film of oil between the piston rings and the liner and also so that any acid produced by combustion of the fuel is neutralized

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

by the oil and does not cause corrosion. Some of this lubrication will be supplied by so called "splash lubrication" which is the oil splashed up into the liner by the rotating crankshaft. However larger medium speed marine diesel engines also use separate pumps to supply oil under pressure to the cylinder liner.

The oil is led through drillings onto the liner surface where grooves distribute it circumferentially around the liner, and the piston rings spread it up and down the surface of the liner.

A pre lub pump is sometimes fitted especially to engines where the main pump is engine driven. This pump is electrically driven and circulates oil around the engine prior to starting.



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

4 Chemical Safe Handling

4.1 Safe Handling of Chemicals

Safety precautions when for handling chemicals onboard

- All chemical products must be stored and labelled in accordance with the instructions on the material safety data sheet (MSDS)
- Ensure MSDS is available in chemical storage room.
- Chemicals must not be stored together with inflammable material and gas cylinders.
- In transport and transfer of chemicals, proper handling precautions provided by manufacturer must be observed. All containers for storage should be chemical resistant, leak free, and with good caps of stoppers.
- Chemical containers must be stored with closed lids when they are not being used.
- Chemicals must be stored in their original packaging.
- Always read the material safety data sheet and the text on the packaging carefully when you are about to use a product with which you are not completely familiar with the risks.
- Use proper personal protection equipment (e.g. rubber gloves, face mask) where necessary.
- Surplus chemicals and hazardous waste must be dealt with in accordance with the information in the safety data sheet.
- First Aid equipment must be available in the chemical storage room.
- Workplaces must be cleaned regularly. There must not be chemical spills on the floor.

Material Safety Data Sheet (MSDS)

A material safety data sheet is a technical document which provides detailed and comprehensive information on a controlled product related to:

- health effects of exposure to the product
- hazard evaluation related to the product's handling, storage or use
- measure to protect workers at risk of exposure
- emergency procedures

A Material Safety Data Sheet (MSDS) is an essential starting point for the development of a complete health and safety program. It also contains information on the use, storage, handling and emergency procedures all related to the hazards of the material. The MSDS contains much more information about the material than the label. MSDSs are prepared by the supplier or manufacturer of the material. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure, and what to do if such incidents occur.

A supplier material safety data sheet must provide at least nine categories or sections of content and approximately sixty items of information distributed among those categories. The categories must have the following similar headings:

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

1. *Hazardous Ingredients*
   This section will include:
   - The chemical names and concentrations concerning the hazardous ingredients
   - The LD 50 and LC50 indicate the short term toxic potential
   - CAS number which is useful in locating more information especially if the product is known by numerous names

2. *Preparation Information*
   This section includes:
   - The name address and telephone number of who prepared the MSDS
   - The date the MSDS was prepared. If more than three years old, it must be updated

3. *Product Information*
   This section:
   - Identifies the product by the name on the supplier label
   - Provides the chemical name, family and formula (including molecular weight)
   - Lists the product identifiers, manufacturer and supplier names, addresses and emergency telephone numbers

4. *Physical Data*
   This section includes information indicating how it looks and how it will behave when it is used, stored, spilled and how it will react with other products indicated through:
   - The state it is in e.g. liquid
   - The odour and appearance of the product
   - The specific gravity, vapour density, evaporation rate, boiling point and the freezing point
   - The vapour pressure, the higher the concentration the higher the possible air concentration
   - The odour threshold, which is the lowest airborne concentration of a chemical that can be perceived by smell
   - The pH reflecting the corrosive or irritant nature of the product

5. *Fire and Explosion Hazard*
   This section describes:
   - The temperature and conditions that can cause the chemical to catch fire or explode o UEL (upper explosion limit) or UFL (upper flammable limit) will indicate the highest concentration of a substance in the air that will produce a fire or explosion when a source of ignition (heat, spark or flame) is present:
     - LEL (lower explosion limit) or LFL (lower flammable limit) will indicate the lowest concentration of a substance in the air that will produce a fire or explosion when a source or ignition is present o From the LEL to the UEL, the mixture is explosive. Below the UEL the mixture is too lean to burn; above the LEL the mixture is too rich to burn. However, concentrations

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

above the UEL are still very dangerous because if the concentration is lowered (by introducing fresh air), it will enter the explosive range
- Means of extinction including the type of fire extinguisher required
- Personal Protective Equipment required for fire-fighting
- Some of the storage requirements however more of this information is found in the reactivity data section

6. *Reactivity Data*
This section describes:
   - The chemical stability of the product and its reactions to light, heat, moisture, shock and incompatible materials
   - Storage requirements based on the reactivity or instability of the product
   - Incompatible products that must not be mixed or stored near each other
   - The need for disposal before they become extremely reactive

7. *Toxicology Properties*
This section describes:
   - The harmful effects of exposure
   - How the product is likely to enter the body and what effects it has on the organs in the body
   - The short-term (acute) and long-term (chronic) health effects from exposure to the product
   - The exposure limits, which indicates the maximum concentration in air of a hazardous substance (gas, vapour, dust, mist, fume) to which nearly all workers (without personal protective equipment) can be repeatedly exposed without adverse health effects. Exposure limits are expressed in three ways:
     - TWA (time weighted average) indicating the maximum average concentration to which workers can safety be exposed for a normal 8-hour workday or 48-hour workweek
     - STEL (short-term exposure limit) indicating the maximum concentration to which workers can safely be exposed for a period of up to 15 minutes. The STEL is higher than the TWA. It may not be sustained more than four times a day
     - C (ceiling) describes the concentration that may not be safely exceeded at any time, even for an instant. The C is higher that the STEL
   - If these limits are to be exceeded, the worker must use recommended personal protective equipment. Exposure limits are expressed as ppm for gases and vapours and as mg/m3 for dusts, fumes and mists
   - Note these limits may be expressed as OEL, PEL and TLV
   - Information used to assess the health problems of any employee who uses the chemical and determine if that worker's problems are related to the chemical

8. *Preventative Measures:*
This section provides:
   - Instruction for the safe use, handling and storage of the product

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

- The personal protective equipment or safety devices required
- The steps for cleaning up spills
- Information on the waste disposal requirements

9. *First Aid Measures:*
   This section describes:
   - Specific first aid measures related to acute effects of exposure to the product
   - First aid steps in the correct sequence
   - Information to assist in planning for emergencies The MSDS may contain additional sections providing further information related to the specific product.

4.2 Chemicals used for cooling fresh water treatment

Treatment of Cooling Water

Cooling water should be treated properly and corrosion inhibitor should be added. The analysis and treatment of cooling water are recommended to be carried out by a famous and familiar specialist. Otherwise, keep the treatment procedures strictly according to the instructions from the supplier.

Some recommended products are listed as follows:

Manufacturer	Brand Name	Constituent	Delivery Form	Min. Dosage
Chevron (FAMM)	Havoline XLi	Carboxylates	Liquid	50 liter / 1,000 liter
Drew Ameriod Marine Boonton	DEWT-NC	Nitrite	Powder	3.2 kg / 1,000 liter
	LIQUIDEWT		Liquid	8 liter / 1,000 liter
	MAXIGARD		Liquid	16 liter / 1,000 liter
VECOM	CWT DIESEL QC2	Nitrite	Liquid	12 liter / 1,000 liter
UNITOR CHEMICALS	DISELGUARD NB	Nitrite	Powder	3 kg / 1,000 liter
Nalfleet Marine Chemical	9-108	Nitrite, Borate	Liquid	2.25 liter / 1,000 liter
	9-131C	Nitrite, Polymer	Liquid	8 liter / 1,000 liter

Note:

- *Oily inhibitors adhere to cooling surface and influence cooling efficiency, which are not recommended for cooling water. Only nitriteborate based inhibitors are recommended.*
- *Do not mix the inhibitors of different types or properties.*
- *Some inhibitors may be toxic and hazardous. Strict control is required when handling inhibitors.*

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

4.3 Chemicals used for Boilers

Oxygen Scavengers

- Continuously injected to maintain a reserve within the boiler of 0.02 to 0.1 ppm and a feed water O_2 content of less than 10 ppb

Carbohydrazide – is a combined form of Hydrazine

- It is superior to hydrazine in performance and is designed to minimize the vapours during handling
- Carbohydrazide and its reaction products create no dissolved solids

Diethylhydroxylamine DEHA

- Like hydrazine, provides a passive oxide film (magnetite) on metal surfaces to minimize corrosion
- Contributes to pH neutralization to an extent that separate condensate control may not be necessary
- Protects entire system – feedwater, boiler and condensate

Sodium sulphite Na_2SO_3

- Takes the form of a soft white powder
- Slightly alkaline
- Will react with oxygen to form Sodium Sulphate at about 8ppm Sodium Sulphite to 1ppm Oxygen
- Use limited to low pressure boilers due to reducing alkalinity by its action

Alkaline

- Provides the basic alkalinity for optimum corrosion and scale control
- Assists in precipitation and blowdown of magnesium and calcium salts
- Can be used as a neutraliser after acid cleaning operations in different system

Sludge conditioning agents

- Coagulants
- Mainly polyelectrolytes
- Prevents the precipitated sodium based particles forming soft scales
- Will keep oil in an emulsion
- the water must be kept alkaline

Antifoams

- Reduce the stability of water film around steam bubble and cause it to collapse.

Dispersing agents

- Sludge conditioners such as starch or tannin.
- Prevent solid precipitates uniting to form sizeable crystals e.g. MgSO4

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

5. Marine Pollution Prevention

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes.

The MARPOL Convention was adopted on 2 November 1973 at IMO. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention and a new Annex VI was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years.

The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes.

5.1 Annex I – Regulations for the Prevention of Pollution by Oil (entered into force 2 October 1983)

Covers prevention of pollution by oil from operational measures as well as from accidental discharges; the 1992 amendments to Annex I made it mandatory for new oil tankers to have double hulls and brought in a phase-in schedule for existing tankers to fit double hulls, which was subsequently revised in 2001 and 2003.

5.2 Annex II – Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983)

Details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk; some 250 substances were evaluated and included in the list appended to the Convention; the discharge of their residues is allowed only to reception facilities until certain concentrations and conditions (which vary with the category of substances) are complied with.
In any case, no discharge of residues containing noxious substances is permitted within 12 miles of the nearest land.

5.3 Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992)

Contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications.

For the purpose of this Annex, “harmful substances” are those substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code) or which meet the criteria in the Appendix of Annex III.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

5.4 Annex IV – Prevention of Pollution by Sewage from Ships (entered into force 27 September 2003)

Contains requirements to control pollution of the sea by sewage; the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; sewage which is not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land.

5.5 Annex V – Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988)

Deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastics.

5.6 Annex VI – Prevention of Air Pollution from Ships (entered into force 19 May 2005)

Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances; designated emission control areas set more stringent standards for SOx, NOx and particulate matter. A chapter adopted in 2011 covers mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships.

6.Gauges and Measuring Instruments

6.1 Flow meters

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

A flow meter is a device used to measure the flow rate or quantity of a gas or liquid moving through a pipe. Flow measurement applications are very diverse and each situation has its own constraints and engineering requirements. Flow meters are referred to by many names, such as flow gauge, flow indicator, liquid meter, etc. depending on the particular industry; however the function, to measure flow, remains the same.

Types of Flowmeters

Precision flow meters are used to provide accurate monitoring and/or flow control. Some industrial applications require precise calculation of quantity to measure the flow to a required measurement accuracy of ± 0.5%.

What are the various types of flow meters onboard?

Positive Displacement Flow Meters

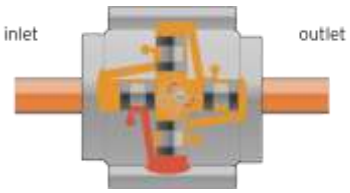
Positive Displacement (PD) Flow meters are volumetric flow measurement instruments that measure flow by passing a precise volume of fluid with each revolution. PD flow meters are precision instruments whose internal moving components are hydraulically locked in tandem with the volume of fluid moving through the flow meter. The result is that the meter can measure intermittent flows, very low flow rates, and liquids of almost any viscosity. The PD meter instantly moves when there is fluid motion, and instantly stops when the fluid motion stops.

This type of measurement is not affected by the liquid's viscosity, density or the turbulence in the pipe. All incompressible fluids will occupy the same volume and there is no need to correct the meter's output to compensate for these factors.

There are many types of positive displacement flow meters, including; reciprocating piston, oscillating or rotary piston, bi-rotor types (spur gear, oval gear, helical gear, rotary vane), and nutating disc (wobble plate).

1. Piston flow meters

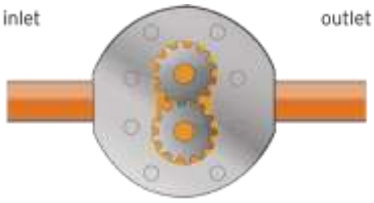
Piston flow meters are of single and multiple-piston types. The pistons displace fluid in the same way that a syringe operates. Each piston displacement captures the same amount of fluid.



2. Gear flow meters

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Gear flow meters use two round gears that are mounted in overlapping compartments. The measured fluid is trapped in the voids of the gear teeth and transported from the inlet port to the outlet port as the fluid flow causes the gears to rotate.



3. Helical flow meters

Helical [Gear] Flow Meters use two screw-shaped rotors to chop the fluid stream into fixed displacement volumes. The rotors' orientation is in-line with the fluid flow path. These meters rotate with a very low pressure drop, and can turn at high rpm's making them accurate over wide flow ranges and compatible with very high viscosity fluid applications.

4. Other PD Flow Meters

Oval-gear meters have two rotating, oval-shaped gears with synchronized, close fitting teeth. A fixed quantity of liquid passes through the meter for each revolution.

Rotary vane meters consist of equally divided, rotating impellers, in two or more compartments, inside the meter's housings. The impellers are in continuous contact with the casing. A fixed volume of liquid is swept to the meter's outlet from each compartment as the impeller rotates.

Nutating disk meters have a moveable disk mounted on a concentric sphere located in spherical side-walled chambers. The pressure of the liquid passing through the measuring chamber causes the disk to rock (wobble) in a circulating path without rotating on its axis. The disk/sphere is the only moving part in the measuring chamber.

Mass

The output signal is directly related to the mass passing through the meter.
Thermal and Coriolis flow meters fall into this category.

Velocity

The output signal is directly related to the velocity passing through the meter.

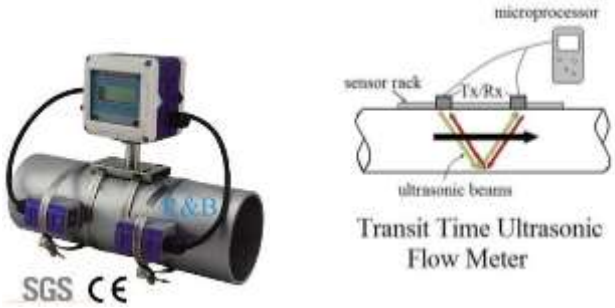
1. **Electromagnetic flowmeter**

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Magnetic flowmeters use Faraday's Law of Electromagnetic Induction to determine the flow of liquid in a pipe. In a magnetic flowmeter, a magnetic field is generated and channeled into the liquid flowing through the pipe. Following Faraday's Law, flow of a conductive liquid through the magnetic field will cause a voltage signal to be sensed by electrodes located on the flow tube walls. When the fluid moves faster, more voltage is generated. Faraday's Law states that the voltage generated is proportional to the movement of the flowing liquid. The electronic transmitter processes the voltage signal to determine liquid flow.

2. Ultrasonic Flowmeter

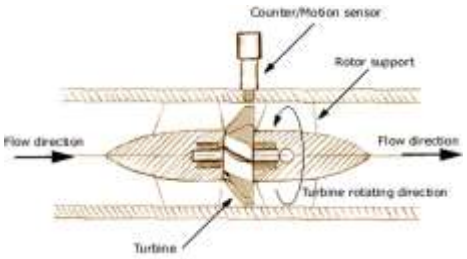
Ultrasonic flow meters use sound waves to determine the velocity of a fluid flowing in a pipe. At no flow conditions, the frequencies of an ultrasonic wave transmitted into a pipe and its reflections from the fluid are the same. Under flowing conditions, the frequency of the reflected wave is different due to the Doppler Effect. When the fluid moves faster, the frequency shift increases linearly. The transmitter processes signals from the transmitted wave and its reflections to determine the flow rate.



3. Turbine Flow Meter

There are many different manufacturing designs of turbine flow meters, but in general they are all based on the same simple principle. Fluid moves through a pipe and acts on vanes, causing a turbine rotor to spin. The rotor spins as the liquid passes through the blades. The turbine blade motion is sensed by a magnetic pick-up and an electrical pulse is generated. The number of electrical pulses counted for a given period of time is directly proportional to flow volume.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

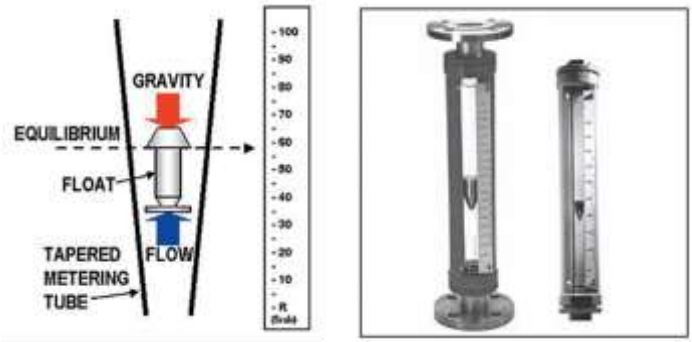


4. Sonar flow meter

Sonar flow processing captures two measurements: 1) volumetric flow rate (phase fraction) monitoring turbulent eddies and 2) compositional (sound speed) detecting the speed at which sound waves propagate through the fluid within the pipe.

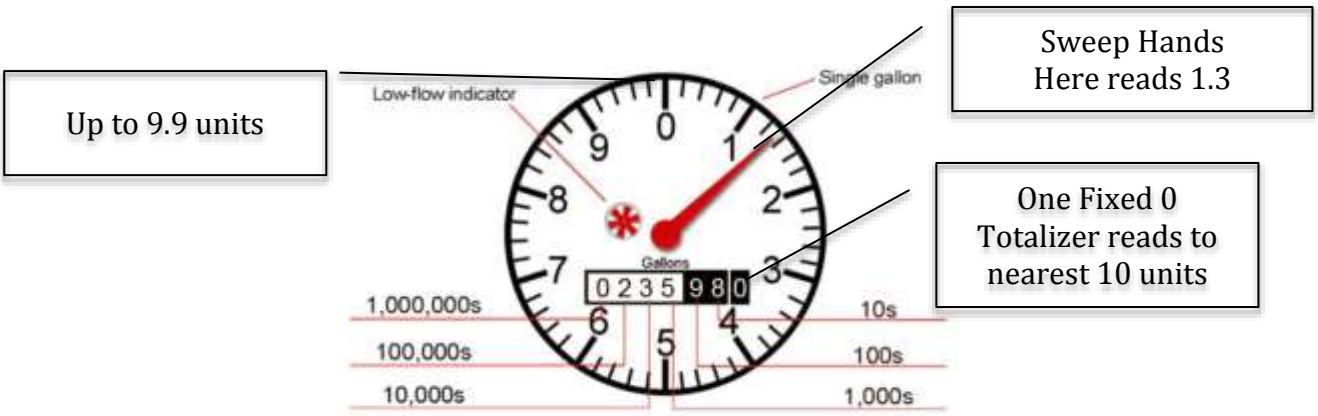
5. Variable Area Flow Meter or Rotameter

The variable area flow meter consists of a vertically oriented glass (or plastic) tapered tube with a larger inside diameter at the top, and a metering float which is free to move within the tube. Fluid flow causes the float to rise in the tube as the upward pressure differential and buoyancy of the fluid overcome the effect of gravity. The float rises to a level where the area between the float and tube reach a state of dynamic equilibrium between the upward differential pressure and buoyancy factors, and downward gravity force. The height of the float is an indication of the flow rate.

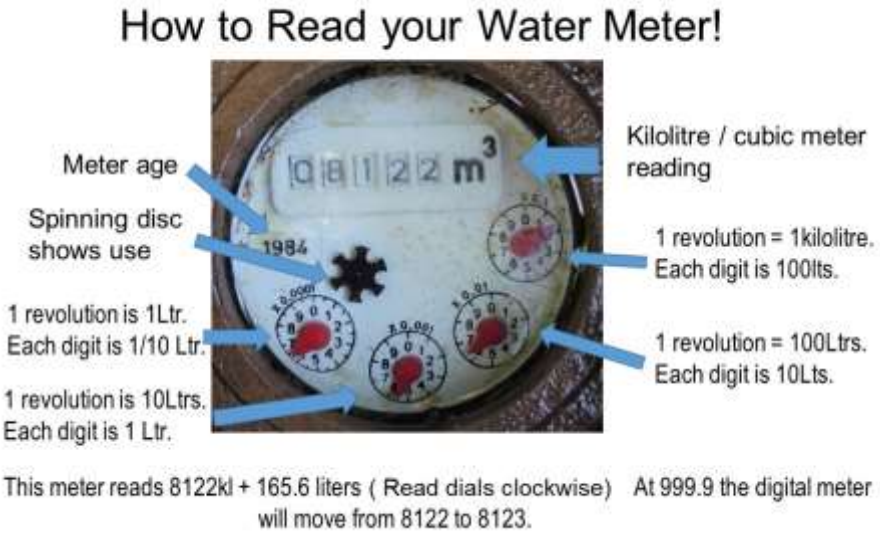


Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

How to read flowmeter



Totalizer reading : 0235980
Sweep hand reading: + 1.3
Amount: 235981.3
Unit: Gallons



Reading : 08122
X 0.1 : + 0.1
X 0.01 : + 0.06
X 0.001 : + 0.005
X 0.0001 : + 0.0006
Amount : 08122.1656 m^3

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

6.2 PRESSURE GAUGES

What is Pressure?

Pressure is the amount of force acting per unit area.
Mathematically: P = F / A

Where:
P is the pressure; F is the force; A is the area of the surface on contact

Unit of Pressure:

SI unit of pressure is the Pascal (Pa), equal to one Newton per square meter (N/m2). Other unit of pressure includes pounds per square inch, bar, gram-force or kilogram-force per square centimeter (gf/cm2, kgf/cm2), etc.

V·T·E	Pascal	Bar	Technical atmosphere	Standard atmosphere	Torr	Pounds per square inch
	(Pa)	(bar)	(at)	(atm)	(Torr)	(lbf/in^2)
1 Pa	≡ 1 N/m^2	10^{-5}	1.0197×10^{-5}	9.8692×10^{-6}	7.5006×10^{-3}	$1.450\,377 \times 10^{-4}$
1 bar	10^5	≡ 100 kPa ≡ 10^6 dyn/cm^2	1.0197	0.986 92	750.06	14.503 77
1 at	$9.806\,65 \times 10^4$	0.980 665	≡ 1 kgf/cm^2	0.967 8411	735.5592	14.223 34
1 atm	$1.013\,25 \times 10^5$	1.013 25	1.0332	1	≡ 760	14.695 95
1 Torr	133.3224	$1.333\,224 \times 10^{-3}$	$1.359\,551 \times 10^{-3}$	≡ 1/760 ≈ $1.315\,789 \times 10^{-3}$	≡ 1 Torr ≈ 1 mmHg	$1.933\,678 \times 10^{-2}$
1 lbf/in^2	6.8948×10^3	6.8948×10^{-2}	$7.030\,69 \times 10^{-2}$	6.8046×10^{-2}	51.714 93	≡ 1 lbf/in^2

Absolute Pressure – is a zero reference against a perfect vacuum, using an absolute scale, so it is equal to gauge pressure plus atmospheric pressure.

Gauge Pressure – is a zero reference against ambient air pressure, so it is equal to absolute pressure minus atmospheric pressure.

Atmospheric Pressure – Sometimes also called barometric pressure, atmospheric pressure is the pressure exerted by the weight of air in the atmosphere of Earth. The atmospheric pressure varies with temperature and altitude above sea level.

Differential Pressure – The difference in pressure between two points.

Pressure Measurement

Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure and display pressure in an integral unit are called **pressure gauges** *or vacuum gauges*. A **manometer** is a good example as it uses a column of liquid to both measure and

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

indicate pressure. Likewise the widely used Bourdon gauge is a mechanical device which both measures and indicates, and is probably the best known type of gauge.

A vacuum gauge is an absolute pressure gauge used to measure the pressures lower than the ambient atmospheric pressure.

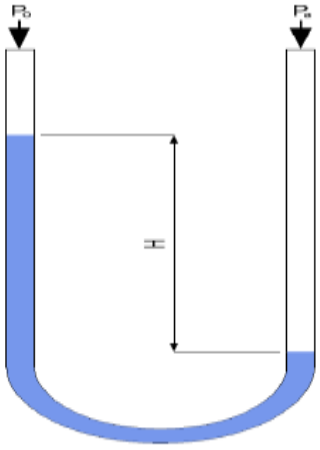
Other methods of pressure measurement involve sensors which can transmit the pressure reading to a remote indicator or control system
(Reference: From Wikipedia, the free encyclopedia)

Type of Pressure Gauge

a. Hydrostatic gauges – (such as the mercury column manometer) compare pressure to the hydrostatic force per unit area at the base of a column of fluid.

b. Piston – Piston type Gauges counterbalance the pressure of fluid with a spring or a solid weight, in which case it is known as a deadweight tester and may be used for calibration of other gauges.

c. Liquid column (Manometer) – By using the pressure head equation, liquids can be used for instrumentation where gravity is present. Liquid column gauges consist of vertical column of liquid in the tube that has ends which are expose to different pressures. The column will rise of fall until its weight (a force applied due to gravity), is in equilibrium with the pressure differential between the two ends of the tube (a force applied due fluid pressure). A very simple version is a U-shaped tube half full of liquid, one side of which is connected to the region of interest while the reference pressure (which might be the atmospheric pressure or a vacuum) is applied to the other. The difference in liquid level represent the applied pressure.



The difference in fluid height in a liquid column manometer is proportional to the pressure difference, H= (Pa - Po)/gp

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

d. McLeod Gauge – A McLeod gauge isolates a sample of gas and compresses it in modified mercury manometer until the pressure is a few millimeters of mercury. Unlike other manometer gauges, McLeod gauge reading is dependent in the composition of the gas.

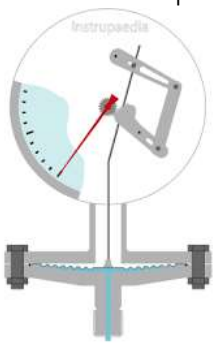
A McLeod gauge, drained of mercury

e. Aneroid Gauge – Based on metallic pressure sensing-element that flexes elastically under the effect of pressure difference across the element. "Aneroid " means "without fluid", and the term originally distinguished these gauges from the hydrostatic gauges. Aneroid gauge are often called mechanical gauge in modern language.

f. Bourdon – The bourdon pressure gauge uses the principle that a flatted tube tends to straighten or regain its circular form in cross section when pressurized.
In practice, a flatted thin-wall, closed end tube is connected to the hollow end of a fixed pipe containing the fluid pressure to be measured. As the pressure increases, the closed end moves in an arc, and this motion is converted into the rotation a (segment of a) gear by a connecting link that is usually adjustable. Bourdon tubes measures gauge pressures, relative to ambient atmospheric pressure, as opposed to absolute pressure, vacuum is sensed as a reversed motion. Bourdon tube is widely adopted because of superior sensitivity, linearity, and accuracy.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

g.) Diaphragm – Type of aneroid gauge that uses deflection of a flexible membrane that separates regions of different pressure. The deformation of a thin diaphragm is dependent in the difference in pressure between its two faces. The reference face can be open to atmosphere to measure gauge pressure, open to second port to measure differential pressure, or can be sealed against a vacuum, or other fixed reference pressure to measure absolute pressure.



h.) Bellows – In gauges intended to sense small pressures, or pressure differences, or required that an absolute pressure be measured, the gear train and needle is driven by an enclosed and sealed bellows chamber.

Reading of pressure gauges

Exercise

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

6.3 LEVEL GAUGES

Level gauges – are meters used to determine the level of a liquid or solid in a fixed storage or process tank.

Level Measuring Instrument

a.) Sight glass – A transparent tube through which the operator of a tank can observe the level of liquid contained within.
Simple sight glasses may just a plastic or glass tube connected to the bottom of the tank at one end and the top of the tank at the other. The level of liquid in the sight glass will be the same as the level of liquid in the tank.

b.) Hydrostatic Pressure – A vertical column of fluid generates a pressure at the bottom of the column owing to the action of gravity in the fluid. The greater the vertical height of the fluid, the greater the pressure. A simple pressure gauge attached to the bottom of the vessel may be calibrated to indicate the level of the liquid.

c.) Float Type – (Magnetic and mechanical float), Float level sensors often involves the opening and closing of a mechanical switch, either through direct contact with the switch, or magnetic operation of a reed. With magnetically actuated float sensors, switching occurs when a permanent magnet sealed inside a float rises and falls to the actuation level. With mechanically actuated float, switching occurs as a result of the movement of a float against a miniature (micro) switch.

d.) Displacement type – These instrument exploits Archimedes Principle. Any object wholly or partially immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the object. The weight of the displaced fluid is directly proportional to the volume of the displaced fluid (if the surrounding fluid is of uniform density).

e.) Echo Type – Time of flight of a travelling wave reflected from the surface of the process liquid is measured indicating the distance travelled and hence, the liquid height inside the vessel.

f.) Capacitive Type – Increase or decrease in the level of process fluids, changes the capacitance between a conductive rod and process vessels walls. Change in the capacitance cause change with liquid level.

g.) Portable level measuring instrument

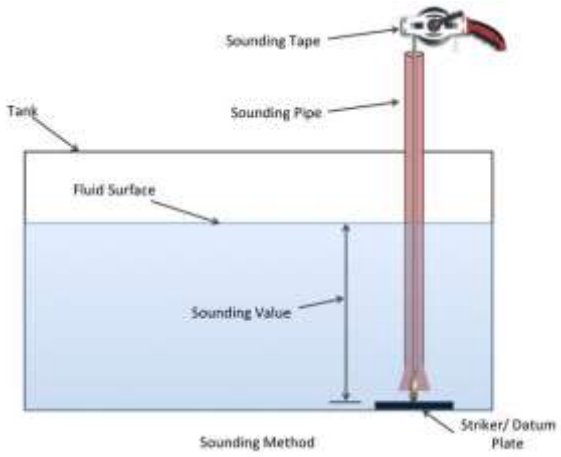
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

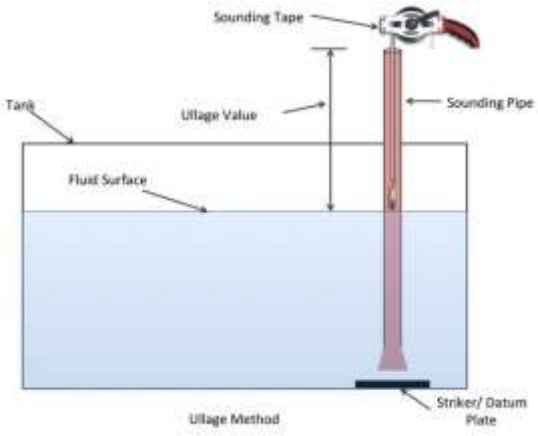
Tank Gauge Measuring Tape

Hermetic Gauging Equipment

Measuring Stick

Tank Sounding





How to use sounding table

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

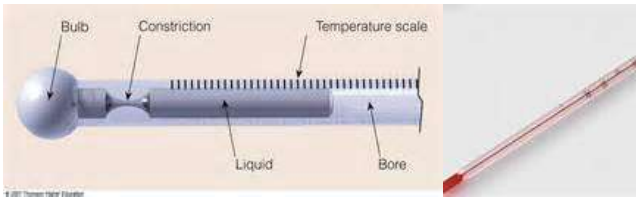
6.4 THERMOMETER

A **thermometer** is a device that measures temperature. A thermometer has two important element, (1) a temperature sensor, (e.g. the bulb of a mercury-in -glass thermometer) in which some physical change occurs with temperature, and (2) some means of converting this physical change into a numerical value. (E.g. the visible scale that is marked on a mercury-in-glass thermometer).

Alcohol Thermometer

An organic liquid is contained in a glass bulb which is connected to a capillary of the same glass and the end is sealed with an expansion bulb. The space above the liquid is a mixture of nitrogen and the vapor of the liquid. For the working temperature range, the meniscus or interface between the liquid is within the capillary. With increasing temperature, the volume of liquid expands and the meniscus moves up the capillary. The position of the meniscus shows the temperature against an inscribed scale.

The liquid used can be pure ethanol, toluene, kerosene or Isoamyl acetate, depending on manufacturer and working temperature range. Since these are transparent, the liquid is made more visible by the addition of a red or blue dye. One half of the glass containing the capillary is usually enameled white or yellow to give a background for reading the scale.



Mercury Thermometer

The **mercury-in-glass** or **mercury thermometer** consists of a bulb containing mercury attached to a glass tube of narrow diameter; the volume of mercury in the tube is much less than the volume of the bulb. The volume of mercury changes slightly with temperature; the small change in volume drives the narrow mercury column a relatively long way up the tube. The space above the mercury may be filled with nitrogen or it may be at less than atmospheric pressure, a partial vacuum.

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Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Hygrometer

A hygrometer – is an instrument used for measuring the moisture content in the atmosphere. Humidity measurement instruments usually rely on measurements of some other quantity such as temperature, pressure, mass or a mechanical or electrical change in a substance as moisture is absorbed. By calibration and calculation, these measured quantities can lead to a measurement of humidity.

Psychrometer - (Wet-and-dry-bulb thermometer)

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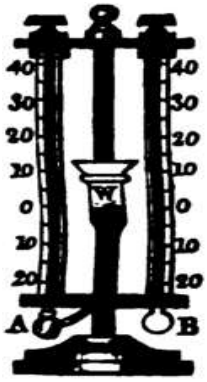
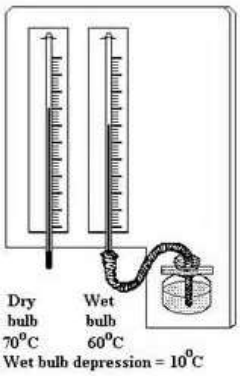
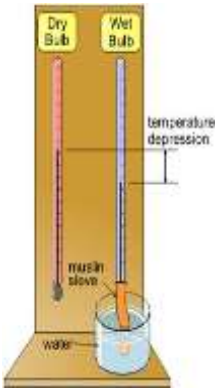
A psychrometer, or wet-and-dry-bulb thermometer, consists of two thermometers, one that is dry and one that is kept moist with distilled water on a sock or wick. At temperatures above the freezing point of water, evaporation of water from the wick lowers the temperature, so that the wet-bulb thermometer usually shows a lower temperature than that of the dry-bulb thermometer. When the air temperature is below freezing, however, the wet-bulb is covered with a thin coating of ice and may be warmer than the dry bulb.

Relative humidity is computed from the ambient temperature as shown by the dry-bulb thermometer and the difference in temperatures as shown by the wet-bulb and dry-bulb thermometers. Relative humidity can also be determined by locating the intersection of the wet and dry-bulb temperatures on a psychrometric chart. The two thermometers coincide when the air is fully saturated, and the greater the difference the drier the air.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



Digital Thermometer – Digital thermometers are temperature sensing instrument that are easily portable, have a permanent probes, and a convenient digital display. The way the digital thermometer works depends upon the type of sensor. Sensor types include resistance temperature detector (RTD), thermocouple, and thermistor.


Pyrometer (Infrared/Contact) Thermometer

Pyrometer – Type of remote sensing thermometer used to measure the temperature of a surface. It is a device, which from a distance, determines the temperature of a surface from the spectrum of the thermal radiation it emits, a process known as pyrometry and sometimes radiometry.

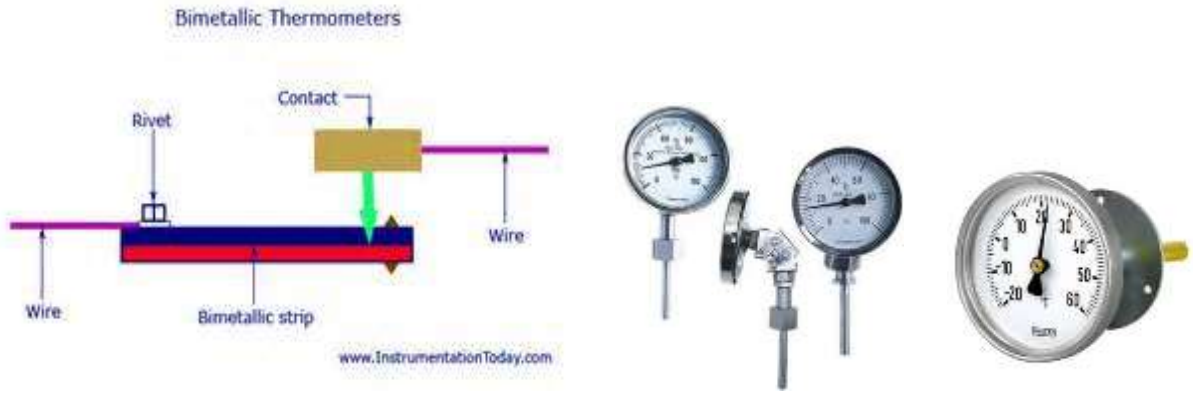



Bimetallic Thermometer

Bimetallic Thermometer – Bimetallic thermometer are made of bimetallic strips formed by joining two different metals having different thermal expansion coefficient. Basically, bimetallic strip is a mechanical element which can sense temperature and transform it into a mechanical displacement.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Bimetallic Strips – Used to convert temperature change into mechanical displacement. The strip consist of two strip of different metals which expands at different rates as they are heated, usually steel and cooper, and in some cases steel and brass. The strips are joined together throughout their length by riveting, brazing or welding. The different expansions force the flat strip to bend one way if heated, and in the opposite direction if cooled below its initial temperature.



THERMISTOR – Thermistors are one of the most commonly used devices for the measurement of temperature. Thermistors are resistors whose resistance changes with the temperature. While for most of the metals, the resistance increases with temperature, the thermistors response negatively to the temperature and their resistance decreases with the increase in temperature. The thermistor are made up of ceramic like semi conducting materials. They are mostly composed of oxides of manganese, nickel and cobalt.

RESISTANCE THERMOMETER – Also called Resistance Temperature Detector (RTD), are sensors used to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core, but other constructions are also used. The RTD wire is a pure material, typically platinum, nickel or copper. The material has an accurate resistance / temperature relationship which is used to provide indication of temperature. Platinum is the best metal for RTDs due to its very linear resistance-temperature relationship, highly repeatable, over a wide temperature range. As RTD element are fragile, they are often house in a protective probes.

PLATINUM THERMAL RESISTANCE BULB

The temperature-resistance characteristics of platinum wire is internationally utilized for measuring temperature in the range of –200°C to 650°C.

Platinum thermal resistance bulbs are known to be most suitable when used temperature sensors which require extreme accuracy and stability.

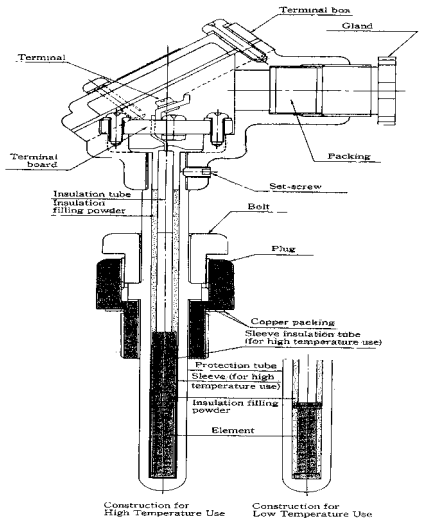
High Temperature Platinum Thermal Resistance Bulb

The platinum resistance bulb is used to measure and monitor for exhaust gas and steam temperature of the main engine of a ship. This resistance elements, provided as a unit by depositing platinum wires and internal conductors are to aluminum oxide bobbin, matches a thermocouple in mechanical strength.

The platinum thermal resistance bulb allows accuracy and stability even under such strict environment as a continuous high working temperature of 700°C.

Low Temperature Platinum Thermal Resistance Bulb

The low temperature thermal resistance bulb is used to measure and monitor the temperature of lubricating oil, cooling water and bearings of various ship-engines as well as the air temperature.



Thermocouple

A thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature. Thermocouples are a widely used type of temperature sensor.

Thermocouple Principles

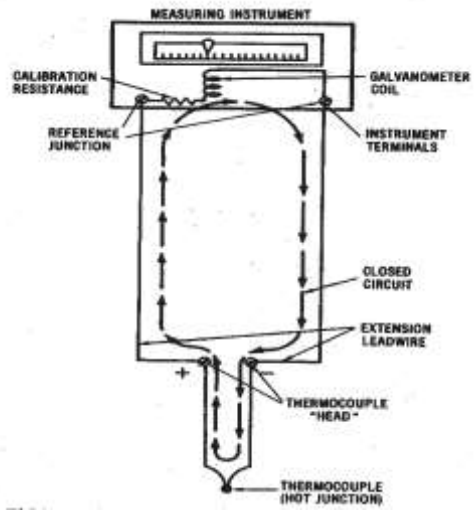
The thermocouple is, perhaps, the only practical industrial method for measuring temperatures between 500 to 1500° Celsius. The filled system is not designed for these high temperature. The resistance thermometer must be specially designed if it is to be used in those range. For temperature less than 500°C, the thermocouple is often used, notwithstanding the fact that certain thermocouple installations cost than a filled system would for the same job.

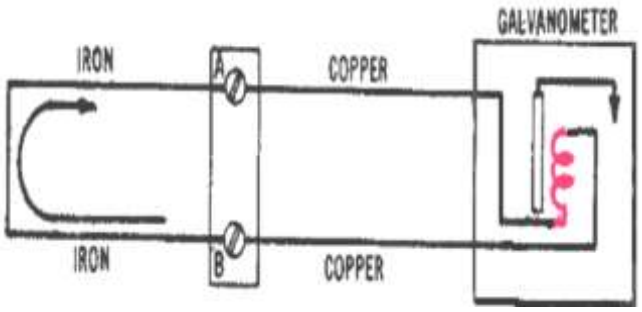
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

One of the distinct advantage of the thermocouple is that it's the voltage output can readily be transmitted over large distance. A second advantage is that a thermocouple can be fabricated in about 10 minutes in almost any instrument shop. The thermocouple itself is relatively inexpensive. The recording or indicating instruments used with a thermocouple may be of the null-balance type or of the deflection type. The use of null-balance instruments usually results in a higher installation cost than that for a filled system.

EMF Property of Metal

One of the natural properties of metals is that if two different metals come in contact with each other, an electromotive force (EMF) is developed. The amount of EMF developed depends on two things: the metals involved and the temperature at the junction. It is possible to take any two metals and join them, and heat the junction through a range of temperatures. A table of equivalent values can be tabulated by noting the temperature and recording the EMF developed. Such data, called conversion tables, have been developed for certain combination of metals. The EMF is expressed in millivolts. .





Calibration

Thermometers can be calibrated either by comparing them with other calibrated thermometers or by checking them against known fixed points on the temperature scale. The best known of these fixed points are the melting and boiling points of pure water. (Note that the boiling point of water varies with pressure, so this must be controlled.)

Nowadays manufacturers will often use a thermostat bath or solid block where the temperature is held constant relative to a calibrated thermometer. Other thermometers to be calibrated are put into the same bath or block and allowed to come to equilibrium, then the scale marked, or any deviation

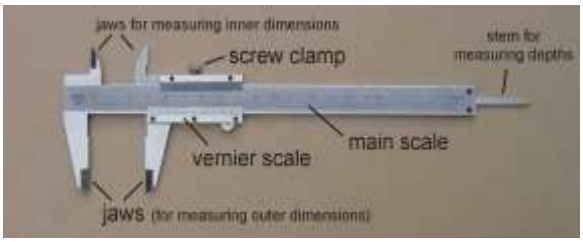
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

from the instrument scale recorded.[36] For many modern devices calibration will be stating some value to be used in processing an electronic signal to convert it to a temperature.

6.5 Vernier Caliper / Micrometer / Dial Gauge

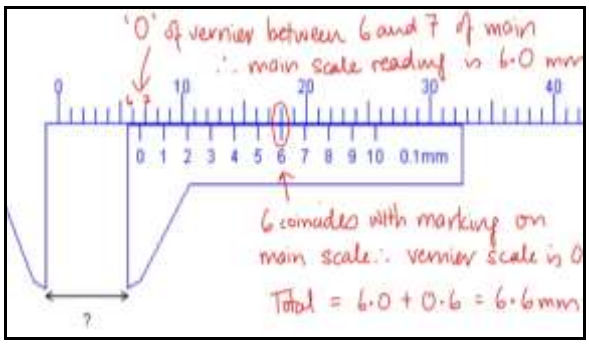
Vernier Caliper - is a precision instrument that can be used to measure internal and external distances extremely accurately.

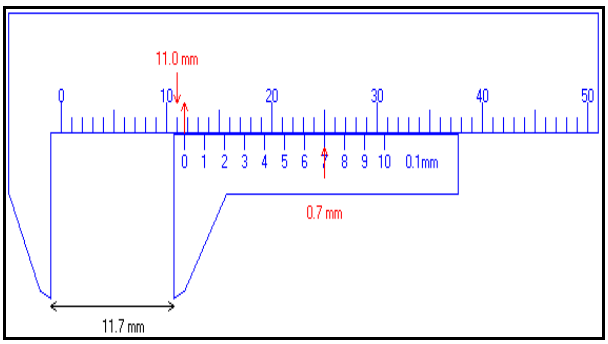
Vernier Caliper



Digital Caliper

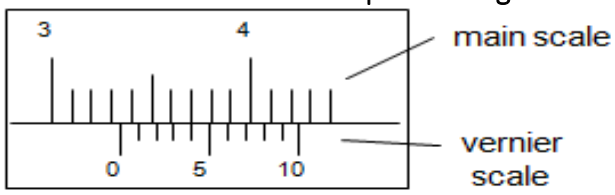
How to read Vernier Caliper

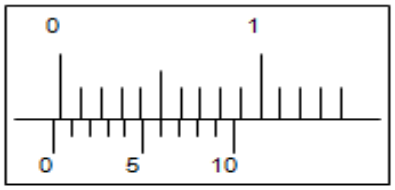




Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

How to calibrate Vernier Caliper reading





Calibrated Reading: 3.4 – (-0.06) = 3.34 cm

Application and Practical Exercise

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

A. Vernier Calipers

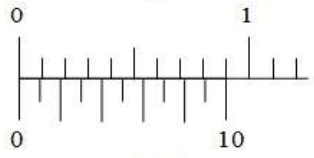
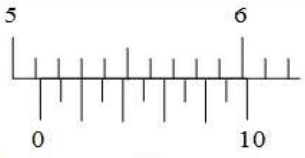
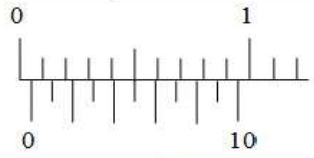
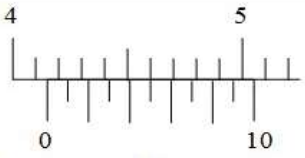
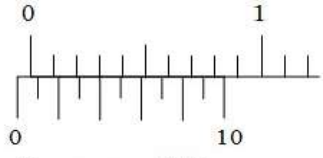
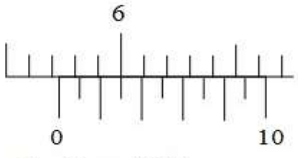
Practical Skill: How to use the vernier calipers for measuring dimensions?

Step 1: Unscrew the screw clamp, close the calipers and record the zero error, if any.

Step 2: For outer dimensions: Open the caliper, put the object in between the outside jaws of the calipers, close the calipers and turn the screw clamp tight
For inner dimensions: Open the caliper, put the inside jaws of the calipers in between the object, close the calipers and turn the screw clamp tight.

Step 3: Read the main scale, followed by the vernier scale.

Step 4: Record the correct reading by subtracting the zero error (if any).

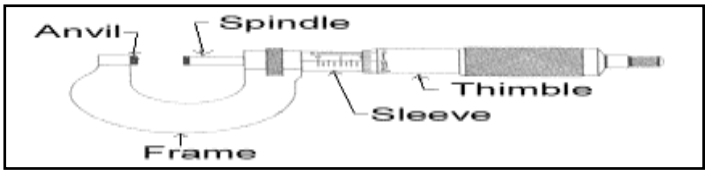
Scenario Types	Step 1	Step 3
NO zero error	 Zero error – 0.00 cm	 Reading – 5.12 cm
	Step 4	Correct reading = 5.12 – 0.00 = 5.12 cm
Positive zero error	 Zero error = + 0.05 cm	 Reading = 4.15 cm
	Step 4	Correct reading = 4.15 – 0.05 = 4.10 cm
Negative zero error	 Zero error = - 0.06 cm	 Reading = 5.73 cm
	Step 4	Correct reading = 5.73 – (- 0.06) = 5.79 cm

Micrometer

A micrometer allows a measurement of the size of a body. It is one of the most accurate mechanical devices in common use.

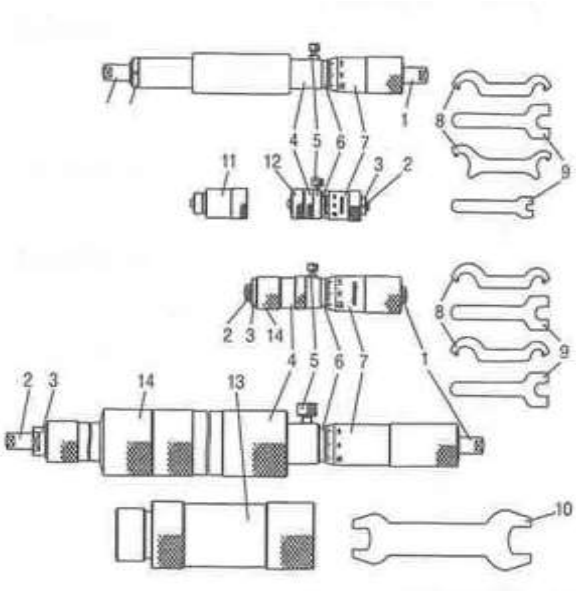
Outside Micrometer

Parts of Outside Micrometer



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

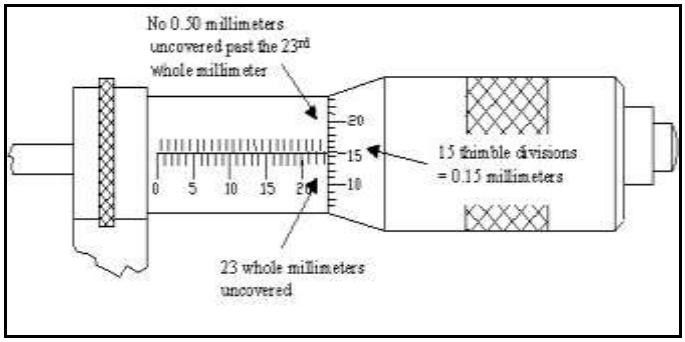
Inside Micrometer

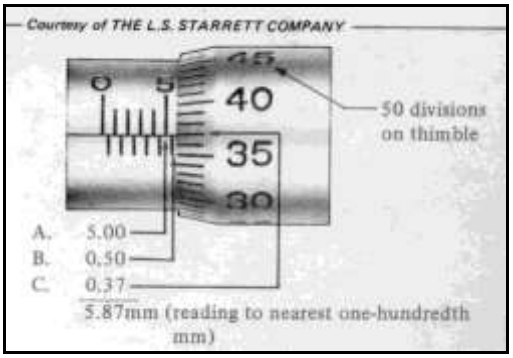


Parts of Inside Micrometer

1. Anvil
2. Adjusting Anvil
3. Adjusting nut
4. Main Body
5. Clamp
6. Sleeve
7. Thimble
8. 8-10 Wrench
9. 11. Extension Rod
10. 12. Cap
11. 13. Extension Pipe
12. 14. Adjusting Rod

How to read Micrometer





How to calibrate Micrometer reading

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

UPGRADING TRAINING FOR OILERS/WIPERS

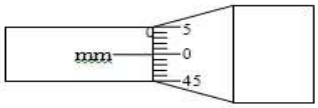
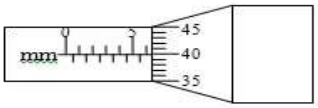
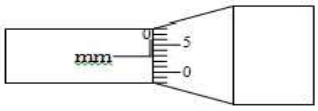
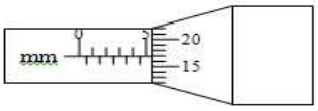
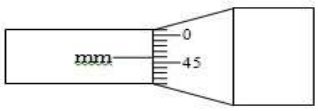
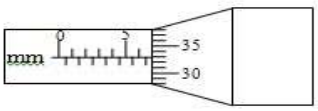
Practical Skill: **How to use the micrometer screw gauge?**

Step 1: Close the screw gauge by turning the thimble, followed by the ratchet until it starts to click, and record the **zero** error.

Step 2: Open the screw gauge, put the object in between the anvil and spindle and gently close the screw gauge by turning the ratchet until it starts to click.

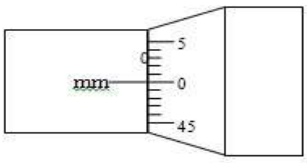
Step 3: Read the **main** scale, followed by the **thimble** scale.

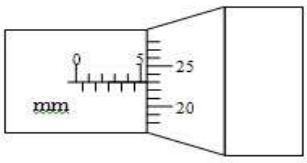
Step 4: Record final reading by **subtracting** the zero error.

Scenario Types	Step 1	Step 3
NO zero error	 Zero error = **0.00** mm	 Reading = **6.40** mm
	Step 4	Correct reading = **6.40** – **0.00** = **6.40 mm**
Positive zero error	 Zero error = **+ 0.03** mm	 Reading = **5.17** mm
	Step 4	Correct reading = **5.17** – **0.03** = **5.14 mm**
Negative zero error	 Zero error = **- 0.04** mm	 Reading = **6.83** mm
	Step 4	Correct reading = **6.83** – **(- 0.04)** = **6.87 cm**

Practical Exercise

1.

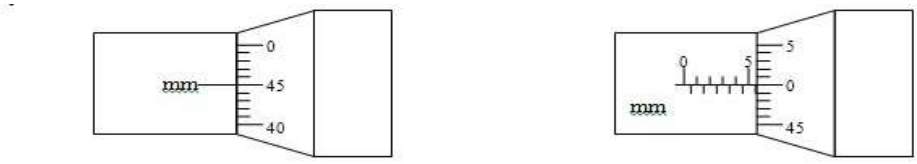




Corrected Reading = **5.23** – **0.00** = **5.23 mm**

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

2.



Corrected Reading = **5.50** – **(- 0.05)** = **5.55 mm**

3.

Corrected Reading = **4.64** – **0.04** = **4.60 mm**

4.

Corrected Reading = **6.33** – **(- 0.03)** = **6.36 mm**

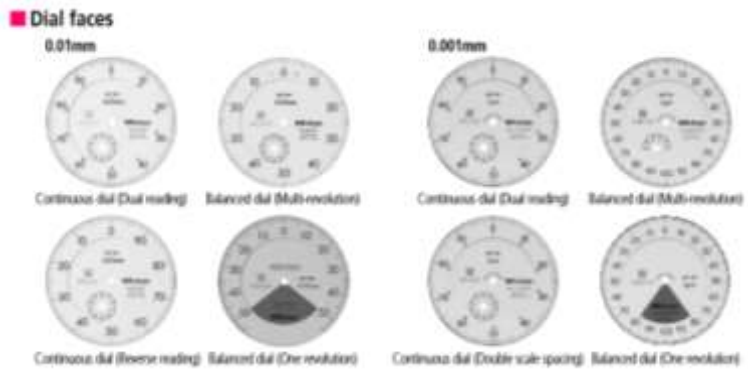
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Dial Gauge

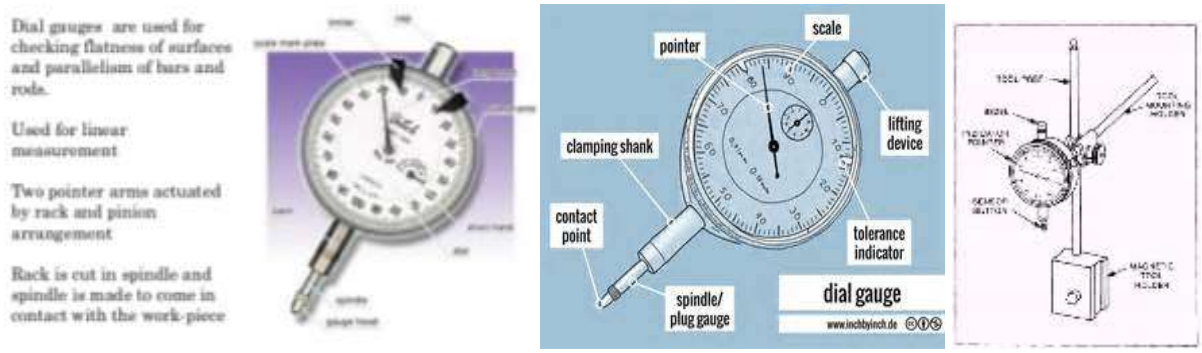
A dial gauge is a precision measurement commonly used to measure machined parts for production tolerances or wear.

The dial gauge has long been a standard use of engineers, artisans, and do-it-yourself enthusiasts for taking very fine measurements on precision parts. High levels of accuracy are possible in extremely small increments with typical measurement ranges running from 0.015 inches to 12 inches (0.25 – 300 mm) in increments as small as 500 thousands of an inch (0.001 mm).

Dial Gauge Parts



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



Dial Gauge Calibration

Dial indicators help users measure the distance between two plates, but the readings given by the tool could be faulty. Any measurement tool can fall prey to a myriad of possible factors that can create false measurements. Slipped teeth or incorrect zero settings result in wildly varying and incorrect readings. Calibrating a dial indicator prior to using it is the only way to be sure that the tool is reading correctly and its measurements are accurate.

Dial Indicator measurement and Calibration Procedure

NOTE: Standards and equipment used must have a valid calibration certificate.

Clean the Dial Indicator's measuring surfaces the stand and the gauge blocks to be used.
Ensure the dial indicator and stand are very securely attached. Zero the Dial Indicator at the start and adjust as required by the manufacturers' specifications. If you cannot zero it then mark it as a fail. When testing the Dial Indicator, one of the points must be near the lower limit that the instrument can measure, another somewhere in the middle, and the third near the upper limit. Use a conversion factor to convert gauge block lengths to Metric

Step 1:

Measure the ambient temperature and record it. Ex: temperature is <18°C or >24°C.

Step 2:

Test Characteristic: Range of motion, Stylus, Dial, and all Screws

Test Method: Visual, Touch

Acceptable Limit: No damage to critical parts, smooth movement, all screws tight

Step 3:

Test Characteristic: Dial Repeatability then set the dial to zero.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

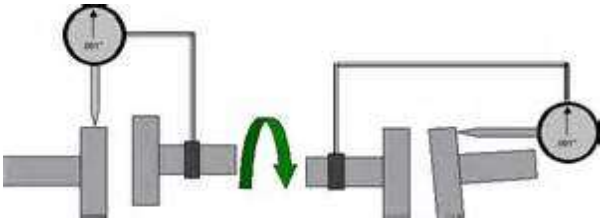
Test Method: Position the instrument using the stand so that it rests just above the surface and is perpendicular to it. Make sure the stand is very secure. Push the Contact spindle repeatedly then set the dial to zero. For dial correction; example 0.500 mm = 0 mm measured value, see the below graph.

Acceptable Limit: +/- 0.001" or 0.025 mm

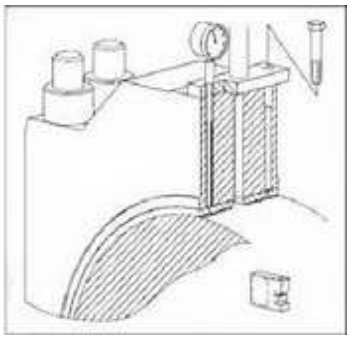
For Example:

Step 3	
Gauge Block	Measured Value
0.500	0
0.125	-0.375
0.250	-0.250
0.375	-0.125
0.625	0.125
0.750	0.250
0.875	0.375

Ship Application Example:
(Reference Job Cards and Instruction Manuals)



Shaft Alignment

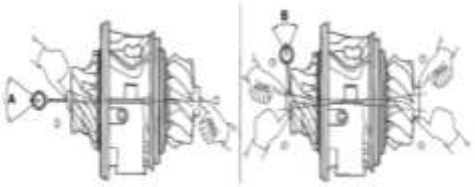


Main Engine Bearing clearance

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

8.3 Axial clearance A and possible radial movement B

8.3 ロータの軸方向遊び A と径方向遊び B



▶ Following removal and before installation of the cartridge group, the axial clearance A and possible radial movement B must be measured and noted.

▶ センターカートリッジ部を取外した後および取付ける前にロータの軸方向遊び A および径方向遊び B を計測し、記録してください。

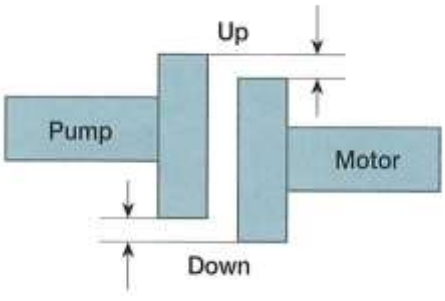
Turbo Charger Axial and Radial Clearances

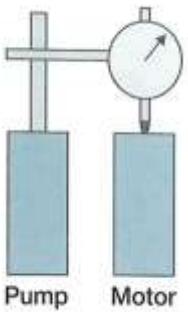
Daihatsu Camshaft clearance

Proper Alignment of Pump and Motor using Dial Gauge

5. *Adjustment of the height*

- Mount the dial gauge corresponding to the shape of coupling and other factors





6. *Adjustment of a miss alignment and clearance*

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Adjustment of a miss alignment and clearance between mating faces of the motor and pump couplings, by slightly tightening the anchor bolts of the motor.

After finishing the adjustment, tighten the anchor bolts

Checking Shaft Alignment

7-1 Case where alignment is checked with pump and motor coupled

a. For measurement on the shaft coupling periphery, a dial indicator is fixed, as shown in Fig.1 (a), on the motor end coupling periphery, and the pump end coupling is given one complete turning, and in this case the half value of reading is taken as the measurement value, which must comply with the value in Table 1.

b. For comparing the distance between the faces at four points using a thickness gauge, as shown in Fig.1 (b), the shaft is given one complete revolution by hand, and the difference between maximum and minimum readings is taken as the value of measurement, which must comply with the value in Table 1.

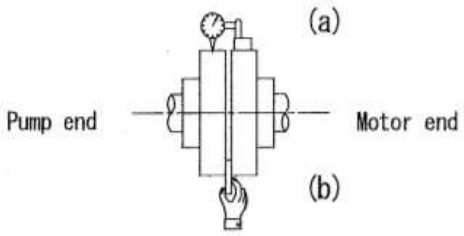


Fig.1 Check with dial indicator and thickness gauge

Table.1 Permissible amount of misalignment

No. of motor frame	Coupling periphery (mm)	Coupling and face (mm)
M280M (ML5-280M) and less	0.05 and less	0.10 and less
More than M 315S (ML5-315S)	0.07 and lese	0.16 and lese

c. Smooth movement should be ensured by rotating by hand.
d. Coupling periphery and end faces should be protected against rust or damage.
e. On completing the adjustment of alignment, dowel pins are inserted.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

7-2 Case where alignment is checked by disconnecting pump from motor.

a. After removing coupling bolts, as shown in Fig .1 or Fig.2 check alignment by measuring parallel and angular misalignment at 4 points, 90° apart, on the coupling periphery.

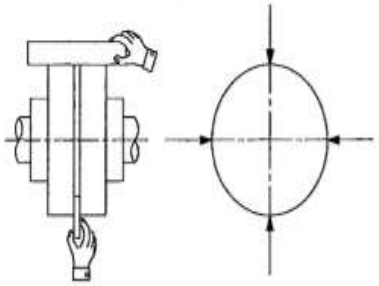


Fig.2 Check with straight edge and thickness gauge

b. Check alignment according to Table.1.
c. Ensure the rotating direction of the motor.
d. Fit the bolts to the coupling.
e. For others, follow the procedures shown in 7.1 c, d, and e.

Note: A thickness gauge should be adopted for alignment only at the times of repair, intermediate inspection and periodical inspection. It is preferable to use a dial indicator for checkup after initial installation or piping arrangement.

13. Connection of Rigid Shaft Couplings

On completing installation, the alignment must be checked and care must be taken so that no misalignment will occur after connecting with piping.
Since alignment is duly carried out in the factory, unreasonable readjustment should be avoided. Even though misalignment occurs, readjustment must be made carefully by loosening both of the bolts on the suction and discharge flanges and the foundation.

Smooth movement should be ensured by rotating by hand
Case where alignment is checked with motor and pump shaft coupled on the surface plate, permissible amount of misalignment must comply with the value in Table 1.

Table.1 Permissible amount of misalignment

OUT PUT (kW)	Alignment for Motor and Impeller (mm)	Alignment for Impeller and Casing (mm)
37 and less	0.03 and less	0.03 and less
More Than 40	0.05 and less	0.05 and lese

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

(Reference)
Take either of the two measurement methods of alignment, which are described below.

a) After coupling motor and pump shaft, measure the value of the shaft end periphery, a dial indicator is fixed, as shown in Fig 1 (a), on the motor flange, and the pump shaft is given one complete turning, and in this case the half value of reading is taken as the measurement value, which must comply with the value in Table 1.

b) After coupling motor and pump, measure the value of casing ring inner side, a dial indicator is fixed, as shown in fig 1 (b), on the shaft, and the pump shaft is given one complete turning, and in this case the half value of reading is taken as the measurement value, which must comply with the value in Table 1.

(a) (b)

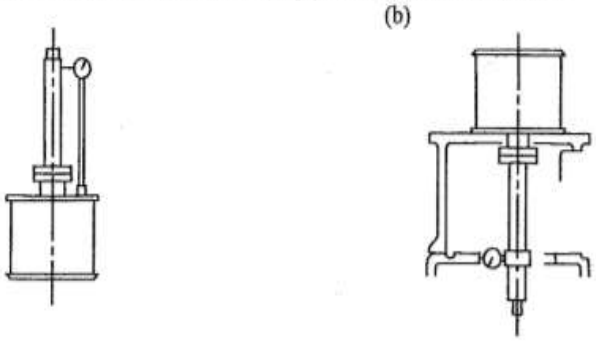
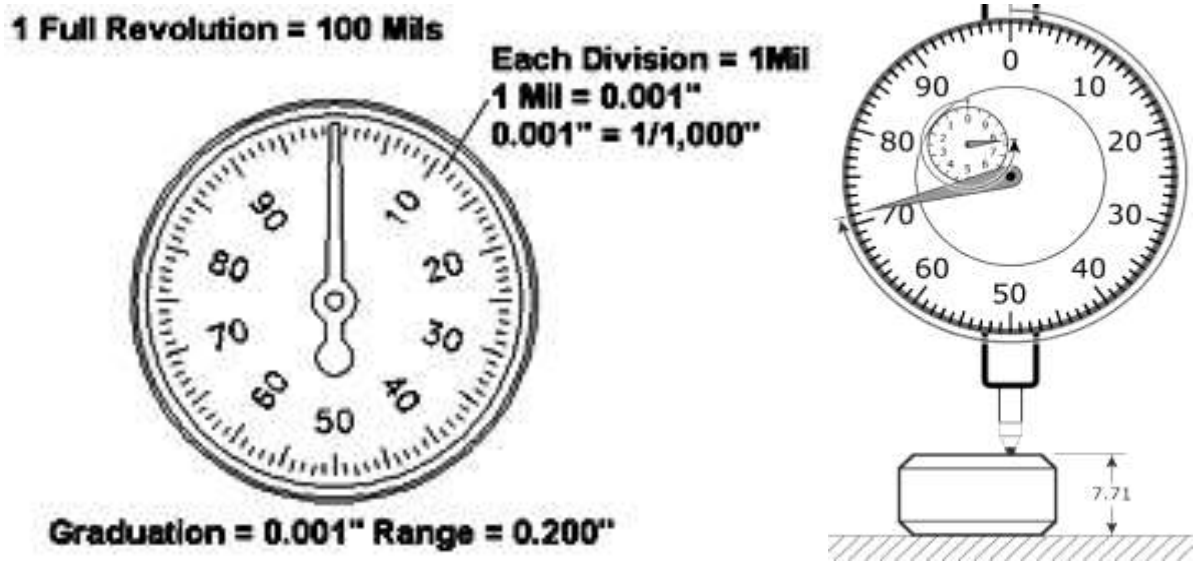


Fig 1. Check with dial indicator

How to read Dial Gauge



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

UPGRADING TRAINING FOR OILERS/WIPERS

1. Mount your dial indicator on a stand. Your dial indicator should have an attachment that you can use to secure it to a stand. The stand will stabilize your dial indicator while you take your measurements.

   If you do not have a stand, it is still possible to calibrate your dial indicator, but it will not be as easy.

2. Turn the outer dial face until the hand points to 0. The outer dial face can be moved by twisting the rim of the dial. Spin the outer face until the hand hovers over zero. Your calibration measurements will ensure that the dial indicator does read measurements starting at zero.

   If you discover errors, you will be able to correct for them by readjusting the outer face so that the hand hovers over the zero point.

3. Begin displacing your spindle. Stop at every 1/10 measurement to calculate errors. Continue to check for errors at 1/10 measurements for the first two revolutions of your dial.

4. Check for errors at half revolutions. For the next five revolutions, stop at every half revolution to calculate for errors, rather than at the 1/10 mark.
   - If your dial indicator makes more than seven revolutions, check for errors at every revolution after your reach seven.[4]
   - Do not let go of the spindle because you will need to check for errors in the reverse.

5. Begin to reverse your revolutions. Follow the same error-checking procedure, but in reverse. Check the measurement at each of the same points, so for the first five revolutions you will stop at the half revolution to measure. Then check the measurement at the 1/10 marks for the remaining two revolutions.

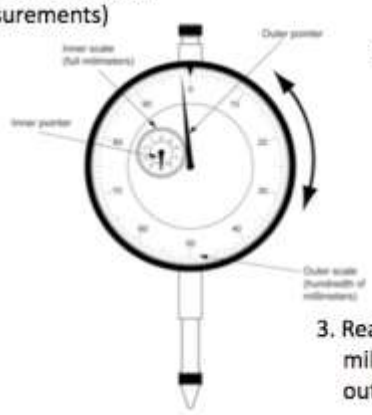
6. Take five measurements of the same item. Displace the spindle five times using the same surface. Move the spindle quickly for some measurements and slowly for others. Write down each of the five measurements to check for deviations. Because you're measuring the same surface repeatedly, each measurement should come out the same if your dial indicator is ready to use.

   If your dial indicator is showing errors, adjust the outer face and clean the spindle. Dust can accumulate on the spindle and cause issues with taking measurements. Repeat the calibration process until there are no errors.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Reading the dial indicator

1. Read the whole millimetres from the inner scale (only for absolute measurements)



2. Read the tenths of millimetres (numbers on outer scale)

3. Read the hundredths of millimetres (small divisions on outer scale).

Practical Exercise

1. 

2. 

3. 

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

6.6 Filters / Strainers

The filter is a fine mesh screen which is used to remove impurities from oil, water, and air on the ship. Filters are mounted in pairs as a duplex system so that one can be used and other is kept on standby at a time. The filter can be utilized both in low pressure (suction) and discharge (high pressure) side of the system and is used to remove the smallest part of dirt which is carried away in the system. The cleaning frequency of filters depends on the type of the filter and is decided by the manufacturer. The schedule is generally included in the planned maintenance system on board.

The strainer is a type of filter used mostly on low pressure or suction side and is used to remove large contamination particles from the system. It is because the mesh screen openings in the strainer are bigger in size and are similar to those of coarse filter. If the suction condition is critical, then the strainer can be fitted on the discharge side. It will purely depend upon the make and recommendation of the manufacturer. Usually, strainers are cleaned whenever they are opened up or when the pressure drop on the filter side is high.

Type of Filters Used on Ship

Types of filters depending upon the Media

1) Hydraulic Filter: Hydraulic filters are handy for removing solid contamination from lube and fuel oil systems of marine machinery. Without filters in the lube or fuel oil system, the internal machinery parts, bearings, piston, rings, liners, etc. can get damaged, which will result in the inefficient working of the machinery. Different applications of hydraulic filters are:

a) Fine Mesh Screen Filter: It is the most commonly used filter in lube and fuel oil systems on board. It can be used both on suction and discharge side of the system. It is used in cylinder lube oil line, main engine and auxiliary engine fuel oil line & diesel oil line, boiler fuel oil line and in different lube oil systems on board, etc.

b) Magnetic filter: This normally consists of filter elements which are magnetic in nature and which help in catching fine metal or ferrous particles that run in the system. These elements are surrounded by a basket screen which also acts as a filter and simplifies the cleaning of the filter. Magnetic filters are used in lube oil system.

c) Auto Back Wash Filter: In auto backwash filters, when the pressure difference increases, an indication of filter getting clogged, the auto system cuts off the filter and opens the bypass. The auto wash takes place with the help of an electric motor connected to a shaft which cleans the filter. During this operation, the drain of the filter gets open.

Auto Backwash filter

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

d) Centrifugal filter: As the name suggests, these filters work on the principle of centrifugal force removing high-density fluids and impurity from the oil. It is normally used for lube oil systems. Most of the Auxiliary engines have attached centrifugal filters.

e) Manual clean filter: In the manual filter, there is a handle with a shaft which is connected inside to a filter. When the pressure difference increases, the filter unit is bypassed, and the filter is cleaned manually with the help of a lever.

Filter with lever

2) Water Filter: The sea water and fresh water systems on board ship are provided with line filters to trap the solid impurities flowing in the system. Normally the sea water side has more numbers of filters incorporated in the line as compared to the fresh water system as the latter is a closed system. The different applications for water filters are:

a) Sea chest Strainer: Sea chest is fitted in the main suction line of the sea water inlet system to the ship. The filter casing is normally fitted with marine growth preventive system. Normally a strainer is used in the sea chest so that the flow of water in the sea line is always maintained.

b) Fire line suction filter: Fire pump has a suction filter to avoid any solid impurity to come inside the fire line. The filter mesh screen has a moderate opening screen hole for the flow of water.

c) Bilge line filter: All the bilge well suctions are provided with a strainer as the well contains the maximum solid contamination. The filter may have a bucket screen or a plate screen to trap solid impurities like rags etc.

d) Fresh water system filter: All the freshwater systems such as drinking water system, sanitary water system, boiler feed water system etc. are incorporated with a line filter on the suction side of the pump.

3) Air Filter: These filters are used on board so that the compressed air supplied to different machinery and systems get pure air for efficient operation of the same. The different application of the air filters are:

a) Control air filter: The control air system or the pneumatic control of the propulsion plant is very critical. It must not contain any moisture for it may block the passages in the system and the main propulsion plant may not start or reverse etc. The control air filter removes the moisture and collects it in a chamber from where it can be drained.

b) Turbocharger filter: Turbocharger filters are made of copper mesh which is used on the blower side so that the air sucked by the blower must not carry any solid or carbon particles; else it may damage the blades and reduce the combustion efficiency.

TC filter

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

c) IG system scrubber filter: I.G system scrubber plant contains moist exhaust. To remove the moisture from the same, a demister filter is used.

d) Compressor filter: All the air used on board is supplied by main or auxiliary air compressor on board. The air is sucked into the compressor through an air filter located in the first stage and is made up of paper and metal mesh.

Air Compressor Filter

4) Special filters: Some special filters which are used on board the ship are:

a) OWS 1st and 2nd stage filter: The filters used in OWS are expensive and normally of the disposable type. The first stage filter normally consists of felt filter. The second stage filter uses coalesce for bringing down the oil content to below 15 ppm.

OWS Filter

b) Oxygen analyzer filter: Oxygen analyzer is an instrument which is used to measure oxygen content in enclosed area. It consists of a probe fitted with an integrated air filter to remove dirt from the air drawn.

c) Cartridge filter: This type of filters are used for portable generators, auxiliary compressors and a power pack on board and can be used for fuel oil and lube oil filtration. They are usually of the disposable type and can be used only once.

Cleaning of filter / strainers

Cleaning of sea chest strainers

Cleaning of sea chest strainers is one of critical operations on board. Failure to follow basic safety rules lead to possible ER flooding. Both inboard and especially outboard valves must be in good order and do not leak. Whenever cleaning required the following procedure to be followed:

1. Before closing inboard and outboard valves check condition of sea chest strainer vent valve. Open it slightly and make sure water is flowing from it. If there is no water then vent valve is chocked. It must be unblocked by supplying of water or compressed air. In case vent valve cannot be unblocked or broken special attention to the following steps to be paid.
2. Close inboard and outboard valves of sea chest strainer. Open vent valve and ensure there is no water flowing through it. In case there is a water coming out a risk assessment must be conducted to evaluate flow rate and danger of flooding. Only after water ingress decided manageable cleaning could be commenced. Subject to approval from Captain and Company for undertaking a risk.
3. Loose nuts/bolts which hold down sea chest filter cover. Never remove them all, at least 4 check nuts must be left loosen but in place. This will secure cover from being flushed away be water. Make sure there is no water ingress before proceeding. In case of water ingress in must be evaluated for possibility of flooding. If there is no leakage or it small enough to be managed by constant pumping remaining nuts/bolts could be removed and cover taken away.
4. Clean the strainer. Inspect for damages. Repair or replace if necessary.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

5. Clean and inspect the strainer body
6. Inspect cover gasket. Renew if necessary.
7. Inspect vent valve. Clean, repair or replace if necessary.
8. Assemble strainer. Tighten the cover.
9. Open outboard valve slightly. Check for proper tightening of cover. Release the air from strainer by opening the vent valve until water comes. Failure to do this may cause sea water pumps to loose suction as air from strainer travels through the SW system.
10. Open the inboard valve.

7.Basic Marine Electricity

7.1 General Information on Electric Shock

With every contraction, the heart pumps blood carrying oxygen throughout the body. The rhythm of the heartbeat is controlled by electrical impulses, which can be seen on an electrocardiogram. Current passing through the heart can cause an irregular heartbeat called arrhythmia, or even total disorganization of the rhythm, called ventricular fibrillation.

When ventricular fibrillation occurs, the heart stops pumping. The victim rapidly loses consciousness and dies if a healthy heartbeat is not restored by applying a second electric shock with a device called a defibrillator. Heart rhythm disturbances can occur at the time of the shock or in the 24 hours following the accident.

Muscles are stimulated by electricity. The effect of an electric shock depends on which muscles the current goes through. A current of more than 10 mA causes sustained contraction (tetanus) of the flexors, that is, the muscles that close the fingers and draw the limbs towards the body. The victim thus cannot let go of the source of current.

If the extensors (the muscles that open the figures and extend the limbs away from the body) are tetanized, the victim is propelled away from the current source, sometimes as much as ten metres!

Muscles, ligaments and tendons may tear as a result of the sudden contraction caused by an electric shock. Tissue can also be burned if the shock is lasting and the current is high.
Nerves are the tissue that offers the least resistance to the passage of an electric current. Some nerve damage caused by shock clears up with time, but some is permanent. The victim may feel pain, tingling, numbness, weakness or difficulty moving a limb.

When a shock occurs, the victim may be simply dazed or may experience amnesia, seizure or respiratory arrest.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Ultimate damage to the nerves and the brain will depend on the extent of the injuries caused by the heat along the path of the electric current and may develop up to three years after the shock. Nerve damage can also cause psychiatric disorders.

Electrical burns are not like burns caused by fire or by touching something hot. Electrical burns result from the heat generated by an electric current passing through the body, which literally cooks the tissue from within.

We've all felt that buzzing or tingling sensation without experiencing injury. A current as low as 0.25 milliamperes (mA) can cause this feeling.

- Starting at 10 mA, most people cannot let go of the shock source because their muscles contract.
- Above 50 mA, an electric current can trigger cardiac arrest if it passes through the heart.
- Above 100 mA, electrical marks appear on the body at the points of contact.
- Above 10,000 mA (10 amperes), burns are severe and amputation is required.

The damage may be much more serious than the external injuries suggest. This is known as the Iceberg Effect.

Electrical marks appear at the body's point of contact with the current. They are typically tiny charred or hard craters that do not hurt because the nerves have been destroyed. If a lot of tissue is destroyed, the waste generated can cause serious kidney or blood circulation disorders.

Electrical burns often have serious consequences: scarring, amputation, loss of function, loss of sensation and even death.

Electric shock can also affect the eyes, causing cataracts to develop over time.

Other disorders can appear in the weeks or months following the accident, depending on which organs the current passed through.
The table below shows relationship between Electrical Shock Currents and Physiological Effects on Human body.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Influence of Electric Shock	Direct Current (mA)		Alternating Current (mA)			
			60 Hz		1000Hz	
	Male	Female	Male	Female	Male	Female
Minimum sensed current	5.2	3.5	1.1	0.7	12	8
A little shock without pain *Possible control the muscle	9.0	6.0	1.8	1.2	17	11
A few shock with pain *Possible control the muscle	62	41	9	6	55	37
A shock with pain *Limit to escape out of source	74	50	16	10.5	75	50
Severe shock with pain *Rigor of muscle & difficulty breathe	90	60	23	15	94	63
Possible occurrence the ventricle spasm *Electric shock = 0.03second	1300	1300	1300	1300	1300	1300
Possible occurrence the ventricle spasm *Electric shock = 0.03second	500	500	500	500	500	500
Absolutely occurrence the ventricle spasm *Absolutely death	2.75 times above current					

Danger of Electricity

What are the physical differences between shocks by AC and DC current? Both are dangerous and can be lethal in high amounts. Learn more here.

An AC current is alternating in nature and follows a sine curve. It changes direction continuously and passes through zero to a maximum positive value and then to a maximum negative value. The voltage of an AC current is a RMS or root mean square value, and the peak or maximum value is 1.4 times the RMS value. It means that a 220 V AC supply is going to 308 Volts before coming down to zero and changing direction.

DC current is direct current and does not change in magnitude, though it can be negative or positive depending on the direction of the circuit. DC current is ideal for electronic circuits whereas AC is ideal for electrical installation and motors, etc.

The three basic factors that determine what kind of shock you experience are the amplitude of the current, the duration of the current passing through the body, and the frequency.

Direct currents actually have zero frequency, as the current is constant. However, there are physiological effects during electrocution no matter what type of current.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

The factor deciding the effects of the AC and DC current is the path the current takes through the body. If it is from the hand to the foot, it does not pass through the heart, and then the effects are not so lethal.

However DC current will make a single continuous contraction of the muscles compared to AC current, which will make a series of contractions depending on the frequency it is supplied at. In terms of fatalities, both kill but more milliamps are required of DC current than AC current at the same voltage.

If the current takes the path from hand to hand thus passing through the heart it can result in fibrillation of the heart. Fibrillation is a condition when all the heart muscles start moving independently in a disorganized manner rather than in a state of coordination. It affects the ability of the heart to pump blood, resulting in brain damage and eventual cardiac arrest.

Either AC or DC currents can cause fibrillation of the heart at high enough levels. This typically takes place at 30 mA of AC (rms, 60 Hz) or 300 – 500 mA of DC.

Though both AC and DC currents and shock are lethal, more DC current is required to have the same effect as AC current. For example, if you are being electrocuted or shocked 0.5 to 1.5 milliamps of AC 60 Hz current is required and up to 4 mA of DC current is required. For the let-go threshold in AC a current of 3 to 22 mA is required against 15 to 88 of DC current.

Some interesting facts about electric shock,

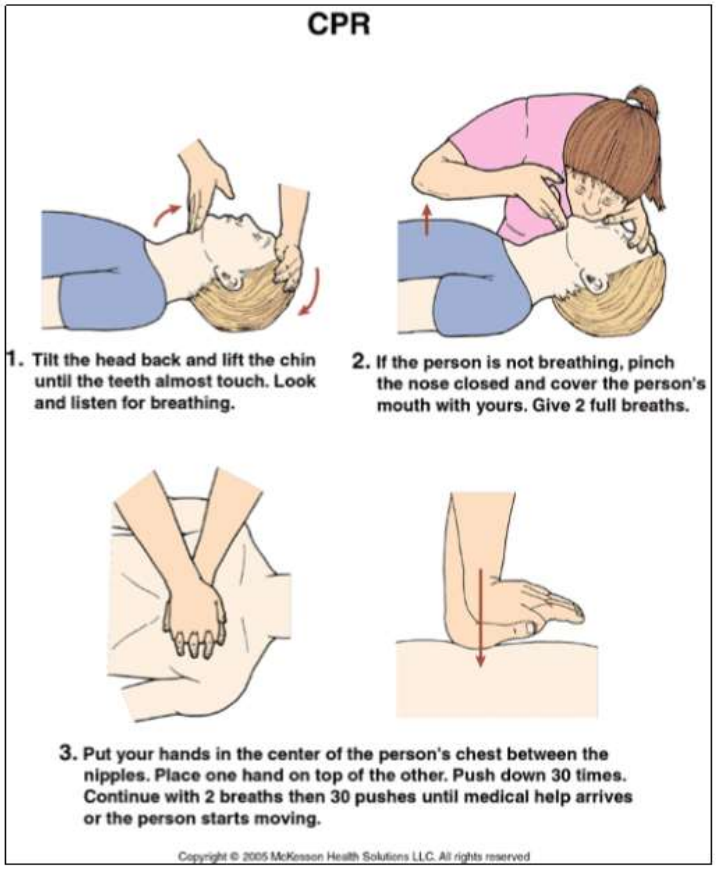
- It is the magnitude of current and the time duration that produces effect. That means a low value current for a long duration can also be fatal. The safe current/time limit for a victim to survive at 500mA is 0.2 seconds and at 50 mA is 2 seconds.
- The voltage of the electric supply is only important as it ascertains the magnitude of the current. As Voltage = Current x Resistance, the bodily resistance is an important factor. Sweaty or wet persons have a lower body resistance and so they can be fatally electrocuted at lower voltages.
- Let-go current is the highest current at which subject can release a conductor. Above this limit, involuntary clasping of the conductor is present. It is 22 mA in AC and 88 mA in DC.
- Apart from electric shock the other equally dangerous hazards of playing (or working) with electricity are electrical arc flash and electrical arc blast.
- Placing your hand in your pocket may protect you by preventing a current from traveling through the heart making a shock non-lethal.
- The severity of the electric shock depends on the following factors: body resistance, circuit voltage, amplitude of current, path of the current, area of contact, and duration of contact.
- Death may also occur from falling in case of electric shock.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

- Burn injury may occur at both the entrance and exit of the current.
- Low frequency AC is more dangerous than high frequency AC.
- AC and DC both kill so treat them with respect.

Symptoms of Electric Shock

The symptoms described below must be treated immediately with artificial respiration or Cardiopulmonary Resuscitation (CPR) until the victim recovers. These are symptoms of electric shock and should not be considered fatal. It is not unusual for a person suffering from these symptoms to recover even after several hours of artificial respiration or cardiopulmonary resuscitation (CPR).
See the illustration for cardiopulmonary resuscitation (CPR) techniques.



The symptoms are listed in order from mild to most serious case.

(1) Breathing stops
Normal breathing can usually be restored after continuing artificial respiration for a short while.
(2) Breathing stop, face is pallid and pulse is very weak or undetectable.

(3) Totally unconscious
In the worst of cases, the body of the victim may become rigid within two or three minutes after the shock.

Prevention of Electric Shock

The person, who performs operation, maintenance, repair, etc. or the person in the position of supervising these persons must observe the following safety guidelines to prevent an electric shock.

Safety Guidelines

These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage. Note that the danger to you is not only in your body providing a conducting path but particularly your heart. Any involuntary muscle contractions caused by an electric shock, while perhaps harmless in them, may cause collateral damage. There are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally. The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions.

a) Switch off the electric power supply. Discharge the remaining electric power by earthing the wire and then confirm that there is no voltage.
b) Don't work alone - in the event of an emergency, another person's presence may be essential.
c) Always keep one hand in your pocket whenever you are around a powered line-connected or high voltage system.
d) Wear rubber bottom shoes or sneakers.
e) Wear eye protection - large plastic lens eyeglasses or safety goggles.
f) Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.
g) Set up your work area away from possible grounds that you may accidentally contact.
h) Know the equipment you are going to work on, instrument and tools, that are to be used.
i) When handling static sensitive components, an anti-static wrist strap is recommended.

It is recommended that static dissipative materials are used as the medium for discharging static charge to ground. Materials which are conductive (e.g. stainless steel surfaces) are not recommended for use as a static-safe work surface; the low electrical resistance could result in a transient-like (surge) discharge of static electricity. A rapid discharge is far more damaging to the electronic device than a gradually paced discharge through a static dissipative

j) Don't attempt repair work when you are tired. Not only will you be more careless, but also your primary diagnostic tool - deductive reasoning – will not be operating at full capacity.
k)Finally, never assume anything without checking it out for yourself. Don't take shortcuts!
l) Tag the power supply switch when doing electrical work.

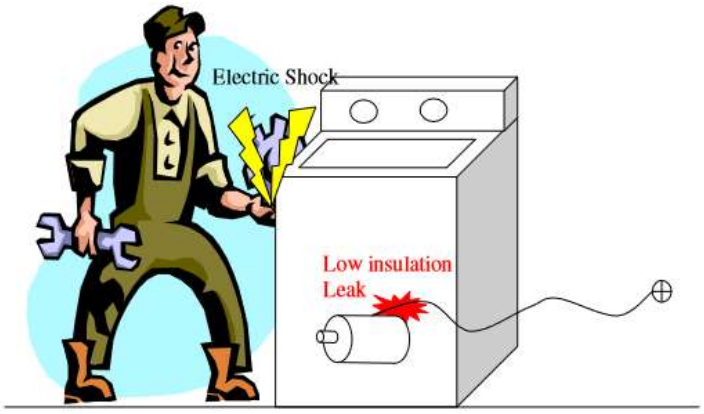
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

(Ex. “Do Not Turn on Power: Maintenance Work”)

If someone turns on the power while maintenance work is being done, an accident could occur.

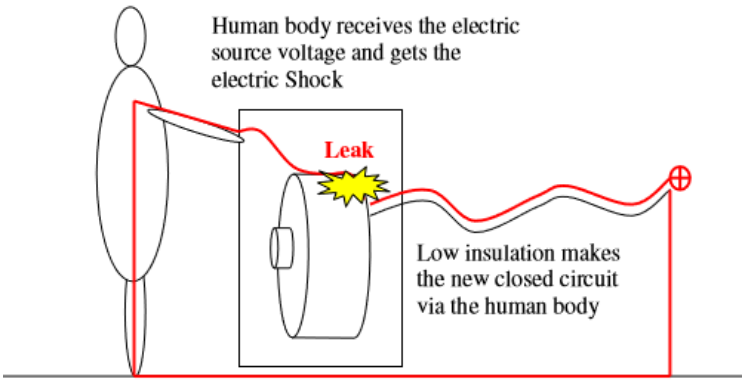
Importance of Earth line

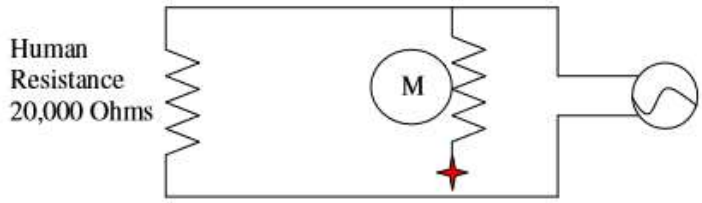
The earth line protects the human injuries for example the electric shock. Especially risk machines located in the lavatory, kitchen, laundry, etc. outfits the earth line.
Why does the earth line make it possible to protect the human injury?

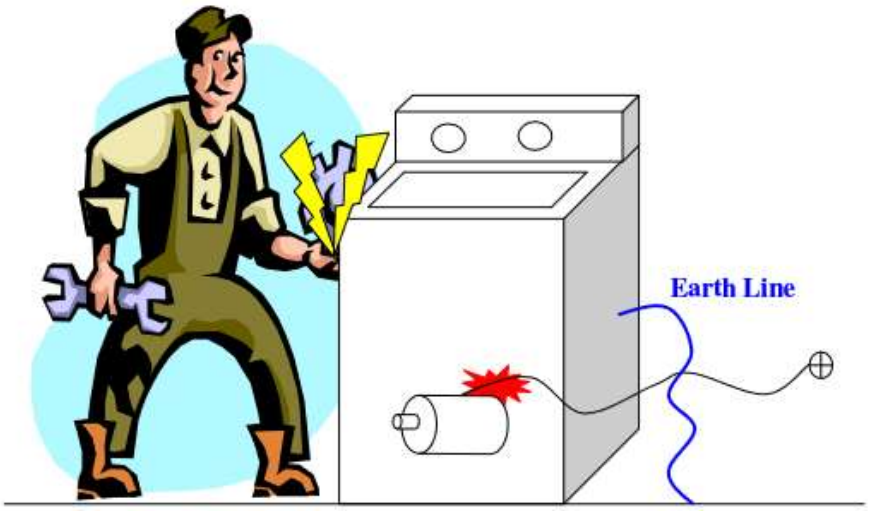


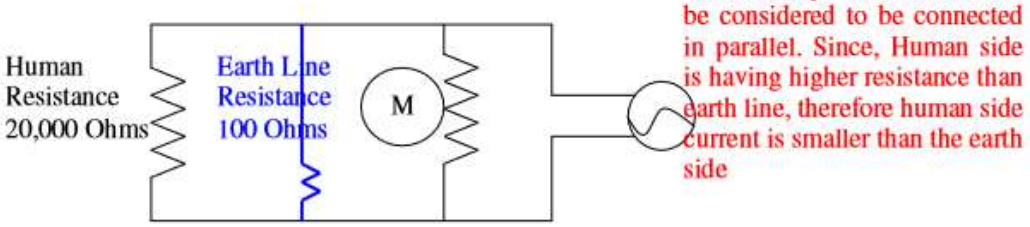
The human body, consisting of about 60% water, is effectively a liquid conductor.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00









Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

7.2 Electric Finished Drawing

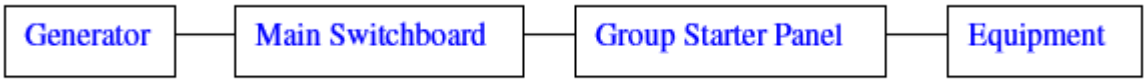
The Electric Finished Drawing is composed of the Wiring diagrams, the Arrangements, the Test results, the Maker Drawings and the Spare parts. The engineer can understand the flow of electric power supply to the equipment's such as lighting equipment's, switches, motors, junction boxes, etc., the location and type of equipment's and the type of cables, being used, by reading the wiring diagrams and arrangements drawings.

Wiring Diagrams

The wiring diagrams provide information regarding the voltage, location and so on for systems such as Power system, Lighting system, Interior communication system, Electric Navigation equipment, Control system, etc. We can get the outline information regarding the current and outline of equipment's by using the wiring diagrams. The important wiring diagrams are explained in the following sections:

Electric Power System Wiring Diagram

Wiring Diagram of Power System shows the electric power flow form the Generator to the electric power machinery with the help of One-Line diagrams.



The first part of this diagram shows the Symbol list. Most of the symbols consist of many letters; therefore it is very difficult to read them on the diagram. Normally simplified symbol is used.
An Engineer can understand the following items from the wiring diagram.

1) Kind or type of cable
2) Circuit Mark Number or Cable Number
3) Type of Circuit breaker
4) Type of Transformer
5) Junction Box Number

But wiring diagram is written by the One-Line cable, therefore an Engineer finds it difficult to understand the details of actual wire connection. In order to understand the details, it is necessary to use the maker instruction manual and so on.

The Figure 2.1(A) shows a one line diagram of the electric power flow from No.1 Diesel Generator to Main Switch Board bus bar via ACB

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

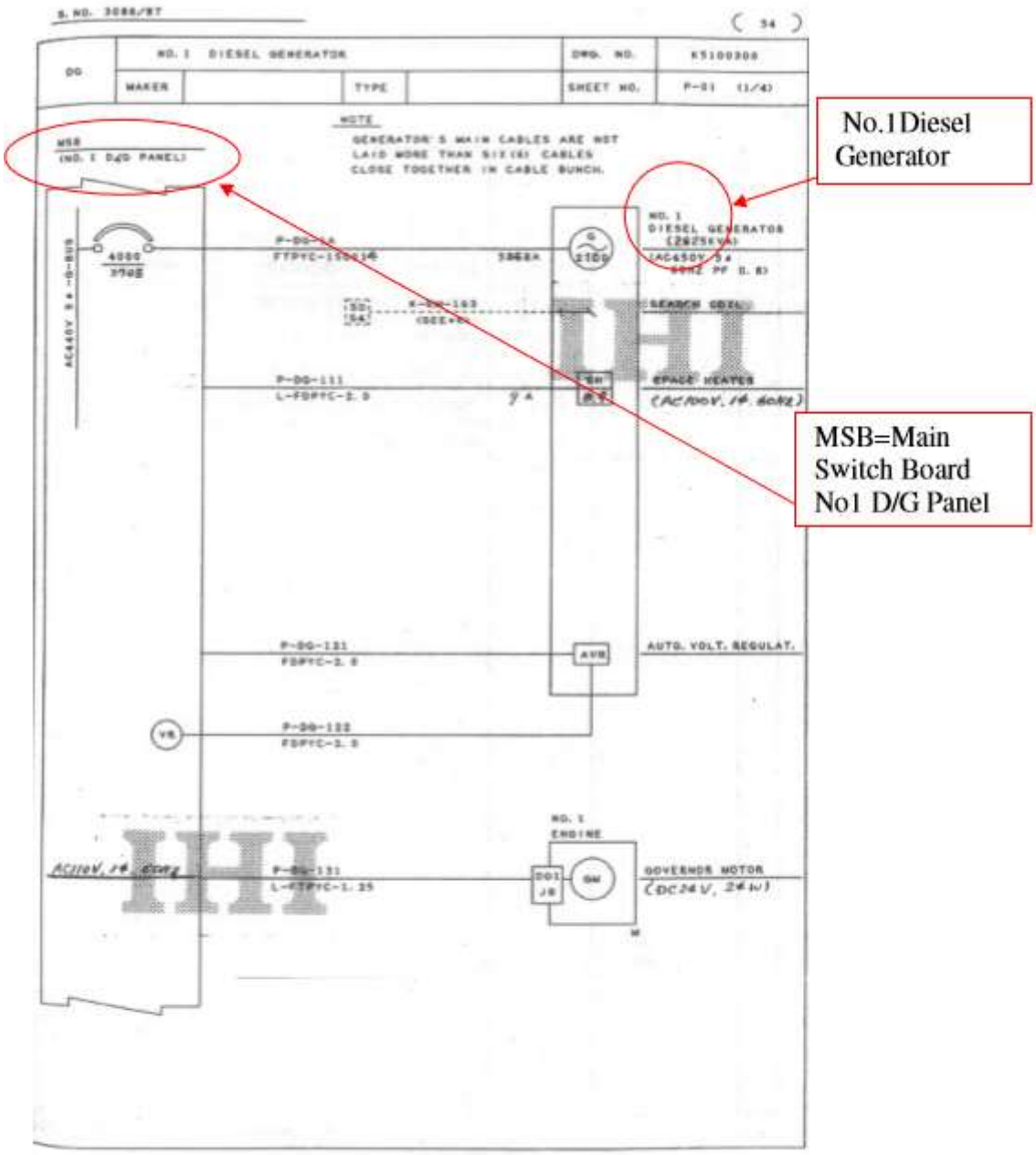


Fig. 2.1 (A) Typical Electric Power System Wiring Diagram

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

The Figure 2.1 (B) shows one line diagram for power flow from 440 volt Main Switch board to 440 volt GSP (Group Starter Panel).

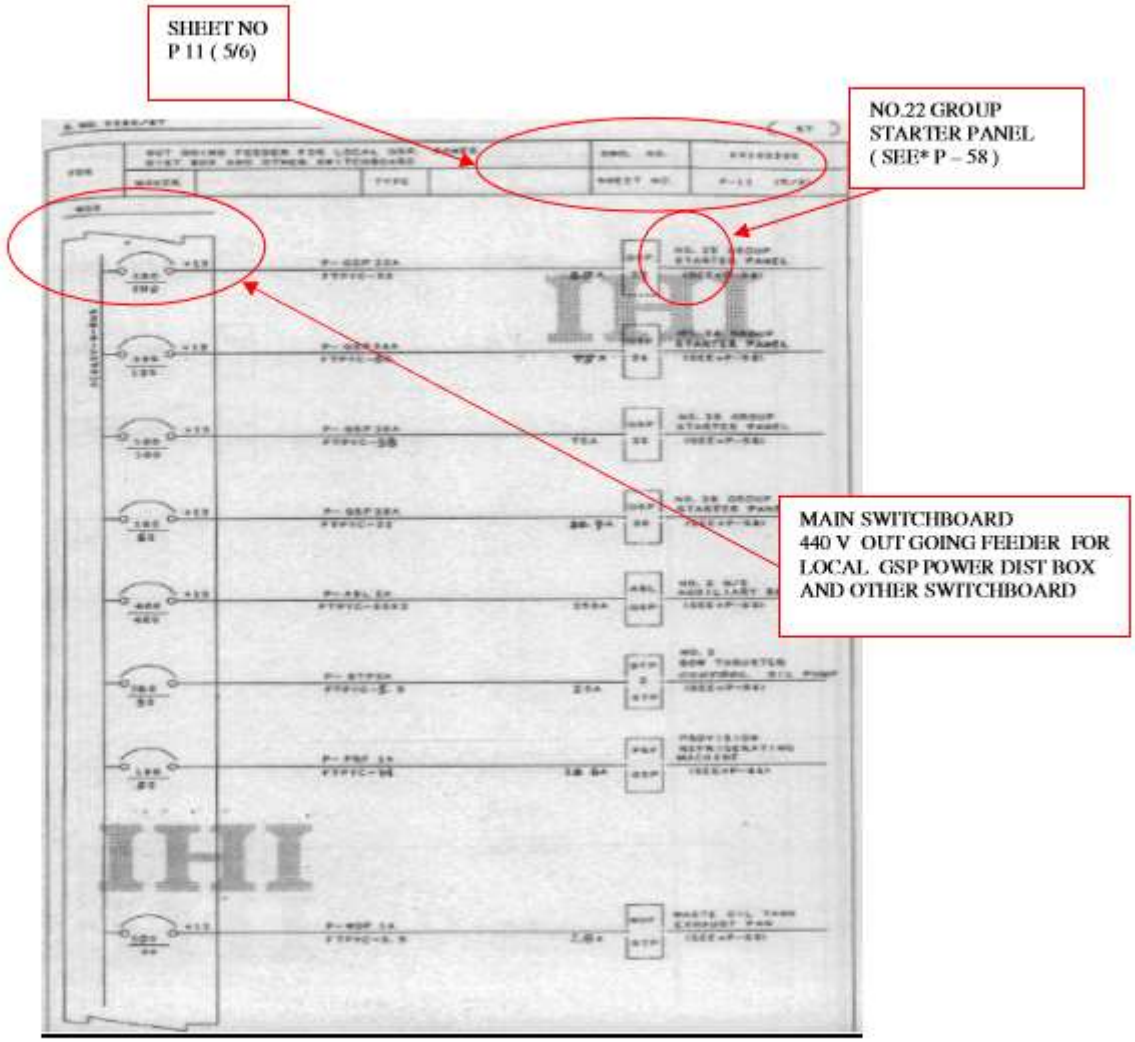


Fig. 2.1 (B) Typical Electric Power System Wiring Diagram

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

The Figure 2.1 (C) shows one line diagram for power flow from GSP to 440 volts Junction Box and Feeder Panel and from Junction Box electric power reaches the final equipment i.e. NO3 CARGO HOLD EXHAUST FAN(1) in this case.

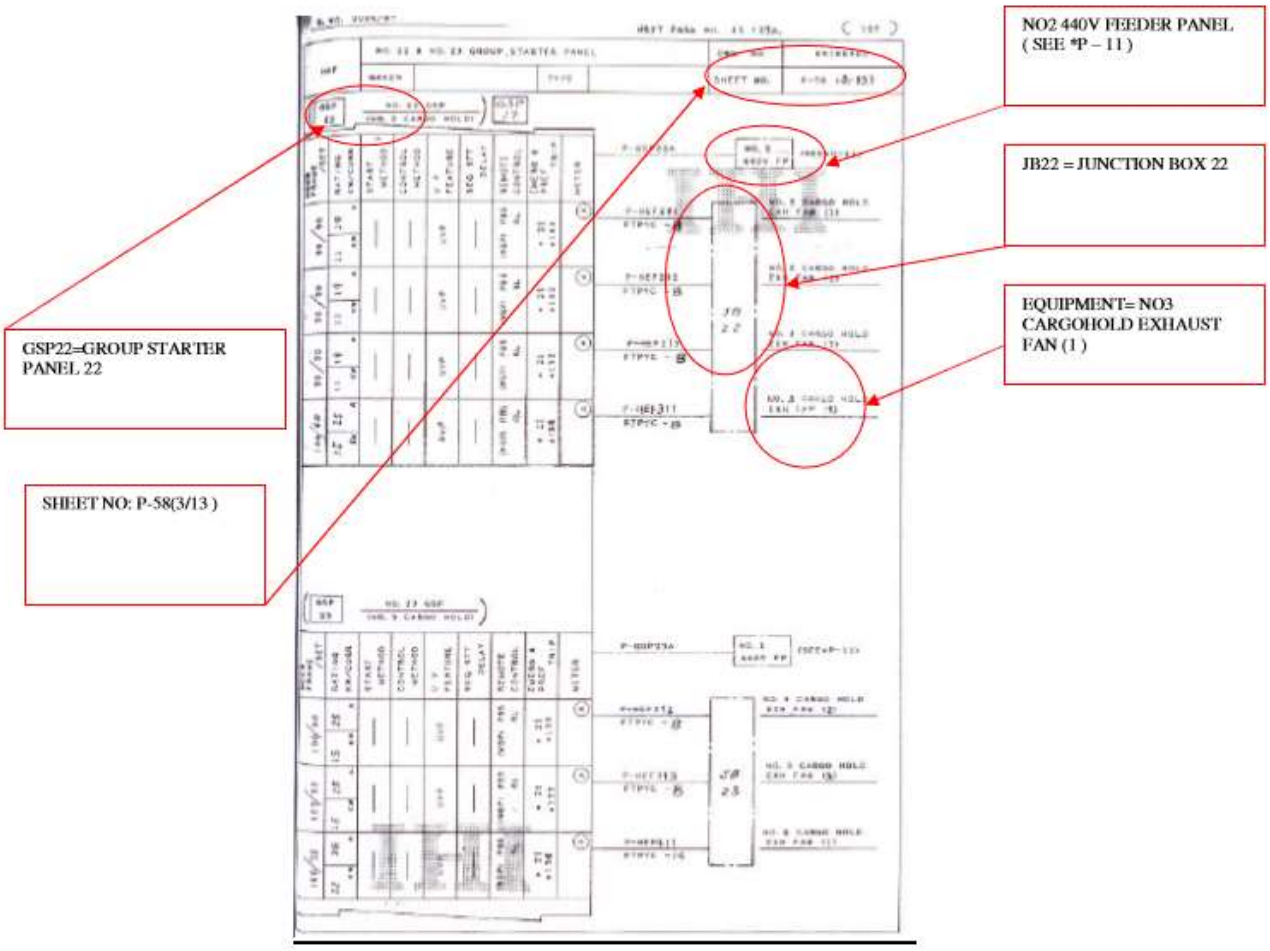
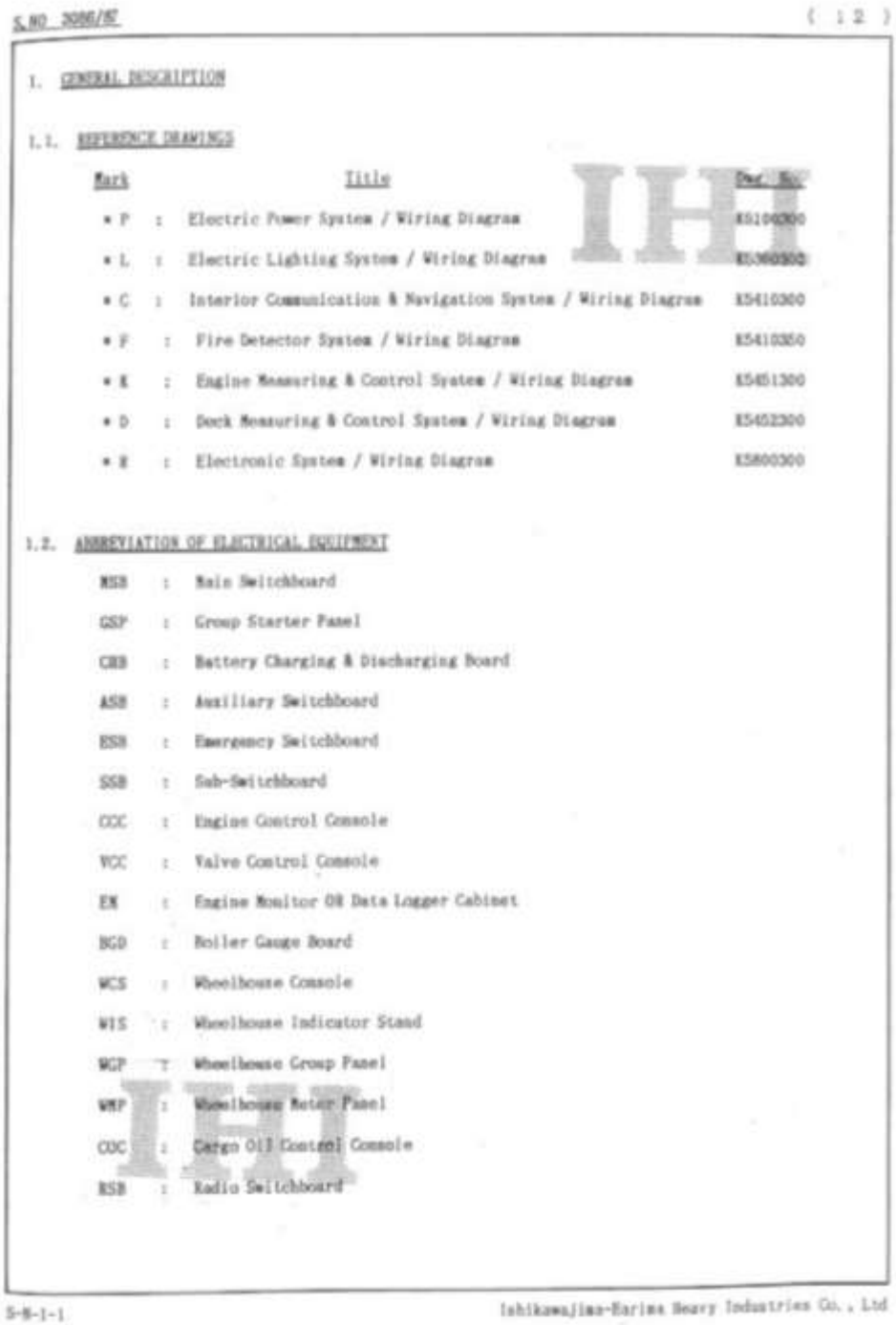


Fig. 2.1 (C) Typical Electric Power System Wiring Diagram

To enable us to locate the equipments in the electrical drawings, we need to follow the reference drawings – the mark, the drawing title and the drawing number. As illustrated below in Figure1.2, letter “P” is designated to electric power system wiring diagram, whereas letter “L” refers to lighting system wiring diagram.

GSP22

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



S.NO 3086/ST (12)

1. GENERAL DESCRIPTION

1.1. REFERENCE DRAWINGS

Mark		Title	Dwg. No.
* P	:	Electric Power System / Wiring Diagram	E5100300
* L	:	Electric Lighting System / Wiring Diagram	E5300300
* C	:	Interior Communication & Navigation System / Wiring Diagram	E5410300
* F	:	Fire Detector System / Wiring Diagram	E5410350
* E	:	Engine Measuring & Control System / Wiring Diagram	E5451300
* D	:	Deck Measuring & Control System / Wiring Diagram	E5452300
* E	:	Electronic System / Wiring Diagram	E5800300

1.2. ABBREVIATION OF ELECTRICAL EQUIPMENT

MSB	:	Main Switchboard
GSP	:	Group Starter Panel
CBB	:	Battery Charging & Discharging Board
ASB	:	Auxiliary Switchboard
ESB	:	Emergency Switchboard
SSB	:	Sub-Switchboard
CCC	:	Engine Control Console
VCC	:	Valve Control Console
EM	:	Engine Monitor OR Data Logger Cabinet
BGD	:	Boiler Gauge Board
WCS	:	Wheelhouse Console
WIS	:	Wheelhouse Indicator Stand
WGP	:	Wheelhouse Group Panel
WMP	:	Wheelhouse Meter Panel
COC	:	Cargo Oil Control Console
RSB	:	Radio Switchboard

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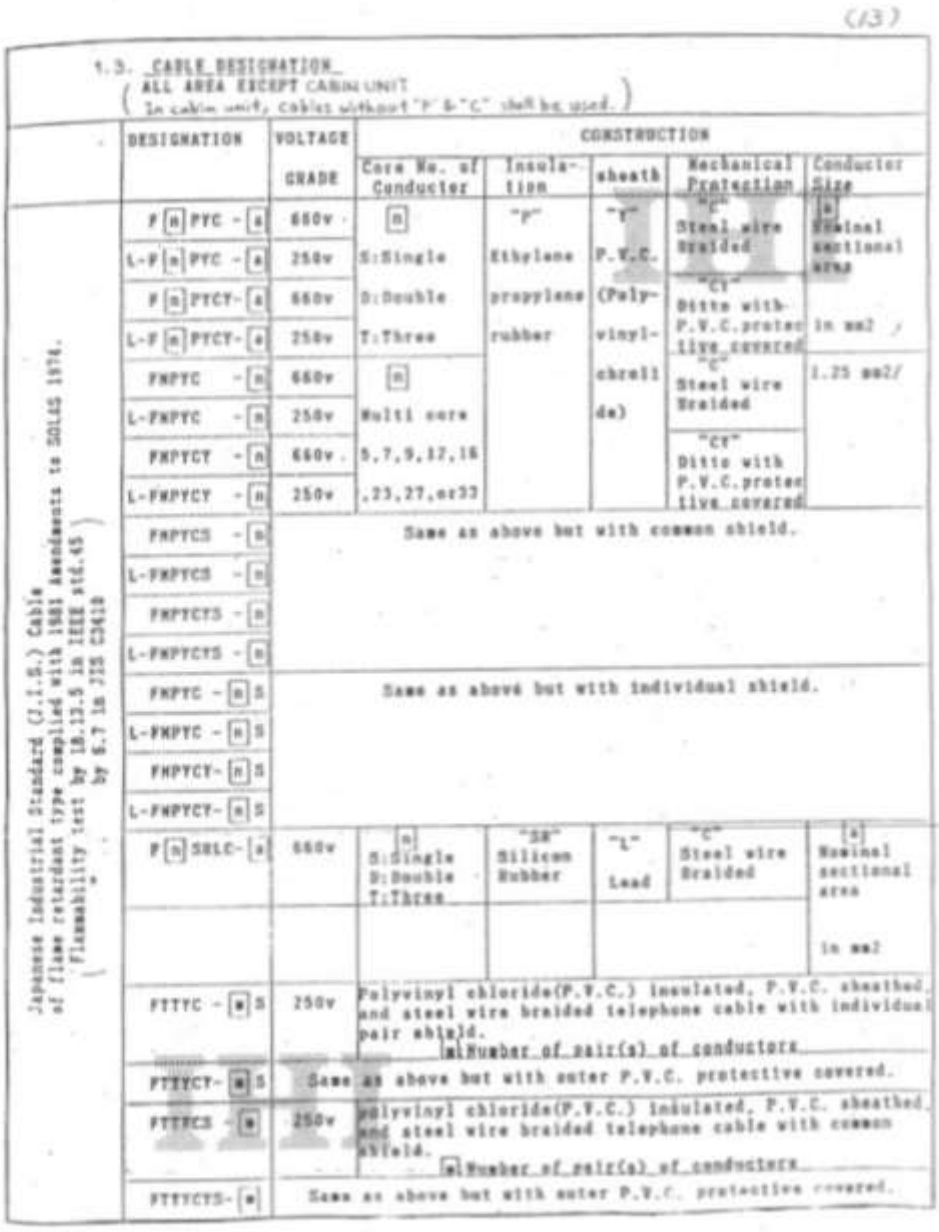
Fig. 2.2 General Description/Abbreviation of electrical Equipment

The Figure 2.3 shows a typical cable designation, which helps to identify the electrical cable type, insulation grade, number of cores etc.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



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1.3. CABLE DESIGNATION

(ALL AREA EXCEPT CABIN UNIT
In cabin unit, cables without "F" & "C" shall be used.)

Japanese Industrial Standard (J.I.S.) Cable
of flame retardant type complied with 1981 Amendments to SOLAS 1974.
Flammability test by 18.13.5 in IEEE std.45
by 6.7 in JIS C3410

DESIGNATION	VOLTAGE GRADE	CONSTRUCTION				
		Core No. of Conductor	Insulation	sheath	Mechanical Protection	Conductor Size
F [n] PYC - [s]	660v	[n]	"P"	"Y"	"C" Steel wire Braided	[s] Nominal sectional area
L-F [n] PYC - [s]	250v	S:Single	Ethylene	P.V.C.		
F [n] PYCY- [s]	660v	D:Double	propylene	(Poly-	"CY" Ditto with P.V.C.protective covered	in mm2
L-F [n] PYCY- [s]	250v	T:Three	rubber	vinyl-		
FNPYC - [n]	660v	[n]		chrolide)	"C" Steel wire Braided	1.25 mm2/
L-FNPYC - [n]	250v	Multi core				
FNPYCY - [n]	660v	5,7,9,12,16			"CY" Ditto with P.V.C.protective covered	
L-FNPYCY - [n]	250v	,23,27,or37				
FNPYCS - [n]	Same as above but with common shield.					
L-FNPYCS - [n]						
FNPYCYS - [n]						
L-FNPYCYS - [n]						
FNPYC - [n] S	Same as above but with individual shield.					
L-FNPYC - [n] S						
FNPYCY- [n] S						
L-FNPYCY- [n] S						
F [n] SRLC- [s]	660v	[n] S:Single D:Double T:Three	"SR" Silicon Rubber	"L" Lead	"C" Steel wire Braided	[s] Nominal sectional area in mm2
FTTYC - [n] S	250v	Polyvinyl chloride(P.V.C.) insulated, P.V.C. sheathed and steel wire braided telephone cable with individual pair shield. [n] Number of pair(s) of conductors				
FTTYCY- [n] S	Same as above but with outer P.V.C. protective covered.					
FTTYCS - [n]	250v	Polyvinyl chloride(P.V.C.) insulated, P.V.C. sheathed and steel wire braided telephone cable with common shield. [n] Number of pair(s) of conductors				
FTTYCYS- [n]	Same as above but with outer P.V.C. protective covered.					

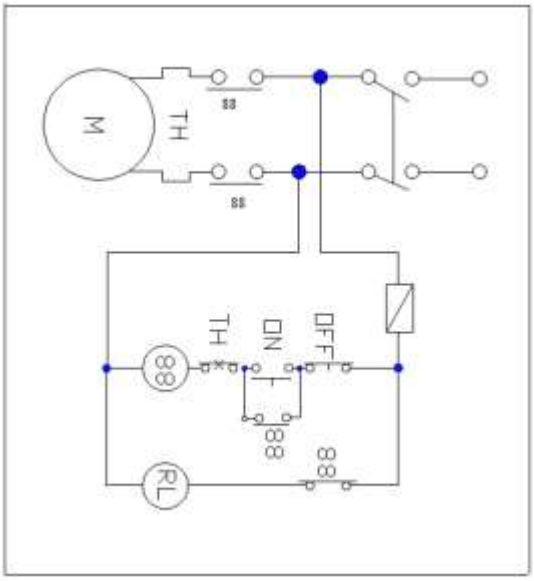
Fig. 2.3 Table showing Cable Designation (Symbol Mark Table of Power Wiring Diagram)

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

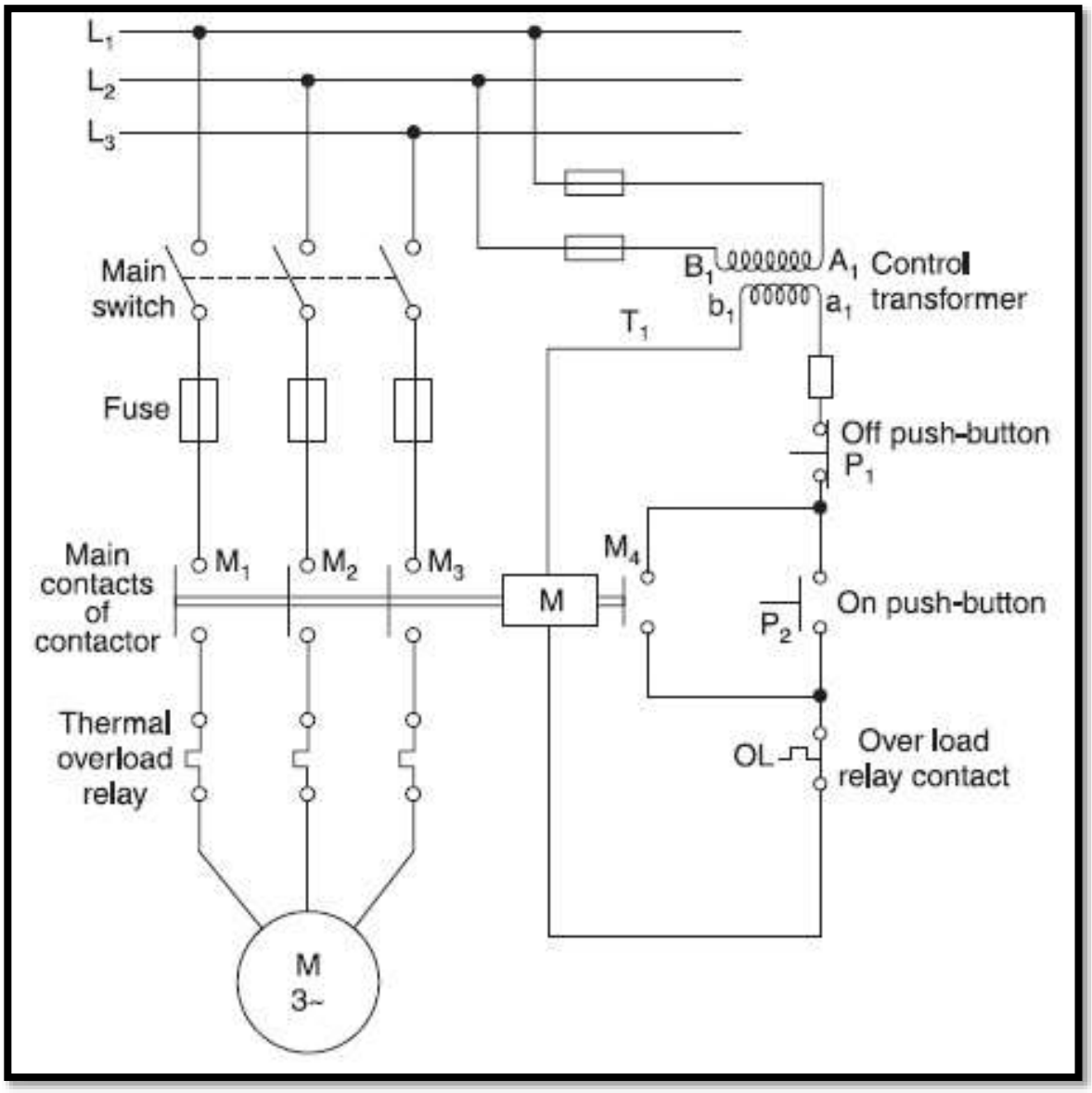
BASIC SYMBOLS

SYMBOL	DESCRIPTION
	GANG/GENERAL SYMBOL
	CONDUCTOR(GENERAL)
	JUNCTION OF CONDUCTOR
	CROSSING OF CONDUCTORS(CONNECTED)
	CROSSING OF CONDUCTORS(NONCONNECTED)
	TERMINAL
G	GENERATOR
Ex	EXCITER
	FIELD
M	MOTOR
GM	GOVERNOR MOTOR
A	AMMETER (~ ALTERNATING)
V	VOLTMETER (⊖ DIRECT)
F	FREQUENCYMETER
W	WATTMETER
VAR	VARMETER
WH	WATTHOURMETER
PF	POWER-FACTOR METER
Sy	SYNCHROSCOPE
IRM	INSULATION RESISTANCE METER
PSI	PHASE SEQUENCE INDICATOR
HM	RUNNING HOUR METER
T	TEMPERATURE METER/THERMOMETER
PT	POTENTIAL TRANSFORMER
CPT	CONTROL POWER TRANSFORMER
Tr	TRANSFORMER (GENERAL)
CT	CURRENT TRANSFORMER
SH	SHUNT
	BATTERY

SYMBOL	DESCRIPTION
	EARTH(GROUND)
R	RESISTANCE/RESISTOR
R	VARIABLE RESISTANCE/VARIABLE RESISTOR
C	CAPACITANCE/CAPACITOR
Rr DI	RECTIFIER(GENERAL)/DIODE
F	ENCLOSED FUSE
BI	BELL
Bz	BUZZER
IL	INCANDECENT LAMP
EIL	EMERGENCY LIGHT
FL	FLUORESCENT LAMP
	HEATER(GENERAL)
	SHUNT TRIP COIL
UNT	UNDERVOLTAGE TRIP COIL
	SWITCHED BOARD(PANEL BOARD)
	DEVICE FITTED IN THE OTHER PANAL (UNIT)
*	INDICATOR LAMP * -- LENS COLOR WL- WHITE RL- RED GL- GREEN YL- YELLOW OL- ORANGE BL- BLUE TL- TRANSPERENT
	ELECTROMAGNETIC COIL (GENERAL)
	DEVICE OR EQUIPMENT (GENERAL)LETTER OR SYMBOL TO BE PUT IN
	CONNECTION REFERENCE
	WITHDRAWABLE TYPE
ATr	AUTO TRANSFORMER 50,65,80 PERCENT TAPS
MB	MAGNET BREAK
S	SUPPLIED BY SHIPYARD



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



7.3 Main Switchboard

Switch Board is assembled to provide the functions such as monitoring, controlling, measuring, indicating, safety devices and so on for the electrical circuits or equipment's. Therefore, the Switch Board rationally manages and controls all the electrical circuits and equipment's as a central station. Main Switch Board distributes the electric power to the ship's loads and protects the electrical equipment's by the safety devices, depending on the troubles. Switch Board is equipped with the Air Circuit Breaker, Circuit Breaker, Auto Synchronizer, Synchronism Lamp, Synchronism Scope, Earth Lamp, Auto Power Control System, Voltage Monitoring System, Frequency Monitoring System, Voltage Establish Relay, Reverse Power Trip Device and Insulation Resistance Meter.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

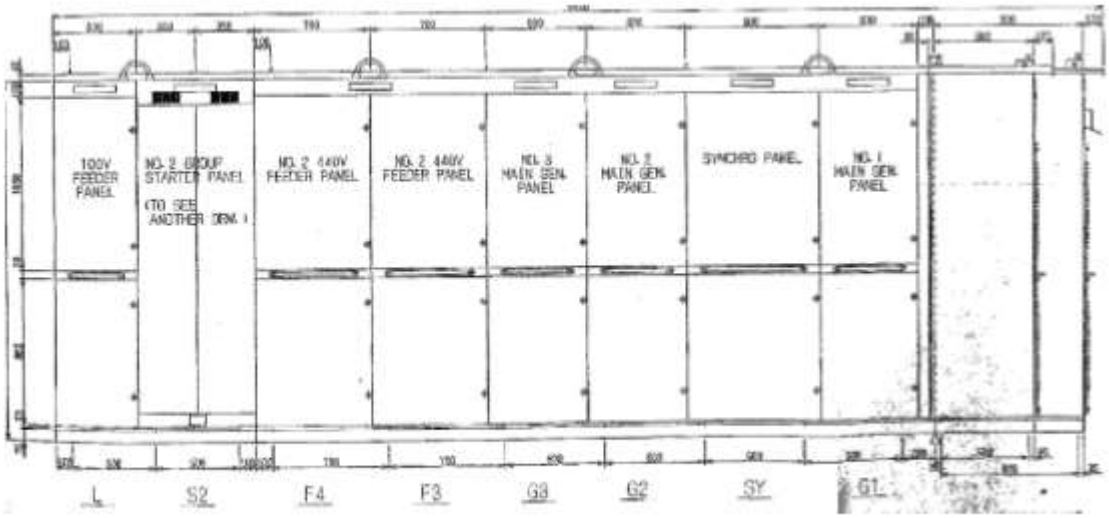


Fig. 3.1 Layout of Main Switch Board

A typical layout of a ship's main switchboard is shown above. This is invariably made up of panels, which are arranged to accommodate all the electrical components necessary for receiving and distributing the electrical supply. Power produced by the generators is delivered to the various motors, lightings, galley services, navigation aids, steering gear, deck machinery, etc., which comprise the ships electrical load.

The electrical energy is routed through the main switchboard, then distributed via switchboards or panels to section and distribution boards and then ultimately to the final load consumers. The switchboard is capable of withstanding mechanical, electrical and thermal stresses, which may arise from shock or vibration of the vessel or short circuit fault. The central section of the main switchboard is used for the control of the main generators. The breakers of the generator panels are used for essential services and flanking these are group motor starter panels. The majority of ships have a 3-phase A.C. 440 - volt insulated supply. Lighting and low power single-phase supplies usually operate at the lower voltage of 110 volt A.C. The Main switchboard will also supply to the Emergency switchboard.

The other essential services to the engine room, bridge supplies and feeder panels, provisions will be made for alarms and earth insulation resistance monitors on each volts and parts sections. The switchboards or panels are usually linked (or interlocked) to an isolating system. The breakers are isolating the supply side and delivery side, when switching on / off or when tripped at the occurrence of troubles.

To parallel the incoming generator on to the bus bar smoothly, it needs to be synchronized with the running generator which is already connected to bus bars.

The following conditions are essential:

- Same frequency

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

The frequency differential between the Bus (Running generator) and the Incoming generator is sufficiently small. The incoming generator voltage is set by its AVR to be equal to the bus bar voltage

- Same voltage

The voltage differential between the Bus (Running generator) and the Incoming generator is sufficiently small.

- Same phase sequence

The voltage phase between the Bus (Running generator) and the Incoming generator is extremely same.
The speed of the incoming machine is controlled and fine tuning is observed on the Synchronism Scope or synchronizing lamps.

Manual synchronization operation

When we operate the generator in parallel by manual, we carry out the following operation to satisfy the above requirements.

1. Start the incoming generator
2. Adjust the frequency to sufficiently small differential between the Bus (Running generator) and the Incoming generator by governor motor for the incoming generator
3. Confirm that the frequency differential between the Bus (Running generator) and the Incoming generator is sufficiently small.
4. Confirm that the voltage differential between the Bus (Running generator) and the Incoming generator is sufficiently small.

If the voltage differential is not sufficiently small, adjust the voltage by adjusting the set point (Voltage Trimmer) of the Automatic Voltage Regulator.

5. Close the ACB of the incoming generator at the time of same phase by confirming the Synchroscope.

∆ CAUTION Manual Synchronous Closing Operation
Do not close generator ACB unless it synchronizes with the generator: **a) Close the generator ACB within a range of approximately 15º on the FAST side, considering the synchronization point as the 12 O'clock position** **b) ACB synchronous closing operation outside the range described in item a) above may pull the generator out of synchronism and cause abnormal tripping of the ACB** **ACB abnormal tripping may result in no voltage on the main bus**

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Synchroscope

The incomer is adjusted so that Synchroscope indicator rotates slowly clockwise in the "FAST" direction and the circuit breaker of incoming generator should be closed as the indicator approaches 12 o'clock. If synchronized, when running slow, the incoming machine would draw a motoring current, which may operate its reverse power relay and 'trip" the circuit breaker of the machine already on the "bus bar' due to overloading. The likely consequence of attempting to close the incoming breaker when the generators are not in synchronism are that at the instant of closing the breaker the voltage phase difference causes a large circulating current between the machines, which results in a large magnetic force to pull the generators into synchronism. This means rapid acceleration of one rotor and deceleration of the other. The large forces may physically damage the generators and their prime movers, which may include deformation of the stator windings, restrict movement of stator core and frame. It may also cause failure of the rotor diodes in brushless type generators, twisted rotor shafts, damage of shaft keys and broken couplings. The large circulating current may also trip each generator breaker. The ultimate result is blackout.

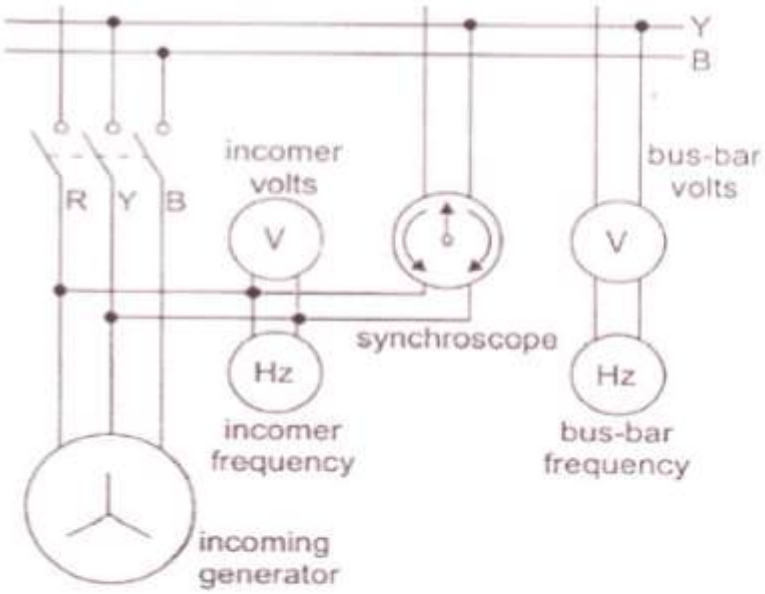


Fig. 3.2 Arrangement of Synchronizing Instrument

Automatic Synchronization operation

The auto synchronizing function detects whether the generator frequency is higher or lower than the bus bar frequency and controls automatically the governor motor which minimizes the frequency difference. When the difference in frequency and voltage become smaller than the set values, the function gives a closing signal to the circuit breaker so that the circuit breaker will be closed at the point where the phase of the generator coincides with that of the bus bar.

Synchronizing unit monitors the voltage, phase angle and frequency of the incoming generator with respect to the bus bars.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Automatic Power Control System

The Auto Power Control System is an automation system for parallel operation of generators. There are the Proportional load control and the Optimum load control. The Proportional load control is generator load equal control.

The Optimum load control is the method that one generator load is adjusting the balance load, others generator or generators is / are setting load. That setting load is optimum load for generator. Both methods control the number of the generator, when total load is reached setting load, stand-by generator is started automatically, closes ACB of incoming generator automatically and then load is shifted to incoming generator automatically.

Safety Devices

The ability of Protection system to discontinue only faulty circuits and to maintain the electrical supplies to proper circuits is known as protection discrimination. In other words discrimination occurs when the breaker nearest to the fault operates, leaving all the other breakers or protective devices intact.

Voltage Monitoring System

The Voltage Monitoring System monitors voltage of bus-bar side and generator side. When voltage is over the low and high setting point, this system outputs the alarm and trip signal to the breakers.

Frequency Monitoring System

The Frequency Monitoring System monitors frequency of bus bar. When frequency is over the low and high setting point depend on the abnormal of the generator trouble or abnormal fluctuation load, this system outputs the alarm signal, preference signal and stand-by generator auto start signal.

Voltage Establishing Relay

The Voltage Establish Relay monitors voltage of generator. When generator output voltage is reached setting point, this relay outputs the signal to the other device. This signal uses to confirm the voltage before closing the ACB and so on.

Reverse Power Protection Device

When the running generator receives electric power from the other generator via a bus bar, it means generator changing to motor. The Reverse Power Protection Device detects the reverse power by the induction coil and outputs the tripping signal to the generator ACB to protect the generator from overheat or burn-out.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Insulation Resistance Meter

Regulations require that Main switchboard should be fitted with earth fault indicators to indicate the presence of an earth fault in each isolated section of a distribution system e.g. on 440 V and 220 V sections. Earth fault indicators can either be a set of lamps or an instrument calibrated in Kilo ohms.

Earth indicator lamps are arranged as shown in below in Figure 3.2. If system is healthy the lamps will glow with equal brightness as there is a potential difference across each of them. If earth fault occurs on one line, the lamp connected in that line is dim or extinguished and other lamps glow comparatively brighter. The reason is that there would be no potential difference across the faulty lamp, due to potential falling to zero or near zero.

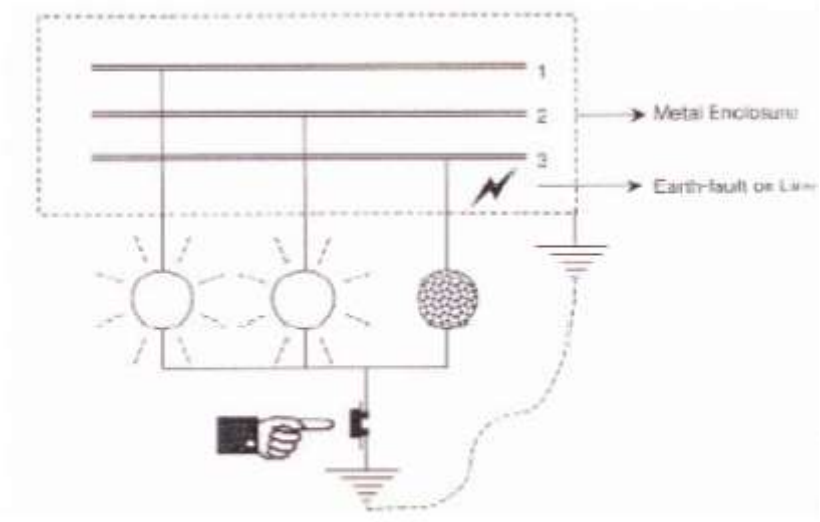
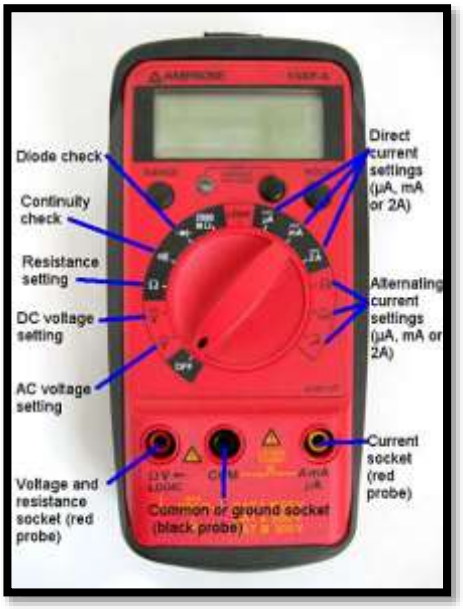


Fig. 3.2 Earth lamp Connection

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

7.4 ELECTRICAL MEASUREMENTS TOOLS

Multimeter



Routine electrical test work involves measuring current, voltage and resistance i.e. Amps, Volts and Ohms. This is most conveniently done using a multi-meter with all the necessary functions and ranges. The instrument may be the traditional switched-range analogue type (pointer and scale) or the more common digital type with auto-ranging and numerical display.

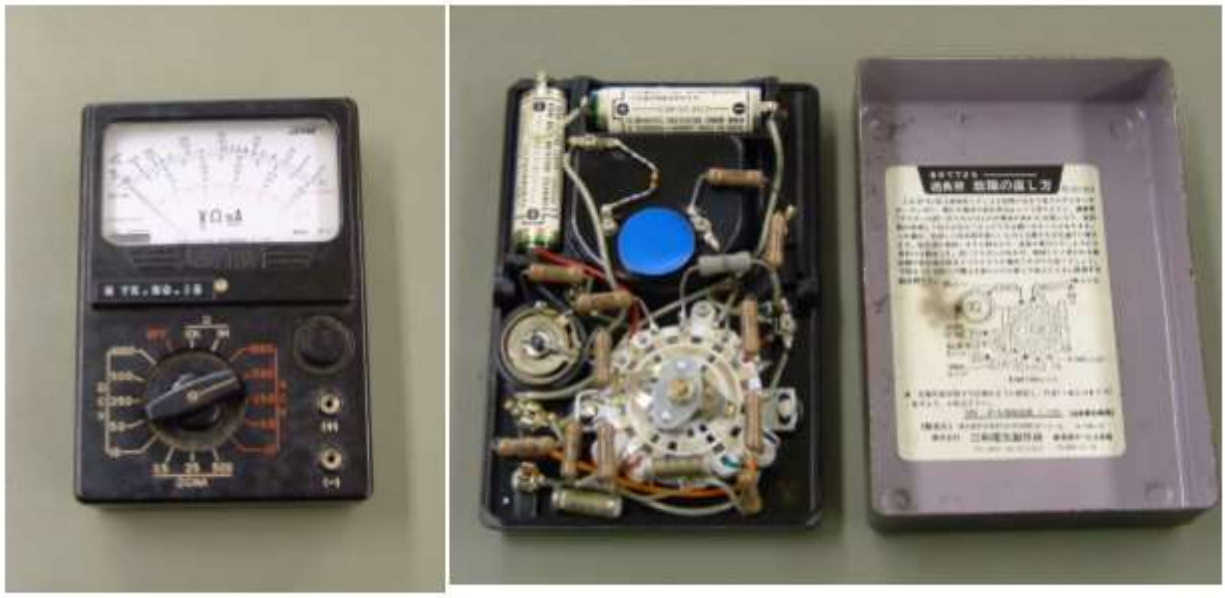
Digital meters are normally high impedance, therefore has high accuracy compared to analogue type, which has low impedance. Digital meters have a clear numeric readout, which may be supported by a bar graph display. Where distorted voltage waveforms are likely (e.g. with variable frequency motor drives), it is necessary to use a “true-rms” meter for accuracy. Digital meters are also available, which display the test voltage waveform shape with a storage oscilloscope facility on the LCD screen. Digital meter is useful to measure the imperceptible voltage and resistance and it is possible to measure accurately, especially the semiconductor resistance and voltage of sharp movement.

In all instrument models, an internal battery is fitted for use when measuring resistance. Before measuring the resistance of a component, it is essential that the circuit is switched off, locked off and any capacitor discharged. The instrument is likely to be damaged otherwise. The multi-meter should be checked for correct operation before use. The manufacturer’s instructions should be carefully followed for this, but a general procedure is as follows: Use correct probe leads and insert into the correct sockets on the meter.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

If the multi-meter is an analogue type:

Ensure the pointer indicates zero- adjust if necessary. Set the selector switch to "Ω"and connect probe tips together. Pointer should deflect to indicate 0 Ω. If not at the zero point, adjust trimming controls. Check each resistance range in this way. Set selector switch to "A.C.V" (highest range). Connect probes to a suitable known live supply (with care) such as the electrical workshop test panel. Pointer should indicate correct voltage.



Pic. 6.1 Inside view Analog Multimeter

Very special care is necessary when using a multi-meter to check for live voltage. If the multi-meter has been accidentally set to current or resistance range, the instrument acts as a low resistance across live supply. The resulting short-circuit current may easily cause the meter to explode with local fire damage and very serious consequences for the operator.

Fused probe leads are therefore highly recommended for use with a multi-meter. Instrument battery failure is checked when the instrument is set to read "Ω" with the probe tips connected together. If the pointer fails to reach "0 Ω" after the adjustment of the resistance range trimmer, the battery must be replaced. The instrument should be switched-off when not in use to preserve battery life.

If the multi-meter is of digital type:

Switch on and connect the two probe tips together. Set selector switches to "D.C.V" (highest range). Display should indicate zero (000).

Repeat for all "D.C.V" selector switch positions and note the shift of the decimal point. Separate the probe tips. Set the selector switches to "Ω" (highest range). Display should indicate "0l" (over-range) or "100" (depends on the model).

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Connect probe tips together- display should indicate zero (000). Repeat for all "Ω" selector switch positions and note movement of the decimal point.

Set selector switches to "AC V" (highest range). Connect probes to suitable known live supply. Display should indicate correct voltage. Test the D.C. voltage range also and note the polarity indication on the meter. Instrument battery failure is usually indicated by the numeric display. The display may show "BT" or the decimal point may blink.

The instrument should be switched off when not in use to preserve battery life It is to be remembered that checking a circuit with a faulty instrument can be dangerous.

Procedure for measuring Resistance

1. PROVE the correct operation of the instrument.
2. ISOLATE and lock off the equipment. PROVE the equipment to be dead.
3. SWITCH multi-meter to appropriate resistance range, connect the probes to the equipment and note the resistance value.

Procedure for measuring Voltage

1. PROVE the correct instrument operation.
2. SWITCH the instrument to the highest voltage range.
3. CONNECT the probes to the terminals being tested. Take care not to touch the probe tips, as equipment being tested is LIVE
4. NOTE the voltage reading.
   No harm will be caused to the instrument by operating the selector range switches while connected to live supply. But great care must be taken not to switch into either the current or resistance mode. This may cause the instrument to trip on overload and possible damage to instrument and injury to person.
5. DISCONNECT the probes and switch off the instrument.

Procedure for measuring Current

The multi-meter current measuring facility is intended for only small current components and in particular for electronic circuits. The multi-meter is not to be used for measuring current to motors and other power circuits

The procedure to measure small current in mili Amps: *

1. PROVE the correct instrument operation.
2. SWITCH the instrument to the highest current range.
3. TURN OFF the power to the circuit to be tested and discharge all capacitors.
4. OPEN the circuit in which current is to be measured-removing a fuse link often gives a continent point for current measurement.
5. SECURELY connect the probes in SERIES with the load in which current is to be measured. *
6. TURN ON the power to the circuit being tested; note the current size on the meter display *

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

7. TURN OFF the power to the circuit being tested and discharge all capacitors.
8. Disconnect the test probes and switch the instrument to OFF and reconnect the circuit that was being tested.

Current Clamp-meter

Fig. 6.2 Clamp Meter

The most convenient way to measure current is by the clamp- meter. Power current (A.C.) can be measured by clamp-meter, which acts as a current transformer. The value of the current is obtained from the magnetic flux strength around the conductor. The instrument tongs are clipped around a single conductor and usually displayed on digital display.

Care to be taken when measuring current in uninsulated conductor. If clamp-meter is clipped around a three core or two-core cable, the reading will indicate zero, as the net flux in balanced 3 or 2 cores is zero.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Insulation Testing (Megger Test)

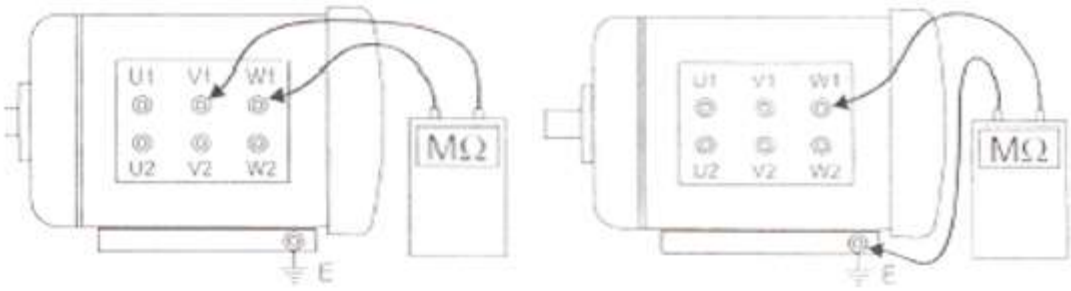


Fig. 6.3 Insulation Resistance connection for Motor

The measurement of the insulation resistance (IR) gives one of the best guides to the state of health of electrical equipment.

The resistance is measured between insulated conductors and earth and between conductors. The Megger is high reading resistance meter using a high-test voltage – usually D.C.

Test voltage of 500volts D.C. is suitable for ships equipment's rated 440 V A.C.

Test voltage of 1000 volts D.C. is suitable for testing high voltage systems.

To test the meter, short the two probes together, switch ON to MΩ and press the test button- The pointer should indicate approximately 0MΩ Before applying the test, the equipment must be disconnected from the live power supply and locked off.

For IR test on three-phase machine, measure and log the phase-to-phase insulation resistance value. Three windings should be measured U-V, V-W and W-U.

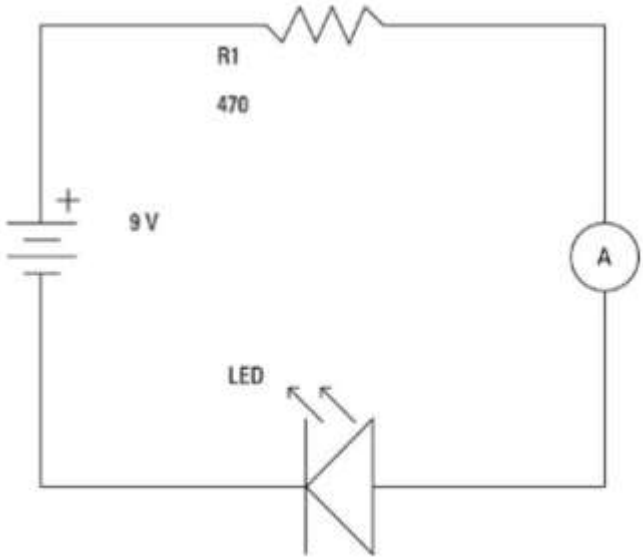
Measure and record the phase-to-earth insulation resistance values. Three readings should be measured as U-E, V-E and W-E

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

How to measure current in an electronic circuit?

Electric current is measured in amperes, but actually in most electronics work, you'll measure current in milliamps, or mA. To measure current, you must connect the two leads of the ammeter in the circuit so that the current flows through the ammeter. In other words, the ammeter must become a part of the circuit itself.

The only way to measure the current flowing through a simple circuit is to insert your ammeter into the circuit. Here, the ammeter is inserted into the circuit between the LED and the resistor.



Note that it doesn't matter where in this circuit you insert the ammeter. You'll get the same current reading whether you insert the ammeter between the LED and the resistor, between the resistor and the battery, or between the LED and the battery.

8. Operate Main and Auxiliary Machinery and associated control system

8.1. Piping diagram Symbols and Color Coding

Piping system in the engine room is quite complicated. It is necessary to all personnel working in the engine room to familiarize them actually, to understand and locate the arrangement of all equipment's connected in a piping system in order to operate safely. To clearly identify the kind of fluid flowing in the system, color markings are stenciled in the engine room piping's. Piping symbol lists are provided in the finished plan/maker's instruction manuals. Actual sample of piping system is incorporated in this handbook and explained in detailed manner to use as guide during operation. Some of the components may vary depending on the design requirements of the machineries.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Color Identification Plate

System	Piping Color	
Cooling Fresh Water Line	Blue	
Feed Water / Condensate Water Line	Blue	
Fresh Water Line	Light Blue	
Drinking Water Line	Light Blue	
Ballast Water Line	Green	
Fire Fighting Line	Green	
Cooling Sea Water Line and Other Sea Water Line	Green	
F.O. Line	Red	
D.O. Line	Red	
Lubrication Oil Line	Yellow	
Cylinder Oil Line	Yellow	
Compressor Air Line/Control Air Line	Gray	
Bilge Line	Black	
Steam Line	Silver	
Acetylene Line	Brown	
Oxygen Line	Black	
CO2 Fire Extinguishing Line	Pink	

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Symbol List for Piping Machinery Piping Diagram

SYMBOL	NAME	SYMBOL	NAME
	STOP VALVE (GLOBE)		THREE WAY COCK (T-PORT)
	STOP VALVE (ANGLE)		SAFETY VALVE OR RELIEF VALVE (GLOBE)
	SCREW DOWN STOP CHECK VALVE (GLOBE)		SAFETY VALVE OR RELIEF VALVE (ANGLE)
	SCREW DOWN STOP CHECK VALVE (ANGLE)		BIB VALVE
	NEEDLE VALVE (GLOBE)		LOCKED COCK (WITH SCREW END)
	NEEDLE VALVE (ANGLE)		BUTTERFLY VALVE
	LIFT CHECK VALVE (GLOBE)		BUTTERFLY VALVE (WITH HANDLE) ELECTRIC MOTOR DRIVEN
	LIFT CHECK VALVE (ANGLE)		BUTTERFLY VALVE (WITH HANDLE) AIR PISTON OPERATED
	THREE WAY VALVE		BUTTERFLY VALVE (WITH OUT HANDLE) AIR PISTON OPERATED
	HOSE VALVE (GLOBE)		BUTTERFLY VALVE (WITH OUT HANDLE) REMOTE HYDRAULIC OPERATED
	HOSE VALVE (ANGLE)		STOP GLOBE VALVE (WITH HANDLE) AIR PISTON OPERATED
	GATE VALVE		STOP GLOBE VALVE (WITH OUT HANDLE) AIR PISTON OPERATED
	SWING CHECK VALVE OR DUAL PLATE CHECK VALVE		CHECK GLOBE VALVE (WITHOUT HANDLE) AIR PISTON OPERATED
	EMERGENCY SHUT OFF VALVE (REMOTE OPERATED)		STOP ANGLE VALVE (WITH HANDLE) AIR PISTON OPERATED
	SELF CLOSING VALVE		CHECK ANGLE VALVE (WITH HANDLE) AIR PISTON OPERATED
	SELF CLOSING VALVE (BY COUNTER WEIGHT)		THREE-WAY VALVE (WITH HANDLE) AIR PISTON OPERATED
	REGULATING VALVE		THREE-WAY VALVE (WITH OUT HANDLE) AIR PISTON OPERATED
	STORM VALVE		STOP GLOBE VALVE (WITH HANDLE) ELECTRIC MOTOR OPERATED
	COCK		STOP CHECK VALVE (WITH HANDLE) ELECTRIC MOTOR OPERATED
	THREE WAY COCK (L-PORT)		STOP ANGLE VALVE (WITH HANDLE) ELECTRIC MOTOR OPERATED

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

SYMBOL	NAME	SYMBOL	NAME
	CHECK ANGLE VALVE(WITH HANDLE) ELECTRIC MOTOR OPERATED		AIR VENT VALVE
	THREE WAY VALVE (WITH HANDLE)ELECTRIC MOTOR DRIVEN		BALL VALVE
	STOP GLOBE VALVE (SOLENOID DRIVEN)		Y-TYPE STRAINER
	THREE WAY VALVE (SOLENOID DRIVEN)		SIMPLEX STRAINER
	DIAPHRAGM OPERATED VALVE (WITHOUT HANDLE)		DUPLEX STRAINER
	DIAPHRAGM OPERATED VALVE (WITH HANDLE)		MUD BOX
	DIAPHRAGM OPERATED VALVE (WITHOUT HANDLE, WITH POSITIONER)		ROSE BOX
	DIAPHRAGM OPERATED VALVE (WITH HANDLE, WITH POSITIONER)		SEPARATOR
	PRESSURE REDUCING VALVE (DIRECT TYPE)		DRAIN TRAP
	THREE WAY DIAPHRAGM VALVE (WITH HANDLE)		DRAIN TRAP UNIT (WITH BY-PASS VALVE)
	THREE WAY DIAPHRAGM VALVE (WITH HANDLE, WITH POSITIONER)		SPECTACLE FLANGE, Ⓞ: NORMAL OPEN Ⓒ : NORMAL CLOSE
	THREE WAY TEMPERATURE CONTROL VALVE (ROTARY TYPE)		ORIFICE PLATE
	THREE WAY TEMPERATURE CONTROL VALVE (WAX TYPE)		BLANK FLANGE
	NEEDLE VALVE (SCREW OR BITE CONNECTION TYPE)		BELLMOUTH
	COCK (SCREW OR BITE CONNECTION TYPE)		BONNET TYPE AIR PIPE HEAD (WITH WIRE NET)
	GLOBE VALVE (SCREW OR BITE CONNECTION TYPE)		BONNET TYPE AIR PIPE HEAD (WITHOUT WIRE NET)
	SOLENOID VALVE (SCREW OR BITE CONNECTION TYPE)		SOUNDING HEAD WITH SELF-CLOSING VALVE, SAFETY CHECK DEVICE
	THREE WAY SOLENOID VALVE (SCREW OR BITE CONNECTION TYPE)		SOUNDING HEAD WITH CAP
	FOUR WAY SOLENOID VALVE (SCREW OR BITE CONNECTION TYPE)		HOPPER
	BALL CHECK VALVE		HOPPER WITH COVER

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

SYMBOL	NAME	SYMBOL	NAME
	AIR VENT & FILLING HOPPER WITH COVER	TAL	TEMPERATURE ALARM (LOW) REMOTE
	SCUPPER WITH ROSE PLATE	TS	TEMPERATURE SWITCH
	HAND PUMP	P	PRESSURE GAUGE (LOCAL)
	SIGHT GLASS	C	COMPOUND GAUGE (LOCAL)
	EDUCTOR OR EJECTOR	PC	PRESSURE CONTROLLER
	FLAME ARRESTOR	PI	PRESSURE INDICATOR (REMOTE)
	FILTER REGULATOR	PAH	PRESSURE ALARM (HIGH) REMOTE
DT	DRAIN TRAP FOR SEWAGE	PAL	PRESSURE ALARM (LOW) REMOTE
	SEAL POT	PS	PRESSURE SWITCH (WITH TEST COCK)
	NOISE DAMPER OR VOLUME CHAMBER	PD	DIFFERENTIAL PRESSURE GAUGE(LOCAL)
	SLEEVE TYPE EXPANSION JOINT	PDI	DIFFERENTIAL PRESSURE INDICATOR(REMOTE)
	BELLOWS TYPE EXPANSION JOINT	DPS	DIFFERENTILA PRESSURE SWITCH(WITH TEST COCK)
	RUBBER JOINT	FI	FLOW INDICATOR (LOCAL)
	DECK STAND TYPE HANDLE	FI	FLOW INDICATOR (REMOTE)
	EXPANSION JOINT	FAL	FLOW ALARM (LOW) REMOTE
	REDUCER	FLS	FLOW SWITCH
	THERMOMETER POCKET	L	LEVEL GAUGE (LOCAL)
T	THERMOMETER (LOCAL)	LC	LEVEL CONTROLLER
TC	TEMPERATURE CONTROLLER	LI	LEVEL INDICATOR (REMOTE)
TI	TEMPERATURE INDICATOR (REMOTE)	LAH	LEVEL ALARM (HIGH) REMOTE
TAH	TEMPERATURE ALARM (HIGH)	LAL	LEVEL ALARM (LOW) REMOTE

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

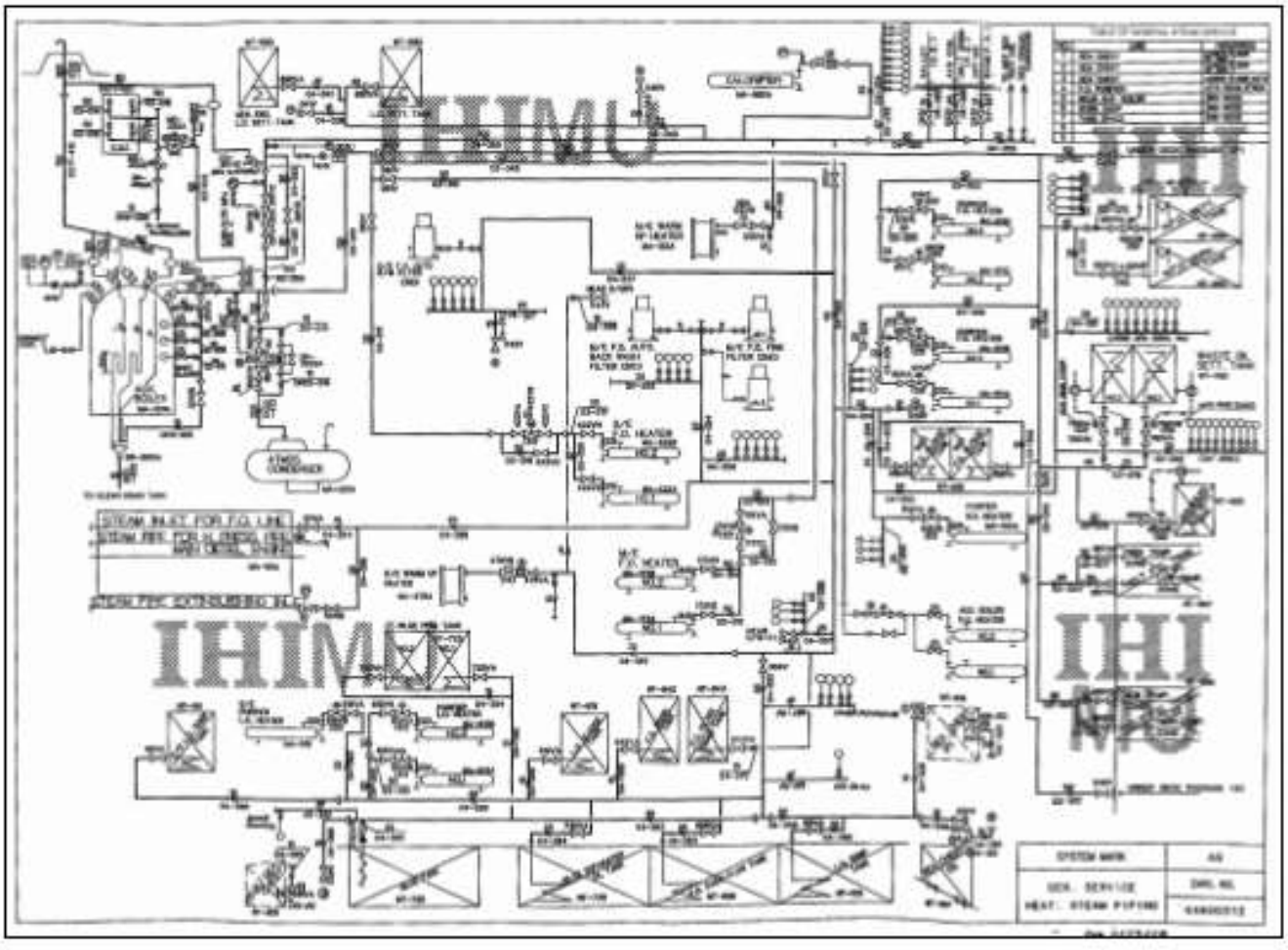
SYMBOL	NAME	SYMBOL	NAME
LSW	LEVEL SWITCH	EP	ELECTRIC/PRESSURE CONVERTER
CR	REMOTE INDICATOR IN ENGINE ROOM		AIR HORN
	TRANSMITTER (WITH TEST COCK)		FLAT TYPE LEVEL GAUGE
WH	REMOTE INDICATOR IN WHEELHOUSE		FLOAT TYPE LEVEL GAUGE
	LOCAL INDICATOR		OUTER FLOAT TYPE LEVEL GAUGE
VI	VISCOSITY INDICATOR (LOCAL)	U	ULLAGE STAND
VC	VISCOSITY CONTROLLER (LOCAL)	LS	LIMIT SWITCH
VI	VISCOSITY INDICATOR (REMOTE)		SWITCH OR SELECTOR (WITH TEST COCK)
VAH	VISCOSITY ALARM (HIGH) REMOTE		FLOW DIRECTION
VAL	VISCOSITY ALARM (LOW) REMOTE		HULL DISTANCE PIECE
BC	REMOTE INDICATOR IN BALLAST CONTROL CONSOLE		PENETRATING PIECE
HY	HYDRAZINE DETECTOR OR METER		FLANGED JOINT
PH	Ph DETECTOR OR METER		CONNECTED CROSSING PIPES
μU	CONDUCTIVITY DETECTOR OR METER		SCREWED OR UNION TYPE JOINT
SM	SMOKE DETECTOR	FS	FLOAT SWITCH
SMA LSB	SMOKE ALARM (HIGH)IN LOCAL GAUGE BOARD	F	FLAT END TYPE OR SLIP-ON FLANGE
O2	O2 METER		OIL TRAY OR COAMING
O2A LSB	02 ALARM HIGH IN LOCAL GAUGE BOARD		AIR VENT PIPE (WITHOUT WIRE NET)
O2I LSB	O2 INDICATOR IN LOCAL GAUGE BOARD		FUSIBLE PLUG
CO2	CO2 METER		BLANK PLATE
OM	OIL CONTENT METER		NOT CONNECTED CROSSING PIPE
OMH	OIL CONTENT ALARM (HIGH)		SYPHONE
OCS	OIL CONTENT SWITCH	SB	SOOT BLOWER

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

8.2. Understanding Piping Diagram

In any emergency situation onboard regarding machinery in the engine room, we always take a look at the piping diagram to plan the course of action.
Also, when we join a ship, one of the first things we do is study the piping diagram to familiarize ourselves with the layout of different systems on board. Therefore, understanding piping diagrams is very important for us as engineers to carry out our job properly. We will discuss piping diagrams in detailed manner in the following section to get a deep understanding of these systems.

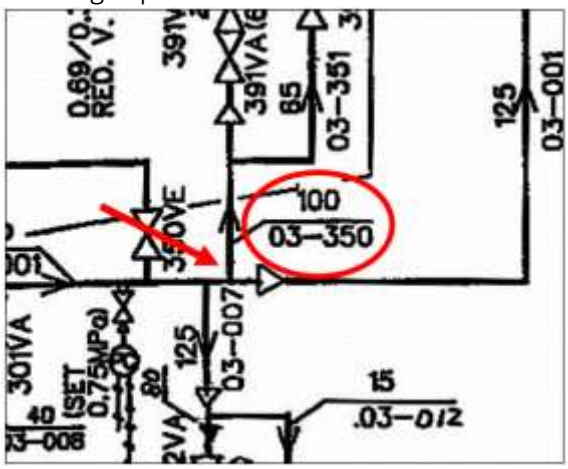
Consider the following diagram which refers to part of General Service Heating Steam Piping System. The arrow indicates that there is a leak in that location. The next question is what kind of pipe are we going to use to replace it and what is its size. Based on the numbers mentioned within the circle, we can find out the details and particulars of the pipe so that a replacement can be made.



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

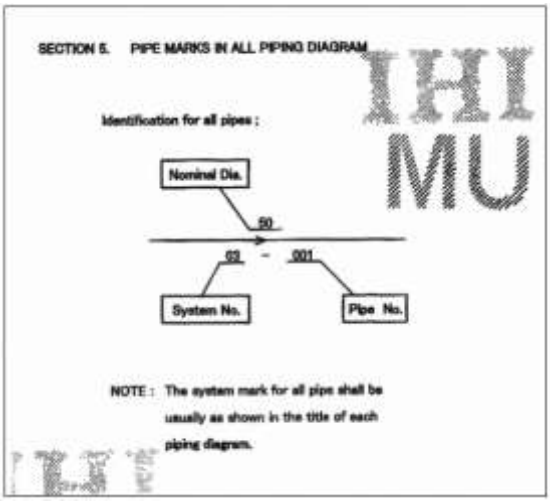
UPGRADING TRAINING FOR OILERS/WIPERS

Let us take note of the numbers in the circle: We have 100 on the top, 03 in the bottom left position and 350 in the bottom right position.



In the below diagram known as Pipe Marks in All Piping Diagram, we see that the top number indicates the nominal diameter, lower left number indicated system number and lower right indicates pipe number.

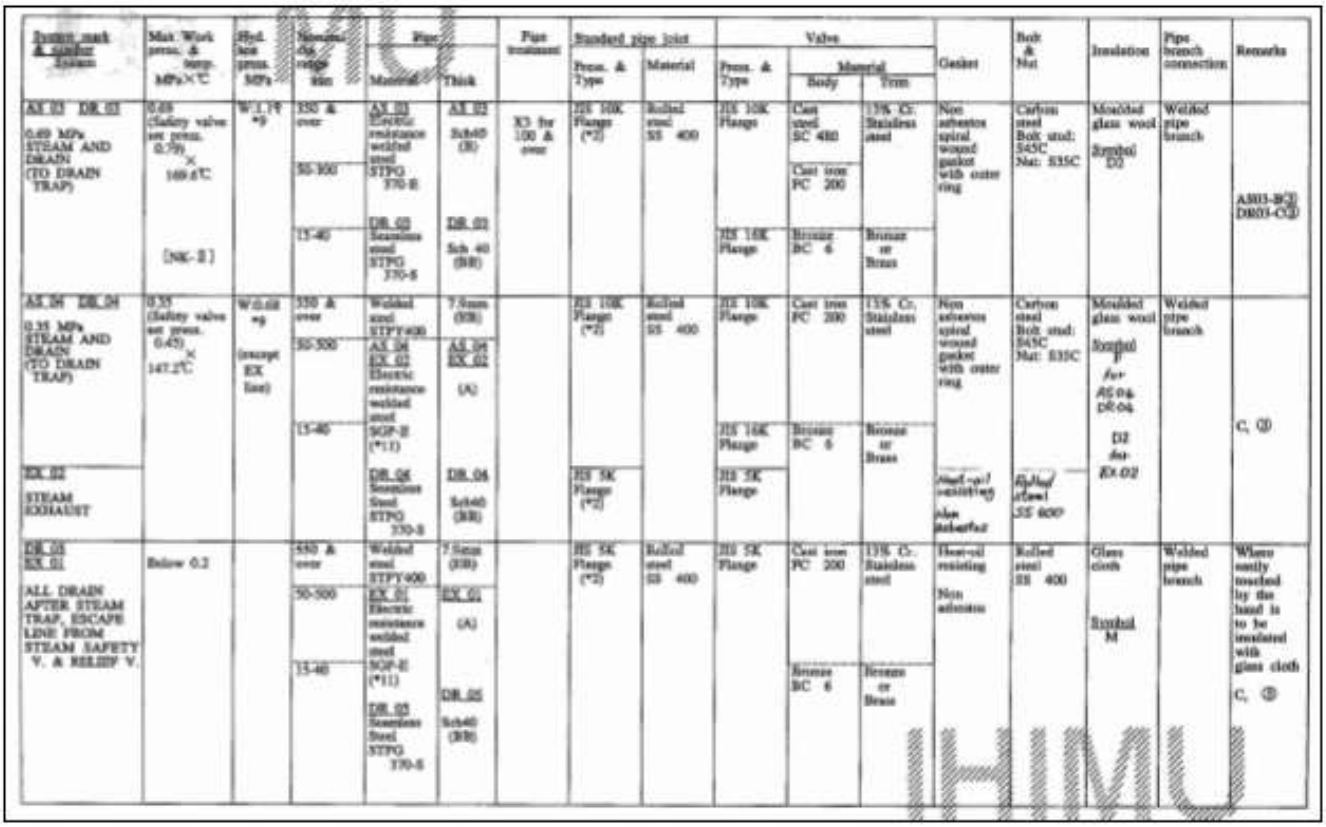
SYSTEM MARK	AS
GEN. SERVICE	DWG. NO.
HEAT. STEAM PIPING	K4600312



So this means that the pipe we are referring to have a nominal diameter of 100 mm, system number 03 and pipe number 350. The pipe number is used for reference purposes of the ship builder.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

The next question that arises is how much is the thickness of the pipe and what is its inner and outer diameter. This information can be gathered with reference to the below schedule of piping in machinery space. The system mark AS is a useful reference to determine more information on the pipe from the table.



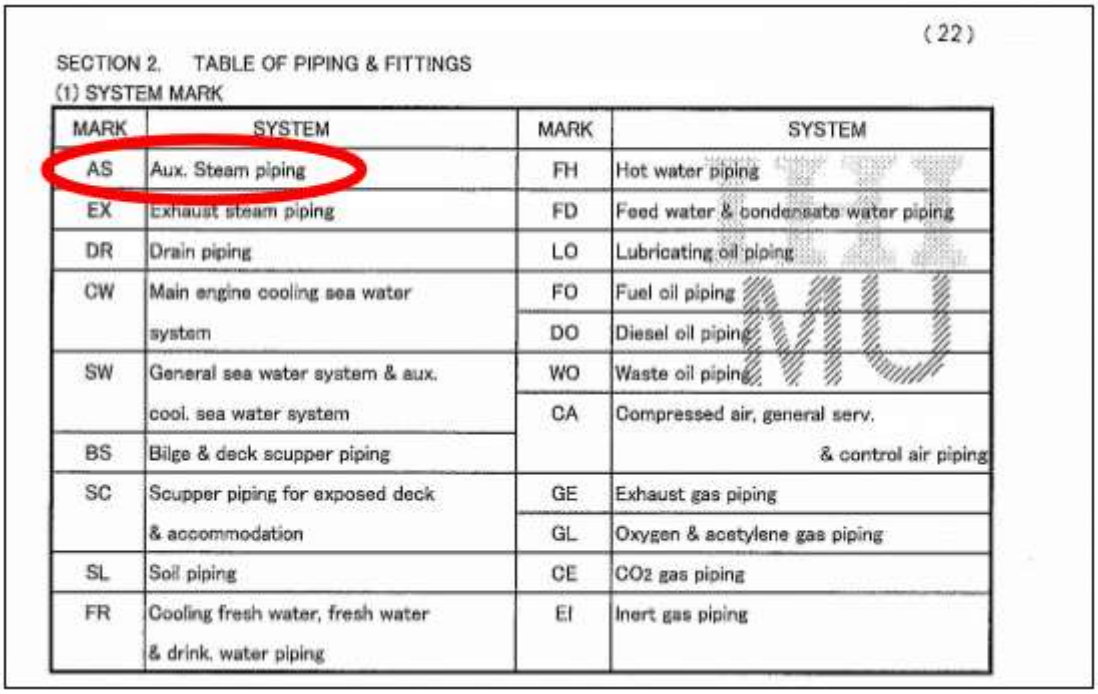
System mark & number System	Max Work press. & temp. MPa×℃	Hyd. test press. MPa	Nominal dia. range mm	Pipe Material	Pipe Thick	Pipe treatment	Standard pipe joint Press. & Type	Standard pipe joint Material
AS 03 DR 03 0.69 MPa STEAM AND DRAIN (TO DRAIN TRAP)	0.69 (Safety valve set press. 0.79) × 169.6℃ [NK-Ⅱ]	W:1.19 *9	350 & over 50-300 15-40	AS 03 Electric resistance welded steel STPG 370-E DR 03 Seamless steel STPG 370-S	AS 03 Sch40 (B) DR 03 Sch 40 (BB)	X3 for 100 & over	JIS 10K Flange (*2)	Rolled steel SS 400

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

UPGRADING TRAINING FOR OILERS/WIPERS

The system mark is actually the categorization of piping in machinery spaces into groups according to their specific function.

We see from the below table that AS refers to Auxiliary Steam Piping. One can see other system marks that designate other groups of pipelines depending on their function, such as EX for exhaust steam piping and DR for drain piping.

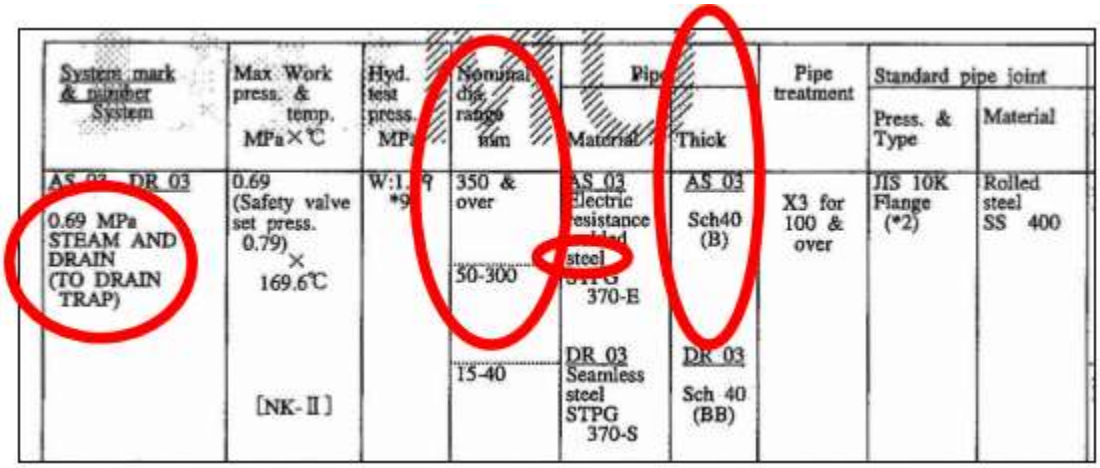


(22)

SECTION 2. TABLE OF PIPING & FITTINGS

(1) SYSTEM MARK

MARK	SYSTEM	MARK	SYSTEM
AS	Aux. Steam piping	FH	Hot water piping
EX	Exhaust steam piping	FD	Feed water & condensate water piping
DR	Drain piping	LO	Lubricating oil piping
CW	Main engine cooling sea water system	FO	Fuel oil piping
		DO	Diesel oil piping
SW	General sea water system & aux. cool. sea water system	WO	Waste oil piping
		CA	Compressed air, general serv. & control air piping
BS	Bilge & deck scupper piping		
SC	Scupper piping for exposed deck & accommodation	GE	Exhaust gas piping
		GL	Oxygen & acetylene gas piping
SL	Soil piping	CE	CO_2 gas piping
FR	Cooling fresh water, fresh water & drink. water piping	EI	Inert gas piping



System mark & number System	Max. Work press. & temp. MPa×℃	Hyd. test press. MPa	Nominal dia. range mm	Pipe Material	Pipe Thick	Pipe treatment	Standard pipe joint Press. & Type	Standard pipe joint Material
AS 03 DR 03 0.69 MPa STEAM AND DRAIN (TO DRAIN TRAP)	0.69 (Safety valve set press. 0.79) × 169.6℃ [NK-Ⅱ]	W:1.9 *9	350 & over	AS 03 Electric resistance welded steel STPG 370-E	AS 03 Sch40 (B)	X3 for 100 & over	JIS 10K Flange (*2)	Rolled steel SS 400
			50-300					
			15-40	DR 03 Seamless steel STPG 370-S	DR 03 Sch 40 (BB)			

The pipe in question belongs to the auxiliary steam system, particularly referring to 0.69 MPa steam line. Since the pipe is 100 mm nominal diameter, it falls under the 50-300 mm range mentioned in the table. The material is steel and of Schedule 40 (B) thickness.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

12.4 DIMENSIONS AND MATERIALS OF PIPES

12.4.1 Steel Pipes

Dimensions

Nominal Diameter mm	Outside Diameter mm	Wall Thickness mm						
		A	Sch.40 B,BB,SB	BC	Sch.80 C,CC	SC	Sch.120 SD	Sch.160 SE
6	10.5			1.0		2.4		
10	17.3			1.0		3.2		
15	21.7	2.8	2.8		3.7	3.7		4.7
20	27.2	2.8	2.9		3.9	3.9		5.5
25	34.0	3.2	3.4		4.5	4.5		6.4
32	42.7	3.5	3.6		4.9	4.9		6.4
40	48.6	3.5	3.7		5.1	5.1		7.1
50	60.5	3.8	3.9		5.5	5.5		8.7
65	76.3	4.2	5.2		7.0	7.0		9.5
[illegible]	[illegible]	4.2	[illegible]		7.6	7.6		11.1
100	114.3	4.5	6.0		8.6	8.6	11.1	
125	139.8	4.5	6.6		9.5	9.5	12.7	
150	165.2	5.0	7.1		11.0	11.0	14.3	
200	216.3	5.8	8.2		12.7	12.7	18.2	
250	267.4	6.6	9.3			15.1	21.4	
300	318.5	6.9	10.3			17.4	25.4	

Since the nominal diameter of the pipe is 100 mm, it corresponds to an outer diameter of 114.3 mm. Also, the wall thickness corresponds to schedule 40 (B) which indicated a thickness of 6.0 mm.

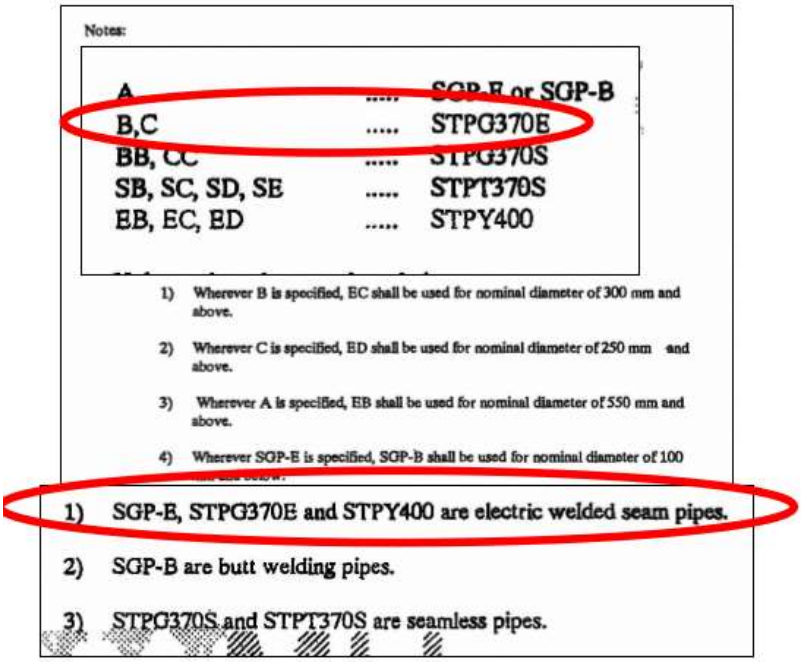
Further, we are able to determine the characteristics of the pipe from the table such as details of its material and construction as well as pipe treatment it has received. In this case, pipe material is STPG 370-E and pipe treatment is designated as X3.

System mark & number System	Max. Work press. & temp. MPa×℃	Hyd. test press. MPa	Nominal dia. range mm	Pipe		Pipe treatment	Standard pipe joint	
				Material	Thick		Press. & Type	Material
AS 03 DR 03 0.69 MPa STEAM AND DRAIN (TO DRAIN TRAP)	0.69 (Safety valve set press. 0.79) × 169.6℃ [NK-II]	W:1.19 *9	350 & over	AS 03 Electric resistance welded steel STPG 370-E	AS 03 Sch40 (B)	X3 for 100 & over	JIS 10K Flange (*2)	Rolled steel SS 400
			50-300					
			15-40	DR 03 Seamless steel STPG 370-S	DR 03 Sch 40 (BB)			

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

UPGRADING TRAINING FOR OILERS/WIPERS

It can be seen from the below table that STPG 370-E refers to electric welded seam pipes and schedule for the pipe is B.



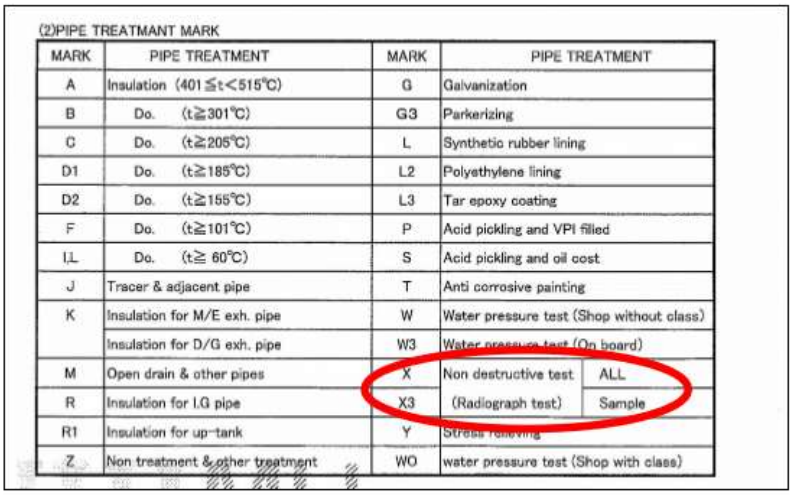
Notes:

A	.....	SGP-E or SGP-B
B,C	.....	STPG370E
BB, CC	.....	STPG370S
SB, SC, SD, SE	.....	STPT370S
EB, EC, ED	.....	STPY400

1) Wherever B is specified, EC shall be used for nominal diameter of 300 mm and above.
2) Wherever C is specified, ED shall be used for nominal diameter of 250 mm and above.
3) Wherever A is specified, EB shall be used for nominal diameter of 550 mm and above.
4) Wherever SGP-E is specified, SGP-B shall be used for nominal diameter of 100

1) SGP-E, STPG370E and STPY400 are electric welded seam pipes.
2) SGP-B are butt welding pipes.
3) STPG370S and STPT370S are seamless pipes.

Pipe treatment X3 means that the pipe in question has been subjected to Non Destructive Testing (NDT) specifically the radiography test.



(2)PIPE TREATMANT MARK

MARK	PIPE TREATMENT	MARK	PIPE TREATMENT	
A	Insulation (401≦t<515℃)	G	Galvanization	
B	Do. (t≧301℃)	G3	Parkerizing	
C	Do. (t≧205℃)	L	Synthetic rubber lining	
D1	Do. (t≧185℃)	L2	Polyathylene lining	
D2	Do. (t≧155℃)	L3	Tar epoxy coating	
F	Do. (t≧101℃)	P	Acid pickling and VPI filled	
I,L	Do. (t≧ 60℃)	S	Acid pickling and oil cost	
J	Tracer & adjacent pipe	T	Anti corrosive painting	
K	Insulation for M/E exh. pipe	W	Water pressure test (Shop without class)	
	Insulation for D/G exh. pipe	W3	Water pressure test (On board)	
M	Open drain & other pipes	X	Non destructive test	ALL
R	Insulation for I.G pipe	X3	(Radiograph test)	Sample
R1	Insulation for up-tank	Y	Stress relieving	
Z	Non treatment & other treatment	WO	water pressure test (Shop with class)	

The next part of the pipe that we must understand is the pipe joint. As the below table indicates, the pipe has a pipe joint in which the rating is 10K (pressure rating) and has a material of steel also. Since the nominal diameter of pipe is 100 mm, the flange we are using is 10K100.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

System mark & number System	Max. Work press. & temp. MPa×℃	Hyd. test press. MPa	Nominal dia. range mm	Pipe Material	Pipe Thick	Pipe treatment	Standard pipe joint Press. & Type	Standard pipe joint Material
AS 03 DR 03 0.69 MPa STEAM AND DRAIN (TO DRAIN TRAP)	0.69 (Safety valve set press. 0.79) × 169.6℃ [NK-Ⅱ]	W:1.19 *9	350 & over	AS 03 Electric resistance welded steel STPG 370-E	AS 03 Sch40 (B)	X3 fo 100 & over	JIS 10K Flange (*2)	Rolled steel SS 400
			50-300					
			15-40	DR 03 Seamless steel STPG 370-S	DR 03 Sch 40 (BB)			

Flange size : 10k 100

To summarize, if we had an accidental leak on this pipeline, we can easily find the correct and exact replacement based on the data we have gathered.

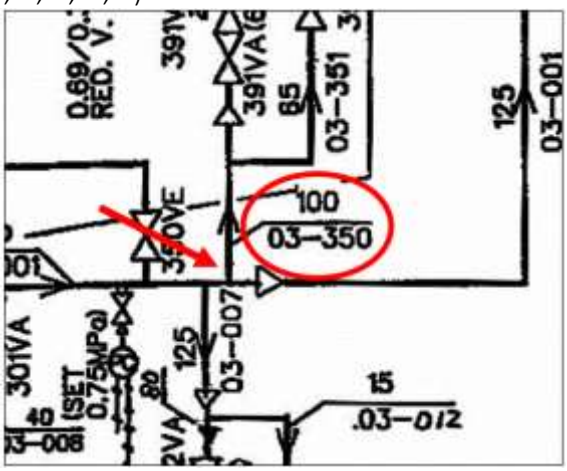
The pipe has a nominal diameter of 100 mm, belongs to the Auxiliary Steam Piping specifically 0.69 MPa steam piping, System No. 03, material steel, electric welded seam pipe, of outer diameter of 114.3 mm, wall thickness of 6 mm, passed NDT test, flanged joint with a 10K100 size flange.

Let us look at the possibility of replacement of valves on this piping. We need to determine the specification of the valve that requires replacement.

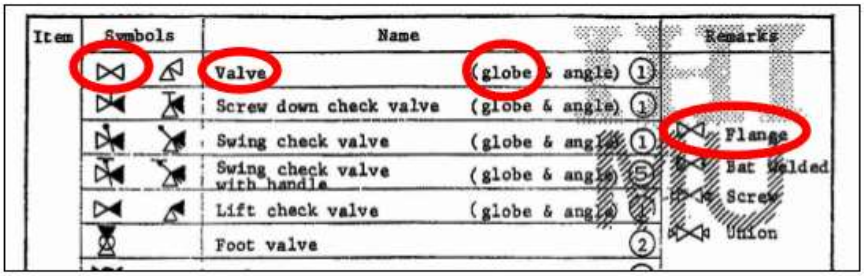
The procedure that we used for determining the specification of pipe is the same for determining that of the valve.

The valve also belongs to the Auxiliary Steam Piping, has a System Mark of AS and System Number 03.

As seen in the diagram, the valve has a connotation of 350VE. 350 refers to the pipeline number of the pipe to which the valve belongs. V indicates that the component is a valve and E means that it is the 5th valve in the line (A, B, C, D, E).



The valve is a globe valve with a flanged connection.



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

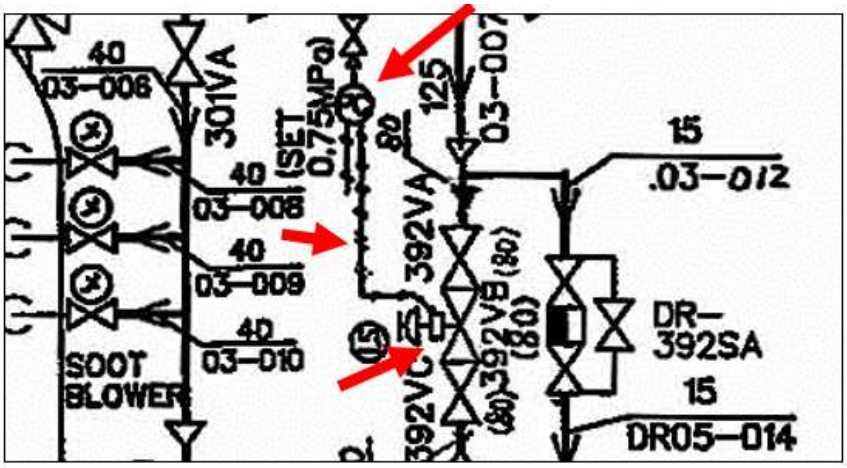
UPGRADING TRAINING FOR OILERS/WIPERS

Regarding the material of the valve, the body is made up of cast iron, with trim constructed of 13% Cr stainless steel. The gasket used is non-asbestos spiral wound gasket with outer ring, bolt & nuts made of carbon steel and insulation of molded glass wool.

Press. & Type	Valve: Material: Body	Valve: Material: Trim	Gasket	Bolt & Nut	Insulation	Pipe branch connection	Remarks
JIS 10K Flange	Cast steel SC 480	13% Cr. Stainless steel	Non asbestos spiral wound gasket with outer ring	Carbon steel Bolt stud: S45C Nut: S35C	Moulded glass wool Symbol D2	Welded pipe branch	AS03-B③ DR03-C③
	Cast iron FC 200						
JIS 16K Flange	Bronze BC 6	Bronze or Brass					

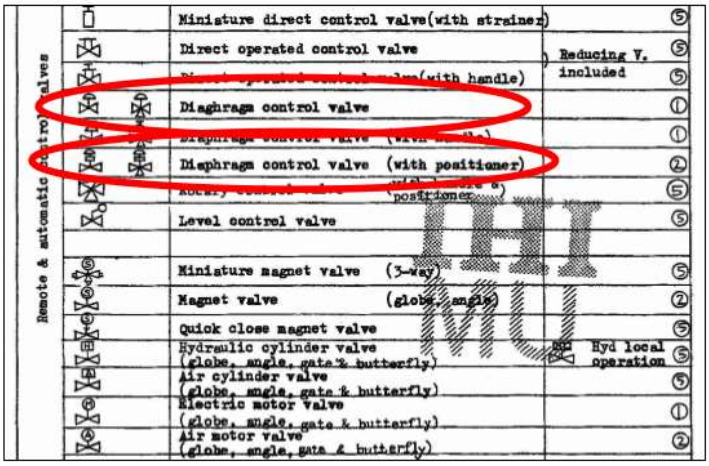
There are different types of valves in piping systems. Each valve symbol is depicted in reference tables shown in the instruction manual. It is possible to read and understand the meaning of each part of the piping diagram by referring to these tables.

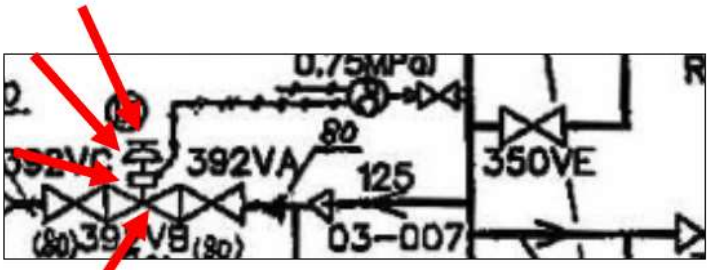
The below diagram shows a globe valve, flange connected, with additional fittings indicated by first arrow, attached to the pipeline indicated by second arrow and finally connected to the symbol indicated by third arrow.



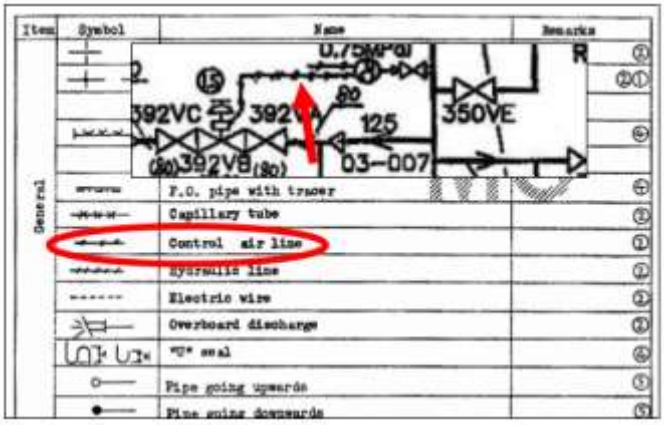
We must refer to the table below to determine the exact nature of valve being considered.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

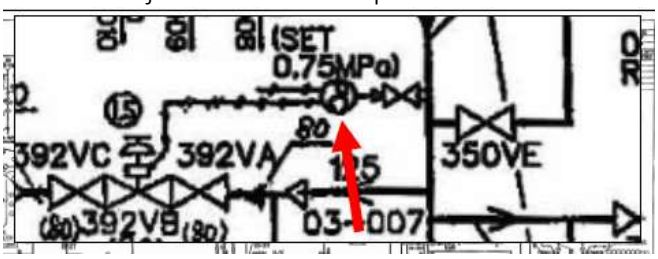




We are referring to a globe valve which is diaphragm operated with a positioner and a handle. The line shown is a control airline used to operate the valve via the diaphragm.

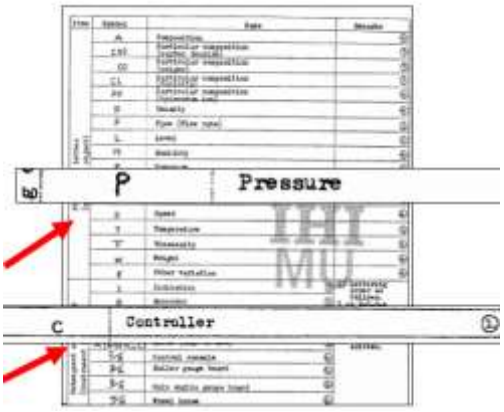


The symbol shown below is a circle with the letters P & C mentioned inside. Additionally, the figures SET 0.75 MPa is mentioned adjacent to the component.

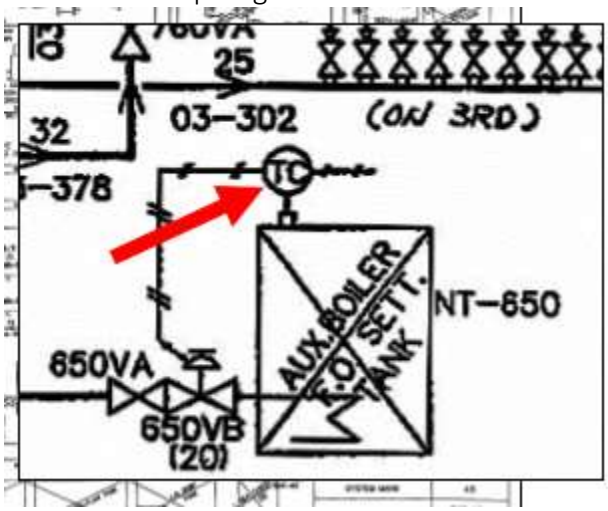


Referring to the below table, we see that P refers to Pressure and C refers to Controller. Hence, we are referring to a pressure controller whose set point if 0.75 MPa.

The controller sends out a compressed air signal via the control airline to the diaphragm controlled valve with a positioner.



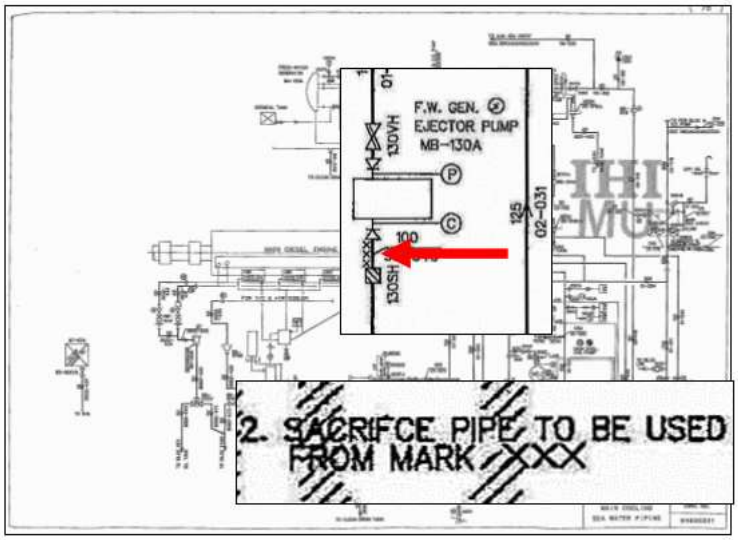
The diagram below shows another controller that is temperature controlled. The valve gets a signal from the temperature of the tank and then controls the steam valve opening for heating the tank. The valve is a globe valve which is diaphragm controlled and with a handle.



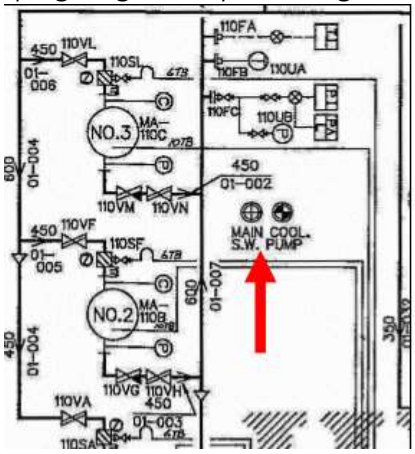
One important aspect of sea water pipes is the use of sacrificial pipes. Sacrificial pipes are clearly indicated on piping diagram of sea water systems. Piping diagrams may therefore be used to determine the exact location of these sacrificial pipes even if the actual pipes are not clearly visible in the engine room or are painted over in the same color as other pipes.

It is important for us to locate and identify these pipes because they require closer monitoring than other pipes that they protect.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00



Other information that may be determined from symbols on piping diagrams include the two symbols shown against the main cooling sea water pumps. We can easily determine the meaning of these and other symbols shown in piping diagrams by referring to the respective table.



Therefore we see from the below table that the symbols refer to automatic start and stop as well as automatic change of pump. This function is activated by a pressure switch attached to the main cooling sea water line which can be confirmed from the diagram itself and from the starter panel of the pump.

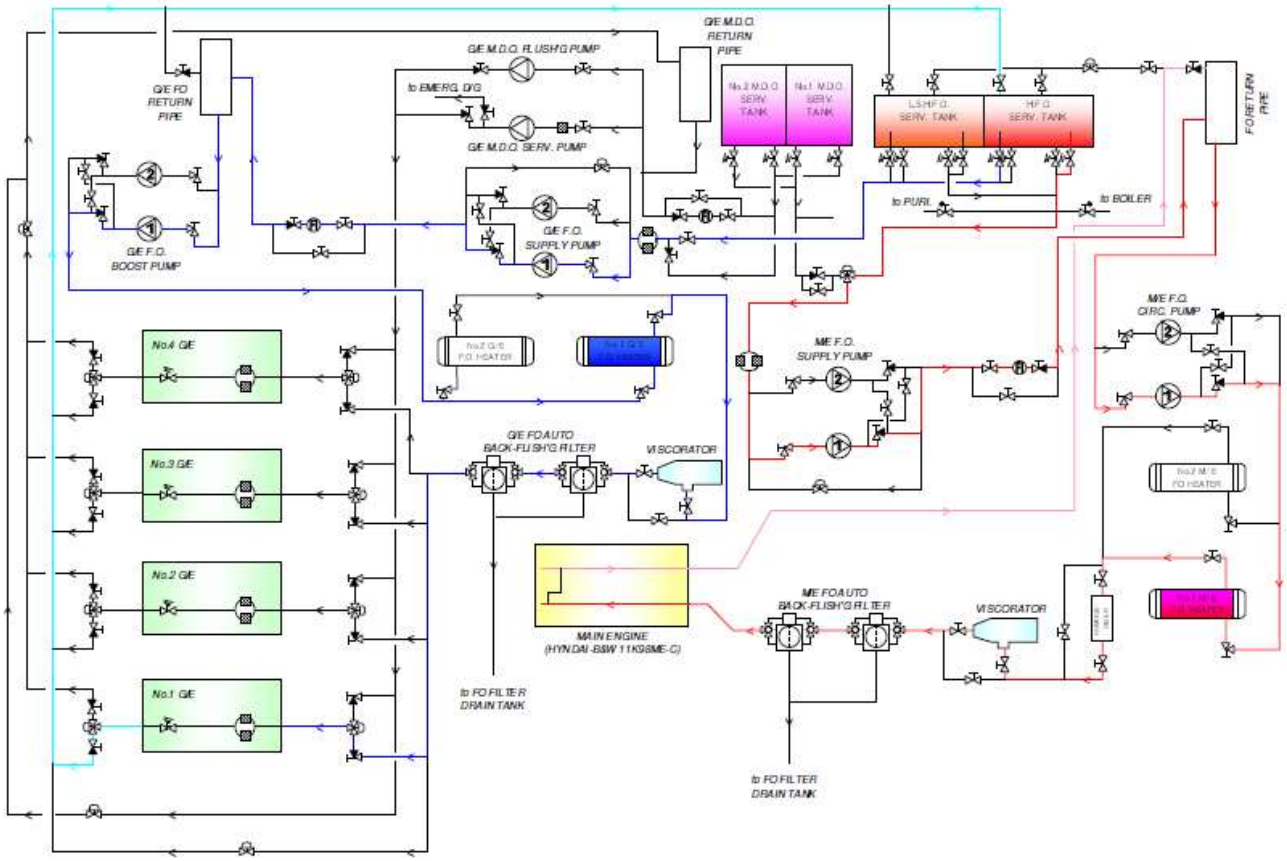
Item	Symbol	Name	Remarks
Pump marks		Remote start & stop	
		Remote start	
		Remote stop	
		Automatic start & stop	
		Automatic start	
		Automatic stop	
		Automatic change	

MAIN COOL. S.W. PUMP

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

8.3. Marine Engine Plant System

8.3.1. Fuel Oil System



The fuel oil system for a diesel engine

Internal combustion engine procedure

The fuel oil system for a diesel engine can be considered in two parts—the fuel supply and the fuel injection systems. Fuel supply deals with the provision of fuel oil suitable for use by the injection system.

Fuel oil supply for a two-stroke diesel engine

Slow-speed two-stroke diesel is usually arranged to operate continuously on heavy fuel and have available a diesel oil supply for maneuvering conditions.

In the system shown in above, the oil is stored in tanks in the double bottom from which it is pumped to a settling tank and heated. After passing through centrifuges the cleaned, heated oil is pumped to a daily service tank. From the daily service tank the oil flows through a three-way valve to a mixing tank. A flow meter is fitted into the system to indicate fuel consumption. Booster pumps are used to pump the oil through heaters and a viscosity regulator to the engine-driven fuel pumps. The fuel pumps will discharge high-pressure fuel to their respective injectors.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

The viscosity regulator controls the fuel oil temperature in order to provide the correct viscosity for combustion. A pressure regulating valve ensures a constant-pressure supply to the engine-driven pumps, and a pre-warming bypass is used to heat up the fuel before starting the engine.

A diesel oil daily service tank may be installed and is connected to the system via a three-way valve. The engine can be started up and maneuvered on diesel oil or even a blend of diesel and heavy fuel oil. The mixing tank is used to collect recirculated oil and also acts as a buffer or reserve tank as it will supply fuel when the daily service tank is empty.

The system includes various safety devices such as low-level alarms and remotely operated tank outlet valves which can be closed in the event of a fire.

Operation on Heavy Fuel Oil

Main engines designed to maneuver on heavy fuel oil are to be operated according to the manufacturer's instructions. All other types of main engines are to be maneuver on diesel oil according to the manufacturers' instructions.

In the event of problems during maneuvering on engines using heavy oil there must be no hesitation in changing over to diesel oil irrespective of whether the engines are being operated using bridge control, or using engine room control.

It is the Chief Engineer's responsibility to inform the Master of the particular engine type's maximum period that it can safely remain in the stopped position. He is also to inform the Master of the procedures which will have to be carried out if the particular engine type's maximum period at standstill during maneuvering is exceeded.

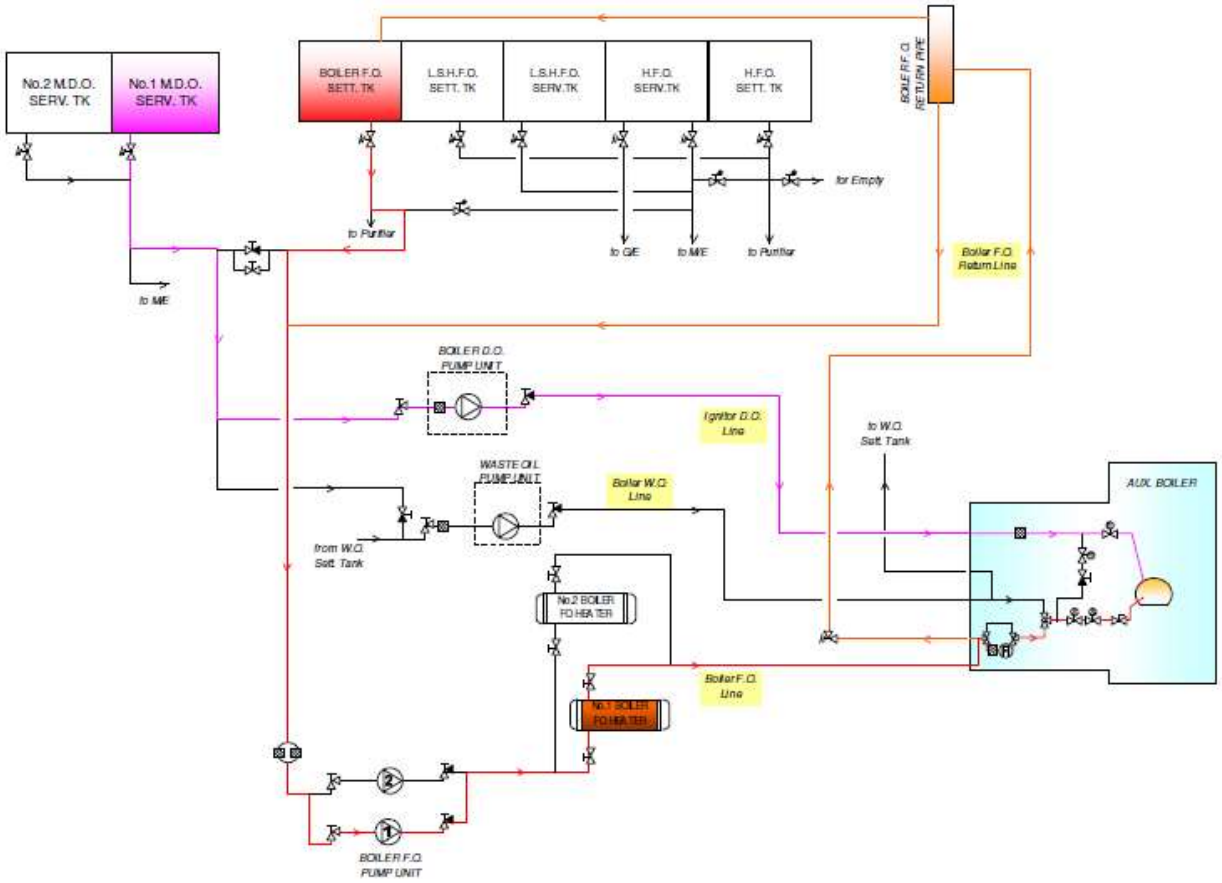
Fuel injection

The function of the fuel injection system is to provide the right amount of fuel at the right moment and in a suitable condition for the combustion process. There must therefore be some form of measured fuel supply, a means of timing the delivery and the atomization of the fuel. The injection of the fuel is achieved by the location of cams on a camshaft. This camshaft rotates at engine speed for a two-stroke engine and at half engine speed for a four-stroke. There are two basic systems in use, each of which employs a combination of mechanical and hydraulic operations. The most common system is the jerk pump; the other is the common rail.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

UPGRADING TRAINING FOR OILERS/WIPERS

Boiler and incinerator Fuel Oil Service System



Marine boiler fuel oil supply system

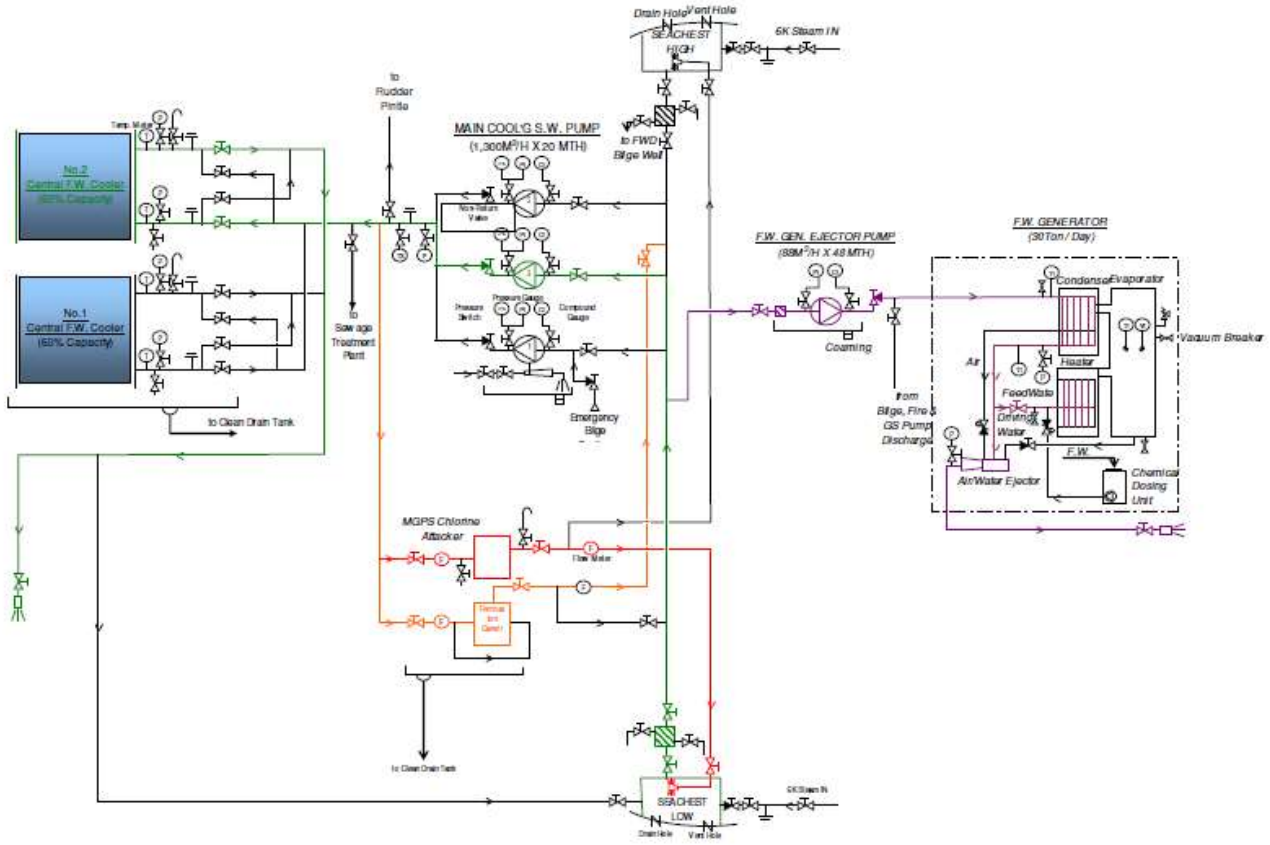
Marine boilers currently burn residual low-grade fuels. This fuel is stored in double-bottom tanks from which it is drawn by a transfer pump up to settling tanks. Here any water in the fuel may settle out and be drained away.

The oil from the settling tank is filtered and pumped to a heater and then through a fine filter. Heating the oil reduces its viscosity and makes it easier to pump and filter. This heating must be carefully controlled otherwise 'cracking' or breakdown of the fuel may take place. A supply of diesel fuel may be available to the burners for initial firing or low-power operation of the boiler.

From the fine filter the oil passes to the burner where it is 'atomised', i.e. broken into tiny droplets, as it enters the furnace. A recirculating line is provided to enable initial heating of the oil.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

8.3.2. Cooling Sea Water System



Cooling of ships engine - how it works , requirement of fresh water & sea water cooling system

Cooling of engines is achieved by circulating a cooling liquid around internal passages within the engine. The cooling liquid is thus heated up and is in turn cooled by a sea water circulated cooler. Without adequate cooling certain parts of the engine which are exposed to very high temperatures, as a result of burning fuel, would soon fail.

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

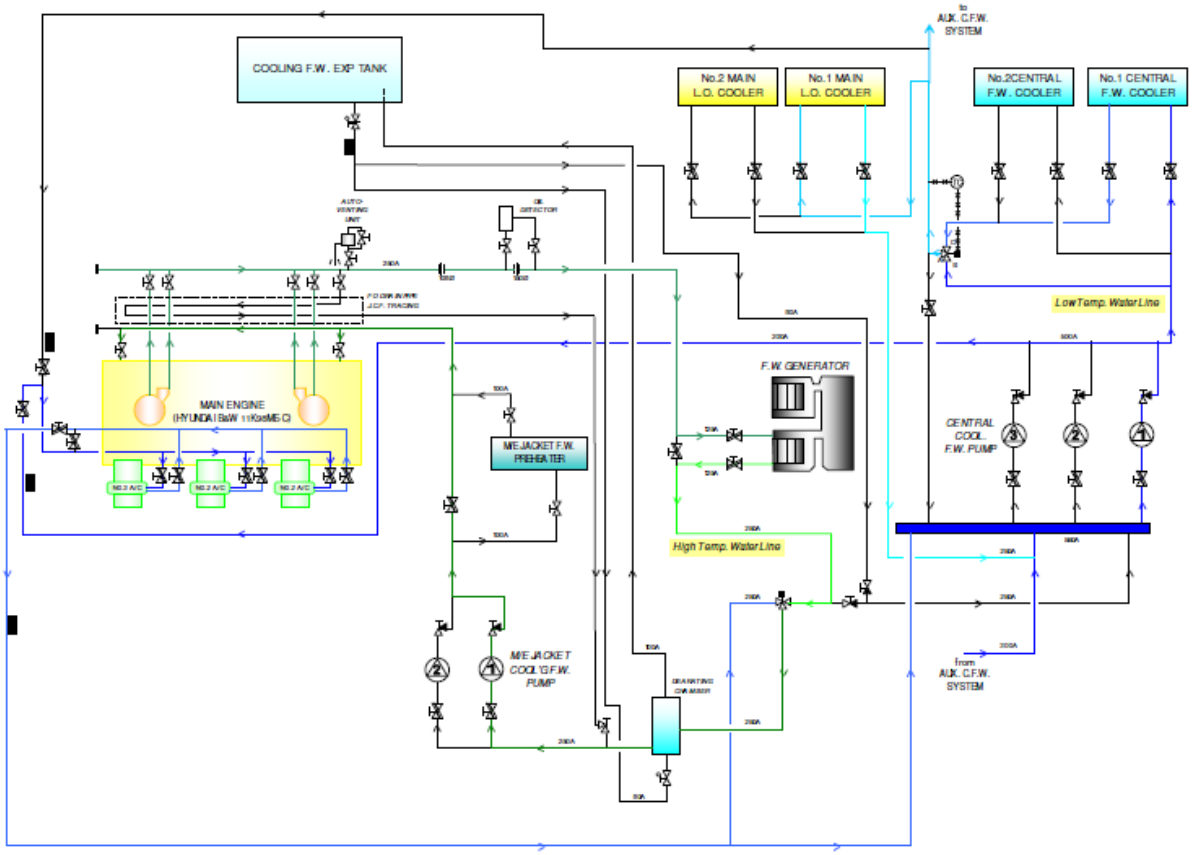
Sea water cooling system

The various cooling liquids which circulate the engine are themselves cooled by sea water. The usual arrangement uses individual coolers for lubricating oil, jacket water, and the piston cooling system, each cooler being circulated by sea water. Some modern ships use what is known as a 'central cooling system' with only one large sea-water-circulated cooler. This cools a supply of fresh water, which then

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

circulates to the other Individual coolers. With less equipment in contact with sea water the corrosion problems are much reduced in this system.

8.3.3 Cooling Fresh Water System

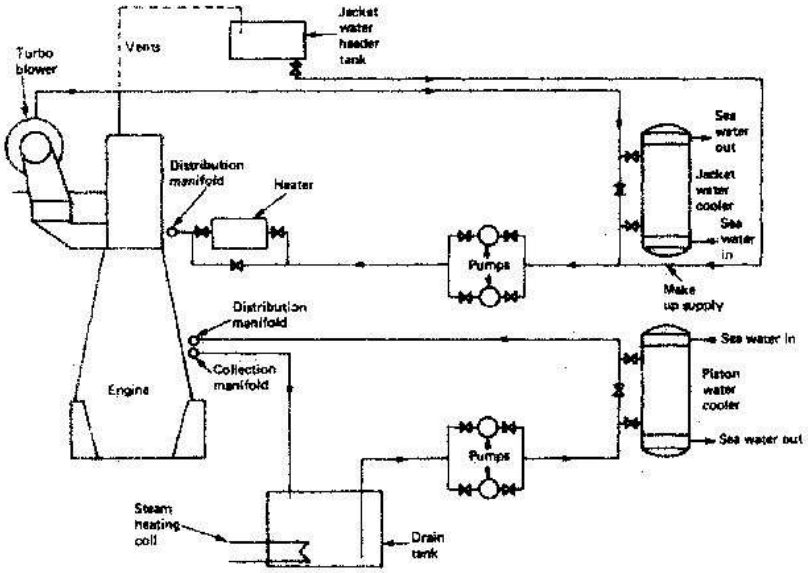


Fresh water cooling system

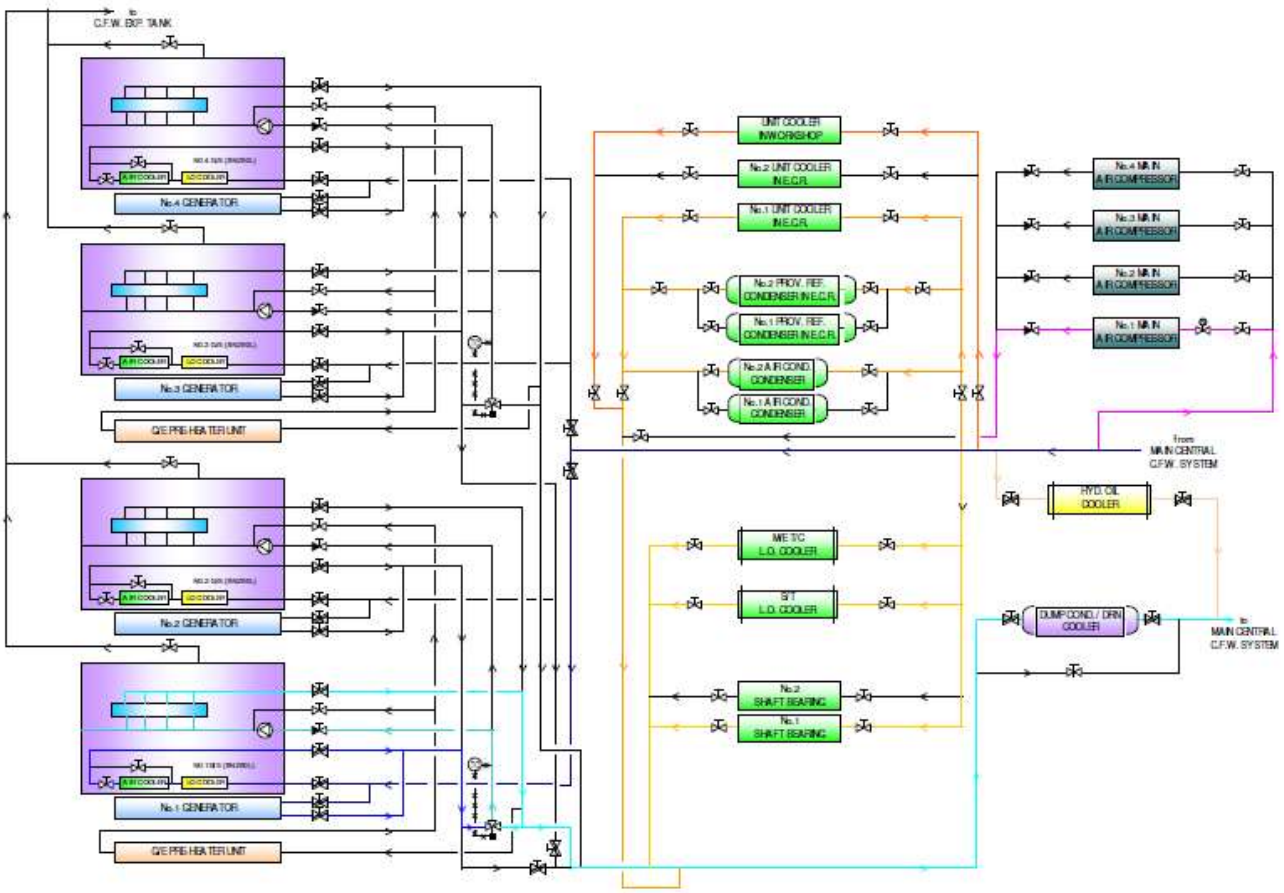
A water cooling system for a slow-speed diesel engine is shown in Figure . It is divided into two separate systems: one for cooling the cylinder jackets, cylinder heads and turbo-blowers; the other for piston cooling.

The cylinder jacket cooling water after leaving the engine passes to a sea-water-circulated cooler and then into the jacket-water circulating pumps. It is then pumped around the cylinder jackets, cylinder heads and turbo-blowers. A header tank allows for expansion and water make-up in the system. Vents are led from the engine to the header tank for the release of air from the cooling water. A heater in the circuit facilitates warming of the engine prior to starting by circulating hot water.

The piston cooling system employs similar components, except that a drain tank is used instead of a header tank and the vents are then led to high points in the machinery space. A separate piston cooling system is used to limit any contamination from piston cooling glands to the piston cooling system only.



8.3.3.1 Auxiliary Central Cooling Fresh Water System



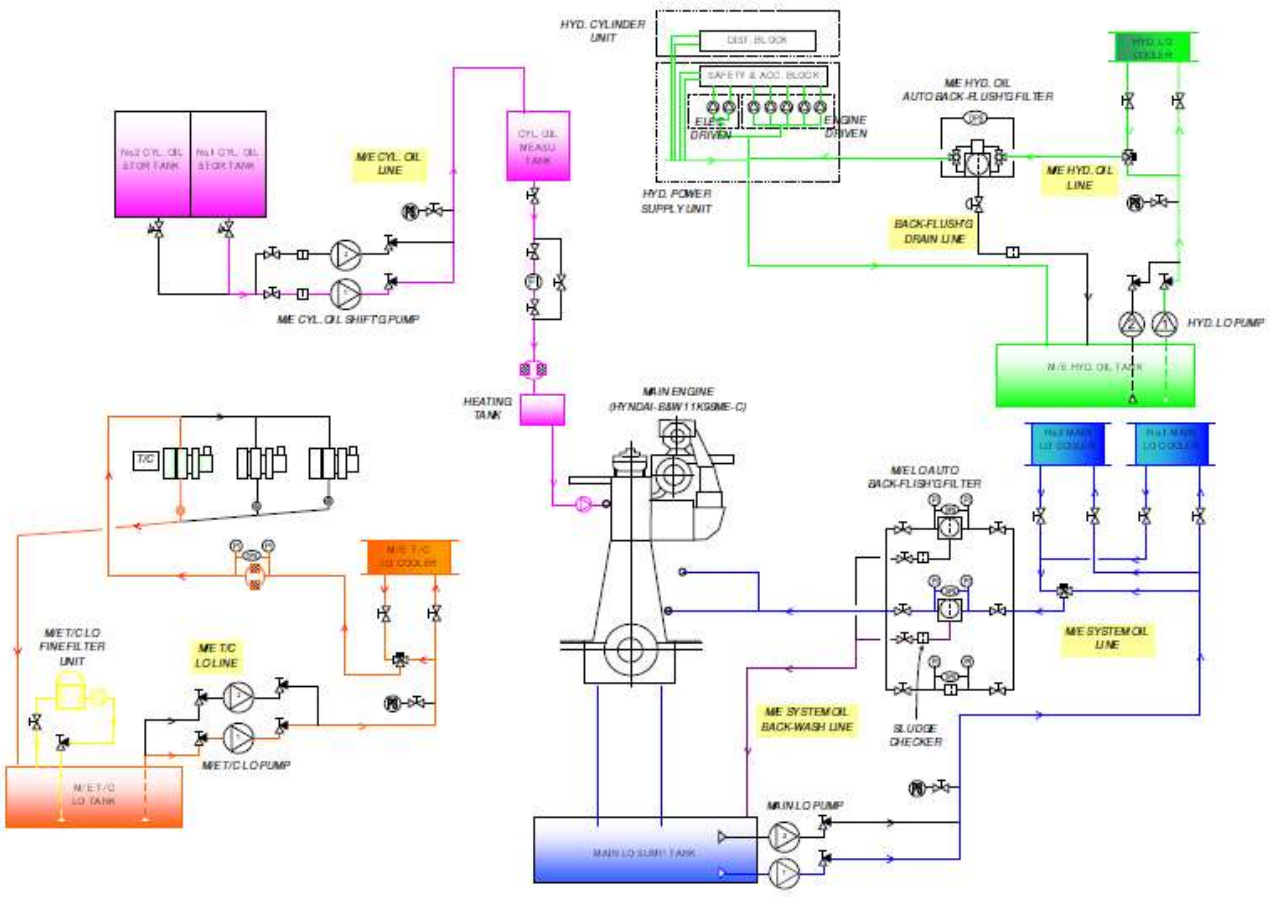
Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

Central cooling system

In a central cooling system the sea water circuit is made up of high and low suctions, usually on either side of the machinery space, suction strainers and several sea water pumps. The sea water is circulated through the central coolers and then discharged overboard.

A low-temperature and high-temperature circuit exist in the fresh water system. The fresh water in the high-temperature circuit circulates the main engine and may, if required, be used as a heating medium for an evaporator. The low-temperature circuit circulates the main engine air coolers, the lubricating oil coolers and all other heat exchangers. A regulating valve controls the mixing of water between the high-temperature and low-temperature circuits.

8.3.4 Lubricating Oil System (Main Engine)



Lubricating oil system for a marine diesel engine - how it works

Function of lubrication: The lubrication system of an engine provides a supply of lubricating oil to the various moving parts in the engine. Its main function is to enable the formation of a film of oil between

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

the moving parts, which reduces friction and wear. The lubricating oil is also used as a cleaner and in some engines as a coolant.

Lubricating oil system

Lubricating oil for an engine is stored in the bottom of the crankcase, known as the sump, or in a drain tank located beneath the engine. The oil is drawn from this tank through a strainer, one of a pair of pumps, into one of a pair of fine filters. It is then passed through a cooler before entering the engine and being distributed to the various branch pipes.

The branch pipe for a particular cylinder may feed the main bearing, for instance. Some of this oil will pass along a drilled passage in the crankshaft to the bottom end bearing and then up a drilled passage in the connecting rod to the gudgeon pin or crosshead bearing.

An alarm at the end of the distribution pipe ensures that adequate pressure is maintained by the pump. Pumps and fine filters are arranged in duplicate with one as standby. The fine filters will be arranged so that one can be cleaned while the other is operating. After use in the engine the lubricating oil drains back to the sump or drain tank for re-use. A level gauge gives a local read-out of the drain tank contents. A centrifuge is arranged for cleaning the lubricating oil in the system and clean oil can be provided from a storage tank.

The oil cooler is circulated by sea water, which is at a lower pressure than the oil. As a result any leak in the cooler will mean a loss of oil and not contamination of the oil by sea water.

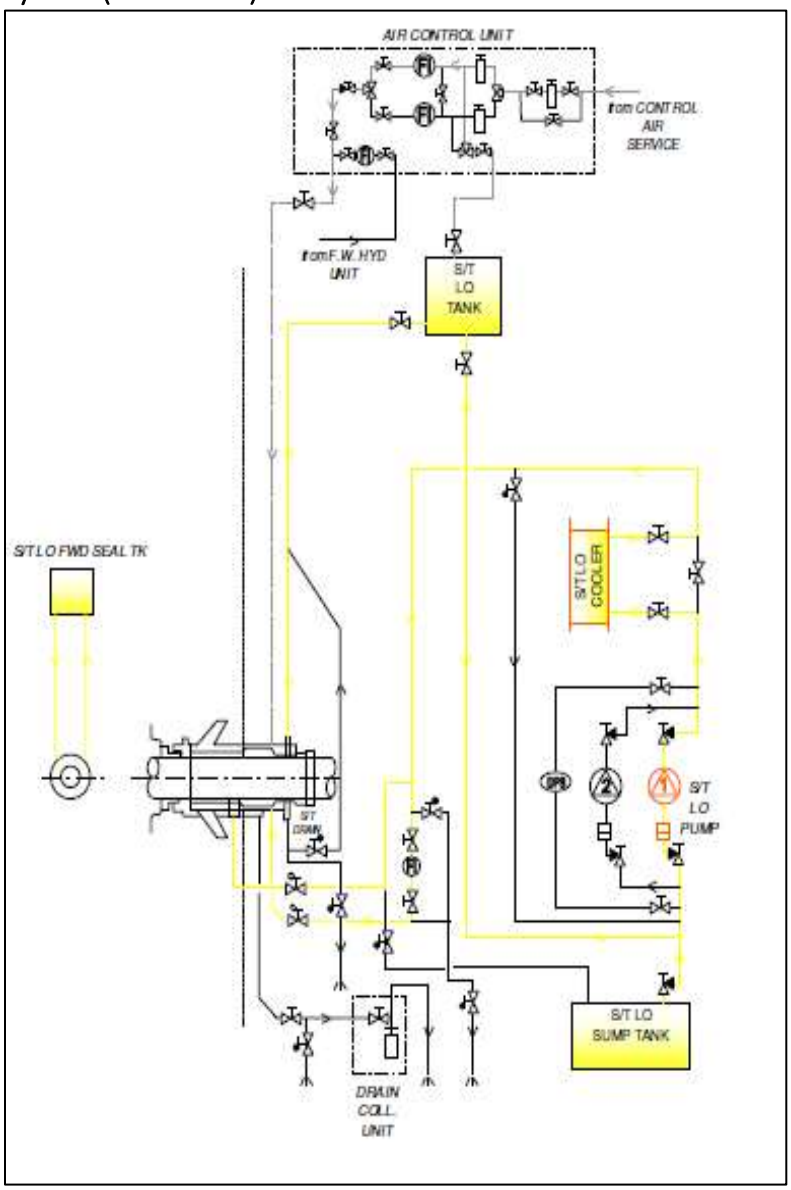
Where the engine has oil-cooled pistons they will be supplied from the lubricating oil system, possibly at a higher pressure produced by booster pumps, e.g. Sulzer RTA engine. An appropriate type of lubricating oil must be used for oil-lubricated pistons in order to avoid carbon deposits on the hotter parts of the system.

Cylinder lubrication

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

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

8.3.4.1 Lubricating Oil System (Stern Tube)



The propeller of the ship is fitted at the aft and attached to a crankshaft coming from the main engine. This is done so that the rotating motion of the Main Engine can be converted into thrust to propel the ship. The propeller shaft or tail shaft is supported by a bearing arrangement which acts as an intermediate phase between the sea and the ship.

The stern tube is a hollow tube passing at the lower stern part of the ship carrying tail shaft and connecting it to the propeller out at sea, bearing for the tail shaft, lubrication arrangement and most importantly the sealing arrangements.

Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

The stern tube bearing arrangement and sealing plays a vital part in ship's operation and pollution prevention.

The two main purpose of the stern tube bearing are:

Withstand load

The propeller which hangs at the aft end exerts load on the shaft, which is supported and withstand by the stern bearing. The bearing is a cast iron bush lined with a white metal having excellent load handling and lubricating property.

The stern tube is fitted at the stern frame and internal framing of vessel's hull at aft peak.

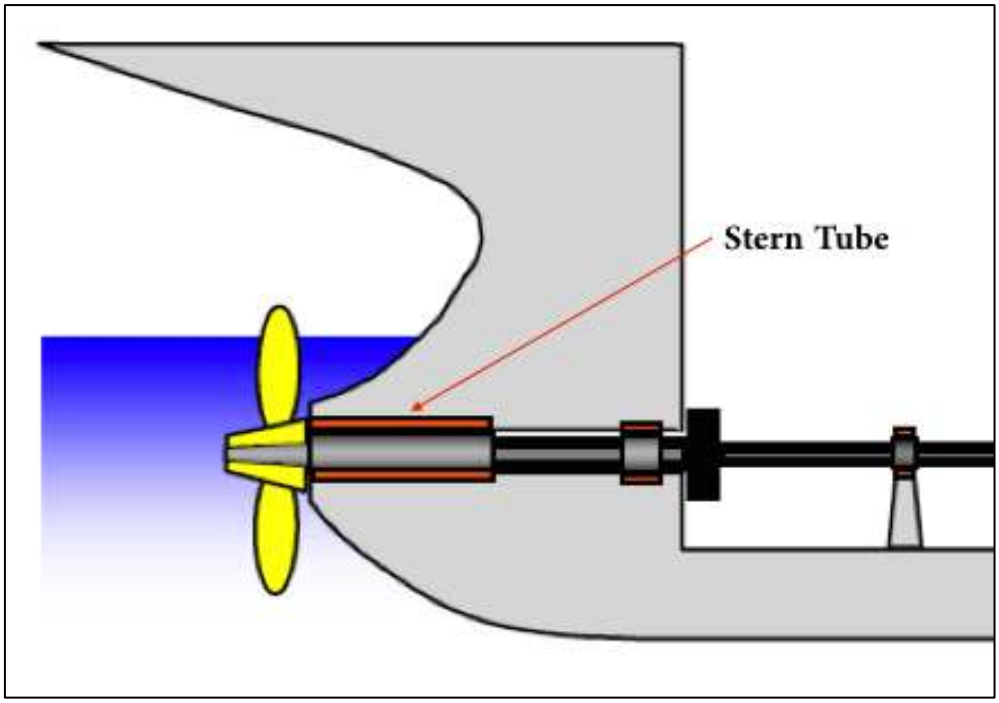
This allows the tail shaft to rotate smoothly in the bearing area for uninterrupted propulsion.

Sealing

The stern tube bearing consists of sealing arrangement to prevent ingress of water and to avoid the lubricating oil to escape into the sea.

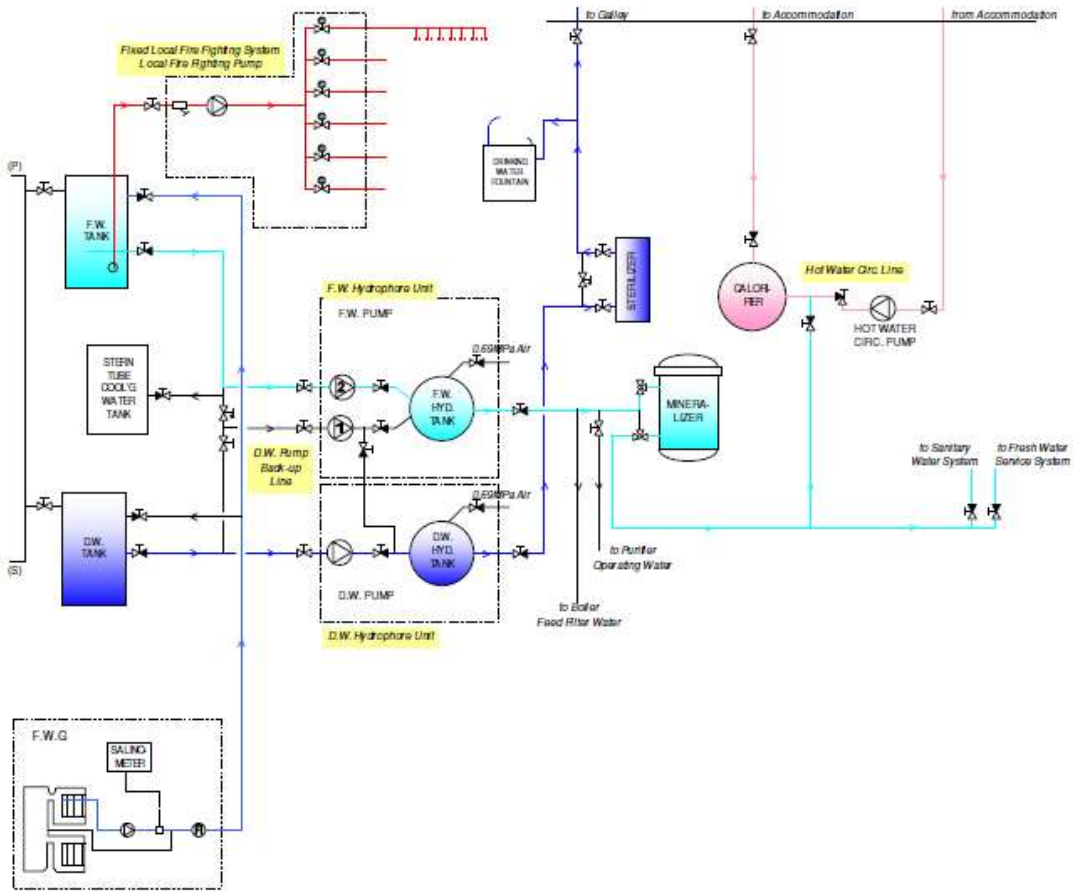
Sealing arrangement

The lubrication system for ships with variable draught (due to loading and unloading of cargo) consists of header tanks located at around 2 to 3 meters above the water line so that the differential pressure ensures no water ingress.



Original Date : 2018 May 11
Revision Date : n/a
Revision No. : 00

8.3.5 Domestic Fresh Water and Sanitary Water System



Composition of domestic water system for a general cargo ship

Use of compressed air in domestic water systems

Domestic water systems usually comprise a fresh water system for washing and drinking and a salt water system for sanitary purposes. Both use a basically similar arrangement of an automatic pump supplying the liquid to a tank which is pressurized by compressed air.

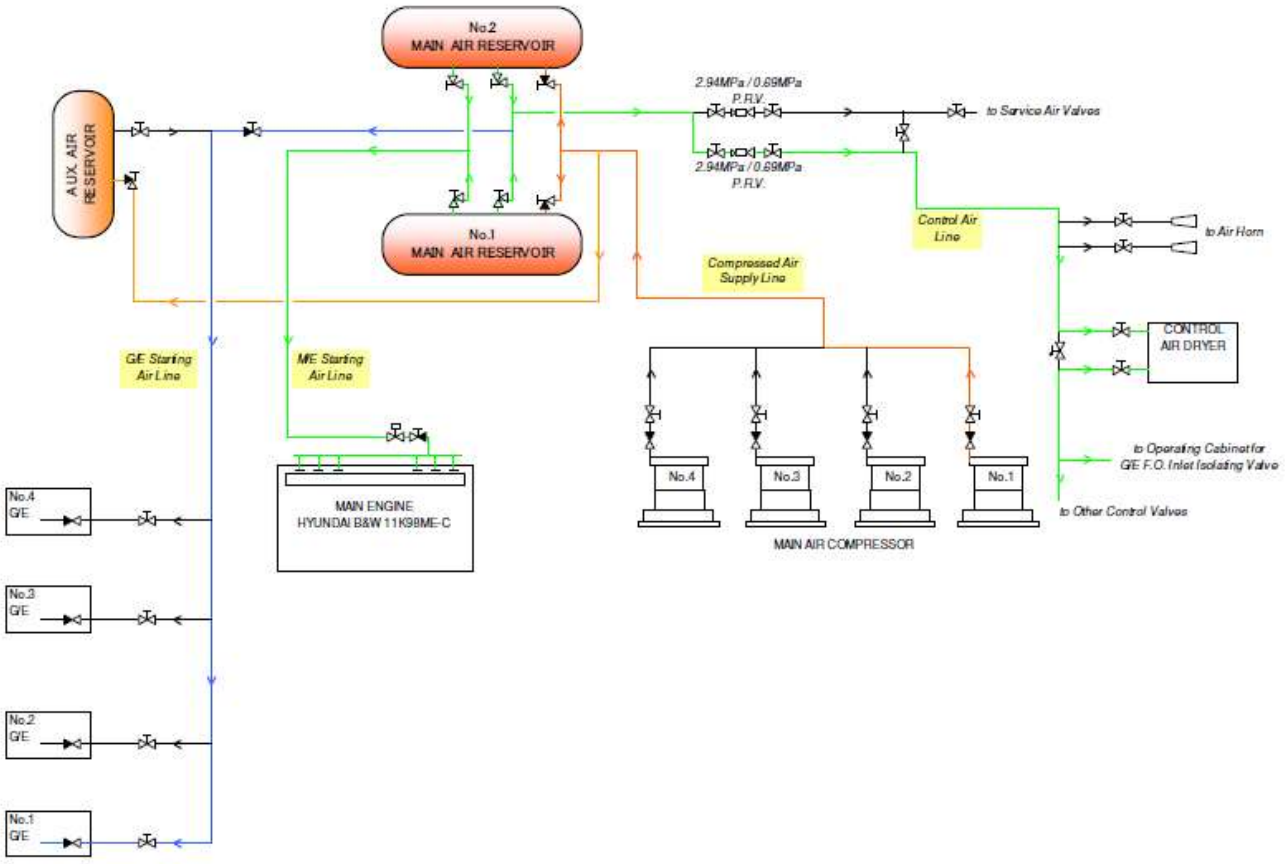
The compressed air provides the head or pressure to supply the water when required. The pump is started automatically by a pressure switch which operates as the water level falls to a predetermined level. The fresh water system has, in addition, a calorifier or heater which is heated, usually with steam.

Fresh water supplied for drinking and culinary purposes must meet purity standards specified by the Department of Transport. Water produced from most evaporator/distillers will not meet these standards and must be treated to ensure it is biologically pure and neutral or slightly alkaline.

Fresh water supply

Domestic water supply either produced on board or bunkered must be sampled frequently and treated in accordance with statutory regulations. Records are to be maintained of chemical treatment dosage. In case of any doubt on the quality of drinking and cooking water, the office must be consulted. Equipment for the sterilization and or demineralization of drinking water is to be maintained as specified by the Manufacturers. Every vessel shall carry designated hoses for taking on potable water. They are to be carefully stowed and labelled "Potable Water Use Only." Care must be taken to ensure that these hoses are kept clean and are kept free from any contamination.
Potable water tanks are to be emptied for inspection and maintenance as specified in the vessel's planned maintenance system. They are to be thoroughly scrubbed, flushed out and the entire system disinfected with chlorine as described in the International Medical Guide for Ships or the UK Ship Captain's Medical Guide. Any personnel entering a potable water tank must wear absolutely clean clothing and footwear. No person suffering from skin infections or communicable diseases are to be allowed to enter the tank.

8.3.6 Compressed Air System



Use of compressed air for ships machinery

The main aim of a compressor, as the name suggests, is to compress air or any fluid in order to reduce its volume. Some of the main applications of compressors onboard ships are main air compressor, deck air compressor, AC compressor and refrigeration compressor. Failure to start or control air compressor can be inconvenient, costly and can carry risks, which need to be managed.

Compressed air has many uses on board ship, ranging from diesel engine starting to the cleaning of machinery during maintenance. Ships compressed air systems are usually divided into one or more of the following:

- Main and auxiliary engine starting air system (high pressure).
- Service air.
- Control air.
- Instrument air.
- Deck services

Low pressure (5-8 bar) air may be supplied by either individual compressors or pressure reducing valves fitted within the high pressure circuit.

High Pressure System

The Main and Auxiliary Engine starting air supply is to be monitored carefully for excess oil and water. Where compressors are fitted with cylinder lubrication then particular attention to the cylinder oil feed is required. Moisture traps and drain valves are to be blown down at regular intervals. Should the blowdown indicate excessive oil or moisture then the reason is to be immediately investigated.

All operating valves in the starting air system are to be operated slowly and with extreme caution. Do not stand directly in front of a high pressure valve when opening or closing. The Engine Room Staff are to be made fully aware by the Chief Engineer of the importance of correct operation and maintenance of the starting air compressors, and the effects of their failure during manoeuvring of the vessel. During manoeuvring of the main engine the starting air compressors are to be monitored locally for any sign of overheating or problem.

Low Pressure System

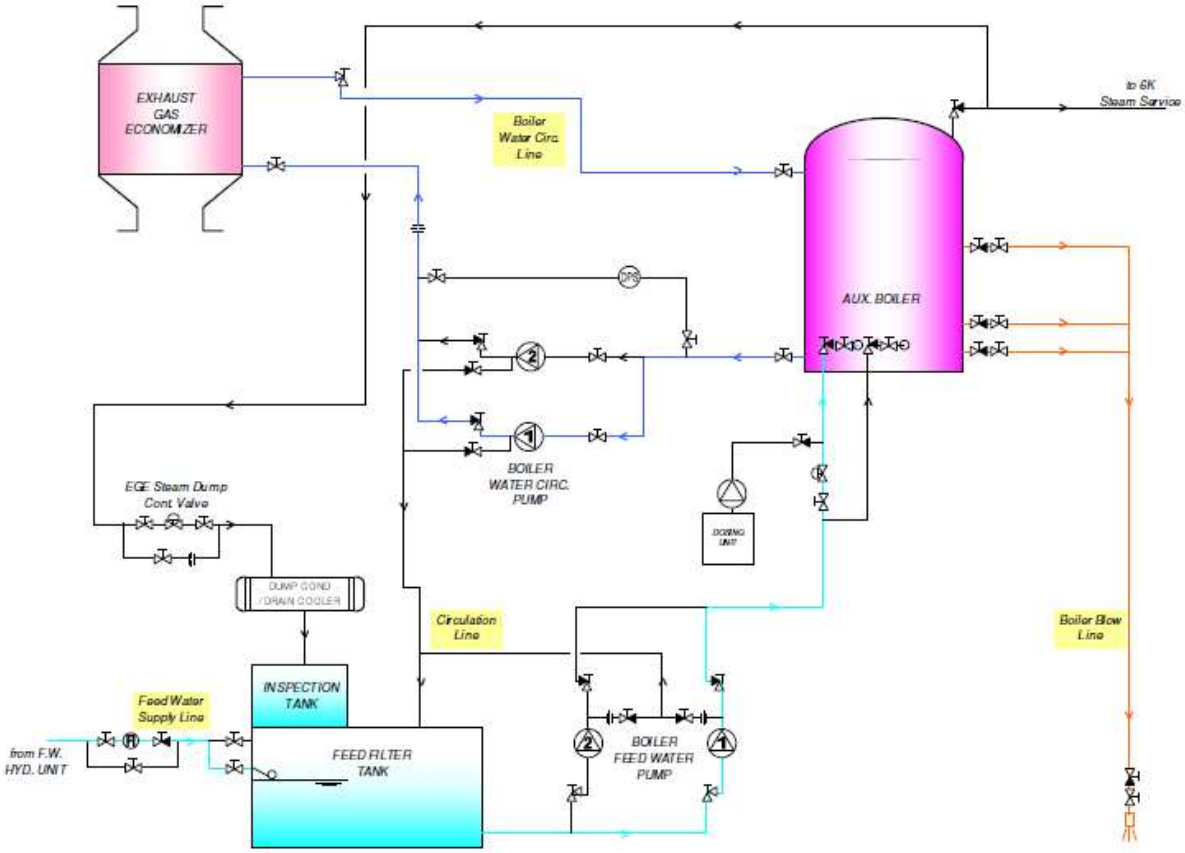
Compressed air equipment which supplies low pressure air for control or instrument purposes must be monitored constantly for moisture or other contaminants. Air, which is wet or contaminated, will have detrimental effects upon engine maneuvering systems and process control.

All filters and moisture traps are to be cleaned and serviced as per the maker's instructions or at intervals determined by operational experience. Short cycling of compressors indicated excessive consumption (leakage) must be investigated immediately. Long periods of compressor running are also to be investigated.

Deck Service Compressors

Unwarranted use of these machines is to be avoided at all times. It is essential that any deck services are shut down when not required. Supply from the main starting compressors via reducing valves is not to be used for deck general service air supply unless an emergency exists.

8.3.7 Boiler Feed Water System



UPGRADING COURSE FOR OILERS/WIPERS

Open feed system for an auxiliary boiler - how it works

The feed system completes the cycle between boiler and turbine to enable the exhausted steam to return to the boiler as feedwater. The feed system is made up of four basic items: the boiler, the turbine, the condenser and the feed pump. The boiler produces steam which is supplied to the turbine and finally exhausted as low-energy steam to the condenser. The condenser condenses the steam to water (condensate) which is then pumped into the boiler by the feed pump.

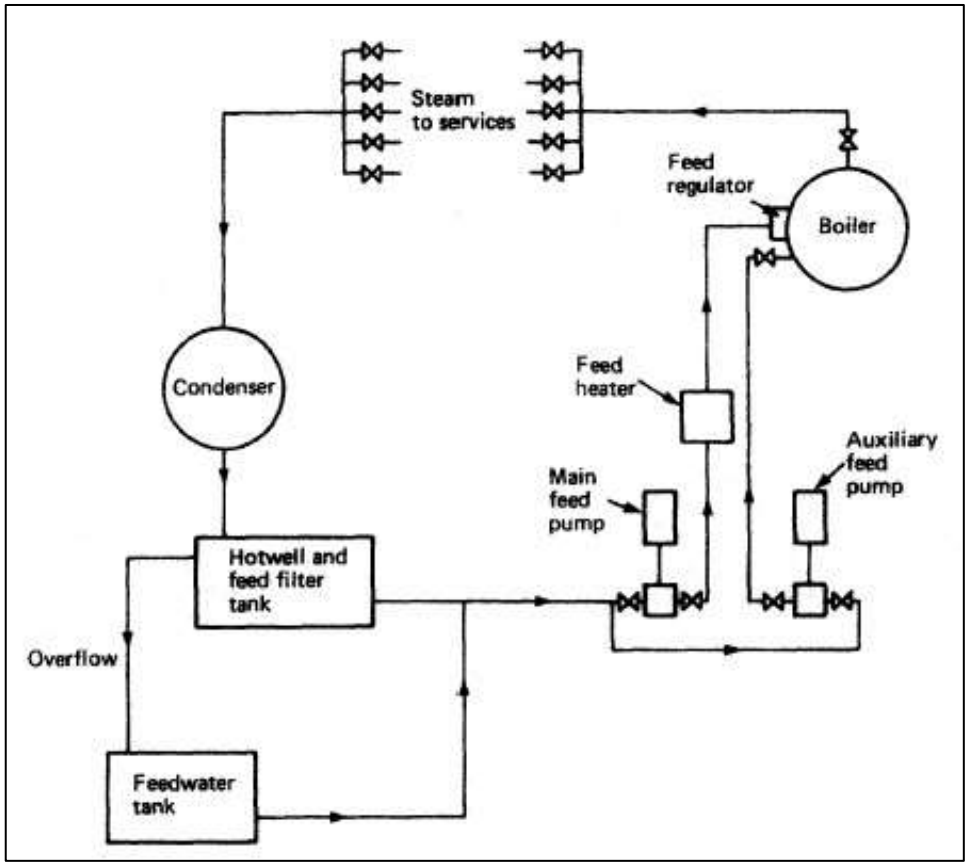
Other items are incorporated into all practical feed systems, such as a drain tank to collect the condensate from the condenser and provide a suction head for the feed pump. A make-up feed tank will provide additional feedwater to supplement losses or store surplus feed from the drain tank.

In a system associated with an auxiliary boiler, as on a motor ship, the drain tank or hotwell will be open to the atmosphere. Such a feed system is therefore referred to as 'open feed'. In high-pressure watertube boiler installations no part of the feed system is open to the atmosphere and it is known as 'closed feed'.

Open feed system

An open feed system for an auxiliary boiler is shown in Figure . The exhaust steam from the various services is condensed in the condenser. The condenser is circulated by sea water and may operate at atmospheric pressure or under a small amount of vacuum. The condensate then drains under the action of gravity to the hotwell and feed filter tank.

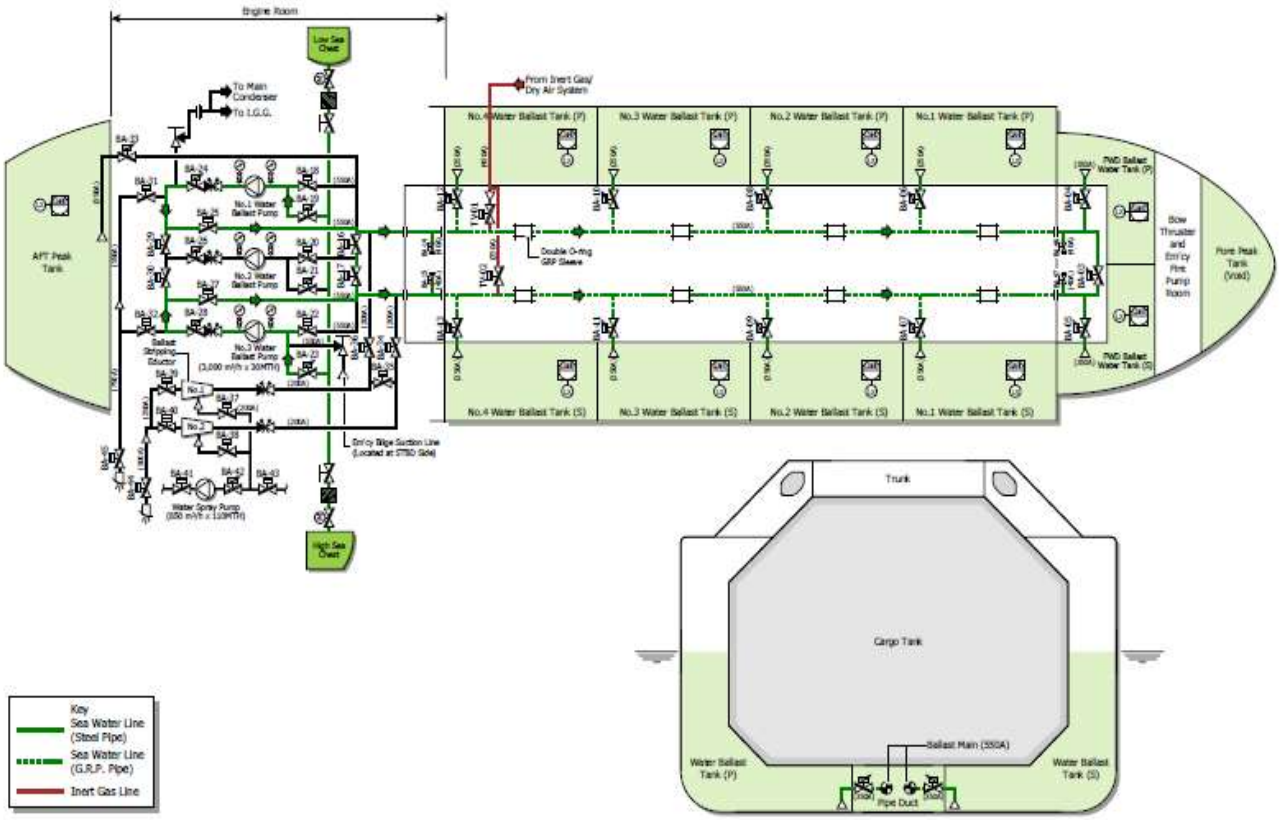
Where the condenser is under an amount of vacuum, extraction pumps will be used to transfer the condensate to the hotwell. The hotwell will also receive drains from possibly contaminated systems, e.g. fuel oil heating system, oil tank heating, etc. These may arrive from a drains cooler or from an observation tank. An observation tank, where fitted, permits inspection of the drains and their discharge to the oily bilge if contaminated.



The feed filter and hotwell tank is arranged with internal baffles to bring about preliminary oil separation from any contaminated feed or drains. The feedwater is then passed through charcoal or cloth filters to complete the cleaning process. Any overflow from the hotwell passes to the feedwater tank which provides additional feedwater to the system when required. The hotwell provides feedwater to the main and auxiliary feed pump suctions.

A feed heater may be fitted into the main feed line. This heater may be of the surface type, providing only heating, or may be of the direct contact type which will de-aerate in addition. De-aeration is the removal of oxygen in feedwater which can cause corrosion problems in the boiler. A feed regulator will control the feedwater input to the boiler and maintain the correct water level in the drum.

8.3.8 Ballast System



Ballast System

Ballast and de-ballast operations on ship must be carried out by an experienced and responsible officer as it is directly related to the stability factor of the ship. A ballast system may differ from ship to ship but the basics of all ballast systems remain same; filling, removing, and transferring water from one tank to other to get the required stability for a ship.

Getting Familiar with the System

- All valves in the ballast system are normally hydraulically operated from the remote operator station in the ship's control centre or in the ECR in manual mode or in automatic sequence.
- The ballast pump suction and discharge valves, along with other valves, have their fail safe in the OPEN position so that if any valve malfunction or get stuck, still remains open to carry out ballast operation.

Different Forms of Ballasting and De-ballasting

Ballasting or De-ballasting can be done in five following ways:

- Transferring water between tanks using gravity.
- Ballasting or De-ballasting tanks from sea using gravity.
- Ballasting the tanks using the ballast pump/pumps.
- De-ballasting the tanks using the ballast pump/pumps.
- De-ballasting the tanks using the stripping ejectors.

Note: Double bottom tanks should always be filled by gravity.

Important Points to Consider while Operating Ship's Ballast System

Care should be taken to ensure that the tank is not over filled; as this will damage the tanks because the pressure vacuum valves have lower capacity than that of the pump. The filling valves will close automatically when the tanks reach their set point level, which have been pre-set.

Also care has to be taken not to run the pump dry or run the pump with discharge valves closed. This can be taken care by automated system, which ensures that the pump will not start until all the necessary valves are opened.

Valves can be put in auto mode, which ensures that the valve closes automatically once ballast tank is filled with required amount of water or once the set point is reached.

Port and starboard sides are considered two separate systems, each having their own automatic sequence for ballast /de-ballasting.

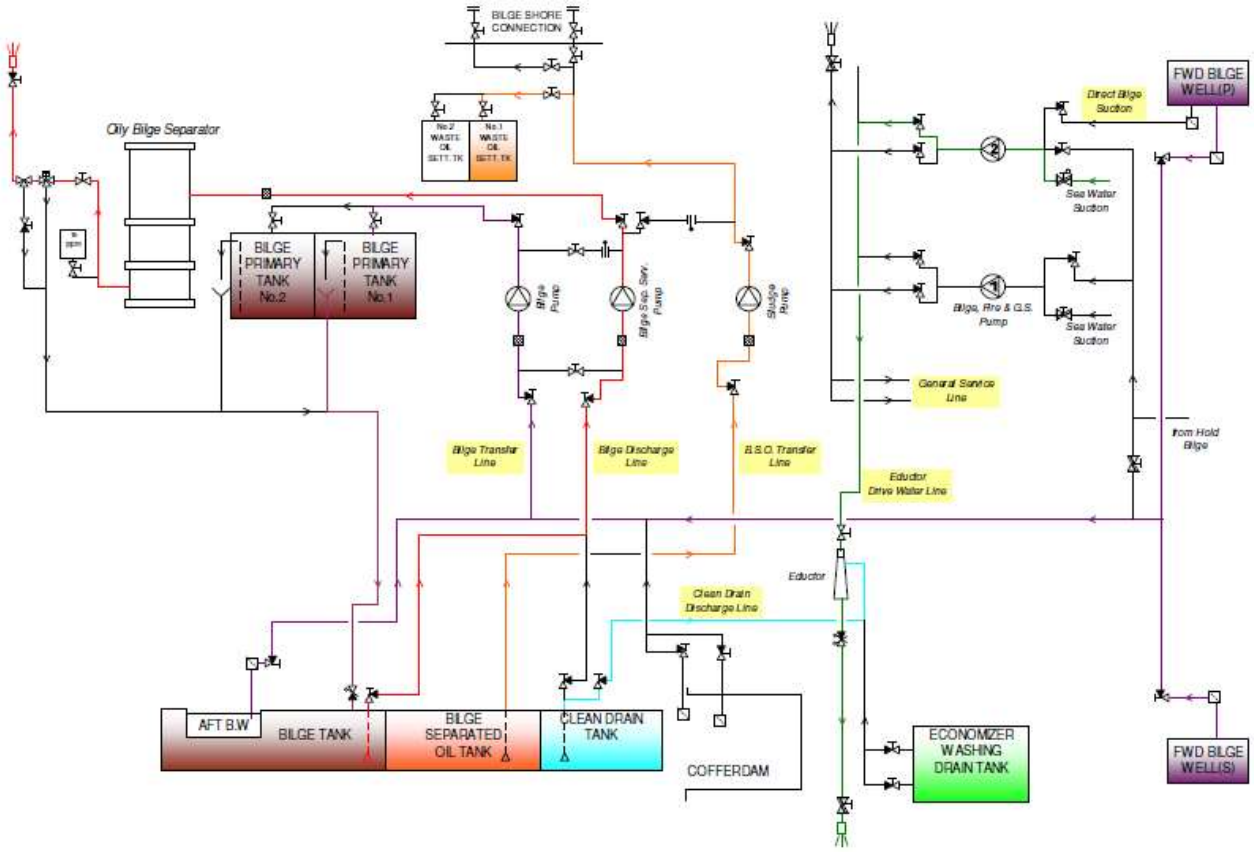
When filling ballast tanks with ballast pumps it should be observed that the motors are not overloaded (check current in ammeter). If this occurs, the number of opened valves to ballast tanks shall immediately be reduced (closed) until current is within allowable limit. Ballast pump motor overload alarm is given for the safety of ballast pump.

Some times during sea voyage one can get an alarm on the ballast pumps suction pressure high. At that time just open the suction valve to the sea chest and close them when the pressure is reduced.

The water in the heeling tanks should always be half of their total capacity. But if required the heeling tanks can be used as ballast tanks. Ballast pump is used to empty or fill the heeling tank.

Also in some ports the port authorities may ask for a sample of the ballast that the ship is carrying. In this case the sample has to be taken from the sounding pipe connection. The locations of all the sounding pipes are provided on the ballast system plan of the ship.

8.3.9 Engine Room Bilge System



Bilge and ballast systems for ships

Arrangements of bilge main

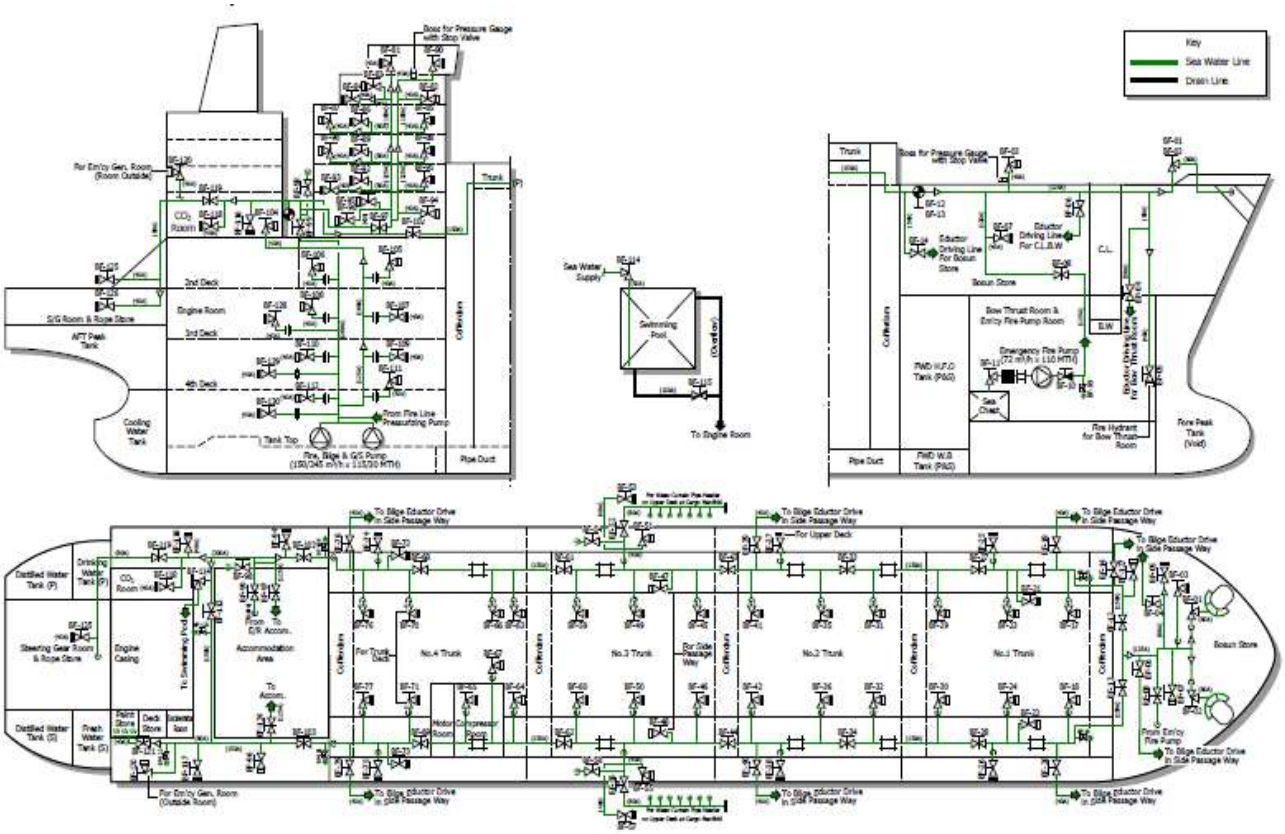
The bilge main is arranged to drain any watertight compartment other than ballast, oil or water tanks and to discharge the contents overboard. The number of pumps and their capacity depend upon the size, type

and service of the vessel. All bilge suctions must be fitted with suitable strainers, which in the machinery space would be mud boxes positioned at floor plate level for easy access. A vertical drop pipe would lead down to the bilge.

The emergency bilge suction or bilge injection valve is used to prevent flooding of the ship. It is a direct suction from the machinery space bilge which is connected to the largest capacity pump or pumps. An emergency bilge pump is required for passenger ships but may also be fitted as an extra on cargo ships. It must be a completely independent unit capable of operating even if submerged.

A centrifugal pump with a priming device is usually used, driven by an electric motor housed in an air bell. The power supply is arranged from the emergency generator. A typical system is shown in figure above. The various pumps and lines are interconnected to some extent so that each pump can act as an alternative or standby for another.

8.3.10 Fire Fighting System



Fire protection & control system for Ships machinery spaces

Fire is a constant hazard at sea. It results in more total losses of ships than any other form of casualty. Almost all fires are the result of negligence or carelessness.

Two basically different types of equipment are available on board ship for the control of fires. These are small portable extinguishers and large fixed installations. The small portable extinguishers are for small fires which, by prompt on-the-spot action, can be rapidly extinguished. The fixed installation is used when the fire cannot be fought or restrained by portable equipment or there is perhaps a greater danger if associated areas were to be set on fire.

The use of fixed installations require evacuation of the area containing the fire which, if it is the machinery space, means the loss of effective control of the ship. Various types of both portable and fixed fire fighting equipment are available.

Fire protection on ships is provided by detection and fire-fighting equipment together with structural features which are intended to contain an outbreak of fire and the employment when required of non-combustible materials to prevent its spread.

Fire is the result of a combination of three factors:

- A substance that will burn.
- An ignition source.
- A supply of oxygen, usually from the air.

These three factors are often considered as the sides of the fire triangle. Removing any one or more of these sides will break the triangle and result in the fire being put out. The complete absence of one of the three will ensure that a fire never starts.

Fires are classified according to the types of material which are acting as fuel. These classifications are also used for extinguishers and it is essential to use the correct classification of extinguisher for a fire, to avoid spreading the fire or creating additional hazards. The classifications use the letters A, B, C, D and E.

1. Class A : Fires burning wood, glass fibre, upholstery and furnishings.
2. Class B : Fires burning liquids such as lubricating oil and fuels.
3. Class C : Fires burning gas fuels such as liquefied petroleum gas.
4. Class D : Fires burning combustible metals such as magnesium and aluminium.
5. Class E : Fires burning any of the above materials together with high voltage electricity.

Many fire extinguishers will have multiple classifications such as A, B and C. Fire fighting at sea may be considered in three distinct stages, detection—locating the fire; alarm—informing the rest of the ship; and control—bringing to bear the means of extinguishing the fire.

Machinery space systems

Machinery spaces are protected by fixed fire extinguishing installations, the fire main and extinguishers. Any statutory fixed installation must be operable from a position outside of the space. Any emergency stops for machinery and vent fans, means of securing openings and fuel tank valve shut-off devices, must also be located external to the space.

Types of portable fire extinguisher

There are four principal types of portable extinguisher usually found on board ship. These are the soda-acid, foam, dry powder and carbon dioxide extinguishers. Details as below :

1. Soda acid portable fire extinguisher

   The container of this extinguisher holds a sodium bicarbonate solution. The screw-on cap contains a plunger mechanism covered by a safety guard.

2. Foam type portable fire extinguisher

   The main container is filled with sodium bicarbonate solution and a long inner polythene container is filled with aluminium sulphate

3. Dry powder fire extinguishers

   The outer container contains sodium bicarbonate powder. A capsule of carbon dioxide gas is located beneath a plunger mechanism in the central cap

4. CO2 portable fire extinguisher

   A very strong container is used to store liquid carbon dioxide under pressure

Fixed fire extinguishing installations

A variety of different fixed fire fighting installations exist, some of which are specifically designed for certain types of ship. A selection of the more general installations will now be outlined.

1. Fire main system for cargo ships

An outbreak of fire requires a source of ignition, the presence of combustible material and ample oxygen. Of the three factors, oxygen is provided in large quantities in machinery spaces, accommodation, dry cargo holds and tanker pumprooms by ventilation fans. Air supply trunkings are not only a source for a supply of oxygen to feed the fire but also have potential for carrying smoke from one area to another....

2. Automatic water spray & water mist system for machinery protected area

   The automatic spray or sprinker system provides a network of sprinkler heads throughout the protected spaces. This system may be used in accommodation areas, and in machinery spaces with certain variations in the equipment used and the method of operation. ....

3. Automatic foam induction system for machinery space fire

   Foam spreading systems are designed to suit the particular ship's requirements with regard to quantity of foam, areas to be protected, etc. Mechanical foam is the usual substance used, being produced by mixing foam making liquid with large quantities of water. Violent agitation of the mixture in air creates air bubbles in the foam. ...

4. CO2 fire extinguishing installations for machinery spaces

   Fire extinguishing installations employing CO2 stored under pressure at ambient temperature are extensively used to protect ships' cargo compartments, boiler rooms and machinery spaces. When released the CO 2 is distributed throughout the compartment, so diminishing the relative oxygen content and rendering the atmosphere inert....

5. Inert gas systems, inert gas generator

   Inert gases are those which do not support combustion and are largely nitrogen and carbon dioxide. Large quantities suitable for fire extinguishing can be obtained by burning fuel in carefully measured amounts or by cleaning the exhaust gases from a boiler.

8.3.11 Troubleshooting

The Basics of Troubleshooting Engine Room Machinery

For marine engineers working on ships, troubleshooting problems related to engine room machinery is the most important task they have to deal with on a daily basis.

We often get questions like – what is the best way to troubleshoot a machinery problem? And to be honest there is no one answer to such question. Technically, there are several aspects that play important roles toward solving a engine room machinery problem.

Though marine engineering training inculcates the very basics of maritime concepts, it is only through hands-on experience that marine engineers understand the vital techniques of engine room operation and maintenance. However, even both of these two factors together are not enough.

The process of troubleshooting ship's machinery involves three important factors which are as follows:
– Requirement
– Approach
– Learning

Requirement

Though the art of troubleshooting cannot be learnt just from marine engineering books, bookish knowledge is equally important. As important as it is to learn solving machinery related issues of ships through experience and practical approach, it is equally essential for a seafarer to have a technical background along with following basic requirements:

– Practical training with real machinery- Ground or hands-on training in workshops, projects, onboard ships etc.

– Simulation training to enhance the problem solving capabilities

– Experience – As stated earlier, practical experience is the best teacher and one should never forget its importance

Approach

Though it is mandatory for a person to have all the “requirements” stated above in order to work on ships, those are also not enough. Fulfilling the requirements is just the first step towards successful troubleshooting. The right approach to learn and understand the machinery is one of the three important factors seafarers must consider for troubleshooting. A healthy approach involves:

– Knowing your machinery inside-out

– Learning starting and stopping procedures of engine room machinery thoroughly

– Reading the maker’s manual for a friendly interface and easy understanding, especially the troubleshooting points

– Understanding what makes machinery perform and what are the power sources that are used to operate? Take a look at important factors such as electricity, oil, water, air, temperature etc.

– Checking and knowing the basic parameters and comparing with previous records
– Checking for the most basic faults- malfunctioning of gauges and parameter display panels even when the components are working fine
– Identifying which parameter is abnormal
– Identifying which component or part of the machinery is in fault
– If identification of troubled component is not possible, start a reverse technique of ruling out the performing component and approaching the faulty one
– Once the component or reason is located, think logically as to where the fault lies – in the region in front or in some other area
– Identify wether other parts connected to the faulty component can be at trouble
– Rectify the problem once identified immediately
– Test the machinery for satisfactory performance
– If problem persists, check the same again and also track other connected parts

Learning

Seafarers often forget that troubleshooting is a continuous learning process. There is no stage such as "know-it-all". There is something new to learn everyday even if one has years of sailing experience. So if sometimes someone is not able to solve a problem at hand, don't be disappointed. Learn from the issue.

Learning from the last problem tackled always adds on to the experience which can be used for future troubleshooting situations. Once the problem is solved, it is better to discuss the same with your team to find other simpler way of tackling the same issue.

Recording the problem faced, the way it is approached and the method used for solving will not only be helpful in future but also serve as a useful resource for other engineers to solve similar situations quickly and easily.

While working in ship's engine room, it's of utmost importance to troubleshoot any problem in a fast and streamlined manner to ensure that the ship's voyage schedule does not suffer. The above three factors together form the basics of troubleshooting engine room machinery problems.

9. Watchkeeping in Engine Room

9.1. Fundamentals of Engine Room Watchkeeping

Watch keeping is an integral part of marine engineer's duties on board ship. A lot of maintenance work can be reduced by following an efficient watch keeping routine in the ship's engine room. Moreover, it can also avoid serious accidents from taking place. But what is the true yard stick for measuring the efficiency of a watch keeping procedure?

A smooth running ship is a product of efficient handling at the bridge and effective management in the engine room under any seagoing condition. When a marine engineer is approved to be the in charge of the engine room, he is eligible and officially authorized to handle a ship's engine of "Unlimited Power". It is therefore important that the watch keeping procedure, a daily routine that has to be carried out every single day, is done in the most systematic manner to prevent any kind of breakdown.

Standard Pressure and Temperature Checks

There are standard pressures and temperature checks to be carried out by the watch keeping engineer, as he gains experience these will become second nature; the various thermometers and pressure gauges being scanned as he walks around the engine room checking the components. This means when a rouge value turns up it is spotted right away either on the component or the engine control station instrument board. This is situated just above the engine control station, either in the engine room or in the modern

control room. The board contains the pressure and temperature gauges for the main systems such as; exhaust temperatures, jacket cooling and lub-oil pressure. We used an arrow to mark the optimum temperatures and pressures on these gauges, and endeavor to maintain them; again any rouge value will show up instantly.

The board is located above the controls, being easily consulted from here. The other main gauges and components that are easily reached are the engine room telegraph, rev-counter, air start reservoirs pressure gauges and of course the controls themselves. Depending on the engine manufacturer, these consist of two levers; left hand one usually air start, right hand lever; fuel control and are used when maneuvering.

Heavy Fuel Oil System (HFO)

The temperature of the HFO system must be kept at the recommended value to control its viscosity. This is important as it must not turn "waxy" when being pumped through various heaters, the fuel pump and into the injectors.

Lube-oil System

The temperature of the lube-oil must be carefully controlled through use of the lube-oil coolers seawater inlet valve. Remember that as the temperature of the lube-oil rises the pressure drops. Conversely, a low lube –oil temperature will increase the oil pressure. A sudden unexplained rise in temperature could signify a bearing in the main engine running hot.

Jacket cooling System

The pressure and temperature of the jacket water cooling also need close monitoring and maintained at optimum values as the cooling water also supplies the turbo-blower air coolers. The pressure in this case is controlled by the circ pump, so any change could be a faulty pump, however, down to the pump or a loss of pressure through a faulty cylinder liner rubber sealing ring, or even a cracked liner.

Temperature is another matter; this must be kept at the recommended value. Any rise could signify a scavenge fire a rise in sea temperature or cooler problem.

The generators temperature and pressures are checked as per the main engine ones.

This leave the thrust block, prop shaft bearings, and stern gland. Here again the sense of touch should be used as a guide to overheating, but there will be temperature gauges on the thrust and prop bearings along with oil - level sight gauges.

Things to know for a watch keeper

1. The watch keeping engineer should make use of internal communication equipment's.
2. Escape route from machinery spaces.
3. Alarm system and distinguish the various alarm special reference to fire alarm.
4. Location of firefighting equipment's and damage control gears in the machinery spaces and their use and safety precautions to be observed.
5. Any machinery not functioning or expected to be noted.
6. Plans to be made for the finest action .If manned, watch keeping engineer should be able to operate propulsion equipment's if there is any need to change direction or speed.
7. In UMS ships, the watch keeping engineer should be available if there is a call.
8. All bridge orders should be executed.
9. On-going maintenance of all machinery to be carried out on all electrical, hydraulic, pneumatic mechanical works. Should know the isolation and by passing the machine when call for standby he should be in state of readiness.
10. Watch keeping engineer should not take any duties other than watch keeping adequate rounds should be taken in steering gear compartments.
11. Watch keeping engineer should not leave the machinery space Un-supervised, he should make substitute if necessary.
12. Watch keeping engineer should take action to contain the effects of damages resulting from break down, fire, flooding, rupture and collision.
13. All events related to main and auxiliary machinery suitably recorded before off duty. He should co-operate with the preventive maintenance work.
14. Any malfunction of machinery or loss of steering and in the event of fire to be informed immediately to bridge.
15. Chief engineer to be informed in case of engine damage or malfunction and break down of propulsion machinery, monitoring and governing system and any emergency.
16. He should make sure air or steam pressure is available for sound signals.
17. In coastal or congested waters he should make sure adequate reserve of power for steering and maneuvering equipment's.
18. Emergency steering and other auxiliary equipment should be kept ready for immediate operation.

General Precautions in Watchkeeping at Sea

1. While at sea, control the operation of all machinery in the engine room at all times, and pay attention to the temperature, vibration, pressure, etc.
2. Familiarize yourself with the main engine, auxiliary machinery, piping system, ship's structure, equipment method of communication, so that you may be prepared to take proper measures to cope with marine accidents such as engine troubles, fire and flooding.

3. During the duty watch, do not leave the engine room without permission. When required to do so, obtain permission from the duty engineer.
4. Always be prepared to respond to the orders from the bridge and instructions of the duty engineer.
5. If you find any abnormal condition or trouble of the main engine, generator, or major auxiliary machinery, which requires switching or stopping of such machinery, report the fact to) the duty engineer, no matter how trivial it is.
6. Pay attention to the ventilation, air circulation and lighting.
7. The rating of the next watch should go to the engine room fifteen minutes before relieving the person on watch and obtain necessary information for watch transfer.
8. Check the Main engine r.p.m. temperature, pressure, sound arid vibration of each point and utilization of electric power, auxiliary machinery for abnormal conditions, and hand them over to the person in charge of the next watch.
9. Condition of tanks in use, fuel oil tanks, bilge's, tanks and other tanks.
10. Contents of maintenance and repair being provided in the engine room.
11. Messages and orders from the duty engineer.
12. Make entries in the oiler's daily log accurately and carefully.
13. When sailing in heavy weather, the rating should make inspection rounds through the engine room in cooperation with the duty engineer, preparing for possible sudden over speed of the main engine.
14. The rating on watch should be ready to render cooperation to the engineer on duty who will be posted in the engine control room or local control handle attending over speed.
15. Dirt of the fuel oil tank accumulated in the bottom tank cause a problem, if agitated by the ship's motion and sucked into the fuel oil pump, pay special attention to clogging of the strainers for the FO and LO pumps and purifier-related FO and LO lines.
16. Air is likely to mix in fuel oil lines and cooling water lines, which requires caution.
17. Relevant tanks (expansion tank! head tank) should be properly filled to prevent overflows.
18. The bearing of the main engine are subject to overheat due to large fluctuation in speed. Pay attention to the temperature and oil pressure in each part, and also touch by hand.
19. Check the bilge water condition and dispose of it as necessary.
20. When electric or gas welding is conducted in the engine store room, notify the duty engineer and bridge. When the fire Alarm cut-off switch is operated, do not forget to return into the normal position upon completion of the welding work.

Main Check-points During Inspection Rounds While on Watch Main engine system check points:

1. Check the level of cooling water expansion tanks for the main engine, diesel generator and rear containers.
2. Check the level of LO head tank (which is usually full) for the turbocharger, and the flow of LO through the sight glass.
3. Check the fuel valve cooling water inspection tank for leakage.

4. Check the differential pressure gauges of backwash filter and it excessive clean the strainer.
5. Inspect the various valves on the main engine upper cylinder cover, visually and by touch.
6. Fuel Valves: injection sound from high pressure pipes, temperature and leakage of cooling water, and presence of FO leakage.
7. Intake and Exhaust Valve; operating condition of the valves, LO lubricating condition, gas leakage, gas leaking sound, smell, cooling water temperature, and exhaust gas temperature.
8. Starting Valve: Check its operation when the engine is on SIB. Check the temperature of the starting air pipe by touch. If it is too hot, the valve is leaking.
9. Safety valve: check for gas leakage from the exhaust port.
10. Indicator valve: Check for gas leakage. If leaking, cover with blank sheet or cap.
11. Generally inspect the cylinder cover for gas leakage or normal noise, leakage from lubricator oil pipes, and section subjected to vibrations and parts which are tightened.
12. Turbocharger: check the suction filter manometer (mmHg), sound and vibration of the blower and turbine sides, LO inlet and outlet temperatures, lows leakage.
13. Main Engine Air Cooler Adjust the outlet air temperature below 45°C to 50°C; check the differential pressure between the inlet and outlet, seawater inlet and outlet temperatures, and leakage (check the controller position of opening).
14. Main engine governor pay attention to the oil level, and reading of the load indicator. Check for oil leaks, a loose link mechanism or any abnormal condition.
15. Local gage board: Check each pressure gauge, control oil pressure and return pressure.
16. Pressure gages at th6 engine room middle stage; Check emergency control air pressure and starting air pressure.
17. Cylinder Oil lubricator check the lubricating condition, motor revolution, and inlet pressure of the hydraulic motor.
18. Main FO Pump; Check leakage and any abnormal condition around the FO pump, and FO and steam leakage from FO heating pipes.
19. Lubricate moving parts such as the revolution indicator.
20. Main engine bearing LO pressure.
21. LO Backwash Filter: Check the pressure difference between inlet and outlet, and leakage.
22. Check the temperature of the crack case of all cylinders and gear case of the main engine. Check cooling fresh water for normal flow, and cylinders for abnormal noise.
23. Trust bearing, Check bearing temperatures forward/aft, and for abnormal noise or heating.
24. Intermediate bearing: Check the oil level, lubricating condition and temperature.
25. Shaft horse power indicator: Check the oil level and forward /aft temperature.
26. Shaft slip ring carbon: Check the operating condition and wear.
27. Stern tube: Maintain and adjust the stem tube La pump outlet pressure.
28. Check sea water temperature at the inlet and outlet of stem tubs LO cooler and leakage and other abnormal condition.
29. Check the oil level of the stern tube LO sump tank, and supply oil as necessary.
30. Check the stern Tube oil sight glass, oil baths forward seal, and also inspect whether the head tank is overflowing or not.

31. Check the stern tube sealing system, the after seal Tube oil head tank level, stern tube inlet pressure, forward seal return lube oil temperature, stern tube return Tube oil' temperature, forward tube seal inlet leakage and other abnormal condition.
32. Lube oil sea water and fresh water cooler for the main engine, check the temperature of the cooling sea water, lube oil inlet and outlet, and fresh water inlet and outlet. Check for leakage and other abnormal conditions.

Generator System Check Points

1. Visually check the local instrument panel of the diesel generator: Tachometer; lube oil rocker arm, booster air, jacket cooling water, fuel oil and nozzle cooling oil pressures.
2. Check the governor oil level, supplement as required.
3. Clean the fuel oil, lube oil notch wire strainer by back wash.
4. Clean the strainers by manually turning.
5. Check the fuel oil pump of each cylinder for operating conditions, leakage and other abnormal conditions.
6. Check the lube oil sump tank level and supplement as required.
7. Check the rocker arm lube oil tank level, and supplement as required.
8. Check the level of lube oil leak collecting tank and fuel oil pump lubricating oil tank level.
9. Check the temperature of lube oil at each outlet of bearing.
10. Check the turbocharger turbine sight glass for oil level and for abnormal noise.
11. Check the direct driven pump for leakage, vibration and other abnormal conditions, and oil as required.
12. Check the valve operating mechanism located at the cylinder cover fear lubrication, and leakage of gas, cooling water and fuel oil.
13. Take the temperature clef of each cooling water cylinder and exhaust gas.
14. Check the inlet and outlet temperatures of tube oil fresh water and sea water coolers and for leakage and other abnormal conditions.
15. Check the operating condition of each controller, and drain of the condensation from the air of reducing valves.
16. Check the bearing of tube oil flow at the site.
17. Check the stand-by generator and peripheral equipment for any abnormal condition.

Turbo Generator Check Points

1. Observe the turbine casing temperature, and check for noise with a probe.
2. Check the pressure of sealing steam, first stage steam and governor oil.
3. Check the oil cylinder lift scale and governor load limited notch.
4. Check the lube oil sump tank and governor oil level.
5. Turn the relevant strainers manually.
6. Check the generator cooler for LO leakage, and LO flow through the sight glass.

7. Observe the reading of the vibration meter.
8. Check the position of opening of low pressure steam intake control valve, and low pressure piston valve.
9. Set the sealing steam pressure and check its reading.
10. Check the turbo generator steam control valve tar leakage and other abnormal conditions.
11. Check the turbo generator steam damping valve for leakage and other abnormal condition.
12. Check the vacuum, water level condensate temperature of T/G service main condenser and so on for any abnormal condition.
13. Check the inlet and outlet-pressure of T /G service condenser condensate pump and vacuum pump, and for leakage, heating and other abnormal conditions.

Boiler System Check Points

1. Check the pressure measured by the main pressure gage, water level and the condition of Nos. 1 and 2 burners.
2. Check the burner control panel to see whether each indicator lamp is normal, and conduct a lamp test.
3. Boiler burning pump unit:
   - Check the indication of the thermal control, and the actual temperature.
   - Check the heater oil pressure, and adjust as required.
   - Check the strainers for leakage and other abnormal conditions.
4. Boiler water level controller:
   - Check the indication of the controller and the valve position of opening.
   - Drain the reducing valve of water and check for abnormal conditions.
5. Boiler surroundings:
   - Check the boiler-mounted valves for leakage.
   - Check that there is no oil in the cascade inspection tank.
   - Check the drain cooler fresh water level, drain outlet temperature, etc. for any abnormal conditions.
6. Check the boiler and, waste oil incinerator for any causes that may lead to fire.

Fuel oil. & Lube oil, Purifier system check points

1. Check the temperature and leakage from the heavy liquid side. (Take care when blowing).
2. Check the gear case oil level.
3. Check the oil flow rate and adjust as necessary.
4. Check vibration and operating condition.
5. Check the oil heater temperature, and for leakage and other abnormal condition.
6. Blow the purifier operating water tank and check its level.
7. Check the purifier service pump for leakage, and other abnormal condition.

Main/auxiliary air compressor system checkpoints

1. Check the cylinder oil level, and supplement as required.
2. Check the crankcase oil level and supplement as required.
3. Check the V -bell tension and cooling water Row.
4. Check the compressor and motor for overheating, vibration and noise.
5. Check the cooling water temperature, position of valve opening, and for leakage of the cooler and any other abnormal conditions.

Refrigerating system (air conditioner, ship's provision stores, dehydrator)

1. Check the refrigerant level in the receiver.
2. Check the crankcase oil level.
3. Check the compressors and motors for overheating, vibration, V -belt tension and other abnormal conditions.
4. Check the electric load current.
5. Check whether the suction and discharge pressures show specified values. In the case of provision chambers, take the temperature of fish, frozen, and vegetable chambers and lobby, and check the frosting condition over the evaporator in each chamber.

Steering gear system check points

1. Lube oil tank level
2. Oil temperature
3. Lube oil tank leakage and other abnormal conditions
4. Lubrication of each section
5. Lubrication of rudder carrier and supply of grease pot (add as required).
6. Color (red /green) of the line filter (green; normal)
7. Pump discharge pressure
8. Check for leakage, vibration, overheating, noise and other abnormal conditions
9. Motor load current and heating
10. Check the pump unit for leakage and other abnormal conditions
11. Lube oil reserve tank level and abnormal condition
12. Check the steering room for any fire hazards

Fresh water generator checks:

1. Vacuum pressure
2. Reading of the salinometer
3. Flushing condition, feed water pressure
4. Water generating rate (adjust as necessary)

5. Whether the cooling water and heating temperature are normal
6. Operating conditions of the ejector and distillate pump
7. Leakage and other abnormal conditions
8. Condense water level

Exhaust gas economizer and surroundings

1. Check the seal air pressure
2. Check the draft gage! and/or exhaust gas temperature difference
3. Check for leakage of gas, steam, and feed water, and other abnormality
4. Lubrication of rudder carrier and supply of grease pot (add as required)

Funnel System

1. Check the feed water heater, relief valve, etc. for leakage
2. Check the pressure and water level of the low pressure steam separator
3. Outside the stack: check the color of smoke and the condition of ventilating fans
4. Inside the stack: check the exhaust gas economizer and steel grit separator tank for vibration and leakage of gas and steam

Fuel oil tank and other tanks

1. Check the level of each Fuel oil service tank and drain water. Check temperature inside tank, indication of the controller and the position of valve opening.
2. Check the Tube oil of each settling tank and drain water. Check temperature inside tanks, indication of controller and position of valve opening.
3. Check the level of the settling tank and drain off water.
4. Check the lube oil storage tank, Settling tank and cylinder oil tank for leakage and other abnormal conditions.
5. Check the level of the drinking water, fresh water pressure tank/pump.
6. Adjust the fresh water tank pressure, and check for any abnormal conditions.
7. Check the oil level of the sludge, waste oil and leaks tanks, and properly dispose of them as required
8. Check the level of the bilge tank, primary tank and cofferdam.
9. Check the waste oil indicator, place where materials are stored and each store rooms for any fire hazards and abnormal condition.
10. Check the condition of the engine room and its bilge's wells, and dispose of bilge water as required.
11. Check the inlet and outlet temperature of the thermo-tank -and fan motor for any abnormal condition.
12. Manually drain the main air vessel water.

13. Drain the air pressure reducing valve header of water.
14. Lubricate the FO and LO transfer pumps and check for leakage from glands.

General Precautions during Watch in Port

1. During a watch in port, pay special attention to the safe operation of auxiliary machinery. If any abnormal conditions found, immediately report to the engineer on watch and take proper corrective action.
2. Make entries on the oiler's log accurately. Especially accurate records of tank soundings taken at noon are required.
3. During the watch in port, ensure to make periodical rounds to inspect the same check points of machinery as in the watch in sea.
4. When in port, as there maybe shore repairers on board for repair maintenance of machinery, ensure to understand the content of the work and check the results.
5. When any ship's equipment or consumable stores are presented to the repairer for the repair work, report to the engineer on watch or the department head and keep a record.
6. If hot work is conducted make strict inspections to avoid fire hazards.
7. Maintain the engine room shipshape and check the location and contents of repair work.
8. Provide assistance for loading ship's equipment and consumable.
9. When bunker is supplied, make rounds for oil spills in cooperation with a person or the supplier's side.
10. Never allow unnecessary visitors in the engine room.
11. During the watch, take care for the security purpose of the ship by meticulously checking fire, the bilge condition and sea valves to prevent flooding, theft, etc.

GENERATOR PROCEDURES (INCLUDING PARALLEL RUN)

Single and parallel run of diesel generators

This description is only for manual operations, although modem generator engines are so designed that all operations such as starting, stopping, single run, parallel run and load transfer can be controlled on the console panel.

Precaution before operation starting:

1. Check the valves for the cooling water, fuel oil exit lubricating oil systems. Some differences may exit depending on the ship or model. It is especially important to check whether valves are properly opened or closed after repair or periodical maintenance.
2. Check the oil level in each tank.

3. Governor lubrication (Use of the proper kind of oil recommended by the manufacture, when supplying)
4. Operate the hand Tube LO pump, until all piston pins, sufficiently lubricated. (Determine by the load of the handle or the pointer of Tube oil pressure gauge whether or not they are sufficiently lubricated.)
5. Rotate the engine manually after confirming that the indicator valves of all cylinders are open. After checking that the engine rotates without interference, disengage the gear and restore and fix the turning bar at the designated location. (Improper fixing of the turning bar may hinder the start.
6. Check to see that the fuel pump rack and common rod operates smoothly and that scale indicates " 0 "when the handle is set to the starting position. Then, lubricate each lever, link, governor motor and oil put of the cooling water pump.
7. Thoroughly drain off the starting air system (including air vessels). Confirming the handle in the stop position, start an air run. After this close the indicator valves of all cylinders.
8. Set the handle starting position, and start the engine by pressing the start button. Continue idle running for 1 to 2 minutes and judge abnormal conditions by checking the turning sound and pressure of each part. If there is no problem, increase the revolution and set the handle in the operating position.
9. After the rated speed is reached, remove the bonnet of the cylinder covers and check the lubrication of the rocker arms, operation of intake/exhaust valve rotators, leakage of cooling water and fuel oil, temperature of cooling water and exhaust gas, e t c .And also, check the generator side hearing lube oil, for the flow rate and temperature, etc.

Procedure for parallel run:

1. The following four conditions are required to be met for parallel run.
   - Both generators are the same in voltage
   - Both generators are the same in frequency
   - Both generators are the same in phase
   - Both generators are the same in wave profile (as they were preset when they were manufactured, there is no need to consider this upon operation).

   Note:

   Synchroscope and synchronizing lamps – When the pointer of the synchroscope rotates in the "fast" or "slow" direction, the lamp slowly alternates bright and dark. When the lamp come to blink slowly and becomes dark, it means that synchronization is achieved.

   Rotating Direction of Pointer:

FAST: The output of the incoming generator has a higher frequency than the bus voltage.
SLOW: The output of the incoming generator has a lower frequency than the bus voltage.

Position of Pointer:

UP:	Same phase
DOWN:	Opposite phase

Rate of Pointer Rotation:

FAST ROTATION:	Large difference in frequency
STOP:	No difference in frequency

2. Put the no. 2 generator (incoming) in operation parallel to the no-1 generator (already in operation)(manual operation)
3. No. 1 generator is designed to maintain voltage of 440 V and a frequency of 60 Hz when it is in operation at its rated speed. If, however, a minor adjustment is required, the AVR (Automatic voltage regulator) or governor motor should be operated.
4. No. 2 generator is also designed to maintain a voltage of 440 V and a frequency of 60Hz when in operation at the rated speed. If however, a minor adjustment is required, do in the same way as in the case of no.1 generator. Set the no.2 generator to show a slightly higher frequency than no. 1 generator, thus the pointer of the synchroscope may rotate in the "fast' direction, and then Lose the ACB (air circuit breaker).
5. Lift the ACB handle of no.2 generator up to the right side horizontal level, reset, and stand-by to close the ACB.
6. Just before the synchroscope pointer slowly passes the uppermost position, turn the handle clockwise to close the ACE; (ACB "on" indicator light will go "on")

Load transfer from NO.1 generator to NO.2:

1. Shift the electric load from No.1 generator to No.2 gradually by continually decreasing the governor setting point of No. 1 generator, and simultaneously increasing that of the No.2, while carefully watching the electric power meter (kW) so that both generators may share the same load.
2. Operate the governor motors very slowly to maintain the rated voltage and frequency.

From parallel to single run

1. Make sure that the total load on No.1 and No.2 generators is within the capacity of a single generator.
2. Slowly transfer the electric load to the generator to be operated alone, by the adjustment of the governor motors, watching the electric power meter in the similar manner as bringing into parallel operation. When the reading of the power meter of the generator to be stopped shows about 5 kW, press the trip button to open (OFF) the ACED.

   Note:
   - If the electric power meter *for* the generator to be stopped reaches near 0 kW, it means a possible reverse power. On the contrary, if the timing is too early, it may cause a blackout by giving an excessive electrical and mechanical load on the generator and its prime mover.

3. After the transfer of the entire load (single operation), watch *for* the change of voltage and frequency. Pay attention to the change in the reading of each gage, and rise in the temperature of cooling water, lubricating oil and exhaust gas, due to a rapid increase in load on both generator and prime mover.
4. Before stopping a generator, ensure that the ACB is in the "OFF' (open) position.

   Note:
   - As there may be a case of three generators in parallel operation, ensure that the generator to be stopped corresponds to the ACB Erroneous operation that may lead to a "blackout."

5. Return the handle of the diesel engine to the "STOP" position to stop the engine.
6. After the engine is stooped, open the indicator valves and conduct an air-run (in order to purge exhaust gas to prevent corrosion owing to sulfuric acid). Then close all the compression indicator valves.
7. Slightly prime by means of manual lube oil pump.
8. Check the status of each valve. As each ship has own operating procedures, strictly follow the instruction and never handle them at crewmember's own discretion.

   Notes:
   - Check the cooling water of the fresh water expansion tank at least once or twice a day. The cooling water maybe reduced not only by evaporation but also by some leakage of exhaust valve cooling water, particularly in blind spots under the engine floor plate.
   - The inlet valve of the CJC filter (lube oil) maybe normally open, or opened only after the generator is placed in operation, depending on the ship. In either case, care should be taken to avoid inadvertently leaving the air cock open after bleeding air.

- Normally the air pressure is preset at 2 kg /cm2 on the inlet side. When the pressure difference from the outlet side decreases, it signifies deterioration in filtering capacity, which gives a guide on the time for replacement. (In other cases, replacement may be made according to operating hours.)

9.2 Fundamentals of Engine Room Team Management / Engine Resource Management

Maritime Resource Management (MRM) is a human factors training program aimed at the maritime industry. The MRM training program was launched in 1993 - at that time under the name Bridge Resource Management - and aims at preventing accidents at sea caused by human error.
In MRM training it is assumed that there is a strong correlation between the attitudes and behaviors of the seafarers on board a ship and the cultures that these seafarers belong to. The most relevant cultures in this respect being the professional, national and organizational cultures. Important target groups for MRM training are therefore, besides ships' officers and crew, all people in shore organizations who have an influence on safety at sea and the work on board a ship.
The use and co-ordination of all the skills, knowledge, experience and resources available to the team to achieve the established goals of safety and efficiency of a voyage or any other safety critical task is the correct definition of Maritime Resource Management.

The objective of resource management is to motivate the team – if necessary – to change its behavior to good resource management practices during everyday operations. This includes understanding of the importance of good management and teamwork and the willingness to change behavior. An overall objective is to increase safety, efficiency and job satisfaction in shipping companies and, eventually, in the maritime industry as a whole.

During everyday operation on board a ship, technical and non-technical skills are integrated into each other and both skills needed to perform tasks as safely and efficiently as possible. The technical skills are related to a specific department, job, function, rank or task.
These are the skills traditionally focused on in the maritime industry and what has since long been covered in the International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW).

Background and History of Engine Room Resource Management (Maritime Resource Management)

MRM is human factors training. This kind of training is sometimes referred to as soft skills training or non-technical training and was through the Manila Amendments introduced in the STCW. As opposed to technical training, non-technical training is generic, i.e. applicable to all. While most technical training has to be carried out with groups kept apart – divided into, for example, deck and engine – the non-technical training may be carried out with no separation of people at all. According to the MRM training concept, MRM training should be carried out as a separate training course without mixing it with technical issues. The purpose is to bring disciplines and ranks together in the same training class, providing them with the

same course contents, terminology and training objectives. The aim is to tear down barriers between people, departments, ship and shore, open up for efficient communication and establish a genuine safety culture within the whole organization. The MRM training concept is developed from similar type of training carried out in the aviation industry. An important event that triggered resource management training in aviation was the Tenerife airport disaster – a collision on the runway of the Los Rodeos Airport on the island of Tenerife on 27 March 1977 between two Boeing 747 airliners. The accident resulted in the highest number of fatalities in aviation history – 583 people lost their lives. Contributing causes of this accident were; fog, stress, communication misunderstandings and a lack of monitoring and challenging errors. Resource Management training in the United States are usually traced back to 1979 when a workshop sponsored by NASA, Resource Management on the Flightdeck, took place. This workshop was the result of NASA research intothe causes of air transport accidents. Research presented at the workshop identified the human error aspects of the majority of air crashes as failures of interpersonal communications, decision making, and leadership. At this meeting, the label Cockpit Resource Management (CRM) was applied to the
training of aircraft crews aiming at reducing pilot error. In the beginning of the 1990s, eight entities gathered with the objective of converting the airline industry's Cockpit Resource Management course to a course aimed at the maritime industry. These entities were:

- Dutch Maritime Pilots' Corporation
- Finnish Maritime Administration
- Norwegian Shipowners' Association
- SAS Flight Academy
- Silja Line
- Swedish Maritime Administration
- Swedish Shipowners' Association
- The Swedish Club

The first course, which was launched in June 1993, was called Bridge Resource Management, or BRM, because it was believed to be the most accurate translation of Cockpit Resource Management. "The cockpit onboard a ship ought to be the bridge."

In 2003 the name of the course was changed from Bridge Resource Management to Maritime Resource Management leading to the concept of Engine Room Resource Management (ERM). The main purpose was to increase attraction amongst other important target groups besides masters, bridge officers and maritime pilots, engineers and shore-based personnel.

Engine-room resource management:

- Allocation, assignment, and prioritization of resources
- Effective communication
- Assertiveness and leadership
- Obtaining and maintaining situational awareness
- Consideration of team experience

- Use English in written and oral form

Adequate knowledge of the English language to enable the officer to use engineering publications and to perform engineering duties

Use internal communication systems

Operation of all internal communication systems on board

Application of leadership and team working skills

- Working knowledge of shipboard personnel management training
- A knowledge of related international maritime conventions and recommendations, and national legislation
- Ability to apply task and workload management including:

1. planning and coordination
2. personnel assignment
3. time and resource constraints
4. prioritization

- Knowledge and ability to apply effective resource management:
    1. allocation, assignment, and prioritization of resources
    2. effective communication on board and ashore
    3. decisions reflect consideration of team experiences
    4. assertiveness and leadership, including motivation
    5. obtaining and maintaining situational awareness

- Knowledge and ability to apply decision-making techniques:

1. situation and risk assessment
2. identify and consider generated options
3. selecting course of action
4. evaluation of outcome effectiveness

Engine Room Resource Management is a method of using all available resources to conduct engineering operations and run a vessel. The resources involve are both EQUIPMENT and PEOPLE. It takes both traditional skills to operate the equipment as well as managerial skills to use personnel resources to their potential.

Human Factor are components that influence engine room personnel and their work environment. These are:

1. Teamwork
2. Situational Awareness
3. Communication
4. Stress
5. Fatigue
6. Leadership and Decision Making
7. Cultural Diversity

Recent studies have shown that 75 – 80% of all marine casualties cited Human Factors as the main reason.

Keys to Effective Engine Room Resource Management
1. Good Situational Awareness (Anticipation of situations in engine room operations)
2. Obtain Information Early
3. Build a Mental Model
4. Preparedness
5. Defined Organization
6. Realistic Decisions
7. Monitor Progress

Engineering Organization Procedures

The Engine Room Personnel's performance is essential to the safety of the vessel. In order to achieve a sound and efficient engine watchkeeping, DEFINED PROCEDURES as well as STANDING ORDERS of the Chief Engineer are necessary. Procedures should be established to ensure that duties and responsibilities of engine room members are clearly defined and assigned to every individual.

Effective Engine Room Procedures will minimize the risk of error that could otherwise have disastrous and irreversible consequences to the vessel. No engine room member should be assigned duties more than he can handle and no duty or responsibility should be re-assigned without notifying the engineer on watch. The engineer on watch should be vigilant especially during important situations such as arrival and departure maneuvering. Engine room members must be given specific area of responsibility in their duties so as not to interfere with other members but they can still share critical information during maneuvering situation.

Engine room members could make use of a CHECKLIST as a tool for written memory aid and to be accomplished a series of task or job order.

Team Building

The members of the engine room watch are a team. It is their responsibility to work together like as sport teamwork. Successful teams have members that support one another and enhance each other's skills.

Successful teams are goal oriented and they always get their work done. As people who care about each other grow together and work together within the engine room and work toward the common goal of a safe and efficient engine room operation, they get to know each other better. Engine room members begin to recognize and appreciate each member's unique qualities and qualifications and this leads to the development of the teamwork and harmony among them.

A good engine room team requires an ATTITUDE of partnership. Every engine room member must respect other members of the team. They all must desire to contribute to the safe and efficient operation of the engine room. Above all, they must learn to trust one each other. This makes it possible for engine room members to rely on one another. It allows them to make up for each other's weaknesses instead of trying to exploit them. Thin also enables one member to accept his weakness without shame or manipulation. Trust allows the engine room members to begin working as a single unit and to begin accomplishing the things that they together recognize as important.

Every engine room member has a role to play or responsibility to do in the engine room. Good engine room teams use every talent and skills of each member to maximize their resources for effective operation. We must always remember that no team member is less important than the other. Although engine room members are all equally important they are also meant to be diverse or different in many aspects of capability. Engine room team members should not COMPETE with each other, but they should COMPLETE each other.

Situational Awareness and Error Trapping

Situational Awareness is an accurate perception of the factors and conditions that affect theship and engineering plant during a specified period of time and situation.

The Elements of having Good Situational Awareness include knowing:
1. your ship, machinery and spaces
2. the normal operating parameters
3. all safety hazards
4. the engineering plant system status
5. the engine crew's status including fatigue and illness
6. the engine crew's knowledge & familiarity with the ship

When engine room members lose their situational awareness, they increase the potential for Human Error. Warnings that Situational Awareness has been decreased include:
1. ambiguity,
2. distractions or pre-occupation
3. general feeling of uncertainty
4. breakdown in communication
5. disregarding proper watch procedures

6. complacency or over confidence

The complexity of operating a modern day ship and the interaction within and outside of the engine room team provides the opportunity for ERRORS being committed by engine room personnel.

The three (3) types of ERROR committed on board are:
1. Failure to plan properly
2. Incorrect sending and receiving of information
3. Incorrect Actions

Accidents onboard particularly in the engine room are rarely caused by a single event. Accidents onboard are usually a sequence or chain of events (errors) that caused an accident. Breaking this error chain is essential to prevent accidents from happening in the engine room. Breaking the error chain is commonly called ERRORTRAPPING.

Communication

Communication is defined as the exchange of information, thoughts and feelings. Effective Communication is the exchange of information in a clear and understood manner. Effective Communication is very important to the success of the engine room organization and in achieving the goals of the engine room team. Effective communication within the engine room operations consists of sign languages and body languages due to the noise inside. It is important to choose words carefully and to speak them loudly, clearly and concisely due to the noise inside the engine room. An effective communication process includes the SENDER, the MESSAGE, the RECEIVER, and the FEEDBACK. The message should consist of correct terminology, and be clearly sent to the receiver. The receiver should be active in the communication process, and be able to give message feedback. The feedback includes acknowledgement, repeating or paraphrasing. Once the receiver has given the feedback, the communication process is complete when the sender acknowledges the feedback of the receiver. The success of the engine room team depends greatly on Effective Communication. Engine room members will not follow their leaders if members do not know what their leaders want or where the leaders want to go. Leaders and members alike can be an effective communicator if they follow the four simple truths.

1. Simplify your message: The key to effective communication is simplicity. Forget about impressing people with big words or complex sentences. If you want to connect with people, keep your words simple.
2. See the person: As you communicate with people, know them by their nature and attitude .
3. Show the truth: Credibility precedes great communication. Believe in what you say. Then, live what you say. There is no greater credibility than conviction in action.
4. Seek a response or feedback. Never forget ask for signs or feedback from people. Give them something to remember, to feel and to do.

Stress

Stress is the effect that a stimulus has on the body. It is anything that can thrill, worry, scare and threaten us. There are three (3) recognized stages of Stress:
1. ALARM stage is when the stress is first encountered, the body adopts to higher level of stress
2. RESISTANCE sets in and lastly is when the body resources are depleted
3. EXHAUSTION takes place.

Not all stress are bad, studies shows that there is an optimal stress level where the body performs best. However too little stress causes boredom while too much stress diminishes a person's situational awareness and causes panic.

When the Alarm stage of stress is recognized in any of the engine room members, good engine room team members must be able to accommodate the stress of other members experiencing stress. This includes reducing other members' individual workload or assigning tasks/duties based on ability or experience.

Fatigue

Fatigue is defined as weariness or exhaustion from work, over exertion, inadequate sound sleep or the cumulative effects of poor sleep over several days. Fatigue slows down visual perception, decision making, memory task and mental calculation.

Signs of Fatigue are:
1. Errors of volition
2. slower task performance
3. decreased morale and motivation
4. poor communication
5. sleeping on duty

Eight (8) hours of sleep is normally required in a 24 hour period to avoid creating a sleep debt. Get the best possible sleep before reporting for duty. If you feel sleepy and time allows it, then get some sleep. If you wake and cannot sleep after thirty (30) minutes, you will have to get up for awhile. Good sleeping habits are all part of preventive strategy to avoid fatigue. Taking a short nap during break from engine room work would be beneficial to your mind and body. A good diet and exercise will allow you - to have quality sleep. A light evening snack would be appropriate before you take your rest for the night. Physical activity or exercise will improve body resistance against stress and fatigue. The following could increase alertness while you are on watch.
1. physical action (walking, stationary jogging, etc)
2. conversation on professional topics
3. balanced nutrition and diet (eat lots of fruits and vegetables and less meat and fats, oily foods should be discarded if possible)
4. drink lots of liquids (eight glasses of water everyday)

Leadership and Group Decision Making

Engine Room Resource Management is based upon Synergy which is: The total result is greater than the sum of the individual taken by themselves. The best leader shares information, communicate openly and encourage participation. The respect of other and the ability to share workload are also traits of a, good leader. Maintaining a constructive and positive attitude and keeping a receptive atmosphere coupled with honesty are necessities of productive leaders. Decision making is an essential skill for the operational team leaders. Team members share the responsibility for solving the problems by contributing timely and valuable information to the team leader.

God called leaders to step forward to lead others as we follow him. Every engine room officer on watch has the capacity to lead if he allows himself to participate in various engine room processes and learns the day-to-day operation.

The strength of the engine room team is determined by the strength of their leaders. Good engine room leaders will remain calm and consistent even during crisis situation. The following are the traits of leaders who can stand crisis situation.
1. Integrity - a virtue wherein the leader's life and words are the same.
2. Convictions - The leader's values won't accepts bribery
3. Positive focus - the leader thinks of positive things only
4. Pure - the leader disciplines his mind to remain clean and pure
5. Secure - the leader is firm, stable in his identity and source of strength.

The best engine room leaders desire to serve his engine room members, not themselves. Servant leadership is not about position or skills. It is about attitude. Servant leadership is never motivated by manipulation or self promotion. The extent of the leader's influence depends on the depths of his concern for other members. It is important for engine morn leaders to be willing to serve.

What you are is what you produced. Good leaders attract and reproduced good engine room members. Traits that attract engine room members to become like their engine room leaders are the following:
1. leaders attract members without really pursuing them.
2. leaders draw deep loyalty from members without ever trying to get it.
3. leaders transformed his members without disenchanting them over the initial engine room situation.
4. leaders work and live along side his members and turn them to be successful.

A good engine room leader places high value on praising his members. Leaders are encouraged to give due recognition to his engine room members for their achievements and good works. Engine room leaders need to value his members, praise their efforts and reward their good performance with recognition. No matter where they fail or how many mistakes they make, don't let this things devalue their worth as a person and as members of the engine room.

Good engine room leaders must be able to create an environment in developing other member's potential to become future engine room leaders themselves. To be able to develop reproduce future engine room leaders, leaders must be:
1. personable and approachable in accepting people to work for him.
2. resourceful and makes use of every situation even the adverse ones, to get the best result in engine room operation.
3. rewarding his members with due recognition and motivation to affirm their good performance in the engine room team.
4. respectable and a model leader to his subordinates and members, showing leadership by good example.

Good engine room leaders must be able to see the good (positive) things in his members rather than the bad (negative) things. He can practice “The 101% Principle” – finding the 1% you can affirm and giving it 100% of your attention. Leadership rule #1 is this: Affirmation comes before confrontation. Good engine room leaders look for the good in his members and affirm it. Only then can they address the problems in the engine room.

Some people are born with greater natural gifts of leadership than others. The ability to lead is really a collection of skills, nearly all of which can be learned and improved. The process of learning and improving leadership ability doesn't happen overnight. Leadership is in fact very complicated. It has many facets: respect, vision, experience, emotional strength, people skills, discipline, timing - the list goes on. Many factors that come into play in leadership cannot be seen with our naked eye. That is why leaders require so much seasoning or improvement. Leadership experts define the relationship between growth and leadership as the capacity to develop and improve their skills that distinguishes leaders from their followers.

Successful engine room leaders are learners. In the book of wisdom it is quoted, "A wise man will hear and increase his learning. So is a good engine room leader. His goal each day must be to get a little better, to build on the previous day's work in the engine room.

Cultural Diversity

Effective ERM requires the understanding and respect for the different cultures of engine room members. It is important to recognize that ERM is the common goal of each engine room member. Open communication could reduce the conflicts within the engine room organization. We must always remember that some individualism can exist during our interaction and operation in the engine room.

9.3 Record Keeping / Forms & Checklist

A recordkeeping system is a system which captures, manages and provides access to records through time. Recordkeeping systems can be either electronic or paper-based. Record keeping is of utmost significance

and that each event occurring onboard has to be best recorded for all the official and legal intentions, we shall discuss what one has to bear in mind while jotting down the entries in a few important log books.

Official Log Book

The heads of their respective departments are fully and the only ones authorized to maintain this statutory log book and the Master has the overall responsibility to oversee its authenticity and appropriateness. The log book is considered to be a running log of all official events such as Arrival / Departure of the vessel to / from port, Draughts, Freeboards, Onboard Emergency Drills, Crew onboard, Fuel/Fresh Water ROB, Master's Handing Over/Taking Over, etc. Although some flag states do provide a short guide for keeping the official log book and while some don't, it is imperative that all entries must be made in a professional and legible manner. A few pointers while making such entries –

- All entries should be made as soon as practicable after an event occurs, since all the logs are running records of the vessel it makes record keeping vulnerable if delayed in entirety.
- Only authorised personnel should make such entries. Master may designate personnel to do so.
- Entries to be signed where required by the person making such entry and by the person witnessing the event.
- All entries must have a date and time recorded
- It will be the Master's responsibility to ensure the Official log book is accurately filled and signed.
- Entries made in the log must not be amended or deleted under any circumstances unless the Master authorizes the cancellation. If it is to be done, it is a good practice to make sure the entry is stroked out with a single line and an initial put against the omitted entry.
- If the entries cannot be contained within the log books' pages due to their length, they must be entered separately in a separate document, endorsed and attached to the log book. A reference number may be given for easy record tracking.

Oil record book

It is one of the most important documents onboard with a written record for compliance of annex I of MARPOL.

- When operating oily water separator, 15 ppm equipment for discharging treated bilge water overboard, the operation is recorded with time, position of ship, quantity discharged and retention.

- Maintenance operation of MARPOL equipment like OWS, Sewage treatment plant and incinerator to be recorded with the type of maintenance, date and time.

- Bunkering operation to be recorded including date, time, bunkering grade, quantity bunkered, port of bunkering, and retention of tank used in bunkered operation.

- Weekly retention of waste water that includes bilge and sludge system to be recorded.
- Any internal bilge or sludge transfer to be recorded with date and time and quantity transferred.
- Any maintenance on OWS is recorded and acknowledged by engineering officer carrying out the operation.
- It should always be accompanied with IOPP certificates and all the receipts of bunker (BDN) and sludge/bilge disposal operation.
- All the operation and records are acknowledged by officer carrying the job along with chief engineer signature.
- At the end of every page, master will sign the oil record book.

Engine Room Tank Sounding Log

- It is used to keep a written record of soundings of all the engine room tanks including waste water tank, fuel oil and diesel oil service settling and bunker tanks.
- A responsible engineer officer (fourth engineer) will take and record sounding for all the tanks.
- Frequency of sounding is normally twice a day – once in the morning and second in the evening.
- Record of sounding is acknowledged by the engineer officer taking the sounding.
- Every day sounding log is counter checked and acknowledged by the chief engineer.

Sewage Management Log

- The sewage management log consists of ISPP certificate, operating procedure of sewage plant, and maintenance procedure of the sewage plant.
- Second engineer is responsible for maintaining the sewage management plan log.
- Any discharge of sewage overboard at sea is recorded in this log along with date, time, position of ship, and quantity discharged.
- All the records are acknowledged by the engineering officer carrying the operation.
- Any maintenance in sewage plant (chlorine tablet dosing etc.) is recorded and acknowledged by the engineering officer carrying out the maintenance.

Saturday/Monday Routine Log

- All the emergency equipment such as LSA, FFA equipment and systems on board ship, which are tried out in weekly, monthly or yearly basis, depending upon equipment operation and company requirement for satisfactory operation, are recorded in this log.

- It includes emergency generator, emergency fire pump, emergency compressor, life boat engine, emergency stops of pumps and ventilation fans, fire dampers and other equipment and systems as per company requirement.

- All officers onboard are designated with particular equipment for carrying out trial operation and procedure, which are to be entered in this log.

- Every entry is to be acknowledged by the officer carrying out the operation with remarks and brief description of the same.

Chief Engineer Night Order Book

- Only Chief engineer is responsible for maintaining this log.
- Chief engineer's instructions are written for night watch officers in this book.
- All engineer officers and trainee engineer officers have to read and acknowledge the order written by the chief engineer.

9.4 Emergency Responses

Blackout is one condition each and every mariner is familiar with and also afraid of. It is one situation everyone on the ship is terrified of because it brings the whole ship to a standstill. From bridge to engine room, from dinning crew members to the sleeping ones, everyone is affected by a blackout.
If you are the one working in the engine room, then a blackout condition is your responsibility and you should be responsible for the same, sooner or later the blame is going to come on you. In this article we will learn what are the first things that need to be done in case of blackout condition on a ship?

Understanding Blackout Condition

Blackout condition is a scenario on a ship, wherein the main propulsion plant and associate machinery such as boiler, purifier and other auxiliaries stop operating due to failure of power generation system of the ship – Generator and alternator.

With technologies and automation, measures are provided to avoid such blackout situation by means of auto load sharing system and auto standby system in which the generator set that is running in parallel or standby comes on load automatically if the running diesel generator fails.

What to Do in Case of a Blackout?

In case of Blackout following precautions and actions should be taken:-

- Never panic in such situation, be calm and composed. Emergency generator will restore the power in no time.
- Inform Officer on bridge briefly about the condition.
- Call for man power and inform the chief engineer.
- If the main propulsion plant is running, bring the fuel lever to zero position.
- Close the feed of the running purifier to avoid overflow and wastage of fuel.
- If auxiliary boiler was running, shut the main steam stop valve to maintain the steam pressure.
- Find out the problem and reason for blackout and rectify the same.
- Before starting the generator set, start the pre- lubrication priming pump if the supply for the same is given from the emergency generator; if not, then use manual priming handle (provided in some generator).
- Start the generator and take it on load. Then immediately start the main engine lube oil pump and main engine jacket water pump.
- Reset breakers and start all the other required machinery and system. Reset breakers that are included in preferential tripping sequence. (Non-essential machinery).
- It requires both skill and patience to tackle a situation like blackout specially when the vessel is sailing or maneuvering. However, the best way to tackle such situations is to be calm and composed; and to know your engine room and machinery very well in advance.

Engine Room Flooding

Engine room flooding as the name indicates, means filling up of the engine room space with water. Engine room flooding can affect the water tight integrity of ship. In this article we will find out what are the main reasons for engine room flooding what has to be done in case of engine room flooding.

The engine room flooding can take place due to mainly three reasons:

1) Leakage from Equipment and system

Engine room flooding can take place due to leakage in the engine room space from machinery or sea or fresh water system. Leakages can generally be from big sea water pump, from sea water or fresh water cooler, leakage from boiler feed water system etc.

The leak can also take place from any of the fresh or sea water pipeline due to which a lot of water can enter the engine room space. Leakage of any ballast water tank in the double bottom of the engine room, leakage from manhole, or crack in the water tank can also lead to engine room flooding.

Sea water or fresh water piping and system of the engine room are huge in size and thus hold large possibility for leakages.

Action to be taken in such situations

– Call for maximum man power to tackle the situation.

– The sooner you find the fault the better.

– Start the other circulating system and isolate the leaking pump, pipe, cooler etc.

– Close inlet and outlet valves of the effected system to stop the leak.

– Inform chief engineer regarding the leak and follow the instruction from him.

– Put a notice or placard regarding leaking equipment or system and trip the breaker until repairs has been done.

– In case of any tank leakage, start transferring the excess content from that tank to other tank and try to minimise it as much as possible.

– Tank should not be used until cement box or welding has taken place or a repair has been done.

2) In case of leakage from Overboard Valve

– If the Leakage is after the valve and if the valve is holding shut the valve if the system involved for that valve permits normal operation of the ship with the valve closed.

– If the valve is not holding then identify the leak. It may be from the valve stem gland or flange joint; try to repair the leak.

– If system for that valve can be isolated without disturbing the normal operation of the ship, put a blank in the valve.

– If the repair is temporary then when ship reaches the port, call the divers to blank the valve opening from outside and carry out permanent repair.

3) Flooding due to crack in the hull or small hole in the hull

– In this case, as soon as you find the leak, call for help from nearest coastal state because if the leakage is more, the ship's stability will be affected.

– By all means, the leakage has to be minimised and finally stopped.

– If the leak is not big enough, then cement box is to be put in place of the leak and repairs are to be done accordingly.

– In case of leakage due to damage from any accident like collision or grounding, there is nothing much that can be done as the opening in the bulkhead is large and there is no chance of stopping the leak. In such cases, the captain has to decide whether the ship is safe place to stay or not and decision for abandoning the ship has to be made.

– In case of abandon ship signal being announced, the crew should muster to their respective lifeboat and abandon ship operation should be carried out.

For any of the above reasons, if the water level ingress in the engine room is very high, then open the emergency bilge ejector valve with consent of the chief engineer and pump out the water overboard. Entry of the same is to be made in Oil record book (ORB) with date, time, and position of the ship and reason of direct discharge with signature of officer involved in operation, chief engineer, and master should be registered.

Fire Engine Room

Precautions against Fire in the Engine Room

- Keep the engine room shipshape by cleaning
- Ventilate the engine room sufficiently to blow off any flammable gas.
- Take precautions in the handling of light oil and of the flammable substances.
- Make efforts to find electric leaks as soon as possible.
- Completely provide fire extinguishing device and make efforts to find fire as soon as possible.

Precautions against Fire on Board Vessels and its Causes

- Fires are generally caused by careless handling of fire and electric leaks. Completely check and dispose of fire and repair electric appliances.
- Never use naked lights or defective portable lamps in the engine room.
- Make efforts to find a fire as soon as possible.
- Do not allow bilge water to accumulate. Keep the tank top clean.
- Completely provide portable fire extinguishers and fixed firefighting installations, and master how to use them.
- Ignition of combustibles owing to careless handing of fire or spread from outside.

- Overheating or combustion gas leakage of the exhaust chamber or overheating or leakage of fuel oil heaters owing to careless handling and inadequate maintenance.
- Pay attention to spontaneous combustion of cargo.

Preventive Measures of Fire

- Strict surveillance and precautions: designation of storage places of combustibles and smoking places, control of the places where the use of fire is prohibited, and disposal of fire after use.
- Good maintenance of portable fire extinguishers and fixed fire fighting installations, and thorough education in their handling.
- Good maintenance of electric installations and preservation of their insulating resistance.
- Give sufficient maintenance and take precautions in the handling of the machines and instruments, e.g. cleaning of exhaust gas pipes and inspection of the surrounding area of the boiler combustion chamber.
- Train and educate crew members through regular drills so that may gain more awareness of fire prevention and to acquire necessary skills to combat fire.

Measures to be taken when fire is found on board

- The person who finds a fire should immediately shout "Fire at (name of location) "or" (name of location) fire) repeatedly in a loud voice and report the fact of the fire outbreak and place to the nearest person. The person in turn should shout likewise repeatedly and report it to the bridge as soon as possible.
- Fight fire by using fire extinguishers, sand, water, blankets, etc. on hand suitable for the nature of the fire.
- Remove combustibles and explosive materials. Release air from the air vessel for starting air in good time.
- When a number of crew members arrive, connect the hose with a nozzle to the hydrant and stage a full scale fire extinguishing operation to prevent the spread of fire.
- The person who has first found a fire should raise the general alarm to notify all crew members, and fight the fire by using fire extinguishers or sand in its early stage.
- In the case of oil fire, cover it with blankets or fight fire with extinguishers located nearby in order to suppress the fire as fighting oil fire with the fire pump may spread it.
- When a fire gains intensity and becomes difficult to control close the engine room openings to prevent air inflow from outside.
- Shift explosives to a remote place away from fire, and release air from the starting air vessel as it is liable to explode.
- Wash away any split oil or oil floating on the surface of bilge water, as it may often catch fire. Put oil stained rags in the specified container.