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Ship Construction Notes for Pre Sea Deck Cadets

7.1 Ship Construction – Syllabus (Directorate General of Shipping Guidelines)

7.1.1 Explain in general terms the basic types of ships, i.e. General Cargo, Bulk Carrier, container, and Oil Tanker.

7.1.2 Explain the principal dimension of a ship – LOA, LBP, EB, MB, MD, GT, NT. Name and explain the principal parts of a ship including peak tanks, double bottom tanks, deep tanks, cargo tanks, ballast tanks, etc.

7.1.3 Introduce the following ships plans: General Arrangement, Fire fighting appliances, life saving appliances, pumping and piping arrangements

7.1.4 Explain the following: beam, frame, bulkhead, hatch, tank, coaming, hatch cover, rudder, deck, hull, bilge, sounding pipe, air pipe, ventilator. Show where these are found on a ship.

7.1.5 Explain draft marks & load lines. Explain the method of reading draft marks in feet and metres.

7.1.6 Conduct practical exercises on reading draft by use of a suitable model.

7.1.7 Explain the causes and simple methods of prevention of corrosion in a ship's structure. Brief notes on paint technology and anti-corrosion techniques.

7.1.1. Explain in general terms the basic types of ships, i.e. General Cargo, Bulk Carrier, Container, and Oil Tanker

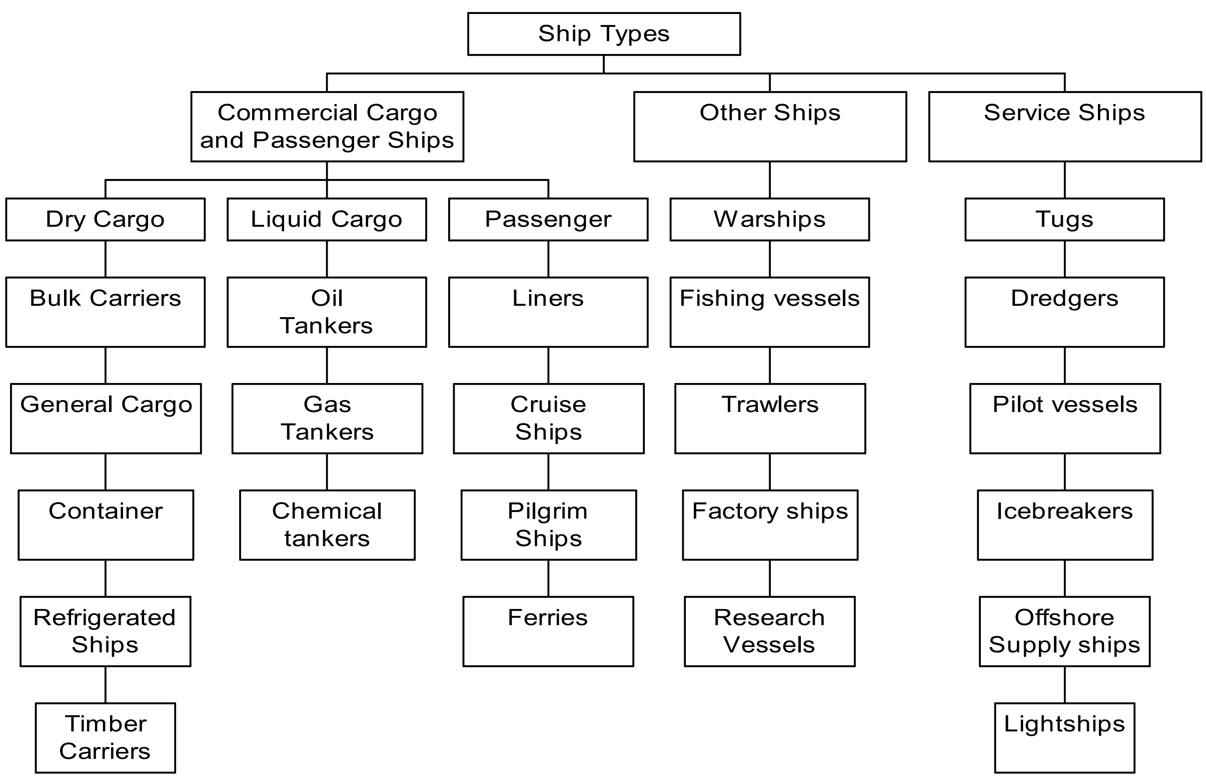
TYPES OF SHIPS

Ships carry goods, i.e. cargo. Some ships carry people, i.e. passengers. Some ships carry animals, i.e. livestock. Some years ago, small ships would carry some, or even all the above, together, in small quantities each.

As time passed, and trade between places increased, the quantity of cargo, the number of passengers, and the number of livestock, which were transported by ships, increased. The size of ships therefore increased.

Gradually, world trade increased so much that the amount of cargo of a particular nature was sufficient to fill an entire ship by itself. Therefore, different types of ships were built and used to transport different types of cargoes.

Initially, there was a broad classification, i.e. cargo ships, tankers, passenger ships, etc. Today, there is "specialization" and "super-specialization" in ships and their types. Some of these ships are discussed in the following paragraphs.



GENERAL CARGO SHIP

The diagram below shows a typical general cargo ship, with four cargo holds forward of the engine room and one cargo hold aft of the engine room. The cargo holds are divided vertically into Lower Hold and 'Tween deck. One or more of the Tween decks may be fitted with a "locker" for the storage of valuable cargoes. In some ships, a part of one of the lower holds may be fitted with a tank that extends from the double bottom upto the Tween deck. The tank would be used for the carriage of vegetable oils and other such cargo.

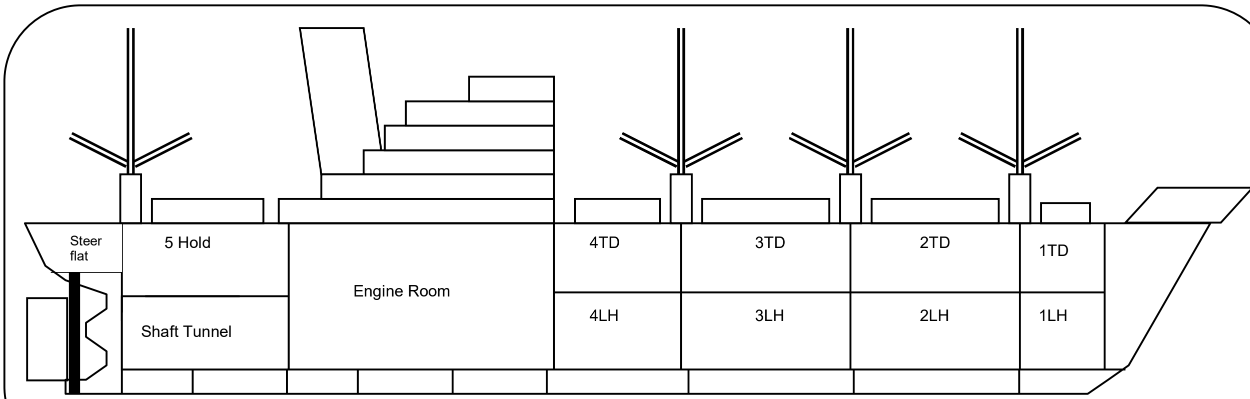


Figure 1: A General Cargo Ship.

Under the lower holds there are "double bottom" tanks. These tanks would be for seawater ballast. Some of these tanks may be for fuel oil (heavy fuel oil or diesel oil). There are double bottom tanks under the engine room too. These would be for the carriage of fuel oils (heavy or diesel).

Since the ship in the diagram above has a cargo hold aft of the engine room, it would need to have a "shaft tunnel" passing through hold no. 5 for the propeller shaft to pass through.

The foremost part of the ship will have a tank called the "Fore Peak" Tank. This would be for the carriage of seawater ballast, though on some ships this tank could be used for fresh water. Above the fore peak tank there would be a store room called the fore peak store, meant for the storage of mooring ropes, paints and other essential ship's stores. The paint locker though it may form part of the fore peak store room space, will have to be separated and isolated with a separate fire fighting system as paints are flammable materials.

Aft of hold no. 5, in the diagram above, in the aftermost part of the ship, is the "After Peak" Tank. This tank is mostly used for fresh water. Normally, the lowermost part of this tank will always have some water within it, thereby providing cooling for the propeller shaft that passes through the aft peak tank. Above the after peak tank is the "Steering Flat" that houses the steering motors and the emergency steering arrangements. On some ships, the emergency fire pump is also located here in the steering flat.

A general cargo ship carries cargo of a "general" nature. The cargo may be packed in a wide variety of packing such as boxes, or crates, or bales. It could also be in bags, The bags used for packing may be of paper, jute, polypropylene or other materials. Cardboard cartons, drums or barrels are also used. Large, heavy cargo may be without any packaging. Various other types or forms of packing may be used.

The list of items carried in a general cargo ship is very large. A few items are named here: Tea, coffee, jute, rice, gunny, tobacco, cotton, steel, manufactured parts, newsprint, milk powder, trucks, cars, buses, railway engines, containers, television sets, VCRs, beer, whiskey, wines, etc. etc.

A general cargo ship is also permitted to carry upto twelve (12) passengers (only). With upto 12 passengers, it is still defined as a general cargo ship. With above 12 passengers, it is defined as a Passenger Ship.

Derricks (on some ships cranes) are used to load and discharge the cargo. Some ports may use shore cranes or shore gear for handling the cargo.

A general cargo ship, being of an average to small size is normally transverse framed with some longitudinal strength members.

BULK CARRIER

Solid bulk cargoes include bulk material other than liquid or gas.

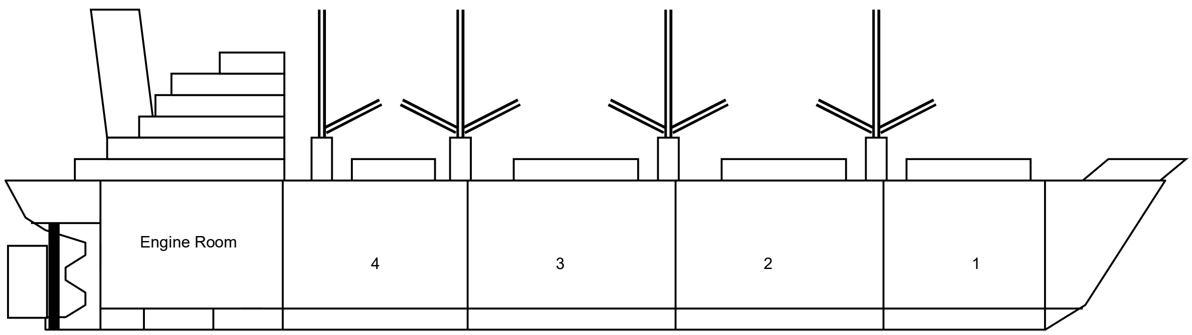


Figure 2: A Bulk Carrier

Discharge is by grabs, and / or elevators. Bulldozers are used to trim while loading. Bulldozers are used to bring cargo to the hatch square for grab discharge.

Bulk cargo includes grains such as wheat, maize, soya bean, ores such as iron, bauxite, chrome, manganese, coal unbroken, mud coal, slurry and bulk chemicals

The diagram above shows a bulk carrier with four cargo holds, without 'tween decks.

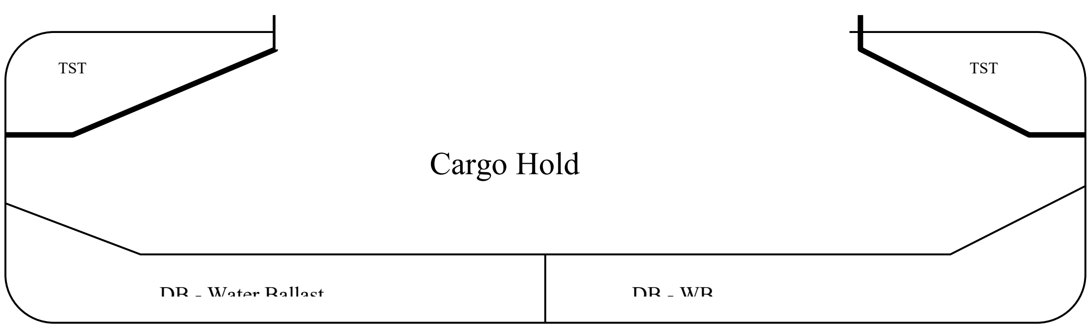


Figure 3: Transverse Section of a Bulk Carrier with "Self Trimming Hatches"

Sometimes bulk grain or other cargo is put into bags while it is still inside the ship and then discharged using slings or nets. Sometimes the discharge may be by slings.

Typically, a bulk carrier would be constructed on the combined system, with longitudinal framing in the double bottoms, bottom of wing tanks and at the deck, and with transverse framing being fitted at the sides. Transverse webs are fitted in the wing tanks at intervals of 3 to 4 metres. Side stringers are fitted at approximately one third and two third depths of the tanks.

The fore peak tank, fore peak store, after peak tank, steering flat and other such features of the general cargo ship that has been described above would essentially be the same.

CONTAINER SHIP

A container ship carries general cargo, and other types of cargoes in “containers”. A container is a steel box, eight feet wide, eight feet high (8’6”, 9’, 9’6”), and either twenty feet or forty feet in length.

A twenty foot container, when full of cargo, can weigh about 24 tonnes, though there are specially strengthened containers designed to carry larger weights. A forty foot container, when full, could typically weigh about 30 tonnes. The weight of the empty container is known as its “tare weight”. The cargo that goes into the container is the “net weight” and the both together (cargo and container) contribute to the “gross weight”.

Loading and discharging are done by ships cranes or by shore cranes and/or gantry cranes. Since twenty to thirty tones of cargo is loaded or discharged in a single “move” the ship can sail out faster.

Containers can be locked and sealed, therefore making theft or pilferage difficult if not impossible, and in any case greatly reduced.

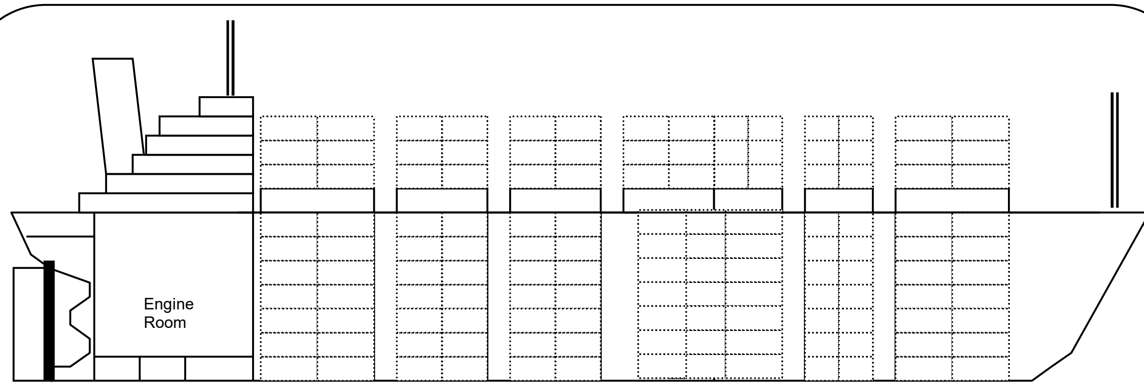


Figure 4: A Cellular Container Ship.

General cargo ships that have been designed to carry some containers can also carry containers. These ships were called the “container oriented cargo vessels”. However, the container trade had become highly sophisticated and specially designed ships are the need of the day.

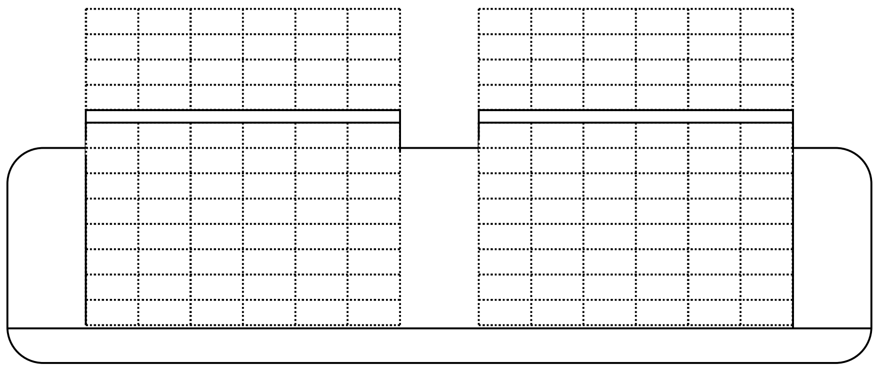


Figure 5: Transverse Section of a Cellular Container Ship

Container ships have been growing larger by the year, and the ships today, carry upwards of 15000 TEU (**T**wenty foot- **E**quivalent- **U**nits).

On these "fully cellular" container ships, it is not necessary to carry out special securing arrangements for lashing the containers. The ships are built with "cell guides" that the containers fit snugly into, thereby making separate lashing un-necessary.

Full containers can be collected from the shipper of the cargo, directly from his warehouse and be brought to the ship by road or rail. Similarly, the container, after the sea voyage, can be sent by road/rail directly to the consignee's doorstep. This mode of cargo transfer is called "door-to-door" and has made the container trade a highly sought after mode of transport and thus very profitable.

TANKER

Since liquid cargoes are carried in large quantities across the seas, a special type of ship is used for this purpose. Such a ship is known as a tanker.

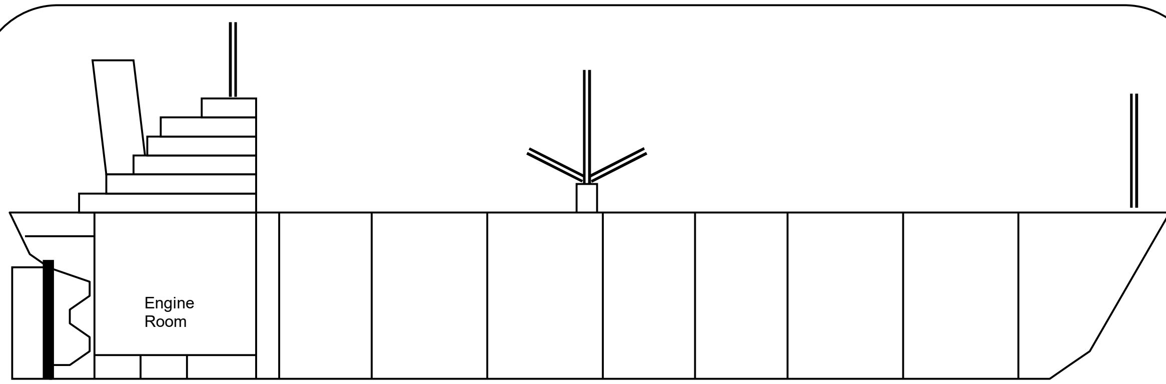


Figure 6: A Tanker

In the above diagram, a typical tanker seven sets of cargo tanks is shown. Normally, each tank is divided into three in the athwart ship direction, i.e. Port, center and starboard.

Tankers carry various types of liquids, though a majority carries petroleum and petroleum products. Tankers have evolved into specialized cargo carriers and today there are different "tanker types" which are briefly mentioned below.

Some of the cargoes that are carried on tankers are crude oil, fuel oil, diesel oil, kerosene, naphta, fresh water, wine, whiskey, milk, chemicals, coconut (palm) oil, etc,

TANKER TYPES

Oil Tankers can be divided into seven basic types, namely:
1 Crude oil tankers,
2 Product tankers,
3 Ore/Oil carriers,
4 Ore/Bulk/Oil carriers,
5 Bitumen carriers,
6 Gas carriers,
7 Chemical carriers.

CRUDE OIL TANKERS:

The general layout of the crude oil tanker is illustrated in the diagram above. They are single decked vessels, with at least two longitudinal bulkheads sub-dividing the tanks into smaller tanks transversely. On older crude oil tankers, double bottoms were located under machinery spaces, but NOT usually elsewhere. New crude oil tankers above 600 tonnes are required to have side tanks and each cargo tank of capacity not greater than 700 cubic metres. New tankers are required to have a double hull if they are of over 5000 tonnes. A deep tank is nearly always fitted forward of the cargo tanks and this is normally used for carrying bunker oil for the ship. The pump room is usually located aft of the cargo tank system. Slop tanks are provided aft of the cargo tank system. Modern crude tankers are provided with wing tanks for the carriage of water ballast.

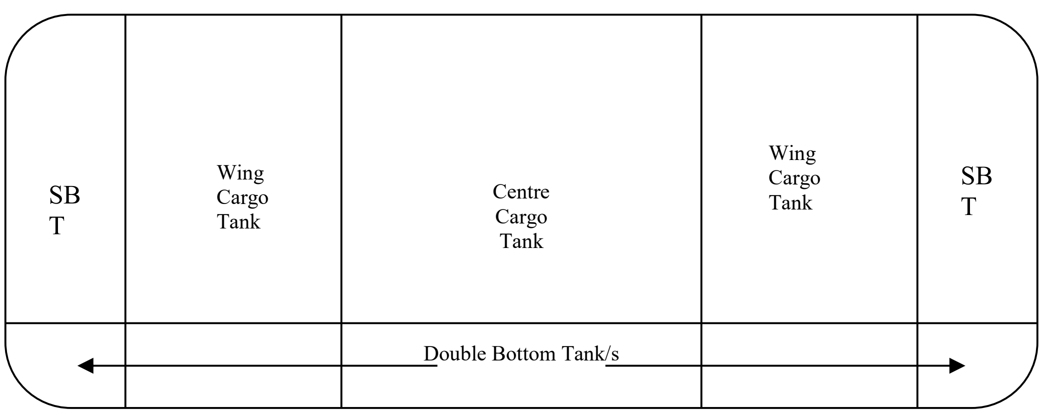


Figure 7: Transverse Section of a Crude Oil Tanker

Crude tankers are large ships. They are employed in transporting crude oil from the oil fields where it is produced to the oil refineries. The crude oil tanker has a relatively simple pipeline system and high capacity cargo pumps to reduce time spent in port for discharging cargo. The pipeline system doesn't provide for a high degree of multi-grade segregation of cargo. The cargo oil tanks may be provided with heating coils.

A new crude oil tanker of 20,000 tons deadweight and over is provided with an Inert Gas System (IGS) and Crude Oil Washing (COW) system. The description of these systems will be handled in detail later in this course, while you are undergoing the Oil Tanker Familiarization Course.

PRODUCT TANKER:

In layout of cargo tanks, ballast tanks, slop tanks, pump room, engine room, double bottom tanks, etc., product tankers are akin to crude oil tankers. They are generally smaller in size than crude oil tankers. The tank internals are coated to protect against cargo contamination by rust and corrosivity of the cargo attacking the steel of the ship. The cargo tanks are tanks are provided with a cargo tank heating system. They have a larger number of small cargo tasks. These ships are provided with elaborate cargo piping system, so designed as to enable the simultaneous carriage of more than one product without co-mingling of products during handling and carriage.

The products usually carried are naphtha, motor spirit, kerosene, diesel, etc. The cargo pumping system is designed to handle cargo at comparatively lower loading/discharging rates. Lower rates are used because some products are extremely volatile, some are viscous, and some are unstable. Product tankers are provided with cargo pumps of lower capacities. A new product tanker of over 20,000 tons deadweight will be provided with an inert gas system.

ORE/OIL CARRIERS:

This is an oil tanker equipped to carry ore in its centre cargo compartments.

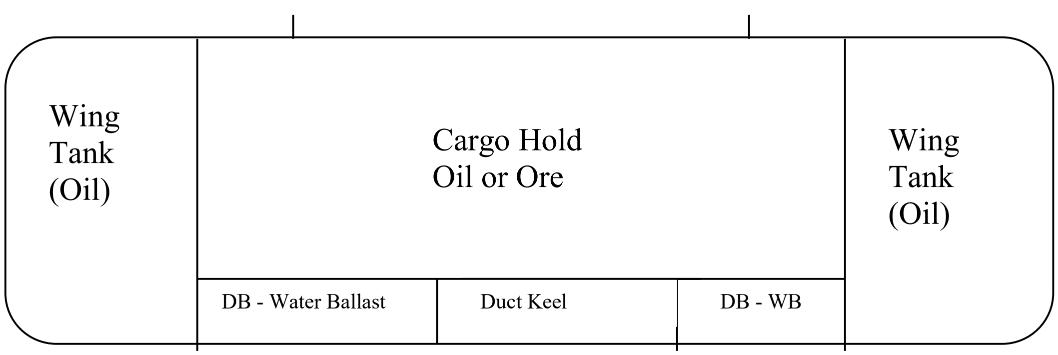


Figure 8: Transverse Section of an Oil Ore Carrier

Compared with similar-sized conventional tankers, the main difference revolves around the centre compartments, which are located over double bottom tanks and have large, heavy steel hatch covers. The centre compartments are arranged so that the longitudinal plating slopes inwards, providing a self-trimming factor when loading ore. The centre compartments are generally free from all structural members, which would hinder loading or discharging ore.

If coils are required for heating the oil, these are installed in the wings or under holds and welded on racks to the plating near the bottom. The centre compartments contain no piping, and are pumped out by wells let into the double bottoms and connected to the cargo piping system through wing tanks.

The wing tanks are arranged in the same manner as a conventional tanker and are capable of carrying oil or ballast, as required. These ships are fitted with a Inert Gas System and Crude Oil Washing System.

ORE/BULK/OIL CARRIERS:

This type of vessel is designed to basically carry ore, grain and other dry bulk cargo. The vessel has large clear holds with no 'tween decks.

The engines are located aft, as in a tanker, and the hatches are provided with gas tight hatch covers. Hopper tanks and double bottom tanks are used to carry ballast.

To enable the OBO to load and discharge liquid cargo, the holds are connected by a duct system or pipeline system to the pump room. The duct keel (in a duct system) may be divided into cargo duct and ballast duct, running longitudinally.

The cargo duct connects the cargo holds to the cargo pump room and is used for loading and discharging liquid cargo to/from the holds.

The ballast duct connects the double bottom tanks and the lower hopper tanks to the ballast tanks and is used for ballasting and deballasting these tanks.

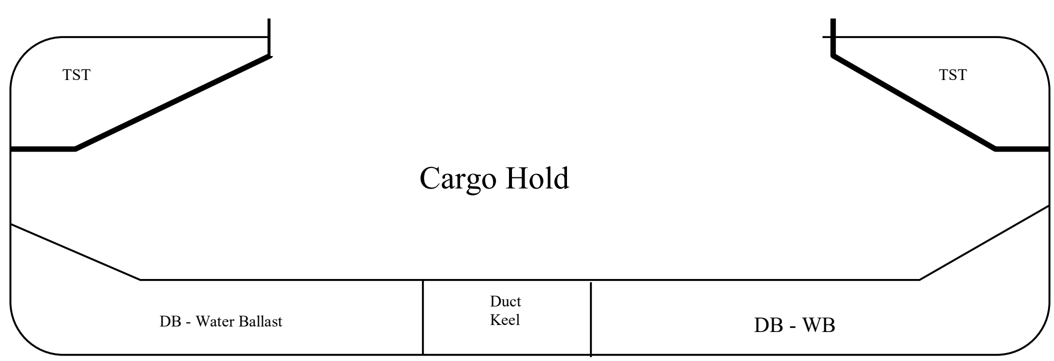


Figure 9: Transverse Section of a Oil / Bulk / Ore Carrier

The duct keel may, in other cases, be used as a pipe tunnel for all pipelines leading to and from the tanks and holds. Liquid cargo is loaded in the holds only. OBOs are provided with Inert Gas Systems and Crude Oil Washing systems.

BITUMEN CARRIERS:

Bitumen can be described as a black to dark brown substance, which can be solid, semi-solid or a viscous liquid, according to temperature. It is derived from certain types of crude oil, and is generally classified according to its penetration number.

Bitumen is used in the manufacture of asphalt and several other similar products. It is transported in bulk by sea, and on land by special rail cars, which are equipped to handle it, but in some cases it is blocked and shipped as a solid.

Bitumen ships are specially built to handle this product at high temperatures. Not only are the ships equipped with wing tanks and double bottoms to isolate the cargo tanks from the shell, but heating coils are rather more elaborate than in normal ships. In addition to the coils covering the bottom of the tanks, additional mattresses or layers of coils are provided at different levels in the tanks. Piping and pumps in the pump room as well as on deck are provided with lagging, and the deck lines are often provided with a steam trace in addition to this. Most grades of bitumen are handled at temperatures that exceed 125^{0}C. Below this temperature they become hard to handle.

This type of vessel is generally equipped with two pumping systems, which are segregated from each other. The bitumen cargo system is served by one system, which is used for nothing else while the vessel is in the bitumen trade. The wing tanks and double bottoms are served by the other system which handles the ballast while the vessel is in this trade, but can also be used to handle cargo should the vessel cargo any cargo other than bitumen. Due to the fact that bitumen is a fairly heavy cargo, the centre tanks provide sufficient cubic capacity to give the vessel a full cargo sand bring her to her marks.

GAS CARRIERS:

Gases such as petroleum gas, natural gas and chemical gases are shipped at sea in liquefied form. There are two basic types of gas tankers, namely pressurized and refrigerated ships. The gas cargo is carried in liquid form either under pressure in a pressurized containment at ambient temperature or cooled to below its atmospheric boiling point temperature in a refrigerated containment at ambient pressure. A third category of gas carriers is the semi-pressurized type. On such ships the cargo is carried in liquid form by partially cooling and partially pressurizing the cargo. On refrigerated and semi-pressurized ships the cargo tanks are insulated to avoid heat penetration.

CHEMICAL TANKERS:

Chemical Tankers carry a wide variety of chemicals across the seas. The tanks of a chemical carrier often require special protection from the harmful effects of the chemicals and the tanks are therefore coated with a suitable substance designed to withstand the harmful effects of the chemicals that are to be carried by the ship. A ship that is not suitably coated for a particular type of cargo is not permitted to carry that cargo.

7.1.2. Explain the principal dimension of a ship – LOA, LBP, EB, MB, MD, GT, NT. Name and explain the principal parts of a ship including peak tanks, double bottom tanks, deep tanks, cargo tanks, ballast tanks, etc.

After Perpendicular (AP) is a perpendicular drawn to the water line at the point where the aft side of the rudderpost meets the summer load line. Where no rudderpost is fitted it is taken as the centre of the rudderstock.

Forward Perpendicular (FP) is the perpendicular drawn to the waterline at the point where the foreside of the stem meets the summer load line.

Length between perpendiculars (LBP) is the length between the forward and after perpendiculars.

Length Overall (LOA) is the length of the vessel taken over all extremities.

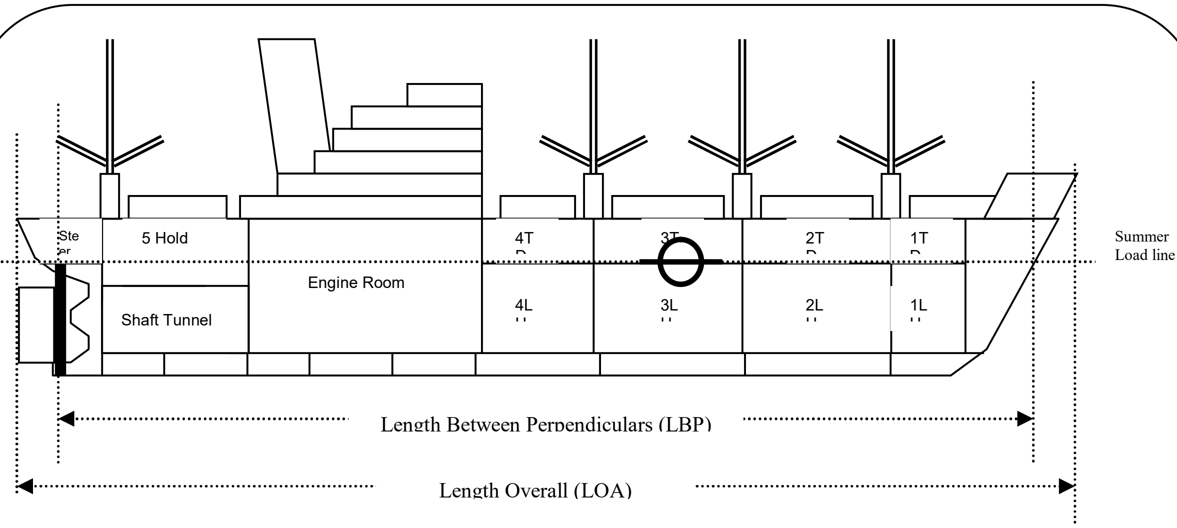


Figure 10: Principal dimensions

Amidships is the point midway between the forward and after perpendiculars.

You will often come across reference to moulded dimensions. ***Moulded dimensions*** are taken from the inside of the steel plates.

Base Line is the horizontal line drawn at the top of the keel plate. All vertical moulded dimensions are taken from the base line.

Moulded Beam (MB) is the maximum moulded breadth of the ship, measured at the midship section.

Moulded draft is the vertical distance from the baseline to the summer load line taken at midship section.

Moulded depth (MD) is the vertical distance from the baseline to the heel of the upper deck beam, at ship's side amidships.

Extreme beam (EB) is the maximum beam (breadth) taken over all extremities.

Extreme Draft is the vertical distance from the lowest point of the keel to the summer load line. Draft marks refer to the extreme draft at all times.

Extreme depth (ED) is the depth of the vessel at shipside from the upper deck to the lowest point of the keel.

Freeboard is the vertical distance measured at ship's side between the summer load line and the freeboard deck. The ***freeboard deck*** is the upper most continuous deck exposed to weather and sea which has permanent means of closing all openings, and below which all openings in the shipside have watertight closing arrangements.

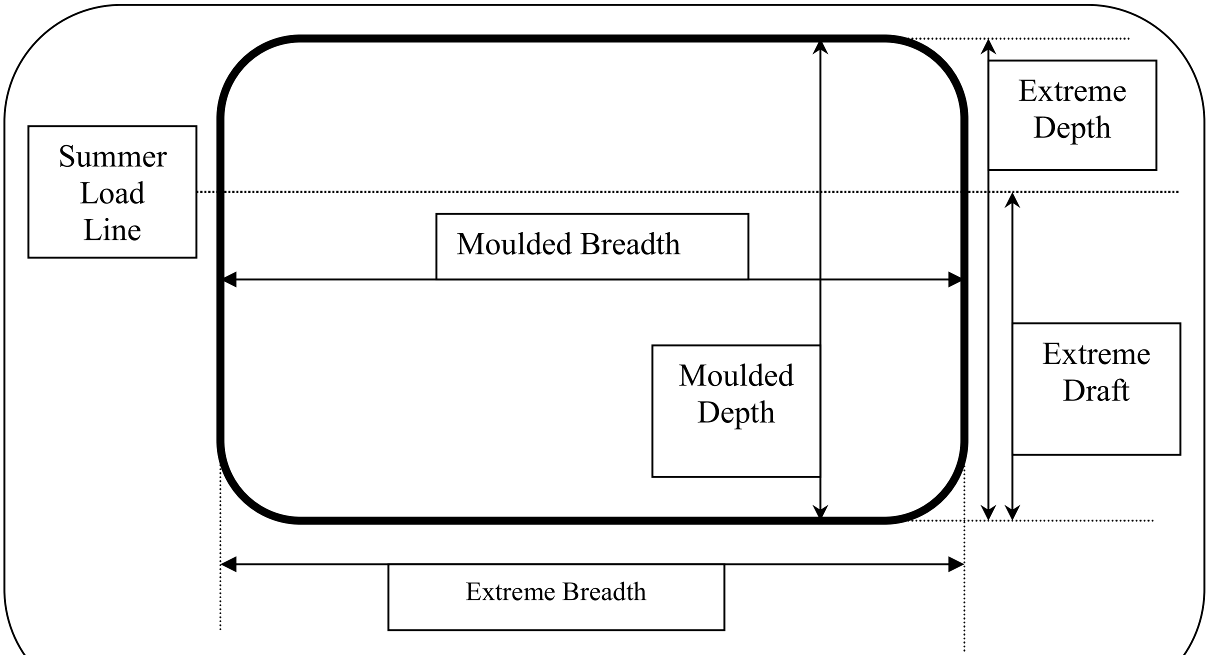


Figure 11: Transverse Principal dimensions

Sheer is the curvature of the decks in the longitudinal direction. Measured as the height of deck at side at any point above the height of deck amidships.

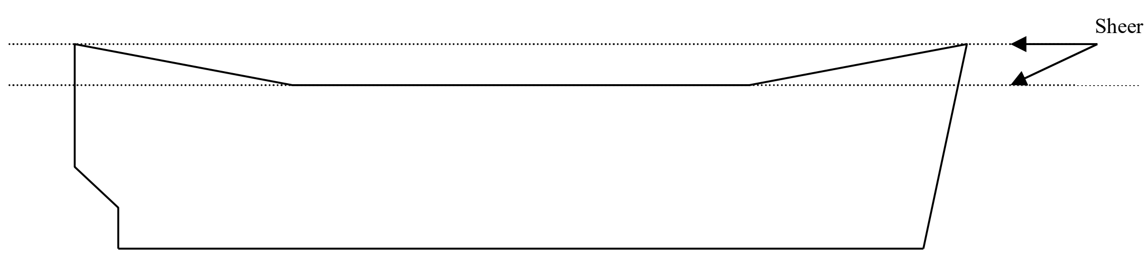


Fig. 12: Sheer

Camber (or round of beam) is the curvature of dcks in the transverse direction.

Rise of floor is the rise of the bottom shell plating above the base line. This rise is measured at the line of the moulded beam.

Tumblehome is the inward curvature of the side shell above the summer load line.

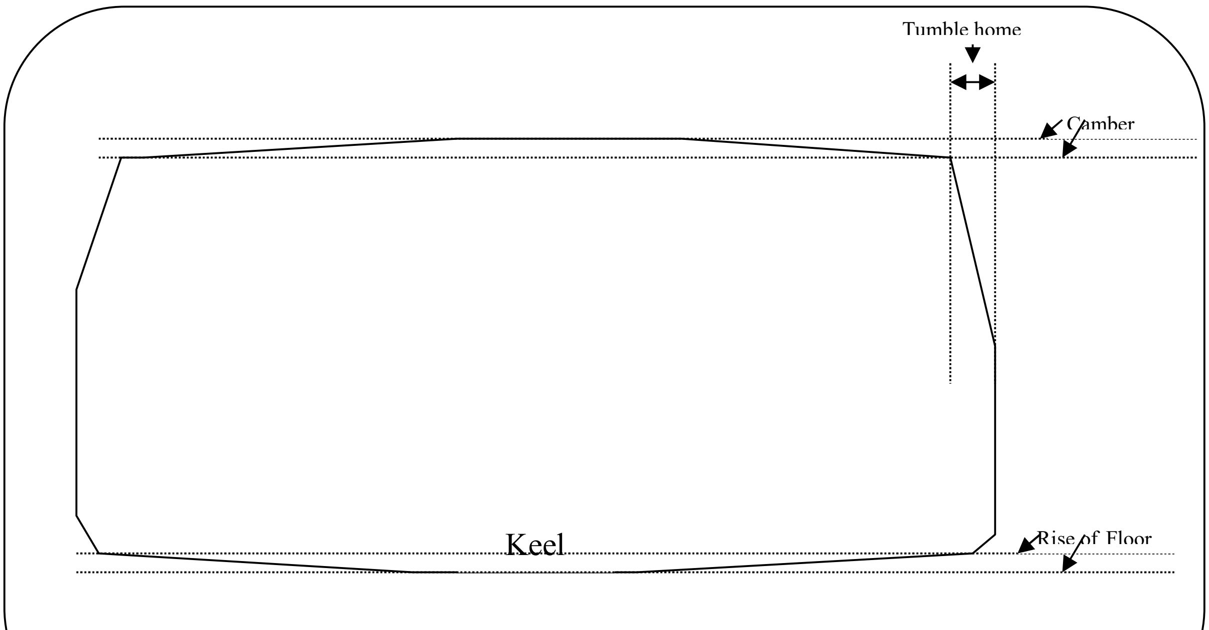


Figure 13: Transverse Ship Form

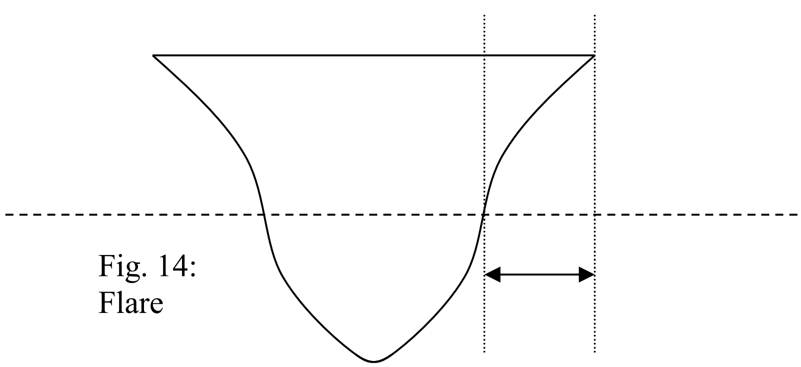
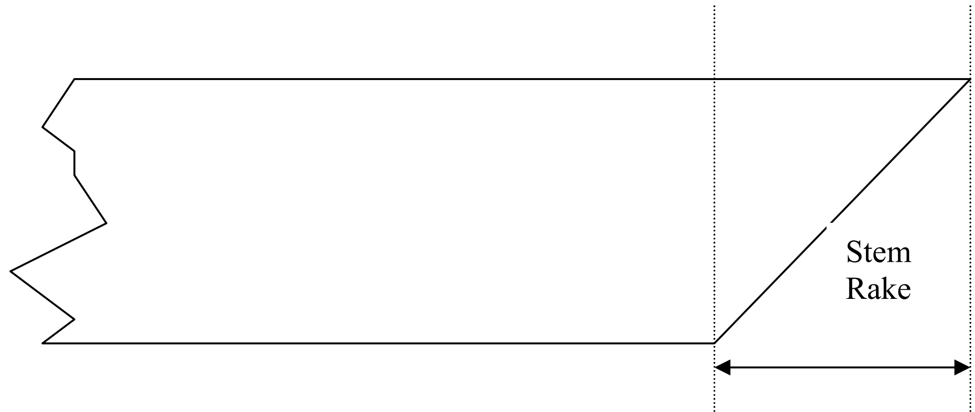
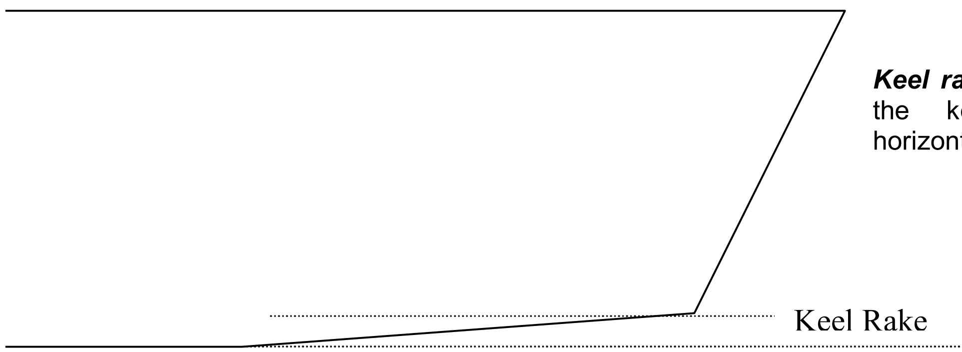


Fig. 14: Flare

Flare is the outward curvature of the side shell above the waterline.

Stem Rake is the inclination of the stem line form the vertical.





Keel rake is the inclination of the keel line from the horizontal.

7.1.3 Introduce the following ships plans: General Arrangement, Fire fighting appliances, life-saving appliances, pumping and piping arrangements.

A General Arrangement (GA) Plan shows the general layout of the ship. Each deck has a plan. The location of tanks, openings, hatches, etc, are all shown on this plan. The accommodation decks plans show the layout of cabins, stores, wheelhouse, chart-room, radio room etc.

Starting from the bottom, we have the plan of the Double Bottom tanks showing the location framewise of each tank. The location of the tank manholes would also be provided on this plan. In the cargo area, location of bilge wells, strum boxes etc. would be provided.

The next deck plan in the cargo area would be that of the tween deck showing the layout of tween deck, hatch covers, the drainage arrangements from the tween deck to the lower hold bilges, position of the CO2 inlets etc.

In the cargo area, we would then have the plan of the main deck showing the layout of hatch covers, their closing arrangements, air pipes, ventilators, sounding pipes, bollards, bits etc. and the important deck piping such as deck waterline, bunkering points etc. The main deck plan would also show location and layout of mast houses and the layout of any tanks that come up to the level of main deck (with their manholes etc.).

On ships that have a forecastle, there would be a plan of the forecastle deck showing the layout of the mooring winches, windlasses, anchors, hawse pipes, spurling pipes and anchor securing arrangements.

On most ships today, the Engine Room is generally located aft.

Plan of the various decks in the Engine Room would show the location of tanks, main engines, generators, boilers, Fresh Water generators, purifiers, engine workshop, engine control room right up to the skylight.

Next comes the plan of the accommodation decks (each deck separately) where the layout of the cabins (including the furniture and fitting), the common spaces such as mess rooms, recreation rooms, galleys (kitchens), pantry etc.

The bridge general arrangement would show the location of all navigation equipment, chart table, radio equipment etc.

Therefore, from the GAP, we can locate any space or fitting on board the ship.

The Life Saving Appliance (LSA) plan shows the location of all the life saving appliances (LSA) that the ship is required to carry. A typical plan is displayed in the classroom for the cadets to study and familiarize.

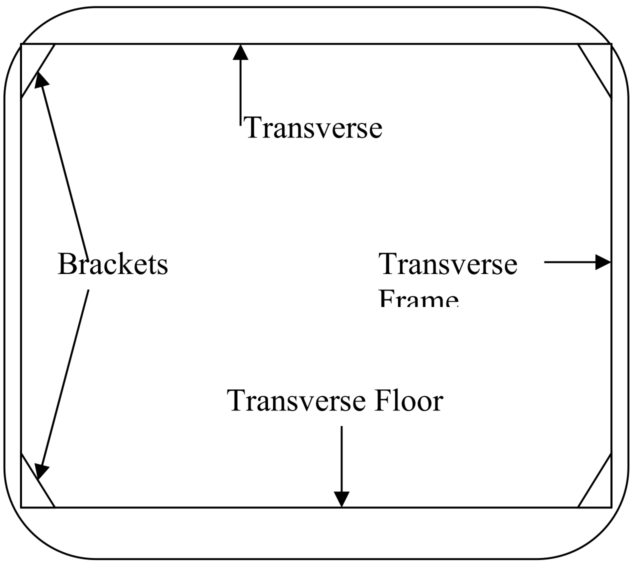
The Fire Fighting Appliance (FFA) Plan shows the location of all fire fighting appliances (FFA) that the ship is required to carry. A typical plan is displayed in the classroom for the cadets to study and familiarize.

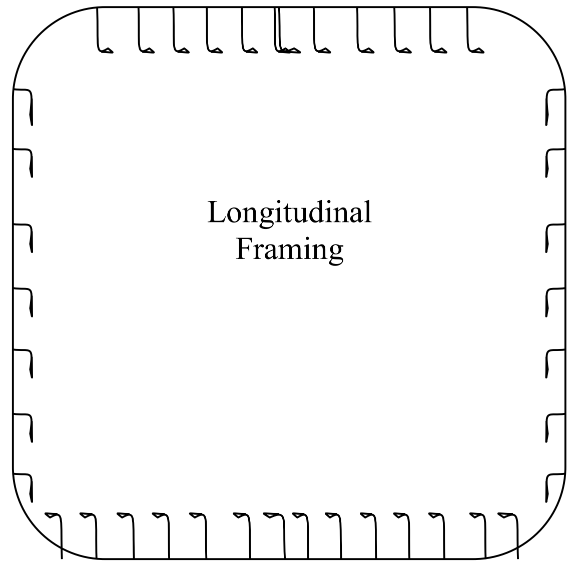
On all ships, it is necessary to know the location and layout of all pipelines, valves and pumps. These will be found on the pumping and piping arrangement plans.

These plans are displayed in the classrooms, for your perusal.

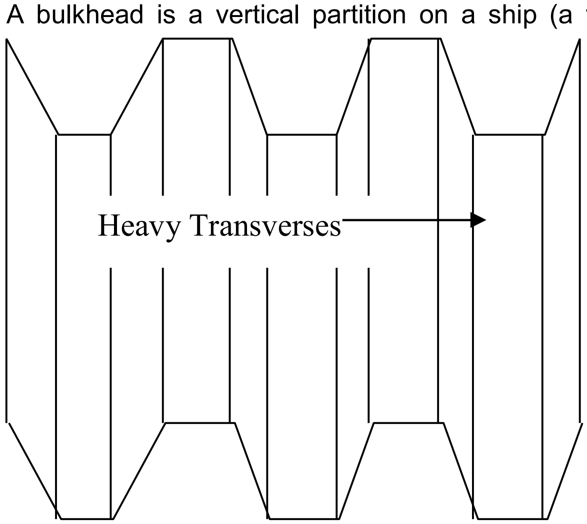
7.1.4. Explain the following parts: beam, frame, bulkhead, hatch, tank, coaming, hatch cover, rudder, deck, hull, bilge, sounding pipe, air pipe, ventilator. Show where these are found on a ship.

Just as the human body is supported by a frame, (the skeleton), so also the ship requires support. Beams and frames are like the ribs of the human body. Beams could be placed in the fore-and-aft direction, but are more normally in the athwathships direction. Framing is either longitudinal or transverse, or a combination of both.





A bulkhead is a vertical partition on a ship (a wall). It may be a bulkhead in an accommodation passageway, or a bulkhead in a cabin, or a tank bulkhead, or the forward or after bulkhead of a cargo hold, or an engine room bulkhead, etc. Bulkheads serve to divide the ship into compartments. They provide structural strength to the ship. Transverse bulkheads (port to starboard) provide transverse strength, and longitudinal bulkheads provide longitudinal strength. Being watertight, bulkheads also serve to restrict flow of liquids from one compartment that may be bilged as a result of damage etc., into adjoining compartments. Bulkheads may be of flat plates, stiffened by frames, etc., or may be corrugated bulkheads. A diagram of a corrugated bulkhead is shown here.

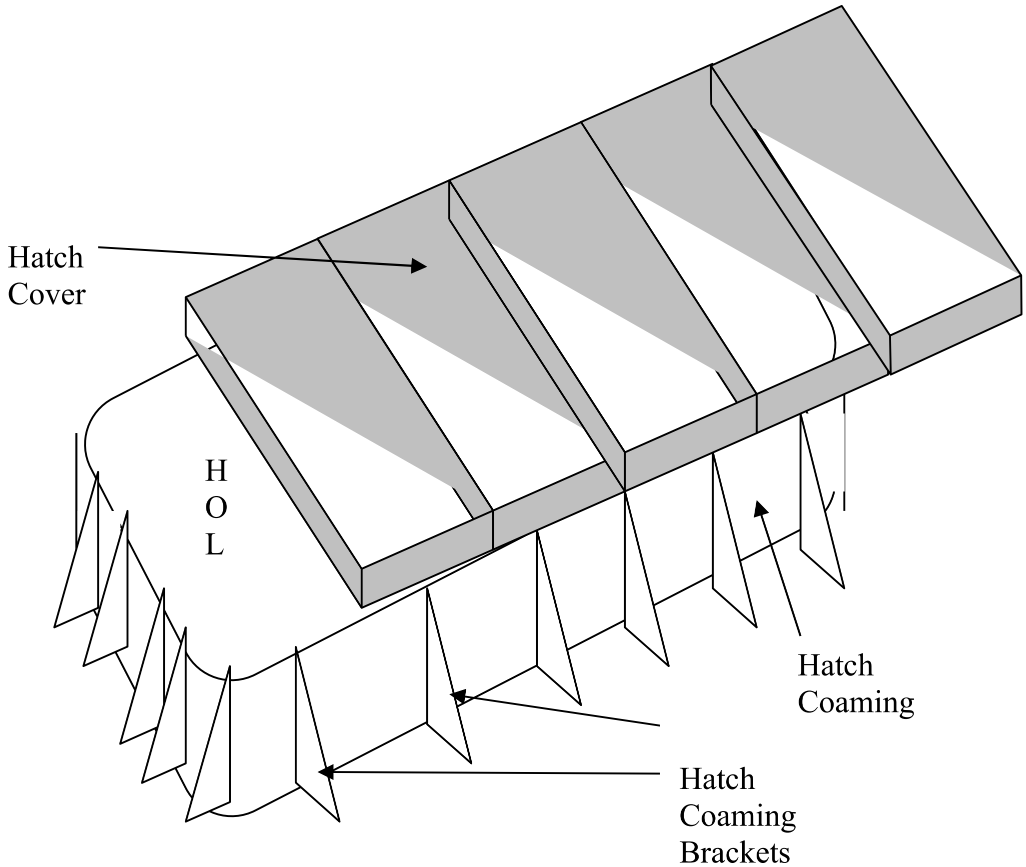


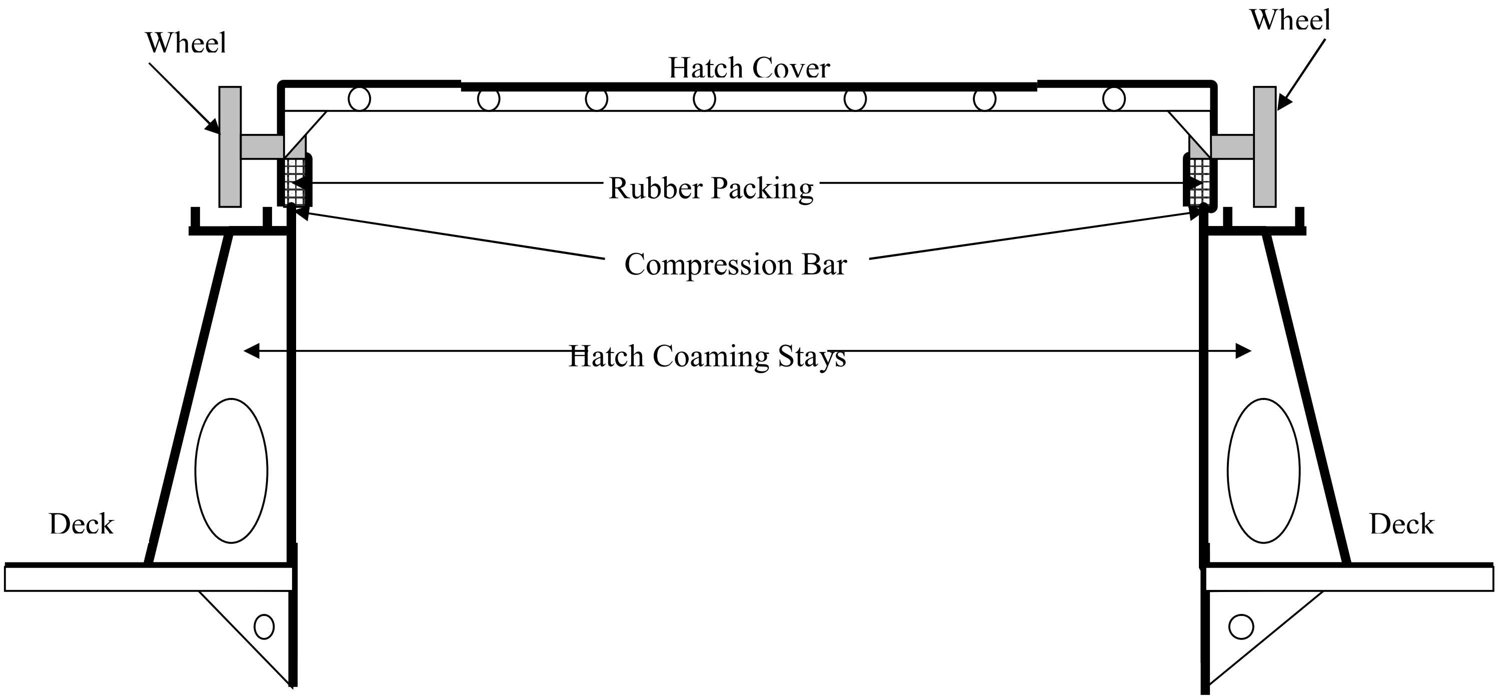
A Hatch is the wide opening to the cargo hold. The cover is known as the "hatch-cover".

The coaming is the vertical structure around the hatch opening on deck, specially strengthened to withstand the loss of strength caused by the large opening in the ship's deck.

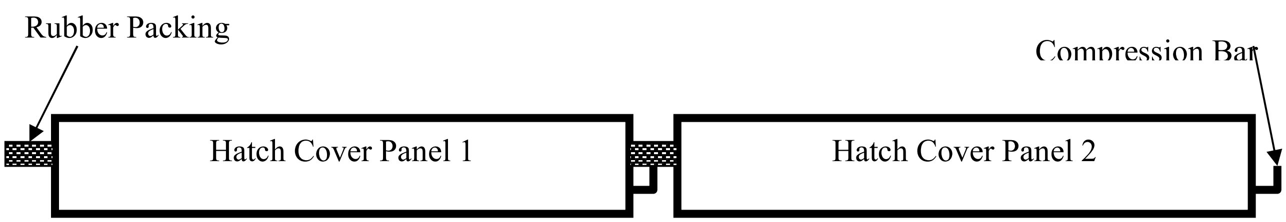
It is raised to withstand the entry of seawater into the ship's holds.

A typical hatch cover consists of "panels" that successively "sit" into the adjoining panel.



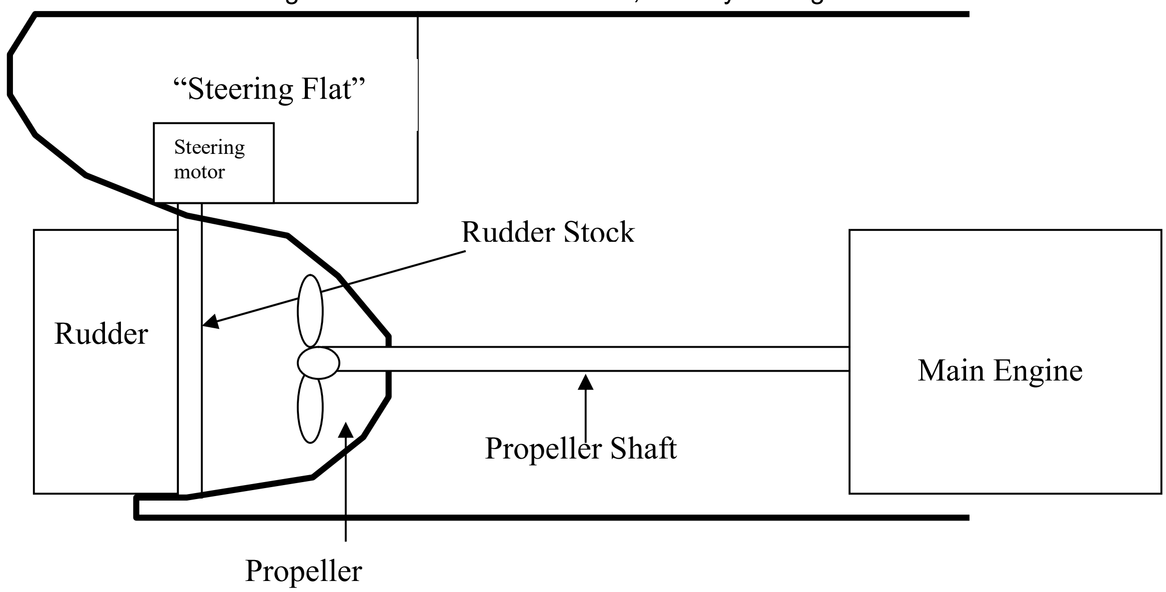


The use of rubber packing ensures that the hatch cover is weather tight. The arrangement for making the hatch cover weather-tight is shown diagrammatically above.

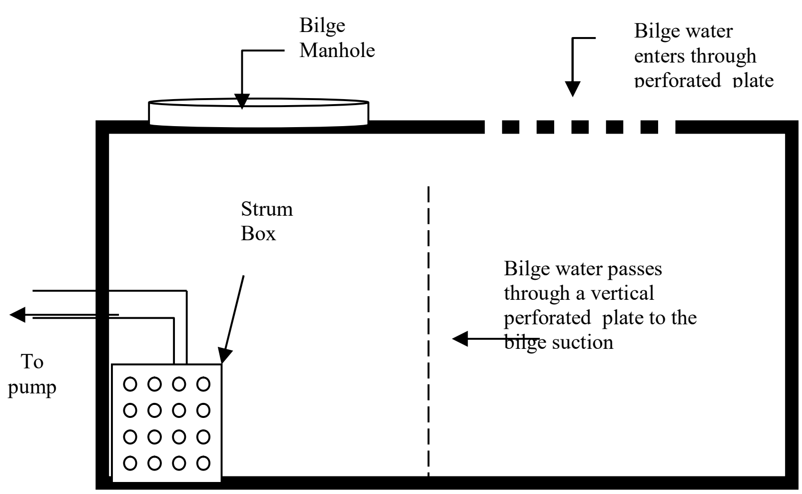


Successive Hatch cover panels each have rubber packing that compresses onto the “compression bar” of the adjacent hatch cover, thereby making the entire fitting weather-tight.

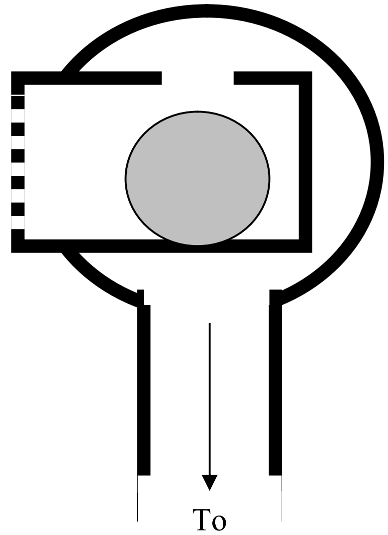
The rudder is used for steering the ship. It is operated by turning a steering wheel in the wheelhouse of the ship, which in turn activates a steering motor located in the steering flat just above the rudderstock. This steering motor turns the rudderstock, thereby turning the rudder.



A Bilge is the "gutter" where water collects and is then pumped out. Bilges are located in each cargo hold to collect the moisture that may condense in the hold, so that it can be pumped out. Bilges are also in the engine room, pump room, and other spaces where waste liquids are likely to collect. The bilge well is connected to the bilge pump through pipelines. The end of the pipe-line that is in the bilge is fitted with a "rose-box" or "strum-box" that prevents unwanted dirt and other such items from entering the bilge pipelines and chocking them.



Tanks and bilges on a ship are fitted with sounding pipes (ullage pipes for certain types of tanks) to enable the crew to check how much liquid is there inside them.



Air pipes are fitted to tanks to enable them to "breathe".

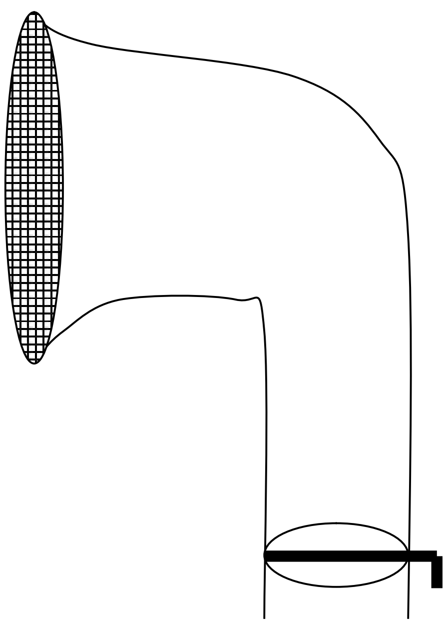
The air pipe must allow free flow of air into or out of the tank as required due to variations of pressure, and at the time of filling or emptying the tanks.

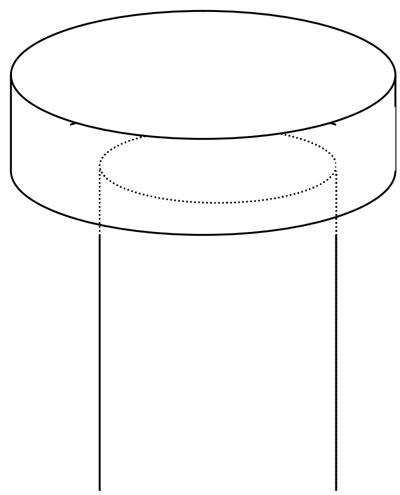
At the same time it must prevent the entry of unwanted seawater that may enter the tank, when waves wash over the ship's decks.

This is achieved by means of a "Ball float" or other such similar device that can fulfill the same function.

Ventilators are fitted to holds and stores to enable these spaces to "breathe". The ventilators may be "forced" ventilators (these have 'fans') or "natural" ventilators. The ventilator may be of different designs, but the most common are the "goose-neck" and the "mushroom" ventilators.

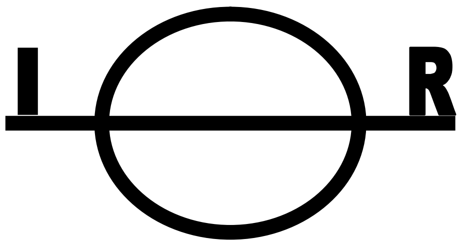
A "Cowl" ventilator (Turning the handle closes the "flap" stopping air flow)

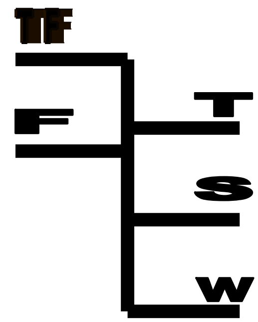




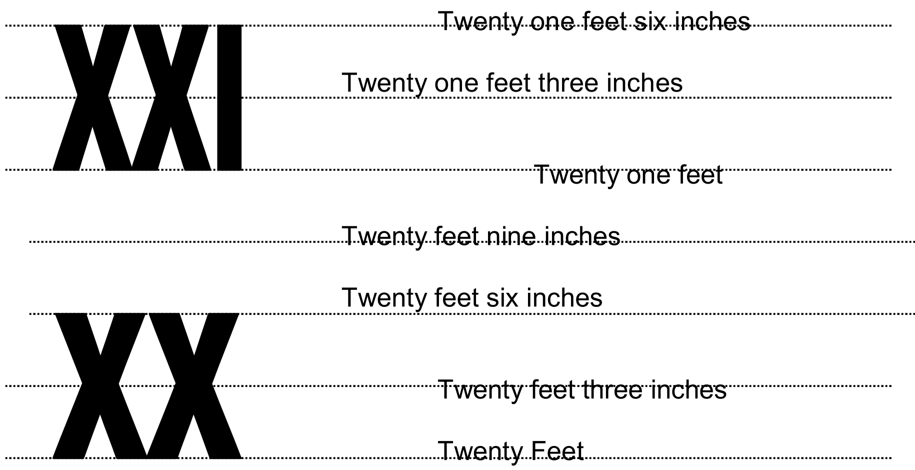
A "Mushroom" ventilator (Turning the head of the "Mushroom" screws down the head till it "Sits" thereby closing the ventilator)

7.1.5. Explain draft marks, load lines. Explain the method of reading draft marks in feet and metres.

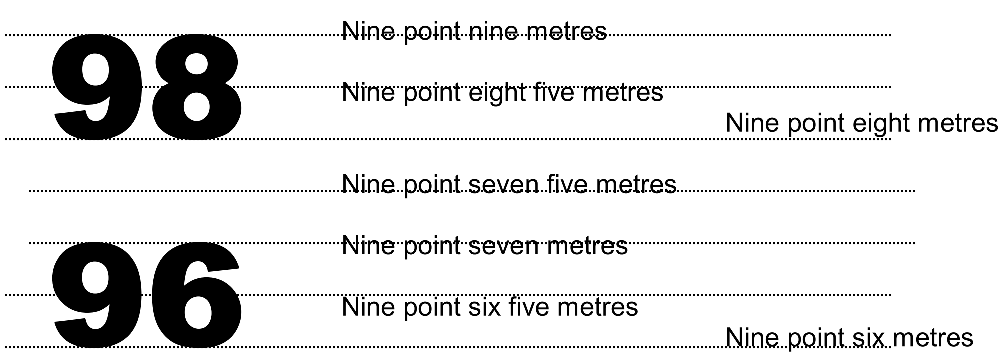




Draft Marks may be in feet or in metres. If the draft marks are in feet, each mark is six inches in height and the gap between each mark is six inches. This makes the draft easy to read.



If the draft marks are in metres, each mark is ten centimeters (one decimeter) in height and the gap between each mark is ten centimeters (one decimeter). This makes the draft easy to read.



7.1.6. Conduct practical exercises on reading draft by use of a suitable model. Cadets must read the draft on the model in the classroom and enter the same in the logbook on a daily basis.

7.1.7 Explain the causes and simple methods of prevention of corrosion in a ship's structure. Brief notes on paint technology and anti-corrosion techniques.

Nearly all metals react with the environment, creating a corrosion product, generally a substance of very similar chemical composition to the original mineral from which the metal was produced.

Atmospheric corrosion: Serious rusting may occur where relative humidity is above about 70 per cent. Even in humid atmospheres the rate of rusting is determined mainly by the pollution of the air through smoke and/or sea salts.

Corrosion due to immersion: When a ship is in service the bottom area is completely immersed. The waterline or boot-topping region is intermittently immersed in seawater. Under normal operating conditions a great deal of care is required to prevent excessive corrosion of these portions of the hull. A steel hull in this environment can provide ideal conditions for the formation of electrochemical corrosion cells.

Any corrosion relation is always accompanied by a flow of electricity from one metallic area to another through a solution in which the conduction of an electric current occurs by the passage of ions. Such a solution is referred to as an electrolyte solution and because of its high salt content seawater is a good electrolyte solution. A simple corrosion cell is formed by two different metals in an electrolyte solution (a galvanic cell). Electro-chemical corrosion in aqueous solutions will result from any anodic and cathodic areas coupled in the solution. It is not always necessary to have two different metals. A steel plate carrying broken mill-scale in seawater could corrode. Corrosion currents flow between areas of well-painted plate and areas of defective paintwork.

In atmospheric corrosion and corrosion involving immersion both oxygen and an electrolyte play an important part. Plates freely exposed to the atmosphere will receive plenty of oxygen but little moisture, and the moisture present therefore becomes the controlling factor. Under conditions of total immersion it is presence of oxygen, which becomes the controlling factor.

Bimetallic (galvanic) corrosion: All corrosion is basically galvanic, but the term 'galvanic corrosion' is usually applied when 2 different metals form a corrosion cell. Many ship corrosion problems are associated with the coupling of metallic parts of different potential, which consequently form corrosion cells. The corrosion rates of metals and alloys in seawater have been extensively investigated and as a result galvanic series of metals and alloys in seawater have been obtained. A typical galvanic series in seawater is shown below, but applies only in a seawater environment; and where metals are grouped together they have no strong tendency to form couples with each other. Some metals appear twice because they are capable of having both a passive and an active state.

Galvanic series of metals and alloys in seawater

Cathodic or protected end

Platinum,
Gold
Silver
Titanium
Stainless steels, passive
Nickel, passive
High duty bronzes
Cooper
Nickel, active

Mill scale
Naval brass
Lead, tin
Stainless steels, active
Iron, steel, cast iron
Aluminum alloys
Aluminum
Zinc
Magnesium

Anodic or corroding end

A metal is said to be passive when the surface is exposed to an electrolyte solution and a reaction is expected but the metal shows no sign of corrosion. Passivation results form the formation of a current barrier on the metal surface, usually in the form of an oxide film. This thin protective film forms, and a change in the overall potential of the metal occurs when a critical current density is exceeded at the anodes of the local corrosion cells on the metal surface.

Among the more common bimetallic corrosion cell problems in ship hulls are those formed by the mild steel hull with the bronze or nickel alloy propeller. Also above the waterline problems exist with the attachment of bronze and aluminum alloy fittings. Where aluminum superstructures are introduced, the attachment to the steel hull and the fitting latter problem is overcome by insulating the two metals and preventing the ingress of water as illustrated in figure.

A further development is the use of explosion-bonded aluminum / steel transition joints. These joints are free of any crevices, the exposed aluminum to steel interface being readily protected by paint.

Stress corrosion: Corrosion and subsequent failure associated with varying forms of applied stress is not uncommon in marine structures. Internal stresses produced by non-uniform cold working, punching and riveting are often more dangerous than applied stresses. For example, localized corrosion is often evident at cold-flanged brackets and punched rivet holes. A particular case of stress corrosion in marine structures has occurred with early wrought aluminum magnesium alloy rivets. With magnesium content above about 5 percent stress corrosion failures with cold driven rivets were not uncommon. Here the corrosive attach is associated with a precipitate at the grain boundaries, produced by excessive cold working, which is anodic towards the solid solution forming the grains of the alloy. Failure occurs along an inter-granular path. Specifications for aluminum/magnesium alloy rivets now limit the magnesium content.

Corrosion/erosion: Erosion is essentially a mechanical action but it is associated with electro-chemical corrosion in producing two forms of metal deterioration. Firstly, in what is known as impingement attack' the action is mainly electrochemical but it is initiated by corrosion. Air bubbles entrained in the flow of water and striking a metal surface may corrode away any protective film that may be present locally. The corded surface becomes anodic to the surrounding surface and corrosion occurs. This type of attack can occur in most places where there is water flow, but particularly where features give rise to turbulent flow. Sea water discharges from the hull are a particular case, the effects being worse if warm water is discharged.

Cavitation damage is also associated with a rapidly flowing liquid environment. At certain regions in the flow (often associated with a velocity increase resulting form a contraction of the flow stream) the local pressures drop below that of the absolute vapour pressure. Vapour cavities, that is areas of partial vacuum, are formed locally, but when the pressure increases clear of this region the vapour cavities collapse or implode. This collapse occurs with the release of considerable energy, and if it occurs adjacent to a metal surface damage results. The damage shows itself a spitting which is thought to be predominantly due to the effects of the mechanical damage. However it is also considered that electrochemical action may play some part in the damage after the initial erosion.

The prevention of corrosion may be broadly considered in two forms, cathodic protection and the application of protective coatings.

Cathodic protection: Only where metals are immersed in an electrolyte can be possible onset of corrosion be prevented by cathodic protection. The fundamental principle of cathodic protection is that the anodic corrosion reactions are suppressed by the application of an opposing current. This superimposed direct electric current enters the metal at every point lowering the potential of the anode metal of the local corrosion cells so that they become cathodes. There are two main types of cathodic protection installation, sacrificial anode systems and impressed current systems.

Sacrificial anode systems: Sacrificial anodes are metals or alloys attached to the hull, which have a more anodic, i.e. less noble, potential than steel when immersed in seawater. These anodes supply the cathodic protection current, but will be consumed in doing so and therefore require replacement for the protection to be maintained. This system has been used for many years, the fitting of zinc plates in way of bronze propellers and other immersed fittings being common practice. Initially results with zinc anodes were not always very effective owing to the use of unsuitable zinc alloys. Modern anodes are based on alloys of zinc, aluminum, or magnesium, which have undergone many tests to examine their suitability; high purity zinc anodes are also used. The cost, with various other practical considerations, may decide which type is to be fitted. Sacrificial anodes may be fitted within the hull, and are often fitted in ballast tanks. However, magnesium anodes are not used in the cargo ballast tanks of oil carriers owing to the 'spark hazard'. Should any part of the anode fall and strike the tank structure when gaseous conditions exist an explosion could result. Aluminum and zinc anode systems may be safely employed.

Impressed current systems: These systems are applicable to the protection of the immersed external hull only. The principle of the systems is that a voltage difference is maintained between the hull and fitted anodes, which will protect the hull against corrosion, but not overprotect it thus wasting current. For normal operating conditions the potential difference is maintained by means of an externally mounted silver/silver chloride reference cell detecting the voltage difference between itself and the hull. An amplifier controller is used to amplify the micro-range reference cell current, and it compares this with the preset protective potential value, which is to be maintained. Using the amplified D.C. signal from the controller a saturable reactor controls a larger current from the ships electrical systems, which is supplied to the hull anodes. An A.C. current from the electrical system would be rectified before distribution to the anodes. Figure shows such a system.

Originally consumable anodes were employed but in recent systems non-consumable relatively noble metals are used; these include lead/silver and platinum/palladium alloys, and platinized titanium anodes are also used. A similar impressed current system employs a consumable anode in the form of an aluminum wire upto 45 meters long, which is trailed behind the ship whilst at sea. No protection is provided in port. Although the initial cost is high, these systems are claimed to be more flexible, to have a longer life, to reduce significantly hull maintenance, and to weigh less than the sacrificial anode systems. Care is required in their use in port alongside ships or other unprotected steel structures.

Paints: Paint consists of pigment dispersed in a liquid referred to as the 'vehicle', which, when spread out thinly changes in time to an adherent dry film., by means of one of the following processes.

a. The vehicle consists of solid resinous material dissolved in a volatile solvent, which evaporates after application of the paint, leaving a dry film.
b. A liquid like linseed oil as a constituent of the vehicle may produce a dry paint film by reacting chemically with the surrounding air.

c. A chemical reaction may occur between the constituents of the vehicle after application, to produce a dry paint film. The reactive ingredients may be separated in two containers ('two-pack paints') and mixed before application. Alternatively ingredients, which only react at higher temperatures, may be selected, or the reactants may be diluted with a solvent so that the reaction occurs only slowly in the can.

Corrosion-inhibiting paints for application to steel have the following vehicle types:

a. Bitumen or pitch
b. Oil based (vegetable drying oils, such as linseed oil and tung oil)
c. Oleo-resinous
d. Alkyd resin
e. Chemical resistant
    i. Epoxy resins.
    ii. Coal tar/epoxy resin.
    iii. Chlorinated rubber and isomerized rubber.
    iv. Polyurethane resins.
    v. Vinyl resins.
f. Zinc-rich paints.
g. Anti-fouling paints. (See note).

<u>Protection by means of paints:</u> It is often assumed that all paint coatings prevent attack on the metal covered simply by excluding the corrosive agency, whether air or water. This is often the main and sometimes the only form of protection. However there are many paints, which afford protection even though they present a porous surface or contain various discontinuities.

Certain pigments in paints confer protection on steel even where it is exposed at a discontinuity. If the reactions at the anode and cathode of the corrosion cell which form positive and negative ions respectively, are inhibited, protection is afforded. Good examples of pigments of this type are red lead and zinc chromate, red lead being an anodic inhibitor, and zinc chromate a cathodic inhibitor. A second mode of protection occurs at gaps where the basis metal. Zinc dust is a commercially available pigment, which fulfils this requirement for coating steel in a salt-water environment. The zinc dust is the sacrificial anode with respect to the steel.

Anti-fouling paints offer protection against vegetable and animal growth, which can lead to increased resistance requiring additional power; hence fuel, to maintain the same speed. The greater the time spent at sea the less the fouling; but areas of operation and seasons also decide the amount of fouling, and with modern anti-fouling compounds the problem today is less important.

Surface preparation: Good surface preparation is essential to successful painting, the primary cause of many paint failures being the inadequacy of the initial material preparation.

It is particularly important before painting new steel that any mill-scale should be removed. Mill-scale is a thin layer of iron oxides, which forms on the steel surface during hot rolling of the plates and sections. Not only does the non-uniform mill-scale set up corrosion cells as illustrated previously, but it may also come away form the surface removing any paint film applied over it.

The most common methods employed to prepare steel surfaces for painting are;

a. <u>Blast cleaning</u> is the most efficient method for preparing the surface. Following the blast cleaning it is desirable to brush the surface, and apply a coat of priming paint as soon as possible since the metal is liable to rust rapidly. Cast iron and steel grit, or steel shot, which is preferred, may be used for the abrasive, but non-metallic abrasives are also available. The use of sand is prohibited in the United Kingdom because the fine dust produced may cause silicosis.

b. Pickling: Immersion of the metal in an acid solution, usually hydrochloric or sulfuric acid in order to remove the mill-scale and rust form the surface. After immersion in these acids the metal will require a through hot water rinse. It is preferable that the treatment is followed by application of a priming coat.

c. Flame Cleaning: Using an oxy-acetylene flame the millscale and rust may be removed form a steel surface. The process does not entirely remove the millscale and rust, but it can be quite useful for cleaning plates under inclement weather conditions, the flame drying out the plate.

d. Hand cleaning by various forms of wire brush is often not very satisfactory, and would only be used where the millscale has been loosened by weathering, i.e. exposure to atmosphere over a long period.

Paint systems on ships: The paint system applied to any part of a ship will be dictated by the environment to which that part of the structure is exposed. Traditionally the painting of the external ship structure was divided into three regions.

1 Below the water line where the plates are continually immersed in seawater. Below the water line, the ship's bottom has priming coats of corrosion-inhibiting paint applied, which are followed by an anti-fouling paint.

2 The water line or boot topping region where immersion is intermittent and a lot of abrasion occurs. Generally modern practice requires a complete paint system for the hull above the water line. This may be based on vinyl and alkyd resins or on polyurethane resin paints.

3 The topsides and superstructure exposed to an atmosphere laden with salt spray, and subject to damage through cargo handling.

Superstructures red lead or zinc chromate based primers are commonly used. White finishing paints are then used extensively for superstructures. These are usually oleo-resinous or alkyd paints, which may be, based on 'non-yellowing' oils, linseed oil-based paints, which yellow on exposure being avoided on modern ships. Where aluminum superstructures are fitted, under no circumstance should lead based paints be applied; zinc chromate paints are generally supplied for application to aluminum.

However now that tougher paints are used for the ships bottom the distinction between regions need not be so well defined, one scheme covering the bottom and water line regions.

Internally by far the greatest problem is the provision of coatings for various liquid cargo and salt-water ballast tanks.

Cargo and ballast tanks: Severe corrosion may occur in a ship's cargo tanks as the combined result of carrying liquid cargoes and sea-water ballast, with warm or cold sea water cleaning between voyages. This is particularly true of oil tankers. Tankers carrying 'white oil' cargoes suffer more general corrosion than those carrying crude oils, which deposit a film on the tank surface providing some protection against corrosion. The latter type may however experience severe local pitted corrosion due to the non-uniformity of the deposited film, and subsequent corrosion of any bare plate when seawater ballast is carried. Epoxy resin paints are used extensively within these tanks, and vinyl resins and zinc rich coatings may also be used.

7.1.8 Explain the term Dry Dock, the reasons for dry-docking a vessel and give a general idea of the activities in a dry dock.

Dry Dock: a dry dock (as opposed to a wet dock) is a place where a ship is laid up for repairs with the entire hull "DRY". These are of three types:
1. Graving dock. 2. Floating dock. 3. Slip way.

1. **Graving Dock**: it is craved out of the earth or land, it will have lock gate at one end, a ship is floated into a graving dock, the lock gate is closed & dock is pumped dry. The ship sits on the on blocks, which may be keel blocks, (located along the central line) bilge blocks (located along the bilge) or other blocks located where necessary. In some cases where a ship may have entered with cargo side shores may be used.

2. **Floating Dock**: unlike the graving dock it is actually floating on the surface of water. It is U shaped open at both ends. The ship is normally floating at a predetermined draft. The floating dock fills its ballast tanks, so that it immerses itself into the water to a depth slightly greater than the draft of the ship of the height of the blocks. The ship enters the floating dock exactly the same manner as entering the graving docks; the difference here is the floating dock now de ballast it's tanks causing it to rise till it's completely dry.

3. **Slip way**: these are generally used for smaller vessels. Ex: small tugs, fishing boats etc. vessel is winched up someway.

A ship is taken into a dry dock for the purpose of carrying out underwater work. These repairs involve mainly cleaning & painting of the ships underwater hull.

While the ship is floating, marine growth such as barnacles and other sea creatures stick the ship's hull making it rough. This causes friction, thereby reducing the ship's speed and increasing the fuel consumption.

In the dry docks the marine growth is removed by using high-pressure water jets, & manual/mechanical cleaning of the ships hull.

Damaged area of paint are then properly prepared using sand blasting, grit blasting or other efficient means to clean the surface of the rust.

The hull is then washed with fresh water and a coat of **primer** (paint) is applied, normally using spray painting machines. Portions of the vessel, which are normally under water, were coated with anti fouling paint (Imp: see note below).

Anti corrosive paints are used on the portion of that normally immerses and comes out of the water on a regular bases.

Topside paints are used on portion of the hull that is above the summer load line.

In the dry dock the ship also carries out cleaning and de-silting of the double bottom tank. While opening the bottom plugs in the dry dock, a very important duty of the ship's officer is to ensure that the bottom plugs are labeled and safely stored and put back before the dry dock is flooded.

Work is also carried out on the echo sounder transducers.

Cleaning, overhauling and painting of the sea chests is carried out in the dry docks as required.

Work on the rudder and propeller, including measurements of clearances are carried out in the dry dock.

Anchors and cables are taken out from the chain lockers ranged on the dry dock floor, marked, and new lead pellets put in. Anchor and cables are painted. Cleaning and painting of chain locker is also carried out in dry docks.

Specifically on tankers all works inside the cargo tanks and other equipment associated with the tankers cargo is carried out while in the dry dock.

Note: Anti fouling paints contains tri butyl tin (TBT). TBT is a fungicide, bactericide & wood preservative. It is known to be the harmful to a wide range of aquatic or marine organisms. The use of TBT or re-application of TBT has been banned with the effect from 1-1-2003 for new ships & 1-1-2008 for existing ships. Other paints such as controlled depletion co-polymer, silicon based coatings, copper based coatings or other equivalent paints that are not harmful for marine equipment must be used after these dates

Typical Marine Paint Systems

Initial Surface Preparation of Steel : Airless blast cleaning to remove millscale and produce a "near white" finish (B.S. 4232 : 1967, Second quality) followed immediately by automatic spray application of a shop primer to protect the steel during fabrication and erection.

		Type of Paint	Method of Application	Coats	Dry Film Thickiness
I	**Ship's bottom systems**				
	a	Conventional bituminous system			
		Bitumen or pitch solution pigmented with aluminum flake	Brush or roller	5	0.15-0.18 mm
		Anti-fouling composition	Brush or roller	1	0.05-0.075 mm
	b	Conventional non-bituminous system			
		Tung oil / phenolic medium pigmented with basic lead sulphate, aluminum flake and extenders	Brush or roller	4	0.15-0.18 mm
		Anti-fouling composition	Brush or roller	1	0.05-0.075 mm
	c	High-performance system			
		Coal tar epoxy (2-pack)	Airless spray	2	0.23-028 mm
		Anti-fouling composition	Airless spray	1	0.05-0.075 mm
II	**Topsides and superstructure systems**				
	a	Conventional system			
		red lead primer in quick-drying alkyd or pheolic medium	Brush or roller	3	0.10-0.13 mm
		Gloss finish, alkyd medium pigmented with rutile titanium dioxide (white) and tinting pigments as required	Brush, roller or spray	2	0.05-0.075 mm
	b	High-performance system			
		High build epoxy (2-pack)	Airless spray	2	0.20-0.25 mm
		Gloss finish, epoxy or poly urethane (2-pack)	Airless spray	1	0.04-0.30 mm
III	**Interior accommodation system**				
		Zinc chromate primer in quick drying alkyd or phenolic medium	Brush, roller or spray	2	0.75-0.10 mm
		Semi-gloss undercoat, alkyd medium pigmented with titanium dioxide and tinting pigments	Brush, roller or spray	1	0.04-0.05 mm
		Gloss finish, alkyd medium pigmented with rutile titanium dioxide and tinting pigments	Brush or spray	1	0.04-0.05 mm
IV	**Dry cargo hold system**				
		Zinc chromate primer in quick drying alkyd or phenolic medium	Brush, roller or spray	2	0.75-0.10 mm
		Bright aluminum finish, lefting aluminum flake in oleoresinous medium	Brush, roller or spray	2	0.05-0.075 mm
V	**System for cargo ballast tanks on oil tankers**				
	a	Crude oil carriers			
		Coal tar epoxy (2-pack)	Airless spray	2	0.20-0.30 mm
	b	Refined products carriers			
		high build epoxy (2-pack)	Airless spray	2	0.25-0.30 mm