FUNCTION 4: CONTROLLING THE OPERATION OF THE SHIP AND CARE FOR PERSONS ON BOARD AT THE MANAGEMENT LEVEL

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence: **4.1 Control trim, stability and stress**		
1.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY		
1. Stress	4	
2. Construction arrangements	27	
3. Watertight and weathertight doors	3	
4. Ship dynamics	2	
5. Corrosion and its prevention	4	
6. Surveys and dry-docking	2	
7. Stability	42	
8. Resistance and fuel consumption	5	
9. Rudders	1	90
1.1.2 EFFECT ON TRIM AND STABILITY IN THE EVENT OF DAMAGE AND FLOODING		
1. Effect of flooding on Transverse Stability and Trim	9	
2. Theories affecting trim and stability	2	11
1.1.3 KNOWLEDGE OF IMO RECOMMENDATIONS CONCERNING SHIP STABILITY **1.** Responsibilities under the relevant requirements of the International Conventions and Codes	2	2
4.2 Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea and the protection of the marine environment		
1.2.1 INTERNATIONAL MARITIME LAW EMBODIED IN INTERNATIONAL AGREEMENTS AND CONVENTIONS		
1. Certificates and other documents required to be carried on board ships by international conventions	1	
2. Responsibilities under the relevant requirements of the International Convention on Load Lines	1	
3. Responsibilities under the relevant requirements of the International Convention for the Safety of Life at Sea	1	
4. Responsibilities under the International Convention for the Prevention of Pollution From Ships	3	
	1	

5. Maritime declarations of health and the requirements of the International Health Regulations **6.** Responsibilities under other international maritime law embodied in international agreements and conventions that impact on the role of management level officers **7.** Responsibilities under international instruments affecting the safety of the ship, passengers, crew and cargo	11 3	
8. Methods and aids to prevent pollution of the marine environment by ships **9.** National legislation for implementing international agreements and conventions	2 1	24
1.3 Maintain safety and security of crew and passengers and the operational condition of safety systems		
4.3.1 KNOWLEDGE OF LIFE-SAVING APPLIANCE REGULATIONS	2	2
1.3.2 ORGANIZATION OF FIRE DRILLS AND ABANDON SHIP DRILLS See IMO model courses 2.03 and 1.23 and STCW Code sections A-V1/3 and A-V1/2	**-**	-
1.3.3 MAINTENANCE OF OPERATIONAL CONDITION OF LIFE-SAVING, FIREFIGHTING AND OTHER SAFETY SYSTEMS See IMO model courses 2.03 and 1.23 and STCW Code sections A-V1/3 and A-V1/2	-	-
4.3.4 ACTIONS TO BE TAKEN TO PROTECT AND SAFEGUARD ALL PERSONS ON BOARD IN EMERGENCIES	4	4
4.3.5 ACTIONS TO LIMIT DAMAGE AND SALVE THE SHIP FOLLOWING A FIRE, EXPLOSION, COLLISION OR GROUNDING	4	4
4.4 Develop emergency and damage control plans and handle emergency situations		
4.4.1 PREPARATION OF CONTINGENCY PLANS FOR RESPONSE TO EMERGENCIES	9	9
4.4.2 SHIP CONSTRUCTION INCLUDING DAMAGE CONTROL	4	4

4.4.3 METHODS AND AIDS FOR FIRE PREVENTION, DETECTION AND EXTINCTION See IMO model course 2.03 and STCW Code section A-V1/3	-	-
4.4.4 FUNCTIONS AND USE OF LIFE SAVING APPLIANCES See IMO model course 1.23 and STCW Code section A-V1/2-1	-	-
4.5 Use of leadership and managerial skills		
4.5.1 SHIPBOARD PERSONNEL MANAGEMENT AND TRAINING **1.** Shipboard Personnel Management **2.** Training on board ships	10 6	16
4.5.2 RELATED INTERNATIONAL MARITIME CONVENTIONS AND RECOMMENDATIONS, AND NATIONAL LEGISLATION **1.** Related international maritime conventions, recommendations and national legislation	4	4
4.5.3 APPLICATION OF TASK AND WORKLOAD MANAGEMENT **1.** Task and Workload Management	8	8
4.5.4 EFFECTIVE RESOURSE MANAGEMENT **1.** Application of effective resource management at a management level	10	10
4.5.5 DECISION-MAKING TECHNIQUES **1.** Situation and risk assessment **2.** Identify and generate options **3.** Selecting course of action **4.** Evaluation of outcome effectiveness	2 2 2 1	7
4.5.6 DEVELOPMENT, IMPLEMENTATION AND OVERSIGHT OF STANDARD OPERATING PROCEDURES	1	1
Total for Function 4: Controlling the Operation of the Ship and Care for Persons on Board at the Management Level		**196 hours**

Teaching staff and Administrations should note that the hours for lectures and exercises are suggestions only as regards sequence and length of time allocated to each objective.

These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for teaching.

4.1 CONTROL TRIM, STABILITY AND STRESS

4.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY

1.1 Stresses in Ship Structures

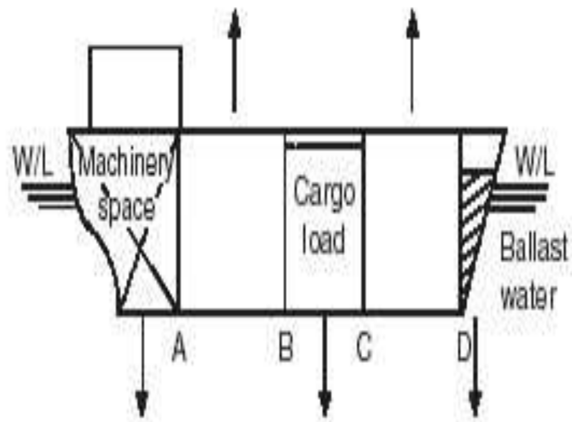
It is the shipowner's responsibility to ensure that his vessel is built to a standard high enough to withstand all the stresses she may be expected to encounter. By their very nature ships are called upon to carry heavy loads, and considerable thought and experience is required to load heavy weights without causing structural damage to the vessel.

Heavy weights tend to cause a downward deflection of the deck area supporting the load. This subsequently produces stresses, with consequent inward and outward deflections of supporting bulkheads, depending on the position of initial loading. These stresses are generally of a localised nature, in the neighbourhood of built-in structures such as windlasses, accommodation blocks etc. and increased scantlings are the norm to prevent excessive distortion. The shipping of heavy seas may add to the load and aggravate the situation, causing unacceptable, excessive distortions.

Another form of stress comes from the water surrounding the ship, which exerts considerable pressure over the bottom and side areas of the shell plating .The pressure will increase with depth of immersion, i.e. the pressure on the bottom shell plates will exceed that on the side shell plates.

Water pressure does not maintain a constant value, and will vary when the vessel is in a seaway, especially when a heavy swell is present. Fluctuations in water pressure tend to cause an 'in and out' movement of the shell plating, with more noticeable effects at the extreme ends of the vessel. The effect of water pressure is usually more prominent at the fore end of the vessel than the after end. The general effect is accentuated by the pitching motion of the vessel and is termed panting.

Panting beams, which are substantial metal beams running from port to starboard, in the forepart of the vessel. They are positioned forward of the collision bulkhead to resist the in and out motion of the shell plating either side of the fore and aft line. Situated at various deck levels, panting beams form a combination with panting stringers on either side in the forepart of the vessel.



Ships shearing stress

A third form of stress is shearing stress in a material, which tends to move one part of the material relative to another.

The two forces of gravity and buoyancy acting in opposition causes the shearing stress to be experienced at various points in ship. Shearing forces are undesirable within a ship in any shape or form, and prudent loading, together with careful ballast distribution, can reduce them.

Values of stresses incurred during the loading period may be mathematically worked out and then plotted to show the areas of stress by graph. It is worth noting that the mathematical calculations are lengthy, and always leave the possibility for error. 'Stress finders' and computerised loadicators have reduced the risk of errors. There are several on the market, generally custom made for individual vessels, and they provide the operator with such items of information as:

1. Bending moment.

2. Shear stress at critical points.

3. Mean draught.

4. Trim of the vessel.

5. GM final, after loading.

6. Deadweight.

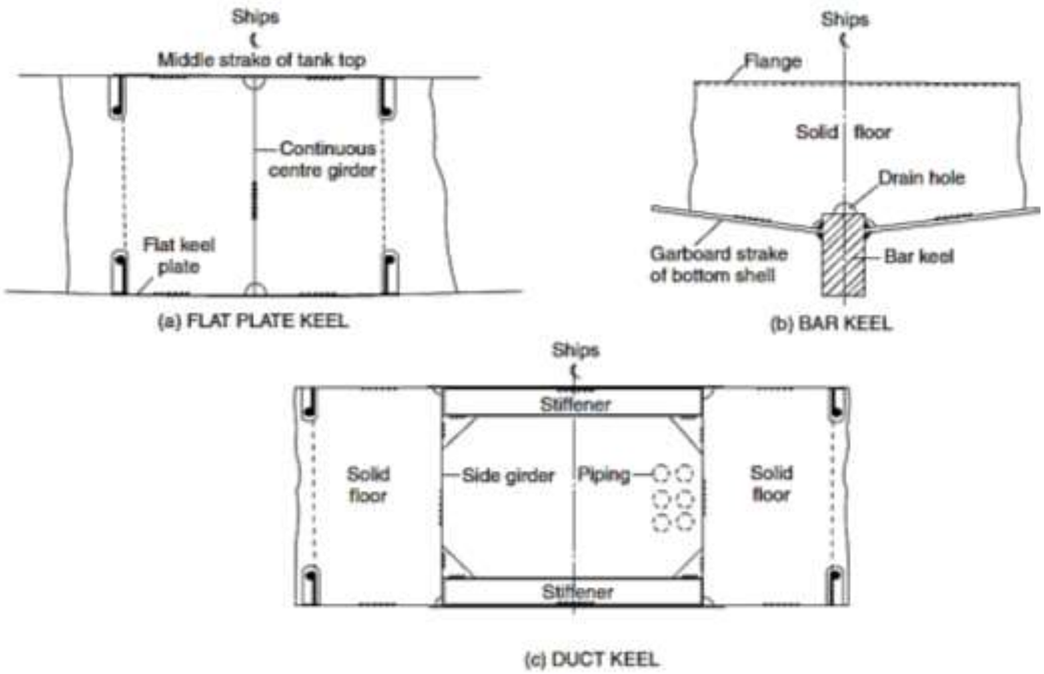
1.2 Construction Arrangements

- **Bottom Structure**

Originally ships were constructed with single bottoms, liquid fuels and fresh water being contained within separately constructed tanks. The double bottom structure which provides increased safety in the event of bottom shell damage, and also provides liquid tank space low down in the ship, only evolved during the early part of the twentieth century. Smaller vessels such as tugs, ferries, and cargo ships of less than 500 gross tonnage have a single bottom construction. Larger ocean-going vessels, other than older tankers, are fitted with some form of double bottom.

- **Keels**

At the centre line of the bottom structure is located the keel, which is often said to form the backbone of the ship. This contributes substantially to the longitudinal strength and effectively distributes local loading caused when docking the ship. The commonest form of keel is that known as the 'flat plate' keel, and this is fitted in the majority of ocean-going and other vessels (see the Figure below (a)). A form of keel found on smaller vessels is the bar keel (Figure (b)). The bar keel may be fitted in trawlers, tugs, etc., and is also found in smaller ferries.
Where grounding is possible this type of keel is suitable with its massive scantlings, but there is always a problem of the increased draft with no additional cargo capacity. If a double bottom is fitted the keel is almost inevitably of the flat plate type, bar keels often being associated with open floors, where the plate keel may also be fitted.
Duct keels (Figure (c)) are provided in the double bottoms of some vessels. These run from the forward engine room bulkhead to the collision bulkhead and are utilized to carry the double bottom piping. The piping is then accessible when cargo is loaded, an entrance to the duct being provided at the forward end of the engine room. No duct is required aft of the engine room as the piping may be carried in the shaft tunnel. A width of not more than 2.0m is allowed for the duct, and strengthening is provided at the tank top and keel plate to maintain continuity of strength of the transverse floors.



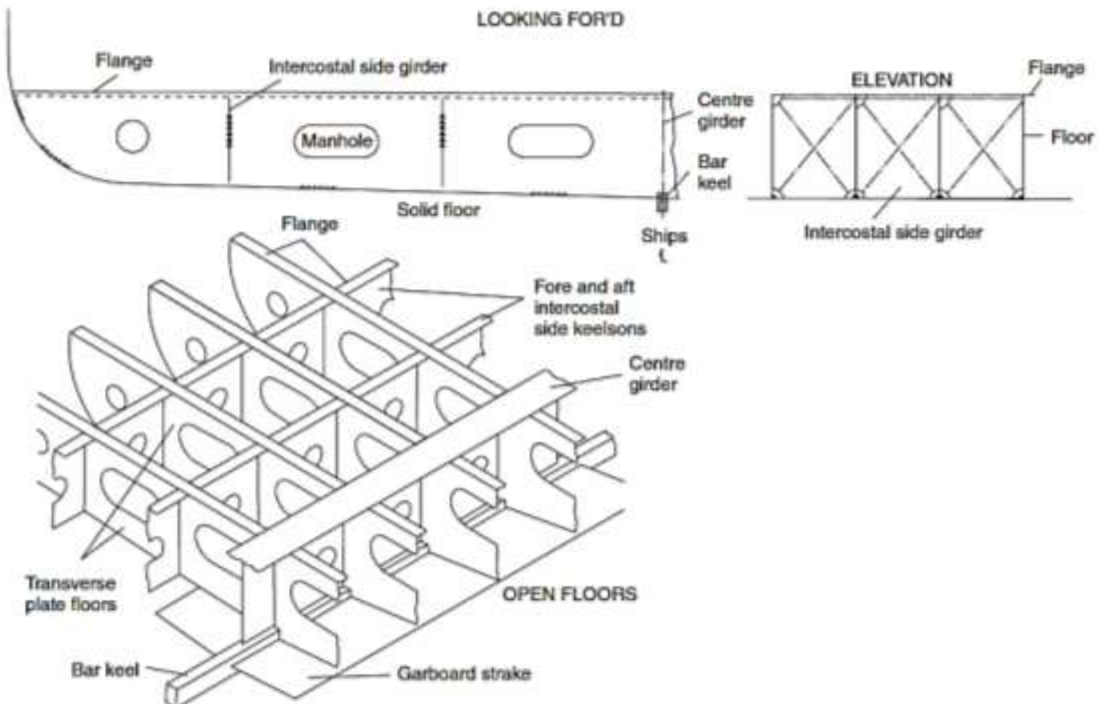
KEELS

- **Single Bottom Structure**

In smaller ships having single bottoms the vertical plate open floors are fitted at every frame space and are stiffened at their upper edge. A centre line girder is fitted and one side girder is fitted each side of the centre line where the beam is less than 10 m. Where the beam is between 10 and 17m two side girders are fitted and if any bottom shell panel has a width to length ratio greater than four additional continuous or intercostal stiffeners are fitted. The continuous centre and intercostal side girders are stiffened at their upper edge and extend as far forward and aft as possible.

The single bottom structure is shown in Figure below and for clarity a 3-dimensional representation of the structure is also provided to illustrate those members which are continuous or intercostal. Both single and double bottoms have continuous and intercostal material and there is often some confusion in the student's mind as to what is implied by these terms.

A wood ceiling may be fitted across the top of the floors if cargoes are to be carried but this does not constitute an inner bottom offering any protection if the outer bottom shell is damaged.



Single botton construction

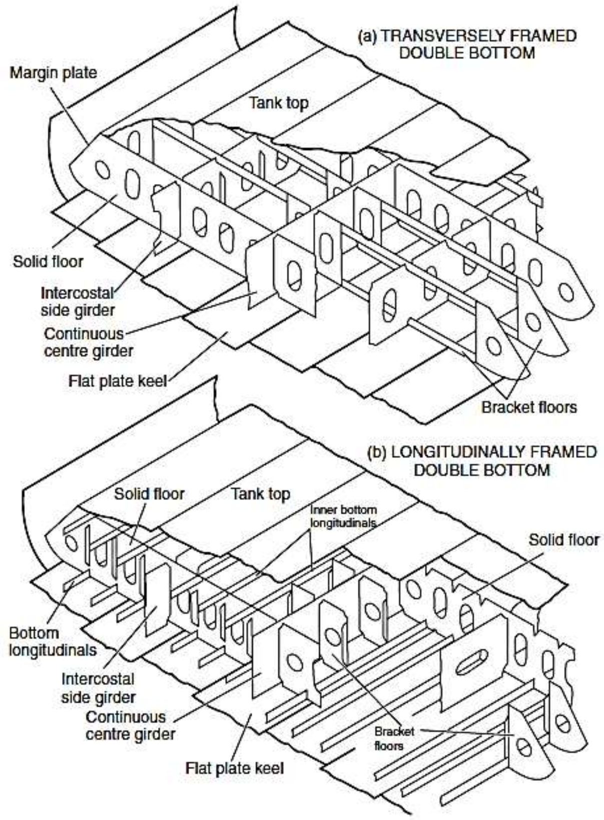
- **Double Bottom Structure**

An inner bottom (or tank top) may be provided at a minimum height above the bottom shell, and maintained watertight to the bilges. This provides a considerable margin of safety, since in the event of bottom shell damage only the double bottom space may be flooded. The space is not wasted but utilized to carry oil fuel and fresh water required for the ship, as well as providing ballast capacity.

The minimum depth of the double bottom in a ship will depend on the classification society's requirement for the depth of centre girder. It may be deeper to give the required capacities of oil fuel, fresh water, and water ballast to be carried in the bottom. Water ballast bottom tanks are commonly provided right forward and aft for trimming purposes and if necessary the depth of the double bottom may be increased in these regions. In way of the machinery spaces the double bottom depth is also increased to provide appreciable capacities of lubricating oil and fuel oil. The increase in height of the inner bottom is always by a gradual taper in the longitudinal direction, no sudden discontinuities in the structure being tolerated.

Double bottoms may be framed longitudinally or transversely (*see* the Figure below), but where the ship's length exceeds 120m it is considered desirable to adopt longitudinal framing. The explanation of this is that on longer ships tests and experience have shown that there is a tendency for the inner bottom and bottom shell to buckle if welded transverse framing is adopted. This buckling occurs as a result of the longitudinal bending of the hull, and may be avoided by having the plating longitudinally stiffened.

Double bottoms in the way of machinery spaces which are adjacent to the after peak are required to be transversely framed.



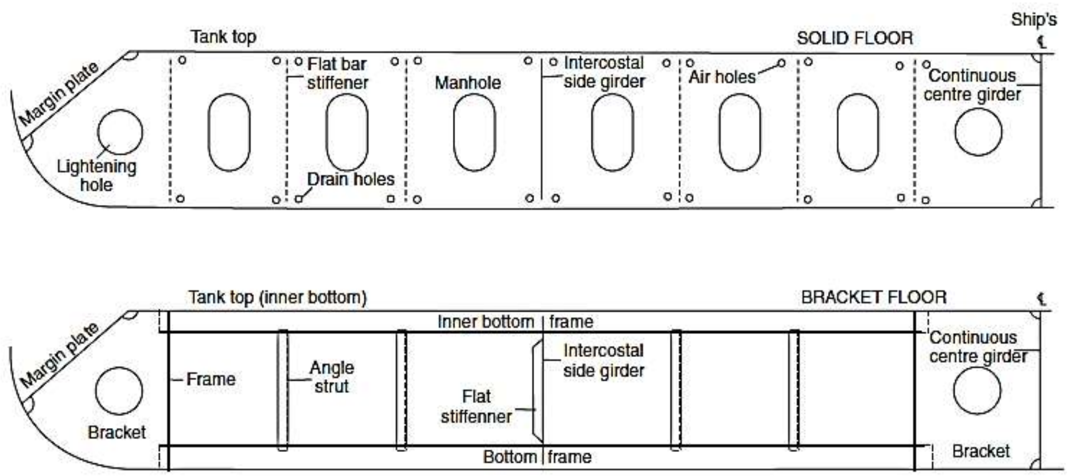
Double bottom construction

- **Inner bottom plating**

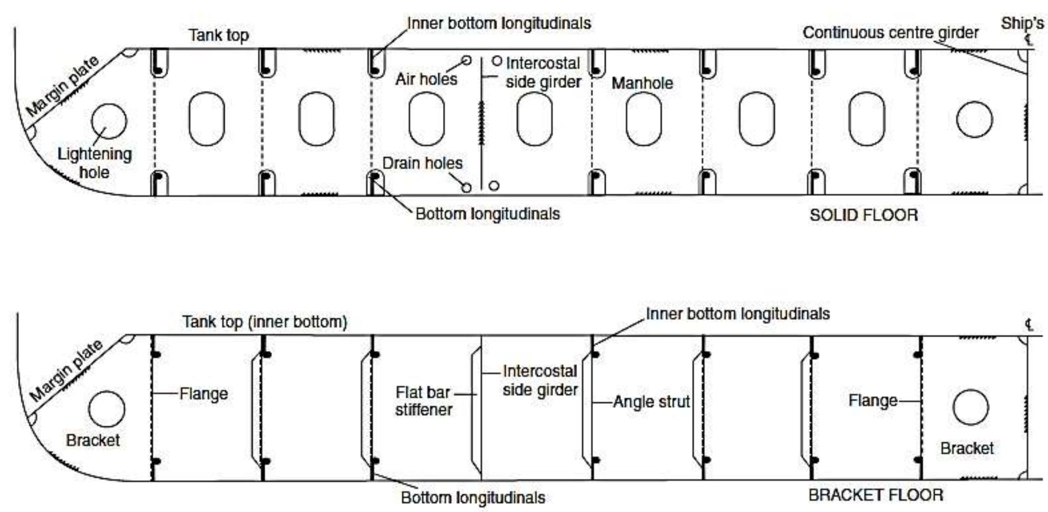
The inner bottom plating may in a general cargo ship be sloped at the side to form a bilge for drainage purposes. It is not uncommon however for it to be extended to the ship's side, and individual bilge wells are then provided for drainage purposes.
In vessels requiring a passenger certificate it is a statutory requirement for the tank top to extend to the ship's side. This provides a greater degree of safety since there is a substantial area of bilge which may be damaged without flooding spaces above the inner bottom.
At the centre line of the ship the middle strake of the inner bottom may be considered as the upper flange of the centre line docking girder, formed by the centre girder and keel plate. It may therefore be heavier than the other strakes of inner bottom plating. Normally a wood ceiling is provided under a hatchway in a general cargo ship, but the inner bottom plating thickness can be increased and the ceiling omitted. If grabs are used for discharging from general cargo ships the plate thickness is further increased, or a double ceiling is fitted.

- **Floors**

Vertical transverse plate floors are provided both where the bottom is transversely and longitudinally framed. At the ends of bottom tank spaces and under the main bulkheads, watertight or oiltight plate floors are provided. These are made watertight or oiltight by closing any holes in the plate floor and welding collars around any members which pass through the floors. Elsewhere ‘solid plate floors’ are fitted to strengthen the bottom transversely and support the inner bottom. These run transversely from the continuous centre girder to the bilge, and manholes provided for access through the tanks and lightening holes are cut in each solid plate floor. Also, small air and drain holes may be drilled at the top and bottom respectively of the solid plate floors in the tank spaces. The spacing of the solid plate floors varies according to the loads supported and local stresses experienced. At intermediate frame spaces between the solid plate floors, ‘bracket floors’ are fitted. The bracket floor consists simply of short transverse plate brackets fitted in way of the centre girder and tank sides (*see* the Figures below).



Transversely framed double bottom construction



Longitudinally framed doubled bottom construction

- **Transversely framed double bottom**

If the double bottom is transversely framed, then transverse solid plate floors, and bracket floors with transverse frames, provide the principal support for the inner bottom and bottom shell plating. Solid plate floors are fitted at every frame space in the engine room and in the pounding region. Also they are introduced in way of boiler seats, transverse bulkheads, toes of brackets supporting stiffeners on deep tank bulkheads, and in way of any change in depth of the double bottom. Where a ship is regularly discharged by grabs, solid plate floors are also fitted at each frame. Elsewhere the solid plate floors may be spaced up to 3.0m apart, with bracket floors at frame spaces between the solid floors. The plate brackets of bracket floors are flanged and their breadth is at least 75 per cent of the depth of the centre girder at the bracket floors. To reduce the span of the frames, which should not exceed 2.5 meters, at the bracket floor, vertical angle or channel bar struts may be fitted. Vertical stiffeners usually in the form of welded flats will be attached to the solid plate floors, which are further strengthened if they form a watertight or oiltight tank boundary.
One intercostal side girder is provided port and starboard where the ship's breadth exceeds 10 m but does not exceed 20 m and two are fitted port and starboard where the ship's breadth is greater. In way of the bracket floors a vertical welded flat stiffener is attached to the side girder. Additional side girders are provided in the engine room, and also in the pounding region.

- **Longitudinally framed double bottom**

In a longitudinally framed double bottom, solid plate floors are fitted at every frame space under the main engines, and at alternate frames outboard of the engine seating. They are also fitted under boiler seats, transverse bulkheads, and the toes of stiffener brackets on deep tank bulkheads. Elsewhere the spacing of solid plate floors does not exceed 3.8m, except in the pounding region where they are on alternate frame spaces. At intermediate frame spaces brackets are fitted at the tank side, and at the centre girder where they may be up to 1.25 m apart. Each bracket is flanged and will extend to the first longitudinal (see the Figure above). One intercostal side girder is fitted port and starboard if the ship's breadth exceeds 14 m, and where the breadth exceeds 21 m two are fitted port and starboard. These side girders always extend as far forward and aft as possible. Additional side girders are provided in the engine room, and under the main machinery, and they should run the full length of the engine room, extending three frame spaces beyond this space. Forward the extension tapers into the longitudinal framing system. In the pounding region there will also be additional intercostal side girders
As the unsupported span of the bottom longitudinals should not exceed 2.5m, vertical angle or channel bar struts may be provided to support the longitudinals between widely spaced solid floors.

- **Additional stiffening in the pounding region**

If the minimum designed draft forward in any ballast or part loaded condition is less than 4.5 per cent of the ship's length then the bottom structure for 30 per cent of the ship's length forward in sea-going ships exceeding 65 m in length is to be additionally strengthened for pounding.

Where the double bottom is transversely framed, solid plate floors are fitted at every frame space in the pounding region. Intercostal side girders are fitted at a maximum spacing of 3 times the transverse floor spacing, and half height intercostal side girders are provided midway between the full height side girders.

If the double bottom is longitudinally framed in the pounding region, where the minimum designed draft forward may be less than 4 per cent of the ship's length, solid plate floors are fitted at alternate frame spaces, and intercostal side girders fitted at a maximum spacing of 3 times the transverse floor spacing. Where the minimum designed draft forward may be more than 4 per cent but less than 4.5 per cent of the ship's length, solid plate floors may be fitted at every third frame space and intercostal side girders may have a maximum spacing of 4 times the transverse floor spacing. As longitudinals are stiffening the bottom shell longitudinally, it should be noted that less side girders need be provided than where the bottom is transversely framed to resist distortion of the bottom with the slamming forces experienced.

Where the ballast draft forward is less than 1 per cent of the ship's length the additional strengthening of the pounding region is given special consideration.

Greater slamming forces (i.e. pounding) are experienced when the ship is in the lighter ballast condition, and is long and slender, by reason of the increased submersion of the bow in heavy weather with impact also on the bow flare.

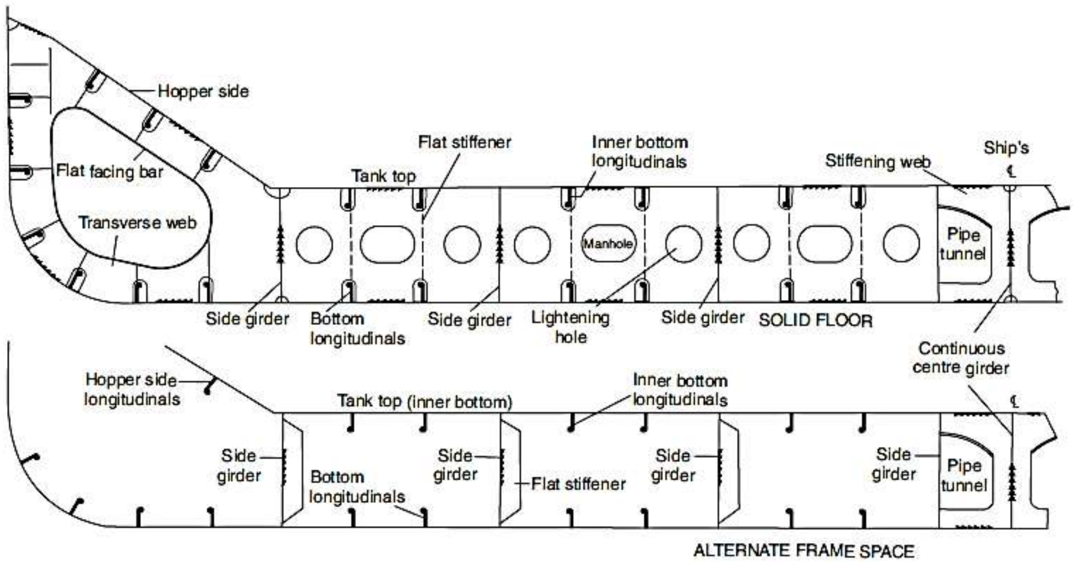
- **Bottom structure of bulk carriers**

Where a ship is classed for the carriage of heavy, or ore, cargoes longitudinal framing is adopted for the double bottom. A closer spacing of solid plate floors is required, the maximum spacing being 2.5m, and also additional intercostal side girders are provided, the spacing not exceeding 3.7m (see Figure below).

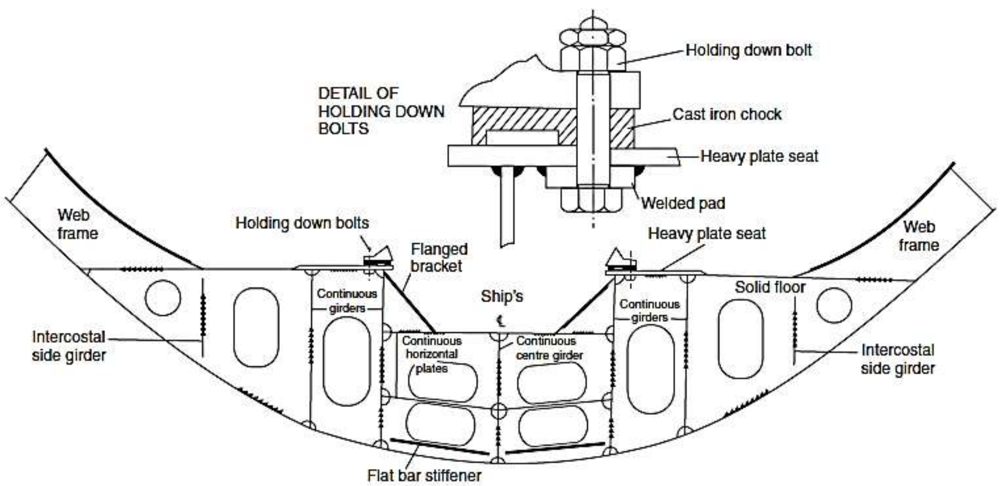
The double bottom will be somewhat deeper than in a conventional cargo ship, a considerable ballast capacity being required; and often a pipe tunnel is provided through this space. Inner bottom plating, floors, and girders all have substantial scantlings as a result of the heavier cargo weights to be supported.

- **Testing double bottom compartments**

Each compartment is tested on completion with a head of water representing the maximum pressure head which may be experienced in service, i.e. to the top of the air pipe. Alternatively air testing is carried out before any protective coatings are applied. The air pressure may be raised to 0.21 kg/cm2, and then lowered to a test pressure of 0.14 kg/cm2. Any suspect joints are then subjected to a soapy liquid solution test. Water head structural tests will be carried out on tanks selected by the surveyor in conjunction with the air tests carried out on the majority of tanks.



Bulk carrier double bottom construction



Engine seats

- **Machinery Seats**

It has already been indicated that in the machinery spaces additional transverse floors and longitudinal intercostal side girders are provided to support the machinery effectively and to ensure rigidity of the structure.

The main engine seatings are in general integral with this double bottom structure, and the inner bottom in way of the engine foundation has a substantially increased thickness. Often the machinery is built up on seatings forming longitudinal bearers which are supported

transversely by tripping brackets in line with the double bottom floors, the longitudinal bearers being in line with the double bottom side girders (*see* Figure above).
Boiler bearers are similarly fabricated with support from transverse brackets and longitudinal members.

Shell Plating and Framing

The shell plating forms the watertight skin of the ship and at the same time, in merchant ship construction, contributes to the longitudinal strength and resists vertical shear forces. Internal strengthening of the shell plating may be both transverse and longitudinal and is designed to prevent collapse of the plating under the various loads to which it is subject.

Shell Plating

The bottom and side shell plating consists of a series of flat and curved steel plates generally of greater length than breadth butt welded together. The vertical welded joints are referred to as 'butts' and the horizontal welded joints as 'seams' (see Figure above). Stiffening members both longitudinal and transverse are generally welded to the shell by intermittent fillet welds with a length of continuous weld at the ends of the stiffening member. Continuous welding of stiffening members to the shell is found in the after peak, the bottom shell within the forward 30 per cent of the length and where higher tensile steel is used. Framing is notched in way of welded plate butts and seams.

- **Bottom shell plating**

Throughout the length of the ship the width and thickness of the keel plate remain constant where a flat plate keel is fitted. Its thickness is never less than that of the adjoining bottom plating.
Strakes of bottom plating to the bilges have their greatest thickness over 40 per cent of the ship's length amidships, where the bending stresses are highest. The bottom plating then tapers to a lesser thickness at the ends of the ship, apart from increased thickness requirements in way of the pounding region.

- **Side shell plating**

As with the bottom shell plating the greater thickness of the side shell plating is maintained within 40 per cent of the vessel's midship length and then tapers to the rule thickness at the ends. The thickness may be increased in regions where high vertical shear stresses occur, usually in way of transverse bulkheads in a vessel permitted to carry heavy cargoes with some holds empty. There is also a thickness increase at

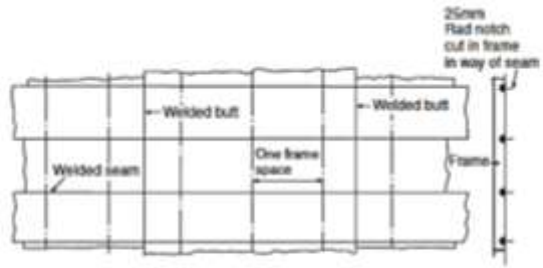


FIGURE 17.1 Shell plating

Shell plating

the stern frame connection, at any shaft brackets, and in way of the hawse pipes where considerable chafing occurs. Further shell plate thickness increases may be found at the panting region, as discussed later in this chapter.

The upper strake of plating adjacent to the strength deck is referred to as the ‘sheerstrake’. As the sheerstrake is at a large distance from the neutral axis it has a greater thickness than the other strakes of side shell plating.

Also, being in a highly stressed region it is necessary to avoid welded attachments to the sheerstrake, or cutouts which would introduce stress raisers.

The upper edge is dressed smooth, and the welding of bulwarks to the edge of the sheerstrake is not permitted within the amidships length of the ship.

Scupper openings above the deck over the same length, and at the ends of the superstructure, are also prohibited in larger vessels. The connection between the sheerstrake and strength deck can present a problem, and a rounded gunwale may be adopted to solve this problem where the plating is heavy. This is often the case over the midship portion of large tankers and bulk carriers. Butt welds are then employed to make connections rather than the less satisfactory fillet weld at the perpendicular connection of the vertical sheerstrake and horizontal strength deck stringer plate. The radius of a rounded gunwale must be adequate (not less than 15 times the thickness) and any welded guardrails and fairleads are kept off the radiused plate if possible.

A smooth transition from rounded gunwale to angled sheerstrake/deck stringer connection is necessary at the ends of the ship.

All openings in the side shell have rounded corners, and openings for sea inlets, etc., are kept clear of the bilge radius if possible. Where this is not possible openings on or in the vicinity of the bilge are made elliptical.

Requirement	*Structural member*
1. Grade D where thickness less than 15 mm otherwise Grade E.	Sheerstrake or rounded gunwale over 40 per cent of length amidships in ships exceeding 250 m in length.
2. Grade A where thickness less than 15 mm. Grade B where thickness 15 to 20 mm. Grade D where thickness 20 to 25 mm. Grade E where thickness greater than 25 mm.	Sheerstrake and rounded gunwale over 40 per cent of length amidships in ships of 250 m or less in length. Bilge strake (other than for vessels of less than 150 m with double bottom over full breadth).
3. Grade A where thickness less than 20 mm. Grade B where thickness 20 to 25 mm. Grade D where thickness 25 to 40 mm. Grade E where thickness over 40 mm.	Bottom plating including keel. Bilge strake (ships of less than 150 m and with double bottom over full breadth).
4. Grade A where thickness less than 30 mm. Grade B where thickness 30 to 40 mm. Grade D where thickness greater than 40 mm.	Side plating.

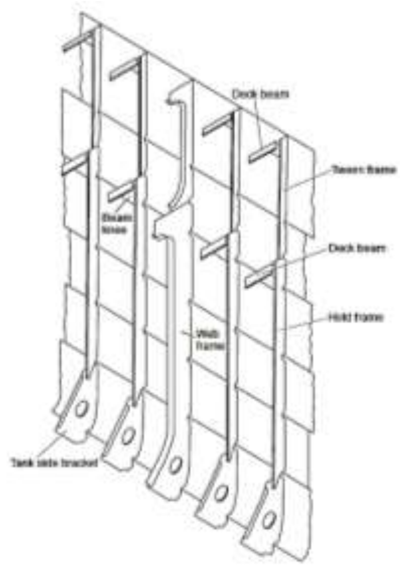
Table: Grades of steel for shell plates

- **Grades of steel for shell plates**

In large ships it is necessary to arrange strakes of steel with greater notch ductility at the more highly stressed regions. Details of Lloyd's requirements for mild steel and over 40 per cent of the length amidships are given in Table above as a guide. The Rules also require thicker plating for the members referred to in Table above outside the amidships region to have greater notch ductility.

Framing

The bottom shell may be transversely or longitudinally framed, longitudinal framing being preferred particularly for vessels exceeding 120m in length.
The side shell framing may also be transversely or longitudinally framed, transverse framing being adopted in many conventional cargo ships, particularly where the maximum bale capacity is required. Bale capacities are often considerably reduced where deep transverses are fitted to support longitudinal framing. Longitudinal framing may be adopted in larger container ships and larger bulk carriers, and it is common within the hopper and topside wing tanks of the latter vessels. Transverse frames are then fitted at the side shell between the hopper and topside tanks.



Side shell with transverse framing

- **Transverse framing**

In a general cargo ship the transverse framing will consist of main and hold frames with brackets top and bottom, and lighter tween deck frames with brackets at the tops only (*see* Figure above).

Scantlings of the main transverse frames are primarily dependent on their position, spacing and depth, and to some extent on the rigidity of the end connections. In way of tanks such as oil bunkers or cargo deep tanks the side frame size will be increased, except where supporting side stringers are fitted within the tank space. Frames supporting hatch end beams and those in way of deck transverses where the deck is framed longitudinally, also have increased scantlings.
Web frames, that is built up frames consisting of plate web and face flat, where the web is considerably deeper than the conventional transverse frame, are often introduced along the side shell (*see* Figure below part (a)). A number are fitted in midship machinery spaces, generally not more than 5 frame spaces apart but may be omitted if the size of normal framing is increased. Forward of the collision bulkhead and in any deep tank adjacent to the collision bulkhead, and in tween decks above such tanks, web frames are required at not more than 5 frame spaces apart. In the tween decks above the after peak tank, web frames are required at every fourth frame space abaft the aft peak bulkhead. In all cases the provision of web frames is intended to increase the rigidity of the transverse ship section at that point.

- **Longitudinal Framing**

If the side shell is longitudinally framed offset bulb sections will often be employed with the greater section scantlings at the lower side shell. Direct continuity of strength is to be maintained, and many of the details are similar to those illustrated for the tanker

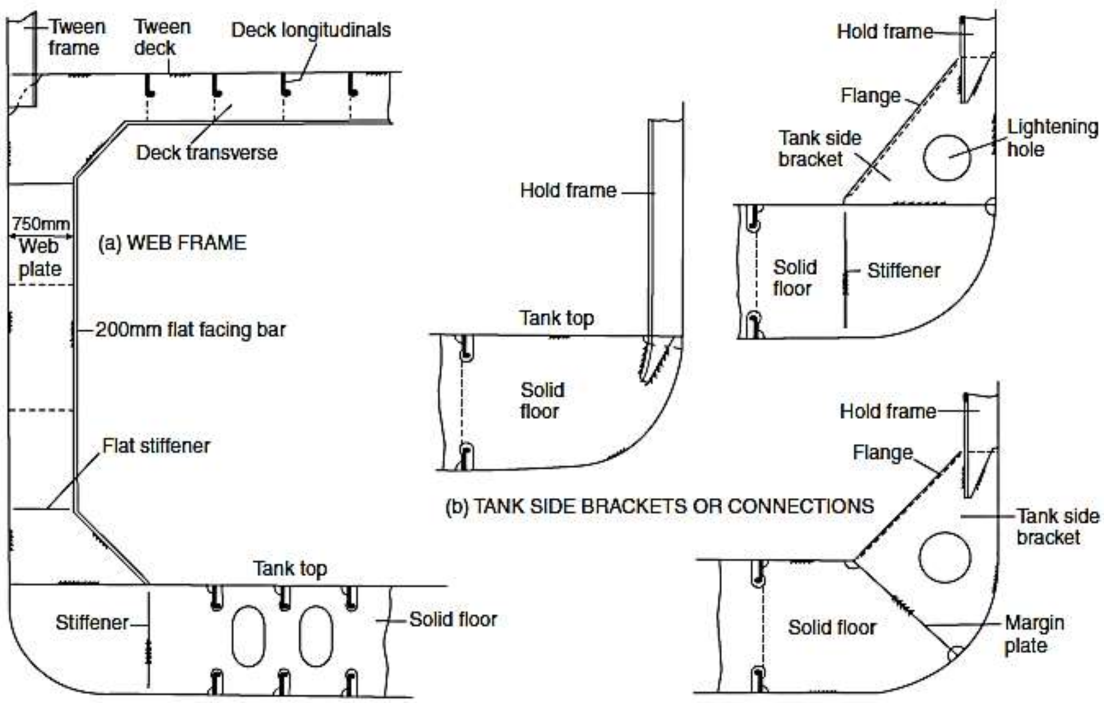
longitudinals. Transverse webs are fitted to support the side longitudinals, these being spaced not more than 3.8m apart, in ships of 100m length or less, with increasing spacing being permitted for longer ships.
In the peaks the spacing is 2.5m where the length of ship is less than 100m increasing linearly to a spacing of 3.5m where the length exceeds 300 m.
Larger container ships are longitudinally framed at the sides with transverse webs arranged in line with the floors in the double bottom to ensure continuity of transverse strength. Many of these ships have a double skin construction with transverse webs and horizontal perforated flats between the two longitudinally framed skins.

- **Tank Side Brackets**

The lower end of the frame may be connected to the tank top or hopper side tank by means of a flanged or edge stiffened tank side bracket as illustrated in Figure below part (b).

- **Local Strengthening of Shell Plating**

The major region in which the shell plating is subjected to local forces at sea is at the forward end.



Web frame and tank side bracket

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- **Additional stiffening for panting**

Additional stiffening is provided in the fore peak structure, the transverse side framing being supported by any, or a combination of the following arrangements:

a. Side stringers spaced vertically about 2m apart and supported by struts or beams fitted at alternate frames. These 'panting beams' are connected to the frames by brackets and if long may be supported at the ships centre line by a partial wash bulkhead. Intermediate frames are bracketed to the stringer (*see* Figure below).

b. Side stringers spaced vertically about 2m apart and supported by web frames.

c. Perforated flats spaced not more than 2.5m apart. The area of perforations being not less than 10 per cent of the total area of the flat. Aft of the forepeak in the lower hold or deep tank spaces panting stringers are fitted in line with each stringer or perforated flat in the fore peak extending back over 15 per cent of the ship length from forward. These stringers may be omitted if the shell plating thickness is increased by 15 per cent for vessels of 150m length or less decreasing linearly to 5 per cent increase for vessels of 215 m length or more. However, where the unsupported length of the main frames exceeds 9m panting stringers in line with alternate stringers or flats in the fore peak are to be fitted over 20 per cent of the ships length from forward whether the shell thickness is increased or not. Stringers usually take the form of a web plate with flat facing bar. In tween deck spaces in the forward 15 per cent of the ships length intermediate panting stringers are fitted where the unsupported length of tween frame exceeds 2.6m in lower tween decks or 3m in upper tween decks.
Alternatively the shell thickness may be increased as above.
In the aft peak space and in deep tween decks above the aft peak similar panting arrangements are required for transverse framing except that the vertical spacing of panting stringers may be up to 2.5m apart.
If the fore peak has longitudinal framing and the depth of tank exceeds 10 m the transverse webs supporting the longitudinals are to be supported by perforated flats or an arrangement of transverse struts or beams.

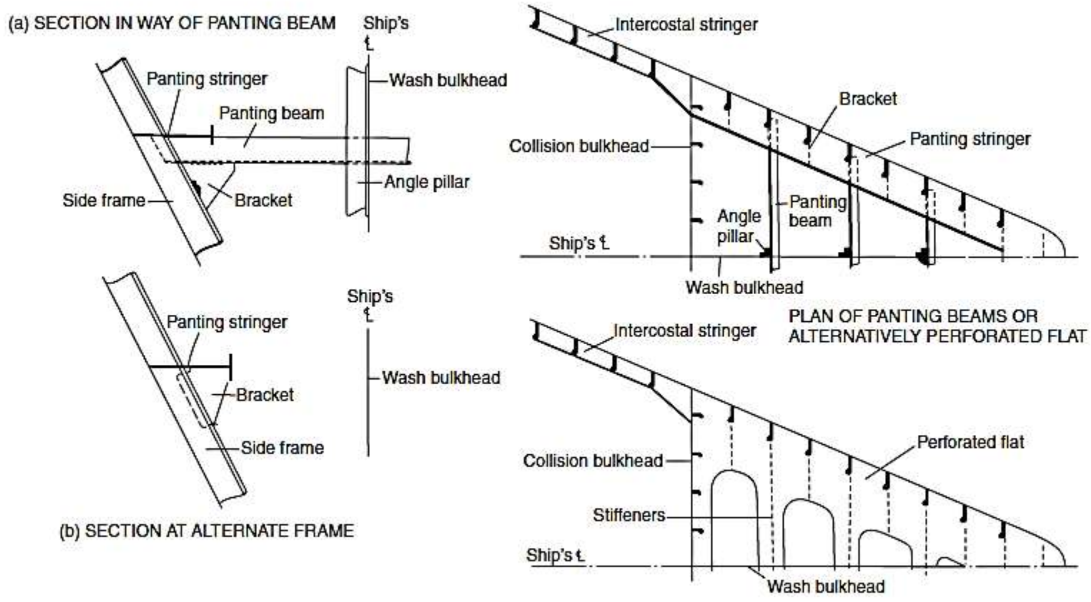


FIGURE 17.4 Panting arrangements forward

Panting arrangement forward

Class	*Above ice load waterline (mm)*	*Below ice light waterline (mm)*
1AS	600	750
1A	500	600
1B	400	500
1C	400	500
1D	400	500

Table: Main Ice Belt Zone

- STRENGTHENING FOR NAVIGATION IN ICE

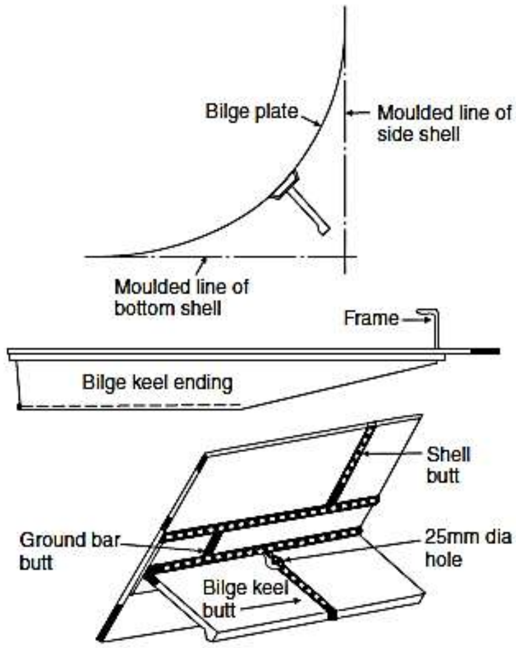
If a vessel is to be assigned a special features notation for navigation in first year ice the additional strengthening required involves primarily an increase in plate thickness and frame scantlings in the waterline region and the bottom forward, and may require some modifications and strengthening at the stem, stern, rudder and bossings, etc.

A main ice belt zone is defined which extends above the ice load waterline (i.e. normally the summer load waterline) and below the ice light waterline (i.e. lightest waterline ship navigates ice in). The extent of this zone depends on the ice class assigned (*see* Table above).

The shell plating thickness in this zone is greater than on a conventional ship and increases with severity of ice class and with position from aft to forward. Below the main ice belt zone forward for at least 40 per cent of the

Ice class	*Region*	*Minimum extent of ice framing*	
		Above ice load waterline (mm)	*Below ice load waterline (mm)*
1AS	Forward (30 per cent length from forward)	1200	To double bottom or top of floors
	Forward (abaft 30 per cent length from forward) and midships	1200	1600
	Aft	1200	1200
1A	Forward (30 per cent length from forward)	1000	1600
1B	Forward (abaft 30 per cent length from forward) and midships	1000	1300
1C	Aft	1000	1000
1D	Forward	1000	1600

Note! Forward is less than 40 per cent of the length aft of the forward perpendicular

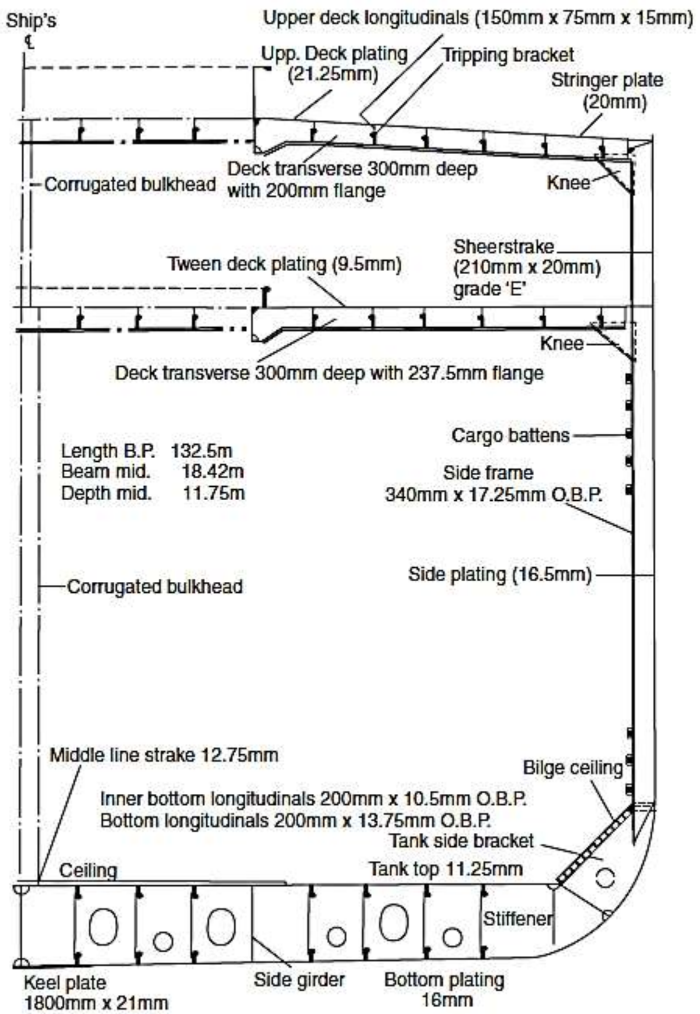


Bilge keels

length from forward for Ice Classes 1AS and 1A increased thickness of shell plating is required.
Transverse main and intermediate frames of the same heavier scantlings are fitted in way of the main ice belt zone to the extent indicated in Table above. If the shell is longitudinally framed longitudinals of increased scantlings are fitted over the same vertical extent given in Table above for transverse framing. Both transverse and longitudinal frame scantling requirements are dependent on the severity of ice class and distance of frame from forward.

The main and intermediate transverse frames terminate at the first major longitudinal member outside the minimum extent of ice framing. Transverse ice framing is supported by ice stringers and decks, and longitudinal framing by web frames the scantlings of which are increased with severity of ice class and distance from forward.

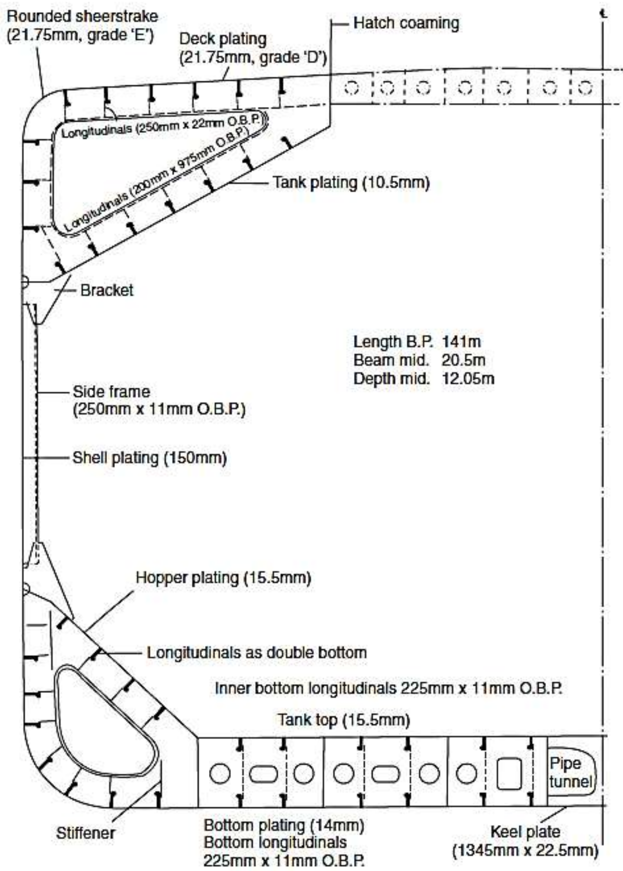
Strengthening for addition of ‘Icebreaker’ notation to ship type notation and assignment of special features notation for navigation in multi-year ice concerns plating and framing but are too extensive to be covered adequately in this text.



General cargo ship – midship section

Bilge Keel

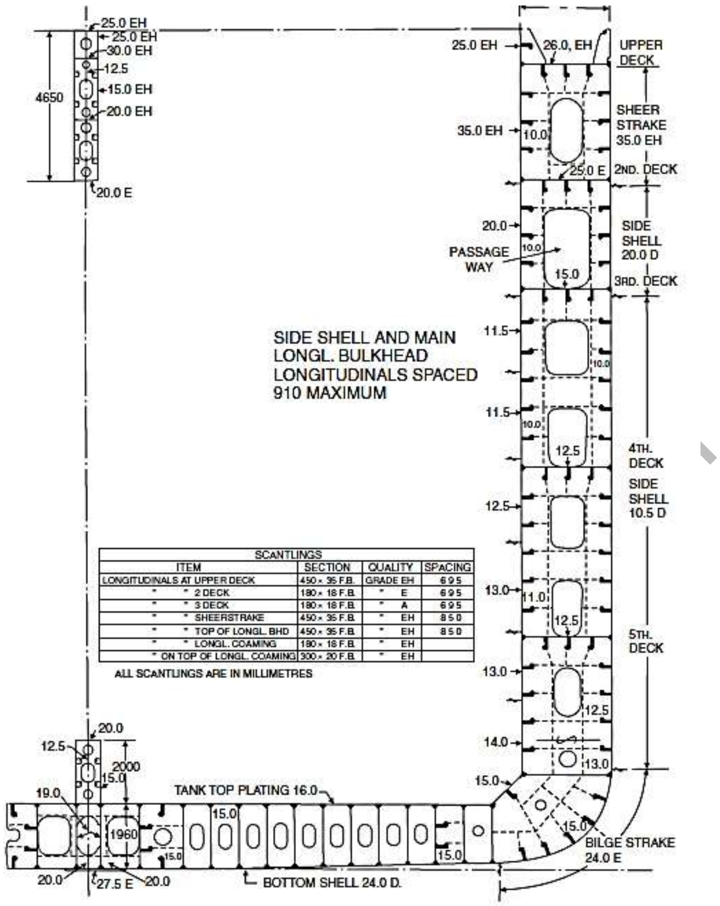
Most ships are fitted with some form of bilge keel the prime function of which is to help damp the rolling motion of the vessel. Other relatively



Bulk carrier – midship section

minor advantages of the bilge keel are protection for the bilge on grounding, and increased longitudinal strength at the bilge.

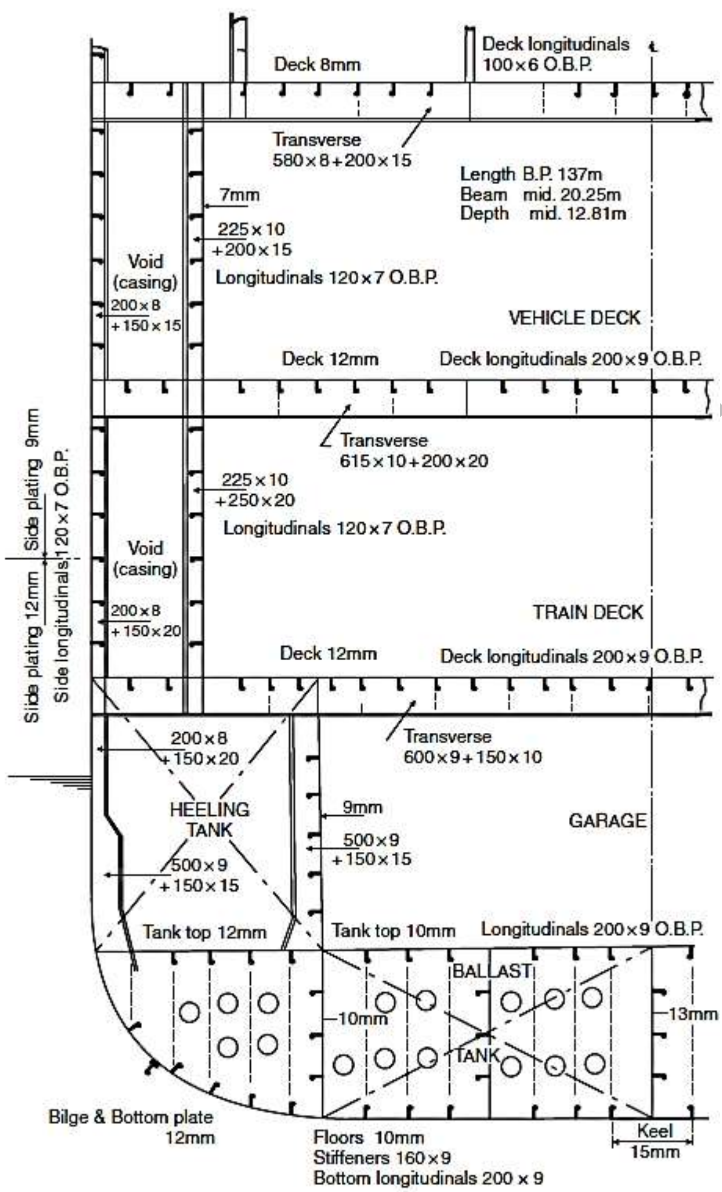
The damping action provided by the bilge keel is relatively small but effective, and virtually without cost after the construction of the ship. It is carefully positioned on the ship so as to avoid excessive drag when the ship



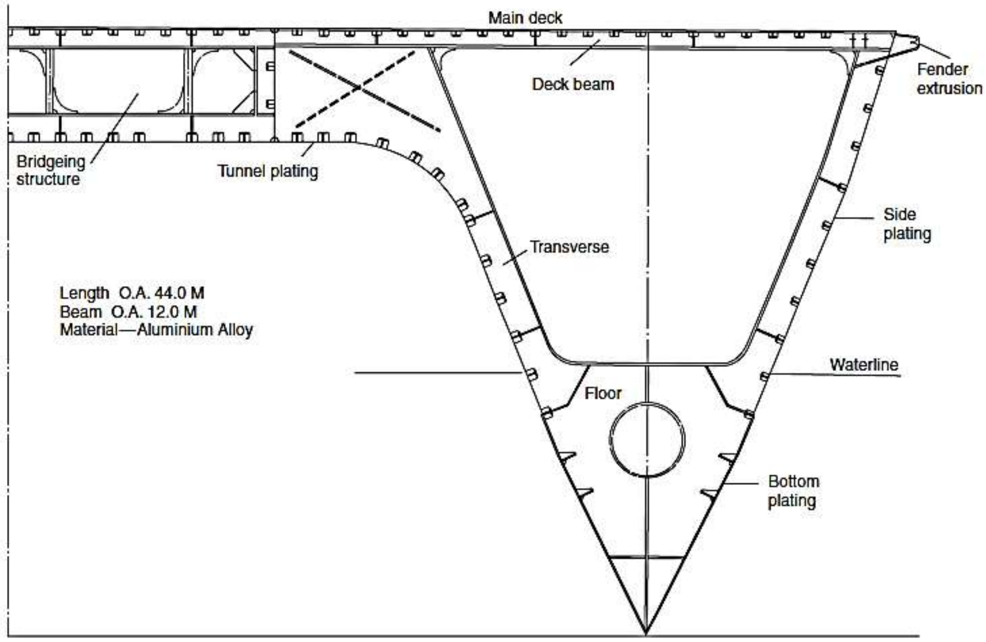
Container ship – midship section

is under way; and to achieve a minimum drag, various positions of the bilge keel may be tested on the ship model used to predict power requirements.

This bilge keel then generally runs over the midship portion of the hull, often extending further aft than forward of amidships and being virtually perpendicular to the turn of the bilge.



Midship section of ro – ro ship



High speed craft (catamaran) – section

There are many forms of bilge keel construction, and some quite elaborate arrangements have been adopted in an attempt to improve the damping performance whilst reducing any drag. Care is required in the design of the bilge keel, for although it would not be considered as a critical strength member of the hull structure, the region of its attachment is fairly highly stressed owing to its distance from the neutral axis. Cracks have originated in the bilge keel and propogated into the bilge plate causing failure of the main structure. In general bilge keels are attached to a continuous ground bar with the butt welds in the shell plating, ground bar and bilge keel staggered. Direct connection between the ground bar butt welds and the bilge plate and bilge keel butt welds and the ground bar are avoided. In ships over 65 m in length, holes are drilled in the bilge keel butt welds as shown in Figure above (Bilge keels).
The ground bar thickness is at least that of the bilge plate or 14 mm whichever is the lesser, and the material grade is the same as that of the bilge plate. Connection of the ground bar to the shell is by continuous fillet welds and the bilge keel is connected to the ground bar by light continuous or staggered intermittent weld. The latter lighter weld ensures that should the bilge keel be fouled failure occurs at this joint without the bilge plate being damaged.
Bilge keels are gradually tapered (at least 3 to 1) at their ends and finish in way of an internal stiffening member.

- **Bulkheads and Pillars**

Bulkheads

Vertical partitions in a ship arranged transversely or fore and aft are referred to as 'bulkheads'. Those bulkheads which are of greatest importance are the main hull transverse and longitudinal bulkheads dividing the ship into a number of watertight compartments. Other lighter bulkheads, named 'minor bulkheads', which act as screens further subdividing compartments into small units of accommodation or stores, are of little structural importance.

The main hull bulkheads of sufficient strength are made watertight in order that they may contain any flooding in the event of a compartment on one side of the bulkhead being bilged. Further they serve as a hull strength member not only carrying some of the ship's vertical loading but also resisting any tendency for transverse deformation of the ship. As a rule the strength of the transverse watertight bulkheads is maintained to the strength deck which may be above the freeboard deck. Finally each of the main hull bulkheads has often proved a very effective barrier to the spread of a hold or machinery space fire.

- SPACING OF WATERTIGHT BULKHEADS—CARGO SHIPS

The minimum number of transverse watertight bulkheads which must be fitted in a dry cargo ship are stipulated. A collision bulkhead must be fitted forward, an aft peak bulkhead must be fitted, and watertight bulkheads must be provided at either end of the machinery space. This implies that for a vessel with machinery amidships the minimum possible number of watertight bulkheads is four. With the machinery aft this minimum number may

be reduced to three, the aft peak bulkhead being at the aft end of the machinery space.

Of these bulkheads perhaps the most important is the collision bulkhead forward. It is a fact that the bow of at least one out of two ships involved in a collision will be damaged. For this reason a heavy bulkhead is specified and located so that it is not so far forward as to be damaged on impact.

Neither should it be too far aft so that the compartment flooded forward causes excessive trim by the bow. Lloyd's Register gives the location for ships whose length does not exceed 200m as not less than 5 and not greater than 8 per cent of the ship's length (Lloyd's Length) from the fore end of the load waterline. As a rule this bulkhead is fitted at the minimum distance in order to gain the maximum length for cargo stowage. The aft peak bulkhead is intended to enclose the stern tubes in a watertight compartment preventing any emergency from leakage where the propeller shafts pierce the hull. It is located well aft so that the peak when flooded would not cause excessive trim by the stern. Machinery bulkheads provide a self-contained compartment for engines and boilers preventing damage to these vital components of the ship by flooding in an adjacent hold. They also localize any fire originating in these spaces.

A minimum number of watertight bulkheads will only be found in smaller cargo ships. As the size increases the classification society will recommend additional bulkheads, partly to provide greater transverse strength, and also to increase the amount of subdivision. Table 18.1 indicates the number of watertight bulkheads recommended by Lloyd's Register for any cargo ship.

These should be spaced at uniform intervals, but the shipowner may require for a certain trade a longer hold, which is permitted if additional approved transverse stiffening is provided. It is possible to dispense with one watertight bulkhead altogether, with Lloyd's Register approval, if adequate approved

Length of ship (metres)		*Total number of bulkheads*	
Above	*Not exceeding*	*Machinery midships*	*Machinery aft*
	65	4	3
65	85	4	4
85	105	5	5
105	115	6	5
115	125	6	6
125	145	7	6
145	165	8	7
165	190	9	8
190	To be considered individually		

Table: Bulkheads for Cargo Ships

structural compensation is introduced. In container ships the spacing is arranged to suit the standard length of containers carried.

Each of the main watertight hold bulkheads may extend to the uppermost continuous deck; but in the case where the freeboard is measured from the second deck they need only be taken to that deck. The collision bulkhead extends to the uppermost continuous deck and the aft peak bulkhead may terminate at the first deck above the load waterline provided this is made watertight to the stern, or to a watertight transom floor.

In the case of bulk carriers a further consideration may come into the spacing of the watertight bulkheads where a shipowner desires to obtain a reduced freeboard. It is possible with bulk carriers to obtain a reduced freeboard under The International Load Line Convention 1966 if it is possible to flood one or more compartments without loss of the vessel. For obvious reasons many shipowners will wish to obtain the maximum permissible draft for this type of vessel and the bulkhead spacing will be critical.

- **Spacing of watertight bulkheads—passenger ships**

Where a vessel requires a passenger certificate (carrying more than 12 passengers), it is necessary for that vessel to comply with the requirements of the International Convention on Safety of Life at Sea, 1974. Under this convention the subdivision of the passenger ship is strictly specified, and controlled by the authorities of the maritime countries who are signatories to the convention. In the United Kingdom the controlling authority is the Marine and Coastguard Agency.

The calculations involved in passenger ship subdivision are dealt with in detail in the theoretical text-books on naval architecture. However the basic principle is that the watertight bulkheads should be so spaced that when the vessel receives reasonable damage, flooding is confined. No casualty will then result either from loss of transverse stability or excessive sinkage and trim.

- **Construction of watertight bulkheads**

The plating of a flat transverse bulkhead is generally welded in horizontal strakes, and convenient two-dimensional units for prefabrication are formed. Smaller bulkheads may be erected as a single unit; larger bulkheads are in two or more units. It has always been the practice to use horizontal strakes of plating since the plate thickness increases with depth below the top of the bulkhead. The reason for this is that the plate thickness is directly related to the pressure exerted by the head of water when a compartment on one side of the bulkhead is flooded. Apart from the depth the plate thickness is also influenced by the supporting stiffener spacing.

Vertical stiffeners are fitted to the transverse watertight bulkheads of a ship, the span being less in this direction and the stiffener therefore of welded inverted ordinary angle bars, or offset bulb plates, the size of the stiffener being dependent on the unsupported length, stiffener spacing, and rigidity of the end connections. Rigidity of the end connections will depend on the form of end connection, stiffeners in holds being bracketed or simply directly welded to the tank top or underside of deck, whilst upper tween stiffeners need not have any connection at all (*see* Figure below).

Vertical stiffeners may be supported by horizontal stringers permitting a reduction in the stiffener scantling as a result of the reduced span. Horizontal stringers are mostly found on those bulkheads forming the boundaries of a tank space, and in this context are dealt with later.

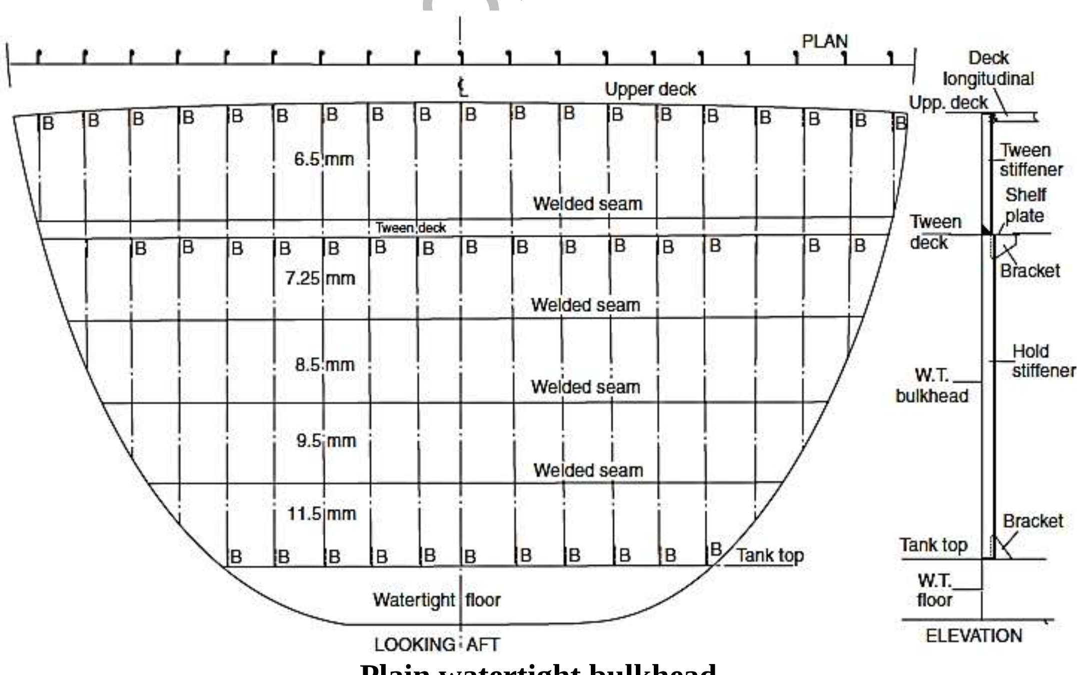
It is not uncommon to find in present day ships swedged and corrugated bulkheads, the swedges like the troughs of a corrugated bulkhead being so designed and spaced as to provide sufficient rigidity to the platebulkhead in order that conventional stiffeners may be dispensed with (*see* Figure below). Both swedges and corrugations are arranged in the vertical direction like the stiffeners on transverse and short longitudinal pillar bulkheads.

Since the plating is swedged or corrugated prior to its fabrication, the bulkhead will be plated vertically with a uniform thickness equivalent to that required at the base of the bulkhead.

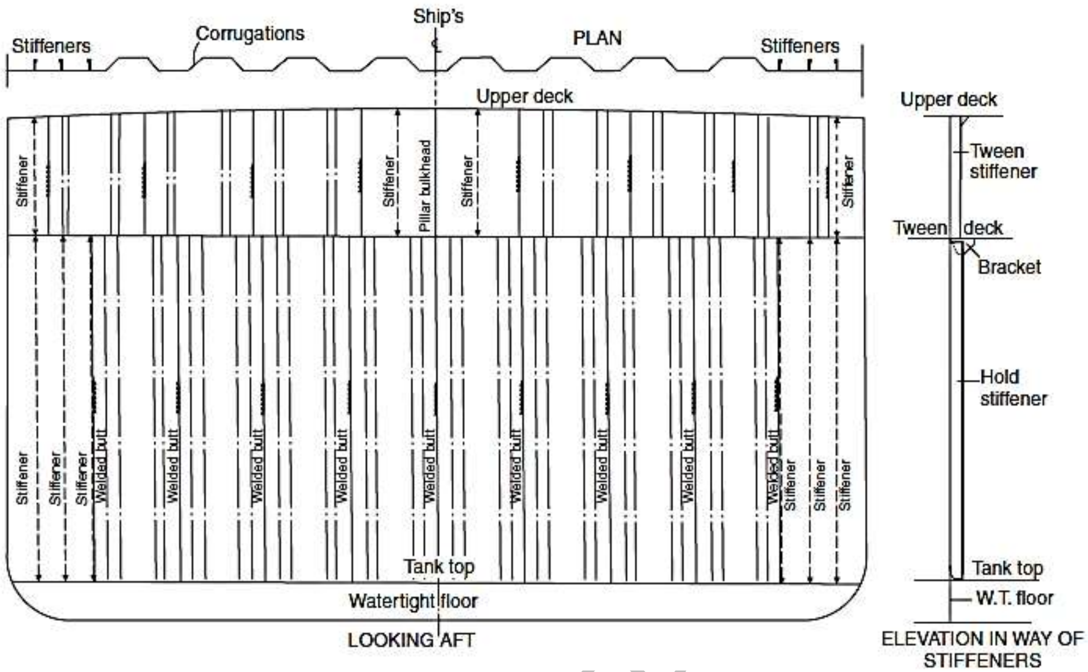
This implies that the actual plating will be somewhat heavier than that for a conventional bulkhead, and this will to a large extent offset any saving in weight gained by not fitting stiffeners.
The boundaries of the bulkhead are double continuously fillet welded directly to the shell, decks, and tank top.
A bulkhead may be erected in the vertical position prior to the fitting of decks during prefabrication on the berth. At the line of the tween decks a 'shelf plate' is fitted to the bulkhead and when erected the tween decks land on this plate which extends 300 to 400 mm from the bulkhead. The deck is lap welded to the shelf plate with an overlap of about 25 mm. In the case of a corrugated bulkhead it becomes necessary to fit filling pieces between the troughs in way of the shelf plate.
If possible the passage of piping and ventilation trunks through watertight bulkheads is avoided. However in a number of cases this is impossible and to maintain the integrity of the bulkhead the pipe is flanged at the bulkhead. Where a ventilation trunk passes through, a watertight shutter is provided.

- **Testing watertight bulkheads**

Both the collision bulkhead, as the fore peak bulkhead, and the aft peak bulkhead provided they do not form the boundaries of tanks are to be tested by filling the peaks with water to the level of the load waterline. All bulkheads, unless they form the boundaries of a tank which is regularly subject to a head of liquid, are hose



Plain watertight bulkhead



Corrugated watertight bulkhead

tested. Since it is not considered prudent to test ordinary watertight bulkheads by filling a cargo hold, the hose test is considered satisfactory.

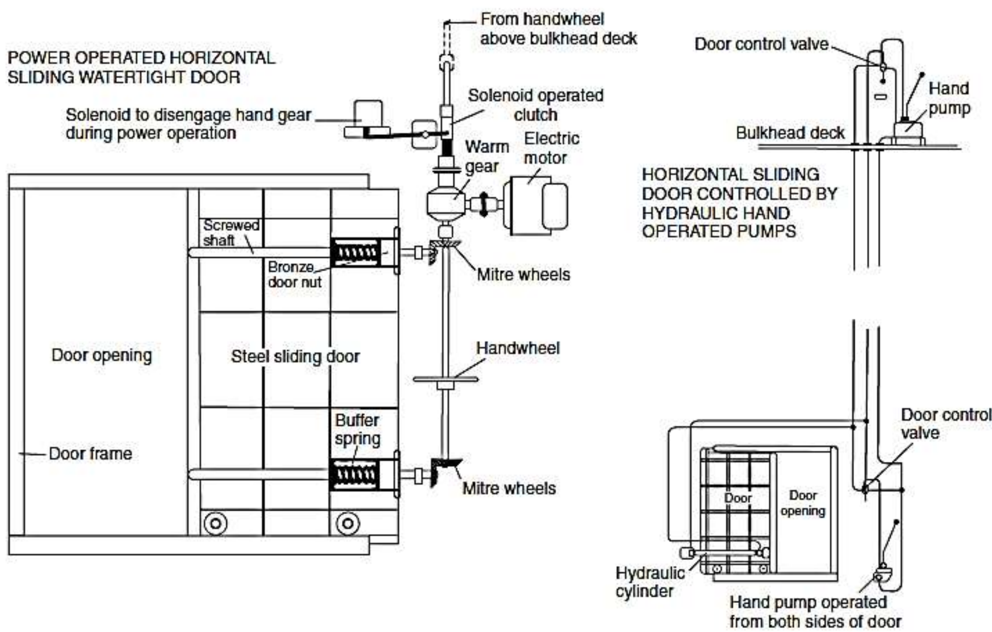
- **Watertight Doors**

In order to maintain the efficiency of a watertight bulkhead it is desirable that it remains intact. However in some instances it becomes necessary to provide access between compartments on either side of a watertight bulkhead and watertight doors are fitted for this purpose. A particular example of this in cargo ships is the direct means of access required between the engine room and the shaft tunnel. In passenger ships watertight doors are more frequently found where they allow passengers to pass between one point of the accommodation and another.

Where a doorway is cut in the lower part of a watertight bulkhead care must be taken to maintain the strength of the bulkhead. The opening is to be framed and reinforced, if the vertical stiffeners are cut in way of the opening. If the stiffener spacing is increased to accommodate the opening, the scantlings of the stiffeners on either side of the opening are increased to give an equivalent strength to that of an unpierced bulkhead. The actual opening is kept as small as possible, the access to the shaft tunnel being about 1000 to 1250 mm high and about 700 mm wide. In passenger accommodation the openings would be somewhat larger.

Mild steel or cast steel watertight doors fitted below the water line are either of the vertical or horizontal sliding type. A swinging hinged type of door could prove impossible to close in the event of flooding and is not permitted. The sliding door must be capable of operation when the ship is listed 15°, and be opened or closed from the vicinity of the door as well as from a position above the bulkhead deck. At this remote control position an indicator must be provided to show whether the door is open or closed.

Vertical sliding doors may be closed by a vertical screw thread which is turned by a shaft extending above the bulkhead and fitted with a crank handle. This screw thread turns in a gunmetal nut attached to the top of the door, and a crank handle is also provided at the door to allow it to be closed from this position. Often horizontal sliding doors are fitted, and these may have a vertical shaft extending above the bulkhead deck, which may be operated by hand from above the deck or at the door. This can also be power driven by an electric motor and worm gear, the vertical shaft working through bevel wheels, and horizontal screwed shafts turning in bronze nuts on the door. The horizontal sliding door may also be opened and closed by a hydraulic ram with a hydraulic hand pump and with control at the door and above the bulkhead deck (*see* Figure below). With the larger number of watertight doors fitted in passenger ships the doors may be closed by means



Watertight doors

of hydraulic power actuated by remote control from a central position above the bulkhead deck.

When in place all watertight doors are given a hose test, but those in a passenger ship are required to be tested under a head of water extending to the bulkhead deck. This may be done before the door is fitted in the ship.

In approved positions in the upper tween decks well above the waterline, hinged watertight doors are permitted. These may be similar to the weathertight doors fitted in superstructures, but are to have gunmetal pins in the hinges.

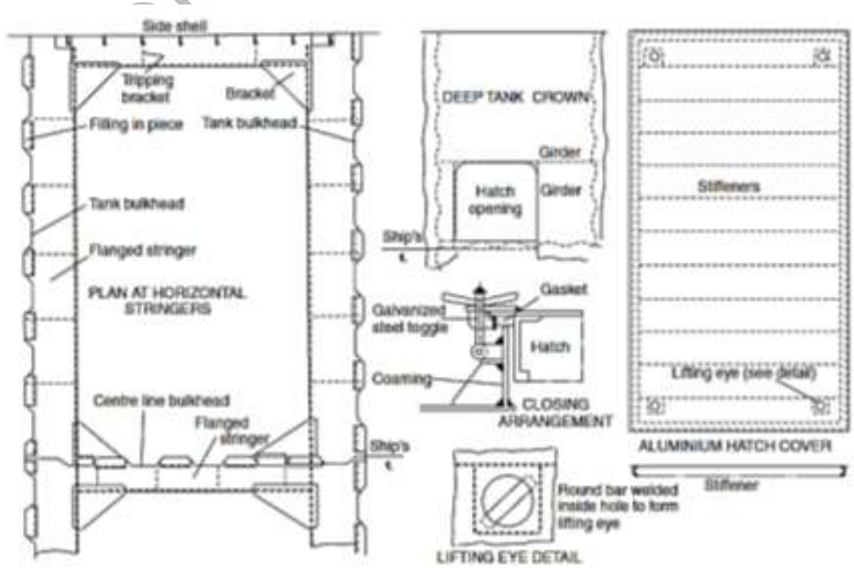
- **Deep Tanks**

Deep tanks were often fitted adjacent to the machinery spaces amidships to provide ballast capacity, improving the draft with little trim, when the ship was light. These tanks were frequently used for carrying general cargoes, and also utilized to carry specialist liquid cargoes. In cargo liners where the carriage of certain liquid cargoes is common practice it was often an advantage to have the deep tanks adjacent to the machinery space for cargo heating purposes. However in modern cargo liners they may require to be judiciously placed in order to avoid excessive stresses in different conditions of loading. Most ships now have their machinery arranged aft or three-quarters aft, and are fitted with deep tanks forward to improve the trim in the light conditions.

Construction of deep tanks

Bulkheads which form the boundaries of a deep tank differ from hold bulkheads in that they are regularly subjected to a head of liquid. The conventional hold bulkhead may be allowed to deflect and tolerate high stresses on the rare occasions when it has to withstand temporary flooding of a hold, but deep tank bulkheads which are regularly loaded in this manner are required to have greater rigidity, and be subject to lower stresses. As a result the plate and stiffener scantlings will be larger in way of deep tanks, and additional stiffening may be introduced.

The greater plating thickness of the tank boundary bulkheads increases with tank depth, and with increasing stiffener spacing. To provide the greater rigidity the vertical stiffeners are of heavier scantlings and more closely spaced. They must be bracketed or welded to some other form of stiffening member at their ends. Vertical stiffener sizes may be reduced, however, by fitting horizontal girders which form a continuous line of support on the bulkheads and ship’s side. These horizontal girders are connected at their ends by flanged brackets and are supported by tripping brackets at the toes of the end brackets, and at every third stiffener or frame. Intermediate



Construction of deep tanks

(*see* Figure above). Where deep tanks are intended to carry oil fuel for the ship's use, or oil cargoes, there will be a free surface, and it is necessary to fit a centre line bulkhead where the tanks extend from side to side of the ship. This bulkhead may be intact or perforated, and where intact the scantlings will be the same as for boundary bulkheads. If perforated, the area of perforations is sufficient to reduce liquid pressures, and the bulkhead stiffeners have considerably reduced scantlings, surging being avoided by limiting the perforation area.
Both swedged and corrugated plating can be used to advantage in the construction of deep tanks since, without the conventional stiffening, tanks are more easily cleaned. With conventional welded stiffening it may be convenient to arrange the stiffeners outside the tank so that the boundary bulkhead has a plain inside for ease of cleaning.
In cargo ships where various liquid cargoes are carried, arrangements may be made to fit cofferdams between deep tanks. As these tanks may also be fitted immediately forward of the machine space, a pipe tunnel is generally fitted through them with access from the engine room. This tunnel carries the bilge piping as it is undesirable to pass this through the deep tanks carrying oil cargoes.

- **Testing deep tanks**

Deep tanks are tested by subjecting them to the maximum head of water to which they might be subject in service (i.e. to the top of the air pipe). This should not be less than 2.45 m above the crown of the tank.

- **Topside Tanks**

Standard general bulk carriers are fitted with topside tanks which may be used for water ballast, and in some instances are used for the carriage of light grains. The thickness of the sloping bulkhead of this tank is determined in a similar manner to that of the deep tank bulkheads. The topside tank is generally stiffened internally by longitudinal framing supported by transverses. Transverses are arranged in line with the end of the main cargo hatchways; and in large ships, a fore and aft diaphragm may be fitted at half the width of the tank, between the deck and the sloping plating.

- **Shaft Tunnel**

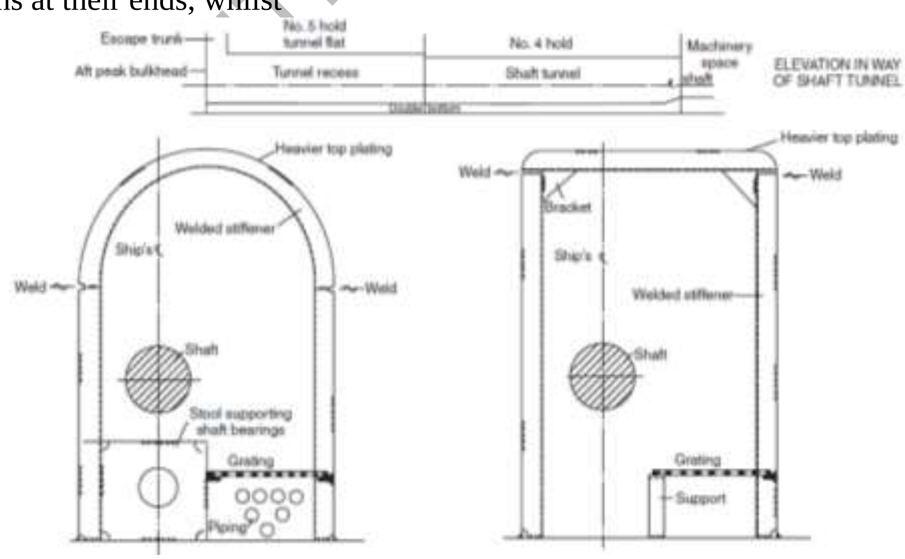
When the ship's machinery is not located fully aft it is necessary to enclose the propeller shaft or shafts in a watertight tunnel between the aft end of the machinery space and the aft peak bulkhead. This protects the shaft from the cargo and provides a watertight compartment which will contain any flooding resulting from damage to the watertight gland at the aft peak bulkhead. The tunnel should be large enought to permit access for inspection and repair of the shafting. A sliding watertight door which may be opened from either side is provided at the forward end in the machinery space bulkhead. Two means of escape from the shaft tunnel must be provided, and as a rule there is a ladder in a watertight trunk leading to an escape hatch on the deck above the waterline, at the aft end of the shaft tunnel. Where the ship narrows at its after end the aftermost hold may be completely plated over at the level of the shaft tunnel to form a tunnel flat, as the narrow stowage space either side of the conventional shaft tunnel could not be utilized. The additional space under this tunnel flat is often used to stow the spare tail shaft. Shaft tunnels also provide a convenient means of carrying piping aft, which is then accessible and protected from cargo damage.

- **Construction of the shaft tunnel**

The thickness of the tunnel plating is determined in the same manner as that for the watertight bulkheads.
Where the top of the tunnel is well rounded the thickness of the top plating may be reduced, but where the top is flat it is increased. Under hatchways the top plating must be increased in thickness unless it is covered by wood of a specified thickness. Vertical stiffeners supporting the tunnel plating have similar scantlings to the watertight bulkhead stiffeners, and their lower end is welded to the tank top (*see* Figure below). On completion the shaft tunnel structure is subject to a hose test.
At intervals along the length of the shaft, stools are built which support the shaft bearings. A walkway is installed on one side of the shaft to permit inspection, and as a result, in a single screw ship the shaft tunnel will be offset from the ship's centre line. This walkway is formed by gratings laid on angle bearers supported by struts, etc., any piping is then led along underneath the walkway.

- **Pillars**

The prime function of the pillars is to carry the load of the decks and weights upon the decks vertically down to the ship's bottom structure where these loads are supported by the upward buoyant forces. A secondary function of pillars is to tie together the structure in a vertical direction. Within the main hull of a cargo ship two different forms of pillar may be found, those in the holds invariably fulfilling the first function, and those in the machinery spaces fulfilling the latter function. Hold pillars primarily in compression are often without bracket connections at their ends, whilst



Shaft tunnels

machinery space pillars are heavily bracketed at their ends to permit tensile loadings. This latter type of pillar may also be found in tank spaces where the crown of tank under pressure can put the pillar in tension.

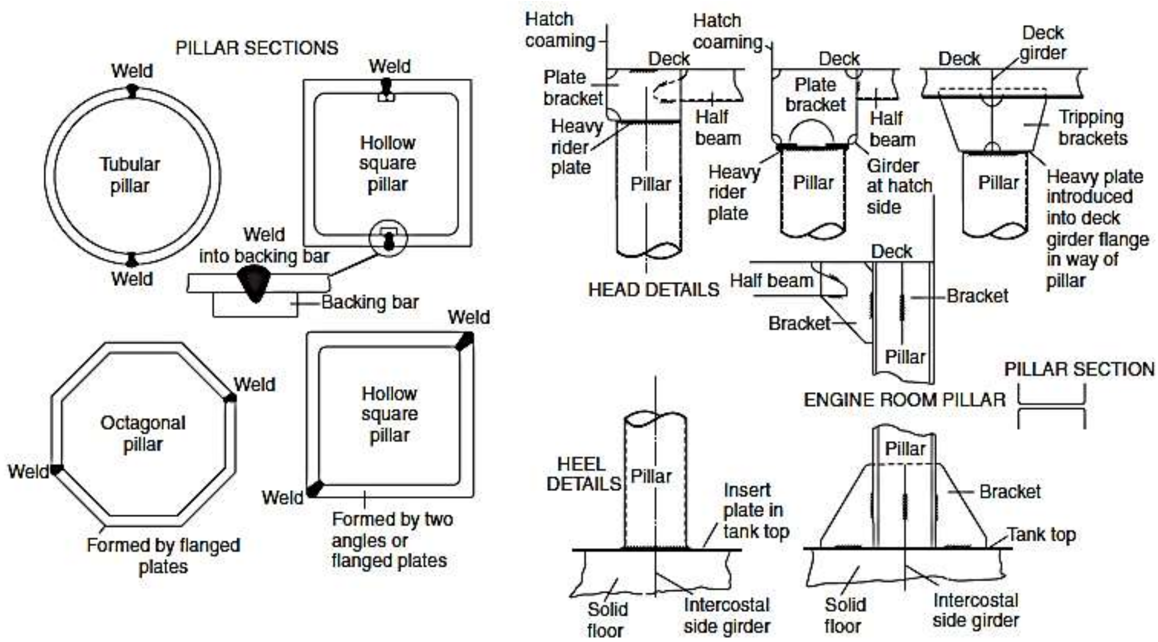
- SPACING OF HOLD PILLARS

Since pillars located in holds will interfere with the stowage arrangements, widely spaced pillars of large fabricated section are used rather than small, solid, closely spaced pillar systems. The arrangement most often found in cargo ships, is a two-row pillar system, with pillars at the hatch corners or mid-length of hatch supporting deck girders adjacent to the hatch sides. As the deck girder size is to some extent dependent on the supported span, where only a mid-hatch length pillar is fitted the girder scantlings will be greater than that where two hatch corner pillars are fitted. In fact pillars may be eliminated altogether where it is important that a clear space should be provided, but the deck girder will then be considerably larger, and may be supported at its ends by webs at the bulkhead. Substantial transverse cantilevers may also be fitted to support the side decks. Pillars may also be fitted in holds on the ship's centre line at the hatch end, to support the heavy hatch end beams securely connected to and supporting the hatch side girders. In a similar position it is not unusual to find short corrugated fore and aft pillar bulkheads. These run from the forward or aft side of the hatch opening to the adjacent transverse bulkhead on the ship's centre line.

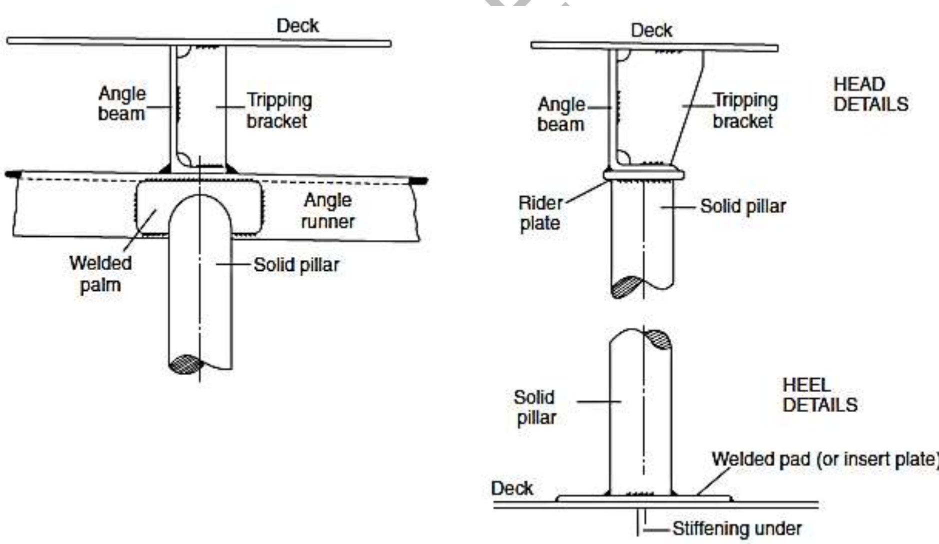
To maintain continuity of loading the tween pillars are arranged directly above the hold pillars. If this is not possible stiffening arrangements should be made to carry the load from the tween pillar to the hold pillar below.

- PILLAR CONSTRUCTION

It has already been seen that the hold pillar is primarily subject to a compressive loading, and if buckling is to be avoided in service the required cross-section must be designed with both the load carried and length of pillar in mind. The ideal section for a compressive strut is the tubular section and this is often adopted for hold pillars, hollow rectangular and octagonal sections also being used. For economic reasons the sections are fabricated in lengths from steel plate, and for the hollow rectangular section welded channels or angles may also be used (*see* Figure below). A small flat bar or cope bar may be tack welded inside these pillar sections to allow them to be welded externally.
Pillars have a bearing fit, and it is important that the loads at the head and heel of the pillar should be well distributed. At the head of the pillar a continuous weld is made to a doubling plate supported by brackets. Details of the head fitting vary from ship to ship and depend very much on the form of hatch side or deck girder which they support. The heel of the hold pillar lands on a heavy doubling or insert plate at the tank top and it is commonly arranged that the point of loading will coincide with a solid floor/side girder



Pillars



Small solid pillars

intersection in the double bottom below. Where this is not possible partial floors and short intercostal side girders may be fitted to distribute the load.
Machinery space pillars are fabricated from angles, channels, or rolled steel joists, and are heavily bracketed to suitably stiffened members (Figure above).

- **Small pillars**

Within the accommodation and in relatively small vessels solid round steel pillars having diameters seldom exceeding 150mm may be fitted. These may have forged palms at their head and heel, the head being welded to a continuous angle fore and aft runner which supports the deck. Alternatively the pillar head may have a direct continuous weld connection to an inverted angle beam or deck girder, with suitable tripping brackets fitted directly above. The heel is then directly welded to the deck which is suitably stiffened below (*see* Figure above). Rolled hollow steel section pillars of similar size with direct welded head and heel fittings are commonly used today in lieu of small solid pillars.

- **Decks, Hatches, and Superstructures**

Decks at different levels in a ship serve various functions; they may be either watertight decks, strength decks, or simply cargo and passenger accommodation decks. Watertight decks are fitted to maintain the integrity of the main watertight hull, and the most important is the freeboard deck which is the uppermost deck having permanent means of closing all openings in the exposed portions of that deck. Although all decks contribute to some extent to the strength of the ship, the most important is that which forms the upper flange of the main hull girder, called the 'strength deck'. Lighter decks which are not watertight may be fitted to provide platforms for passenger accommodation and permit more flexible cargo loading arrangements. In general cargo ships these lighter decks form tweens which provide spaces in which goods may be stowed without their being crushed by a large amount of other cargo stowed above them.

To permit loading and discharging of cargo, openings must be cut in the decks, and these may be closed by non-watertight or watertight hatches.

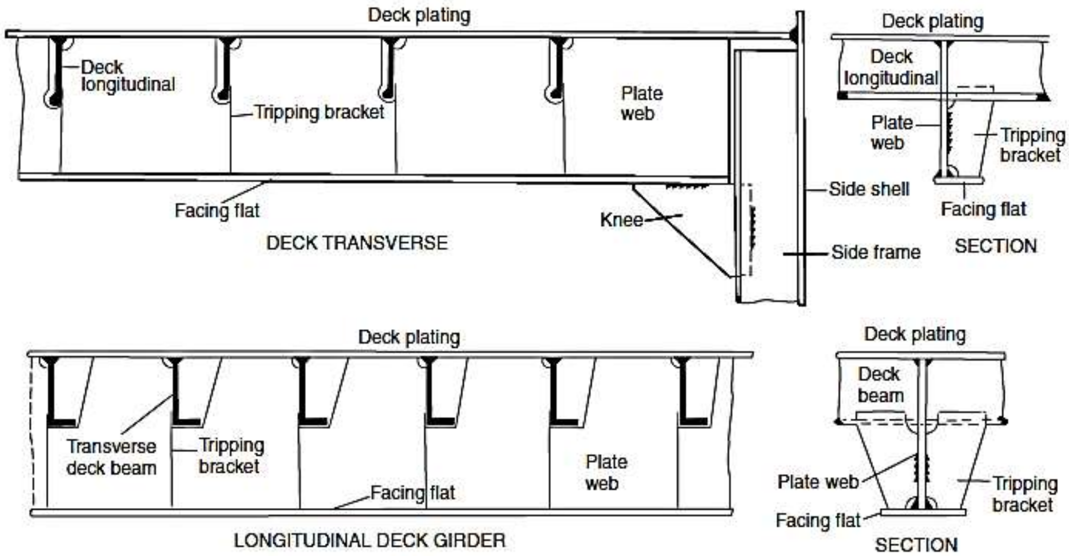
Other openings are required for personal access through the decks; and in way of the machinery space casing openings are provided which allow the removal of machinery items when necessary, and also provide light and air to this space. These openings are protected by houses or superstructures, which are extended to provide accommodation and navigating space. Forward and aft on the uppermost continuous deck a forecastle and often a poop may be provided to protect the ends of the ship at sea.

- **Decks**

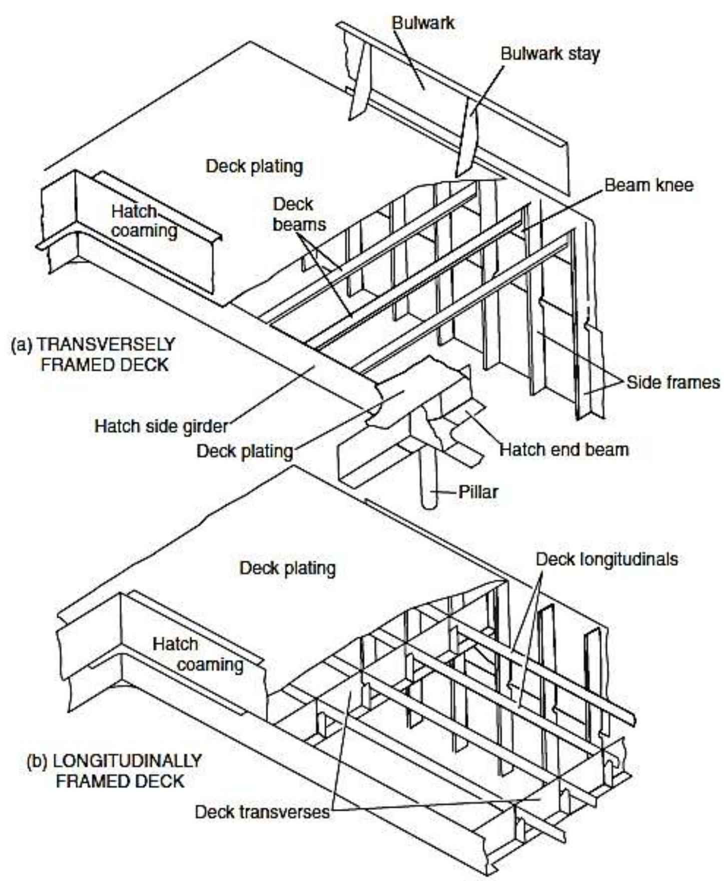
The weather decks of ships are cambered, the camber being parabolic or straight. There may be advantages in fitting horizontal decks in some ships, particularly if containers are carried and regular cross-sections are desired.

Short lengths of internal deck or flats are as a rule horizontal.

Decks are arranged in plate panels with transverse or longitudinal stiffening, and local stiffening in way of any openings. Longitudinal deck girders may support the transverse framing, and deep transverses the longitudinal framing (*see* Figure below).



Deck support



Deck construction

- Deck plating

The heaviest deck plating will be found abreast the hatch openings of the strength deck. Plating which lies within the line of the hatch openings contributes little to the longitudinal strength of the deck and it is therefore appreciably lighter. As the greatest longitudinal bending stresses will occur over the midship region, the greatest deck plate thickness is maintained over 40 per cent of the length amidships, and it tapers to a minimum thickness permitted at the ends of the ship. Locally the plating thickness may be increased where higher stresses occur owing to discontinuities in the structure or concentrated loads.

Other thickness increases may occur where large deck loads are carried, where fork lift trucks or other wheeled vehicles are to be used, and in way of deep tanks. Where the strength deck plating exceeds 30 mm it is to be Grade B steel and if it exceeds 40 mm Grade D over the midships region, at the ends of the superstructure and in way of the cargo hold region in container ships. The stringer plate (i.e. the strake of deck plating adjacent to
the sheerstrake) of the strength deck, over the midship region and container ship cargo hold area, of ships less than 260 metres in length, is to be of Grade B steel if 15 to 20mm thick, Grade D if 20 to 25mm thick and Grade E if more than 25 mm thick. Where the steel deck temperatures fall below 0 °C in refrigerated cargo ships the steel will be of Grades B, D and E depending on thickness.

On decks other than the strength deck the variation in plate thickness is similar, but lighter scantlings are in use.

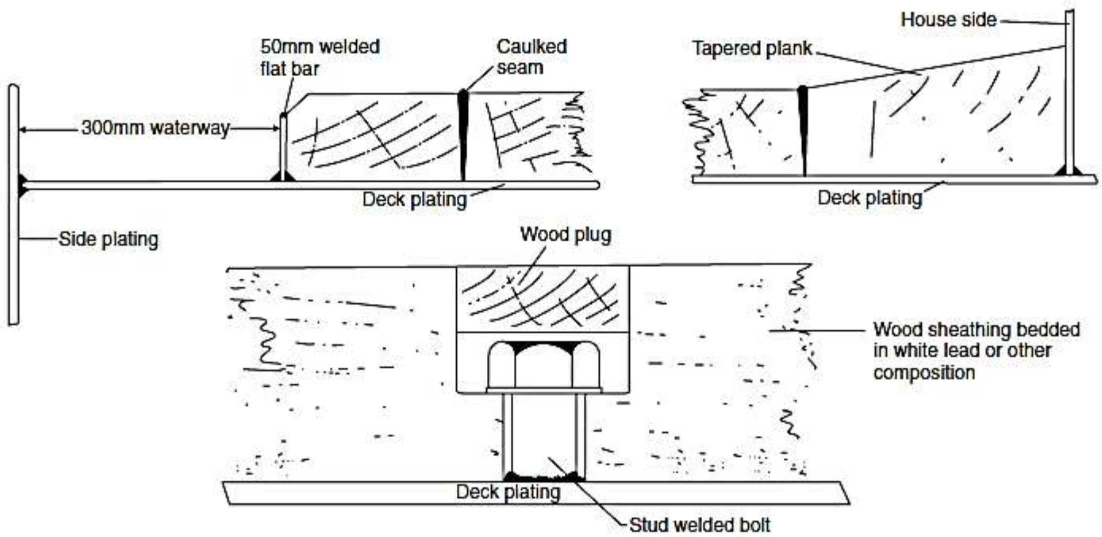
Weather decks may be covered with wood sheathing or an approved composition, which not only improves their appearance, but also provides protection from heat in way of any accommodation. Since this provides some additional strength, reductions in the deck plate thickness are permitted; and on superstructure decks the plating thickness may be further decreased within deckhouses, if sheathed. Before fitting any form of sheathing the deck is treated to prevent corrosion between the deck plating and sheathing (see Figure below).

Any openings abreast the hatch openings in a deck are kept to a minimum and clear of the hatch corners. If such openings are cut, compensation is required to restore the sectional area of deck. All large openings in the decks have well rounded corners, with insert plates fitted, unless the corners are parabolic or elliptical with the major axis fore and aft, local stress concentrations being reduced if the latter type of corner is cut (see Figure below).

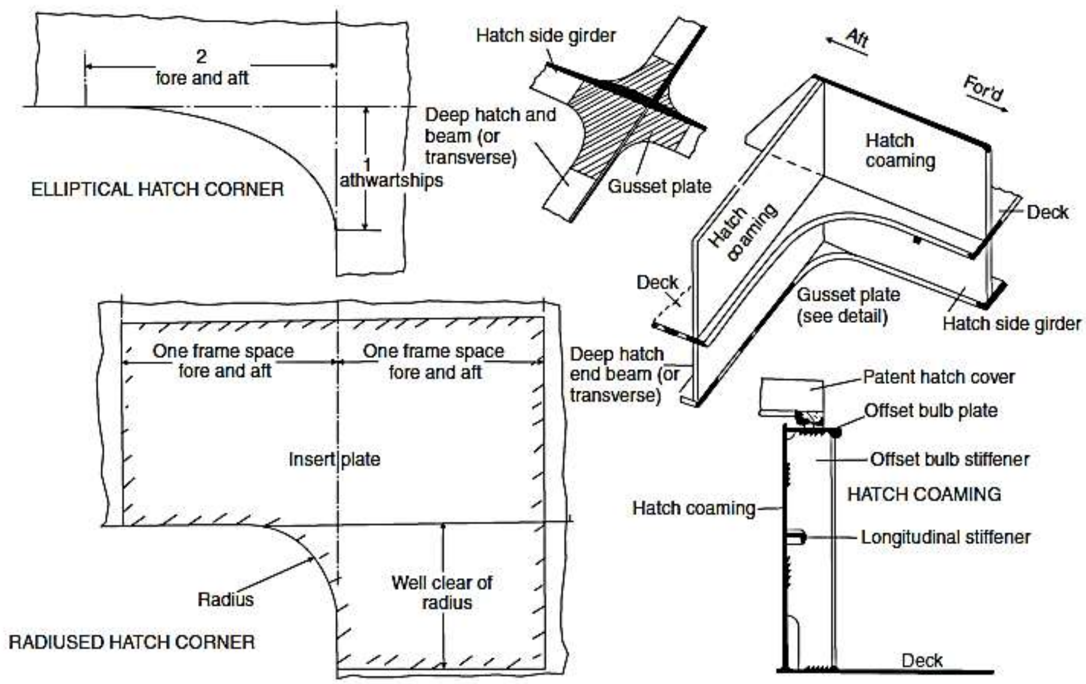
- DECK STIFFENING

Decks may be framed transversely or longitudinally but outside the line of openings it is preferred that longitudinal framing should be adopted for the strength deck.

When the decks are longitudinally framed the scantlings of the longitudinals are dependent on their spacing, the length of ship, whether they are inside or outside the line of hatch openings, their span and the deck loading. Deck transverses support the longitudinals, and these are built from a deep web plate with flange or welded face flat, and are bracketed to the side frame (Figure above). Within the forward 7.5 per cent of the ship's length, the forecastle and weather deck transverses are closely spaced and the longitudinal scantlings increased, the additional transverse and longitudinal



Deck sheathing



Hatch opening

stiffening forward being designed to avoid buckling of the deck plating on impact when shipping seas.

Transversely framed decks are fitted with deck beams at every frame, and these have scantlings which are dependent on their span, spacing, and location in the ship. Those fitted right forward on weather decks, like the longitudinal framing forward, have heavier

scantlings, and the frame spacing is also decreased in this region so they will be closer together. Beams fitted in way of deep tanks, peak tanks, and oil bunkers may also have increased scantlings as they are required to have the same rigidity as the stiffeners of the tank boundary bulkheads. Deck beams are supported by longitudinal deck girders which have similar scantlings to deck transverses fitted with any longitudinal framing. Within the forward 7.5 per cent of the ship's length these deck girders are more closely spaced on the forecastle and weather decks. Elsewhere the spacing is arranged to suit the deck loads carried and the pillar arrangements adopted. Each beam is connected to the frame by a 'beam knee' and abreast the hatches 'half beams' are fitted with a suitable supporting connection at the hatch side girder (*see* Figure above).
Both longitudinals and deck beam scantlings are increased in way of cargo decks where fork lift trucks, and other wheeled vehicles which cause large point loads, are used.
In way of the hatches fore and aft side girders are fitted to support the inboard ends of the half beams, and transverses. At the ends of the hatches heavy transverse beams are fitted and these may be connected at the intersection with the hatch side girder by horizontal gusset plates (Figure above).
Where the deck plating extends inside the coamings of hatches amidships the side coaming is extended in the form of tapered brackets.

- **Hatches**

The basic regulations covering the construction and means of closing hatches in weathertight decks are contained within the Conditions of Assignment of Freeboard of the Load Line Rules 1968. Lloyd's Register provides formulae for determining the minimum scantlings of steel covers, which will be within the requirements of the Load Line Rules. Only the maximum permitted stresses and deflections of covers under specified loadings are given by the Load Line Rules. Under these regulations ships fitted with approved steel covers having direct securing arrangements may have reduced B-100 or B-60 freeboards if they meet the subdivision requirements, but in general they are assigned standard cargo ship Type B freeboards. If steel pontoon type covers which are self-supporting and have no direct securing arrangements are fitted, then the standard Type B freeboard only is assigned. Where portable beams are fitted with wood or light steel covers and tarpaulins, then the ship has an increased Type B freeboard, i.e. there
is a draft penalty. This means that most ships are fitted exclusively with the
stronger stiffened self-supporting steel covers.

- **Hatch coamings**

Heights of coamings and cover closing arrangements in some instances depend on the hatch position. The positions differentiate between regions which are more exposed than others. Position 1 indicates that the hatch is on the exposed freeboard deck, raised quarter deck, or superstructure decks within 25 per cent of the ship's length from forward.
Position 2 indicates that the hatch is located on exposed superstructure decks abaft the forward 25 per cent of the ship's length.
Hatches which are at Position 1 have coamings at least 600 mm high, and those at Position 2 have coamings at least 450 mm high, the height being measured above the sheathing.

Provision is made for lowering these heights or omitting the coaming altogether if directly secured steel covers are fitted and it can be shown that the safety of the ship would not be impaired in any sea condition. Where the coaming height is 600 mm or more the upper edge is stiffened by a horizontal bulb flat and supporting stays to the deck are fitted. Coamings less than 600 mm high are stiffened by a cope or similar bar at their upper edge. The steel coamings extend down to the lower edge of the deck beams, which are then effectively attached to the coamings (Figure above).

- **Hatch covers**

A number of patent steel covers, such as those manufactured by MacGregor-Navire International AB, are available, which will comply with the requirements outlined by the International Conference on Load Lines 1966 and are in accordance with the requirements of the classification societies. The means of securing the hatches and maintaining their watertightness is tested initially and at periodic surveys. These patent covers vary in type the principal ones being fore and aft single pull, folding, roll-up, piggy back, pontoon and side rolling. These are illustrated in Figures below. Single pull covers may be opened or closed by built in electric motors in the leading cover panel (first out of stowage) which drive chain wheels, one on each outboard side of the panel. Each panel wheel is permanently engaged on a fixed chain located along each hatch side coaming. In operation the leading panel pushes the others into stowage and pulls them into the closed position. Alternatively single pull covers are opened or closed by hydraulic or electric motors situated on the hatch end coaming at the ships centre line driving endless chains running along the full length of the hatch side coaming port and starboard and connected to the leading panel. Vertical stowage of panels is at one end of the hatch and covers may have a nesting characteristic if space is at a premium, also on large hatches opening may be to both ends with vertical stowage at each end. Folding covers may be of direct pull type where suitable lifting gear is carried onboard or can be opened or closed by externally mounted hydraulic cylinders actuating

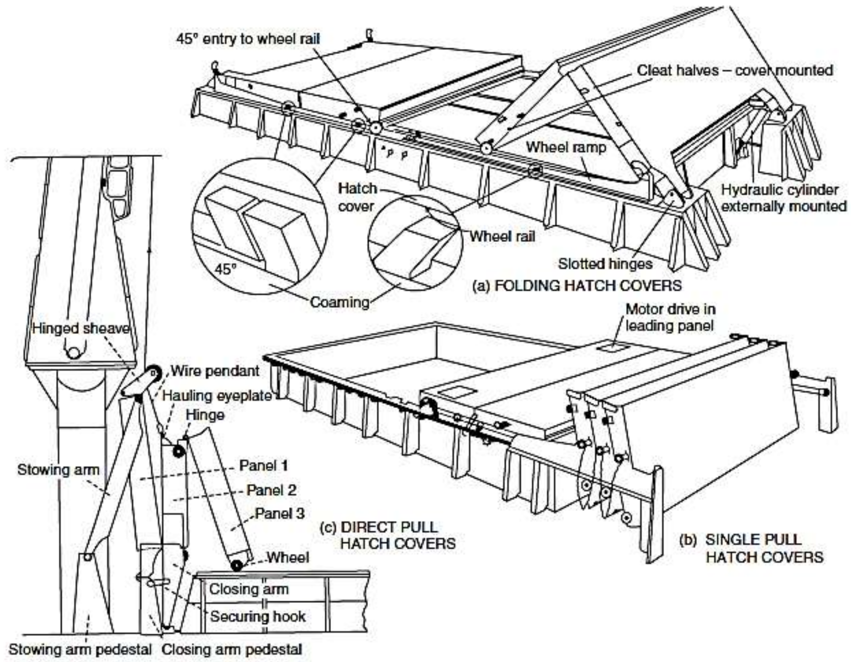


FIGURE 19.5
Hatch covers

the leading panels. The roll-up cover is effectively a continuous articulated slab which is opened by rolling it onto a powered stowage drum at the hatch end. The drum rotation is reversed to close the hatch. Piggy back covers permit horizontal stowage of panels avoiding fouling of lifting devices particularly in way of very large openings such as on bulk carriers and container ships where the hatch need only be partially open for working. The covers consist of a dumb panel which is raised by high lift cylinders and a motorised panel which is rolled underneath the dumb panel. Both panels can then be moved 'piggy back' style to the fully opened hatch position port or starboard or partially opened position fore and aft. Pontoon covers are commonly used on container ships being lifted by the ships or shore cranes with the container spreader. They are closed weathertight in a similar manner to the other patent covers. Side rolling covers can operate on similar principles to the single pull cover except that they remain in the horizontal stowed position when the hatch is open. Various other forms of cover are marketed, and tween deck steel covers are available to be fitted flush with the deck, which is essential nowadays when stowing cargoes in the tweens.

To obtain weathertightness the patent covers have mating boundaries fitted with rubber gaskets; likewise at the hatch coamings, gaskets are fitted and hand or automatically operated cleats are provided to close the covers (*see* Figure below). The gasket and cleat arrangements will vary with the type of cover.

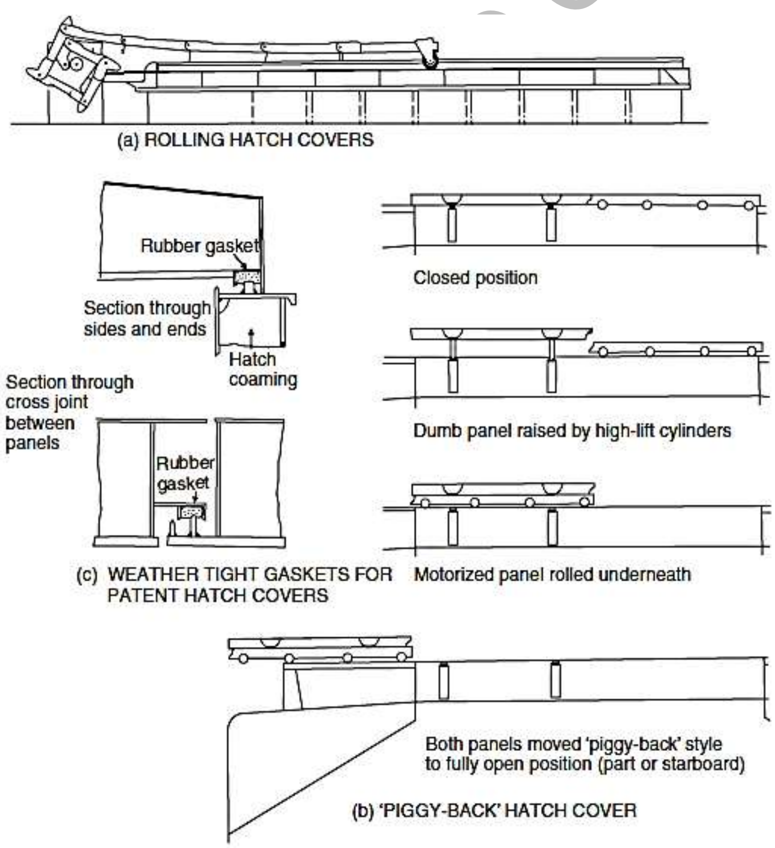
Pontoon covers of steel with internal stiffening may be fitted, these being constructed to provide their own support without the use of portable beams.

Each pontoon section may span the full hatch width, and cover perhaps one-quarter of the hatch length. They are strong enough to permit Type B freeboards to be assigned to the ship,

but to satisfy the weathertightness requirements they are covered with tarpaulins and battening devices.
Where portable beams are fitted wood or stiffened steel plate covers may be used. These and the stiffened beams have the required statutory scantlings but an increase in the freeboard is the penalty for fitting such covers.
The beams sit in sockets at the hatch coamings and the covers are protected by at least two tarpaulins. At the coaming the tarpaulins are made fast by battens and wedges fitted in cleats and the sections of the cover are held down by locked bars or other securing arrangements (*see* Figure below).

- Bulwarks

Bulwarks fitted on weather decks are provided as protection for personnel and are not intended as a major structural feature. They are therefore of light scantlings, and their connections to the adjacent structures are of some importance if high stresses in the bulkwarks are to be avoided. Freeing ports are cut in bulwarks forming wells on decks in order that water may

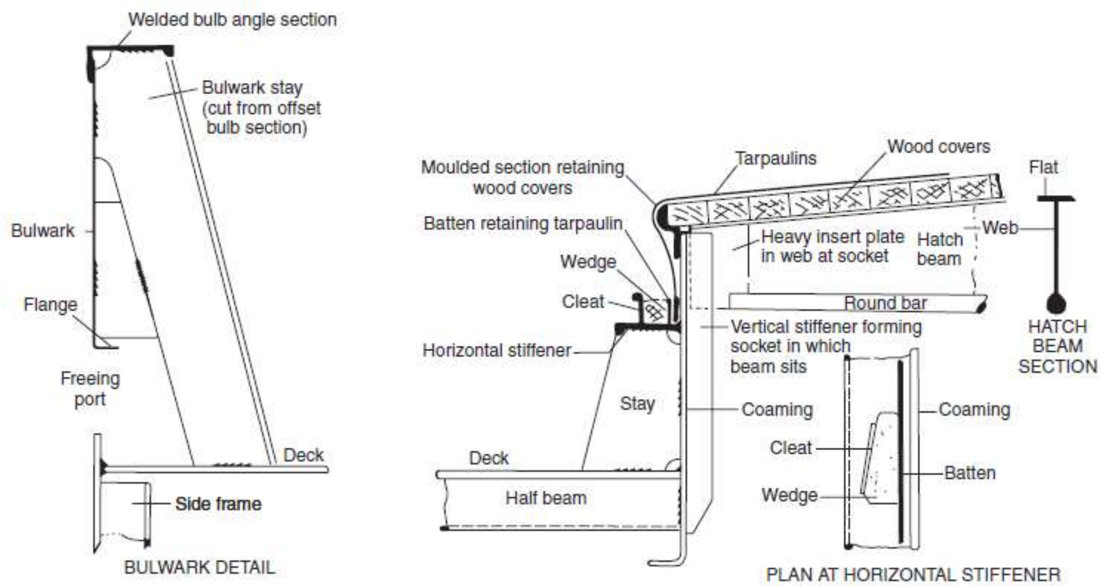


quickly drain away. The required area of freeing ports is in accordance with the Load Line Rules 1968.

- CONSTRUCTION OF BULWARKS

Bulwarks should be at least 1m high on the exposed freeboard and superstructure decks, but a reduced height may be permitted if this interferes with the working of the ship. The bulwark consists of a vertical plate stiffened at its top by a strong rail section (often a bulb angle or plate) and is supported by stays from the deck (Figure below).

On the forecastle of ships assigned B-100 and B-60 freeboards the stays are more closely spaced. Where the bulwark is cut for any reason, the corners



Portable hatch covers and bulwarks

are well rounded and compensation is also provided. No openings are permitted in bulwarks near the ends of the superstructures.

- Superstructures and Deckhouses

Superstructures might be defined as those erections above the freeboard deck which extend to the ship's side or almost to the side. Deckhouses are those erections on deck which are well within the line of the ship's side.

Both structures are of importance in the assignment of the load line as they provide protection for the openings through the freeboard deck. Of particular importance in this respect are the end bulkheads of the superstructures, particularly the bridge front which is to withstand the force of any seas shipped. The bridge structure amidships or the poop aft are, in accordance with statutory regulations, provided as protection for the machinery openings. It is possible however to dispense with these houses or superstructures and increase considerably the scantlings of the exposed machinery casing; but in other than very small vessels it is unlikely that such an arrangement would be adopted. Unless an excessive sheer is provided on the uppermost deck it is necessary to fit a forecastle forward to give added protection in a seaway.

Each structure is utilized to the full, the after structure carrying virtually all the accommodation in modern ships. The crew may be located all aft in the poop structure or partly housed in any bridge structure with the navigating spaces. Passenger liners have considerable areas of superstructures covering tiers of decks and these will house the majority of passengers and some of the crew.
Of great structural importance is the strength of the vessel where superstructures and deckhouses terminate and are non-continuous. At these discontinuities, large stresses may arise and additional strengthening will be required locally as indicated in the following notes on the construction. Long superstructures exceeding 15 per cent of the ship's length and extending within 50 per cent of the vessel's length amidships receive special consideration as they contribute to the longitudinal strength of the ship, and as such must have scantlings consistent with the main hull strength members.

- Forecastle

Sea-going ships must be fitted with a forecastle which extends at least 7 per cent of the ship's length aft of the stem, and a minimum height of the bow at the forecastle deck above the summer load line is stipulated. By increasing the upper deck sheer at the forward end to obtain the same height of bow, the forecastle might be dispensed with, but in practice this construction is seldom found. The side and end plating of the forecastle has a thickness which is dependent on the ship's length and the frame and stiffener spacing adopted, the side plating being somewhat heavier than the aft end plating. If a long forecastle is fitted such that its end bulkhead comes within 50 per cent of the ship's length amidships, additional stiffening is required.

- **Bridge structures**

The side of bridge superstructures whose length exceeds 15 per cent of the ship's length will have a greater thickness than the sides of other houses, the scantling being similar to that required for the ship's side shell. All bridge superstructures and midship deckhouses will have a heavily plated bridge front, and the aft end plating will be lighter than the front and sides. Likewise the stiffening members fitted at the forward end will have greater scantlings than those at the sides and aft end. Additional stiffening in the form of web frames or partial bulkheads will be found where there are large erections above the bridge deck. These are intended to support the sides and ends of the houses above and are preferably arranged over the watertight bulkheads below. Under concentrated loads on the superstructure decks, for example under lifeboat davits, web frames are also provided.
The longer bridge superstructure which is transmitting the main hull girder stresses requires considerable strengthening at the ends. At this major discontinuity, the upper deck sheerstrake thickness is increased by 20 per cent, the upper deck stringer plate by 20 per cent, and the bridge side plating by 25 per cent. The latter plating is tapered into the upper deck sheerstrake with a generous radius, as shown in Figure below, stiffened at its upper edge, and supported by webs not more than 1.5m apart. At the ends of short bridge superstructures less strengthening is required, but local stresses may still be high and therefore the upper deck

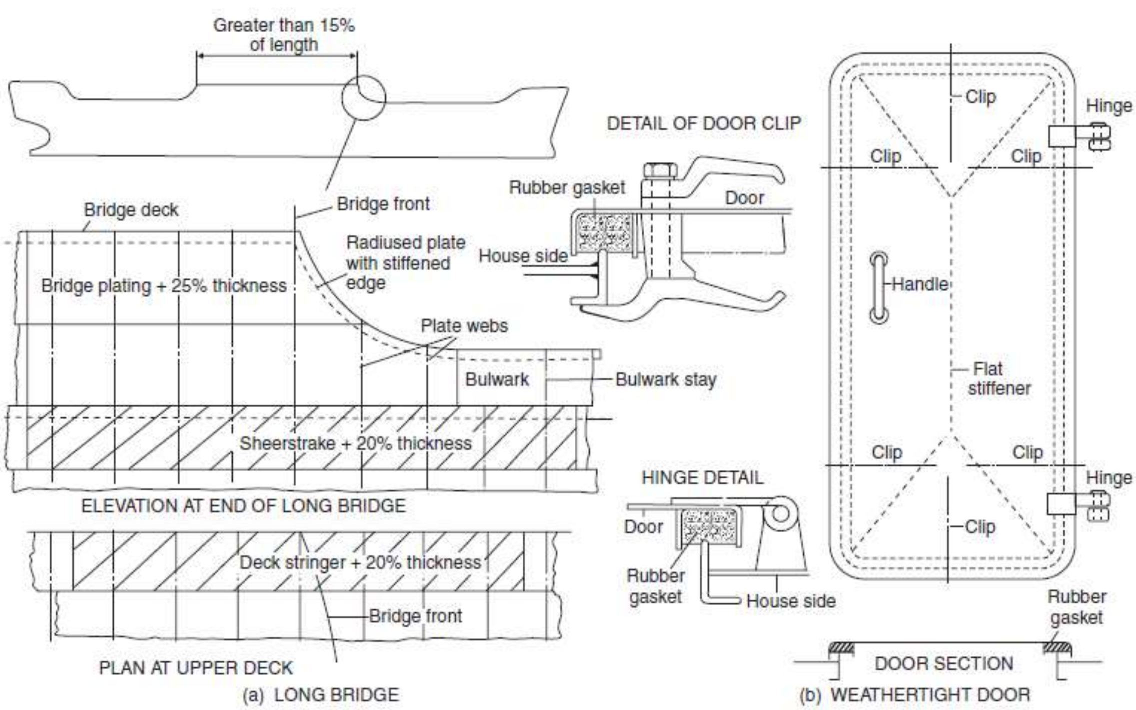
sheerstrake thickness is still increased by 20 per cent and the upper deck stringer by 20 per cent.

- **Poop structure**

Where there is no midship deckhouse or bridge superstructure the poop front will be heavily constructed, its scantlings being similar to those required for a bridge front. In other ships it is relatively exposed and therefore needs adequate strengthening in all cases. If the poop front comes within 50 per cent of the ship's length amidships, the discontinuity formed in the main hull girder is to be considerably strengthened, as for a long bridge exceeding 15 per cent of the ship's length. Where deckhouses are built above the poop deck these are supported by webs or short transverse bulkheads in the same manner as those houses fitted amidships. The after end of any poop house will have increased scantlings since it is more exposed than other aft end house bulkheads.

- **Passenger ship superstructures**

Conventional beam theory the bending stress distribution is linear, increasing from zero at the neutral axis to a maximum at the upper deck and bottom. If a long superstructure is fitted the stress distribution remains



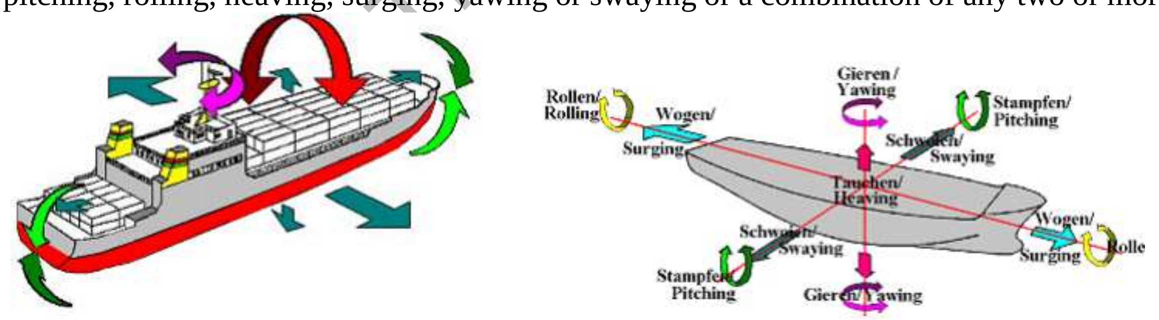
linear and the strength deck is above the upper deck in way of the superstructure deck. If a short superstructure is fitted the stress distribution will be broken at the upper deck, which is the strength deck, the stresses in the superstructure deck being less than those in the upper deck. The long superstructure is referred to as an 'effective superstructure' the erections contributing to the overall strength of the hull girder, and therefore they are substantially built.

In passenger ships with large superstructures the present practice is to make the structure effective with adequate scantlings. Some older ships have been fitted with expansion joints which are in effect transverse cuts introduced to relieve the hull bending stresses in the houses. It has been shown that at the end of deck erections the stresses do not conform to beam theory and the ends are ineffective in contributing to the longitudinal strength. The expansion joints were therefore so arranged that this 'end effect' extended from joint to joint, and lighter scantlings were then permitted for the superstructure. Unfortunately the expansion joint often provided an ideal 'notch' in the structure from which cracks initiated. Aluminium alloy superstructures offer an alternative to the use of expansion joints, since the low modulus of elasticity of the material results in lower stresses in the houses than would be the case with a steel superstructure, all other considerations being equal.

1.3 Ship Dynamics

Ship motion

Voyage are made in a variety of weather conditions which are likely to exert a combination of forces upon the ship and its cargo over a prolonged period. Such forces may arise from pitching, rolling, heaving, surging, yawing or swaying or a combination of any two or more.



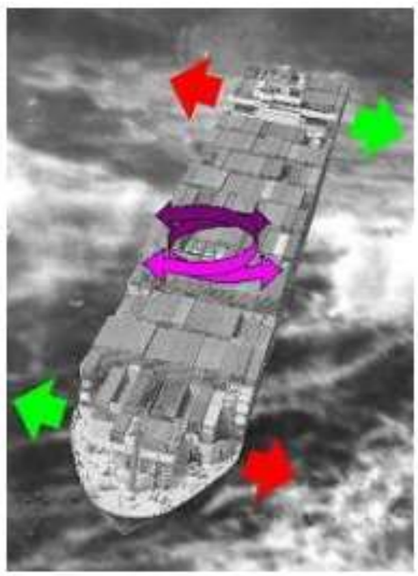
Ship movement at sea

All kinds of ship movement may be divided into three types of linear motion and three type of rotational motion.

Linear motion	Rotational motion
Surging is motion along the longitudinal axis.	Rolling is motion around the longitudinal axis.
Swaying is motion along the transverse axis.	Pitching is motion the transverse axis.
Heaving is motion along the vertical axis	Yawing is motion around the vertical axis.

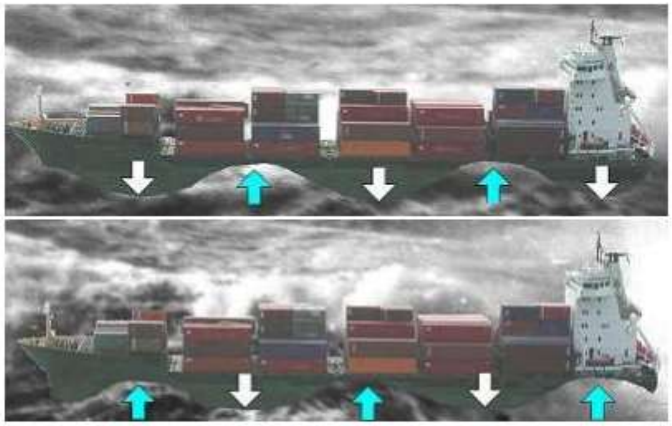
It can in general be stated that the outwardly directed centrifugal accelerations brought about by any rotational motion are not significant. This accordingly applies to yawing, pitching and rolling.

YAWING involves rotation of the ship around its vertical axis. This occurs due to the impossibility of steering a ship on an absolutely straight course.
Depending upon sea conditions and rudder deflection, the ship will swing around its projected course. Yawing is not a cause of shipping damage



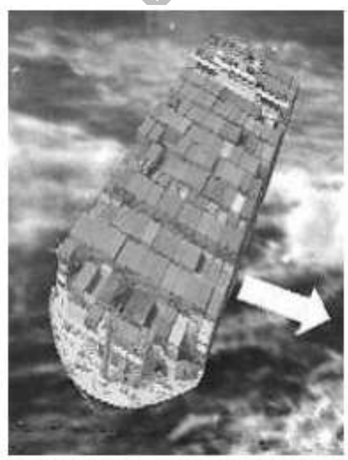
Yawing is motion around the ship's vertical axis

HEAVING involves upward and downward acceleration of ships along their vertical axis.
Only in an absolute calm are upward and downward motion at equilibrium and the ship floats at rest. Buoyancy varies as a ship travels through wave crests and troughs. If the wave troughs predominate, buoyancy falls and the ship "sinks" (top picture), while if the wave crests predominate, the ship "rises" (bottom picture). Such constant oscillation has a marked effect on the containers and their contents



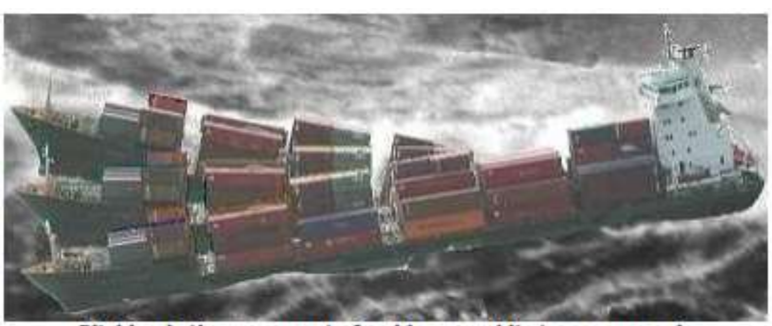
Heaving is motion along the ship's vertical axis

Surging is motion along the ship's longitudinal axis



Swaying is motion along the ship's transverse axis

In ***SURGING*** and ***SWAYING***, the sea's motion accelerates and decelerates the ship forward and backward and side to side. Depending upon the lie of the vessel, these movements may occur in all possible axes, not merely, for example, horizontally. If a vessel's fore-body is on one side of a wave crest and the after-body on the other side, the hull may be subjected to considerable torsion forces



Pitching is the movement of a ship around its transverse axis

In ***PITCHING*** a ship is lifted at the bow and lowered at the stern and vice versa. Pitching angles vary with the length of vessel. In relatively short vessels they are 5° - 8° and sometimes more, while in very long vessels they are usually less than 5°. In a container ship 300 m in length with a pitching angle of 3°, a container stowed in the bay closest to the bow or stern at a distance of approx. 140 m from the pitching axis will cover a distance of 29 m within a pitching cycle, being raised 7.33 m upwards from the horizontal
before descending 14.66 m downwards and finally being raised 7.33 m again and then restarting the process. During upward motion, stack pressures rise, while they fall during downward motion.

Rolling is the movement of a ship around its longitudinal axis, the rolling angle in this case being 10°.

ROLLING involves side-to-side movement of the vessel. The rolling period is defined as the time taken for a full rolling oscillation from the horizontal to the left, back to horizontal then to the right and then back to horizontal. In vessels with a high righting capacity, i.e. stiff ships, rolling periods of ten seconds and below are entirely usual. Rolling angle is measured relative to the horizontal. Just in moderate seas, even very large vessels roll to an angle of 10°.

Rolling angles of 30° are not unusual in heavy weather.

Rolling angle of 45°

On rare occasions, rolling angles may reach 45° and above.
It is easy to imagine what that means for inadequately secured container cargoes.

ROLLING and ***PITCHING*** of a vessel generate upward and downward acceleration forces directed tangentially to the direction of rotation, the values of which increase with distance from the rolling or pitching axis and are inversely proportional to the square of the rolling or pitching periods. At an identical distance from the axis, if the rolling or pitching period is halved, acceleration forces are quadrupled, while if the rolling or pitching period is doubled, acceleration forces are quartered. Rolling or pitching angles generate down-slope forces. Steeper tilting, as occurs during rolling, promote cargo slippage. As already mentioned, the outwardly acting centrifugal accelerations generated by rotational motion are of no significance in rolling and pitching.

Overall, containers and packages may be exposed to such accelerations for very long periods when at sea. Moreover, the oscillations may be superimposed one on the other and be intensified

SLAMMING is the term used to describe the hydrodynamic impacts which a ship encounters due to the up and down motion of the hull, entry into wave crests and the consequent abrupt immersion of the ship into the sea

Slamming describes the hydrodynamic impacts undergone by a ship

Free surfaces on board always increase the risk of capsize.

Bilge keels

A bilge keel is used to reduce a ship's tendency to roll. Bilge keels are employed in pairs (one for each side of the ship). A ship may have more than one bilge keel per side, but this is rare. Bilge keels increase hydrodynamic resistance to rolling, making the ship roll less. Bilge keels are passive stability systems.

On commercial shipping the bilge keel is the form of a strake, or small keel or blister, running along much of the length of the hull. They are typically fitted one on each side, low down on the side of the hull, so as not to increase the draft of the vessel. In battleships they were often quite large and used as part of the torpedo protection system.

A bilge keel is often in a "V" shape, welded along the length of the ship at the turn of the bilge. Although not as effective as stabilizing fins, bilge keels have a major advantage in their low impact on internal ship arrangements. Unlike fins, bilge keels do not have any components inside the hull that would adversely affect cargo or mission spaces. Like fins, bilge keels have the disadvantage of increasing the hydrodynamic resistance of the vessel, thus hindering forward motion.

A bilge keel.

Design considerations

When designing a bilge keel, there are important decisions to consider. To minimize hydrodynamic drag, the bilge keel should be placed in way of a flowline where it does not oppose crossflow. For such a usage the ends of the bilge keel should be tapered and properly faired into the hull. Also, a bilge keel should not protrude from the hull so far that the device could be damaged when the vessel is alongside a pier, even with a few degrees of adverse heel. Bilge keels on commercial vessels should not protrude below the baseline either, where they could be damaged or fouled by grounding. Note that small bilge keels are often fitted to smaller fishing boats precisely to protect the hull on drying moorings and to help keep the vessel upright

Effectiveness

A bilge keel is constructed from flat plate so as to present a sharp obstruction to roll motion. The roll damping provided by a bilge keel is more than that of a barehull ship, but falls short of other roll damping devices. Nevertheless it is considered prudent naval architecture to install a bilge keel whenever possible as it is the only device effective in the severest of seas. Bilge keels can also be used in conjunction with other roll damping devices.

On sailing yachts

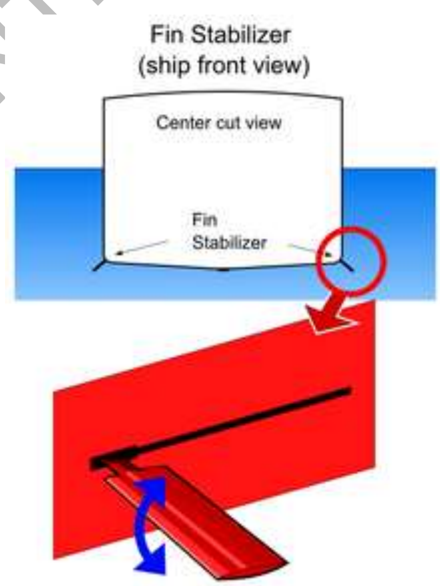
Bilge keels are often fitted to smaller sailing yachts. Bilge keels minimise the draft of the vessel compared to a single fin keel thus enabling it to negotiate shallower water. Bilge keels on sailing yachts extend below the lowest point of the hull extending slightly outwards. Such an arrangement also enables the vessel to stand upright on firm sand or mud at drying moorings without the need for detachable legs, and is simpler than retractable fin keels while giving the hull greater protection. Bilge keels are not as effective as central fin keels in preventing leeway (sideways slippage) caused by crosswinds but are preferred by many small craft owners due to their other advantages.

Fin stabilizer

Active fin stabilizers are normally used to reduce the roll that a vessel experiences while underway or, more recently, while at rest. The fins extend beyond the hull of the vessel below the waterline and alter their angle of attack depending upon heel angle and rate-of-roll of the vessel. They operate similar to airplane ailerons. Cruise ships and yachts frequently use this type of stabilizer system.

When fins are not retractable, they constitute fixed appendages to the hull, possibly extending the beam or draft envelope, requiring attention for additional hull clearances.

While the typical "active fin" stabilizer will effectively counteract roll for ships underway, some modern active fin systems have been shown capable of reducing roll motion when vessels are not underway. Referred to as zero-speed or Stabilization at Rest, these systems work by moving fins of special design, with the requisite acceleration and impulse timing to create effective roll cancellation energy.



Location and diagram of retractable fin stabilizers on a ship.

Photograph of ship stabilizers: a fixed fin stabilizer (front) and bilge keels.

- **Passive and active anti-roll tanks**

Antiroll Tanks are tanks fitted onto ships in order to improve their response to roll motion. Antiroll tanks are tanks within the vessel fitted with baffles intended to slow the rate of water transfer from the port side of the tank to the starboard side. The tank is designed such that a larger amount of water is trapped on the higher side of the vessel. This is intended to have an effect completely opposite to that of the free surface effect. They can be broadly classified into Active and Passive Antiroll tanks.

- *Passive Antiroll Tanks*

Free Surface Tanks

A single partially filled tank that extends across the full breadth of the vessel. Its shape, size and internal baffles allow the liquid inside to slosh from side to side in response to the roll motion of the ship. The phasing of the roll moments acting on the ship and the resultant liquid motion will be such that it reduces the roll motion. This type of tank was first investigated by William Froude, but did not receive much attention until the 1950s when it was revived and used in many naval vessels. They have the added advantage that it is possible to vary tank natural frequency by changes in water level and thus accommodate changes in ships metacentric height. Free Surface Tanks are commonly referred to as "Flume" tanks.

U-Tube Tanks

The use of these tanks were pioneered by Frahm in Germany during the turn of the 20th century and they are often referred to as Frahm tanks. These partially filled tanks consists of two wing tanks connected at the bottom by a substantial crossover duct. The air column above the liquid in the two tanks are also connected by a duct. As in the Free Surface Tanks as the ship begins to roll the fluid flows from wing tank to wing tank causing a time varying roll moment to the ship and with careful design this roll moment is of correct phasing to reduce the roll motion of the ship. They do not restrict fore and aft passage as space above and below water crossover duct is available for other purposes.

External Stabilizer Tanks

This was another concept introduced by Frahm and used in several ships in the early 1900s. In this concept the two wing tanks are connected only by an air duct at the top. Water flows in and out of each tanks via an opening in the hull to the sea. This eliminated the need for a crossover duct as in the other designs, but has its own set of disadvantages. This design promoted corrosion to the tanks due to the explicit interaction with sea water. The holes on the hull causes resistance to forward motion. The force required to accelerate sea water outside the ship (which is initially at rest) to the speed of the ship as it enters the ship is a substantial drag component (momentum drag) as its magnitude increases with the square of ship speed. More recently a variation of these tanks have been used in oil drilling rig applications where forward motion is of little relevance.

- *Controlled Passive Antiroll Tanks*

Active U-Tube Tanks

This is similar to a U-Tube Tank but the water crossover duct is much larger and the air crossover contains a servo-controlled valve system. Since this valve controls the flow of air very little power is required. When valve is closed passage of air from one tank to other is prevented and hence resulting compression of air in tank prevents flow of water also. When valve opens free movement of water and air is possible.

- *Active Antiroll Tanks*

The border between controlled-passive and active stabilisation is not that distinct. Active stabilisation generally implies that the system requires the use of machinery of significant power and the system must be much more effective in reducing roll in order to justify this high cost.

Active Tank Stabilizer

This concept utilises an axial flow pump to force the water from one side of the ship to other rather than allowing it to slosh as in passive systems. Webster (1967) studied the design of such a tank in detail. The main disadvantage to this is that when the pump is operated there is a time lag for a sizeable amount of fluid to arrive at a tank, thus limiting instant roll stabilisation. Hence compared to fin stabiliser systems this is highly inefficient.

- **Noise and Vibration control**

Noise generated on board ships and submarines can have far-reaching effects on the ability of the vessel to operate safely and efficiently. Military vessels in particular need to be quiet to avoid detection by sonar, so many methods have been used to limit a vessel's noise signature. Controlling noise is therefore a defense measure, most acutely for submarines.

Prevention

At the design table, the naval architect makes the necessary choices concerning the ship's structure to achieve an optimized design towards noise and vibration control. Decisions are made about the engine and shaft, what kind of instruments and material can be used to reduce noise and vibrations throughout the vessel and what is the best way to implement these. Advanced computer technology tries to simulate these vibrations under different ship conditions to provide an overview of weak spots. The generated vibrations are also compared with the natural frequencies of the different parts/sections and adaptions can be done to the structure.

Control at source

To control the vibrations at the origin, isolating fittings, elastic mounting of engines, elastic holding of pipes or dampers can be installed. These will absorb a part of the vibrations (and the noise) produced by the machines.

Maintenance

Regular maintenance will have a major influence on the performance of instruments and machines. Lubrication of the joints, tightening of the bolts, good alignment of stern contour of the vessel, adjusting of variables following the weekly and monthly schedule are the most effective routes to noise and vibration control.

1.4 Watertight and Weathertight Doors

A ship is nothing more than a water tight container or storage compartment with its own means of propulsion. Its purpose is to load and carry cargo, whether the cargo is passengers, fish, or a host of other commodities. Each type of ship is specialised for the trade in which it will operate. One of the most important factor of design is to ensure that the water in which your vessel floats, does not enter the hull and cause progressive flooding. We call this characteristic of a vessel its *watertight integrity*.

Definitions

Watertight means:

a. In relation to a fitting above deck, that it is so constructed as to resist effectively the passage of water under pressure, except for slight seepage.

b. In relation to the structure of the vessel, capable of preventing the passage of water in any direction if the head of pressure were up to the freeboard deck, which in your case would mean the main deck.

Weathertight means that the structure or fitting will prevent the passage of water through the structure or fitting in any ordinary sea conditions.

Hull Watertight Integrity

The steel plating in a metal vessel, the planking in a wooden one, or the FRP laminate, have as their primary purpose, the task of keeping the interior of the vessel free from water. In all types of vessel construction, a structural framework is built first to provide the strength. This, when combined with the external covering, forms the hull. In steel and aluminium ships, the hull is made watertight by welding the steel plates together and to the framework. Often the frame is built upside down and the shell plating is welded onto the inverted frame. The hull is then righted and the internal welds are completed. This procedure allows for a better weld and hence improved water tightness since all welds are 'downwelds'.

FRP and ferro cement hulls are continuous with no joints and are inherently watertight, as is their deck/hull connection.

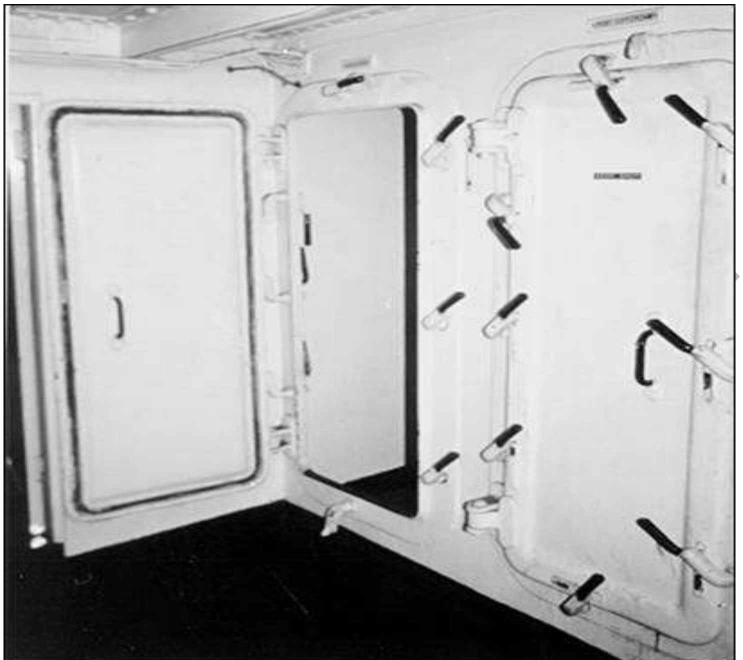
Vessels constructed of timber are not normally totally watertight but rely on seepage of water to swell the planking and thus make them watertight.

Openings in Watertight Bulkheads

Openings may be necessary in watertight bulkheads to allow the passage of pipes or electrical cables, and special arrangements are made to ensure that the watertight integrity of the bulkhead is maintained. All pipes passing through a watertight bulkhead must be flanged to the bulkhead and do not pass directly through it (see Fig. below). The pipe on the left has a valve incorporated in it for filling the tank on the other side of the bulkhead. There is a spindle running up to the main deck from where this valve can be operated. The siting of the valve outside of the tank it is servicing reduces corrosion and maintenance.

Pipes Passing Through Watertight Bulkhead

Doors may also be necessary, in watertight bulkheads, to allow the vessel to continue its normal operation whilst at sea. These doors can be of either a sliding or hinged type and must be capable of operation from both sides of the bulkhead. (See Fig below).

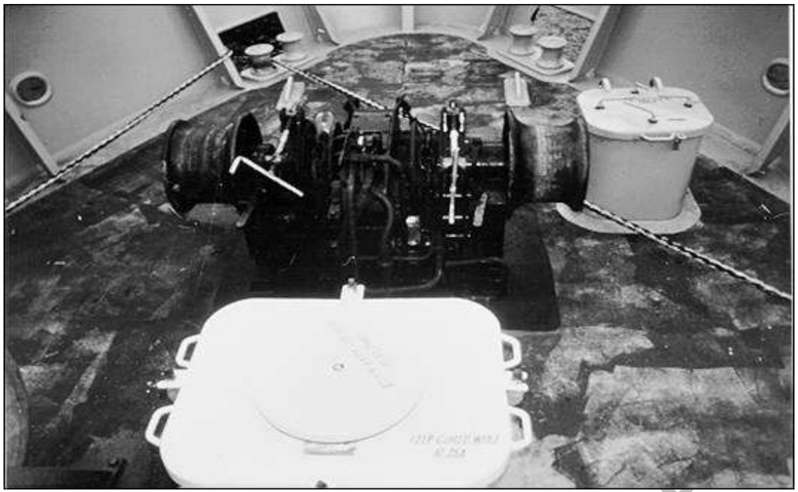


Internal Watertight Door

- **Hull and Deck Openings**

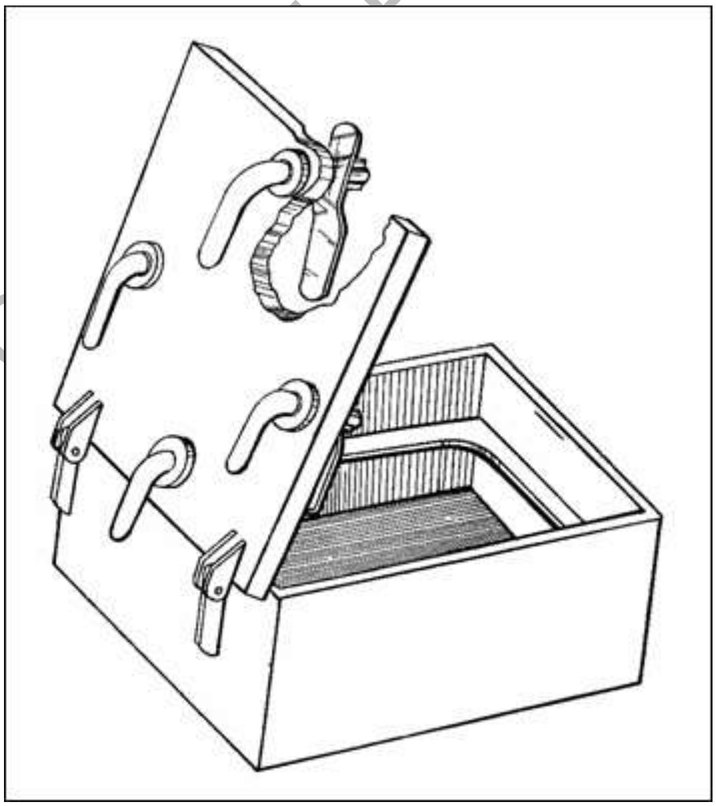
<u>Access Hatchways</u>

Figure below shows the hatchways on the fore deck of a vessel that provide access to compartments below the main deck.



Access Hatchways on Fore Deck

Hatchways must have a raised coaming to reduce the amount of water that could enter the ship should a wave wash over the deck while the hatch was opened. The height of the coaming varies according to the ship's length.



Raised Coaming

The figure above shows a cut away section of a hatchway coaming. When a hatchway is cut into the deck of a vessel, the corners are rounded to reduce stresses.

Weathertight Doors

Doors providing access from the main deck to lower compartments must have sills, which serve the same purpose as hatchway coamings. The sill heights are the same as for hatch coamings. Access doors can be hinged and should be marked "THIS DOOR IS TO BE KEPT CLOSED AT SEA". (See Fig. below).

External Weathertight Door

Ventilators and Airpipes

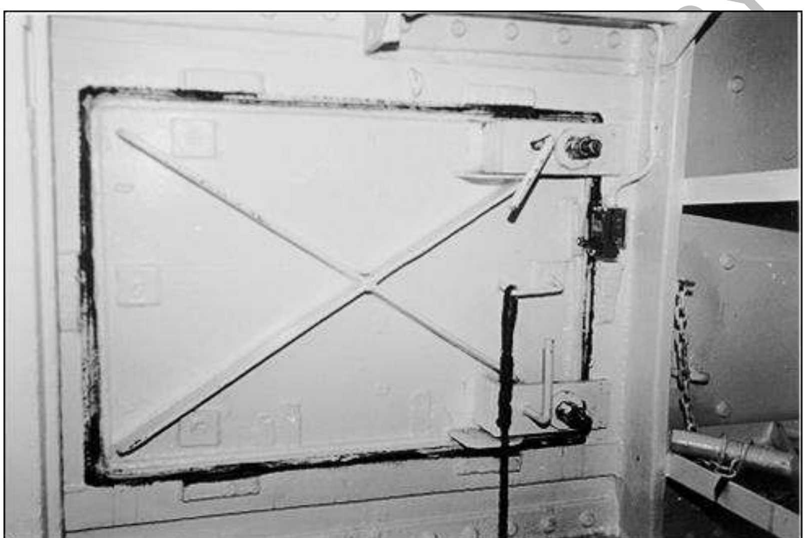
Ventilators must be a minimum height above the deck and must have some means of making them watertight. This may be metal flaps, or in smaller vessels, wooden plugs and canvas covers. Airpipes, where exposed, should be of substantial construction and if the diameter of the bore exceeds 30mm bore then the pipe should be provided with means of closing watertight.

Side Scuttles (portholes)

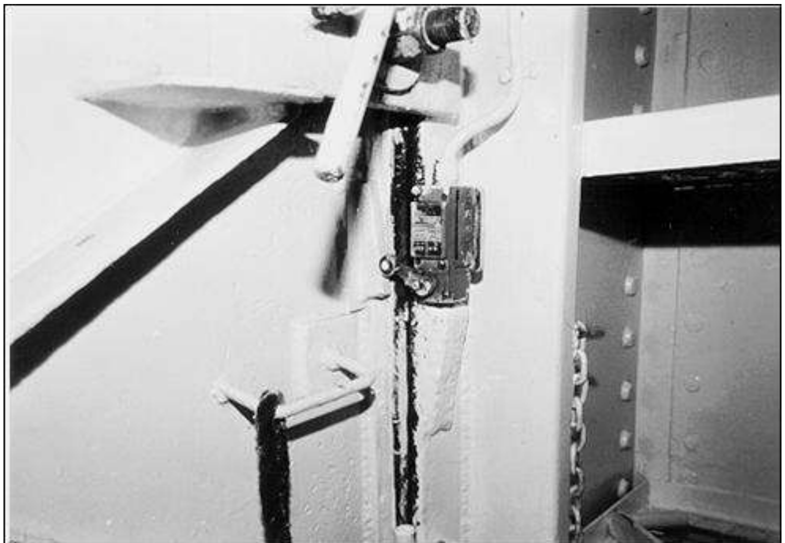
All portholes below the main deck should have hinged metal covers (deadlights) that can be closed watertight.

Access Openings in the Hull

In Fig. below the loading hatch in the side of the hull is bolted and secured while at sea. An alarm system is fitted which will sound on the bridge if the door is opened.



Opening in the Hull



Watertight Door Open Alarm Switch

In the figure above shows a closer view of the trip switch which will sound the alarm if the side door were opened while at sea.

Scuppers, Inlets and Discharges

All sea inlets are to be fitted with valves of steel or material of equivalent strength attached direct to the hull or approved skin fittings (in case of non metal hulls).

Drainage Arrangements From Weather Decks

Weather decks are to be provided with freeing ports, open rails or scuppers capable of rapidly clearing the deck of all water under all weather conditions.

Maintenance of Watertight Integrity

Watertight integrity can be breached through any activity or happening that allows the ingress of water in unwanted areas or compartments of the vessel.

Typical examples include:

- ✓ Lack of maintenance to seals, screw threads and other locking devices.
- ✓ Damage caused by collision, grounding or heavy weather.
- ✓ Leaving hatches, doors, vents etc open.
- ✓ Blocked freeing ports or scuppers.
- ✓ Cracks along welds in metal vessels or loss of caulking from planked seams in timber vessels.

1.5 Corrosion and its Prevention

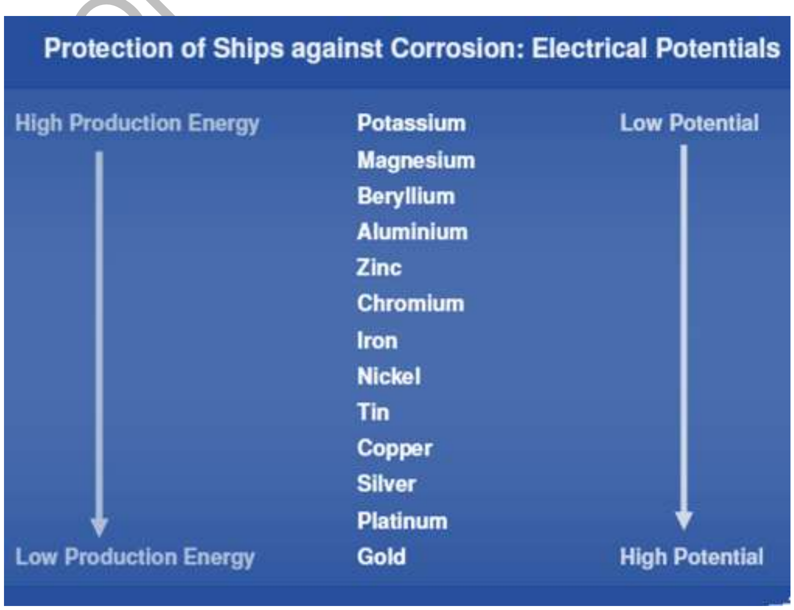
Corrosion Processes

The driving force behind corrosion of metal objects is the desire of metallic elements to return to the state they are predominantly found in nature e.g oxides.

Corrosion is like a cancer

Extraction of a pure metal from its ore state requires energy, and it is this energy which makes metals inherently unstable and seek to react with their environment.

- ✓ Metals which have a higher energy input in their production processes are more susceptible to corrosion, and have a lower electrical potential.



There are 2 main types of corrosion on ships:

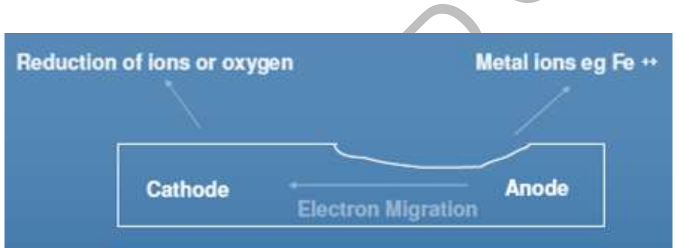
- ✓ Atmospheric
- ✓ Immersed

The three essential elements necessary for corrosion to occur are:

- ✓ Water
- ✓ Contaminants in the water (eg salts)
- ✓ Oxygen

Corrosion is primarily electrochemical in nature, with a chemical reaction accompanied by the passage of an electrical current.

In order for this to happen, a difference in electrical potential must exist between different areas of the substrate.



The main factors which influence the rate of corrosion are:

- ✓ Diffusion
- ✓ Temperature
- ✓ Conductivity
- ✓ Type of ions
- ✓ Acidity and Alkalinity
- ✓ Electrochemical potential

Factors which control the rate of Corrosion:

<u>Diffusion</u>

- ✓ Freshly exposed bare steel will corrode at a greater rate than that covered with a compact layer of rust since diffusion of reactants to and from the metal surface is much easier.
- ✓ The corrosion rate is heavily controlled by the diffusion of oxygen through the water to the metal surface.

- ✓ Areas covered by a thin, conducting, moisture film, such as in emptied ballast tanks, will corrode faster than areas under immersion.
- ✓ The areas at the top of Ballast Tanks and at the top of double bottoms where air has become entrapped, tend to corrode more quickly than deeply submerged areas where oxygen availability is lower.

Temperature

- ✓ Diffusion rates are controlled by temperature, so metals corrode at faster rates at higher temperatures than at lower temperatures.
- ✓ Underdeck areas, and regions adjoining the engine room or hot cargo, will tend to corrode preferentially.
- ✓ In modern double hull tankers, with fully segregated ballast tanks, the empty tanks act as insulation from the sea so cargoes retain their heat longer. So the cargo side of the ballast tank corrodes more quickly than was the case with single hull tankers.

Heavy corrosion of hatch coaming and topside tank plating vertical strake

Conductivity

- ✓ For corrosion to occur there must be a conductive medium between the two parts of the corrosion reaction.
- ✓ Corrosion will not occur in distilled water, and the rate of corrosion will increase as the conductivity increases due to the presence of more ions in solution.
- ✓ The corrosion rate of steel reaches a maximum close to the normal ionic content of sea water.

Types of Ions

- ✓ Some types of ions present in sea water or in cargoes are more corrosive than others. Chloride ions are usually the most destructive, with sulphate and sulphur containing ions also a major problem.

- ✓ Chloride ions destroy the protective properties of any rusts produced, by preventing the formation of the more protective densely packed oxides.
- ✓ Sulphur containing ions become involved in additional electron generating reactions within rust itself. Sulphur can originate from the inert gas system and from cargoes such as crude oil.

pH

- ✓ In sea water (pH ~ 8) the reaction which balances the iron dissolution is the reduction of dissolved oxygen to form hydroxyl ions.
- ✓ If the pH falls to 0 (ie becomes acidic) then there is an excess of hydrogen ions which can become involved in the cathodic reaction to generate hydrogen. Hydrogen and hydrogen ions diffuse very rapidly making the steel corrode more quickly.
- ✓ If the pH rises to 14 (ie becomes alkaline) there is an excess of hydroxyl ions and corrosion stops.
- ✓ Many blisters found in ballast tanks, particularly double bottoms, are highly alkaline so the steel underneath is very bright.

Potential

- ✓ Every metal takes up a specific electrochemical potential when immersed in a conducting liquid. This is called the half potential since it can only be measured by comparing it to another known reference. Common reference electrodes are the Saturated Calomel Electrode (SCE), silver/silver chloride and copper/copper sulphate.
- ✓ The potential that a metal takes up can be changed by connecting it to another dissimilar metal (by using sacrificial anodes) or by applying an external potential (impressed current cathodic protection).

Microbiologically Induced Corrosion (MIC)

- ✓ Some of the first double hull tankers showed excessive corrosion in the bottoms of the cargo tanks.
- ✓ Black slimes were found, along with a Hydrogen Sulphide smell. These indicated the presence of Sulphate Reducing Bacteria (SRB's).
- ✓ These bacteria have a threshold of activity above ~35C. In single hull tankers the sea water generally cooled the steel to below this temperature, so it was not a problem.
- ✓ Corrosion is normally seen as localised pits, filled with a black ferrous product.
- ✓ Design of tanks should be such that there are no areas where mud and stagnant water can accumulate.

Control of corrosion

There are two methods used for corrosion control on ships:

– Modifying the corrosive environment

- Inhibitors
- Cathodic Protection

– Excluding the corrosive environment

- Coatings

- **by Inhibitors**

- ✓ Corrosion inhibitors are used in areas where the electrolyte solution is of a known and controllable quantity.
- ✓ On ships this occurs in onboard equipment (boilers, tanks, pipes).
- ✓ Anodic inhibitors work by migrating to the anode and react to form salts which act as a protective barrier. Examples are chromates, nitrites, phosphates and soluble oils.
- ✓ Cathodic inhibitors migrate to the cathode, and either inhibit oxygen absorption or hydrogen evolution. Examples are salt compounds of magnesium, zinc, nickel or arsenic.

by Cathodic Protection

- ✓ Sir Humphrey Davy and his associate Michael Faraday first suggested this as a method to protect ships hulls in 1824.
- ✓ Zinc protector plates were attached to copper sheathed hulls of Navy vessels to reduce copper corrosion. The first full vessel to be protected in this way was “Samarang”.
- ✓ The principle of Cathodic Protection is to convert all the anode areas to cathodes, by polarising them to the same electrical potential as the cathodes.

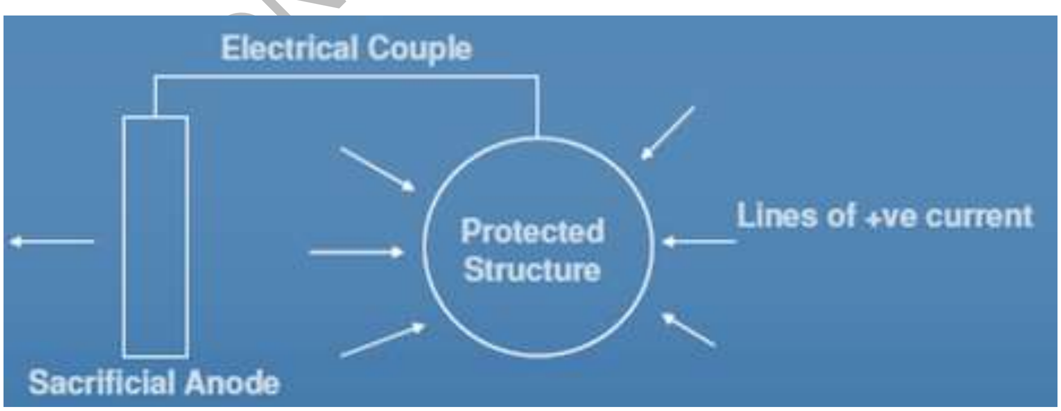
  - There are two methods:

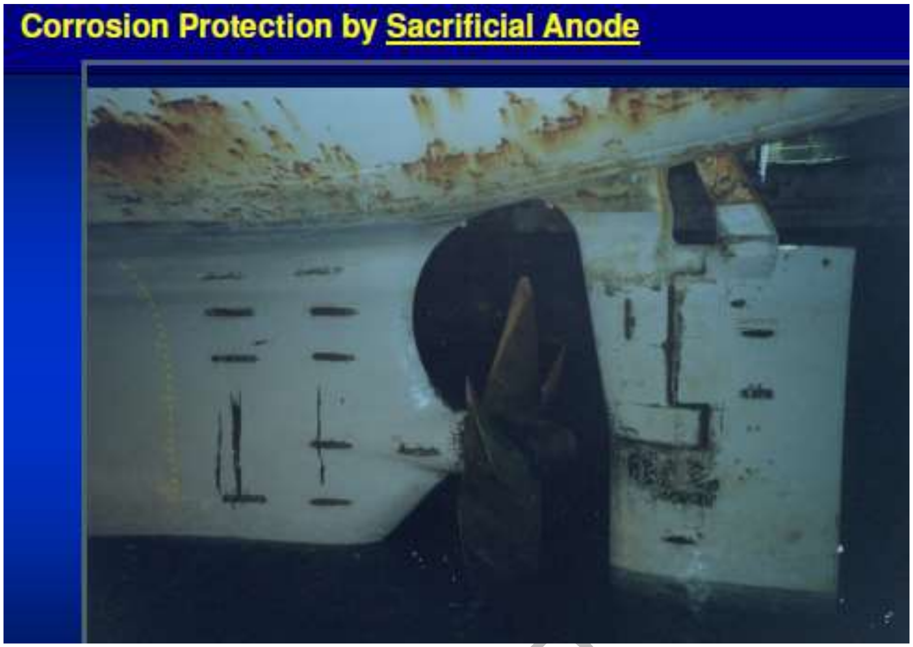
– Sacrificial anodes

– Application of an external electric current (ie an impressed current)

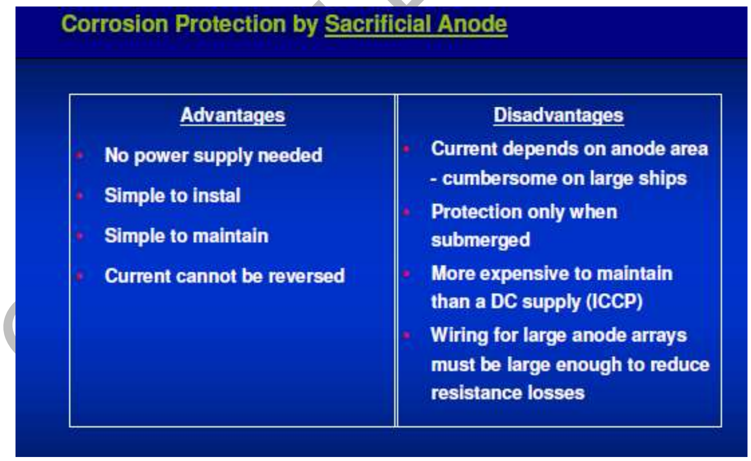
by Sacrificial Anode

• A lower potential material is placed in electrical contact with the metal surface to be protected.
• The lower potential material becomes the anode and corrodes preferentially.
• Common materials used are Magnesium, Zinc and Aluminium.

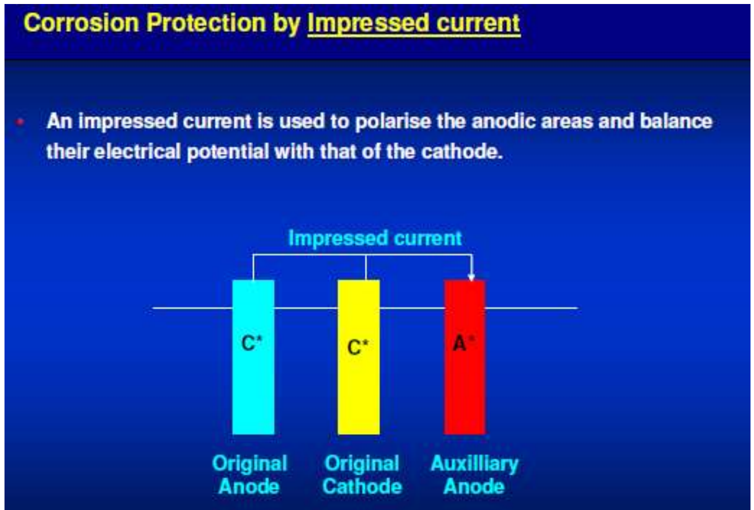




Corrosion Protection by Sacrificial Anode

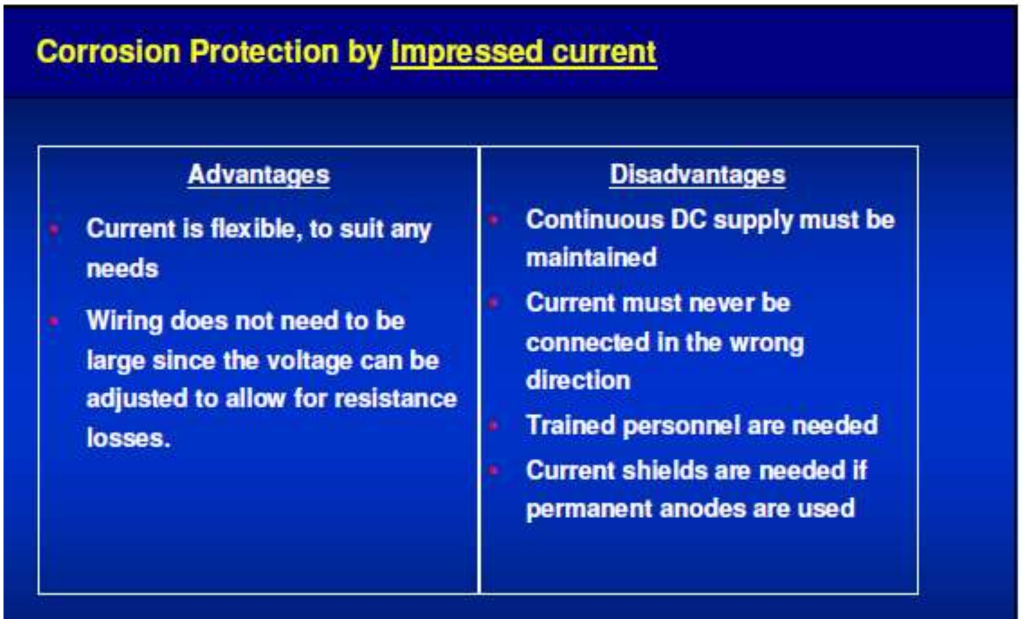


An impressed current is used to polarise the anodic areas and balance their electrical potential with that of the cathode.



Corrosion Protection by Impressed current
An impressed current is used to polarise the anodic areas and balance their electrical potential with that of the cathode.
Impressed current
C*
C*
A*
Original Anode
Original Cathode
Auxilliary Anode

Cathodic Protection by Impressed current



Corrosion Protection of Ships

Corrosion protection of our ships in the marine environment has challenged us for years in the areas of their hulls and internal tanks, the use of coaltars being prevalent. Nowadays however there are many innovative types of epoxy coatings and specialized paints available to combat corrosion attack

Ships and offshore structures require protection against the marine environment. This protection is required above and below the waterline as well as the splash zone in offshore structures, being exposed to both air and liquid assault.
Storage tanks such as fresh water and ballast tanks also require special internal anti-corrosive coating as do the oil storage tanks in oil tankers.

The properties and applications of these coatings are provided by guidelines, rules, and regulations set out by governing bodies such as SOLAS and the IMO.

Depending on their particular application, corrosive resistant coatings can be supplied in various categories such as paint and epoxies.

Susceptible Areas
These areas are listed below:

- **Hulls**

This includes the area above and below the waterline and can sometimes be combined with an anti-friction coatings on the hull below the waterline.

- **Decks**

Decks liable to corrosion due to salt being deposited on the plating and also due to the wearing of the coating due to deck-work

- **Tanks**

Ballast Tanks

Ballast tanks are very susceptible to corrosion due to their constant wet and dry conditions when the ship is ballasted or carrying a full cargo.
Ballast tanks have been in the news regarding the spreading of non-indigenous seawater borne marine bacteria, organisms and barnacles. Coatings to eradicate these have been developed and are applied after a coating of anti corrosive material.

Freshwater Storage Tanks
These tanks used to be cement washed and then chlorinated to prevent corrosion and protect against E-Coli and Legionnaires disease. More modern methods are available today.

Treatment of Susceptible Areas

- **Hulls**

Area Below the Waterline
This underwater area is protected from corrosion following the hull construction before it is launched. One of the more popular protection used is two part coal-tar epoxy in conjunction with a vinyl tar coat.
This combination has been found satisfactory and can be repaired at the ships yearly drydock survey.

- **Decks and Hulls Above the Waterline.**

Ships decks are also liable to corrosion due to being immersed in seawater during adverse weather depositing salt on the plating. When I was at sea the sailors were forever chipping away and repainting the deck or hanging over the side in a bosun's chair, attacking the hull. This was not complimentary to my after lunch snooze before going on the 4-8 watch. Anyway, protection of deck and above waterline areas is carried out using a well tested combination of alkyd and chlorinated rubber.

- **Tanks**

Ballast Tanks

Ballast tanks are very susceptible to corrosion due to constant humidity promoted by their surface wet and dry conditions depending if the ship is ballasted or carrying a full cargo. Ballast tanks have been accused of being the importer and spreading of non-indigenous seawater borne marine bacteria, organisms and barnacles. Coatings to eradicate these have been developed and are applied after a coating of anticorrosive material.
Ballast tanks used to be coated with coal tar epoxy (CTE) but now epoxy products produced in hydrocarbon refining has been developed. This is applied in two coats and is one of the current methods used against corrosion in ballast tanks.

<u>Freshwater Storage Tanks</u>
These tanks used to be cement washed and then chlorinated to prevent corrosion and protect against E-Coli and Legionnaires disease. I well remember the taste of the newly bunkered fresh water after the mate had liberally dosed it with chlorine. Yuck! Not nice in afternoon tea, to say nothing about the rum!
Nowadays an application of pure epoxy, applied under strict guidelines by an experienced contractor is one method. This can be supplemented with a strictly controlled addition of silver nitrate or chlorine to the tank being used to control any bacteria in the water.

<u>Cargo Tanks</u>
This is a vast subject due to the various cargoes carried by today's merchant vessels from crude oil to chemicals, so will cover this fully in a future article on Cargo Tank Protective Coatings.
However, in the interim we will have a quick look at the protection of oil storage tanks in a crude oil tanker. The corrosion in these areas is caused by the sulphurous and water contained in the crude, combined with other water vapour and the flexing of the ship's structure. Microbes also compliment corrosion as they ingress into the protective coating. The new high tensile steels used in ships construction and the innovation of double hulled vessels has had a detrimental effect on tanks, being sited to have exacerbated corrosion and pitting instances.
Crude oil tank internals can be protected by applications of Coal tar and pure epoxy coatings.

1.6 Surveys and Dry-Docking

Inspection by Classification Societies

Every seagoing vessel must be "classed" by a classification society. The classification society certifies that the vessel is "in class," signifying that the vessel has been built and maintained in accordance with the rules of the classification society and complies with applicable rules and regulations of the vessel's country of registry and the international conventions of which that country is a member. In addition, where surveys are required by international conventions and corresponding laws and ordinances of a flag state, the classification society will undertake them on application or by official order, acting on behalf of the authorities concerned.

Each vessel is inspected by a surveyor of the classification society in three surveys of varying frequency and thoroughness: every year for the annual survey, every two to three years for intermediate surveys and every five years for special surveys. Should any defects be found, the classification surveyor will issue a "recommendation" for appropriate repairs that have to be made by the shipowner within the time limit prescribed. Vessels may be required, as part of the annual and intermediate survey process, to be dry-docked for inspection of the underwater portions of the vessel and for necessary repair stemming from the inspection. Special surveys always require dry-docking. The classification society also undertakes on request other surveys and checks that are required by regulations and requirements of the flag state. These surveys are subject to agreements made in each individual case and/or to the regulations of the country concerned.

1.7 Stability

Approximate Calculation of Areas and Volumes of Ship Shapes, First and Second Moments

- **Simpson's Rules for areas and centroids**

Areas and volumes

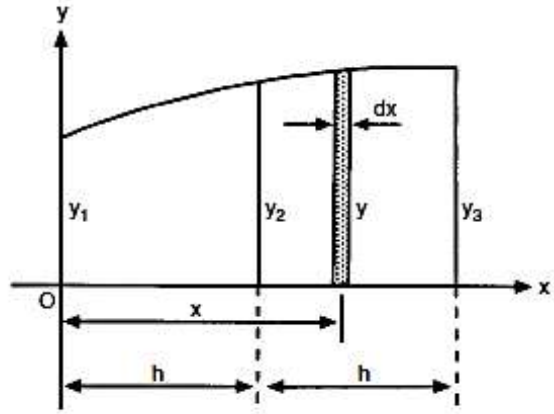
Simpson's Rules may be used to find the areas and volumes of irregular figures.

The rules are based on the assumption that the boundaries of such figures are curves which follow a definite mathematical law. When applied to ships they give a good approximation of areas and volumes. The accuracy of the answers obtained will depend upon the spacing of the ordinates and upon how near the curve follows the law.

Simpson's First Rule

This rule assumes that the curve is a parabola of the second order. A parabola of the second order is one whose equation, referred to co-ordinate axes, is of the form $y = a_0 + a_1 x + a_2 x^2$ where a_0, a_1 and a_2 are constants.

Let the curve in Figure below be a parabola of the second order. Let y_1, y_2 and y_3 be three ordinates equally spaced at 'h' units apart.



The area of the elementary strip is y dx.Then the area enclosed by the curve and the axes of reference is given by:

$$\text{Area of figure} = \int_O^{2h} y\,dx$$

But

$$y = a_0 + a_1x + a_2x^2$$

$$\therefore \text{Area of figure} = \int_O^{2h} (a_0 + a_1x + a_2x^2)\,dx$$

$$= \left[a_0x + \frac{a_1x^2}{2} + \frac{a_2x^3}{3}\right]_O^{2h}$$

$$= 2a_0h + 2a_1h^2 + \tfrac{8}{3}a_2h^3$$

$$\text{Assume that the area of figure} = Ay_1 + By_2 + Cy_3$$

Using the equation of the curve and substituting 'x' for O, h and 2 h respectively:

$$\begin{aligned}\text{Area of figure} &= Aa_0 + B(a_0 + a_1h + a_2h^2) \\ &\quad + C(a_0 + 2a_1\mathbf{h} + 4a_2h^2) \\ &= a_0(A + B + C) + a_1h(B + 2C) \\ &\quad + a_2h^2(B + 4C) \\ \therefore 2a_0h + 2a_1h^2 + \tfrac{8}{3}a_2h^3 &= a_0(A + B + C) + a_1h(B + 2C) \\ &\quad + a_2h^2(B + 4C)\end{aligned}$$

Equating coefficients:

$$A + B + C = 2h, \quad B + 2C = 2h, \quad B + 4C = \tfrac{8}{3}h$$

From which:

$$A = \frac{h}{3} \quad B = \frac{4h}{3} \quad C = \frac{h}{3}$$

$$\therefore \text{Area of figure} = \frac{h}{3}(y_1 + 4y_2 + y_3)$$

This is *Simpson's First Rule.*

It should be noted that Simpson's First Rule can also be used to find the area under a curve of the third order, i.e., a curve whose equation, referred to the co-ordinate axes, is of the form $y = a_0 + a_1x + a_2x^2 + a_3x^3$, where a_0, a_1, a_2 and a_3 are constants.

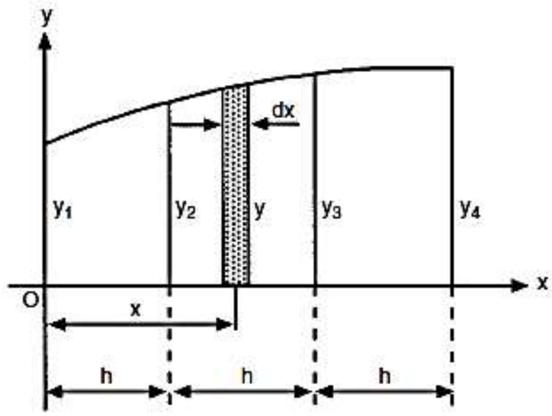
Summary

A coefficient of 1/3 with multipliers of 1, 4, 1, etc.

Simpson's Second Rule

This rule assumes that the equation of the curve is of the third order, i.e. of

a curve whose equation, referred to the co-ordinate axes, is of the form $y = a_0 + a_1x + a_2x^2 + a_3x^3$, where a_0, a_1, a_2 and a_3 are constants



In figure avove:

$$\text{Area of elementary strip} = y\,dx$$

$$\begin{aligned}\text{Area of the figure} &= \int_O^{3h} y\,dx \\ &= \int_O^{3h} (a_0 + a_1x + a_2x^2 + a_3x^3)\,dx \\ &= \left[a_0x + \tfrac{1}{2}a_1x^2 + \tfrac{1}{3}a_2x^3 + \tfrac{1}{4}a_3x^4\right]_O^{3h} \\ &= 3a_0h + \tfrac{9}{2}a_1h^2 + 9a_2h^3 + \tfrac{81}{4}a_3h^4\end{aligned}$$

$$\begin{aligned}\text{Let the area of the figure} &= Ay_1 + By_2 + Cy_3 + Dy_4 \\ &= Aa_0 + B(a_0 + a_1h + a_2h^2 + a_3h^3) \\ &\quad + C(a_0 + 2a_1h + 4a_2h^2 + 8a_3h^3) \\ &\quad + D(a_0 + 3a_1h + 9a_2h^2 + 27a_3h^3) \\ &= a_0(A + B + C + D) + a_1h(B + 2C + 3D) \\ &\quad + a_2h^2(B + 4C + 9D) + a_3h^3(B + 8C + 27D)\end{aligned}$$

Equating coefficients:

$$\begin{aligned}A + B + C + D &= 3h \\ B + 2C + 3D &= \tfrac{9}{2}h \\ B + 4C + 9D &= 9h \\ B + 8C + 27D &= \tfrac{81}{4}h\end{aligned}$$

From which:

$$A = \tfrac{3}{8}h, \quad B = \tfrac{9}{8}h, \quad C = \tfrac{9}{8}h, \quad D = \tfrac{3}{8}h$$

$$\therefore \text{ Area of figure } = \tfrac{3}{8}hy_1 + \tfrac{9}{8}hy_2 + \tfrac{9}{8}hy_3 + \tfrac{3}{8}hy_4$$

or

$$\text{Area of figure } = \tfrac{3}{8}h(y_1 + 3y_2 + 3y_3 + y_4)$$

Summary

A coefficient of 3/8 with multipliers of 1, 3, 3, 1, etc.

Simpson's Third Rule

In figure below:

$$\text{Area of the elementary strip } = y\,dx$$

$$\text{Area between } y_1 \text{ and } y_2 \text{ in figure } = \int_0^h y\,dx$$

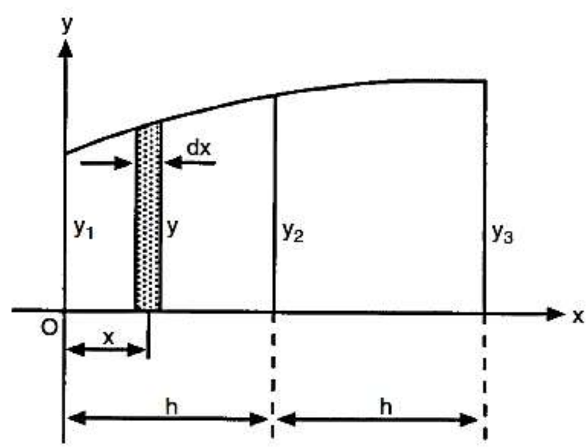
$$= a_0h + \tfrac{1}{2}a_1h^2 + \tfrac{1}{3}a_2h^3$$

$$\text{Let the area between } y_1 \text{ and } y_2 = Ay_1 + By_2 + Cy_3$$

$$\begin{aligned}\text{Then area } &= Aa_0 + B(a_0 + a_1h + a_2h^2) \\ &\quad + C(a_0 + 2a_1h + 4a_2h^2) \\ &= a_0(A + B + C) + a_1h(B + 2C) \\ &\quad + a_2h^2(B + 4C)\end{aligned}$$

Equating coefficients:

$$A + B + C = h, \quad B + 2C = h/2, \quad B + 4C = h/3$$



From which:

$$A = \frac{5h}{12}, \quad B = \frac{8h}{12}, \quad C = -\frac{h}{12}$$

$$\therefore \text{ Area of figure between } y_1 \text{ and } y_2 = \frac{5}{12}hy_1 + \frac{8}{12}hy_2 + \left(-\frac{1}{12}hy_3\right)$$

or

$$\text{Area} = \frac{h}{12}(5y_1 + 8y_2 - y_3)$$

This is the Five/eight (or Five/eight minus one) rule, and is used to find the area between two consecutive ordinates when three consecutive ordinates are known.

Summary
A coefficient of 1/12 with multipliers of 5, 8, -1, etc.

Areas of water-planes and similar figures using extensions of Simpson's Rules

Since a ship is uniformly built about the centre line it is only necessary to calculate the area of half the water-plane and then double the area found to obtain the area of the whole water-plane.

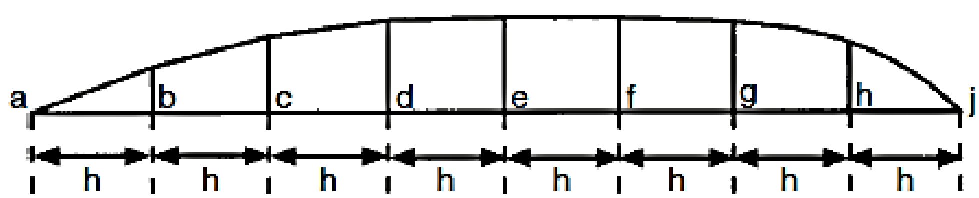
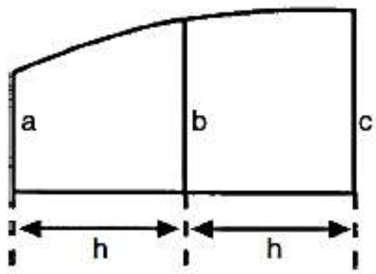


Figure above represents the starboard side of a ship's water-plane area. To find the area, the centre line is divided into a number of equal lengths each 'h' m long. The length 'h' is called the *common interval*. The half-breadths, a, b, c, d, etc., are then measured and each of these is called a *half-ordinate*.

Using Simpson's First Rule

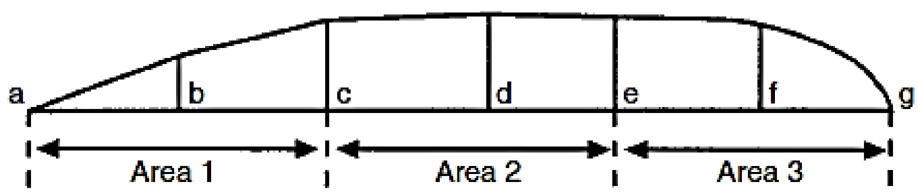
This rule can be used to find areas when there are an odd number of ordinates.

$$\text{Area of Figure 10.5(a)} = \frac{h}{13}(a + 4b + c)$$



If the common interval and the ordinates are measured in metres, the area found will be in square metres.

Let this rule now be applied to a water-plane area such as that shown in Figure below.



	1	4	1		1	4	1
			+ 1	4	+ 1		
Combined multiplier	1	4	2	4	2	4	1

The water-plane is divided into three separate areas and Simpson's First Rule is used to find each separate area:

$$\text{Area 1} = h/3(a + 4b + c)$$
$$\text{Area 2} = h/3(c + 4d + e)$$
$$\text{Area 3} = h/3(e + 4f + g)$$
$$\text{Area of } \tfrac{1}{2}\text{ WP} = \text{Area 1} + \text{Area 2} + \text{Area 3}$$
$$\therefore \text{Area of } \tfrac{1}{2}\text{ WP} = h/3(a + 4b + c) + h/3(c + 4d + e) + h/3(e + 4f + g)$$

or

$$\text{Area of } \tfrac{1}{2}\text{ WP} = h/3(a + 4b + 2c + 4d + 2e + 4f + g)$$

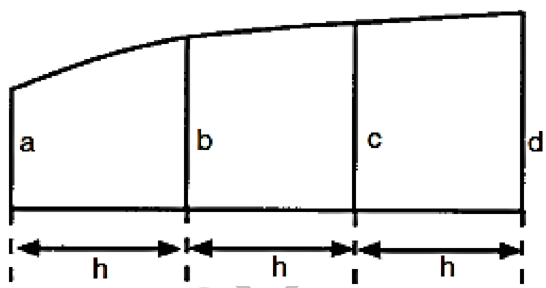
This is the form in which the formula should be used. Within the brackets the half-ordinates appear in their correct sequence from forward to aft.

The coefficients of the half-ordinates are referred to as Simpson's

Multipliers and they are in the form: 1424241. Had there been nine half ordinates, the Multipliers would have been: 142424241. It is usually much easier to set out that part of the problem within the brackets in tabular form. Note how the Simpson's multipliers begin and end with 1, as shown in Figure above.

Using the extension of Simpson's Second Rule

This rule can be used to find the area when the number of ordinates is such that if one be subtracted from the number of ordinates the remainder is divisible by 3.



AREA OF FIGURE ABOVE $= \frac{3}{8}h(a + 3b + 3c + d)$

Now consider a water-plane area which has been divided up using seven half-ordinates as shown in Figure above.

The water-plane can be split into two sections as shown, each section having four ordinates.

	1	3	3	1			
				+			
				1	3	3	1
Combined multipliers	1	3	3	2	3	3	1

$$\text{Area 1} = \tfrac{3}{8}h(a + 3b + 3c + d)$$
$$\text{Area 2} = \tfrac{3}{8}h(d + 3e + 3f + g)$$
$$\text{Area of } \tfrac{1}{2}\text{ WP} = \text{Area 1} + \text{Area 2}$$
$$\therefore \text{ Area of } \tfrac{1}{2}\text{ WP} = \tfrac{3}{8}h(a + 3b + 3c + d) + \tfrac{3}{8}h(d + 3e + 3f + g)$$

or

$$\text{Area of } \tfrac{1}{2}\text{ WP} = \tfrac{3}{8}h(a + 3b + 3c + 2d + 3e + 3f + g)$$

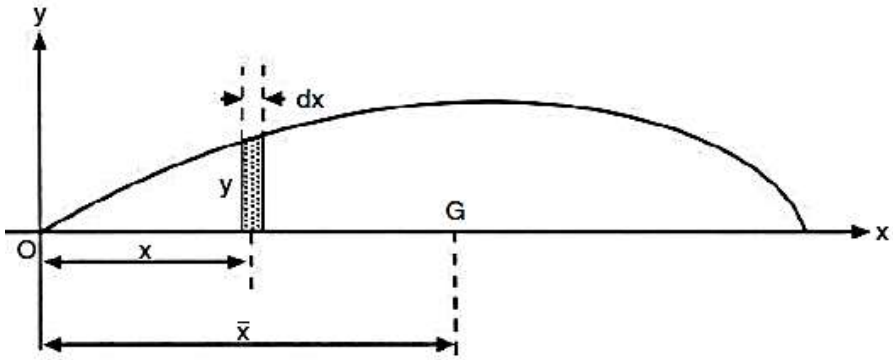
This is the form in which the formula should be used. As before, all of the ordinates appear in their correct order within the brackets. The multipliers are now 1332331. Had there been 10 ordinates the multipliers would have been 1332332331. Note how the Simpson's multipliers begin and end with 1, as shown in Figure above.

<u>Centroids and centres of gravity</u>

To find the centre of flotation

The *centre of flotation* is the centre of gravity or *centroid* of the water-plane area, and is the point about which a ship heels and trims. It must lie on the longitudinal centre line but may be slightly forward or aft of amidships (from say 3 per cent L forward of amidships for oil tankers to say 3 per cent L aft of amidships for container ships).

To find the area of a water-plane by Simpson's Rules, the half-breadths are used as ordinates. If the moments of the half-ordinates about any point are used as ordinates, then the total moment of the area about that point will be found. If the total moment is now divided by the total area, the quotient will give the distance of the centroid of the area from the point about which the moments were taken. This may be shown as follows:



$$\text{Area of strip} = y\,dx$$
$$\text{Area of the } \tfrac{1}{2}\text{ WP} = \int_O^L y\,dx$$
$$\text{Area of the WP} = 2 \times \int_O^L y\,dx$$

The value of the integral is found using the formula:

$$\int_O^L y\,dx = \frac{h}{3}(a + 4b + 2c + 4d + e)$$

Thus, the value of the integral is found by Simpson's Rules using values of the variable y as ordinates.

$$\text{Moment of strip about OY} = x\,y\,dx$$
$$\text{Moment of } \tfrac{1}{2}\text{ WP about OY} = \int_O^L x\,y\,dx$$
$$\text{Moment of WP about OY} = 2 \times \int_O^L x\,y\,dx$$

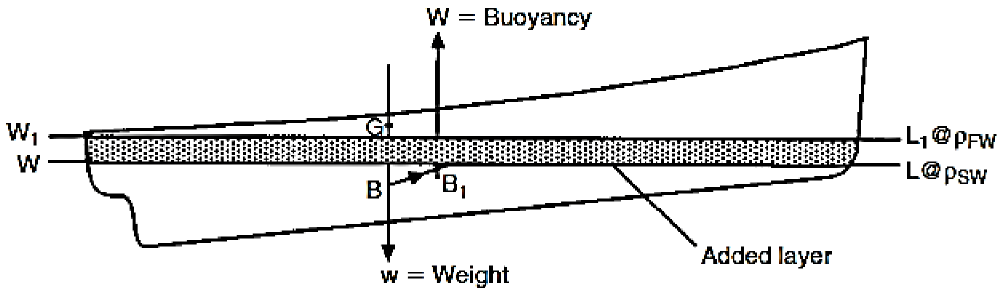
The value of this integral is found by Simpson's Rules using values of the product x y as ordinates.

Let the distance of the centre of flotation be $\overline{X}$ from OY, then:

$$\overline{X} = \frac{\text{Moment}}{\text{Area}}$$
$$= \frac{2 \times \int_O^L x\,y\,dx}{2 \times \int_O^L y\,dx} = \frac{\Sigma_2}{\Sigma_1} \times \text{CI}$$

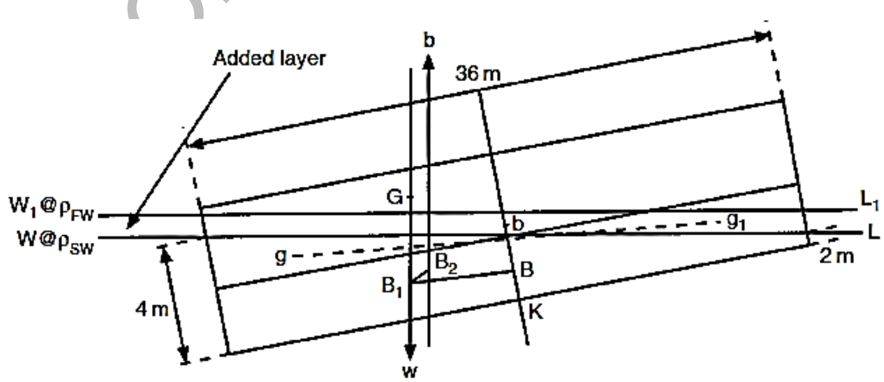
Effect of change of density on draft and trim

When a ship passes from water of one density to water of another density the mean draft is changed and if the ship is heavily trimmed, the change in the position of the centre of buoyancy will cause the trim to change.



Let the ship in Figure above float in salt water at the waterline WL. B represents the position of the centre of buoyancy and G the centre of gravity. For equilibrium, B and G must lie in the same vertical line.

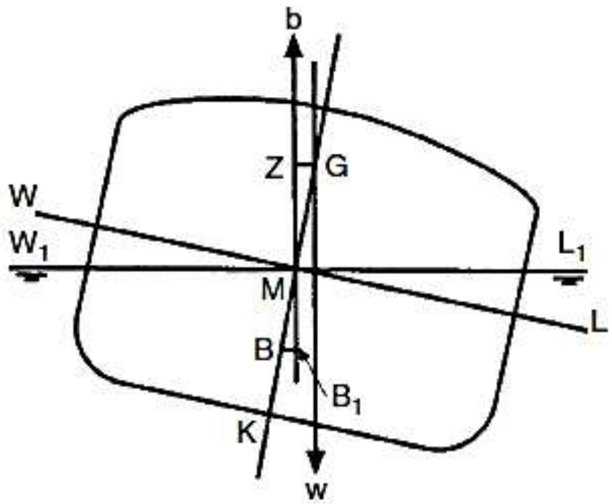
If the ship now passes into fresh water, the mean draft will increase. Let W_1L_1 represent the new waterline and b the centre of gravity of the extra volume of the water displaced. The centre of buoyancy of the ship, being the centre of gravity of the displaced water, will move from B to B_1 in a direction directly towards b. The force of buoyancy now acts vertically upwards through B_1 and the ship's weight acts vertically downwards through G, giving a trimming moment equal to the product of the displacement and the longitudinal distance between the centres of gravity and buoyancy. The ship will then change trim to bring the centres of gravity and buoyancy back in to the same vertical line.



Stability at Moderate and Large Angles of Heel

Angle of loll

When a ship with negative initial metacentric height is inclined to a small angle, the righting lever is negative, resulting in a capsizing moment. This effect is shown in Figure (a) below and it can be seen that the ship will tend to heel still further.



(a)

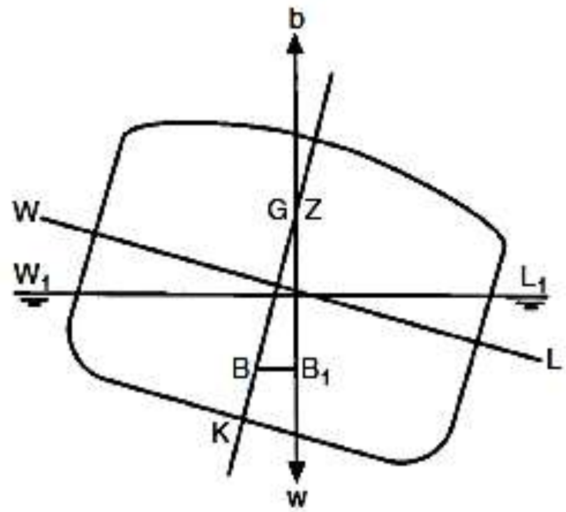
At a large angle of heel the centre of buoyancy will have moved further out the low side and the force of buoyancy can no longer be considered to act vertically upwards though M, the initial metacentre. If, by heeling still further, the centre of buoyancy can move out far enough to lie vertically under G the centre of gravity, as in Figure (b) below, the righting lever and thus the righting moment, will be zero.

The angle of heel at which this occurs is referred to as the *angle of loll* and may be defined as the angle to which a ship with negative initial metacentric height will lie at rest in still water.

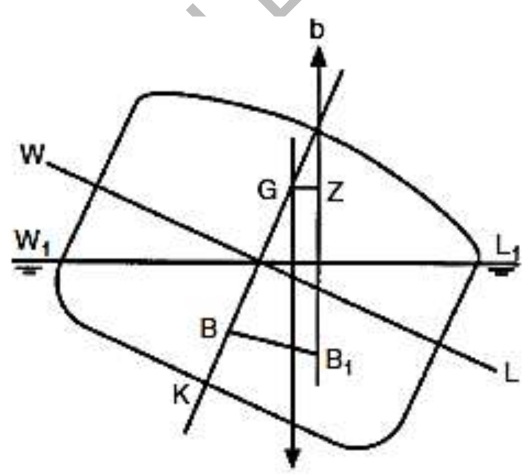
If the ship should now be inclined to an angle greater than the angle of loll, as shown in Figure (c) below, the righting lever will be positive, giving a moment to return the ship to the angle of loll.

From this it can be seen that the ship will oscillate about the angle of loll instead of the upright.

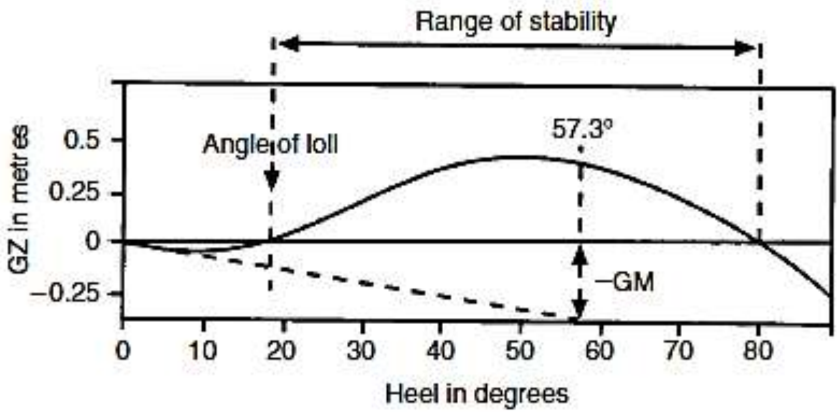
The curve of statical stability for a ship in this condition of loading is illustrated in Figure below. Note from the figure that the GZ at the angle of



(b)



(c)



Curve of statical stability for a ship in this condition of loading

loll is zero. At angles of heel less than the angle of loll the righting levers are negative, whilst beyond the angle of loll the righting levers are positive up to the angle of vanishing stability.

Note how the range of stability in this case is measured from the angle of loll and not from the 'o–o' axis.

To calculate the angle of loll

When the vessel is 'wall-sided' between the upright and inclined waterlines, the GZ may be found using the formula:

lines, the GZ may be found using the formula:

$$GZ = \sin\theta(GM + \tfrac{1}{2}BM\tan^2\theta)$$

At the angle of loll:

$$GZ = 0$$
$$\therefore \text{ either } \sin\theta = 0$$

or

$$(GM + \tfrac{1}{2}BM\tan^2\theta) = 0$$

If

$$\sin\theta = 0$$

then

$$\theta = 0$$

But then angle of loll cannot be zero, therefore:

$$\begin{aligned}(GM + \tfrac{1}{2}BM\tan^2\theta) &= 0\\ \tfrac{1}{2}BM\tan^2\theta &= -GM\\ BM\tan^2\theta &= -2GM\\ \tan^2\theta &= \frac{-2GM}{BM}\\ \tan\theta &= \sqrt{\frac{-2GM}{BM}}\end{aligned}$$

The angle of loll is caused by a negative GM, therefore:

$$\tan\theta = \sqrt{\frac{-2(-GM)}{BM}}$$

or

$$\tan\theta = \sqrt{\frac{2GM}{BM}}$$

where

ɵ = the angle of loll
GM = a negative initial metacentric height

BM = the BM when upright

Simplified Stability Data

Simplified stability information

- It has become evident that the masters' task of ensuring that his ship complies with the minimum statutory standards of stability is in many instances not being adequately carried out. Afeature of this is that undue traditional reliance is being placed on the value of GM alone, while other important criteria which govern the righting lever GZ curve are not being assessed as they should be. For this reason the Department, appreciating that the process of deriving and evaluating GZ curves is often difficult and time-consuming, strongly recommends that in future simplified stability information be incorporated into ships' stability booklets. In this way masters can more readily assure themselves that safe standards of stability are met.

- Simplified stability information eliminates the need to use cross curves of stability and develop righting lever GZ curves for varying loading conditions by enabling a ship's stability to be quickly assessed, to show whether or not all statutory criteria are complied with, by means of a single diagram or table. Considerable experience has now been gained and three methods of presentation are in common use. These are:
  (a) The Maximum Deadweight Moment Diagram or Table.
  (b) The Minimum Permissible GM Diagram or Table.
  (c) The Maximum Permissible KG Diagram or Table.

  In all three methods the limiting values are related to salt water displacement or draft. Free surface allowances for slack tanks are, however, applied slightly differently.

- Consultation with the industry has revealed a general preference for the Maximum Permissible KG approach, and graphical presentation also appears to be preferred rather than a tabular format. The Department's view is that any of the methods may be adopted subject to:
  (a) clear guidance notes for their use being provided and
  (b) submission for approval being made in association with all other basic data and sample loading conditions.

In company fleets it is, however, recommended that a single method be utilised throughout.

- It is further recommended that the use of a *Simplified Stability Diagram* as an adjunct to the *Deadweight Scale* be adopted to provide a direct means of comparing stability relative to other loading characteristics. Standard work forms for calculating loading conditions should also be provided.
- It is essential for masters to be aware that the standards of stability obtainable in a vessel are wholly dependent on exposed openings such as hatches, doorways, air

pipes and ventilators being securely closed weathertight; or in the case of automatic closing appliances such as airpipe ball valves that these are properly maintained in order to function as designed.

- Shipowners bear the responsibility to ensure that adequate, accurate and uptodate stability information for the master's use is provided. It follows that it should be in a form which should enable it to be readily used in the trade in which the vessel is engaged.

Maximum Permissible Deadweight

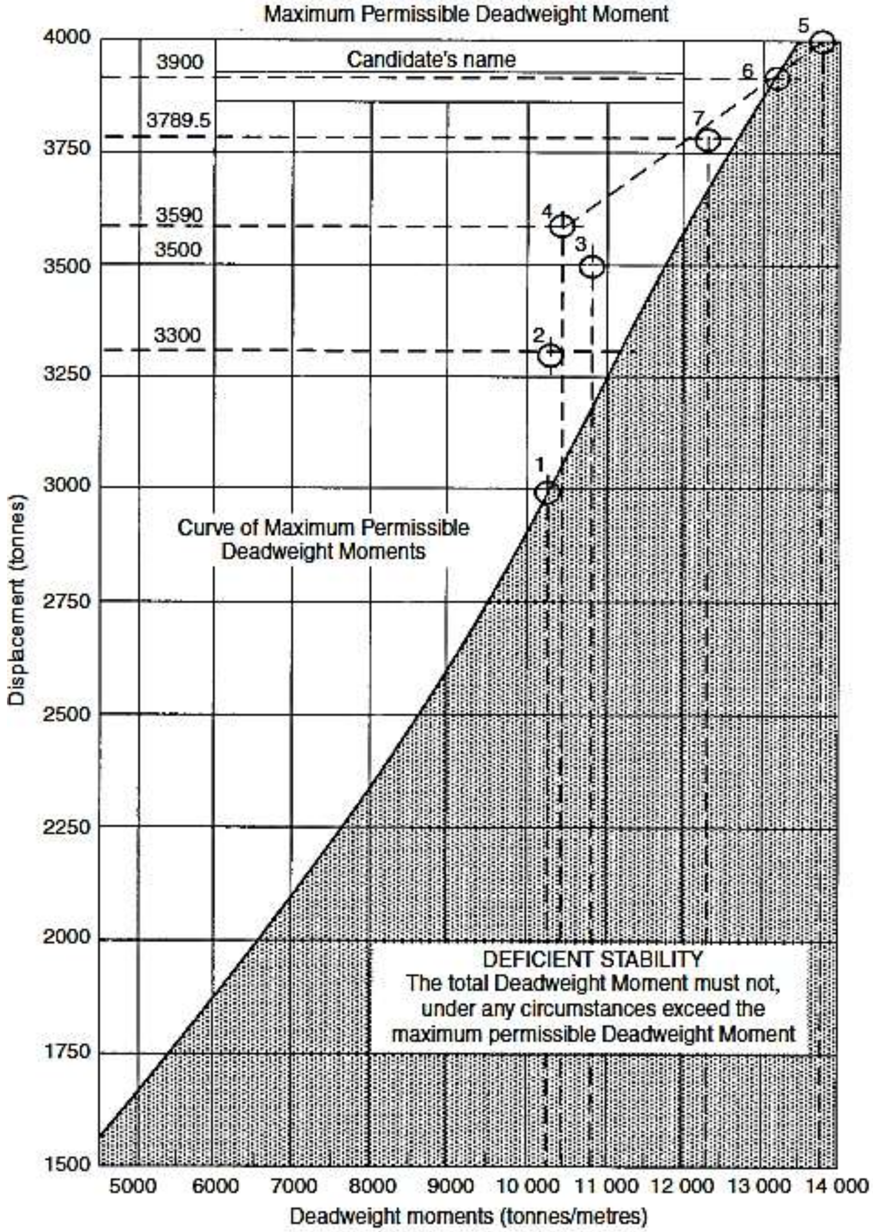
Moment Diagram

This is one form of simplified stability data diagram in which a curve of Maximum Permissible Deadweight Moments is plotted against displacement in tonnes on the vertical axis and Deadweight Moment in tonnes metres on the horizontal axis, the Deadweight Moment being the moment of the Deadweight about the keel.

The total Deadweight Moment at any displacement must not, under any circumstances, exceed the Maximum Permissible Deadweight Moment at that displacement. Figure below illustrates this type of diagram. The ship's displacement in tonnes is plotted on the vertical axis from 1500 to 4000 tonnes while the Deadweight Moments in tonnes metres are plotted on the horizontal axis.

From this diagram it can be seen that, for example, the Maximum Deadweight Moment for this ship at a displacement of 3000 tonnes is 10260 tonnes metres (Point 1). If the light displacement for this ship is 1000 tonnes then the Deadweight at this displacement is 2000 tonnes. The maximum kg for the Deadweight tonnage is given by:

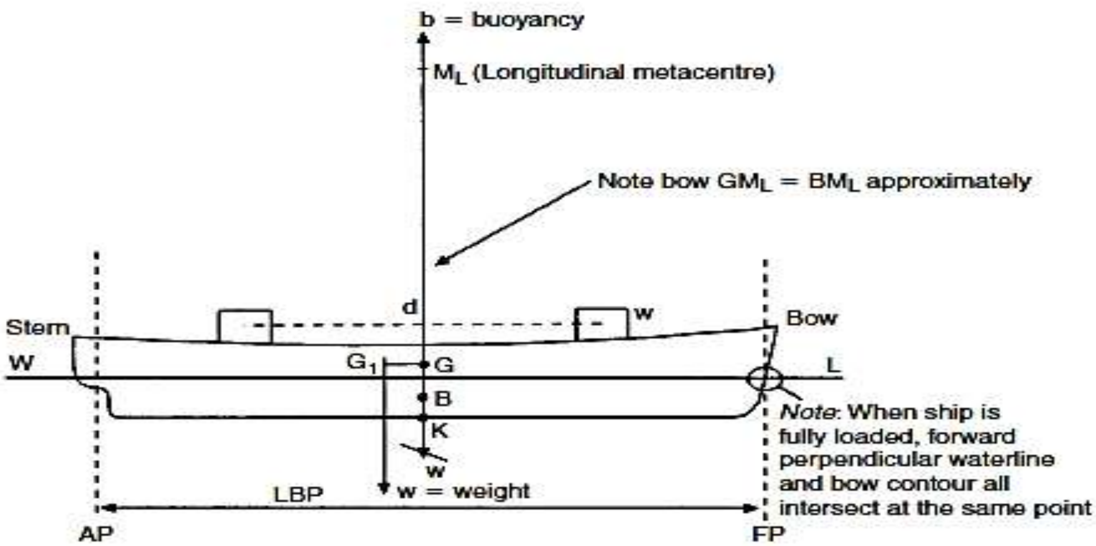
$$\text{Maximum kg} = \frac{\text{Deadweight Moment}}{\text{Deadweight}} = \frac{10\,260}{2000} = 5.13\,\text{m}$$



Trim and List

Trim may be considered as the longitudinal equivalent of list. Trim is also known as ‘longitudinal stability’. It is in effect transverse stability turned through 90°. Instead of trim being measured in degrees it is measured as the difference between the drafts forward and aft. If difference is zero then the ship is on even keel. If forward draft is greater than aft draft, the vessel is trimming *by the bow*. If aft draft is greater than the forward draft, the vessel is trimming *by the stern*.

Consider a ship to be floating at rest in still water and on an even keel as shown in Figure below.
The centre of gravity (G) and the centre of buoyancy (B) will be in the same vertical line and the ship will be displacing her own weight of water. So W = b.



Now let a weight 'w', already on board, be shifted aft through a distance 'd', as shown in Figure above. This causes the centre of gravity of the ship to shift from G to G1, parallel to the shift of the centre of gravity of the weight shifted, so that:

$$GG_1 = \frac{w \times d}{W}$$

or

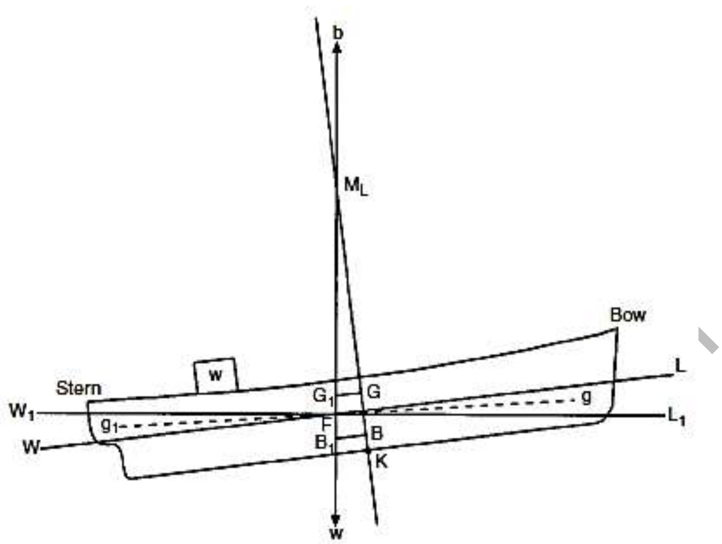
$$W \times GG_1 = w \times d$$

A trimming moment of $W \times GG_1$ is thereby produced.
But

$$W \times GG_1 = w \times d$$

$$\therefore \text{The trimming moment} = w \times d$$

The ship will now trim until the centres of gravity and buoyancy are again in the same vertical line, as shown in the figure below. When trimmed, the wedge of buoyancy LFL1 emerges and the wedge WFW1 is immersed. Since the ship, when trimmed, must displace the same weight of water as when on an even keel, the volume of the immersed wedge must be equal to the volume of the emerged wedge and F, the point about which the ship trims, is the centre of gravity of the water-plane area. The point F is called the 'centre of flotation' or 'tipping centre'.



A vessel with a rectangular water-plane has its centre of flotation on the centre line amidships but, on a ship, it may be a little forward or abaft amidships, depending on the shape of the water-plane. In trim problems, unless stated otherwise, it is to be assumed that the centre of flotation is situated amidships.
Trimming moments are taken about the centre of flotation since this is the point about which rotation takes place.
The longitudinal metacentre (ML) is the point of intersection between the verticals through the longitudinal positions of the centres of buoyancy. The vertical distance between the centre of gravity and the longitudinal metacenter (GML) is called the longitudinal metacentric height.
BML is the height of the longitudinal metacentre above the centre of buoyancy and is found for any shape of vessel by the formula:

$$BM_L = \frac{I_L}{V}$$

where

I_L = the longitudinal second moment of the water-plane about the centre of flotation
V = the vessel's volume of displacement

The derivation of this formula is similar to that for finding the transverse BM.

For a rectangular water-plane area:

$$I_L = \frac{BL^3}{12}$$

where

L = the length of the water-plane
B = the breadth of the water-plane

Thus, for a vessel having a rectangular water-plane:

$$BM_L = \frac{BL^3}{12V}$$

For a box-shaped vessel:

$$BM_L = \frac{I_L}{V} = \frac{BL^3}{12V} = \frac{BL^3}{12 \times L \times B \times d}$$

$$BM_L = \frac{L^2}{12d}$$

where

L = the length of the vessel
d = the draft of the vessel

Hence, BM_L is independent of ships Br. Mld

For a triangular prism:

$$BM_L = \frac{I_L}{V} = \frac{BL^3}{12 \times \frac{1}{2} \times L \times B \times d}$$

$$BM_L = \frac{L^2}{6d}$$, so again is independent of Br. Mld

It should be noted that the distance BG is small when compared with BML or GML and, for this reason, BML may, without appreciable error, be substituted for GML in the formula for finding MCT 1 cm.

Nemoto´s Formula

When utmost accuracy is required, as in draught surveys for quantity loaded or discharged, a second correction for trim, using Nemoto´s formula, may be applied to the displacement. It is usually only applied when the trim exceeds 1% of the ship´s length.

Correction (tonnes) = $t^2x50/L = dM/dZ$

Where: t is the trim in metres
L is the length between perpendiculars in metres
d is the mean draught

dM/dZ = MCT 1cm at (d+0.5)m – MCT 1cm at (d-0.5)m

The correction is always added to the displacement.

Dynamical Stability

Dynamical stability is defined as the work done in inclining a ship.
Consider the ship shown in the Figure below. When the ship is upright the force ‘W’ acts upwards through B and downwards through G. These forces act throughout the inclination; b = w.

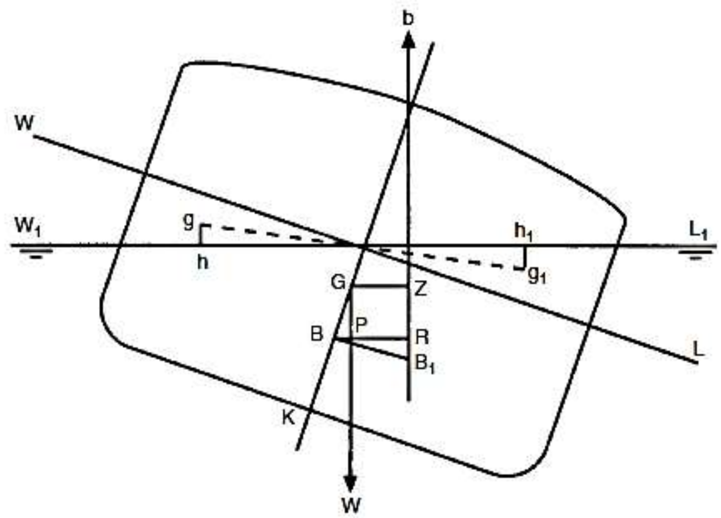


Fig. 23.1

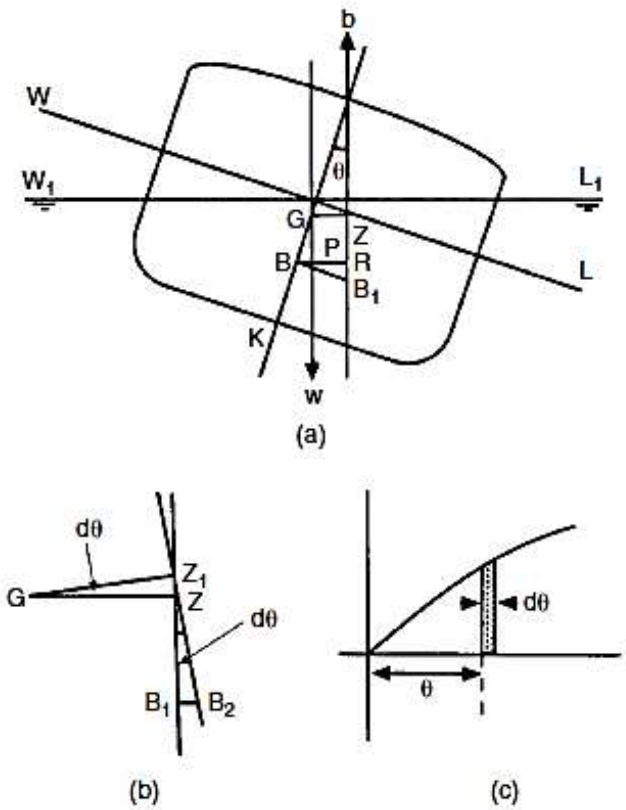
Work done = Weight × Vertical separation of G and B

$$\text{Dynamical stability} = W \times (B_1Z - BG)$$
$$= W \times (B_1R + RZ - BG)$$

$$= W \times \left[\frac{v(gh + g_1h_1)}{V} + PG - BG\right]$$
$$= W \times \left[\frac{v(gh + g_1h_1)}{V} + BG\cos\theta - BG\right]$$
$$\text{Dynamical stability} = W\left[\frac{v(gh + g_1h_1)}{V} - BG(1 - \cos\theta)\right]$$

This is known as *Moseley's formula* for dynamical stability.
If the curve of statical stability for a ship has been constructed the dynamical stability to any angle of heel may be found by multiplying the area under the curve to the angle concerned by the vessel's displacement. i.e.

The derivation of this formula is as follows:
Dynamical stability = W x Area under the stability curve



Consider in the Figure above (a) which shows a ship heeled to an angle ɵ. Now let the ship be heeled through a further very small angle dɵ. The centre of buoyancy B_1 will move parallel to W_1L_1 to the new position B2 as shown in Figure (b) above.

B_2Z_1 is the new vertical through the centre of buoyancy and GZ_1 is the new righting arm. The vertical separation of Z and Z_1 is therefore GZ x dɵ.
But this is also the vertical separation of B and G. Therefore the dynamical stability from _ to (ɵ + dɵ) is W x (GZ x dɵ).
Refer now to Figure (c) above which is the curve of statical stability for the ship. At ɵ the ordinate is GZ. The area of the strip is GZ x dɵ. But W x (GZ x dɵ) gives the dynamical stability from ɵ to (ɵ + d ɵ), and this must be true for all small additions of inclination:

$$\therefore \text{Dynamical stability} = \int_0^{\theta} W \times GZ \times d\theta$$
$$= W\int_0^{\theta} GZ\, d\theta$$

Therefore the dynamical stability to any angle of heel is found by multiplying the area under the stability curve to that angle by the displacement.

It should be noted that in finding the area under the stability curve by the use of Simpson's Rules, the common interval must be expressed in radians:

$$57.3^\circ = 1 \text{ radian}$$
$$1^\circ = \frac{1}{57.3} \text{ radians}$$

or

$$x^\circ = \frac{x}{57.3} \text{ radians}$$

Therefore to convert degrees to radians simply divide the number of degrees by 57.3.

Inclining Test

<u>Preparations for the inclining test</u>

Free surface and tankage

If there are liquids on board the ship when it is inclined, whether in the bilges or in the tanks, they will shift to the low side when the ship heels. This shift of liquids will exaggerate the heel of the ship.

Unless the exact weight and distance of liquid shifted can be precisely calculated, the metacentric height (GM) calculated from the incline test will be in error. Free surface should be minimized by emptying the tanks completely and making sure all bilges are dry; or by completely filling the tanks so that no shift of liquid is possible. The latter method is not the optimum because air pockets are difficult to remove from between structural members of a tank, and the weight and centre of the liquid in a full tank should be accurately determined in order to adjust the lightship values accordingly. When tanks must be left slack, it is desirable that the sides of the tanks be parallel vertical planes and the tanks be regular in shape (i.e. rectangular, trapezoidal, etc.) when viewed from above, so that the free surface moment of the liquid can be accurately determined. For example, the free surface moment of the liquid in a tank with parallel vertical sides can be readily calculated by the formula: $\mathbf{Ib^3/12Q}$

where:

I = length of tank (m)

b = breadth of tank (m)

Q = specific volume of liquid in tank (m^3/t) (Measure Q directly with a hydrometer).

Free surface correction (m) = $\frac{\sum(FSM(1) + FSM(2) + \cdots + FSM(X))}{\nabla}$

where:

FSM = free surface moment (m-t)

Δ = displacement (t)

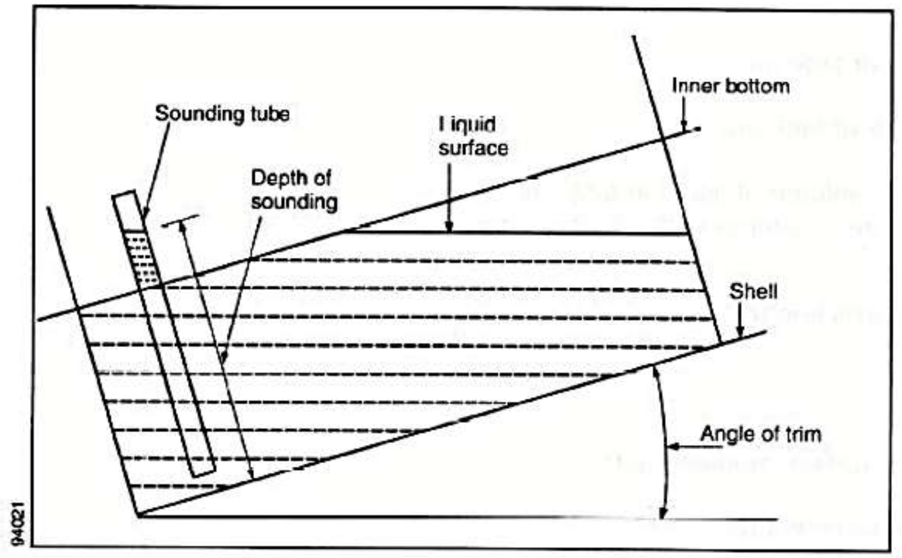
Free surface correction is independent of the height of the tank in the ship, location of the tank, and direction of heel. As the width of the tank increases, the value of free surface moment increases by the third power. The distance available for the liquid to shift is the predominant factor. This is why even the smallest amount of liquid in the bottom of a wide tank or bilge is normally unacceptable and should be removed prior to the inclining experiment. Insignificant amounts of liquids in V-shaped tanks or voids (e.g. a chain locker in the bow), where the potential shift is negligible, may remain if removal of the liquid would be difficult or would cause extensive delays.

Free surface and slack tanks - The number of slack tanks should normally be limited to one port/starboard pair or one centreline tank of the following:

1. fresh water reserve feed tanks;
2. fuel/diesel oil storage tanks;
3. fuel/diesel oil day tanks;
4. lube oil tanks;
5. sanitary tanks; or
6. potable water tanks.

To avoid pocketing, slack tanks should normally be of regular (i.e. rectangular, trapezoidal, etc.) cross section and be 20% to 80% full if they are deep tanks and 40% to 60% full if they are double bottom tanks. These levels ensure that the rate of shifting of liquid remains constant throughout the heel angles of the inclining test. If the trim changes as the ship is inclined, then consideration should also be given to longitudinal pocketing. Slack tanks containing liquids of sufficient viscosity to prevent free movement of the liquids, as the ship is inclined (such as bunker at low temperature), should be avoided since the free surface cannot be calculated accurately. A free surface correction for such tanks should not be used unless the tanks are heated to reduce viscosity. Communication between tanks should never be allowed. Cross connections, including those via manifolds, should be closed. Equal liquid levels in slack tank pairs can be a warning sign of open cross connections. A bilge, ballast, and fuel oil piping plan can be referred to, when checking for cross connection closures.

Pressed up tanks - "Pressed up" means completely full with no voids caused by trim or inadequate venting. Anything less than 100% full, for example the 98% condition regarded as full for operational purposes, is not acceptable. Preferably, the ship should be rolled from side to side to eliminate entrapped air before taking the final sounding. Special care should be taken when pressing fuel oil tanks to prevent accidental pollution. An example of a tank that would appear "pressed up", but actually contains entrapped air is shown in figure below.



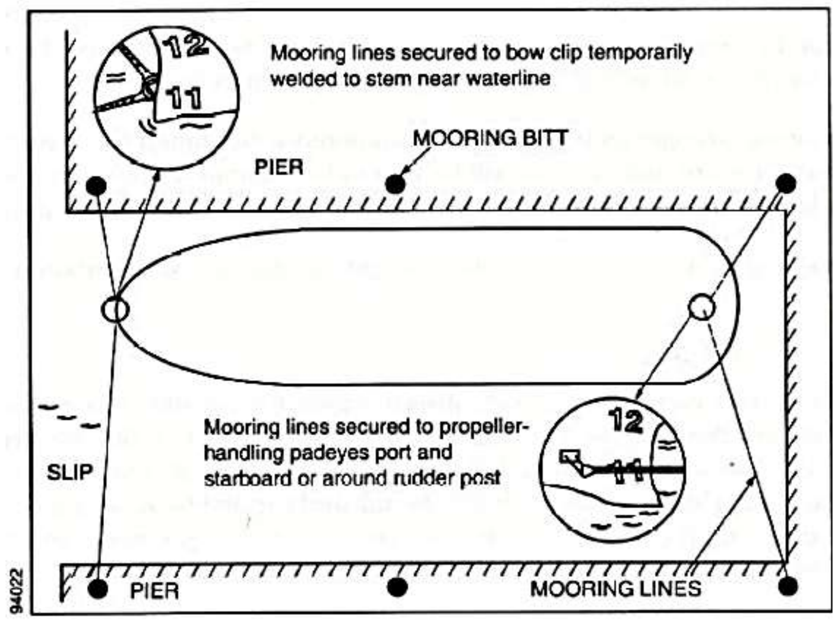
Empty tanks - It is generally not sufficient to simply pump tanks until suction is lost. Enter the tank after pumping to determine if final stripping with portable pumps or by hand is necessary. The exceptions are very narrow tanks or tanks where there is a sharp deadrise, since free surface would be negligible. Since all empty tanks should be inspected, all manholes should be open and the tanks well ventilated andcertified as safe for entry. A safe testing device should be on hand to test for sufficient oxygen and minimum toxic levels. A certified marine chemist's certificate certifying that all fuel oil and chemical tanks are safe for human entry should be available, if necessary.

Mooring arrangements

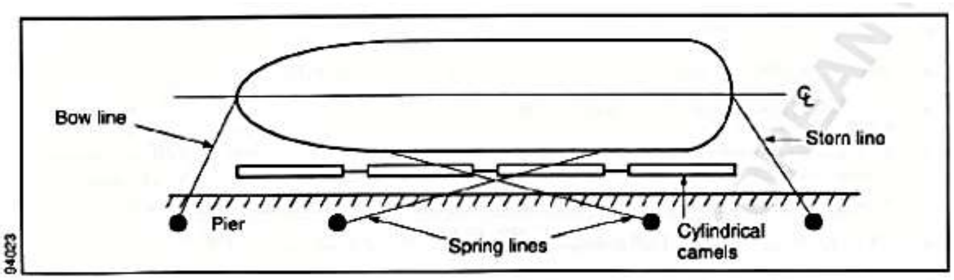
The importance of good mooring arrangements cannot be overemphasized. The arrangement selection will be dependent upon many factors. Among the most important are depth of water, wind, and current effects.

Whenever possible the ship should be moored in a quiet, sheltered area free from extraneous forces such as propeller wash from passing vessels, or sudden discharges from shore side pumps. The depth of water under the hull should be sufficient to ensure that the hull will be entirely free of the bottom. The tide conditions and the trim of the ship during the test, should be considered. Prior to the test, the depth of water should be measured and recorded in as many locations as necessary to ensure the ship will not contact the bottom. If marginal, the test should be conducted during high tide or the ship moved to deeper water.

The ship should be held by lines at the bow and the stern, attached to temporary pad eyes installed as close as possible to the centreline of the ship and as near the water line as practical. If temporary pad eyes are not feasible then lines can be secured to bollards and/or cleats on the deck. This arrangement requires that the lines be slackened when the ship is heeled away from the dock. The preferred arrangement is with the ship lying in a slip where it can be moored as shown in figure below. In this case, the lines can be kept taut to hold the ship in place, yet allow unrestricted heeling. Note, however, that wind and/or current may cause a superimposed heeling moment to act on the ship throughout the test. For steady conditions this will not affect the results. Gusty wind or uniformly varying wind and/or current will cause these superimposed heeling moments to change, which may require additional test points to obtain a valid test. The need for additional test points can be determined by plotting test points as they are obtained.



Where the ship can be moored to one side only, it is good practice to supplement the bow and stern lines with two spring lines in order to maintain positive control of the ship, as shown in figure below. The leads of the spring lines should be as long as practicable. Cylindrical camels should be provided between the ship and the dock. All lines should be slack, with the ship free of the pier and camels, when taking readings



If the ship is held off the pier by the combined effect of the wind and current, and the bow and stern lines are secured at centreline near the waterline, they can be taut. This is essentially the same as the preferred arrangement described above. Varying wind and/or current will cause some distortion of the plot.

If the ship is pressed against the camels by wind and/or current, all lines should be slack. The cylindrical camels will prevent binding but again there will be an unavoidable superimposed heeling moment due to the ship bearing against the camels. This condition should be avoided but when used, consideration should be given to pulling the ship free of the dock and camels, and letting the ship drift as readings are taken.

Another acceptable arrangement is where the combined wind and current are such that the ship may be controlled by only one line at either the bow or the stern. In this case the control line need not be attached near the waterline, but it should be led from on or near the centre line of the ship. With all lines but one slack, the ship is free to veer with the wind and/or current as readings are taken. This can sometimes be troublesome because varying wind and/or current can cause distortion of the plot.

Alternate mooring arrangements should be considered if submitted for review prior to the test.

Such arrangements should ensure that the ship will be free to list without restraint for a sufficient period of time to allow the pendulums to damp out motion so that the readings can be recorded.

If a floating crane is used for handling inclining weights, it should not be moored to the ship.

Test weights

Weights, such as porous concrete, that can absorb significant amounts of moisture, should only be used if they are weighed just prior to the inclining test or if recent weight certificates are presented. Each weight should be marked with an identification number and its weight. For small ships, drums completely filled with water may be used. Drums should normally be full and capped to allow accurate weight control.

In such cases, the weight of the drums should be verified in the presence of the Administration representative using a recently calibrated scale.

Heeling the ship by liquid transfer should only be adopted when large ships with high GMs make solid weight transfer impracticable.

Precautions should be taken to ensure that the decks are not overloaded during weight movements. If deck strength is questionable then a structural analysis should be performed to determine if existing framing can support the weight.

Generally, the test weights should be positioned as far outboard as possible on the upper deck. The test weights should be on board and in place prior to the scheduled time of the inclining test.

Where water ballast is permitted, the following should be complied with:

1. inclining tanks should be wall sided and free of large stringers (air pockets).
2. tanks should be directly opposite to maintain ship's trim.
3. specific gravity of ballast water should be measured and recorded.
4. pipe lines to inclining tanks should be full.
5. all ballast valves should be closed prior to the test. Strict valve control should be maintained during the test. If the water is transferred through manifolds or valve boxes, all valves to the branches not used should be tagged or locked to prevent opening during the test.
6. all inclining tanks, should be manually sounded before and after each shift.
7. calculations should account for the change of the VCG during test.
8. accurate sounding/ullage tables should be provided.

Pendulums

The pendulums should be long enough to give a measured deflection, to each side of upright, of at least 15cm. Generally, this will require a pendulum length of at least 3 m. It is recommended that pendulum lengths of 4-6 m be used. Usually, the longer the pendulum the greater the accuracy of the test; however, if excessively long pendulums are used on a tender ship the pendulums may not settle down and the accuracy of the pendulums would then be questionable. If the pendulums are of different lengths, the possibility of collusion between station recorders is avoided.

On smaller ships, where there is insufficient headroom to hang long pendulums, the 15 cm deflection should be obtained by increasing the test weight so as to increase the heel. On most ships the typical inclination is between one and four degrees.

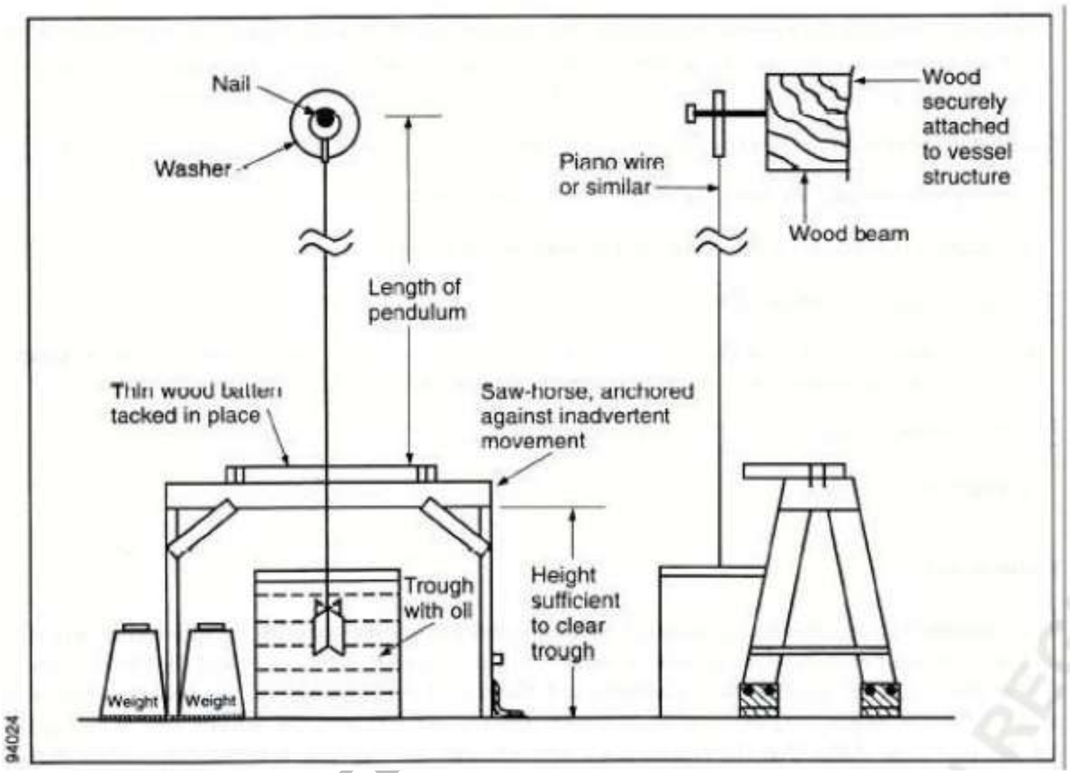
The pendulum wire should be piano wire or other monofilament material. The top connection of the pendulum should afford unrestricted rotation of the pivot point. An example is that of a washer with the pendulum wire attached suspended from a nail.

A trough filled with a liquid should be provided to dampen oscillations of the pendulum after each weight movement. It should be deep enough to prevent the pendulum weight from touching the bottom.

The use of a winged plumb bob at the end of the pendulum wire can also help to dampen the pendulum oscillations in the liquid.

The battens should be smooth, light-coloured wood, 1 to 2 cm thick, and should be securely fixed in position so that an inadvertent contact will not cause them to shift. The batten should be aligned close to the pendulum wire but not in contact with it.

A typical satisfactory arrangement is shown in figure below. The pendulums may be placed in any location on the ship, longitudinally and transversely. The pendulums should be in place prior to the scheduled time of the inclining test.



It is recommended that inclinometers or other measuring devices only be used in conjunction with at least one pendulum.

Where a U-tube is used, the following should be complied with:

1. the ends of the device should be securely positioned as far outboard as possible.
2. arrangements should be made for recording all readings at both ends. For easy reading and checking for air pockets clear plastic tube or hose should be used throughout.
3. the horizontal distance between ends should be sufficient to obtain a level difference of at least 15 cm between the upright and the maximum inclination to each side.

Equipment required

Besides the physical equipment necessary such as the inclining weights, pendulums, small boat, etc., the following are necessary and should be provided by or made available to the person in charge of the inclining:

1. engineering scales for measuring pendulum deflections (rules should be subdivided sufficiently to achieve the desired accuracy);
2. sharp pencils for marking pendulum deflections;
3. chalk for marking the various positions of the inclining weights;
4. a sufficiently long measuring tape for measuring the movement of the weights and locating different items on board;
5. a sufficiently long sounding tape for sounding tanks and taking freeboard readings;
6. one or more well maintained specific gravity hydrometers with range sufficient to cover 0.999 to 1.030, to measure the specific gravity of the water in which the ship is floating (a hydrometer for measuring specific gravity of less than 1.000 may be needed in some locations);
7. other hydrometers as necessary to measure the specific gravity of any liquids on board;
8. graph paper to plot inclining moments versus tangents;
9. a straight edge to draw the measured waterline on the lines drawing;
10. a pad of paper to record data;
11. an explosion proof testing device to check for sufficient oxygen and absence of lethal gases in tanks and other closed spaces such as voids and cofferdams;
12. a thermometer; and
13. draught tubes (if necessary).

Test procedure

The inclining experiment, the freeboard/draught readings and the survey may be conducted in any order and still achieve the same results. If the person conducting the inclining test is confident that the survey will show that the ship is in an acceptable condition and there is the possibility of the weather becoming unfavourable, then it is suggested that the inclining be performed first and the survey last. If the person conducting the test is doubtful that the ship is complete enough for the test, it is recommended that the survey be performed first since this could invalidate the entire test, regardless of the weather conditions. It is very important that all weights, the number of people on board, etc., remain constant throughout the test.

Initial walk through and survey

The person responsible for conducting the inclining test should arrive on board the ship well in advance of the scheduled time of the test to ensure that the ship is properly prepared for the test. If the ship to be inclined is large, a preliminary walk through may need to be done the day preceding the actual incline. To ensure the safety of personnel conducting the walk through, and to improve the documentation of surveyed weights and deficiencies, at least two persons should make the initial walk through. Things to check include: all compartments are open, clean, and dry, tanks are well ventilated and gas free, movable or suspended items are secured and their position documented, pendulums are in place, weights are on board and in place, a crane or other method for moving weights is available, and the necessary plans and equipment are available Before beginning the inclining test, the person conducting the test should:

1. consider the weather conditions. The combined adverse effect of wind, current and sea may result in difficulties or even an invalid test due to the following:
    a. inability to accurately record freeboards and draughts;
    b. excessive or irregular oscillations of the pendulums;
    c. variations in unavoidable superimposed heeling moments.

In some instances, unless conditions can be sufficiently improved by moving the ship to a better location, it may be necessary to delay or postpone the test. Any significant quantities of rain, snow, or ice should be removed from the ship before the test. If bad weather conditions are detected early enough and the weather forecast does not call for improving conditions, the Administration representative should be advised prior to departure from the office and an alternate date scheduled;

2. make a quick overall survey of the ship to make sure the ship is complete enough to conduct the test and to ensure that all equipment is in place. An estimate of items which will be outstanding at the time of the inclining test should be included as part of any test procedure submitted to the Administration. This is required so that the Administration representative can advise the shipyard/naval architect if in their opinion the ship will not be sufficiently complete to conduct the incline and that it should be rescheduled.
   If the condition of the ship is not accurately depicted in the test procedure and at the time of the inclining test the Administration representative considers that the ship is in such condition that an accurate incline cannot be conducted, the representative may refuse to accept the incline and require that the incline be conducted at a later date;

3. enter all empty tanks after it is determined that they are well ventilated and gas free to ensure that they are dry and free of debris. Ensure that any pressed up tanks are indeed full and free of air pockets. The anticipated liquid loading for the incline should be included in the procedure required to be submitted to the Administration;
4. survey the entire ship to identify all items which need to be added to the ship, removed from the ship, or relocated on the ship to bring the ship to the lightship condition. Each item should be clearly identified by weight and vertical and longitudinal location. If necessary, the transverse location should also be recorded. The inclining weights, the pendulums, any temporary equipment and dunnage, and the people on board during the inclining test are all among the weights to be removed to obtain the lightship condition. The person calculating the lightship characteristics from the data gathered during the incline and survey and/or the person reviewing the inclining test may not have been present during the test and should be able to determine the exact

location of the items from the data recorded and the ship's drawings. Any tanks containing liquids should be accurately sounded and the soundings recorded;

a. it is recognized that the weight of some items on board, or that are to be added, may have to be estimated. If this is necessary, it is in the best interest of safety to be on the safe side when estimating, so the following rules of thumb should be followed:
   - ✓ when estimating weights to be added:
     - estimate high for items to be added high in the ship.
     - estimate low for items to be added low in the ship.
     - when estimating weights to be removed:
     - estimate low for items to be removed from high in the ship.
     - estimate high for items to be removed from low in the ship.
   - ✓ when estimating weights to be relocated:
     - estimate high for items to be relocated to a higher point in the ship.
     - estimate low for items to be relocated to a lower point in the ship.

Freeboard/draught readings

Freeboard/draught readings should be taken to establish the position of the waterline in order to determine the displacement of the ship at the time of the inclining test. It is recommended that at least five freeboard readings, approximately equally spaced, be taken on each side of the ship or that all draught marks (forward, midship, and aft) be read on each side of the ship. Draught mark readings should be taken to assist in determining the waterline defined by freeboard readings, or to verify the vertical location of draught marks on ships where their location has not been confirmed. The locations for each freeboard reading should be clearly marked. The longitudinal location along the ship should be accurately determined and recorded since the (moulded) depth at each point will be obtained from the ship's lines. All freeboard measurements should include a reference note clarifying the inclusion of the coaming in the measurement and the coaming height.

Draught and freeboard readings should be read immediately before or immediately after the inclining test. Weights should be on board and in place and all personnel who will be on board during the test including those who will be stationed to read the pendulums, should be on board and in location during these readings. This is particularly important on small ships. If readings are made after the test, the ship should be maintained in the same condition as during the test. For small ships, it may be necessary to counterbalance the list and trim effects of the freeboard measuring party. When possible, readings should be taken from a small boat.

A small boat should be available to aid in the taking of freeboard and draught mark readings. It should have low freeboard to permit accurate observation of the readings.

The specific gravity of the flotation water should be determined at this time. Samples should be taken from a sufficient depth of the water to ensure a true representation of the flotation water and not merely surface water, which could contain fresh water from run off of rain. A hydrometer should be placed in a water sample and the specific gravity read and recorded. For large ships, it is recommended that samples of the flotation water be taken forward, midship, and aft and the readings averaged. For small ships, one sample taken from midships should be sufficient. The temperature of the water should be taken and the measured specific gravity corrected for deviation from the standard, if necessary. A correction to water specific gravity is not necessary if the specific gravity is determined at the inclining experiment site.

Correction is necessary if specific gravity is measured when sample temperature differs from the temperature at the time of the inclining (e.g., if check of specific gravity is done at the office).

A draught mark reading may be substituted for a given freeboard reading at that longitudinal location if the height and location of the mark has been verified to be accurate by a keel survey while the ship was in dry dock.

A device, such as a draught tube, can be used to improve the accuracy of freeboard/draught readings by damping out wave action.

The dimensions given on a ship's lines drawing are normally moulded dimensions. In the case of depth, this means the distance from the inside of the bottom shell to the inside of the deck plate. In order to plot the ship's waterline on the lines drawing, the freeboard readings should be converted to moulded draughts. Similarly, the draught mark readings should be corrected from extreme (bottom of keel) to moulded (top of keel) before plotting. Any discrepancy between the freeboard/draught readings should be resolved.

The mean draught (average of port and starboard reading) should be calculated for each of the locations where freeboard/draught readings are taken and plotted on the ship's lines drawing or outboard profile to ensure that all readings are consistent and together define the correct waterline. The resulting plot should yield either a straight line or a waterline which is either hogged or sagged. If inconsistent readings are obtained, the freeboards/draughts should be retaken.

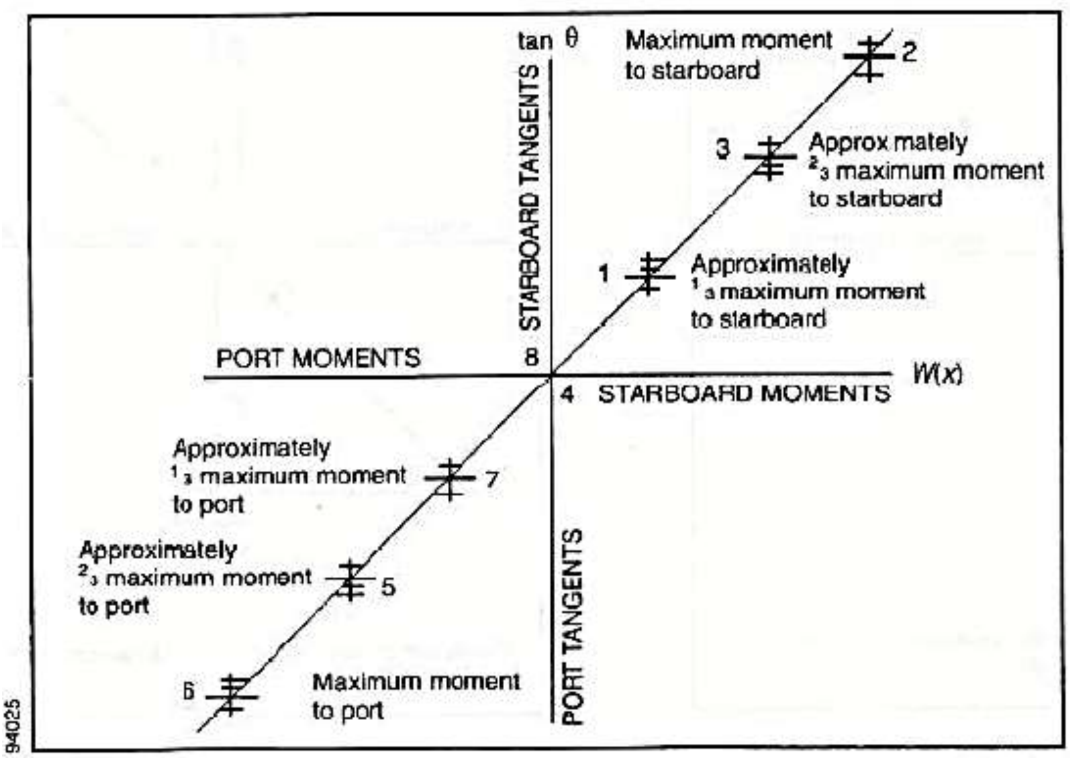
The incline

Prior to any weight movements the following should be checked:

1. the mooring arrangement should be checked to ensure that the ship is floating freely. (This should be done just prior to each reading of the pendulums).
2. the pendulums should be measured and their lengths recorded. The pendulums should be aligned so that when the ship heels, the wire will be close enough to the batten to ensure an accurate reading but will not come into contact with the batten. The typical satisfactory arrangement is shown in figure below.

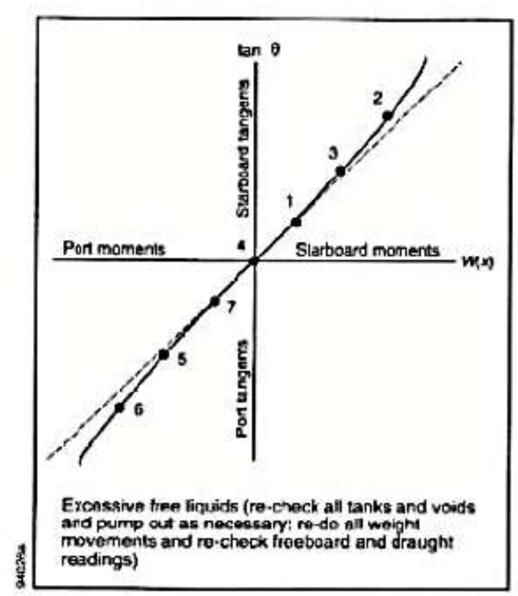
3. the initial position of the weights is marked on the deck. This can be done by tracing the outline of the weights on the deck.
4. the communications arrangement is adequate.
5. all personnel are in place.

A plot should be run during the test to ensure that acceptable data is being obtained. Typically, the abscissa of the plot will be heeling moment (weight times distance) and the ordinate will be the tangent of the heel angle (deflection of the pendulum divided by the length of the pendulum). This plotted line does not necessarily pass through the origin or any other particular point for no single point is more significant than any other point. A linear regression analysis is often used to fit the straight line. The weight movements shown in figure below give a good spread of points on the test plot.



Plotting all of the readings for each of the pendulums during the inclining experiment aids in the discovery of bad readings. Since (W)(x)/tan θ should be constant, the plotted line should be straight. Deviations from a straight line are an indication that there were other moments acting on the ship during the inclining.

These other moments should be identified, the cause corrected, and the weight movements repeated until a straight line is achieved. Figures below illustrate examples of how to detect some of these other moments during the inclining, and a recommended solution for each case. For simplicity, only the average of the readings is shown on the inclining plots.



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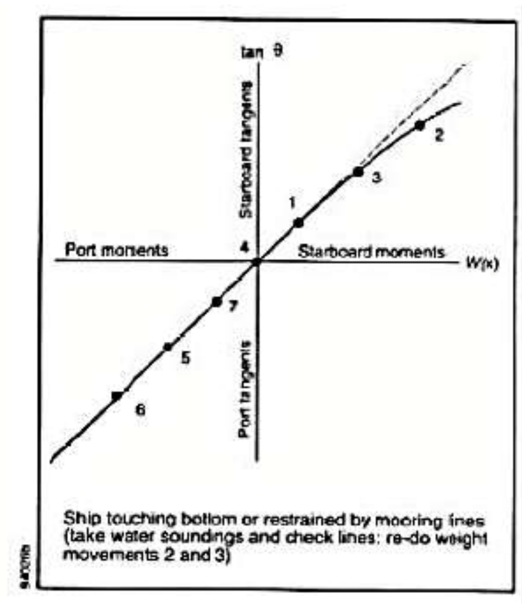
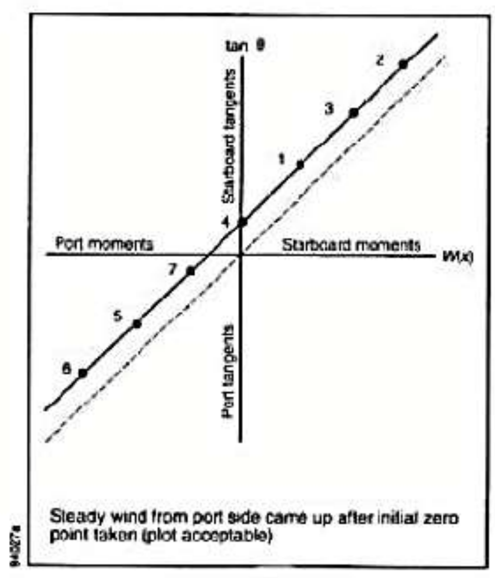
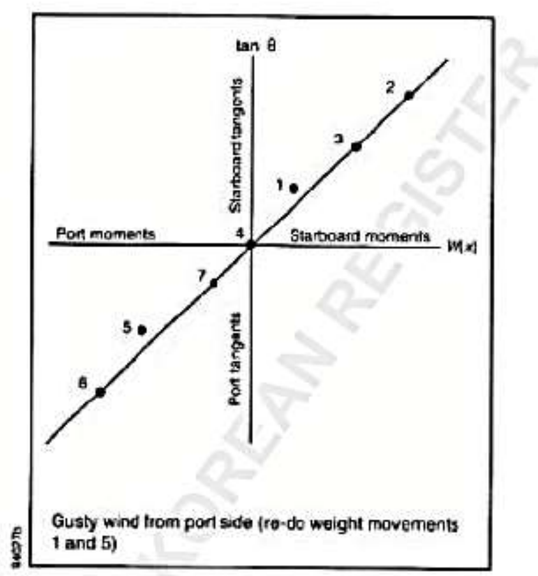


Figure A1-4.3.2-3





Once everything and everyone is in place, the zero position should be obtained and the remainder of the experiment conducted as quickly as possible, while maintaining accuracy and proper procedures, in order to minimize the possibility of a change in environmental conditions during the test.

Prior to each pendulum reading, each pendulum station should report to the control station when the pendulum has stopped swinging. Then, the control station will give a "standby" warning and then a "mark" command. When "mark" is given, the batten at each position should be marked at the location of the pendulum wire. If the wire was oscillating slightly, the centre of the oscillations should be taken as the mark. If any of the pendulum readers does not think the reading was a good one, the reader should advise the control station and the point should be retaken for all pendulum stations. Likewise, if the control station suspects the accuracy of a reading, it should be repeated for all the pendulum stations. Next to the mark on the batten should be written the number of the weight movement, such as zero for the initial position and one through seven for the weight movements.

Each weight movement should be made in the same direction, normally transversely, so as not to change the trim of the ship. After each weight movement, the distance the weight was moved (centre to centre) should be measured and the heeling moment calculated by multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum by dividing the deflection by the length of the pendulum. The resultant tangents are plotted on the graph. Provided there is good agreement among the pendulums with regard to the tan θ value, the average of the pendulum readings may be graphed instead of plotting each of the readings.

Inclining data sheets should be used so that no data is forgotten and so that the data is clear, concise, and consistent in form and format. Prior to departing the ship, the person conducting the test and the Administration representative should initial each data sheet as an indication of their concurrence with the recorded data.

See more information in Code on intact stability for all types of ships covered by IMO; RESOLUTION A.749(18); Adopted on 4 November 1993.

Recommendations on Intact Stability for Passenger and CARGO Ship Under 100 metres in length

Recommended Criteria

The following criteria are recommended for passenger and cargo ships:

a. The area under the righting lever curve (GZ curve) should not be less than 0.055 metre-radians up to θ= 30° angle of heel and not less than 0.09 metre-radians up to θ= 40° or the angle of flooding θ_f* if this angle is less than 40°
Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30° and θ_f*, if this angle is less than 40° , should not be less than 0.03 metre-radians.

*θ is an angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

b. The righting lever GZ should be at least 0.20 m. at an angle of heel equal to or greater than 30°.
c. The righting lever GZ should be at least 0.20 m. at an angle of heel equal to or greater than 30°.
d. The maximum righting arm should occur at an angle of heel preferably exceeding 30° but not less than 25°
e. the initial metacentric height GM○should not be less than 0.15 m.

The following additional criteria are recommnended for passenger ships:

a. The angle of heel on account of crowding of passengers to one side as defined in Appendix II 2.(9) should not exceed 10° .
b. The angle of heel on account turning should not exceed 10° when calculated using the following formula:

$$M_R = 0.02 \frac{V_o^2}{L} \Delta (KG - \frac{d}{2})$$

where :

M_R = heeling moment in metre-tons,

V_o = service speed in m./sec,

L = length of ship at waterline in m.,

Δ = displacement in metric tons,

d = mean draught in m.,

KG = height of centre of gravity above keel in m.

The criteria mentioned minimum values, but no maximúm values are recommended. It is advisable to avoid excessive values, since these might lead to acceleration forces which could be prejudicial to the ship, its complement, its equipment and to the safe carriage of the cargo.
Where anti-rolling devices are installed in a ship the Adminiatration should be satisfied that the above criteria can be maintained when the devices are in operation.
A number of influences such as beam wind on ships with large windage area, icing of topsides , water trapped on deck, rolling characteristics, following seas, etc. adversely affect stability and the Administration is advised to take these into account so far as is deemed necessary.
Regard should be paid to the possible adverse effects on stability where certain bulk cargoes are carried. In this connexion attention should be paid to the Code of Safe Practice

for Bulk Cargoes. Ships carrying grain in bulk should comply with the criteria mentioned in addition to the stability requirements in Chapter VI of the International Convention for the Safety of Life at Sea, 1960.

Inclining Test

When construction is finished , each ship should undergo an inclining test , actual displacement and coordinates of the centre of gravity being determined for the light ship condition.

The Administration may allow the inclining test of an individual ship to be dispensed with provided basic stability data are available from the inclining test of a sister ship.

Stability Information

The master of any ship to which the present Recommendation applies should receive information which will enable him to assess with ease and certainty the stability of his ship in different service conditions. A duplicate of this information should be communicated to the Administration.

Stability information should comprise:

i. Stability characteristic8 of typical loading conditions;
ii. Information in the form. of tables or diagrams which will enable the master to assess the stability of his ship and verify whether it is sufficient in all loading conditions differing from the standard ones. This information should include, in particular , a curve or table giving, as a function of the draughts , the required initial metacentric height (or any other stability parameter) which ensures that the stability is in compliance with the criteria given in 5.a. above;
iii. Information on. the proper use of anti-rolling devices if these are installed in the ship;
iv. Additionally, information enabling the ship's master to determine the initial metacentric height by means of rolling test as described in the Appendix to the Memorandum to Administrations reproduced at Appendix III would be desirable;
v. Notes on the corrections to be made to the initial metacentric height take account of free surface liquids.

For more information see in RESOLUTION A.167 (ES. IV) Superseded by A.749(18); Recommendation on intact stability for passenger and cargo ships under 100 metres in length

Rolling of Ships

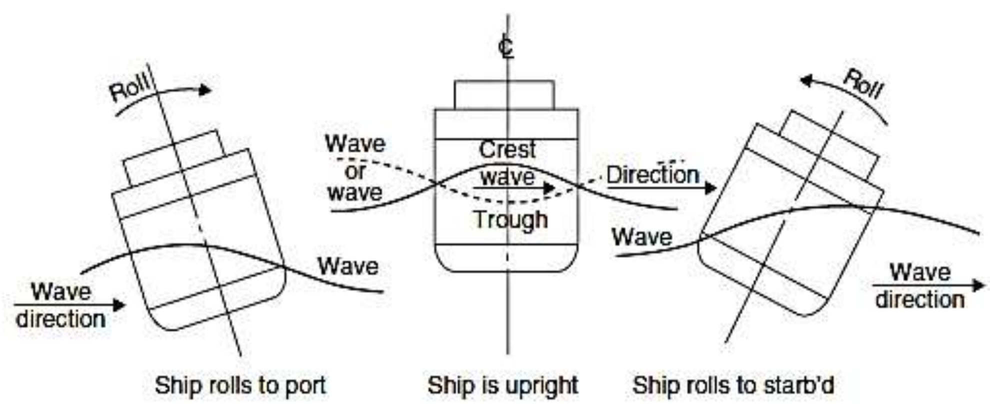
Synchronous rolling of ships

Synchronous rolling is caused by the ship's rolling period TR becoming synchronous or resonant with the wave period. When this occurs, the ship will heel over and, in exceptional circumstances, be rolled further over by the action of the wave.

Consequently, there is a serious danger that the vessel will heel beyond a point or angle of heel from which it cannot return to an upright condition.

The ship ends up having negative stability, and will capsize.
In Figure below shows a ship with synchronous rolling problems.
To reduce synchronous rolling:

1. Use water ballast changes to alter the KG of the vessel. This should alter the GMT and hence the natural rolling period TR to a non-synchronous value.
2. Change the course heading of the ship so that there will be a change in the approaching wave frequencies. In other words, introduce a yawing effect.



Synchronous rolling in waves

3. Alter the ship's speed until synchronism or resonance no longer exists with the wave frequency.

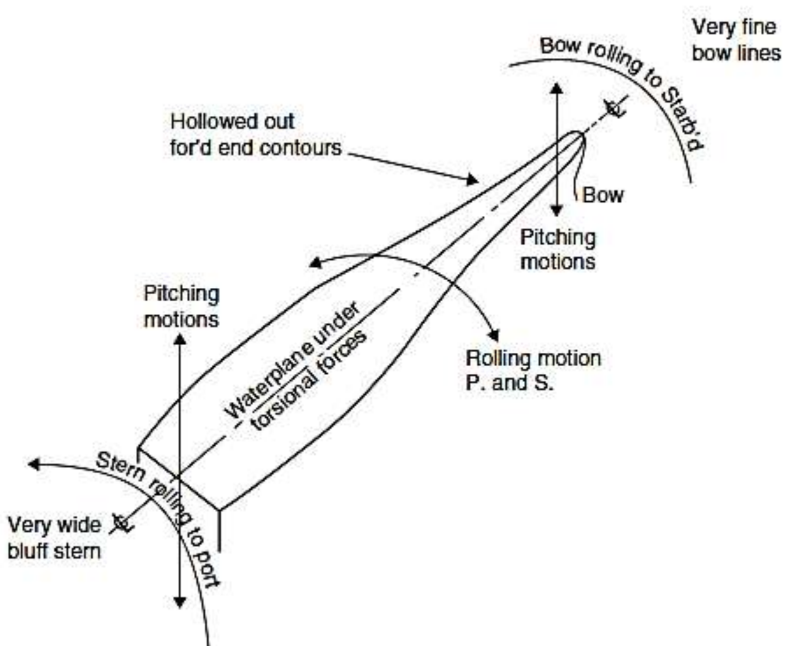
Parametric rolling of ships
Parametric rolling is produced by pitching motions on vessels which have very fine bowlines together with very wide and full stern contours. One such ship type is the container ship. Figure below shows a ship with parametric rolling problems.

The cause depends very much on the parameters of the vessel, hence the name 'parametric rolling'. It is most marked when the pitching period T_P is either equal to, or half that of the vessel's rolling period T_R.

As the stern dips into the waves it produces a rolling action. This remains unchecked as the bow next dips into the waves due to pitching forces. It is worst when $T_P = T_R$ or when $T_P = 1/2 \times T_R$.

In effect, the rolling characteristics are different at the stern to those at the bow. It causes a twisting or torsioning along the ship leading to extra rolling motions.

If $T_P = T_R$, or $T_P = 1/2 \times T_R$, then interaction exists and the rolling of the ship is increased. A more dangerous situation develops because of the interplay between the pitching and rolling motions.



Pitch induced or parametric rolling on a container vessel

Parametric rolling is worse when a ship is operating at reduced speed in heavy sea conditions. Such condition can cause containers to be lost overboard due to broken deck lashings.

The IMO suggest that parametric rolling is particularly dangerous when the wavelength is 1.0 to 1.5 times the ship's length.

Parametric rolling problems are least on box-shaped vessels or full-form barges where the aft and forward contours are not too dissimilar. Very little transverse and longitudinal interplay occurs.

To reduce parametric rolling:

1. A water ballast could be used to alter the GMT and hence the natural rolling period TR, to a non-synchronous value.
2. The ship needs to have an anti-rolling acting stabilising system. Antirolling stability tanks that transfer water across the ship or vertically between two tanks are effective for all ship speeds. A quick response time is vital to counteract this type of rolling.
3. Hydraulic fin stabilisers would also help to reduce parametric rolling.

They maybe telescopic or hinged into the sides of the vessel at or near to amidships.

4. Alter the ship's forward speed.
5. Alter the ship's course.

Dry-Docking and Grounding

When a ship enters a drydock she must have a positive initial GM, be upright, and trimmed slightly, usually by the stern. On entering the drydock the ship is lined up with her centreline vertically over the centreline of the keel blocks and the shores are placed loosely in position. The dock gates are then closed and pumping out commences. The rate of pumping is reduced as the ship's stern post nears the blocks. When the stern lands on the blocks the shores are hardened up commencing from aft and gradually working forward so that all of the shores will be hardened up in position by the time the ship takes the blocks overall. The rate of pumping is then increased to quickly empty the dock.

As the water level falls in the drydock there is no effect on the ship's stability so long as the ship is completely waterborne, but after the stern lands on the blocks the draft aft will decrease and the trim will change by the head. This will continue until the ship takes the blocks overall throughout her length, when the draft will then decrease uniformly forward and aft.

The interval of time between the stern post landing on the blocks and the ship taking the blocks overall is referred to as the *critical period*. During this period part of the weight of the ship is being borne by the blocks, and this creates an upthrust at the stern which increases as the water level falls in the drydock. The upthrust causes a virtual loss in metacentric height and it is essential that positive effective metacentric height be maintained throughout the critical period, or the ship will heel over and perhaps slip off the blocks with disastrous results.

The purpose of this chapter is to show the methods by which the effective metacentric height may be calculated for any instant during the drydocking process.

Figure below shows the longitudinal section of a ship during the critical period. 'P' is the upthrust at the stern and 'l' is the distance of the centre of flotation from aft. The trimming moment is given by P x l. But the trimming moment is also equal to MCTC x change of trim.

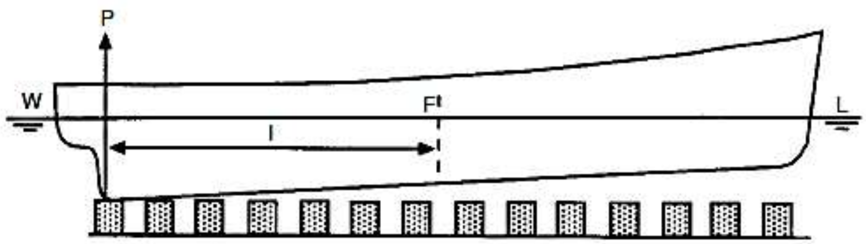


Fig. 35.1

Therefore

$$P \times l = MCTC \times t$$

or

$$P = \frac{MCTC \times t}{l}$$

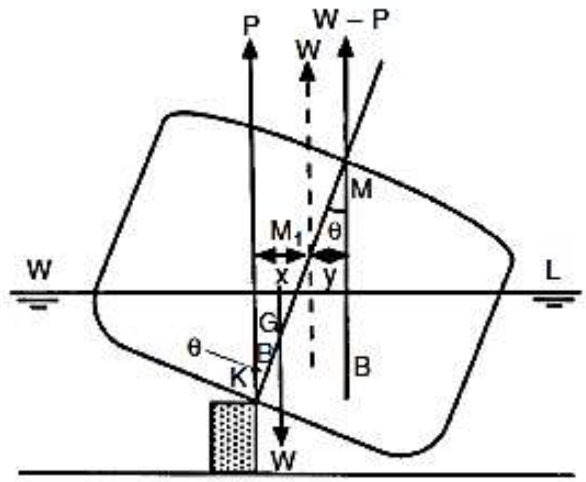
Where

P = the upthrust at the stern in tonnes
t = the change of trim since entering the drydock in centimetres
l = the distance of the centre of flotation from aft in metres

Now consider Figure below which shows a transverse section of the ship during the critical period after she has been inclined to a small angle (ɵ degrees) by a force external to the ship. For the sake of clarity the angle of heel has been magnified. The weight of the ship (W) acts downwards through the centre of gravity (G). The force P acts upwards through the keel (K) and is equal to the weight being borne by the blocks. For equilibrium the force of buoyancy must now be (W - P) and will act upwards through the initial metacentre (M).

There are, thus, three parallel forces to consider when calculating the effect of the force P on the ship's stability. Two of these forces may be replaced by their resultant in order to find the effective metacentric height and the moment of statical stability.

Method (a)



In Figure below consider the two parallel forces P and (W - P). Their resultant W will act upwards through M_1 such that:

$$(W - P) \times y = P \times X$$

or

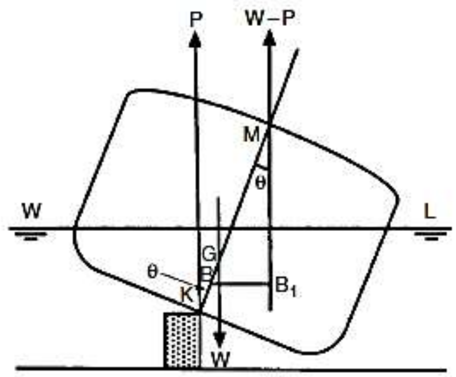
$$\begin{aligned}(W - P) \times MM_1 \times \sin\theta &= P \times KM_1 \times \sin\theta \\ (W - P) \times MM_1 &= P \times KM_1 \\ W \times MM_1 - P \times MM_1 &= P \times KM_1 \\ W \times MM_1 &= P \times KM_1 + P \times MM_1 \\ &= P\,(KM_1 + MM_1) \\ &= P \times KM \\ MM_1 &= \frac{P \times KM}{W}\end{aligned}$$

There are now two forces to consider: W acting upwards through M_1 and W acting downwards through G. These produce a righting moment of W x GM_1 - sin ɵ.
Note also that the original metacentric height was GM but has now been reduced to GM_1. Therefore MM_1 is the virtual loss of metacentric height due to drydocking.

Or

$$\text{Virtual loss of GM } (MM_1) = \frac{P \times KM}{W}$$

Method (b)



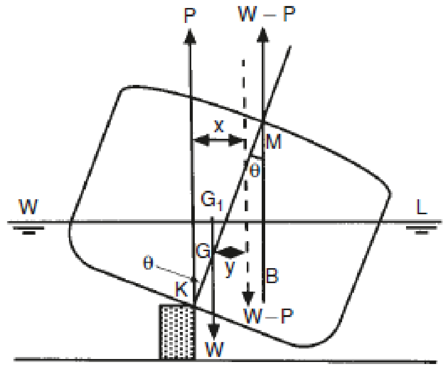
Now consider the two parallel forces W and Pin Figure above. Their resultant (W - P) acts downwards through G_1 such that:

$$W \times y = P \times X$$

or

$$\begin{aligned} W \times GG_1 \times \sin\theta &= P \times KG_1 \times \sin\theta \\ W \times GG_1 &= P \times KG_1 \\ &= P(KG + GG_1) \\ &= P \times KG + P \times GG_1 \\ W \times GG_1 - P \times GG_1 &= P \times KG \\ GG_1(W - P) &= P \times KG \\ GG_1 &= \frac{P \times KG}{W - P} \end{aligned}$$

There are now two forces to consider: (W - P) acting upwards through M and (W - P) acting downwards through G_1. These produce a righting moment of (W - P) x G1M x sin ɵ.
The original metacentric height was GM but has now been reduced to G_1M. Therefore GG_1 is the virtual loss of metacentric height due to drydocking.



Or

$$\text{Virtual loss of GM } (GG_1) = \frac{P \times KG}{W - P}$$

1.8 Resistance and fuel consumption

Frictional resistance

Frictional resistance is the net fore-and-aft forces upon the ship due to tangential fluid forces. Frictional resistance accounts for nearly 80 percent of total resistance in slow-speed ships like oil tankers and as much as 50 percent in high-speed ships like container vessels.
We have seen earlier that frictional resistance is due to the viscosity of the fluid.

The combined effects of wetted surface, surface condition, surface length and speed comprise the resistance due to friction and can be calculated with the formula:

Rf = 0.97 x Cf x Sw x V^2 where:

Rf = Resistance in pounds
Cf = Coefficient of friction
Sw = Wetted surface
V = Velocity in ft/sec
0.97 = Constant for fresh water

As the water passes, friction slows the water molecules next to the hull, creating a layer of water that is carried along with the hull. This layer, called the boundary layer, is initially quite thin and the flow within it is laminar. As it progresses along the surface, variable pressures cause turbulence. The layer gradually increases in thickness: near the stern, it breaks away into eddies. It is within this layer that friction is generated *between* the water molecules and not as might be supposed, between the water and the surface. Where the flow is laminar, the coefficient of friction is quite small; it is theoretically possible for canoes to maintain laminar flow for the full length of the hull. Practically, however, this is not possible. Turbulent flow sets in near the bow with an attendant increase in friction. The major factors affecting the frictional coefficient are the smoothness of the hull, velocity and length of the hull.

Since the builder and the paddler are responsible for the velocity and surface condition, the designer's influence is restricted to surface area and length. U.S. Navy studies have shown that, for conventional shapes (i.e. those that are not extreme in dimensions or configuration), wetted surface varies with length, amount of deadwood, Beam/Draft ratio and hull shape, in that order of importance.

Reynold Number

In fluid mechanics and heat transfer, the Reynolds number Re is a dimensionless number that gives a measure of the ratio of inertial forces ($V\rho$) to viscous forces ($\mu\ /L$) and, consequently, it quantifies the relative importance of these two types of forces for given flow conditions.

Reynolds numbers frequently arise when performing dimensional analysis of fluid dynamics and heat transfer problems, and as such can be used to determine dynamic similitude between different experimental cases. They are also used to characterize different flow regimes, such as laminar or turbulent flow: laminar flow occurs at low Reynolds numbers, where viscous forces are dominant, and is characterized by smooth, constant fluid motion, while turbulent flow occurs at high Reynolds numbers and is dominated by inertial forces, which tend to produce random eddies, vortices and other flow fluctuations.

Reynolds number is named after Osborne Reynolds (1842–1912), who proposed it in 1883.

Flow in Pipe

For flow in a pipe or tube, the Reynolds number is generally defined as:

$$\mathrm{Re} = \frac{\rho V D}{\mu} = \frac{V D}{\nu} = \frac{Q D}{\nu A}$$

where:

- V is the mean fluid velocity in (SI units: m/s)
- D is the diameter (m)
- μ is the dynamic viscosity of the fluid (Pa·s or N·s/m²)
- ν is the kinematic viscosity ($\nu = \mu / \rho$) (m²/s)
- ρ is the density of the fluid (kg/m³)
- Q is the volumetric flow rate (m³/s)
- A is the pipe *cross-sectional* area (m²)

Typical values of Reynolds number

Note: these values are meaningless without a definition of the characteristic length in each case.

- Spermatozoa ~ 1×10^{-4}
- Blood flow in brain ~ 1×10^{2}
- Blood flow in aorta ~ 1×10^{3}

Onset of turbulent flow ~ 2.3×10^3-5.0×10^4 for pipe flow to 10^6 for boundary layers

- Typical pitch in Major League Baseball ~ 2×10^{5}
- Person swimming ~ 4×10^{6}
- Blue Whale ~ 3×10^{9}
- A large ship (RMS Queen Elizabeth 2) ~ 5×10^{9}

Residuary resistance

Residual resistance R_R comprises wave resistance and eddy resistance. Wave resistance refers to the energy loss caused by waves created by the vessel during its propulsion through the water, while eddy resistance refers to the loss caused by flow separation which creates eddies, particularly at the aft end of the ship.

Wave resistance at low speeds is proportional to the square of the speed, but increases much faster at higher speeds. In principle, this means that a speed barrier is imposed, so that a further increase of the ship's propulsion power will not result in a higher speed as all the power will be converted into wave energy. The residual resistance normally represents 8-25% of the total resistance for low-speed ships, and up to 40-60% for high-speed ships.

Incidentally, shallow waters can also have great influence on the residual resistance, as the displaced water under the ship will have greater difficulty in moving aftwards.

In general, the shallow water will have no influence when the seawater depth is more than 10 times the ship draught.

The procedure for calculating the specific residual resistance coefficient C_R is described in specialised literature, and the residual resistance is found as follows:

$$R_R = C_R \times K$$

Froude number

The Froude number (Fr) is a dimensionless number defined as the ratio of a characteristic velocity to a gravitational wave velocity. It may equivalently be defined as the ratio of a body's inertia to gravitational forces. In fluid mechanics, the Froude number is used to determine the resistance of a partially submerged object moving through water, and permits the comparison of objects of different sizes. Named after William Froude, the Froude number is based on the speed–length ratio as defined by him.

The Froude number is defined as:

$$\mathrm{Fr} = \frac{v}{c}$$

where v is a characteristic velocity, and c is a characteristic water wave propagation velocity. The Froude number is thus analogous to the Mach number. The greater the Froude number, the greater the resistance.

<u>Froude number in different applications</u>

Ship hydrodynamics

For a ship, the Froude number is defined as:

$$\mathrm{Fr} = \frac{v}{\sqrt{gL}},$$

where v is the velocity of the ship, g is the acceleration due to gravity, and L is the length of the ship at the water line level, or L_{wl} in some notations. It is an important parameter with respect to the ship's drag, or resistance, including the wave making resistance. Note that the Froude number used for ships, by convention, is the square of the Froude number as defined above. The Denny Ship Model Experiment tank in Dumbarton, Scotland, has a bust of Froude near the front door.

Shallow water waves

For shallow water waves, like for instance tidal waves and the hydraulic jump, the characteristic velocity v is the average flow velocity, averaged over the cross-section perpendicular to the flow direction. The wave velocity, c, is equal to the square root of gravitational acceleration g, times cross-sectional area A, divided by free-surface width B:

$$c = \sqrt{g\frac{A}{B}},$$

so the Froude number in shallow water is:

$$\mathrm{Fr} = \frac{v}{\sqrt{g\frac{A}{B}}}.$$

For rectangular cross-sections with uniform depth d, the Froude number can be simplified to:

$$\mathrm{Fr} = \frac{v}{\sqrt{gd}}.$$

For Fr < 1 the flow is called a subcritical flow, further for Fr > 1 the flow is characterised as supercritical flow. When Fr ≈ 1 the flow is denoted as critical flow.

An alternate definition used in fluid mechanics is

$$\widehat{\mathrm{Fr}} = \frac{v^2}{gd},$$

where each of the terms on the right have been squared. This form is the reciprocal of the Richardson number.

Uses

The Froude number is used to compare the wave making resistance between bodies of various sizes and shapes.
In free-surface flow, the nature of the flow (supercritical or subcritical) depends upon whether the Froude number is greater than or less than unity. You can easily see the line of "critical" flow in you kitchen or bathroom sink. Leave it un-plugged and let the faucet run. Near the place where the stream of water hits the sink, the flow is supercritical. It 'hugs' the surface and moves fast. On the outer edge of the flow pattern the flow is subcritical. This flow is thicker and moves more slowly. The boundary between the two areas is called a "hydraulic jump". That's where the flow is just critical and Froude number is equal to 1.0.
The Froude number has been used to study trends in animal locomotion in order to better understand why animals use different gait patterns as well as to form hypotheses about the gaits of extinct species.
Froude number scaling is frequently used in construction of dynamically similar free-flying models in which lift = weight. Since these models oppose gravity, their linear accelerations at model scale match those of full-size aircraft.

Speed length ratio

Hull speed or displacement speed is the speed at which the wavelength of the boat's bow wave (in displacement mode) is equal to the boat length. As boat speed increases from rest, the wavelength of the bow wave increases, and usually its crest to trough dimension (height) increases as well. When hull speed is reached, a boat in pure displacement mode will appear trapped in a trough behind its very large bow wave.

From a technical perspective, at hull speed the bow and stern waves interfere constructively, creating relatively large waves, and thus a relatively large value of wave drag. Though the term "hull speed" seems to suggest that it is some sort of "speed limit" for a boat, in fact drag for a displacement hull increases smoothly and at an increasing rate with speed as hull speed is approached and exceeded, often with no noticeable inflection at hull speed.
The concept of *hull speed* is not used in modern naval architecture, where considerations of speed-length ratio or Froude number are considered more helpful.

Background

As a ship moves in the water, it creates standing waves that oppose its movement. This effect increases dramatically in full-formed hulls at a Froude number of about 0.35, which corresponds to a speed-length ratio *(see below for definition)* of slightly less than 1.20 (this is due to a rapid increase of resistance due to the transverse wave train). When the Froude Number grows to ~0.40 (speed-length ratio about 1.35), the wave-making resistance increases further due the divergent wave train. This trend of increase in wave-making resistance continues up to a Froude Number of about 0.45 (speed-length ratio about 1.50) and does not reach its maximum until a Froude number of about 0.50 (speed-length ratio about 1.70).
This very sharp rise in resistance at around a speed-length ratio of 1.3 to 1.5 probably seemed insurmountable in early sailing ships and so became an apparent barrier. This leads to the concept of 'hull speed'.

Empirical calculation and speed-length ratio

Hull speed can be calculated by the following formula:

$$v_{hull} \approx 1.34 \times \sqrt{L_{WL}}$$

where:

"L_{WL}" is the length of the waterline in feet, and
"v_{hull}" is the hull speed of the vessel in knots

The constant may be given as 1.34 to 1.51 knot·ft −½ in imperial units (depending on the source), or 4.50 to 5.07 km·h−1·m-½ in metric units.

The ratio of speed to $\sqrt{L_{WL}}$ is often called the "speed-length ratio", even though it's a ratio of speed to the square root of length.

Hull design implications

Wave making resistance depends dramatically on the general proportions and shape of the hull: modern displacement designs that can easily exceed their 'hull speed' without planing include hulls with very fine ends, long hulls with relatively narrow beam and wave-piercing designs. These benefits are commonly realised by some canoes, competitive rowing boats, catamarans, fast ferries and other commercial, fishing and military vessels based on such concepts.

Vessel weight is also a critical consideration: it affects wave amplitude, and therefore the energy transferred to the wave for a given hull length.

Heavy boats with hulls designed for planing generally cannot exceed hull speed without planing. Light, narrow boats with hulls not designed for planing can easily exceed hull speed without planing; indeed, the unfavorable amplification of wave height due to constructive interference diminishes as speed increases above hull speed. For example, world-class racing kayaks can exceed hull speed by more than 100%, even though they do not plane. Semi-displacement hulls are usually intermediate between these two extremes.

Admiralty coefficient

The Admiralty coefficient A is a constant valid for a given ship and is useful when simple ship estimations are needed.
The Admiralty coefficient A is constant for a given hull and gives the approximate relationships between the needed propulsion power P, ship speed V and displacement ∇. Thus, the constant A is defined as follows:

$$A = \frac{\nabla^{2/3} \times V^3}{P} = \frac{\nabla_{des}^{2/3} \times V_{des}^3}{P_{des}}$$

when for example, as basis, referring to the design draught D_{des}.
For equal propulsion power $P = P_{des}$ we get the ship speed

$$V = V_{des} \times \left(\frac{\nabla_{des}}{\nabla}\right)^{2/9}$$

For equal ship speed $V = V_{des}$ we get the propulsion power

$$P = P_{des} \times \left(\frac{\nabla}{\nabla_{des}}\right)^{2/3}$$

Normally, the draught ratio D/D_{des} may be given instead of the displacement ratio, but the correlation between draught and displacement may be found by means of the block coefficient relationship described previously under “Variation of block coefficient for a given ship”

1.9 Rudders

Rudder Forces and Moments

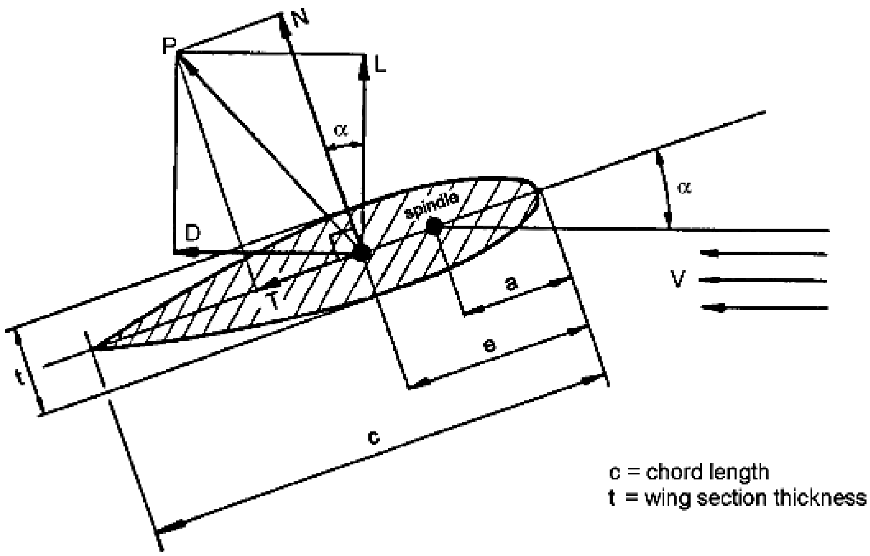
A rudder behind a ship acts as an airfoil or a wing; it produces lift and drag in a proper flow. A cross section of a rudder (or a lifting surface) is such that at a rudder angle (or angle of attack of the flow) a relative large force perpendicular to the flow direction comes into existence.
In figure below shows the components of the force produced by the rudder. The rudder profile has been placed with an angle of attack α in a homogeneous flow with a constant velocity V. Practically, V is defined as the velocity of the fluid far before the rudder, For small angle of attack, α, the total force P on the profile acts at about e ≈ 0.25 . c, provided thar the span width s is large with respect to the chord length c. This force P can be decomposed in a lift force L perpendicular to the flow and a drag force D in the direction of the flow. The total force P can be decomposed in a normal force N and a tangential force T, too.

Rudder forces are made dimensionless by the stagnation pressure ½ ρ V^2 and the projected rudder area A_r:

$$C_L = \frac{L}{\frac{1}{2}\rho V^2 A_r} \quad \text{and} \quad C_D = \frac{D}{\frac{1}{2}\rho V^2 A_r}$$

$$C_N = \frac{N}{\frac{1}{2}\rho V^2 A_r} \quad \text{and} \quad C_T = \frac{T}{\frac{1}{2}\rho V^2 A_r}$$

From the force component, as presented in figure below, follow:



Forces on a Rudder section

$$
\begin{aligned}
P &= \sqrt{L^2+D^2} = \sqrt{N^2+T^2} \\
N &= L\cos\alpha + D\sin\alpha \quad \text{and} \quad C_N = C_L\cos\alpha + C_D\sin\alpha \\
T &= D\cos\alpha - L\sin\alpha \quad \text{and} \quad C_T = C_D\cos\alpha - C_L\sin\alpha
\end{aligned}
$$

For the rudder moment, it is important to know about which point it has been defined. The moment M_e about the front (or nose) of the rudder is:

$$M_e = N \cdot e \quad \text{and} \quad C_{M_e} = \frac{M_e}{\frac{1}{2}\rho V^2 A_r \cdot c}$$

Thus the chord length c has been used for making the rudder moment dimensionless, so:

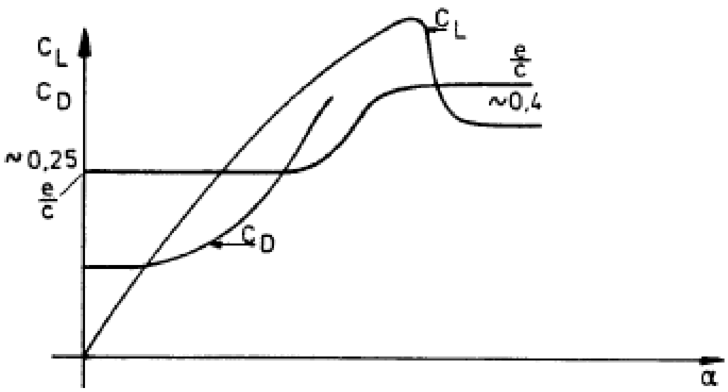
$$C_{M_e} = \frac{N \cdot e}{\frac{1}{2}\rho V^2 A_r \cdot c} = C_N \cdot \frac{e}{c} \quad \text{or:} \quad \frac{e}{c} = \frac{C_{M_e}}{C_N}$$

An example of these characteristics has been given in figure below. The lift coefficient increase almost linearly with the angle of attack until a maximum value is reached, whereupon the wing is said to "stall". At small angle of attack, the center of the lift forces acts at about e/c ≈ 0.25. At higher angle of attack – before stalling of the wing - the flow starts to separate at the suction side of the wing and the center of the lift force shifts backwards, for instance to about e/c ≈ 0.40.

The moment M_{rs} about the rudder stock is:

$$M_{rs} = N * (e - a)$$

A rudder moment is called positive here, when it is right turning. Sometimes, a definition of the rudder moment about a point fixed at e = 0.25 * c will be found in the literature.



Lift, Drag and moment characteristics of a wing section

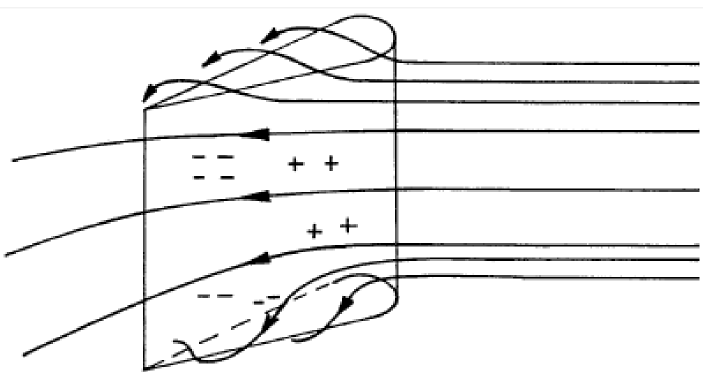
The aspect ratio s/c of the rudder is an important parameter. The geometrical aspect ratio is defined by the ratio of the mean span width $\bar{s}$ and the mean chord length $\bar{c}$:

$$AR = \frac{\bar{s}}{\bar{c}}$$

For an arbitrary rudder plan form can be written:

$$\bar{c} = \frac{A_r}{\bar{s}} \qquad \text{thus:} \qquad AR = \frac{\bar{s}^2}{A_r}$$

Because of the finite aspect ratio, three - dimensional effect will apprear at the upper and lower side of the rudder. A fluid flow aroun the corners appears, of which the effect on the lift coefficient will increase with a decreasing aspect ratio.



Flow around corners of a lifting surface

At larger aspect ratios, the flow becomes more two dimensional over a larger part of the rudder surface. The flow around the corners can be avoided by walls or end-plates. A rudder which almost joint the stern of the ship at the upper side of the rudder, has a considerably increased effective aspect ratio. Then, theoretically, the effective aspect ratio is twice the geometrical aspect radio.
A flat plate has a relative large increase of the lift coefficient with the angle of attack, so a high $\partial C_T / \partial \alpha$ value.

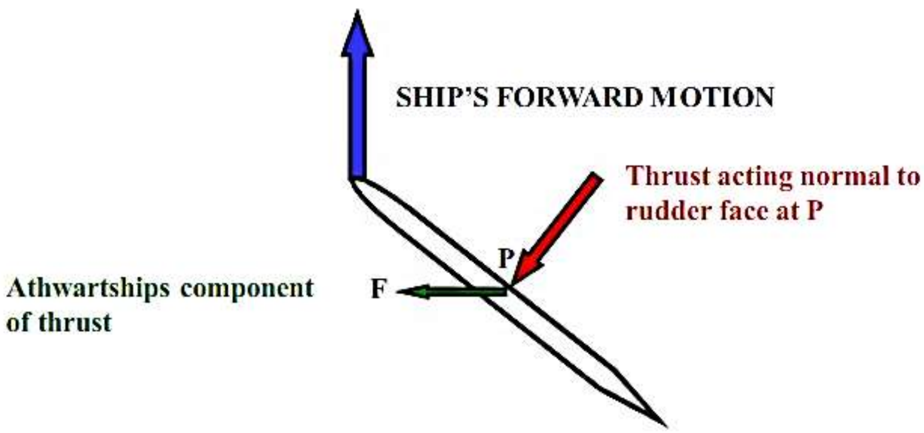
$$\frac{\partial C_L}{\partial \alpha} = 2\pi \qquad \text{for a flat plate (with } \alpha \text{ in radians)}$$

The great disadvantage of a flat plate as a rudder is the fast flow separation; the flow will separate already at small angles of attack. A flat plate stalls already at a small angle of attack. A wing section thicknessw, T, of 9 percent of the chord length, c, is often considered as a practical minimum value, so t/c ≥0.09.

Angle of heel when turning

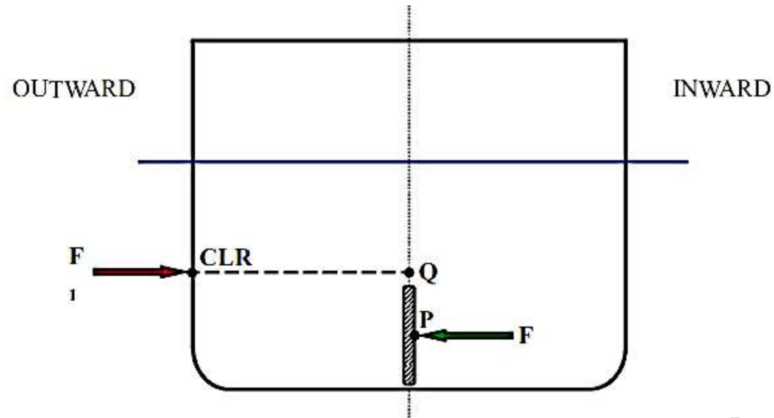
Consider a ship turning to starboard.
The sequence of events is as follows:

1. Rudder put over to starboard.
2. The athwartships component of thrust (F) acts on the face of the rudder at P, P being the center of pressure which coincides with the geometric centre of the rudder face.



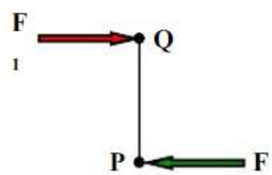
3. An equal and opposite reaction (F_1) resists the athwart ships motion at the centre of lateral resistance (CLR).

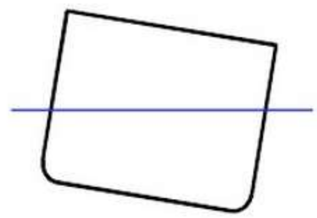
(The CLR is at the centroid of the ship's longitudinal area below the waterline.)



4. An inward heeling couple is set up for which the heeling moment is:

$$F \times PQ$$





When the ship achieves a steady rate of turn the inward heel is overcome by the effect of centrifugal force acting outwards through the ship's centre of gravity (G)

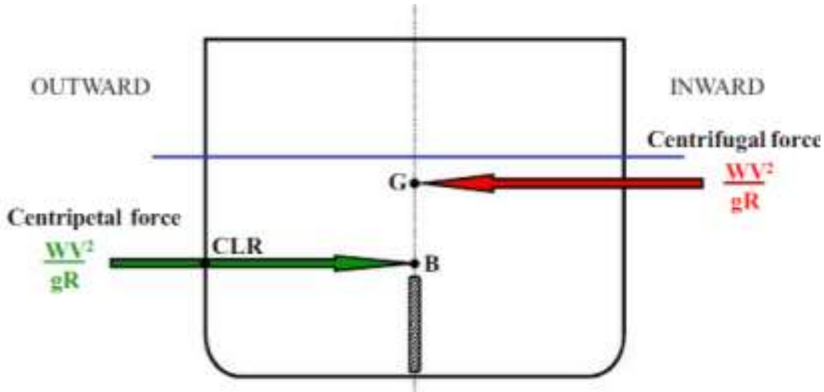
CENTRIFUGAL FORCE = WV^2/gR TONNES

Where: W is ship displacement;
V is ship speed in metres per second;
$g = 9.81\ m/sec^2$;
R is the radius of the turning circle

The centrifugal force is opposed by an equal and opposite centripetal force which acts through the CLR.

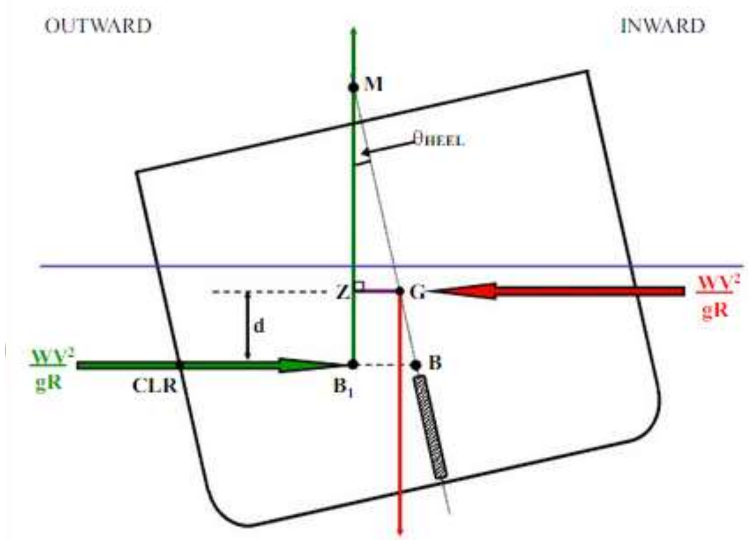
The CLR is assumed to be at be same height above the keel as the centre of buoyancy (B).

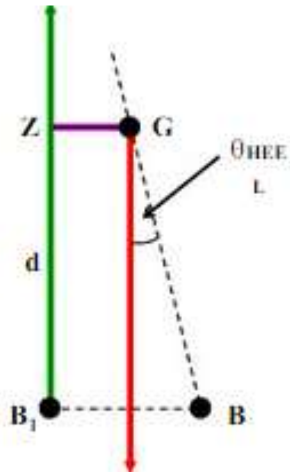
Consider the diagram.



The original inward heeling moment is overcome by this out ward heeling couple which develops in the steady turn state.
In the turn the ship will settle at an angle of stedy heel when the outward heeling moment balances the normal righting moment (RM =GZ x Displacement).

At small angles of heel: GZ = GM x Sine ϴ





B and B1 are assumed to be at the same depth.

$$\text{Cos}\,\theta = \frac{\text{ADJ}}{\text{HYP}} = \frac{d}{BG}$$

Therefore: **d= BG Cos θ**
(at small angle of heel)

At the small angle of heel shown:
RIGHTING MOMENT = HEELING MOMENT

Therefore:
$$W \times GZ = \frac{WV^2}{gR} \times d$$

If:
$$d = BG\,\text{Cos}\,\theta \quad \text{and:} \quad GZ = GM\,\text{Sin}\,\theta$$

Then:
$$W \times GM\,\text{Sin}\,\theta = \frac{WV^2}{gR} \times BG\,\text{Cos}\,\theta$$

Transposing gives:
$$gR \times W \times GM\,\text{Sin}\,\theta = WV^2 \times BG\,\text{Cos}\,\theta$$

Divide both sides by Cos θ:
$$\frac{gR \times W \times GM\,\text{Sin}\,\theta}{\text{Cos}\,\theta} = WV^2 \times BG$$

Gives:
$$gR \times W \times GM \times \text{Tan}\,\theta = WV^2 \times BG$$

Thus:
$$\text{Tan}\,\theta = \frac{WV^2 \times BG}{gR \times W \times GM}$$

Finally:
$$\text{Tan}\,\theta = \frac{V^2 \times BG}{g \times R \times GM}$$

Note: in practice the outward angle of heel will be slightly less than that given by the formula because of the small inward heeling moment set by the athwarthships component of thrust on the rudder.

However, if the rudder is returned quickly to the amidships position, the outward angle of heel due to turning will instantaneously increase. If the rudder is suddenly reserved i.e. put hard-a-port on a starboard turning circle, an even more serious outward angle of heel would arise (albeit temporarily) which could cause excessive heeling in extreme situations cargo shift or even capsizing.

4.1.2 EFFECT ON TRIM AND STABILITY IN THE EVENT OF DAMAGE AND FLOODING

Effect of Flooding on Transverse Stability

When a space is flooded without free communication with the sea, the stability can be calculated by taking account of the mass of water and the free surface effect. Examples would be the accumulation of water in 'tween-decks as a result of firefighting, or flooding through a crack in the hull or through a fractured pipe. The ship's hydrostatic data for the increased displacement are applicable for the calculations.

If a compartment is holed so that water can flow freely in and out of it, that compartment can be considered as part of the sea and no longer part of the ship. The buoyancy of the space up to the water level before damage is lost and the waterplane area of the ship is reduced by the waterplane area of the damaged compartment. These changes give rise to changes in the hydrostatic data needed to calculate the transverse stability and trim.

The lost buoyancy, expressed in tonnes, is the mass of water which could enter the space up to the original waterplane, i.e. the volume x permeability x density of water in which the ship is floating.

The lost waterplane area is the area of the bilged compartment at the original

waterplane. If the compartment is completely contained below the waterline, e.g. a double-bottom tank, there is no loss of waterplane area provided the tank top remains intact. The original waterplane area may be given in the ship's data or it can be calculated from

$$\text{waterplane area} = \frac{100 \times TPC}{1.025}$$

Of the two corrections in this objective, the first is the second moment of lost waterplane area about its own centroid, the second a correction to give the loss about the new centroid of the intact waterplane. In the case of symmetrical flooding, the second correction is zero. For wing compartments, the second correction is very much greater than the first, even for compartments extending half the breadth of the ship.

Generally, the displacement of the ship and the position of the centre of gravity will remain unchanged after bilging. However, if a tank containing a liquid is bilged, the weight of the tank contents is lost, causing a reduction in displacement and a shift in the position of the ship's centre of gravity. The lost buoyancy would be comparable with the lost weight, causing a similar shift in the centre of buoyancy with the result that there would be little change of draught, trim or list,. The loss of waterplane area would result in a reduction of GM.

Permeability

Permeability is the amount of water that can enter a compartment or tank after it has been bilged. When an empty compartment is bilged, the whole of the buoyancy provided by that compartment is lost. Typical values for permeability, μ, are as follows:

Empty compartment	μ = 100%
Engine room	μ = 80% to 85%
Grain-filled cargo hold	μ = 60% to 65%
Coal-filled compartment	μ = 36% approximately
Filled water ballast tank (when ship is in salt water)	μ = 0%

Consequently, the higher the value of the permeability for a bilged compartment, the greater will be a ship's loss of buoyancy when the ship is bilged.
The permeability of a compartment can be found from the formula:

$$\mu = Permeability = \frac{Broken\ stowage}{Stowage\ factor}\ x\ 100\ per\ cent$$

The broken stowage to be used in this formula is the broken stowage per tonne of stow.

When a bilged compartment contains cargo, the formula for finding the increase in draft must be amended to allow for the permeability. If 'μ' represents the permeability, expressed as a fraction, then the volume of lost buoyancy will be 'μ *v*' and the area of the intact water-plane will be 'A - μ *v*' square metres. The formula then reads:

$$x = \frac{\mu\ v}{A - \ \mu\ a}$$

Angle of Heel

Buoyancy is lost at the damaged compartment and an equal amount of buoyancy is gained at the position of the new centre of flotation. The transverse shift in the ship's centre of buoyancy is, therefore, lost buoyancy x transverse distance from centre of flotation divided by the displacement. On the assumption that the centre of gravity is still on the centreline, the shift in buoyancy is the heeling arm.

The angle of heel would be given by the intersection of the GZ curve for the damaged ship with the heeling-arm curve BB1 cos θ. Since KN curves for the damaged condition are not available, the GZ curve has to be constructed, using values for the intact ship at a displacement corresponding to the damaged draught and a KG chosen to give the modified value of GM. The angle of heel read from the curve will be approximate. If the angle is small it can be calculated from, tan θ = BB_1 /GM

Effect of Flooding on Trim

Similar calculations are necessary to find the longitudinal position of the centre of flotation after damage, and the reduction of BML. The change in GML is used to calculate the change in MCT 1cm.

Buoyancy has been lost at the damaged compartment and replaced at the centre of flotation, hence the trimming moment is the product of lost buoyancy and the distance from the centre of the damaged compartment to the new centre of flotation. The change of trim and the draught at each end are then calculated in the usual way.

Flooding of a compartment near an end of the ship causes a large shift in the centre of flotation away from the damaged end and a large reduction in MCT 1cm. Combined with the sinkage due to lost buoyancy, this may produce a large increase in draught at the damaged end. The original trim of the ship will influence the chances of the ship surviving the damage.

A ship already trimmed towards the damaged end is more vulnerable than one on an even keel or trimmed the other way.

Measures to Improve Stability or Trim when Damaged

The immediate action should be to restrict the flooding and, if possible, to stop it. In the event of collision or stranding damage, it will not be possible to stop the flooding or reduce it significantly by the use of pumps. Even a comparatively small hole below the waterline admits water at a much higher rate than the capacity of bilge or ballast pumps. All watertight doors, valves, dampers in ventilation shafts and access hatches should be closed to prevent flooding progressing to other compartments. Where cross flooding arrangements are required, they should be put into operation at once to restrict the resulting list.

In passenger ships, the guidance in the damage control booklet should be followed.

The same applies to cargo ships where damage control information is provided.

In nearly all cases, damage will result in sinkage, list and trim, loss of stability and loss of longitudinal strength. Corrective action for one condition will affect the others.

Excessive list or trim should be corrected by moving weights, fuel, water or liquid cargoes, when possible. If ballast is added, it increases the sinkage. In some cases it may be possible to pump out ballast to improve list or trim and lighten the ship at the same time. If the ballast is taken from double-bottom tanks, however, the stability will be further reduced.

Stability may be improved by transferring fuel from wing or cross bunker tanks to double bottoms if suitable tanks are empty. Efforts should be made to reduce free surface to a minimum. Water accumulating in upper decks as a result of fire fighting should be drained to the lowest level possible if means of pumping it out of the ship cannot be arranged.

After collision or stranding damage, particularly near the middle length of the ship, the longitudinal strength will be impaired and account should be taken of that when deciding on the transfer or addition of weights.

Cases have occurred where a slow leakage of water has been absorbed by a cargo, such as grain, with no water reaching the drain wells. The added weight, high on one side of the hold, has led to a steadily increasing list and eventual capsizing. As the source of the leakage was inaccessible, nothing could be done. Cargo spaces should be thoroughly inspected whenever they are empty for signs of leakage, indicating cracks or damage to overside discharge valve covers.

4.1.3 KNOWLEDGE OF IMO RECOMMENDATIONS CONCERNING SHIP STABILITY

Intact Stability Code

IMO has long developed intact stability criteria for various types of ships, culminating in the completion of the Code on Intact Stability for All Types of Ships Covered by IMO Instruments (IS Code) in 1993 (resolution A.749 (18)) and later amendments thereto (resolution MSC.75(69)). The IS Code included fundamental principles such as general precautions against capsizing (criteria regarding metacentric height (GM) and righting lever (GZ)); weather criterion (severe wind and rolling criterion); effect of free surfaces and icing; and watertight integrity. The IS Code also addressed related operational aspects like information for the master, including stability and operating booklets and operational procedures in heavy weather.

In 2008, the Maritime Safety Committee, at its eighty-fifth session, adopted the International Code on Intact Stability, 2008 (2008 IS Code), following extensive considerations by the SLF Sub-Committee and taking into account technical developments, to update the 1993 Intact Stability Code. MSC 85 also adopted amendments to the SOLAS Convention and to the 1988 Load Lines Protocol to make the 2008 IS Code mandatory, which entered into force on 1 July 2010. The 2008 IS Code provides, in a single document, both mandatory requirements and recommended provisions relating to intact stability that will significantly influence the design and the overall safety of ships.

4.2 MONITOR AND CONTROL COMPLIANCE WITH LEGISLATIVE REQUIREMENTS AND MEASURES TO ENSURE SAFETY OF LIFE AT SEA AND THE PROTECTION OF THE MARINE ENVIRONMENT.

4.2.1 International Maritime Law Embodied in International Agreements and Conventions

Law of the sea

The law of the sea is a body of customs, treaties, and international agreements by which governments maintain order, productivity, and peaceful relations on the sea.

Branch of international law concerned with public order at sea. Much of this law is codified in the United Nations Convention on the Law of the Sea, signed Dec. 10, 1982. The convention, described as a “constitution for the oceans,” represents an attempt to codify international law regarding territorial waters, sea-lanes, and ocean resources. It came into force in 1994 after it had been ratified by the requisite 60 countries; by the early 21st century the convention had been ratified by more than 150 countries.

According to the 1982 convention, each country’s sovereign territorial waters extend to a maximum of 12 nautical miles (22 km) beyond its coast, but foreign vessels are granted the right of innocent passage through this zone. Passage is innocent as long as a ship refrains from engaging in certain prohibited activities, including weapons testing, spying, smuggling, serious pollution, fishing, or scientific research. Where territorial waters comprise straits used for international navigation (e.g., the straits of Gibraltar, Mandeb, Hormuz, and Malacca), the navigational rights of foreign shipping are strengthened by the replacement of the regime of innocent passage by one of transit passage, which places fewer restrictions on foreign ships. A similar regime exists in major sea-lanes through the waters of archipelagos (e.g., Indonesia).

Beyond its territorial waters, every coastal country may establish an exclusive economic zone (EEZ) extending 200 nautical miles (370 km) from shore. Within the EEZ the coastal state has the right to exploit and regulate fisheries, construct artificial islands and installations, use the zone for other economic purposes (e.g., the generation of energy from waves), and regulate scientific research by foreign vessels. Otherwise, foreign vessels (and aircraft) are entitled to move freely through (and over) the zone.

With regard to the seabed beyond territorial waters, every coastal country has exclusive rights to the oil, gas, and other resources in the seabed up to 200 nautical miles from shore or to the outer edge of the continental margin, whichever is the further, subject to an overall limit of 350 nautical miles (650 km) from the coast or 100 nautical miles (185 km) beyond the 2,500-metre isobath (a line connnecting equal points of water depth). Legally, this area is known as the continental shelf, though it differs considerably from the geological definition of the continental shelf. Where the territorial waters, EEZs, or continental shelves of neighbouring countries overlap, a boundary line must be drawn by agreement to achieve an equitable solution. Many such boundaries have been agreed upon, but in some cases when the countries have been unable to reach agreement the boundary has been determined by the International Court of Justice (ICJ; e.g., the boundary between Bahrain and Qatar) or by an arbitration tribunal (e.g., the boundary between France and the United Kingdom). The most common form of boundary is an equidistance line (sometimes modified to take account of special circumstances) between the coasts concerned.

The high seas lie beyond the zones described above. The waters and airspace of this area are open to use by all countries, except for those activities prohibited by international law (e.g., the testing of nuclear weapons). The bed of the high seas is known as the International Seabed Area (also known as “the Area”), for which the 1982 convention established a separate and detailed legal regime. In its original form this regime was unacceptable to developed countries, principally because of the degree of regulation involved, and was subsequently modified extensively by a supplementary treaty (1994) to meet their concerns. Under the modified regime the minerals on the ocean floor beneath the high seas are deemed “the common heritage of mankind,” and their exploitation is administered by the International Seabed Authority (ISA). Any commercial exploration or mining of the seabed is carried out by private or state concerns regulated and licensed by the ISA, though thus far only exploration has been carried out. If or when commercial mining begins, a global mining enterprise would be established and afforded sites equal in size or value to those mined by private or state companies. Fees and royalties from private and state mining concerns and any profits made by the global enterprise would be distributed to developing countries. Private mining companies are encouraged to sell their technology and technical expertise to the global enterprise and to developing countries.

On many issues the 1982 convention contains precise and detailed regulations (e.g., on innocent passage through territorial waters and the definition of the continental shelf), but on other matters (e.g., safety of shipping, pollution prevention, and fisheries conservation and management) it merely provides a framework, laying down broad principles but leaving the elaboration of rules to other treaties. Regarding the safety of shipping, detailed provisions on the safety and seaworthiness of ships, collision avoidance, and the qualification of crews are contained in several treaties adopted under the auspices of the International Maritime Organization (IMO), a specialized agency of the United Nations (UN). The IMO also has adopted strict antipollution standards for ships. Pollution of the sea from other sources is regulated by several regional treaties, most of which have been adopted under the aegis of the United Nations Environment Programme. The broad standards for fisheries conservation in and management of the EEZ (where most fishing takes place) laid out in the 1982 convention have been supplemented by nonbinding guidelines contained in the Code of Conduct for Responsible Fisheries adopted in 1995 by the UN Food and Agriculture Organization. Principles of management for high seas fishers are laid down in the UN fish stocks treaty (1995), which manages straddling and highly migratory fish stocks, and in detailed measures adopted by several regional fisheries commissions.

Countries first attempt to settle any disputes stemming from the 1982 convention and its provisions through negotiations or other agreed-upon means of their choice (e.g., arbitration). If such efforts prove unsuccessful, a country may, subject to some exceptions, refer the dispute for compulsory settlement by the UN International Tribunal for the Law of the Sea (located in Hamburg, Ger.), by arbitration, or by the ICJ. Resort to these compulsory procedures has been quite limited.

Safety

International Convention on Load Lines, 1966, as amended

It has long been recognized that limitations on the draught to which a ship may be loaded make a significant contribution to her safety. These limits are given in the form of freeboards, which constitute, besides external weathertight and watertight integrity, the main objective of the Convention.

The first International Convention on Load Lines, adopted in 1930, was based on the principle of reserve buoyancy, although it was recognized then that the freeboard should also ensure adequate stability and avoid excessive stress on the ship's hull as a result of overloading.

In the 1966 Load Lines convention, adopted by IMO, provisions are made determining the freeboard of ships by subdivision and damage stability calculations.

The regulations take into account the potential hazards present in different zones and different seasons. The technical annex contains several additional safety measures concerning doors, freeing ports, hatchways and other items. The main purpose of these measures is to ensure the watertight integrity of ships' hulls below the freeboard deck.

All assigned load lines must be marked amidships on each side of the ship, together with the deck line. Ships intended for the carriage of timber deck cargo are assigned a smaller freeboard as the deck cargo provides protection against the impact of waves

- ✓ Load Lines 1966 - Annexes

The Convention includes Annex I, divided into four Chapters:

- Chapter I - General;
- Chapter II - Conditions of assignment of freeboard;
- Chapter III - Freeboards;
- Chapter IV - Special requirements for ships assigned timber freeboards.

Annex II covers Zones, areas and seasonal periods.

Annex III contains certificates, including the International Load Line Certificate.

Amendments 1971, 1975, 1979, 1983

The 1966 Convention provided for amendments to be made by positive acceptance. Amendments could be considered by the Maritime Safety Committee, the IMO Assembly or by a Conference of Governments. Amendments would then only come into force 12 months after being accepted by two-thirds of Contracting Parties.In practice, amendments adopted between 1971 and 1983 never received enough acceptances to enter into force. These included:

- ✓ the 1971 amendments - to make certain improvements to the text and to the chart of zones and seasonal areas;
- ✓ the 1975 amendments - to introduce the principle of 'tacit acceptance' into the Convention;
- ✓ the 1979 amendments - to make some alterations to zone boundaries off the coast of Australia; and
- ✓ the 1983 amendments - to extend the summer and tropical zones southward off the coast of Chile.

Adoption of tacit amendment procedure 1988

The 1988 Protocol Adoption: 11 November 1988

Entry into force: 3 February 2000

The Protocol was primarily adopted in order to harmonize the Convention's survey and certification requirement with those contained in SOLAS and MARPOL 73/78.

All three instruments require the issuing of certificates to show that requirements have been met and this has to be done by means of a survey which can involve the ship being out of service for several days.

The harmonized system alleviates the problems caused by survey dates and intervals between surveys which do not coincide, so that a ship should no longer have to go into port or repair yard for a survey required by one Convention shortly after doing the same thing in connection with another instrument.

The 1988 Load Lines Protocol revised certain regulations in the technical Annexes to the Load Lines Convention and introduced the tacit amendment procedure (which was already applicable to the 1974 SOLAS Convention).Amendments to the Convention may be considered either by the Maritime Safety Committee or by a Conference of Parties.

Amendments must be adopted by a two-thirds majority of Parties to the Convention present and voting. Amendments enter into force six months after the deemed date of acceptance - which must be at least a year after the date of communication of adoption of amendments unless they are rejected by one-third of Parties. Usually, the date from adoption to deemed acceptance is two years.

The 1995 amendments

Adopted: 23 November 1995

Entry into force: 12 months after being accepted by two-thirds of Contracting Governments.
Status: superseded by 2003 amendments

The 2003 amendments

Adopted: June 2003

Entry into force: 1 January 2005

The amendments to Annex B to the 1988 Load Lines Protocol include a number of important revisions, in particular to regulations concerning: strength and intact stability of ships; definitions; superstructure and bulkheads; doors; position of hatchways, doorways and ventilators; hatchway coamings; hatch covers; machinery space openings; miscellaneous openings in freeboard and superstructure decks; cargo ports and other similar openings; spurling pipes and cable lockers; side scuttles; windows and skylights; calculation of freeing ports; protection of the crew and means of safe passage for crew; calculation of freeboard; sheer; minimum bow height and reserve buoyancy; and others.

The amendments, which amount to a comprehensive revision of the technical regulations of the original Load Lines Convention, do not affect the 1966 LL Convention and only apply to approximately those ships flying the flags of States Party to the 1988 LL Protocol.

International Convention for the Safety of Life at Sea, 974, as amended (SOLAS)

The International Convention for the Safety of Life at Sea (SOLAS), 1974, requires flag States to ensure that their ships comply with minimum safety standards in construction, equipment and operation. It includes articles setting out general obligations, etcetera, followed by an annexe divided into twelve chapters.[1] Of these, chapter five (often called 'SOLAS V') is the only one that applies to all vessels on the sea, including private yachts and small craft on local trips as well as to commercial vessels on international passages. Many countries have turned these international requirements into national laws so that anybody on the sea who is in breach of SOLAS V requirements may find themselves subject to legal proceedings.

Chapter I – General Provisions

Surveying the various types of ships and certifying that they meet the requirements of the convention.

Chapter II-1 – Construction – Subdivision and stability, machinery and electrical installations

The subdivision of passenger ships into watertight compartments so that after damage to its hull, a vessel will remain afloat and stable.

Chapter II-2 – Fire protection, fire detection and fire extinction

Fire safety provisions for all ships with detailed measures for passenger ships, cargo ships and tankers.

Chapter III – Life-saving appliances and arrangements

Life-saving appliances and arrangements, including requirements for life boats, rescue boats and life jackets according to type of ship.

Chapter IV – Radiocommunications

The Global Maritime Distress Safety System (GMDSS) requires passenger and cargo ships on international voyages to carry radio equipment, including satellite Emergency Position Indicating Radio Beacons (EPIRBs) and Search and Rescue Transponders (SARTs).

Chapter V – Safety of navigation

This chapter requires governments to ensure that all vessels are sufficiently and efficiently manned from a safety point of view. It places requirements on all vessels regarding voyage and passage planning, expecting a careful assessment of any proposed voyages by all who put to sea. Every mariner must take account of all potential dangers to navigation, weather forecasts, tidal predictions, the competence of the crew, and all other relevant factors. It also adds an obligation for all vessels' masters to offer assistance to those in distress and controls the use of lifesaving signals with specific requirements regarding danger and distress messages. It is different from the other chapters, which apply to certain classes of commercial shipping, in that these requirements apply to all vessels and their crews, including yachts and private craft, on all voyages and trips including local ones.

Chapter VI – Carriage of Cargoes

Requirements for the stowage and securing of all types of cargo and cargo containers except liquids and gases in bulk.

Chapter VII – Carriage of dangerous goods

Requires the carriage of all kinds of dangerous goods to be in compliance with the International Maritime Dangerous Goods Code (IMDG Code).

Chapter VIII – Nuclear ships

Nuclear powered ships are required, particularly concerning radiation hazards, to conform to the Code of Safety for Nuclear Merchant Ships.

Chapter IX – Management for the Safe Operation of Ships

Requires every shipowner and any person or company that has assumed responsibility for a ship to comply with the International Safety Management Code (ISM).

Chapter X – Safety measures for high-speed craft

Makes mandatory the International Code of Safety for High-speed craft (HSC Code).

Chapter XI-1 – Special measures to enhance maritime safety

Requirements relating to organisations responsible for carrying out surveys and inspections, enhanced surveys, the ship identification number scheme, and operational requirements.

Chapter XI-2 – Special measures to enhance maritime security

Includes the International Ship and Port Facility Security Code (ISPS Code). Confirms that the role of the Master in maintaining the security of the ship is not, and cannot be, constrained by the Company, the charterer or any other person. Port facilities must carry out security assessments and develop, implement and review port facility security plans. Controls the delay, detention, restriction, or expulsion of a ship from a port. Requires that ships must have a ship security alert system, as well as detailing other measures and requirements.

Chapter XII – Additional safety measures for bulk carriers

Specific structural requirements for bulk carriers over 150 metres in length.

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)

Adoption: 7 July 1978; Entry into force: 28 April 1984; Major revisions in 1995 and 2010

The 1978 STCW Convention was the first to establish basic requirements on training, certification and watchkeeping for seafarers on an international level. Previously the standards of training, certification and watchkeeping of officers and ratings were established by individual governments, usually without reference to practices in other countries. As a result standards and procedures varied widely, even though shipping is the most international of all industries.

The Convention prescribes minimum standards relating to training, certification and watchkeeping for seafarers which countries are obliged to meet or exceed.

The 1995 amendments, adopted by a Conference, represented a major revision of the Convention, in response to a recognized need to bring the Convention up to date and to respond to critics who pointed out the many vague phrases, such as "to the satisfaction of the Administration", which resulted in different interpretations being made.

The 1995 amendments entered into force on 1 February 1997. One of the major features of the revision was the division of the technical annex into regulations, divided into Chapters as before, and a new STCW Code, to which many technical regulations were transferred. Part A of the Code is mandatory while Part B is recommended.

Dividing the regulations up in this way makes administration easier and it also makes the task of revising and updating them more simple: for procedural and legal reasons there is no need to call a full conference to make changes to Codes.

Another major change was the requirement for Parties to the Convention are required to provide detailed information to IMO concerning administrative measures taken to ensure compliance with the Convention. This represented the first time that IMO had been called upon to act in relation to compliance and implementation - generally, implementation is down to the flag States, while port State control also acts to ensure compliance. Under Chapter I, regulation I/7 of the revised Convention, Parties are required to provide detailed information to IMO concerning administrative measures taken to ensure compliance with the Convention, education and training courses, certification procedures and other factors relevant to implementation.The information is reviewed by panels of competent persons, nominated by Parties to the STCW Convention, who report on their findings to the IMO Secretary-General, who, in turn, reports to the Maritime Safety Committee (MSC) on the Parties which fully comply. The MSC then produces a list of "confirmed Parties" in compliance with the STCW Convention.

STCW Convention chapters

Chapter I: General provisions
Chapter II: Master and deck department
Chapter III: Engine department
Chapter IV: Radiocommunication and radio personnel
Chapter V: Special training requirements for personnel on certain types of ships
Chapter VI: Emergency, occupational safety, medical care and survival functions
Chapter VII: Alternative certification
Chapter VIII: Watchkeeping

The STCW Code

The regulations contained in the Convention are supported by sections in the STCW Code. Generally speaking, the Convention contains basic requirements which are then enlarged upon and explained in the Code. Part A of the Code is mandatory. The minimum standards of competence required for seagoing personnel are given in detail in a series of tables. Part B of the Code contains recommended guidance which is intended to help Parties implement the Convention. The measures suggested are not mandatory and the examples given are only intended to illustrate how certain Convention requirements may be complied with. However, the recommendations in general represent an approach that has been harmonized by discussions within IMO and consultation with other international organizations.

The **Manila amendments to the STCW Convention and Code** were adopted on 25 June 2010, marking a major revision of the STCW Convention and Code. The 2010 amendments entered into force on 1 January 2012 under the tacit acceptance procedure and are aimed at bringing the Convention and Code up to date with developments since they were initially adopted and to enable them to address issues that are anticipated to emerge in the foreseeable future.

Amongst the amendments adopted, there are a number of important changes to each chapter of the Convention and Code, including:

- Improved measures to prevent fraudulent practices associated with certificates of competency and strengthen the evaluation process (monitoring of Parties' compliance with the Convention);
- Revised requirements on hours of work and rest and new requirements for the prevention of drug and alcohol abuse, as well as updated standards relating to medical fitness standards for seafarers;
- New certification requirements for able seafarers;
- New requirements relating to training in modern technology such as electronic charts and information systems (ECDIS);
- New requirements for marine environment awareness training and training in leadership and teamwork;
- New training and certification requirements for electro-technical officers;
- Updating of competence requirements for personnel serving on board all types of tankers, including new requirements for personnel serving on liquefied gas tankers;
- New requirements for security training, as well as provisions to ensure that seafarers are properly trained to cope if their ship comes under attack by pirates;
- Introduction of modern training methodology including distance learning and web-based learning;
- New training guidance for personnel serving on board ships operating in polar waters; and
- New training guidance for personnel operating Dynamic Positioning Systems.

Passengers

Special Trade Passenger Ships Agreement and Rules, 1971; Protocol on Space Requirements for Special Trade Passenger Ships, 1973

Adoption: 6 October 1971
Entry into force: 2 January 1974

The carriage of large numbers of unberthed passengers in special trades such as the pilgrim trade in a restricted sea area around the Indian Ocean is of particular interest to countries in that area. It was regulated by the Simla Rules of 1931, which became outdated following the adoption of the 1948 and 1960 SOLAS Conventions.

As a result, IMO convened an International Conference in 1971 to consider safety requirements for special trade passenger ships in relation to the 1960 SOLAS Convention.

Included in an Annex to the Agreement are Special Trade Passenger Ships Rules, 1971, which provide modifications to the regulations of Chapters II and III of the 1960 SOLAS Convention.

Protocol on Space Requirements for Special Trade Passenger Ships, 1973

Adoption: 13 July 1973
Entry into force: 2 June 1977

Following the International Conference on Special Trade Passenger Ships, 1971, IMO, in cooperation with other Organizations, particularly the World Health Organisation (WHO), developed technical rules covering the safety aspects of carrying passengers on board such ships.

The Protocol on Space Requirements for Special Trade Passenger Ships was adopted in 1973. Annexed to this Protocol are technical rules covering the safety aspect of the carriage of passengers in special trade passenger ships.

The space requirements for special trade passenger ships are complementary to the 1971 Special Trade Passenger Ships Agreement.

Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974

Adoption: 13 December 1974

Entry into force: 28 April 1987

<u>Introduction</u>

A Conference, convened in Athens in 1974, adopted the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974.

The Convention is designed to consolidate and harmonize two earlier Brussels conventions dealing with passengers and luggage and adopted in 1961 and 1967 respectively.

The Convention establishes a regime of liability for damage suffered by passengers carried on a seagoing vessel. It declares a carrier liable for damage or loss suffered by a passenger if the incident causing the damage occurred in the course of the carriage and was due to the fault or neglect of the carrier.

However, unless the carrier acted with intent to cause such damage, or recklessly and with knowledge that such damage would probably result, he can limit his liability.

For the death of, or personal injury to, a passenger, this limit of liability is set at

46,666 Special Drawing Rights (SDR) (about US$59,700) per carriage.

As far as loss of or damage to luggage is concerned, the carrier's limit of liability varies, depending on whether the loss or damage occurred in respect of cabin luggage, of a vehicle and/or luggage carried in or on it, or in respect of other luggage.

<u>The 1989 Protocol</u>

Adoption: 19 November 1976

Entry into force: 30 April 1989

The Athens Convention also used the "Poincaré franc", based on the "official" value of gold, as the applicable unit of account.

A Protocol to the Convention, with the same provisions as in the Protocols to the

1971 Fund Convention and the 1969 Liability Convention, was accordingly adopted in November 1976, making the unit of account the Special Drawing Right (SDR).

<u>The 1990 Protocol</u>

Adoption: 29 March 1990

Entry into force: 90 days after being accepted by 10 States

Status: See status of conventions

The main aim of the Protocol is to raise the amount of compensation available in the event of deaths or injury at 175,000 SDR (around US$224,000). Other limits are 1,800 SDR (about US$2,300) for loss of or damage to cabin luggage and 10,000 SDR (about US$12,800) for loss of or damage to vehicles.

The Protocol also makes provision for the "tacit acceptance" procedure to be used to amend the limitation amounts in the future.

Review of the Athens Convention – new Protocol

IMO's Legal Committee is currently carrying out a review of the Athens Convention, with the aim of drafting amendments to the Convention, taking into account the work of the International Civil Aviation Organization (ICAO) in amending the Warsaw Convention, which covers liability in respect of the carriage by air of passengers, luggage and goods.

The review of the Athens Convention focuses on the introduction of provision of financial security (compulsory insurance) as well as on other subjects such as the introduction of strict liability and the updating of limits of compensation. It is hoped that these amendments, once adopted, will encourage wider acceptance of the Athens Convention.

The Legal Committee at its 82nd session in October 2000 agreed that a draft protocol to the Athens Convention would be ready for consideration by a diplomatic conference during the biennium 2002-2003.

The draft Protocol introduces, among other things, the requirement of compulsory insurance for passenger claims, and proposes changes to the purely fault-based liability system which is a feature of the 1974 Convention.

Special Drawing Rights

The daily conversion rates for Special Drawing Rights (SDRs) can be found on the International Monetary Fund website at www.imf.org.

4.2.1 INTERNATIONAL MARITIME LAW EMBODIED IN INTERNATIONAL AGREEMENTS AND CONVENTIONS

1.1 Certificates and Other Documents Required to be Carried on Board Ships by International Conventions and Agreements

Note: All certificates to be carried on board must be valid and drawn up in the form corresponding to the model where required by the relevant international convention or instrument.

No.	Contents	Reference
1	**All ships to which the referenced convention applies**	
	International Tonnage Certificate (1969) An International Tonnage Certificate (1969) shall be issued to every ship, the gross and net tonnage of which have been determined in accordance with the Convention.	Tonnage Convention, article 7
	International Load Line Certificate An International Load Line Certificate shall be issued under the provisions of the International Convention on Load Lines, 1966, to every ship which has been surveyed and marked in accordance with the Convention or the Convention as modified by the 1988 LL Protocol, as appropriate.	LL Convention, article 16; 1988 LL Protocol, article 16
	International Load Line Exemption Certificate An International Load Line Exemption Certificate shall be issued to any ship to which an exemption has been granted under and in accordance with article 6 of the Load Line Convention or the Convention as modified by the 1988 LL Protocol, as appropriate.	LL Convention, article 6; 1988 LL Protocol, article 16
	Coating Technical File	SOLAS 1974,

No.	Contents	Reference
	A Coating Technical File, containing specifications of the coating system applied to dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers of 150 m in length and upwards, record of the shipyard's and shipowner's coating work, detailed criteria for coating sections, job specifications, inspection, maintenance and repair, shall be kept on board and maintained throughout the life of the ship.	regulation II-1/3-2; Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers (resolution MSC.215(82))
	Construction drawings A set of as-built construction drawings and other plans showing any subsequent structural alterations shall be kept on board a ship constructed on or after 1 January 2007.	SOLAS 1974, regulation II-1/3-7; MSC/Circ.1135 on As-built construction drawings to be maintained on board the ship and ashore
	Ship Construction File A Ship Construction File with specific information should be kept on board oil tankers of 150 m in length and above and bulk carriers of 150 m in length and above, constructed with single deck, top-side tanks and hopper side tanks in cargo spaces, excluding ore carriers and combination carriers: .1 for which the building contract is placed on or after 1 July 2016; .2 in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 July 2017; or .3 the delivery of which is on or after 1 July 2020 shall carry a Ship Construction File containing information in accordance with regulations and guidelines, and updated as appropriate throughout the ship's life in order to facilitate safe operation, maintenance, survey, repair and emergency measures.	SOLAS 1974, regulation II-1/3-10; MSC.1/Circ.1343 on Guidelines for the information to be included in a Ship Construction File
	Stability information Every passenger ship regardless of size and every cargo ship of 24 m and over shall be inclined on completion and the elements of their stability determined. The master shall be supplied with stability information containing such information as is necessary to enable him, by rapid and simple procedures, to obtain accurate guidance as to the stability of the ship under varying conditions of service to maintain the required intact stability and stability after damage. For bulk carriers, the	SOLAS 1974,regulations II-1/5 and II-1/5-1; LL Convention; 1988 LL Protocol, regulation 10

No.	Contents	Reference
	information required in a bulk carrier booklet may be contained in the stability information.	
	Damage control plans and booklets On passenger and cargo ships, there shall be permanently exhibited plans showing clearly for each deck and hold the boundaries of the watertight compartments, the openings therein with the means of closure and position of any controls thereof, and the arrangements for the correction of any list due to flooding. Booklets containing the aforementioned information shall be made available to the officers of the ship.	SOLAS 1974, regulation II-1/19; MSC.1/Circ.1245
	Minimum safe manning document Every ship to which chapter I of the Convention applies shall be provided with an appropriate safe manning document or equivalent issued by the Administration as evidence of the minimum safe manning.	SOLAS 1974, regulation V/14.2
	Fire safety training manual A training manual shall be written in the working language of the ship and shall be provided in each crew mess room and recreation room or in each crew cabin. The manual shall contain the instructions and information required in regulation II-2/15.2.3.4. Part of such information may be provided in the form of audio-visual aids in lieu of the manual	SOLAS 1974, regulation II-2/15.2.3
	Fire control plan/booklet General arrangement plans shall be permanently exhibited for the guidance of the ship's officers, showing clearly for each deck the control stations, the various fire sections together with particulars of the fire detection and fire alarm systems and the fire-extinguishing appliances, etc. Alternatively, at the discretion of the Administration, the aforementioned details may be set out in a booklet, a copy of which shall be supplied to each officer, and one copy shall at all times be available on board in an accessible position. Plans and booklets shall be kept up to date; any alterations shall be recorded as soon as practicable. A duplicate set of fire control plans or a booklet containing such plans shall be permanently stored in a prominently marked weathertight enclosure outside the deckhouse for the assistance of shoreside fire-fighting personnel.	SOLAS1974, regulations II-2/15.2.4 and II-2/15.3.2
	Onboard training and drills record Fire drills shall be conducted and recorded in accordance with the provisions of regulations III/19.3 and III/19.5.	SOLAS 1974, regulation II-2/15.2.2.5
	Fire safety operational booklet	SOLAS 1974,regulation II-2/16.2

No.	Contents	Reference
	The fire safety operational booklet shall contain the necessary information and instructions for the safe operation of the ship and cargo handling operations in relation to fire safety. The booklet shall be written in the working language of the ship and be provided in each crew mess room and recreation room or in each crew cabin. The booklet may be combined with the fire safety training manuals required in regulation II-2/15.2.3.	
	Maintenance plans The maintenance plan shall include the necessary information about fire protection systems and fire-fighting systems and appliances as required under regulation II-2/14.2.2. For tankers, additional requirements are referred to in regulation II-2/14.4.	SOLAS 1974,regulations II-2/14.2.2 and II-2/14.4
	Training manual The training manual, which may comprise several volumes, shall contain instructions and information, in easily understood terms illustrated wherever possible, on the life-saving appliances provided in the ship and on the best methods of survival. Any part of such information may be provided in the form of audio-visual aids in lieu of the manual.	SOLAS 1974,regulation III/35
	Nautical charts and nautical publications Nautical charts and nautical publications for the intended voyage shall be adequate and up to date. An electronic chart display and information system (ECDIS) is also accepted as meeting the chart carriage requirements of this subparagraph.	SOLAS 1974,regulations V/19.2.1.4 and V/27
	International Code of Signals and a copy of Volume III of IAMSAR Manual All ships required to carry a radio installation shall carry the International Code of Signal; all ships shall carry an up-to-date copy of Volume III of the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual.	SOLAS 1974,regulation V/21
	Records of navigational activities All ships engaged on international voyages shall keep on board a record of navigational activities and incidents including drills and pre-departure tests. When such information is not maintained in the ship's logbook, it shall be maintained in another form approved by the Administration.	SOLAS 1974,regulations V/26 and V/28.1
	Manoeuvring booklet The stopping times, ship headings and distances recorded on trials, together with the results of trials to determine the ability of ships having multiple propellers to navigate and manoeuvre with one or more propellers inoperative, shall be available on board for the use of the master or designated personnel.	SOLAS 1974,regulation II-1/28

No.	Contents	Reference
	Material Safety Data Sheets (MSDS) Ships carrying oil or oil fuel, as defined in regulation 1 of annex 1 of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, shall be provided with material safety data sheets, based on the recommendations developed by the Organization, prior to the loading of such oil as cargo in bulk or bunkering of oil fuel.	SOLAS 1974, regulation VI/5-1; resolution MSC.286(86)
	AIS test report The Automatic Identification System (AIS) shall be subjected to an annual test by an approved surveyor or an approved testing or servicing facility. A copy of the test report shall be retained on board and should be in accordance with a model form set out in the annex to MSC.1/Circ.1252	SOLAS 1974, regulation V/18.9;MSC.1/Circ.1252
	Certificates for masters, officers or ratings Certificates for masters, officers or ratings shall be issued to those candidates who, to the satisfaction of the Administration, meet the requirements for service, age, medical fitness, training, qualifications and examinations in accordance with the provisions of the STCW Code annexed to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978. Formats of certificates are given in section A-I/2 of the STCW Code. Certificates must be kept available in their original form on board the ships on which the holder is serving.	STCW 1978, article VI, regulation I/2; STCW Code, section A-I/2
	Records of hours of rest Records of daily hours of rest of seafarers shall be maintained on board.	STCW Code, section A-VIII/1;Maritime Labour Convention, 2006; Seafarers' Hours of Work and the Manning of Ships Convention, 1996 (No.180); IMO/ILO Guidelines for the development of tables of seafarers' shipboard working arrangements and formats of records of seafarers' hours of work or hours of rest Note: The Maritime Labour Convention, 2006

No.	Contents	Reference
		shall come into force on 20/08/2013
	International Oil Pollution Prevention Certificate An international Oil Pollution Prevention Certificate shall be issued, after survey in accordance with regulation 6 of Annex I of MARPOL, to any oil tanker of 150 gross tonnage and above and any other ship of 400 gross tonnage and above which is engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties to MARPOL . The certificate is supplemented with a Record of Construction and Equipment for Ships other than Oil Tankers (Form A) or a Record of Construction and Equipment for Oil Tankers (Form B), as appropriate.	MARPOL Annex I, regulation 7
	Oil Record Book Every oil tanker of 150 gross tonnage and above and every ship of 400 gross tonnage and above other than an oil tanker shall be provided with an Oil Record Book, Part I (Machinery space operations). Every oil tanker of 150 gross tonnage and above shall also be provided with an Oil Record Book, Part II (Cargo/ballast operations).	MARPOL Annex I, regulations 17 and 36
	Shipboard Oil Pollution Emergency Plan Every oil tanker of 150 gross tonnage and above and every ship other than an oil tanker of 400 gross tonnage and above shall carry on board a Shipboard Oil Pollution Emergency Plan approved by the Administration.	MARPOL Annex I, regulation 37; resolution MEPC.54(32), as amended by resolution MEPC.86(44)
	International Sewage Pollution Prevention Certificate An International Sewage Pollution Prevention Certificate shall be issued, after an initial or renewal survey in accordance with the provisions of regulation 4 of Annex IV of MARPOL, to any ship which is required to comply with the provisions of that Annex and is engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties to the Convention.	MARPOL Annex IV, regulation 5; MEPC/Circ.408
	Garbage Management Plan Every ship of 100 gross tonnage and above and every ship which is certified to carry 15 persons or more shall carry a garbage management plan which the crew shall follow.	MARPOL Annex V, regulation 10; resolution MEPC.71(38); MEPC/Circ.317
	Garbage Record Book Every ship of 400 gross tonnage and above and every ship which is certified to carry 15 persons or more engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties to the Convention and every fixed and floating platform engaged in exploration and exploitation of the seabed shall be provided with a Garbage Record Book.	MARPOL Annex V, regulation 10

No.	Contents	Reference
	Voyage data recorder system – certificate of compliance The voyage data recorder system, including all sensors, shall be subjected to an annual performance test. The test shall be conducted by an approved testing or servicing facility to verify the accuracy, duration and recoverability of the recorded data. In addition, tests and inspections shall be conducted to determine the serviceability of all protective enclosures and devices fitted to aid location. A copy of the certificate of compliance issued by the testing facility, stating the date of compliance and the applicable performance standards, shall be retained on board the ship.	SOLAS 1974, regulation V/18.8
	Cargo Securing Manual All cargoes other than solid and liquid bulk cargoes, cargo units and cargo transport units, shall be loaded, stowed and secured throughout the voyage in accordance with the Cargo Securing Manual approved by the Administration. In ships with ro-ro spaces, as defined in regulation II-2/3.41, all securing of such cargoes, cargo units and cargo transport units, in accordance with the Cargo Securing Manual, shall be completed before the ship leaves the berth. The Cargo Securing Manual is required on all types of ships engaged in the carriage of all cargoes other than solid and liquid bulk cargoes, which shall be drawn up to a standard at least equivalent to the guidelines developed by the Organization.	SOLAS 1974,regulations VI/5.6 and VII/5; MSC.1/Circ.1353
	Document of Compliance A document of compliance shall be issued to every company which complies with the requirements of the ISM Code. A copy of the document shall be kept on board.	SOLAS 1974,regulation IX/4; ISM Code, paragraph 13
	Safety Management Certificate A Safety Management Certificate shall be issued to every ship by the Administration or an organization recognized by the Administration. The Administration or an organization recognized by it shall, before issuing the Safety Management Certificate, verify that the company and its shipboard management operate in accordance with the approved safety management system.	SOLAS 1974, regulation IX/4; ISM Code, paragraph 13
	International Ship Security Certificate (ISSC) or Interim International Ship Security Certificate An International Ship Security Certificate (ISSC) shall be issued to every ship by the Administration or an organization recognized by it to verify that the ship complies with the maritime security provisions of SOLAS chapter XI-2 and part	SOLAS 1974, regulation XI-2/9.1.1; ISPS Code, part A, section 19 and appendices.

No.	Contents	Reference
	A of the ISPS Code. An interim ISSC may be issued under the ISPS Code, part A, section 19.4.	
	Ship Security Plan and associated records Each ship shall carry on board a ship security plan approved by the Administration. The plan shall make provisions for the three security levels as defined in part A of the ISPS Code. Records of the following activities addressed in the ship security plan shall be kept on board for at least the minimum period specified by the Administration: .1 training, drills and exercises; .2 security threats and security incidents; .3 breaches of security; .4 changes in security level; .5 communications relating to the direct security of the ship such as specific threats to the ship or to port facilities the ship is, or has been, in; .6 internal audits and reviews of security activities; .7 periodic review of the ship security assessment; .8 periodic review of the ship security plan; .9 implementation of any amendments to the plan; and .10 maintenance, calibration and testing of any security equipment provided on board, including testing of the ship security alert system.	SOLAS 1974,regulation XI-2/9; ISPS Code. part A, sections 9 and 10
	Continuous Synopsis Record (CSR) Every ship to which chapter I of the Convention applies shall be issued with a Continuous Synopsis Record. The Continuous Synopsis Record provides an onboard record of the history of the ship with respect to the information recorded therein.	SOLAS 1974, regulation XI-1/5
	International Anti-fouling System Certificate Ships of 400 GT and above engaged in international voyages, excluding fixed or floating platforms, FSUs, and FPSOs, shall be issued after inspection and survey an international Anti-fouling System Certificate together with a Record of Anti-fouling Systems.	AFS Convention, regulation 2(1) of annex 4
	Declaration on Anti-fouling System Ships of 24 m or more in length, but less than 400 GT engaged in international voyages, excluding fixed or floating platforms, FSUs, and FPSOs, shall carry a declaration signed by the owner or owner's authorized agents. Such a declaration shall be accompanied by appropriate documentation (such as a paint receipt or a contractor invoice) or contain appropriate endorsement.	AFS Convention, regulation 5(1) of annex 4
	International Air Pollution Prevention Certificate	MARPOL Annex VI,

No.	Contents	Reference
	Ships constructed before the date of entry into force of the Protocol of 1997 shall be issued with an International Air Pollution Prevention Certificate. Any ship of 400 gross tonnage and above engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties and platforms and drilling rigs engaged in voyages to waters under the sovereignty or jurisdiction of other Parties to the Protocol of 1997 shall be issued with an International Air Pollution Prevention Certificate.	regulation 6
	International Energy Efficiency Certificate An International Energy Efficiency Certificate for the ship shall be issued after a survey in accordance with the provisions of regulation 5.4 to any ships of 400 gross tonnage and above before that ship may engage in voyages to ports or offshore terminals under the jurisdiction of other Parties.	MARPOL Annex VI, regulation 6
	Ozone-depleting Substances Record Book Each ship subject to MARPOL Annex VI, regulation 6.1 that has rechargeable systems that contain ozone-depleting substances shall maintain an ozone-depleting substances record book.	MARPOL Annex VI, regulation 12.6
	Fuel Oil Changeover Procedure and Logbook (record of fuel changeover) Those ships using separate fuel oils to comply with MARPOL Annex VI, regulation 14.3 and entering or leaving an emission control area shall carry a written procedure showing how the fuel oil changeover is to be done. The volume of low-sulphur fuel oils in each tank as well as the date, time and position of the ship when any fuel oil changeover operation is completed prior to the entry into an emission control area or commenced after exit from such an area shall be recorded in such logbook as prescribed by the Administration.	MARPOL Annex VI, regulation 14.6
	Manufacturer's Operating Manual for Incinerators Incinerators installed in accordance with the requirements of MARPOL Annex VI, regulation 16.6.1 shall be provided with a Manufacturer's Operating Manual, which is to be retained with the unit.	MARPOL Annex VI, regulation 16.7
	Bunker Delivery Note and Representative Sample Bunker Delivery Note and representative sample of the fuel oil delivered shall be kept on board in accordance with requirements of MARPOL Annex VI, regulations 18.6 and 18.8.1.	MARPOL Annex VI, regulations 18.6 and 18.8.1
	Ship Energy Efficiency Management Plan (SEEMP) All ships of 400 gross tonnage and above, excluding platforms	MARPOL Annex VI, regulation 22;

No.	Contents	Reference
	(including FPSOs and FSUs) and drilling rigs, regardless of their propulsion, shall keep on board a ship specific Ship Energy Efficiency Management Plan (SEEMP). This may form part of the ship's Safety management System (SMS).	MEPC.1/Circ.795
	EEDI Technical File Applicable to ships falling into one or more of categories in MARPOL Annex VI, regulations 2.25 to 2.35.	MARPOL Annex VI, regulation 20
	Technical File Every marine diesel engine installed on board a ship shall be provided with a Technical File. The Technical File shall be prepared by the applicant for engine certification and approved by the Administration, and is required to accompany an engine throughout its life on board ships. The Technical File shall contain the information as specified in paragraph 2.4.1 of the NOx Technical Code	NOx Technical Code, paragraph 2.3.4
	Record Book of Engine Parameters Where the Engine Parameter Check method in accordance with paragraph 6.2 of the NOx Technical Code is used to verify compliance, if any adjustments or modifications are made to an engine after its pre-certification, a full record of such adjustments or modifications shall be recorded in the engine's Record Book of Engine Parameters.	NOx Technical Code, paragraph 2.3.7
	Exemption Certificate1 When an exemption is granted to a ship under and in accordance with the provisions of SOLAS 1974, a certificate called an Exemption Certificate shall be issued in addition to the certificates listed above.	SOLAS 1974, regulation I/12; 1988 SOLAS Protocol, regulation I/12
	LRIT conformance test report A Conformance test report should be issued, on satisfactory completion of a conformance test, by the Administration or the ASP who conducted the test acting on behalf of the Administration and should be in accordance with the model set out in appendix 2 of MSC.1/Circ.1307.	SOLAS 1974, regulation V/19-1; MSC.1/Circ.1307
	Noise Survey Report Applicable to new ships of 1,600 gross tonnage and above, excluding dynamically supported crafts, high-speed crafts, fishing vessels, pipe-laying barges, crane barges, mobile offshore drilling units, pleasure yachts not engaged in trade, ships of war and troopships, ships not propelled by mechanical means, pile driving vessels and dredgers. A noise survey report shall always be carried on board and be accessible for the crew.	SOLAS 1974, regulation II-1/3-12; Code on noise levels on board ships, section 4.3 Note: The above mandatory requirements are expected to enter into force

No.	Contents	Reference
	For existing ships, refer to section "Other certificates and documents which are not mandatory – Noise Survey Report" (resolution A.468(XII).	on 1/7/2014
	Ship-specific Plans and Procedures for Recovery of Persons from the Water All ships shall have ship-specific plans and procedures for recovery of persons from the water. Ships constructed before 1 July 2014 shall comply with this requirement by the first periodical or renewal safety equipment survey of the ship to be carried out after 1 July 2014, whichever comes first. Ro-ro passenger ships which comply with regulation III/26.4 shall be deemed to comply with this regulation. The Plans and Procedures should be considered as a part of the emergency preparedness plan required by paragraph 8 of the ISM Code	SOLAS 1974 regulation, III/17-1; Resolution MSC.346(91); MSC.1/Circ.1447 Note: The above mandatory requirements are expected to enter into force on 1/7/2014
1	**In addition to the certificates listed in section 1 above, passenger ships shall carry:**	
	Passenger Ship Safety Certificate A certificate called a Passenger Ship Safety Certificate shall be issued after inspection and survey to a passenger ship which complies with the requirements of chapters II-1, II-2, III, IV and V and any other relevant requirements of SOLAS 1974. A Record of Equipment for the Passenger Ship Safety Certificate (Form P) shall be permanently attached.	SOLAS 1974, regulation I/12; 1988 SOLAS Protocol, regulation I/12
	Special Trade Passenger Ship Safety Certificate, Special Trade Passenger Ship Space CertificateA Special Trade Passenger Ship Safety Certificate issued under the provisions of the Special Trade Passenger Ships Agreement, 1971. A certificate called a Special Trade Passenger Ship Space Certificate shall be issued under the provisions of the Protocol on Space Requirements for Special Trade Passenger Ships, 1973.	STP 71, rule 5 SSTP 73, rule 5
	Search and rescue cooperation plan Passenger ships to which chapter I of the Convention applies shall have on board a plan for cooperation with appropriate search and rescue services in event of an emergency.	SOLAS 1974, regulation V/7.3
	List of operational limitations Passenger ships to which chapter I of the Convention applies shall keep on board a list of all limitations on the operation of the ship, including exemptions from any of the SOLAS regulations, restrictions in operating areas, weather restrictions, sea state restrictions, restrictions in permissible loads, trim,	SOLAS 1974, regulation V/30

No.	Contents	Reference
	speed and any other limitations, whether imposed by the Administration or established during the design or the building stages.	
	Decision support system for masters In all passenger ships, a decision support system foremergency management shall be provided on the navigation bridge.	SOLAS 1974, regulation III/29
3	**In addition to the certificates listed in section 1 above, cargo ships shall carry:**	
	Cargo Ship Safety Construction Certificate A certificate called a Cargo Ship Safety Construction Certificate shall be issued after survey to a cargo ship of 500 gross tonnage and over which satisfies the requirements for cargo ships on survey, set out in regulation I/10 of SOLAS 1974, and complies with the applicable requirements of chapters II-1 and II-2, other than those relating to fire-extinguishing appliances and fire-control plans.	SOLAS 1974, regulation I/12; 1988 SOLAS Protocol, regulation I/12
	Cargo Ship Safety Equipment Certificate A certificate called a Cargo Ship Safety Equipment Certificate shall be issued after survey to a cargo ship of 500 gross tonnage and over which complies with the relevant requirements of chapters II-1 and II-2, III and V and any other relevant requirements of SOLAS 1974. A Record of Equipment for the Cargo Ship Safety Equipment Certificate (Form E) shall be permanently attached.	SOLAS 1974, regulation I/12; 1988 SOLAS Protocol, regulation I/12
	Cargo Ship Safety Radio Certificate A certificate called a Cargo Ship Safety Radio Certificate shall be issued after survey to a cargo ship of 300 gross tonnage and over, fitted with a radio installation, including those used in life-saving appliances, which complies with the requirements of chapter IV and any other relevant requirements of SOLAS 1974. A Record of Equipment for the Cargo Ship Safety Radio Certificate (Form R) shall be permanently attached.	SOLAS 1974, regulation I/12, as amended by the GMDSS amendments; 1988 SOLAS Protocol, regulation I/12
	Cargo Ship Safety Certificate A certificate called a Cargo Ship Safety Certificate may be issued after survey to a cargo ship which complies with the relevant requirements of chapters II-1, II-2, III, IV and V and other relevant requirements of SOLAS 1974 as modified by the 1988 SOLAS Protocol, as an alternative to the Cargo Ship Safety Construction Certificate, Cargo Ship Safety Equipment Certificate and Cargo Ship Safety Radio Certificate. A Record of Equipment for the Cargo Ship Safety Certificate (Form C) shall be permanently attached.	1988 SOLAS Protocol, regulation I/12
	Document of authorization for the carriage of grain and	SOLAS 1974,

No.	Contents	Reference
	grain loading manual A document of authorization shall be issued for every ship loaded in accordance with the regulations of the International Code for the Safe Carriage of Grain in Bulk. The document shall accompany or be incorporated into the grain loading manual provided to enable the master to meet the stability requirements of the Code.	regulation VI/9; International Code for the Safe Carriage of Grain in Bulk, section 3
	Certificate of insurance or other financial security in respect of civil liability for oil pollution damage A certificate attesting that insurance or other financial security is in force shall be issued to each ship carrying more than 2,000 tonnes of oil in bulk as cargo. It shall be issued or certified by the appropriate authority of the State of the ship's registry after determining that the requirements of article VII, paragraph 1, of the CLC Convention have been complied with.	CLC 1969, article VII
	Certificate of insurance or other financial security in respect of civil liability for bunker oil pollution damage Certificate attesting that insurance or other financial security is in force in accordance with the provisions of this Convention shall be issued to each ship of greater than 1,000 GT after the appropriate authority of a State Party has determined that the requirements of article 7, paragraph 1 have been complied with. With respect to a ship registered in a State Party such certificate shall be issued or certified by the appropriate authority of the State of the ship's registry; with respect to a ship not registered in a State Party it may be issued or certified by the appropriate authority of any State Party. A State Party may authorize either an institution or an organization recognized by it to issue the certificate referred to in paragraph 2.	Bunker Convention 2001, article 7
	Certificate of insurance or other financial security in respect of civil liability for oil pollution damage A certificate attesting that insurance or other financial security is in force in accordance with the provisions of the 1992 CLC Convention shall be issued to each ship carrying more than 2,000 tonnes of oil in bulk as cargo after the appropriate authority of a Contracting State has determined that the requirements of article VII, paragraph 1, of the Convention have been complied with. With respect to a ship registered in a Contracting State, such certificate shall be issued by the appropriate authority of the State of the ship's registry; with respect to a ship not registered in a Contracting State, it may be issued or certified by the appropriate authority of any Contracting State.	CLC 1992, article VII

No.	Contents	Reference
	Enhanced survey report file Bulk carriers and oil tankers shall have a survey report file and supporting documents complying with paragraphs 6.2 and 6.3 of annex A and annex B of resolution A.744(18) –Guidelines on the enhanced programme of inspections during surveys of bulk carriers and oil tankers. Note: refer to requirements of survey report file and supporting documents for bulk carriers and oil tankers as referred to in paragraphs 6.2 and 6.3 of annex A/annex B, part A/part B, 2011 ESP Code.	SOLAS 1974, regulation XI-1/2; resolution A.744(18) Note: The 2011 ESP Code is expected to come into force on 1/1/2014 and to supersede resolution A.744(18)
	Record of oil discharge monitoring and control system for the last ballast voyage Subject to the provisions of paragraphs 4 and 5 of regulation 3 of MARPOL Annex I, every oil tanker of 150 gross tonnage and above shall be equipped with an oil discharge monitoring and control system approved by the Administration. The system shall be fitted with a recording device to provide a continuous record of the discharge in litres per nautical mile and total quantity discharged, or the oil content and rate of discharge. The record shall be identifiable as to time and date and shall be kept for at least three years.	MARPOL Annex I, regulation 31
	Oil Discharge Monitoring and Control (ODMC) Operational Manual Every oil tanker fitted with an Oil Discharge Monitoring and Control system shall be provided with instructions as to the operation of the system in accordance with an operational manual approved by the Administration.	MARPOL Annex I, regulation 31; resolution A.496(XII); resolution A.586(14); resolution MEPC.108(49)
	Cargo Information The shipper shall provide the master or his representative with appropriate information, confirmed in writing, on the cargo, in advance of loading. In bulk carriers, the density of the cargo shall be provided in the above information.	SOLAS 1974, regulations VI/2 and XII/10; MSC/Circ.663
	Ship Structure Access Manual This regulation applies to oil tankers of 500 gross tonnage and over and bulk carriers, as defined in regulation IX/1, of 20,000 gross tonnage and over, constructed on or after 1 January 2006. A ship's means of access to carry out overall and close-up inspections and thickness measurements shall be described in a Ship structure access manual approved by the Administration, an updated copy of which shall be kept on board.	SOLAS 1974, regulation II-1/3-6
	Bulk Carrier Booklet	SOLAS 1974, regulations VI/7

No.	Contents	Reference
	To enable the master to prevent excessive stress in the ship's structure, the ship loading and unloading solid bulk cargoes shall be provided with a booklet referred to in SOLAS regulation VI/7.2. The booklet shall be endorsed by the Administration or on its behalf to indicate that SOLAS regulations XII/4, 5, 6 and 7, as appropriate, are complied with. As an alternative to a separate booklet, the required information may be contained in the intact stability booklet.	and XII/8; Code of Practice for the Safe Loading and Unloading of Bulk Carriers (BLU Code)
	Crude Oil Washing Operation and Equipment Manual (COW Manual) Every oil tanker operating with crude oil washing systems shall be provided with an Operations and Equipment Manual detailing the system and equipment and specifying operational procedures. Such a Manual shall be to the satisfaction of the Administration and shall contain all the information set out in the specifications referred to in regulation 35 of Annex I of MARPOL.	MARPOL Annex I, regulation 35; resolution MEPC.81(43)
	Condition Assessment Scheme (CAS) Statement of Compliance, CAS Final Report and Review Record A Statement of Compliance shall be issued by the Administration to every oil tanker which has been surveyed in accordance with the requirements of the Condition Assessment Scheme (CAS) and found to be in compliance with these requirements. In addition, a copy of the CAS Final Report which was reviewed by the Administration for the issue of the Statement of Compliance and a copy of the relevant Review Record shall be placed on board to accompany the Statement of Compliance.	MARPOL Annex I, regulations 20 and 21; resolution MEPC.94(46); resolution MEPC.99(48); resolution MEPC.112(50); resolution MEPC.131(53); resolution MEPC.155(55)
	Subdivision and stability information Every oil tanker to which regulation 28 of Annex I of MARPOL applies shall be provided in an approved form with information relative to loading and distribution of cargo necessary to ensure compliance with the provisions of this regulation and data on the ability of the ship to comply with damage stability criteria as determined by this regulation.	MARPOL Annex I, regulation 41
	VOC Management Plan A tanker carrying crude oil, to which MARPOL Annex VI, regulation 15.1 applies, shall have on board and implement a VOC Management Plan.	MARPOL Annex VI, regulation 15.6
4	**In addition to the certificates listed in sections 1 and 3 above, where appropriate, any ship carrying noxious liquid chemical substances in bulk shall carry:**	
	International Pollution Prevention Certificate for the	MARPOL Annex II,

No.	Contents	Reference
	Carriage of Noxious Liquid Substances in Bulk (NLS Certificate) An international pollution prevention certificate for the carriage of noxious liquid substances in bulk (NLS Certificate) shall be issued, after survey in accordance with the provisions of regulation 8 of Annex II of MARPOL, to any ship carrying noxious liquid substances in bulk and which is engaged in voyages to ports or terminals under the jurisdiction of other Parties to MARPOL. In respect of chemical tankers, the Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk and the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk, issued under the provisions of the Bulk Chemical Code and International Bulk Chemical Code, respectively, shall have the same force and receive the same recognition as the NLS Certificate.	regulation 8
	Cargo record book Ships carrying noxious liquid substances in bulk shall be provided with a Cargo Record Book, whether as part of the ship's official log book or otherwise, in the form specified in appendix II to Annex II.	MARPOL Annex II, regulation 15.2
	Procedures and Arrangements Manual (P & A Manual) Every ship certified to carry noxious liquid substances in bulk shall have on board a Procedures and Arrangements Manual approved by the Administration.	MARPOL Annex II, regulation 14; resolution MEPC.18(22)
	Shipboard Marine Pollution Emergency Plan for Noxious Liquid Substances Every ship of 150 gross tonnage and above certified to carry noxious liquid substances in bulk shall carry on board a shipboard marine pollution emergency plan for noxious liquid substances approved by the Administration.	MARPOL Annex II, regulation 17
5	**In addition to the certificates listed in sections 1 and 3 above, where applicable, any chemical tanker shall carry:**	
	Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk A certificate called a Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk, the model form of which is set out in the appendix to the Bulk Chemical Code, should be issued after an initial or periodical survey to a chemical tanker engaged in international voyages which complies with the relevant requirements of the Code. Note: The Code is mandatory under Annex II of MARPOL for chemical tankers constructed before 1 July 1986.	BCH Code, section 1.6; BCH Code, as modified by resolution MSC.18(58), section 1.6
	International Certificate of Fitness for the Carriage of	IBC Code,

No.	Contents	Reference
	Dangerous Chemicals in Bulk A certificate called an International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk, the model form of which is set out in the appendix to the International Bulk Chemical Code, should be issued after an initial or periodical survey to a chemical tanker engaged in international voyages, which complies with the relevant requirements of the Code. Note: The Code is mandatory under both chapter VII of SOLAS 1974 and Annex II of MARPOL for chemical tankers constructed on or after 1 July 1986.	section 1.5; IBC Code as modified by resolutions MSC.16(58) and MEPC.40(29), section 1.5
6	**In addition to the certificates listed in sections 1 and 3 above, where applicable, any gas carrier shall carry:**	
	Certificate of Fitness for the Carriage of Liquefied Gases in Bulk A certificate called a Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, the model form of which is set out in the appendix to the Gas Carrier Code, should be issued after an initial or periodical survey to a gas carrier which complies with the relevant requirements of the Code.	GC Code, section 1.6
	International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk A certificate called an International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, the model form of which is set out in the appendix to the International Gas Carrier Code, should be issued after an initial or periodical survey to a gas carrier which complies with the relevant requirements of the Code. Note: The Code is mandatory under chapter VII of SOLAS 1974 for gas carriers constructed on or after 1 July 1986.	IGC Code, section 1.5; IGC Code, as modified by resolution MSC.17(58), section 1.5
7	**In addition to the certificates listed in sections 1, and 2 or 3 above, where applicable, any high-speed craft shall carry:**	
	High-Speed Craft Safety Certificate A certificate called a High-Speed Craft Safety Certificate shall be issued after completion of an initial or renewal survey to a craft which complies with the requirements of the 1994 HSC Code or the 2000 HSC Code, as appropriate.	SOLAS 1974, regulation X/3; 1994 HSC Code, section 1.8; 2000 HSC Code, section 1.8
	Permit to Operate High-Speed Craft A certificate called a Permit to Operate High-Speed Craft shall be issued to a craft which complies with the requirements set out in paragraphs 1.2.2 to 1.2.7 of the 1994 HSC Code or the 2000 HSC Code, as appropriate.	1994 HSC Code, section 1.9; 2000 HSC Code, section 1.9

No.	Contents	Reference
8	**In addition to the certificates listed in sections 1, and 2 or 3 above, where applicable, any ship carrying dangerous goods shall carry:**	
	Document of compliance with the special requirements for ships carrying dangerous goods The Administration shall provide the ship with an appropriate document as evidence of compliance of construction and equipment with the requirements of regulation II-2/19 of SOLAS 1974. Certification for dangerous goods, except solid dangerous goods in bulk, is not required for those cargoes specified as class 6.2 and 7 and dangerous goods in limited quantities.	SOLAS 1974, regulation II-2/19.4
9	**In addition to the certificates listed in sections 1, and 2 or 3 above, where applicable, any ship carrying dangerous goods in packaged form shall carry:**	
	Dangerous goods manifest or stowage plan Each ship carrying dangerous goods in packaged form shall have a special list or manifest setting forth, in accordance with the classification set out in the IMDG Code, the dangerous goods on board and the location thereof. Each ship carrying dangerous goods in solid form in bulk shall have a list or manifest setting forth the dangerous goods on board and the location thereof. A detailed stowage plan, which identifies by class and sets out the location of all dangerous goods on board, may be used in place of such a special list or manifest. A copy of one of these documents shall be made available before departure to the person or organization designated by the port State authority.	SOLAS 1974, regulations VII/4.5 and VII/7-2; MARPOL Annex III, regulation 4
	In addition to the certificates listed in sections 1, and 2 or 3 above, where applicable, any ship carrying INF cargo shall carry:	
	International Certificate of Fitness for the Carriage of INF Cargo A ship carrying INF cargo shall comply with the requirements of the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code) in addition to any other applicable requirements of the SOLAS regulations and shall be surveyed and be provided with the International Certificate of Fitness for the Carriage of INF Cargo.	SOLAS 1974, regulation VII/16; INF Code (resolution MSC.88(71)), paragraph 1.3
1	**In addition to the certificates listed in sections 1, and 2 or 3 above, where applicable, any Nuclear Ship shall carry:**	
	A Nuclear Cargo Ship Safety Certificate or Nuclear	SOLAS 1974,

No.	Contents	Reference
	Passenger Ship Safety Certificate, in place of the Cargo Ship Safety Certificate or Passenger Ship Safety Certificate, as appropriate. Every Nuclear powered ship shall be issued with the certificate required by SOLAS chapter VIII.	regulation VIII/10
Other certificates and documents which are not mandatory		
	Special purpose ships	
	Special Purpose Ship Safety Certificate In addition to SOLAS certificates as specified in paragraph 7 of the Preamble of the Code of Safety for Special Purpose Ships, a Special Purpose Ship Safety Certificate should be issued after survey in accordance with the provisions of paragraph 1.6 of the Code for Special Purpose Ships. The duration and validity of the certificate should be governed by the respective provisions for cargo ships in SOLAS 1974. If a certificate is issued for a special purpose ship of less than 500 gross tonnage, this certificate should indicate to what extent relaxations in accordance with 1.2 were accepted.	Resolution A.534(13), as amended by MSC/Circ.739; 2008 SPS Code (resolution MSC.266(84)), SOLAS 1974, regulation I/12; 1988 SOLAS Protocol, regulation I/12
	Offshore support vessels	
	Offshore Supply Vessel Document of Compliance The Document of Compliance should be issued after satisfied that the vessel complies with the provisions of the Guidelines for the design and construction of Offshore Supply Vessels, 2006.	Resolution MSC.235(82)
	Certificate of Fitness for Offshore Support Vessels When carrying such cargoes, offshore support vessels should carry a Certificate of Fitness issued under the "Guidelines for the Transport and Handling of Limited Amounts of Hazardous and Noxious Liquid Substances in Bulk on Offshore Support Vessels". If an offshore support vessel carries only noxious liquid substances, a suitably endorsed International Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk may be issued instead of the above Certificate of Fitness.	Resolution A.673(16); MARPOL Annex II, regulation 13(4)
	Diving systems	
	Diving System Safety Certificate A certificate should be issued either by the Administration or any person or organization duly authorized by it after survey or inspection to a diving system which complies with the requirements of the Code of Safety for Diving Systems. In every case, the Administration should assume full responsibility for the certificate.	Resolution A.536(13), section 1.6

No.	Contents	Reference
	Passenger submersible craft	
	Safety Compliance Certificate for Passenger Submersible Craft Applicable to submersible craft adapted to accommodate passengers and intended for underwater excursions with the pressure in the passenger compartment at or near one atmosphere. A Design and Construction Document issued by the Administration should be attached to the Safety Compliance Certificate.	MSC/Circ.981, as amended by MSC/Circ.1125
	Dynamically supported craft	
	Dynamically Supported Craft Construction and Equipment Certificate To be issued after survey carried out in accordance with paragraph 1.5.1(a) of the Code of Safety for Dynamically Supported Craft.	Resolution A.373(X), section 1.6
	Mobile offshore drilling units	
	Mobile Offshore Drilling Unit Safety Certificate To be issued after survey carried out in accordance with the provisions of the Code for the Construction and Equipment of Mobile Offshore Drilling Units, 1979, or, for units constructed on or after 1 May 1991, the Code for the Construction and Equipment of Drilling Units, 1989.	Resolution A.414(XI), section 1.6; resolution A.649(16), section 1.6; resolution A.649(16), as modified by resolution MSC.38(63), section 1.6; 2009 MODU Code (resolution A.1023(26))
	Wing-In-Ground (WIG) Craft	
	Wing–in–ground Craft Safety Certificate A certificate called a WIG Craft Safety Certificate should be issued after completion of an initial or renewal survey to a craft, which complies with the provisions of the Interim Guidelines for WIG craft.	MSC/Circ.1054, section 9
	Permit to Operate WIG Craft A permit to operate should be issued by the Administration to certify compliance with the provisions of the Interim Guidelines for WIG craft.	MSC/Circ.1054, section 10
	Noise levels	
	Noise Survey Report Applicable to existing ships to which SOLAS II-1/3-12 does not apply.	Resolution A.468(XII), section 4.3

No.	Contents	Reference
	A noise survey report should be made for each ship in accordance with the Code on Noise Levels on Board Ships.	

Tonnage

All seagoing ships of 24 m in length and above require an, International Tonnage Certificate 1969"– ITC 69), ships of less than 24 m in length a (national) tonnage certificate. The length is to be measured according to article 2, paragraph 8 of the International Convention on Tonnage Measurement of Ships, 1969 – (ITC).

The tonnage certificate reflects the result of the measurement of the volume of the ship's spaces and shows both, the gross tonnage and the net tonnage. These tonnage figures affect, inter alia, harbour dues, canal- and pilotage charges, safety requirements, technical equipment, number of crew, fleet- and traffic statistics as well as the registration and the insurance of ships.

Transit charges for the Suez- and the Panama Canal are calculated according to different provisions, which are reflected by special Suez- and Panama Canal tonnage certificates.

The International Tonnage Certificate remains valid until alterations in construction or the use of spaces are made, the subdivision load line is changed or the ship is transferred to the flag of another State.

1.2 International Convention on Load Lines

Adoption: 5 April 1966; Entry into force: 21 July 1968

It has long been recognized that limitations on the draught to which a ship may be loaded make a significant contribution to her safety. These limits are given in the form of freeboards, which constitute, besides external weathertight and watertight integrity, the main objective of the Convention.

The first International Convention on Load Lines, adopted in 1930, was based on the principle of reserve buoyancy, although it was recognized then that the freeboard should also ensure adequate stability and avoid excessive stress on the ship's hull as a result of overloading.

In the 1966 Load Lines convention, adopted by IMO, provisions are made for determining the freeboard of ships by subdivision and damage stability calculations.

The regulations take into account the potential hazards present in different zones and different seasons. The technical annex contains several additional safety measures concerning doors, freeing ports, hatchways and other items. The main purpose of these measures is to ensure the watertight integrity of ships' hulls below the freeboard deck.

All assigned load lines must be marked amidships on each side of the ship, together with the deck line. Ships intended for the carriage of timber deck cargo are assigned a smaller freeboard as the deck cargo provides protection against the impact of waves

The Convention includes three annexes.

Annex I is divided into four Chapters:
Chapter I - General;
Chapter II - Conditions of assignment of freeboard;
Chapter III - Freeboards;
Chapter IV - Special requirements for ships assigned timber freeboards.
Annex II covers Zones, areas and seasonal periods.
Annex III contains certificates, including the International Load Line Certificate.

Various amendments were adopted in 1971, 1975, 1979, and 1983 but they required positive acceptance by two-thirds of Parties and never came into force.

1.3 International Convention for the Safety of Life at Sea (SOLAS), 1974

Adoption: 1 November 1974; Entry into force: 25 May 1980

The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The first version was adopted in 1914, in response to the Titanic disaster, the second in 1929, the third in 1948, and the fourth in 1960. The 1974 version includes the tacit acceptance procedure - which provides that an amendment shall enter into force on a specified date unless, before that date, objections to the amendment are received from an agreed number of Parties.

As a result the 1974 Convention has been updated and amended on numerous occasions. The Convention in force today is sometimes referred to as SOLAS, 1974, as amended.
Technical provisions

The main objective of the SOLAS Convention is to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done. Control provisions also allow Contracting Governments to inspect ships of other Contracting States if there are clear grounds for believing that the ship and its equipment do not substantially comply with the requirements of the Convention - this procedure is known as port State control.The current SOLAS Convention includes Articles setting out general obligations, amendment procedure and so on, followed by an Annex divided into 12 Chapters.

Chapter I - General Provisions

Includes regulations concerning the survey of the various types of ships and the issuing of documents signifying that the ship meets the requirements of the Convention. The Chapter also includes provisions for the control of ships in ports of other Contracting Governments.

Chapter II-1 - Construction - Subdivision and stability, machinery and electrical installations

The subdivision of passenger ships into watertight compartments must be such that after assumed damage to the ship's hull the vessel will remain afloat and stable. Requirements for watertight integrity and bilge pumping arrangements for passenger ships are also laid down as well as stability requirements for both passenger and cargo ships.

The degree of subdivision - measured by the maximum permissible distance between two adjacent bulkheads - varies with ship's length and the service in which it is engaged. The highest degree of subdivision applies to passenger ships.

Requirements covering machinery and electrical installations are designed to ensure that services which are essential for the safety of the ship, passengers and crew are maintained under various emergency conditions.

"Goal-based standards" for oil tankers and bulk carriers were adopted in 2010, requiring new ships to be designed and constructed for a specified design life and to be safe and environmentally friendly, in intact and specified damage conditions, throughout their life. Under the regulation, ships should have adequate strength, integrity and stability to minimize the risk of loss of the ship or pollution to the marine environment due to structural failure, including collapse, resulting in flooding or loss of watertight integrity.

Chapter II-2 - Fire protection, fire detection and fire extinction
Includes detailed fire safety provisions for all ships and specific measures for passenger ships, cargo ships and tankers.

They include the following principles: division of the ship into main and vertical zones by thermal and structural boundaries; separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries; restricted use of combustible materials; detection of any fire in the zone of origin; containment and extinction of any fire in the space of origin; protection of the means of escape or of access for fire-fighting purposes; ready availability of fire-extinguishing appliances; minimization of the possibility of ignition of flammable cargo vapour.

Chapter III - Life-saving appliances and arrangements

The Chapter includes requirements for life-saving appliances and arrangements, including requirements for life boats, rescue boats and life jackets according to type of ship. The International Life-Saving Appliance (LSA) Code gives specific technical requirements for LSAs and is mandatory under Regulation 34, which states that all life-saving appliances and arrangements shall comply with the applicable requirements of the LSA Code.

Chapter IV – Radiocommunications

The Chapter incorporates the Global Maritime Distress and Safety System (GMDSS). All passenger ships and all cargo ships of 300 gross tonnage and upwards on international voyages are required to carry equipment designed to improve the chances of rescue following an accident, including satellite emergency position indicating radio beacons (EPIRBs) and search and rescue transponders (SARTs) for the location of the ship or survival craft.
Regulations in Chapter IV cover undertakings by contracting governments to provide radiocommunication services as well as ship requirements for carriage of radiocommunications equipment. The Chapter is closely linked to the Radio Regulations of the International Telecommunication Union.

Chapter V - Safety of navigation

Chapter V identifies certain navigation safety services which should be provided by Contracting Governments and sets forth provisions of an operational nature applicable in general to all ships on all voyages. This is in contrast to the Convention as a whole, which only applies to certain classes of ship engaged on international voyages.

The subjects covered include the maintenance of meteorological services for ships; the ice patrol service; routeing of ships; and the maintenance of search and rescue services.

This Chapter also includes a general obligation for masters to proceed to the assistance of those in distress and for Contracting Governments to ensure that all ships shall be sufficiently and efficiently manned from a safety point of view.

The chapter makes mandatory the carriage of voyage data recorders (VDRs) and automatic ship identification systems (AIS).

Chapter VI - Carriage of Cargoes

The Chapter covers all types of cargo (except liquids and gases in bulk) "which, owing to their particular hazards to ships or persons on board, may require special precautions". The regulations include requirements for stowage and securing of cargo or cargo units (such as containers). The Chapter requires cargo ships carrying grain to comply with the International Grain Code.

Chapter VII - Carriage of dangerous goods

The regulations are contained in three parts:
Part A - Carriage of dangerous goods in packaged form - includes provisions for the classification, packing, marking, labelling and placarding, documentation and stowage of dangerous goods. Contracting Governments are required to issue instructions at the national level and the Chapter makes mandatory the International Maritime Dangerous Goods (IMDG) Code, developed by IMO, which is constantly updated to accommodate new dangerous goods and to supplement or revise existing provisions.

Part A-1 - Carriage of dangerous goods in solid form in bulk - covers the documentation, stowage and segregation requirements for these goods and requires reporting of incidents involving such goods.

Part B covers Construction and equipment of ships carrying dangerous liquid chemicals in bulk and requires chemical tankers to comply with the International Bulk Chemical Code (IBC Code).

Part C covers Construction and equipment of ships carrying liquefied gases in bulk and gas carriers to comply with the requirements of the International Gas Carrier Code (IGC Code).

Part D includes special requirements for the carriage of packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes on board ships and requires ships carrying such products to comply with the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code).

The chapter requires carriage of dangerous goods to be in compliance with the relevant provisions of the International Maritime Dangerous Goods Code (IMDG Code).

Chapter VIII - Nuclear ships

Gives basic requirements for nuclear-powered ships and is particularly concerned with radiation hazards. It refers to detailed and comprehensive Code of Safety for Nuclear Merchant Ships which was adopted by the IMO Assembly in 1981.

Chapter IX - Management for the Safe Operation of Ships

The Chapter makes mandatory the International Safety Management (ISM) Code, which requires a safety management system to be established by the shipowner or any person who has assumed responsibility for the ship (the "Company").

Chapter X - Safety measures for high-speed craft

The Chapter makes mandatory the International Code of Safety for High-Speed Craft (HSC Code).

Chapter XI-1 - Special measures to enhance maritime safety

The Chapter clarifies requirements relating to authorization of recognized organizations (responsible for carrying out surveys and inspections on Administrations' behalves); enhanced surveys; ship identification number scheme; and port State control on operational requirements.

Chapter XI-2 - Special measures to enhance maritime security

Regulation XI-2/3 of the chapter enshrines the International Ship and Port Facilities Security Code (ISPS Code). Part A of the Code is mandatory and part B contains guidance as to how best to comply with the mandatory requirements. Regulation XI-2/8 confirms the role of the Master in exercising his professional judgement over decisions necessary to maintain the security of the ship. It says he shall not be constrained by the Company, the charterer or any other person in this respect.

Regulation XI-2/5 requires all ships to be provided with a ship security alert system. ,Regulation XI-2/6 covers requirements for port facilities, providing among other things for Contracting Governments to ensure that port facility security assessments are carried out and that port facility security plans are developed, implemented and reviewed in accordance with the ISPS Code.Other regulations in this chapter cover the provision of information to IMO, the control of ships in port, (including measures such as the delay, detention, restriction of operations including movement within the port, or expulsion of a ship from port), and the specific responsibility of Companies.

Chapter XII - Additional safety measures for bulk carriers

The Chapter includes structural requirements for bulk carriers over 150 metres in length.

1.4 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978.

Adoption: 7 July 1978; Entry into force: 28 April 1984; Major revisions in 1995 and 2010

The 1978 STCW Convention was the first to establish basic requirements on training, certification and watchkeeping for seafarers on an international level. Previously the standards of training, certification and watchkeeping of officers and ratings were established by individual governments, usually without reference to practices in other countries. As a result standards and procedures varied widely, even though shipping is the most international of all industries.

The Convention prescribes minimum standards relating to training, certification and watchkeeping for seafarers which countries are obliged to meet or exceed.

The 1995 amendments, adopted by a Conference, represented a major revision of the Convention, in response to a recognized need to bring the Convention up to date and to respond to critics who pointed out the many vague phrases, such as "to the satisfaction of the Administration", which resulted in different interpretations being made.
The 1995 amendments entered into force on 1 February 1997. One of the major features of the revision was the division of the technical annex into regulations, divided into Chapters as before, and a new STCW Code, to which many technical regulations were transferred. Part A of the Code is mandatory while Part B is recommended.
Dividing the regulations up in this way makes administration easier and it also makes the task of revising and updating them simpler: for procedural and legal reasons there is no need to call a full conference to make changes to Codes.

Another major change was the requirement for Parties to the Convention are required to provide detailed information to IMO concerning administrative measures taken to ensure compliance with the Convention. This represented the first time that IMO had been called upon to act in relation to compliance and implementation - generally, implementation is down to the flag States, while port State control also acts to ensure compliance. Under Chapter I, regulation I/7 of the revised Convention, Parties are required to provide detailed information to IMO concerning administrative measures taken to ensure compliance with the Convention, education and training courses, certification procedures and other factors relevant to implementation.The information is reviewed by panels of competent persons, nominated by Parties to the STCW Convention, who report on their findings to the IMO Secretary-General, who, in turn, reports to the Maritime Safety Committee (MSC) on the Parties which fully comply. The MSC then produces a list of "confirmed Parties" in compliance with the STCW Convention.

STCW Convention chapters

2. Chapter I: General provisions
3. Chapter II: Master and deck department
4. Chapter III: Engine department
5. Chapter IV: Radiocommunication and radio personnel
6. Chapter V: Special training requirements for personnel on certain types of ships
7. Chapter VI: Emergency, occupational safety, medical care and survival functions
8. Chapter VII: Alternative certification
9. Chapter VIII: Watchkeeping

The STCW Code

The regulations contained in the Convention are supported by sections in the STCW Code. Generally speaking, the Convention contains basic requirements which are then enlarged upon and explained in the Code.Part A of the Code is mandatory. The minimum standards of competence required for seagoing personnel are given in detail in a series of tables. Part B of the Code contains recommended guidance which is intended to help Parties implement the Convention. The measures suggested are not mandatory and the examples given are only intended to illustrate how certain Convention requirements may be complied with. However, the recommendations in general represent an approach that has been harmonized by discussions within IMO and consultation with other international organizations.

The Manila amendments to the STCW Convention and Code were adopted on 25 June 2010, marking a major revision of the STCW Convention and Code. The 2010 amendments entered into force on 1 January 2012 under the tacit acceptance procedure and are aimed at bringing the Convention and Code up to date with developments since they were initially adopted and to enable them to address issues that are anticipated to emerge in the foreseeable future.

Amongst the amendments adopted, there are a number of important changes to each chapter of the Convention and Code, including:

- Improved measures to prevent fraudulent practices associated with certificates of competency and strengthen the evaluation process (monitoring of Parties' compliance with the Convention);
- Revised requirements on hours of work and rest and new requirements for the prevention of drug and alcohol abuse, as well as updated standards relating to medical fitness standards for seafarers;
- New certification requirements for able seafarers;
- New requirements relating to training in modern technology such as electronic charts and information systems (ECDIS);
- New requirements for marine environment awareness training and training in leadership and teamwork;
- New training and certification requirements for electro-technical officers;
- Updating of competence requirements for personnel serving on board all types of tankers, including new requirements for personnel serving on liquefied gas tankers;
- New requirements for security training, as well as provisions to ensure that seafarers are properly trained to cope if their ship comes under attack by pirates;
- Introduction of modern training methodology including distance learning and web-based learning;
- New training guidance for personnel serving on board ships operating in polar waters; and
- New training guidance for personnel operating Dynamic Positioning System

1.5 Responsibilities Under the International Convention for the Prevention of Pollution From Ships, 1973, and the Protocol of 1978 Relating Thereto (MARPOL 73/78)

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.

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.

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.

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.

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.

In July 2011, IMO adopted the most recent amendments to MARPOL Annex IV which are expected to enter into force on 1 January 2013. The amendments introduce the Baltic Sea as a special area under Annex IV and add new discharge requirements for passenger ships while in a special area.

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.

In July 2011, IMO adopted extensive amendments to Annex V which are expected to enter into force on 1 January 2013. The revised Annex V prohibits the discharge of all garbage into the sea, except as provided otherwise, under specific circumstances.

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.

In 2011, after extensive work and debate, IMO adopted ground breaking mandatory technical and operational energy efficiency measures which will significantly reduce the amount of greenhouse gas emissions from ships; these measures were included in Annex VI and are expected to enter into force on 1 January 2013.

1.6 Maritime Declarations of Health and the Requirements of the International Health Regulations

A Maritime Declaration of Health is the form used to provide such information. It covers:

- details of the ship
- status of any Ship Sanitation Certification
- number of passengers
- previous ports visited
- health questions, including whether:
  - anyone has died on board
  - anyone is sick
  - there is any case of disease which could be infectious
  - there is any condition that could lead to the spread of disease.

This information ensures compliance with Article 37 of the International Health Regulations 2005.
A Maritime Declaration of Health must be completed by the Master of the vessel and countersigned by the ship's surgeon if one is carried. It should be delivered to the Medical Officer of Health or a health protection officer after. In practice, completed Maritime Declarations of Health are sent to the vessel's agent for forwarding to health authorities, or given to a Customs or Ministry for Primary Industries agent to forward.

Any illness reported on the Maritime Declaration of Health should have been declared on the Advance Notice of Arrival or the 'no change of health status' form. Where an illness is reported, the Maritime Declaration of Health should be handed directly to a health protection officer or medical officer of health upon arrival, unless authorities advise otherwise.

1.7 Responsibilities under other international maritime law embodied in international agreements and conventions that impact on the role of management level engineering officers

Maritime Labour Convention, 2006

The Maritime Labour Convention, 2006 ("MLC, 2006") establishes minimum working and living standards for all seafarers working on ships flying the flags of ratifying countries. It's also an essential step forward in ensuring a level-playing field for countries and shipowners who, until now, have paid the price of being undercut by those who operate substandard ships.

The Maritime Labour Convention, 2006 or MLC, 2006 is an international labour Convention adopted by the International Labour Organization (ILO). It provides international standards for the world's first genuinely global industry.

Widely known as the "seafarers' bill of rights," the MLC, 2006 was adopted by government, employer and workers representatives at a special ILO International Labour Conference in February 2006.

It is unique in that it aims both to achieve decent work for seafarers and to secure economic interests through fair competition for quality ship owners.

The Convention is comprehensive and sets out, in one place, seafarers' rights to decent working conditions. It covers almost every aspect of their work and life on board including:

- minimum age
- seafarers' employment agreements
- hours of work or rest
- payment of wages
- paid annual leave
- repatriation at the end of contract
- onboard medical care
- the use of licensed private recruitment and placement services
- accommodation, food and catering
- health and safety protection and accident prevention and
- seafarers' complaint handling

The Convention was designed to be applicable globally, easy to understand, readily updatable and uniformly enforced and will become the "fourth pillar" of the international regulatory regime for quality shipping, complementing the key Conventions of the International Maritime Organization (IMO) dealing with safety and security of ships and protection of the marine environment.

All seafarers working on board ships that fly the flag of countries that have ratified the MLC, 2006 are covered, once it enters into force for the country concerned, (12 months after its ratification is registered by the ILO).

The MLC, 2006 defines seafarers as “all persons who are employed or are engaged or work in any capacity on board a ship to which the Convention applies.” This includes not just the crew involved in navigating or operating the ship but also, for example, persons working in hotel positions that provide a range of services for passengers on cruise ships or yachts.

It applies to a wide range of ships operating on international and national or domestic voyages. It covers all ships other than those which navigate exclusively in inland waters or waters within, or closely adjacent to sheltered waters or areas where port regulations apply. The Convention applies to all those ships, whether publicly or privately owned, that are ordinarily engaged in commercial activities, except:

- ships engaged in fishing or in similar pursuits
- ships of traditional build such as dhows and junks
- warships or naval auxiliaries

Assistance and Salvage

International Convention on Salvage, Adopted: 28 April 1989; Entry into force: 14 July 1996 The Convention replaced a convention on the law of salvage adopted in Brussels in 1910 which incorporated the "'no cure, no pay" principle under which a salvor is only rewarded for services if the operation is successful.

Although this basic philosophy worked well in most cases, it did not take pollution into account. A salvor who prevented a major pollution incident (for example, by towing a damaged tanker away from an environmentally sensitive area) but did not manage to save the ship or the cargo got nothing. There was therefore little incentive to a salvor to undertake an operation which has only a slim chance of success.

The 1989 Convention seeks to remedy this deficiency by making provision for an enhanced salvage award taking into account the skill and efforts of the salvors in preventing or minimizing damage to the environment.

Special compensation

The 1989 Convention introduced a "special compensation" to be paid to salvors who have failed to earn a reward in the normal way (by salving the ship and cargo).

Damage to the environment is defined as "substantial physical damage to human health or to marine life or resources in coastal or inland waters or areas adjacent thereto, caused by pollution, contamination, fire, explosion or similar major incidents."

The compensation consists of the salvor's expenses, plus up to 30% of these expenses if, thanks to the efforts of the salvor, environmental damage has been minimized or prevented. The salvor's expenses are defined as "out-of-pocket expenses reasonably incurred by the salvor in the salvage operation and a fair rate for equipment and personnel actually and reasonably used".

The tribunal or arbitrator assessing the reward may increase the amount of compensation to a maximum of 100% of the salvor's expenses, "if it deems it fair and just to do so".

If, on the other hand, the salvor is negligent and has consequently failed to prevent or minimize environmental damage, special compensation may be denied or reduced. Payment of the reward is to be made by the vessel and other property interests in proportion to their respective salved values.

Need to Render Assistance

Every year, thousands of migrants and asylum seekers undertake perilous journeys at sea in search of safety, refuge from persecution, or simply better economic conditions. Under international maritime law, vessel masters have an obligation to render assistance to those in distress at sea. In most circumstances, the embarkation of distressed persons present numerous logistical and political considerations for masters, owners and charterers, which prevent timely disembarkation to a place of safety. In recognition of this dilemma, the International Maritime Organization (IMO) has recently adopted amendments to two relevant maritime conventions.

The 1974 International Convention for the Safety of Life at Sea (SOLAS Convention) obliges the
"master of a ship at sea which is in a position to be able to provide assistance, on receiving information from any source that persons are in distress at sea, is bound to proceed with all speed to their assistance, if possible informing them or the search and rescue service that the ship is doing so…"

The 1979 International Convention on Maritime Search and Rescue (SAR Convention) obliges State Parties to:
"…ensure that assistance be provided to any person in distress at sea… regardless of the nationality or status of such a person or the circumstances in which that person is found"… and to *"provide for their initial medical or other needs , and deliver them to a place of safety."*

On 1 July 2006, amendments to the SOLAS and SAR Conventions concerning the treatment of persons rescued at sea entered into force.

The SOLAS amendments add to and clarify the existing obligations to provide assistance, adding the words: *"This obligation to provide assistance applies regardless of the nationality or status of such persons or the circumstances in which they are found."* Of further significance to vessel masters, owners and charterers, is the amendments to the SOLAS and SAR Conventions mandating Contracting States to:

1) coordinate and cooperate to ensure that masters of ships providing assistance by embarking persons in distress at sea are released from their obligation with minimum further deviation from the ship's intended voyage; and
2) arrange disembarkation as soon as reasonably practicable.

To the benefit of owners and charterers alike, these amendments firmly obligate Contracting States to assist vessel masters. The overwhelming majority of member states of the IMO have adopted the SOLAS Convention. While not as popular as SOLAS, many member states have additionally adopted the SAR Convention. When making arrangements to disembark persons rescued at sea, vessel owners, charterers, insurers and local correspondents would be well advised to engage immediately nearby Contracting States at the onset of rescue efforts.

Convention on Limitation of Liability for Maritime Claims, 1976 (LLMC 1976)

The International Maritime Organization (IMO) first set limits on maritime accident liability in 1957 with the Convention Relating to the Limitation of the Liability of Owners of Seagoing Ships. That convention came into force in 1968.

In 1976, the Convention on Limitation of Liability for Maritime Claims (LLMC) came into force with much higher liability limits. In some cases the amounts were two or three times the amounts specified in the earlier convention.

Environmental standards had improved or been implemented for the first time in some regions during these years. The U.S. Clean Water Act and growing public knowledge of pollution and its impact on the environment mirrored sentiments in Europe.
Medical treatments of potential victims were also becoming more elaborate and expensive at this time and contributed to the potential exposure of ship owners. The cost controls put in place try and balance personal protections with the responsibilities of a ship owner. With ongoing unlimited risk much of the financing for new ships would be unavailable except as a high risk product.

Loss of Life or Injury
Loss of life and personal injury is one of two types of claims made under the LLMC. The 1976 Convention set the maximum liability for ships 500 gross tonsand under at 333,000 SDR. Special Drawing Rights, or SDR, is a type of financial instrument used by the International Monetary Fund.
From the IMF SDR fact sheet:
"*The SDR is neither a currency, nor a claim on the IMF. Rather, it is a potential claim on the freely usable currencies of IMF members. Holders of SDRs can obtain these currencies in exchange for their SDRs in two ways: first, through the arrangement of voluntary exchanges between members; and second, by the IMF designating members with strong external positions to purchase SDRs from members with weak external positions. In addition to its role as a supplementary reserve asset, the SDR serves as the unit of account of the IMF and some other international organizations.*"

In the 2004 version of the LLMC the maximum liability for loss of life or injury was raised to 2 million SDR. At the same time larger ships were also included when the maximum gross tonnage was raised to 2000 tons.
Larger ships were subject to the following amounts before June 8, 2015.

- For each ton from 2,001 to 30,000 tons, 800 SDR
- For each ton from 30,001 to 70,000 tons, 600 SDR
- For each ton in excess of 70,000, 400 SDR

New limits after June 8, 2015:

- Less than 2000 tons 3.02 million SDR
- For each ton from 2,001 to 30,000 tons, 1,208 SDR

- For each ton from 30,001 to 70,000 tons, 906 SDR
- For each ton in excess of 70,000, 604 SDR

Classification Societies

A non-governmental organization in the shipping industry, a classification society establishes and maintains technical standards for construction and operation of marine vessels and offshore structures. The primary role of the society is to classify ships and validate that their design and calculations are in accordance with the published standards. It also carries out periodical survey of ships to ensure that they continue to meet the parameters of set standards. The society is also responsible for classification of all offshore structures including platforms and submarines.

Flag states maintain a ship register in which all ships that sail under their flag need to be registered. Classification societies are licensed by flag states to survey and classify ships and issue certificates on their behalf. They classify and certify marine vessels and structures on the basis of their structure, design and safety standards.

A classification society's workforce comprises of ship surveyors, mechanical engineers, material engineers, piping engineers, and electrical engineers. Surveyors employed by a classification society inspect ships at all stages of their development and operations to make sure that their design, components, and machinery are developed and maintained in accordance with the standards set for their class. The process covers inspection of engines, shipboard pumps and other vital ship's machines. They also inspect offshore structures such as oil rigs, submarines and other marine structures.

General Average and Marine Insurance

General average

The carriage of goods by sea is deemed to be a joint venture between ship-owners and cargo-owners, and the maritime convention places a responsibility on the ship-owner to safeguard the common interest and incur necessary additional or extraordinary costs in so doing. There is no governing international statute and consequently the "Comite Maritime International" C.M.I. sponsored conditions (York-Antwerp Rules 1974 – and subsequent amendments) are incorporated in most marine contracts of carriage (Bills of Lading).

Situations may arise whereby the carrying vessel experiences a fortuity [incident] during the course of the voyage resulting in additional and/or extraordinary expenses being incurred by the ship-owners. Typical examples of a fortuity are engine/machinery breakdown, fire, or collision with another vessel and/or fixed or floating object, such incidents resulting in additional expenditure in saving the venture/cargo.

In the event of additional or extraordinary costs being incurred in successfully (or partially) saving the venture, ship-owners will look to cargo owners to contribute towards such costs. In such circumstances, ship-owners may declare

General Average, and in doing so will automatically exercise a Maritime Lien on the cargo for its pro-rata [proportional] share of the total additional and/or extraordinary costs.

Before any cargo is released ship-owners will require from each Bill of Lading holder a signed General Average Bond plus either a cash deposit or a General

Average Guarantee signed by Cargo (re)insurers, based on the percentage of the invoice value of the cargo deemed to reflect the proportion due from cargo interests.

Marine insurance

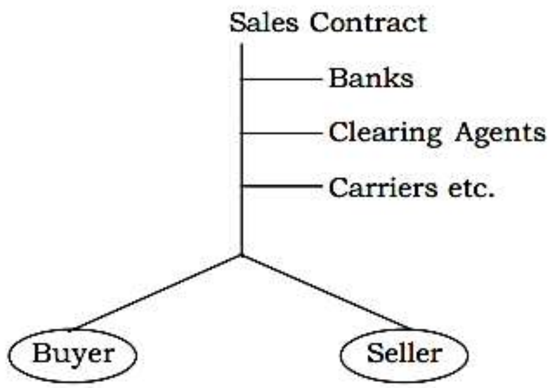
Importance of Marine insurance in commerce; Marine insurance plays a very important role in the field of overseas commerce and internal trade of a country. It is closely linked with Banking and Shipping. Banks generally finance the goods which are transported by ships or by other means of transport in the case of internal trade and Marine Insurance protects such goods against loss or damage. Without such protection the entire trade structure is bound to suffer.

Marine Insurance can be divided broadly into two groups

- Cargo Insurance
- Hull Insurance

Marine insurance plays an important role in domestic trade as well as in international trade. Most contracts of sale require that the goods must be covered, either by the seller or the buyer, against loss or damage.

Who is responsible for affecting insurance on the goods, which are the subject of sale? It depends on the terms of the sale contract. A contract of sale involves mainly a seller and a buyer, apart from other associated parties like carriers, banks, clearing agents, etc.



- The principal types of sale contracts, so far as Marine insurance is directly concerned, are as follows:

As stated earlier, Marine Insurance is closely linked up with the trade of a country internal as well as international. A sale contract which is an essential feature in the trade involves a seller and a buyer, apart from the other parties like the carrier, the bank, and the clearing agent. Whether the insurance of the goods in transits is to be the responsibility of the seller or the buyer depends on the type of the sale contract in any transaction. There are different types of sales contracts the most important of which, as affecting the Marine Insurance are:

- F.O.B. (Free on Board) In this case, the seller is responsible for loss of or damage to the goods until they are placed on board the steamer for on carriage. Thereafter the buyer becomes responsible and he has, therefore, the option to insure where he likes.
- C.I.F. (Cost, Insurance and Freight) In this case the seller assumes responsibility for the insurance and the insurance charges are indicated in the invoice along with the other charges.
- C & F (Cost and Freight) In this case, normally the buyers responsibility attaches from the time the goods are placed on board the vessel and he has therefore to take care of the insurance.
- F.O.R. (Free on Rail) This is same as F.O.B. but it concerns mainly the internal trade transactions.

Features of marine insurance

1. Offer & Acceptance: It is a prerequisite to any contract. Similarly the goods under marine (transit) insurance will be insured after the offer is accepted by the insurance company. Example: A proposal submitted to the insurance company along with premium on 1/4/2011 but the insurance company accepted the proposal on 15/4/2011. The risk is covered from 15/4/2011 and any loss prior to this date will not be covered under marine insurance.

2. Payment of premium: An owner must ensure that the premium is paid well in advance so that the risk can be covered. If the payment is made through cheque and it is dishonored then the coverage of risk will not exist. It is as per section 64VB of Insurance Act 1938- Payment of premium in advance.(Details under insurance legislation Module).
3. Contract of Indemnity: Marine insurance is contract of indemnity and the insurance company is liable only to the extent of actual loss suffered. If there is no loss there is no liability even if there is operation of insured peril. Example: If the property under marine (transit) insurance is insured for Rs 20 lakhs and during transit it is damaged to the extent of Rs 10 lakhs then the insurance company will not pay more than Rs 10 lakhs.
4. Utmost good faith: The owner of goods to be transported must disclose all the relevant information to the insurance company while insuring their goods. The marine policy shall be voidable at the option of the insurer in the event of misrepresentation, mis-description or non-disclosure of any material information. Example: The nature of goods must be disclosed i.e whether the goods are hazardous in nature or not, as premium rate will be higher for hazardous goods.
5. Insurable Interest: The marine insurance will be valid if the person is having insurable interest at the time of loss. The insurable interest will depend upon the nature of sales contract. Example: Mr A sends the goods to Mr B on FOB(Free on Board) basis which means the insurance is to be arranged by Mr B. And if any loss arises during transit then Mr B is entitled to get the compensation from the insurance company. Example: Mr A sends the goods to Mr B on CIF (Cost, Insurance and Freight) basis which means the insurance is to be arranged by Mr A. And if any loss arises during transit then Mr A is entitled to get the compensation from the insurance company.
6. Contribution: If a person insures his goods with two insurance companies, then in case of marine loss both the insurance companies will pay the loss to the owner proportionately. Example; Goods worth Rs. 50 lakhs were insured for marine insurance with Insurance company A and B. In case of loss, both the insurance companies will contribute equally.
7. Period of marine Insurance: The period of insurance in the policy is for the normal time taken for a particular transit. Generally the period of open marine insurance will not exceed one year. It can also be issued for the single transit and for specific period but not for more than a year.
8. Deliberate Act: If goods are damaged or loss occurs during transit because of deliberate act of an owner then that damage or loss will not be covered under the policy.
9. Claims: To get the compensation under marine insurance the owner must inform the insurance company immediately so that the insurance company can take necessary steps to determine the loss.

1.8 Responsibilities Under International Instruments Affecting the Safety of the Ship, Passengers, Crew and Cargo

International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM), Adopted: 13 February 2004; Entry into force: 12 months after ratification by 30 States, representing 35 per cent of world merchant shipping tonnage

Invasive aquatic species present a major threat to the marine ecosystems, and shipping has been identified as a major pathway for introducing species to new environments. The problem increased as trade and traffic volume expanded over the last few decades, and in particular with the introduction of steel hulls, allowing vessels to use water instead of solid materials as ballast. The effects of the introduction of new species have in many areas of the world been devastating. Quantitative data show the rate of bio-invasions is continuing to increase at an alarming rate. As the volumes of seaborne trade continue overall to increase, the problem may not yet have reached its peak.

However, the Ballast Water Management Convention, adopted in 2004, aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments

Under the Convention, all ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan. All ships will also have to carry a ballast water record book and an international ballast water management certificate. The ballast water management standards will be phased in over a period of time. As an intermediate solution, ships should exchange ballast water mid-ocean. However, eventually most ships will need to install an on-board ballast water treatment system.

The Convention will require all ships to implement a Ballast Water and Sediments Management Plan. All ships will have to carry a Ballast Water Record Book and will be required to carry out ballast water management procedures to a given standard. Existing ships will be required to do the same, but after a phase-in period.

The Convention is divided into Articles; and an Annex which includes technical standards and requirements in the Regulations for the control and management of ships' ballast water and sediments.

General Obligations

Under Article 2 General Obligations Parties undertake to give full and complete effect to the provisions of the Convention and the Annex in order to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments.

Parties are given the right to take, individually or jointly with other Parties, more stringent measures with respect to the prevention, reduction or elimination of the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments, consistent with international law. Parties should ensure that ballast water management practices do not cause greater harm than they prevent to their environment, human health, property or resources, or those of other States.

Reception facilities

Under Article 5 Sediment Reception Facilities Parties undertake to ensure that ports and terminals where cleaning or repair of ballast tanks occurs, have adequate reception facilities for the reception of sediments.

Research and monitoring

Article 6 Scientific and Technical Research and Monitoring calls for Parties individually or jointly to promote and facilitate scientific and technical research on ballast water management; and monitor the effects of ballast water management in waters under their jurisdiction.

Survey, certification and inspection

Ships are required to be surveyed and certified (Article 7 Survey and certification) and may be inspected by port State control officers (Article 9 Inspection of Ships) who can verify that the ship has a valid certificate; inspect the Ballast Water Record Book; and/or sample the ballast water. If there are concerns, then a detailed inspection may be carried out and "the Party carrying out the inspection shall take such steps as will ensure that the ship shall not discharge Ballast Water until it can do so without presenting a threat of harm to the environment, human health, property or resources."

Changes to SOLAS Chapter V – navigation bridge visibility during ballast water exchange

Applicability: Ships 55 metres in length and above, as defined in SOLAS Chapter V, Regulation 2.4, constructed on or after July 1, 1998.

Changes to SOLAS Chapter V – Safety of navigation, introduced by IMO Resolution MSC.201 (81), will come into effect on July 1, 2010. While some changes are operational, others introduce new requirements applicable to navigation records.

What has been amended?

A new paragraph, 4, has been added to SOLAS Chapter V, Regulation 22 – Navigation bridge visibility.

As a consequence of this amendment, notwithstanding the existing requirements, any increase in blind sectors or reduction in horizontal fields of vision resulting from ballast water exchange operations is to be taken into account by the Master before determining that it is safe to proceed with the exchange.

As an additional measure, to compensate for possible increased blind sectors or reduced horizontal.

1.8 Methods and Aids to Prevent Pollution of the Marine Environment by Ships

- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention).

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, commonly called the "London Convention" or "LC '72" and also abbreviated asMarine Dumping, is an agreement to control pollution of the sea by dumping and to encourage regional agreements supplementary to the Convention. It covers the deliberate disposal at sea ofwastes or other matter from vessels, aircraft, and platforms. It does not cover discharges from land-based sources such as pipes and outfalls, wastes generated incidental to normal operation of vessels, or placement of materials for purposes other than mere disposal, providing such disposal is not contrary to aims of the Convention. It entered into force in 1975. As of 2013, there were 87 Parties to the Convention.

- International Convention Relating to Intervention on the High Seas in cases of Oil Pollution Casualties, 1969.

International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties 1969 (INTERVENTION 1969) is an international maritime convention affirming the right of a coastal State to "take such measures on the high seas as may be necessary to prevent, mitigate or eliminate grave and imminent danger to their coastline or related interests from pollution or threat of pollution of the sea by oil, following upon a maritime casualty or acts related to such a casualty"

The Convention applies to all seagoing vessels except warships or other vessels owned or operated by a State and used on Government non-commercial service.
While exercising the right to take measures "necessary to prevent, mitigate or eliminate grave and imminent danger to their coastline or related interests" from oil pollution, the coastal State is obligated to:

- Prior to taking measures to consult other affected States, including the flag State, ship-owner, cargo owner and independent experts from the list maintained by theInternational Maritime Organization (excluding cases of extreme urgency requiring measures to be taken immediately);

- Use its best endeavours to avoid any risk to human life and to afford persons in distress any assistance which they may need, and in appropriate cases to facilitate the repatriation of ships crews;
- Notify all interested States, owners of ships and cargoes and the IMO of all measures taken;
- Ensure that all measures are proportionate to actual or threatened damage;
- Pay compensation to the extent of the damage caused by measures which exceed those reasonably necessary to achieve the end.

- International Convention on Civil Liability for Oil Pollution Damage, 1969.

The International Convention on Civil Liability for Oil Pollution Damage, 1969, renewed in 1992 and often referred to as the CLC Convention, is an international maritime treaty that was adopted to ensure that adequate compensation would be available where oil pollution damage was caused by maritime casualties involving oil tankers (i.e. ships that carry oil as cargo).

Liability
The convention introduces strict liability for shipowners. In cases when the shipowner is deemed guilty of fault for an instance of oil pollution, the convention does not cap liability. When the shipowner is not at fault, the convention caps liability at between 3 million special drawing rights (SDR) for a ship of 5,000 GT to 59.7 million SDR for ships over 140,000 GT. These limits translate to around US$3.8 million to US$76.5 million, although SDR exchange rates fluctuate daily.The HNS Conventionto compensation for damages occurring from spill of dangerous goods is based on the same legal framework.

<u>Insurance</u>
If a ship carries more than 2000 tons of oil in cargo, CLC requires shipowners to maintain "insurance or other financial security" sufficient to cover the maximum liability for one oil spill.

<u>Coverage</u>
As of April 2014, 133 states, representing 96.7 per cent of the world fleet, are contracting parties to the CLC Protocol 1992. Bolivia, North Korea, Honduras, andLebanon—which are generally flag of convenience states—have not ratified the treaty

2.0 National Legislation for Implementing International Agreements and Conventions

In this topic you will analyze the national legislation that is the flag state laws are covered to an extent that meets or exceed the standard laid down in the international conventions, codes and agreements. Emphasis should be on monitoring compliance, identifying areas where there may be potential for non-compliance or differences compared to international standards.

4.3 MAINTAIN SAFETY AND SECURITY OF CREW AND PASSENGERS AND THE OPERATIONAL CONDITION OF SAFETY SYSTEMS

4.3.1 Life-Saving Appliance Regulations

General requirements for life-saving appliances

Life-saving appliances on all ships have to be fitted with retro-reflective material where it will assist in detection and in accordance with the recommendations of the Organization in A.658 (16);

Unless expressly provided otherwise in the opinion of the Administration, all LSA prescribed in this part shall:

- be constructed with proper workmanship and materials;
- not be damaged in stowage throughout the air temperature range -30°C to +65°C;
- if they are likely to be immersed in seawater during their use, operate throughout the seawater temperature range -1°C to +30°C;
- where applicable, be rot-proof, corrosion-resistant, and not be unduly affected by seawater, oil or fungal attack;
- where exposed to sunlight, be resistant to deterioration;
- be of a highly visible color on all parts where this will assist detection;
- be fitted with retro-reflective material where it will assist in detection and in accordance with the recommendations of the Organization in A.658(16);
- if they are to be used in a seaway, be capable of satisfactory operation in that environment;
- be clearly marked with approval information including the Administration which approved it, and any operational restrictions;
- where applicable, be provided with electrical short circuit protection to prevent damage or injury.

The Administration shall determine the period of acceptability of life-saving appliances which are subject to deterioration with age. Such life-saving appliances shall be marked with a means for determining their age or the date by which they must be replaced. Permanent marking with a date of expiry is the preferred method of establishing the period of acceptability. Batteries not marked with an expiration date may be used if they are replaced annually, or in the case of a secondary battery (accumulator), if the condition of the electrolyte can be readily checked.

Lifebuoys and life-jackets

Every lifebuoy shall:

- have an outer diameter of not more than 800 mm and an inner diameter of not less than 400 mm;
- be constructed of inherently buoyant material; it shall not depend upon rushes, cork shavings or granulated cork, any other loose granulated material or any air compartment which depends on inflation for buoyancy;
- be capable of supporting not less than 14.5 kg of iron in fresh water for a period of 24 hours;
- have a mass of not less than 2.5 kg;
- not sustain burning or continue melting after being totally enveloped in a fire for a period of 2 seconds;
- be constructed to withstand a drop into the water from the height at which it is stowed above the waterline in the lightest seagoing condition or 30 m, whichever is the greater, without impairing either its operating capability or that of its attachedcomponents;
- if it is intended to operate the quick release arrangement provided for the self-activated smoke signals and self-igniting lights, have a mass sufficient to operate the quick release arrangement;
- be fitted with a grabline not less than 9.5 mm in diameter and not less than 4 times the outside diameter of the body of the buoy in length. The grabline shall be secured at four equidistant points around the circumference of the buoy to form four equal loops.

Self-igniting lights shall:

- be such that they cannot be extinguished by water;
- be of white colour and capable of either burning continuously with a luminous intensity of not less than 2 cd in all directions of the upper hemisphere or flashing (discharge flashing) at a rate of not less than 50 flashes and not more than 70 flashes per min with at least the corresponding effective luminous intensity;
- be provided with a source of energy capable of meeting the requirement of previous paragraph for a period of at least 2 hours;

- be capable of withstanding the drop test into the water from the height at which it is stowed above the waterline in the lightest seagoing condition or 30 m, whichever is the greater, without impairing either its operating capability or that of its attached components.

Self-activating smoke signals shall:

- emit smoke of a highly visible color at a uniform rate for a period of at least 15 min when floating in calm water;
- not ignite explosively or emit any flame during the entire smoke emission time of the signal;
- not be swamped in a seaway;
- continue to emit smoke when fully submerged in water for a period of at least 10s;
- be capable of withstanding the drop test into the water from the height at which it is stowed above the waterline in the lightest seagoing condition or 30 m, whichever is the greater, without impairing either its operating capability or that of its attached components.

Buoyant lifelines shall:

- be non-kinking;
- have a diameter of not less than 8 mm; and
- have a breaking strength of not less than 5 kN.

Life-jackets:

An adult life-jacket shall be so constructed that:

- shall not sustain burning or continue melting after being totally enveloped in a fire for a period of 2 seconds.
- at least 75% of persons, who are completely unfamiliar with the lifejacket, can correctly don it within a period of one min without assistance, guidance or prior demonstration;
- after demonstration, all persons can correctly don it within a period of one minute without assistance;

- it is clearly capable of being worn in only one way or, as far as is practicable, cannot be donned incorrectly;
- it is comfortable to wear;
- it allows the wearer to jump from a height of at least 4.5 m into the water without injury and without dislodging or damaging the lifejacket.
- shall have buoyancy which is not reduced by more than 5% after 24h submersion in fresh water.
- shall be fitted with a whistle firmly secured by a cord

An adult lifejacket shall have sufficient buoyancy and stability in calm fresh water to:

- .1 lift the mouth of an exhausted or unconscious person not less than 120 mm clear of the water with the body inclined backwards at an angle of not less than 20° from the vertical position;
- .2 turn the body of an unconscious person in the water from any position to one where the mouth is clear of the water in not more than 5 s.
- shall allow the person wearing it to swim a short distance and to board a survival craft.

A child lifejacket shall be constructed and perform the same as an adult lifejacket except as follows:

- donning assistance is permitted for small children;
- it shall only be required to lift the mouth of an exhausted or unconscious wearer clear of the water a distance appropriate to the size of the intended wearer;
- assistance may be given to board a survival craft, but wearer mobility shall not be significantly reduced.

In addition to the markings with approval information including the Administration which approved it, and any operational restrictions, a child lifejacket shall be marked with:

- The height or weight range for which the lifejacket will meet the testing and evaluation criteria recommended by the Organization in A.689.(17)
- a "child" symbol as shown in the "child's lifejacket" symbol adopted by the Organization in A.760(18)

<u>Inflatable lifejackets</u>

A lifejacket which depends on inflation for buoyancy shall have not less than two separate compartments and comply with the all requirements for ordinary lifejacket, and shall:

- inflate automatically on immersion, be provided with a device to permit inflation by a single manual motion and be capable of being inflated by mouth;

- in the event of loss of buoyancy in any one compartment be capable of complying with the all requirements for ordinary lifejacket;
- shall have buoyancy which is not reduced by more than 5% after 24h submersion in fresh water after inflation by means of the automatic mechanism.

Life-jacket light shall:

- have a luminous intensity of not less than 0.75 cd in all directions of the upper hemisphere;
- have a source of energy capable of providing a luminous intensity of 0.75 cd for a period of at least 8 hours;
- be visible over as great a segment of the upper hemisphere as is practicable when attached to a lifejacket;
- be of white color.

If the light referred above is a flashing light it shall, in addition:

- be provided with a manually operated switch; and
- flash at a rate of not less than 50 flashes and not more than 70 flashes per min with an effective luminous intensity of at least 0.75 cd.

Immersion suits, anti-exposure suits and thermal protective aids

The immersion suit

The immersion suit shall be constructed with waterproof materials such that:

- it can be unpacked and donned without assistance within 2 min, taking into account any associated clothing*, and a lifejacket
- if the immersion suit is to be worn in conjunction with a lifejacket;
- it will not sustain burning or continue melting after being totally enveloped in a fire for a period of 2 seconds;
- it will cover the whole body with the exception of the face. Hands shall also be covered unless permanently attached gloves are provided;
- it is provided with arrangements to minimize or reduce free air in the legs of the suit;

- following a jump from a height of not less than 4.5 m into the water there is no undue ingress of water into the suit.

An immersion suit which also complies with the requirements of life-jackets may be classified as a life-jacket.

An immersion suit which has buoyancy and is designed to be worn without a lifejacket shall be fitted with a light and the whistle complying with the requirements for life-jackets.

If the immersion suit is to be worn in conjunction with a lifejacket, the lifejacket shall be worn over the immersion suit. A person wearing such an immersion suit shall be able to don a lifejacket without assistance.

In that case immersion suit shall permit the person wearing it:

- to climb up and down a vertical ladder at least 5 m in length;
- to perform normal duties associated with abandonment;
- to jump from a height of not less than 4.5 m into the water without damaging or dislodging the immersion suit, or being injured;
- to swim a short distance through the water and board a survival craft.

An immersion suit made of material which has no inherent insulation shall be:

- .1 marked with instructions that it must be worn in conjunction with warm clothing;
- .2 so constructed that, when worn in conjunction with warm clothing, and with a lifejacket if the immersion suit is to be worn with a lifejacket, the immersion suit continues to provide sufficient thermal protection, following one jump by the wearer into the water from a height of 4.5 m, to ensure that when it is worn for a period of 1h in calm circulating water at a temperature of 5°C, the wearer's body core temperature does not fall more than 2°C.

An immersion suit made of material with inherent insulation, when worn either on its own or with a lifejacket, if the immersion suit is to be worn in conjunction with a lifejacket, shall provide the wearer with sufficient thermal insulation, following one jump into the water from a height of 4.5 m, to ensure that the wearer's body core temperature does not fall more than 2°C after a period of 6h immersion in calm circulating water at a temperature of between 0°C and 2°C.

A person in fresh water wearing either an immersion suit or an immersion suit with a lifejacket, shall be able to turn from a face-down to a face-up position in not more than 5 seconds.

<u>Anti-exposure suits</u>

The anti-exposure suit shall be constructed with waterproof materials such that it:

- provides inherent buoyancy of at least 70 N;
- is made of material which reduces the risk of heat stress during rescue and evacuation operations;
- covers the whole body with the exception of the head and hands and, where the Administration so permits, feet; gloves and a hood shall be provided in such a manner as to remain available for use with the anti-exposure suits;
- can be unpacked and donned without assistance within 2 min;
- does not sustain burning or continue melting after being totally enveloped in a fire for a period of 2 seconds;
- is equipped with a pocket for a portable VHF telephone;
- has a lateral field of vision of at least 120°.

An anti-exposure suit which also complies with the requirements of life-jackets may be classified as a life-jacket.

An anti-exposure suit shall permit the person wearing it:

- to climb up and down a vertical ladder of at least 5 m in length;
- to jump from a height of not less than 4.5 m into the water with feet first, without damaging or dislodging the suit, or being injured;
- to swim through the water at least 25 m and board a survival craft;
- to don a lifejacket without assistance; and
- to perform all duties associated with abandonment, assist others and operate a rescue boat.

An anti-exposure suit shall be fitted with a light complying with the requirements for life jackets.

An anti-exposure suit shall:

- if made of material which has no inherent insulation, be marked with instructions that it must be worn in conjunction with warm clothing;
- be so constructed, that when worn as marked, the suit continues to provide sufficient thermal protection following one jump into the water which totally submerges the wearer and shall ensure that when it is worn in calm circulating water at a temperature of 5°C, the wearer's body core temperature does not fall at a rate of more than 1.5°C per hour, after the first 0.5 hours.

<u>Thermal protective aids</u>

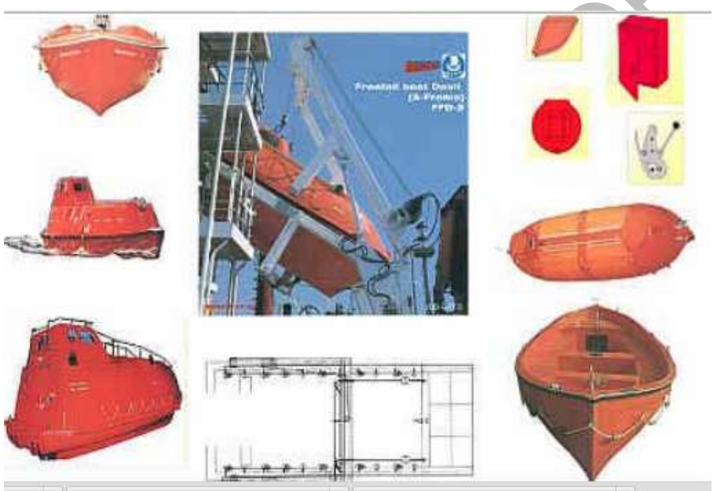
A thermal protective aid shall be made of waterproof material having a thermal conductance of not more than 7800 W/(m2.K) and shall be so constructed that, when used to enclose a person, it shall reduce both the convective and evaporative heat loss from the wearer's body.

- The thermal protective aid shall:

- cover the whole body of persons of all sizes wearing a lifejacket with the exception of
- the face. Hands shall also be covered unless permanently attached gloves are provided;
- be capable of being unpacked and easily donned without assistance in a survival craft or rescue boat;
- permit the wearer to remove it in the water in not more than 2 min, if it impairs ability
- to swim.

The thermal protective aid shall function properly throughout an air temperature range -30°C to +20°C.

General requirements for lifeboats



All lifeboats shall be properly constructed and shall be of such form and proportions that they have ample stability in a seaway and sufficient freeboard when loaded with their full complement of persons and equipment. All lifeboats shall have rigid hulls and shall be capable of maintaining positive stability when in an upright position in calm water and loaded with their full complement of persons and equipment and holed in any one location below the waterline, assuming no loss of buoyancy material and no other damage.

Each lifeboat shall be fitted with a certificate of approval, endorsed by the Administration, containing at least the following items:

- manufacturer's name and address;
- lifeboat model and serial number;
- month and year of manufacture;
- number of persons the lifeboat is approved to carry; and
- with approval information including the Administration which approved it, and any operational restrictions.

The certifying organization shall provide the lifeboat with a certificate of approval which, in addition to the above items, specifies:

- number of the certificate of approval;
- material of hull construction, in such detail as to ensure that compatibility problems in repair should not occur;
- total mass fully equipped and fully manned;
- statement of approval.

All lifeboats shall be of sufficient strength to:

- enable them to be safely launched into the water when loaded with their full complement of persons and equipment;
- be capable of being launched and towed when the ship is making headway at a speed of 5 knots in calm water.

Hulls and rigid covers shall be fire-retardant or non-combustible. Seating shall be provided on thwarts, benches or fixed chairs which are constructed so as to be capable of supporting:

- a static load equivalent to the number of persons each weighing 100 kg for which spaces are provided in compliance with the seating requirements shown on figure below.
- a load of 100 kg in any single seat location when a lifeboat to be launched by falls is dropped into the water from a height of at least 3 m;
- a load of 100 kg in any single seat location when a free-fall lifeboat is launched from a height of at least 1.3 times its free-fall certification height.

Except for free-fall lifeboats, each lifeboat to be launched by falls shall be of sufficient strength to withstand a load, without residual deflection on removal of that load:

- in the case of boats with metal hulls, 1.25 times the total mass of the lifeboat when loaded with its full complement of persons and equipment; or
- in the case of other boats, twice the total mass of the lifeboat when loaded with its full complement of persons and equipment.

Except for free-fall lifeboats, each lifeboat to be launched by falls shall be of sufficient strength to withstand, when loaded with its full complement of persons and equipment and with, where applicable, skates or fenders in position, a lateral impact against the ship's side at an impact velocity of at least 3.5 m/s and also a drop into the water from a height of at least 3 m.

The vertical distance between the floor surface and the interior of the enclosure or canopy over 50% of the floor area shall be:

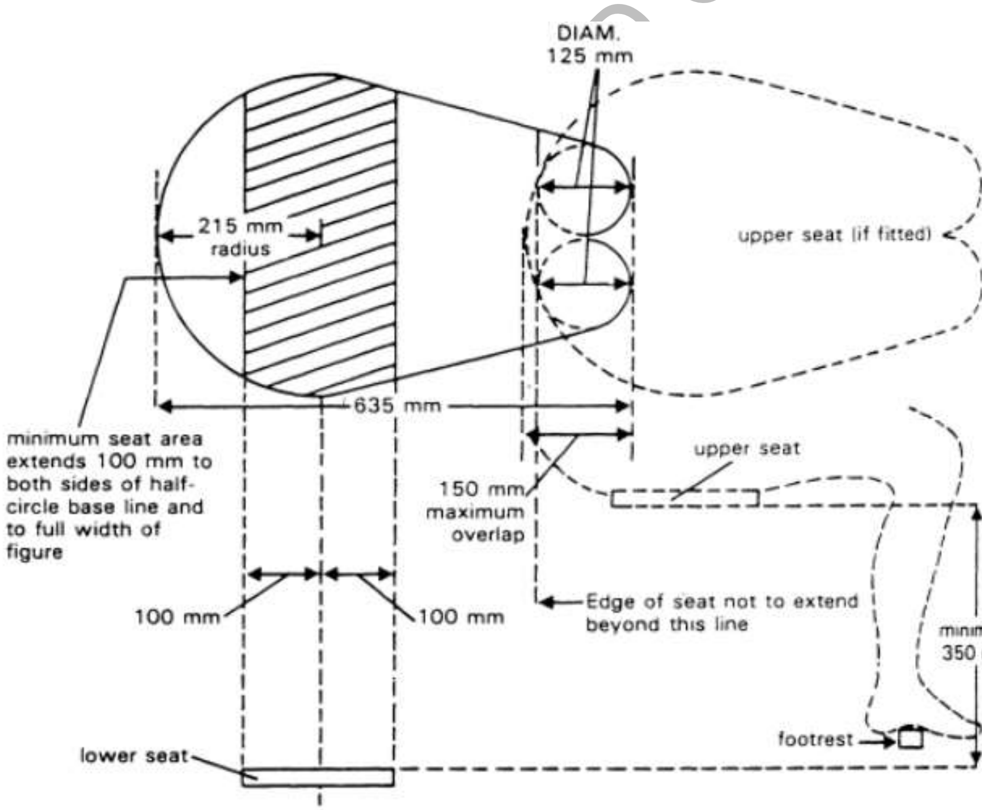
- not less than 1.3 m for a lifeboat permitted to accommodate nine persons or less;

- not less than 1.7 m for a lifeboat permitted to accommodate 24 persons or more; and
- not less than the distance as determined by linear interpolation between 1.3 m and 1.7 m for a lifeboat permitted to accommodate between nine and 24 persons.

No lifeboat shall be approved to accommodate more than 150 persons.

The number of persons which a lifeboat to be launched by falls shall be permitted to accommodate shall be equal to the lesser of:

- the number of persons having an average mass of 75 kg, all wearing lifejackets, that can be seated in a normal position without interfering with the means of propulsion or the operation of any of the lifeboat's equipment; or
- the number of spaces that can be provided on the seating arrangements in accordance with the figure below. The shapes may be overlapped as shown, provided footrests are fitted and there is sufficient room for legs and the vertical separation between the upper and lower seat is not less than 350 mm.



Each seating position shall be clearly indicated in the lifeboat.

Access into lifeboats

- Every passenger ship lifeboat shall be so arranged that it can be rapidly boarded by its full complement of persons. Rapid disembarkation shall also be possible.
- Every cargo ship lifeboat shall be so arranged that it can be boarded by its full complement of persons in not more than 3 min from the time the instruction to board is given. Rapid disembarkation shall also be possible.
- Lifeboats shall have a boarding ladder that can be used at any boarding entrance of the lifeboat to enable persons in the water to board the lifeboat. The lowest step of the ladder shall be not less than 0.4 m below the lifeboat's light waterline.
- The lifeboat shall be so arranged that helpless people can be brought on board either from the sea or on stretchers.
- All surfaces on which persons might walk shall have a non-skid finish.

Lifeboat buoyancy

All lifeboats shall have inherent buoyancy or shall be fitted with inherently buoyant material which shall not be adversely affected by seawater, oil or oil products, sufficient to float the lifeboat with all its equipment on board when flooded and open to the sea. Additional inherently buoyant material, equal to 280 N of buoyant force per person shall be provided for the number of persons the lifeboat is permitted to accommodate. Buoyant material, unless in addition to that required above, shall not be installed external to the hull of the lifeboat.

Lifeboat freeboard and stability

All lifeboats shall be stable and have a positive GM value when loaded with 50% of the number of persons the lifeboat is permitted to accommodate in their normal positions to one side of the centreline.

Under the condition of loading described above:

- each lifeboat with side openings near the gunwale shall have a freeboard, measured from the waterline to the lowest opening through which the lifeboat may become flooded, of at least 1.5% of the lifeboat's length or 100 mm, whichever is the greater;
- each lifeboat without side openings near the gunwale shall not exceed an angle of heel of 20° and shall have a freeboard, measured from the waterline to the lowest opening through which the lifeboat may become flooded, of at least 1.5% of the lifeboat's length or 100 mm, whichever is the greater.

Lifeboat propulsion

Every lifeboat shall be powered by a compression ignition engine. No engine shall be used for any lifeboat if its fuel has a flashpoint of 43°C or less (closed cup test).

The engine shall be provided with either a manual starting system, or a power starting system with two independent rechargeable energy sources. Any necessary starting aids shall also be provided. The engine starting systems and starting aids shall start the engine

at an ambient temperature of -15°C within 2 min of commencing the start procedure unless, in the opinion of the Administration having

regard to the particular voyages in which the ship carrying the lifeboat is constantly engaged, a different temperature is appropriate.

The starting systems shall not be impeded by the engine casing, seating or other obstructions.

The speed of a lifeboat when proceeding ahead in calm water, when loaded with its full complement of persons and equipment and with all engine powered auxiliary equipment in operation, shall be at least 6 knots and at least 2 knots when towing a 25-person life-raft loaded with its full complement of persons and equipment or its equivalent. Sufficient fuel, suitable for use throughout the temperature range expected in the area in which the ship operates, shall be provided to run the fully loaded lifeboat at 6 knots for a period of not less than 24 h.

Water-resistant instructions for starting and operating the engine shall be provided and mounted in a conspicuous place near the engine starting controls.

Lifeboat fittings

All lifeboats except free-fall lifeboats shall be provided with at least one drain valve fitted near the lowest point in the hull, which shall automatically open to drain water from the hull when the lifeboat is not waterborne and shall automatically close to prevent entry of water when the lifeboat is waterborne. Each drain valve shall be provided with a cap or plug to close the valve, which shall be attached to the lifeboat by a lanyard, a chain, or other suitable means. Drain valves shall be readily accessible from inside the lifeboat and their position shall be clearly indicated.

All lifeboats shall be provided with a rudder and tiller. The rudder shall be permanently attached to the lifeboat.

All lifeboats shall be fitted with sufficient watertight lockers or compartments to provide for the storage of the small items of equipment, water and provisions.

Every lifeboat to be launched by a fall or falls, except a free-fall lifeboat, shall be fitted with a release mechanism, which shall be so arranged that all hooks are released simultaneously and release control shall be clearly marked in a color that contrasts with its surroundings.

Every lifeboat shall be fitted with a device to secure a painter near its bow. The device shall be such that the lifeboat does not exhibit unsafe or unstable characteristics when being towed by the ship making headway at speeds up to 5 knots in calm water.

Except for free-fall lifeboats, the painter securing device shall include a release device to enable the painter to be released from inside the lifeboat, with the ship making headway at speeds up to 5 knots in calm water.

Every lifeboat shall be so arranged that an adequate view forward, aft and to both sides is provided from the control and steering position for safe launching and maneuvering.

Lifeboat equipment

1. except for free-fall lifeboats, sufficient buoyant oars to make headway in calm seas.
2. two boat-hooks;
3. a buoyant bailer and two buckets;
4. a survival manual
5. an operational compass which is luminous or provided with suitable means of illumination. In a totally enclosed lifeboat, the compass shall be permanently fitted at the steering position; in any other lifeboat, it shall be provided with a binnacle if necessary to protect it from the weather, and suitable mounting arrangements;
6. a sea-anchor of adequate size fitted with a shock-resistant hawser which provides a firm hand grip when wet. The strength of the sea-anchor, hawser and tripping line if fitted shall be adequate for all sea conditions;
7. two efficient painters of a length equal to not less than twice the distance from the stowage position of the lifeboat to the waterline in the lightest seagoing condition or 15 m, whichever is the greater. On lifeboats to be launched by free-fall launching, both painters shall be stowed near the bow ready for use. On other lifeboats, one painter attached to the release device required to come together with release mechanism shall be placed at the forward end of the lifeboat and the other shall be firmly secured at or near the bow of the lifeboat ready for use;
8. two hatchets, one at each end of the lifeboat;
9. watertight receptacles containing a total of 3 liters of fresh water for each person the lifeboat is permitted to accommodate, of which either 1 liter per person may be replaced by a desalting apparatus capable of producing an equal amount of fresh water in 2 days, or 2 liters per

person may be replaced by a manually powered reverse osmosis desalinator capable of producing an equal amount of fresh water in 2 days;

10. a rustproof dipper with lanyard;
11. a rustproof graduated drinking vessel;
12. a food ration totalling not less than 10,000 kJ for each person the lifeboat is permitted to accommodate; these rations shall be kept in airtight packaging and be stowed in a watertight container;
13. four rocket parachute flares;
14. six hand flares;
15. two buoyant smoke signals;
16. one waterproof electric torch suitable for Morse signalling together with one spare set of batteries and one spare bulb in a waterproof container;
17. one daylight signalling mirror with instructions for its use for signalling to ships and aircraft;
18. one copy of the life-saving signals prescribed by regulation V/16 on a waterproof card or in a waterproof container;
19. one whistle or equivalent sound signal;
20. a first-aid outfit in a waterproof case capable of being closed tightly after use;
21. anti-seasickness medicine sufficient for at least 48 h and one seasickness bag for each person;
22. a jack-knife to be kept attached to the boat by a lanyard;
23. three tin openers;
24. two buoyant rescue quoits, attached to not less than 30 m of buoyant line;
25. if the lifeboat is not automatically self-bailing, a manual pump suitable for effective bailing;
26. one set of fishing tackle;
27. sufficient tools for minor adjustments to the engine and its accessories;
28. portable fire-extinguishing equipment of an approved type suitable for extinguishing oil fires [A.602(15)].
29. a searchlight with a horizontal and vertical sector of at least 6° and a measured luminous intensity of 2500 cd which can work continuously for not less than 3 h;
30. an efficient radar reflector, unless a survival craft radar transponder is stowed in the lifeboat;

31. thermal protective aids complying with the requirements of section 2.5 sufficient for 10% of the number of persons the lifeboat is permitted to accommodate or two, whichever is the greater;
32. in the case of ships engaged on voyages of such a nature and duration that, in the opinion of the Administration a food ration and fishing tackle are unnecessary, the Administration may allow these items to be dispensed with.

Lifeboat markings

- The number of persons for which the lifeboat is approved shall be clearly marked on it in clear permanent characters.
- The name and port of registry of the ship to which the lifeboat belongs shall be marked on each side of the lifeboat's bow in block capitals of the Roman alphabet.
- Means of identifying the ship to which the lifeboat belongs and the number of the lifeboat shall be marked in such a way that they are visible from above

Life rafts

Every liferaft shall be so constructed as to be capable of withstanding exposure for 30 days afloat in all sea conditions.

The liferaft shall be so constructed that when it is dropped into the water from a height of 18 m, the liferaft and its equipment will operate satisfactorily. If the liferaft is to be stowed at a height of more than 18 m above the waterline in the lightest seagoing condition, it shall be of a type which has been satisfactorily drop-tested from at least that height.

The floating liferaft shall be capable of withstanding repeated jumps on to it from a height of at least 4.5 m above its floor both with and without the canopy erected.

The liferaft and its fittings shall be so constructed as to enable it to be towed at a speed of 3 knots in calm water when loaded with its full complement of persons and equipment and with one of its sea-anchors streamed.

The liferaft shall have a canopy to protect the occupants from exposure which is automatically set in place when the liferaft is launched and waterborne.

No liferaft shall be approved which has a carrying capacity of less than six persons

Unless the liferaft is to be launched by an approved launching appliance or is not required to be stowed in a position providing for easy side-to-side transfer, the total mass of the liferaft, its container and its equipment shall not be more than 185 kg.

The liferaft shall be fitted with an efficient painter of length equal to not less than 10 m plus the distance from the stowed position to the waterline in the lightest seagoing condition or 15 m whichever is the greater.

Rescue boats

Rescue boats may be either of rigid or inflated construction or a combination of both and shall:

- be not less than 3.8 m and not more than 8.5 m in length; and
- be capable of carrying at least five seated persons and a person lying on a stretcher.

Rescue boats shall be capable of manoeuvring at a speed of at least 6 knots and maintaining that speed for a period of at least 4 hors.

Rescue boats shall have sufficient mobility and manoeuvrability in a seaway to enable persons to be retrieved from the water, marshal liferafts and tow the largest liferaft carried on the ship when loaded with its full complement of persons and equipment or its equivalent at a speed of at least 2 knots.

A rescue boat shall be fitted with an inboard engine or outboard motor. If it is fitted with an outboard motor, the rudder and tiller may form part of the engine.

Arrangements for towing shall be permanently fitted in rescue boats and shall be sufficiently strong to marshal or tow liferafts.

Inflated rescue boats shall be so constructed as to be capable of withstanding exposure:

- when stowed on an open deck on a ship at sea;
- for 30 days afloat in all sea conditions.

The buoyancy of an inflated rescue boat shall be provided by either a single tube subdivided into at least five separate compartments of approximately equal volume or two separate tubes neither exceeding 60% of the total volume.

In addition to complying with the requirements lifeboats, inflated rescue boats shall be marked with a serial number, the maker's name or trade mark and the date of manufacture.

The inflated rescue boat shall be maintained at all times in a fully inflated condition.

Rocket parachute flares

The rocket parachute flare shall:

- be contained in a water-resistant casing;

- have brief instructions or diagrams clearly illustrating the use of the rocket parachute flare printed on its casing;
- have integral means of ignition;
- be so designed as not to cause discomfort to the person holding the casing when used in accordance with the manufacturer's operating instructions.

The rocket shall, when fired vertically, reach an altitude of not less than 300 m.

At or near the top of its trajectory, the rocket shall eject a parachute flare, which shall:

- burn with a bright red color;
- burn uniformly with an average luminous intensity of not less than 30,000 cd;
- have a burning period of not less than 40 s;
- have a rate of descent of not more than 5 m/s; and
- not damage its parachute or attachments while burning.

Hand flares

The hand flare shall:

- be contained in a water-resistant casing;
- have brief instructions or diagrams clearly illustrating the use of the hand flare printed on its casing;
- have a self-contained means of ignition; and
- be so designed as not to cause discomfort to the person holding the casing and not endanger the survival craft by burning or glowing residues when used in accordance with the manufacturer's operating instructions.

The hand flare shall:

- burn with a bright red colour;
- burn uniformly with an average luminous intensity of not less than 15,000 cd;
- have a burning period of not less than 1 min; and
- Continue to burn after having been immersed for a period of 10s under 100 mm of water.

International Convention on Maritime Search and Rescue, 1979

Adoption: 27 April 1979

Entry into force: 22 June 1985

Introduction

The 1979 Convention, adopted at a Conference in Hamburg, was aimed at developing an international SAR plan, so that, no matter where an accident occurs, the rescue of persons in distress at sea will be co-ordinated by a SAR organization and, when necessary, by co-operation between neighbouring SAR organizations.

Although the obligation of ships to go to the assistance of vessels in distress was enshrined both in tradition and in international treaties (such as the International Convention for the Safety of Life at Sea (SOLAS), 1974), there was, until the adoption of the SAR Convention, no international system covering search and rescue operations. In some areas there was a well-established organization able to provide assistance promptly and efficiently, in others there was nothing at all.

The technical requirements of the SAR Convention are contained in an Annex, which was divided into five Chapters. Parties to the Convention are required to ensure that arrangements are made for the provision of adequate SAR services in their coastal waters. Parties are encouraged to enter into SAR agreements with neigh bouring States involving the establishment of SAR regions, the pooling of facilities, establishment of common procedures, training and liaison visits. The Convention states that Parties should take measures to expedite entry into its territorial waters of rescue units from other Parties.

The Convention then goes on to establish preparatory measures which should be taken, including the establishment of rescue co-ordination centres and subcentres. It outlines operating procedures to be followed in the event of emergencies or alerts and during SAR operations. This includes the designation of an on-scene commander and his duties.

Parties to the Convention are required to establish ship reporting systems, under which ships report their position to a coast radio station. This enables the interval between the loss of contact with a vessel and the initiation of search operations to be reduced. It also helps to permit the rapid determination of vessels which may be called upon to provide assistance including medical help when required.

Amendment Procedure

The SAR Convention allowed for amendments to the technical Annex to be adopted by a Conference of STCW Parties or by IMO's Maritime Safety Committee, expanded to include all Contracting Parties, some of whom may not be members of the Organization. Amendments to the SAR Convention enter into force on a specified date unless objections are received from a required number of Parties.

IMO search and rescue areas

Following the adoption of the 1979 SAR Convention, IMO's Maritime Safety Committee divided the world's oceans into 13 search and rescue areas, in each of which the countries concerned have delimited search and rescue regions for which they are responsible.

Provisional search and rescue plans for all of these areas were completed when plans for the Indian Ocean were finalized at a conference held in Fremantle, Western Australia in September 1998.

Revision of SAR Convention

The 1979 SAR Convention imposed considerable obligations on Parties - such as setting up the shore installations required - and as a result the Convention was not being ratified by as many countries as some other treaties. Equally important, many of the world's coastal States had not accepted the Convention and the obligations it imposed.

It was generally agreed that one reason for the small number of acceptances and the slow pace of implementation was due to problems with the SAR Convention itself and that these could best be overcome by amending the Convention.

At a meeting in October 1995 in Hamburg, Germany, it was agreed that there were a number of substantial concerns that needed to be taken into account, including:

- lessons learned from SAR operations;
- experiences of States which had implemented the Convention;
- questions and concerns posed especially by developing States which were not yet

Party to the Convention;

- need to further harmonize the IMO and International Civil Aviation Organization (ICAO) SAR provisions;
- inconsistent use of Convention terminology and phraseology.

IMO's Sub-Committee on Radio-Communications and Search and Rescue

(COMSAR) was requested to revise the technical Annex of the Convention. A draft text was prepared and was approved by the 68th session of the MSC in May 1997, and was then adopted by the 69th MSC session in May 1998.

The 1998 amendments

Adopted: 18 May 1998

Entry into force: 1 January 2000

The revised technical Annex of the SAR Convention clarifies the responsibilities of Governments and puts greater emphasis on the regional approach and co-ordinatio between maritime and aeronautical SAR operations.

The revised Annex includes five Chapters:

Chapter 1 - Terms and Definitions

This Chapter updates the original Chapter 1 of the same name.

Chapter 2 - Organization and Co-ordination

Replaces the 1979 Chapter 2 on Organization. The Chapter has been re-drafted to make the responsibilities of Governments clearer. It requires Parties, either individually or in co-operation with other States, to establish basic elements of a search and rescue service, to include:

- Legal framework
- Assignment of a responsible authority
- Organization of available resources
- Communication facilities
- Co-ordination and operational functions
- Processes to improve the service including planning, domestic and international cooperative relationships and training.

Parties should establish search and rescue regions within each sea area - with the agreement of the Parties concerned. Parties then accept responsibility for providing search and rescue services for a specified area.
The Chapter also describes how SAR services should be arranged and national capabilities be developed. Parties are required to establish rescue co-ordination centres and to operate them on a 24-hour basis with trained staff who have a working knowledge of English.
Parties are also required to "ensure the closest practicable co-ordination between maritime and aeronautical services".

Chapter 3 - Co-operation between States
Replaces the original Chapter 3 on Co-operation.
Requires Parties to co-ordinate search and rescue organizations, and, where necessary, search and rescue operations with those of neighbouring States. The Chapter states that unless otherwise agreed between the States concerned, a Party should authorize, subject to applicable national laws, rules and regulations, immediate entry into or over its territorial sea or territory for rescue units of other Parties solely for the purpose of search and rescue.

Chapter 4 - Operating Procedures
Incorporates the previous Chapters 4 (Preparatory Measures) and 5 (Operating Procedures).
The Chapter says that each RCC (Rescue Co-ordination Centre) and RSC (Rescue Sub-Centre) should have up-to-date information on search and rescue facilities and communications in the area and should have detailed plans for conduct of search and rescue operations. Parties - individually or in co-operation with others should be capable of receiving distress alerts on a 24-hour basis. The regulations include procedures to be followed during an emergency and state that search and rescue activities should be co-ordinated on scene for the most effective results. The Chapter says that "Search and rescue operations shall continue, when practicable, until all reasonable hope of rescuing survivors has passed".

Chapter 5 - Ship reporting systems
Includes recommendations on establishing ship reporting systems for search and rescue purposes, noting that existing ship reporting systems could provide adequate information for search and rescue purposes in a given area.

IAMSAR Manual
Concurrently with the revision of the SAR Convention, the IMO and the International Civil Aviation Organization (ICAO) jointly developed the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual, published in three volumes covering Organization and Management; Mission Co-ordination; and Mobile Facilities.

The IAMSAR Manual revises and replaces the IMO Merchant Ship Search and Rescue Manual (MERSAR), first published in 1971, and the IMO Search and Rescue Manual (IMOSAR), first published in 1978.
The MERSAR Manual was the first step towards developing the 1979 SAR Convention and it provided guidance for those who, during emergencies at sea, may require assistance from others or who may be able to provide assistance themselves.
In particular, it was designed to aid the master of any vessel who might be called upon to conduct SAR operations at sea for persons in distress. The manual was updated several times with the latest amendments being adopted in 1992 – they entered into force in 1993.
The second manual, the IMOSAR Manual, was adopted in l978. It was designed to help Governments to implement the SAR Convention and provided guidelines rather than requirements for a common maritime search and rescue policy, encouraging all coastal States to develop their organizations on similar lines and enabling adjacent States to co-operate and provide mutual assistance. It was also updated in 1992, with the amendments entering into force in 1993.
This manual was aligned as closely as possible with ICAO Search and Rescue Manual to ensure a common policy and to facilitate consultation of the two manuals for administrative or operational reasons. MERSAR was also aligned, where appropriate, with IMOSAR.

4.3.4 ACTIONS TO BE TAKEN TO PROTECT AND SAFEGUARD ALL PERSONS ON BOARD IN EMERGENCIES

Safety of Passengers
Muster List and Emergency Procedure
Special duties to be undertaken in the event of an emergency shall be allotted to each member of the crew. The muster list should specify details of the general emergency alarm and public address system and also action to be taken by crew and passengers when this alarm is sounded. The muster list shall also specify how the order to abandon ship will be given.
Each passenger ship shall have procedures in place for locating and rescuing passengers trapped in their staterooms.
The muster list shall show all the special duties and shall indicate, in particular, the station to which each member must go, and the duties that he has to perform.

The muster list for each passenger ship shall be in a form approved by the Administration. Before the vessel sails, the muster list shall be completed. Copies shall be posted in several parts of the ship, and in particular in the crew's quarters.
The muster list shall show the duties assigned to the different members of the crew in connection with:

a. closing of the watertight doors, fire doors, valves, scuppers, sidescuttles, skylights, portholes and other similar openings in the ship;
b. equipping of the survival craft and other life-saving appliances;
c. preparation and launching of survival craft;
d. the general preparation of the other life-saving appliances;
e. the muster of the passengers;
f. use of communication equipment;
g. manning of fire parties assigned to deal with fires;
h. special duties assigned in respect to the use of fire-fighting equipment and installations and
i. the extinction of fire, having regard to the ship's fire control plans.

The muster list shall show the duties assigned to members of the crew in relation to passengers in case of emergency. These duties shall include:

a. warning the passengers;
b. seeing that they are suitably clad and have donned their lifejackets correctly;
c. assembling passengers at muster stations;
d. keeping order in the passageways and on the stairways and generally controlling the movements of the passengers; and
e. ensuring that a supply of blankets is taken to the survival craft.

The duties shown by the muster list in relation to the extinction of fire shall include particulars of:

a. the manning of the fire parties assigned to deal with fires;
b. the special duties assigned in respect of the operation of fire-fighting equipment and installations.

The muster list shall specify definite signals for calling all the crew to their boat, liferaft and fire stations, and shall give full particulars of these signals.
These signals shall be made on the whistle or siren and, they shall be supplemented by other signals, which shall be electrically operated. All these signals shall be operable from the bridge.
The muster list shall specify which officers are assigned to ensure that life- saving and fire appliances are maintained in good condition and are ready for immediate use.
The muster list shall specify substitutes for key persons who may become disabled, taking into account that different emergencies may call for different actions.
The muster list shall be prepared before the ship proceeds to sea. After the muster list has been prepared, if any change takes place in the crew which necessitates an alteration in the muster list, the master shall either revise the list or prepare a new list.

The format of the muster list used on passenger ships shall be approved.

Practice Musters and Drills
At the emergency drills each member of the crew shall be required to demonstrate his familiarity with the arrangements and facilities of the ship, his duties, and any equipment he may be called upon to use. Masters shall be required to familiarize and instruct the crews in this regard.

Frequency of drills
In passenger ships, musters of the crew for emergency drill shall take place weekly when practicable and there shall be such a muster when a passenger ship leaves the final port of departure.
In cargo ships, a muster of the crew emergency drill shall take place at intervals of not more than one month, provided that a muster of the crew for emergency drill shall take place within 24 hours of leaving a port if more than 25 per cent of the crew have been replaced at that port.
On the occasion of the monthly muster in cargo ships the boat's equipment shall be examined to ensure that it is complete.
The date upon which musters are held, and details of any training and drills in fire fighting which are carried out on board shall be recorded in such log book. If in any week (for passenger ships) or month (for cargo ships) no muster or a part muster only is held, an entry shall be made stating the circumstances and extent of the muster held. A report of the examination of the boat's equipment on cargo ships shall be entered in the log book, which shall also record the occasions on which the lifeboats are swung out and lowered.
In passenger ships, a muster of the passengers shall be held within 24 hours after leaving port.
Different groups of lifeboats shall be used in turn at successive emergency drill and every lifeboat shall be swung out and, if practicable and reasonable, lowered at least once every four months. The musters and inspections shall be so arranged that the crew thoroughly understand and are practiced in the duties they have to perform, including instructions in the handling and operation of liferafts where these are carried.
The emergency signal for summoning passengers to muster stations shall be a succession of seven or more short blasts followed by one long blast on the whistle or siren.
This shall be supplemented in passenger ships, by other signals, which shall be electrically operated, throughout the ship operable from the bridge. The meaning of all signals affecting passengers, with precise instructions on what they are to do in an emergency, shall be clearly stated in appropriate languages on cards posted in their cabins and in conspicuous places in other passenger quarters.

4.3.5 ACTIONS TO LIMIT DAMAGE AND SALVE THE SHIP FOLLOWING A FIRE, EXPLOSION, COLLISION OR GROUNDING

1. Means of Limiting Damage and Salving the Ship Following a Fire or Explosion

A two-fold strategy is used to limit the potential damage from fires and explosions: prevent the initiation of the fire or explosion and minimize the damage after a fire or explosion has occurred.

- Inerting
- Static electricity
- Controlling static electricity
- Ventilation
- Explosion proof equipment and instruments
- Sprinkler systems
- Miscellaneous design features for preventing fires and explosions

For any fire or combustion explosion to occur, three conditions must be met. First, a combustible or explosive material must be present. Second, oxygen must be present to support the combustion reaction. Finally, a source of ignition must be available to initiate the reaction. If any of the three conditions of the fire triangle are eliminated, the triangle is broken and it is impossible for a fire or combustion explosion to result.
This is the basis for the first four design methods listed above.
Damage due to fires and explosions is minimized by stopping fires or explosions as quickly as possible, and also by designing the process equipment (and control centers) to withstand their effects. This is the basis for design methods five and six listed above.

<u>Inerting</u>

Inerting is the process of adding an inert gas to a combustible mixture to reduce the concentration of oxygen below the minimum oxygen concentration (MOC). The inert gas is usually nitrogen or carbon dioxide, although steam is sometimes used. For many gases the MOC is approximately 10 percent and for many dusts approximately 8 percent. Inerting begins with an initial purge of the vessel with inert gas to bring the oxygen concentration down to safe concentrations. A commonly used control point is 4 percent below the MOC that is 6 percent oxygen if the MOC is 10 percent.

After the empty vessel has been inerted, the flammable material is charged. An inerting system is required to maintain an inert atmosphere in the vapor space above the liquid. This system, ideally, should include an automatic inert gas addition feature to control the oxygen concentration below the MOC. This control system should have an analyzer to continuously monitor the oxygen concentration in relationship to the MOC, and a controlled inert gas feed system to add inert gas when the oxygen concentration approaches the MOC. More frequently, however, the inerting system consists only of a regulator designed to maintain a fixed positive inert pressure in the vapor space; this insures that inert is always flowing out of the vessel rather than air flowing in. The analyzer system, however, results in a significant savings in inert gas usage without sacrificing safety.
Consider an inerting system designed to maintain the oxygen concentration below 10%. As oxygen leaks into the vessel and the concentration rises to 8 percent, a signal from the oxygen

sensor opens the inert gas feed valve. Once again the oxygen level is adjusted to 6 percent. This closed loop control system, with high (8 percent) and low (6 percent) inerting set points, maintains the oxygen concentration at safe levels with a reasonable margin of safety.
There are several purging methods used to initially reduce the oxygen concentration to the low set point, as described below.

Vacuum Purging
Vacuum purging is the most common inerting procedure for vessels. This procedure is not used for large storage vessels because they are usually not designed for vacuums, and usually only withstand a pressure of a few, inches of water.
Reactors, however, are often designed for full vacuum, that is -760 mm Hg gauge or 0.0 mm Hg absolute. Consequently, vacuum purging is a common procedure for reactors. The steps in a vacuum purging process include (1) draw a vacuum on the vessel until the desired vacuum is reached, (2) relieve the vacuum with an inert, such as, nitrogen or carbon dioxide to atmospheric pressure, (3) repeat steps 1 and 2 until the desired oxidant concentration is reached.

Pressure Purging
Vessels may be pressure purged by adding inert gas under pressure. After this added gas is diffused throughout the vessel, it is vented to the atmosphere, usually down to atmospheric pressure. More than one pressure cycle may be necessary to reduce the oxidant content to the desired concentration.

Sweep-Through Purging
The sweep-through purging process adds purge gas into a vessel at one opening, and withdraws the mixed gas from the vessel to the atmosphere (or scrubber) from another opening. This purging process is commonly used when the vessel or equipment is not rated for pressure or vacuum; the purge gas is added and withdrawn at atmospheric pressure.

STATIC ELECTRICITY

A common ignition source within chemical plants is sparks due to static charge buildup and sudden discharge. It is perhaps the most elusive of ignition sources.
Despite considerable efforts, serious explosions and fires due to static ignition continue to plague the chemical process industry.
The best design methods for preventing this type of ignition source are developed by understanding the fundamentals relevant to static charge and using these fundamentals to design specific features within a plant to prevent the accumulation of static charge, or to recognize situations where the build-up of static is inevitable and unavoidable. For unavoidable static buildup, design features are added to continuously and reliably inert the atmosphere around the regions where static sparks are likely.

Static charge buildup is a result of physically separating a poor conductor from a good conductor or another poor conductor. When different materials touch each other, the electrons move across the interface from one surface to the other. Upon separation, more of the electrons remain on one surface than the other; one material becomes positively charged and the other negatively charged.

If both of the materials are good conductors, the charge buildup as a result of separation is small because the electrons are able to scurry between the surfaces. If, however, one or both of the materials are insulators or poor conductors, electrons are not as mobile and ace trapped on one of the surfaces, and the magnitude of the charge is much greater.

Household examples which result in a buildup of a static charge are walking across a rug, placing different materials in a tumble dryer, removing a sweater, and combing hair. The clinging fabrics and sometimes audible sparks are the result of the build-up of a static charge. Common industrial examples are pumping a nonconductive liquid through a pipe, mixing immiscible liquids, pneumatically conveying solids, and leaking steam impacting an ungrounded conductor. The static charges in these examples accumulate to develop large voltages. Subsequent grounding produces large and energetic sparks.

For industrial operations where flammable vapors may be present, any charge accumulation exceeding 350 volts and 0.1 mJ is considered dangerous. Static charges of this magnitude are easy to generate; the static buildup due to walking across a carpet averages about 20 mJ and exceeds several thousand volts.

Liquids	Specific conductivity (mho/cm)	Dielectric constant
Benzene	7.6×10^{-8} to $< 1 \times 10^{-18}$	2.3
Toluene	$< 1 \times 10^{-14}$	2.4
Xylene	$< 1 \times 10^{-15}$	2.4
Heptane	$< 1 \times 10^{-18}$	2.0
Hexane	$< 1 \times 10^{-18}$	1.9
Methanol	4.4×10^{-7}	33.7
Ethanol	1.5×10^{-7}	25.7
Isopropanol	3.5×10^{-6}	25.0
Water	5.5×10^{-6}	80.4
Other materials and air		
Air		1.0
Cellulose	1.0×10^{-9}	3.9 to 7.5
Pyrex	1.0×10^{-14}	4.8
Paraffin	10^{-16} to 0.2×10^{-18}	1.9 to 2.3
Rubber	0.33×10^{-13}	3.0
Slate	1.0×10^{-8}	6.0 to 7.5
Teflon	0.5×10^{-13}	2.0
Wood	10^{-10} to 10^{-13}	3.0

Properties for electrostatic calculations

Charges also accumulate when- -solids-are transported. The buildup results from the separation of solid particle surfaces. Since solid geometries are almost always ill defined, electrostatic calculations for solids are handled empirically. The charge build-up characteristics are determined using generally accepted guidelines.

	$Coulomb/cm^2$
Sliding Contact	$<0.212 \times 10^{-9}$
Rolling Contact	$<0.212 \times 10^{-9}$
Dispersion of Dusts	0.0265 to 0.265×10^{-9}
Pneumatic Transport of Solids	$<1.59 \times 10^{-9}$
Sheets Pressed Together	$<1.59 \times 10^{-9}$
Close Machining	$<2.65 \times 10^{-9}$

Static charge densities for various operations

Process	Charge (coulomb/kg)
Sieving	10^{-9} to 10^{-11}
Pouring	10^{-7} to 10^{-9}
Grinding	10^{-6} to 10^{-7}
Micronizing	10^{-4} to 10^{-7}
Sliding down on incline	10^{-5} to 10^{-7}
Pneumatic transport of solids	10^{-5} to 10^{-7}

Charge buildup for various operations

Electrostatic Voltage Drops
Figure above illustrates a tank with a feed line. Fluid flows through the feed line and drops into the tank. The streaming current builds-up a charge and voltage in the feed line to the vessel and the vessel itself.

Controlling static electricity

Charge buildup, resulting sparks, and the ignition of flammables is an inevitable event if control methods are not appropriately used. In practice, however, design engineers recognize this problem and install special features to prevent sparks by eliminating the buildup and accumulation of static charge and prevent ignition by inerting the surroundings.

Inerting, is the most effective and reliable method for preventing ignition. It is always used when working with flammable liquids which are 5°C (or less) below the flash point (closed cup). Methods for preventing charge buildup are described in the following paragraphs.

Relaxation

When pumping fluids into a vessel through a pipe on top of the vessel, the separation process produces a streaming current Is which is the basis for charge buildup. It is possible to substantially reduce this electrostatic hazard by adding an enlarged section of pipe just prior to entering the tank. This "hold" provides time for charge reduction by relaxation. The residence time in this relaxation section of pipe should be about twice the relaxation time determined.

In actual practice,' it was found that a hold time equal to or greater than one halfthe calculated relaxation time is sufficient to eliminate charge buildup. The "twice the relaxation time" rule, therefore, provides a safety factor of 4.

Bonding and Grounding

The voltage difference between two conductive materials is reduced to zero by bonding the two materials that is, bonding one end of a conducting wire to one of the materials and the other end to the second material.

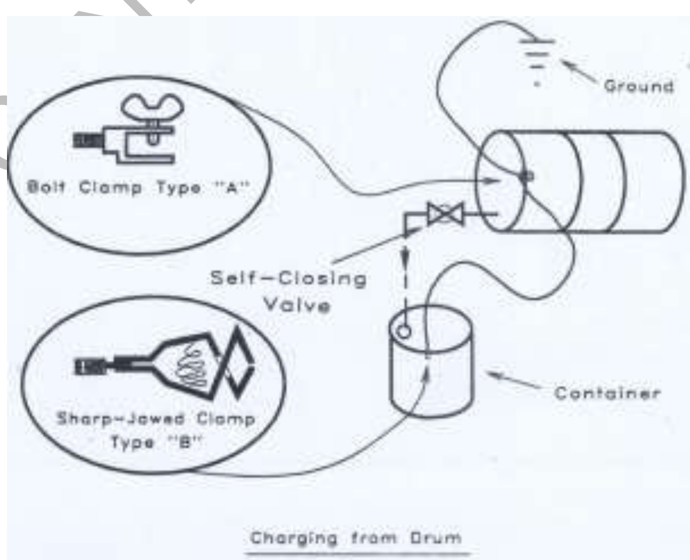
When comparing sets of bonded materials, the sets may have different voltages.

The voltage difference between sets is reduced to zero by bonding each set to ground, that is, grounding.

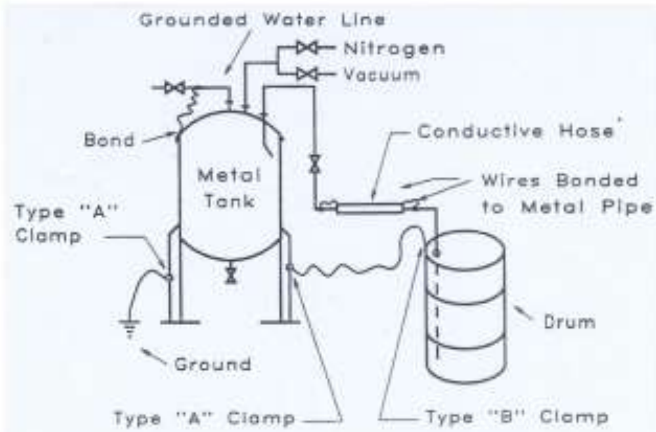
Bonding and grounding reduces the voltage of an entire system to ground level or zero voltage. This also eliminates the charge buildup between various parts of a system, eliminating the potential for static sparks.

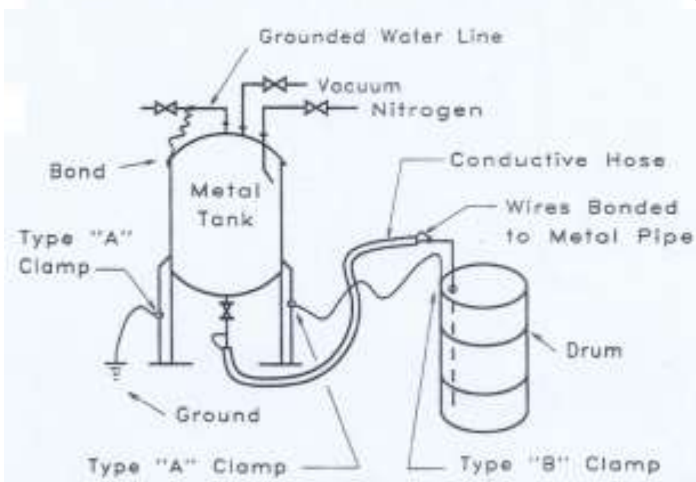
Dip Pipes

An extended line, sometimes called a' dip leg or dip pipe, reduces the electrical charge that accumulates when liquid is allowed to free fall. When using dip pipes, however, care must be taken to prevent siphoning back when the inlet flow is



Bounding and grounding procedures for tanks and vessels

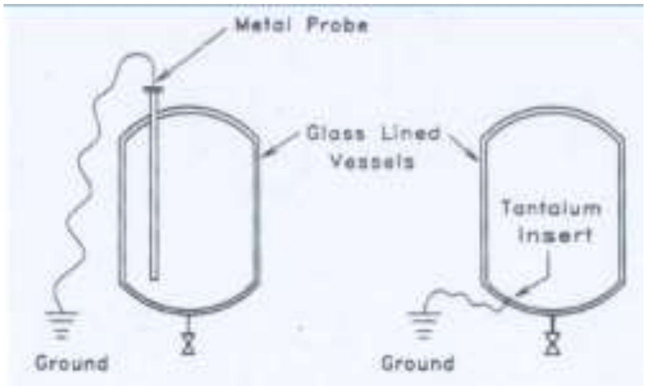




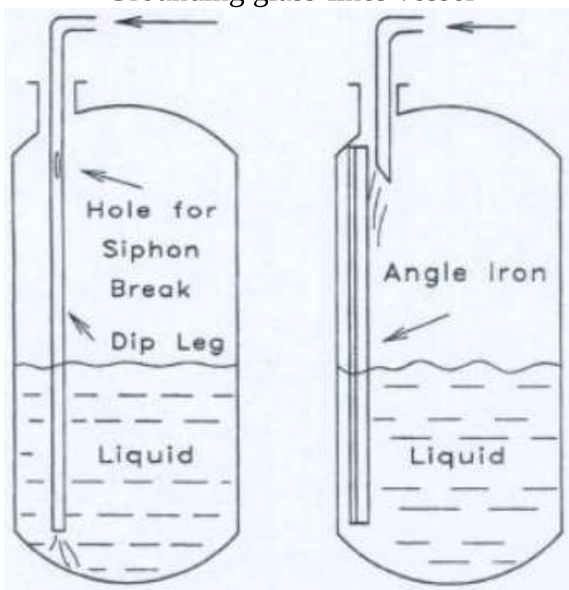
stopped. A commonly used method is to place a hole in the dip pipe near the top of the vessel. Another technique is to use an angle iron instead of a pipe and let the liquid flow down the angle iron. These methods are also used when filling drums.

Increasing Conductivity with Additives

The conductivity of nonconducting organics can sometimes be increased using additives called antistatic additives. Examples of antistats include water or polar solvents, such as alcohols. Water is only effective when it is soluble in the offending



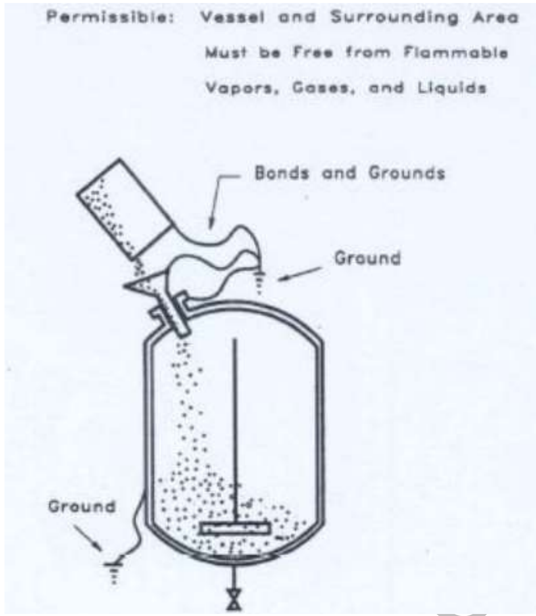
Grounding glass-lines vessel



Dip legs to prevent free fall and accumulation of static charge

liquid, because an insoluble phase gives an additional source of separation and charge buildup.

Handling Solids without Flammable Vapors
Charging solids with a nongrounded and conductive chute can result in a buildup of a charge on the chute. This charge can accumulate and finally produce a spark which may ignite a dispersed and flammable dust.
Solids are transferred safely by bonding and grounding all conductive parts and/or using nonconductive parts (drum and chute).



Handling solids with no flammable vapor present

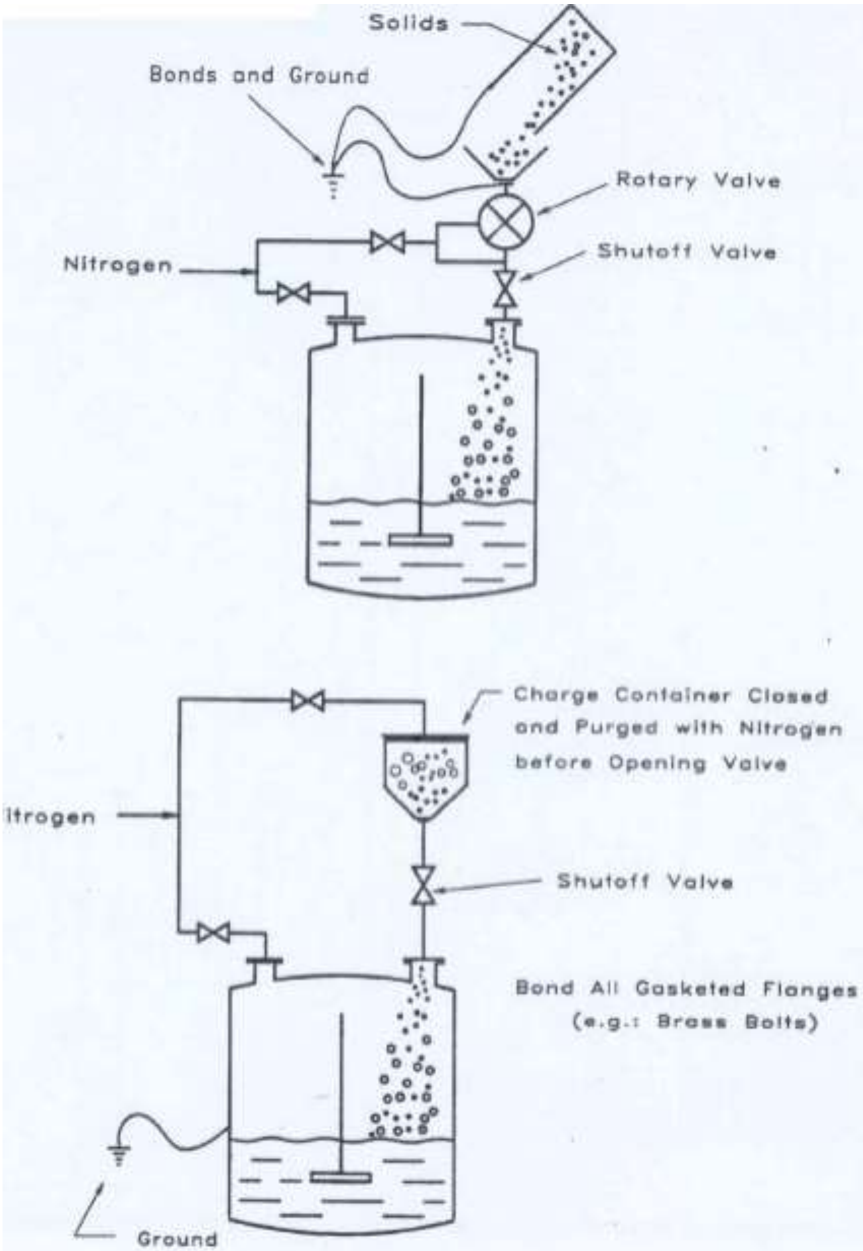
Handling Solids with Flammable Vapors

A safe design for this operation includes closed handling of the solids and liquids under an inert atmosphere.

For solvent-free solids, the use of nonconductive containers is permitted. For solids containing flammable solvents, only conductive and grounded containers are recommended.

Explosion proof equipment and instruments

All electrical devices are inherent ignition sources. Special design features are required to prevent the ignition of flammable vapors and dusts. The fire and explosion hazard is directly proportional to the number and type of electrically powered devices in a process area.
Most safety practices for electrical installations are based on the National Electric Code (NEC). Although states, municipalities, and insurance companies may have their own installation requirements, they are usually based on the NEC.
Process areas are divided into two major types of environments: XP and non- XP. XP, for eXplosion Proof, means flammable materials (particularly vapors) might be present at certain times. Non-XP means that flammable materials are not



Handling solids with flammable vapors present

present even under abnormal conditions. For non-XP designated areas, open flames, heated elements, and other sources of ignition may be present.

Explosion-Proof Housings

In an XP area, the electrical equipment and some instrumentation must have special explosion proof housings. The housings are not designed to prevent flammable vapors and gases from entering but are designed to withstand an internal explosion and prevent the combustion from spreading beyond the inside of the enclosure. A motor starter, for example, is enclosed in a heavy cast walled box with the strength needed to withstand explosive pressures.

The explosion proof design includes the use of conduit with special sealed connections around all junction boxes.

Area and Material Classification

The design of electrical equipment and instrumentation is based on the nature of the process hazards or specific process classifications. The classification method is defined in the National Electrical Code; it is a function of the nature and degree of the process hazards within a particular area. The rating method includes Classes I, II, and III, Groups A-G, and Divisions 1 or 2.

The classes are related to the nature of the flammable material.

Class I: Locations where flammable gases or vapors are present.
Class II: Same for combustible dusts.
Class III: Hazard locations where combustible fibers or dusts are present but not likely to be in suspension.

The groups designate the presence of specific chemical types. Chemicals which are grouped have equivalent hazards

Group A: acetylene
Group B: hydrogen ethylene
Group C: carbon monoxide hydrogen sulfide
Group D: butane ethane ethyl alcohol
Group E: aluminum dust
Group F: carbon black
Group G: flour

Division designations are categorized in relationship to the probability of the material being within the flammable or explosive regions.

Division 1: Probability of ignition is high; that is, flammable concentrations are normally present.
Division 2: Hazardous only under abnormal conditions. Flammables are normally contained in closed containers or systems.

Design of XP Area

When designing an XP area, all pieces of electrical equipment and instrumentation are specified for the class, group, and division as discussed previously. All pieces of equipment and instrumentation within an area must be appropriately specified and installed. The overall classification is only as good as the piece of equipment in an area with the lowest classification.

Ventilation

Proper ventilation is another method used to prevent fires and explosions. The purpose of ventilation is to dilute the explosive vapors with air to prevent explosion and to confine the hazardous flammable mixtures.

Open Air Plants

Open air plants are recommended because the average wind velocities are high enough to safely dilute volitile chemical leaks which may exist within a plant. While safety precautions are always practiced to minimize leaks, accidental releases from pump seals and other process points may occur.

Sprinkler systems

Sprinkler systems are an effective way to contain fires. The system consists of an array of sprinkler heads connected to a water supply. The heads are mounted in a high location (usually near ceilings) and disperse a fine spray of water over an area when activated. The heads are activated by a variety of methods. A common approach activates the heads individually by the melting of a fusible link holding a plug in the head assembly. Once activated they cannot be turned off unless the main water supply is stopped. This approach is called a closed head area system. These systems are used for storage areas, laboratories, control rooms and small pilot areas. Another approach activates the entire sprinkler array from a common control point. The control point is connected to an array of heat and/or smoke detectors that start the sprinklers when an abnormal condition is detected. If a fire is detected, the entire sprinkler array within an area is activated, possibly in areas not even affected by the fire. This approach is called an open head area system. This system is used for plant process areas and larger pilot plants.

Sprinkler systems may cause considerable water damage when activated, depending upon the contents of the building or process structure. Statistically, the amount of water damage is never as great as the damage from fires in areas that should have had sprinklers. Sprinkler systems require maintenance to insure they remain in service and have an adequate and uninterrupted water supply.

There are various fire classes which require different sprinkler designs. The detailed descriptions of these classes and sprinkler specifications are in the National Fire Code. -An average chemical plant is classified as an Ordinary Hazard (Group 3) area. Various sprinkler specifications for this type area are given in Table below.

Sometimes vessels need special water protection to keep the vessel walls cool during fires. High surface temperatures may result in metal failure at pressures far below the vessel's maximum allowable working pressure (MAWP) with potentially disastrous consequences. In hydrocarbon spill fires, unprotected vessels (no insulation or water spray) may fail within minutes.

A water spray protection system around vessels is recommended to prevent this type of failure. These water spray protection systems, commonly called deluge systems, are designed to keep the vessel cool, flush away potentially hazardous spills, and help to knock down gas clouds. The deluge systems may alternatively provide enough time to transfer the material out of the storage tank into another (and safe) area.

These vessel deluge systems are usually designed as open head systems, which are activated when a fire is detected and/or a flammable gas mixture is detected. The deluge system is usually opened when the flammable gas concentration is a fraction of the LFL (approximately 25%) or when a fire is detected through heat. Table below provides design specifications for these deluge systems.

Closed Head Area Systems for small storage areas, laboratories, control rooms, and small pilot plants.

(a) 0.25 gpm/ft^2 of floor area over an area of 3000 ft^2 for normal hydrocarbons such as, hexane, ethanol, toluene, etc.

(b) 0.35 gpm/ft^2 of floor area over an area of 3000 ft^2 for reactive hydrocarbons, such as styrene, butadiene, ethylene oxide, etc.

(c) For areas greater than 3000 ft^2 the system is designed for the most hydraulically remote 3000 ft^2 of the system. For example, if a warehouse area is 10,000 ft^2, the total water requirement is usually based on the most distance 3000 ft^2 area.

Open Head Area Systems for process areas including larger pilot plants.

(a) 0.25 gpm/ft^2 of floor area for normal hydrocarbons such as, hexane, ethanol, toluene, etc.

(b) 0.35 gpm/ft^2 of floor area for reactive hydrocarbons, such as styrene, butadiene, ethylene oxide, etc.

(c) An area covered is based on a particular hazard or potential spill which could include several vessels.

Deluge Water Spray Systems for vessels, heat exchangers, etc. These systems are similiar to open head area systems.

(a) Same as open head area system above, except area is based on surface area of the vessels covered.

(b) Maximum spacing around perimeter of vessel is 8 feet.

(c) Maximum distance from vessel surface is 2 feet.

Nominal Discharge Capacities of approved sprinklers having a nominal 1/2 inch orifice.

Gpm:	18	25	34	50	58
Psi:	10	20	35	75	100

Fire Monitors (usually fixed)

(a) Rate is 500 to 2000 gpm.

(b) Area coverage is 150 ft radius.

Spacings between Nozzles are based on vendors' specifications.

Piping sizes are based on nozzle specifications, nozzle layout, and conventional hydraulic calculations.

Fire protection for chemical plants

Monitors are fixed water hydrants with an attached discharge gun. They are also installed in process areas and storage tank areas. Fire hydrants and monitors are spaced 150 to 250 ft apart around process units, located so that all areas of the plant can be covered by tW9 streams. The monitor is usually located 50 ft from the equipment being protected.' The specifications for monitors are also in Table above.

2. Procedure for Abandoning Ship

The decision to abandon ship is usually very difficult. In some instances, people have perished in their life raft while their abandoned vessel managed to stay afloat. Other cases indicate that people waited too long to successfully get clear of a floundering boat.

Once the decision is made:

- Put on all available waterproof clothing, including gloves, headgear, and life jacket.
- Collect survival kit.
- Note present position.
- Send out MAYDAY message.
- Launch life raft attached to ship.
- Launch dinghy attached to life raft.
- Try to enter life raft directly from the boat (if impossible, use minimal swimming effort to get on board).
- Don't forget the EPIRB (emergency position indicator radio beacon).
- Get a safe distance from the sinking vessel.
- Collect all available flotsam. The most unlikely articles can be adapted for use under survival conditions.
- Keep warm by huddling bodies together. Keep dry, especially your feet.
- Stream a sea anchor.
- Arrange lookout watches.
- Use flares only on skipper's orders when there is a real chance of them being seen.
- Arrange for collecting rainwater. Ration water to maximum one-half quart per person per day, issued in small increments. Do not drink seawater or urine. If water is in short supply, eat only sweets from survival rations.

Act Like a Captain

In emergency situations, the crew of a vessel looks to their leader in an almost unconscious way to determine their own level of anxiety. If the captain projects a calm and confident attitude, the crew will be reassured and since an anxious crew means poor judgment and performance, a captain should do all he or she can to keep the crew calm. The idea here is not to lie to your crew, and certainly not to fake a fearless, macho manner, going down with the ship is a pretty dumb plan. The idea is that, by maintaining a calm, deliberate attitude in the face of a dire situation, you can help your crew remain effective and perhaps help save lives. If you need to fake that attitude to some degree, so be it.

Emergency Communications

When trouble strikes, there are many ways to communicate your distress and seek help. Use your VHF or single-sideband radio and follow the procedures for distress.

There are three levels of priority communications: distress, urgent, and safety, identified by MAYDAY, PAN-PAN, and SECURITE. Understand the differences by reviewing the tip on radio procedures.

4.4 DEVELOP EMERGENCY AND DAMAGE CONTROL PLANS AND HANDLE EMERGENCY SITUATIONS

4.4.1 PREPARATION OF CONTINGENCY PLANS FOR RESPONSE TO EMERGENCIES

Contingency plans for response to emergencies

Emergency response plan is important onboard the ship as this gives the duties and responsibility to be performed by crew members during the emergency situations on board.

Emergency Preparedness in Case of Ship Accidents

Whenever some incident of a serious or harmful nature happens suddenly, we classify it as an emergency. One of the most important factors in dealing with an emergency situation, apart from a sharp mind and the control of respectful fear, is the presence of a solid action plan. This is a general rule that is applicable to all situations whether on board a ship in the middle of the ocean or in a crowded city port amidst a sea of people and machinery.
Emergency situations on a ship tend to be more critical because ships are isolated, solitary floating objects moving in the vast and deep oceans. Since there are so many possible types of emergencies, it is necessary to know about both common and emergency essentials.

Here we will take a look at the general procedures and plans to be followed in case of an emergency situation on board a ship.

Emergency Essentials - Types of Emergencies

For effective usage of the limited emergency equipment available on board, all personnel must be aware of the location of firefighting gear and lifesaving appliances and be trained in their use. They must also be aware of the alarm signals, recognize them, and muster at the muster point in case of any type of emergency.

The general alarm will be sounded in the event of:

- Fire
- Collision
- Grounding
- Cargo hose burst
- Major leakage or spillage of oil cargo
- Any other event which calls for emergency action

Other alarms could include:

- Engineer alarm for unmanned machinery spaces
- Carbon dioxide alarm
- Fire detector alarms
- Cargo tank level alarms
- Refrigerated store alarm

If your ship's alarms are ringing, it does not necessarily mean that the situation is out of control. Alarms are warnings, which are sounded so that people onboard take the emergency measures like wearing their life jackets, or gathering at a common point, depending upon the type of emergency and instructions given to them.

Structure and Function of Emergency Response Teams

The basic structure of any emergency team will usually comprise four sub-groups.

- The Command Center
- The Emergency Team
- The Back Up Squad
- The Technical Team

Different sub-groups will do different tasks and coordinate with the other sub-groups.

Functions of Emergency Team groups:

- The Command Center

The command center will be located on bridge. The master is to take responsibility for the overall safety and navigation of the ship. All communications will be performed from here to the different teams as well as shore. A log must be maintained of all events.

- The Emergency Team

The Emergency Team will have the front line job of tackling the emergency. In general the chief officer will lead the team for the emergency on deck while the 2nd engineer will take charge for engine room emergencies. The duties of each person will have to be laid down and practiced for every emergency so as to avoid duplication, confusion, and chaos.

- The Support Team

The Support Team is to provide first aid and prepare the lifeboats for lowering. Should the above two function not be required, they should assist as directed.

- The Technical Team

The Technical, or Engineer's, Team will maintain the propulsion and maneuvering capability of the ship and auxiliary services as far as is possible in the circumstances.

General Guidelines for Emergency Response

All members of the technical staff must know all the ship emergency codes in detail. All members of the crew should receive appropriate training in accordance with their role at the time of emergency. Mr. Skylight, Mr. Mob, Code Blue, and Oscar are some of the ship emergency codes followed by mariners.
On board passengers must be told about the possible dangers because otherwise the general public starts panicking.
An understanding of the effects on the behavior of the ship of wind, current, shallow water, banks, and narrow channels is equally important so that the technical staff does the wise thing at the time of emergency. Closing of the watertight doors, fire doors, valves, scuppers, side-scuttles, skylights, portholes, and other similar openings in the ship is very important so that ocean water does not enter inside the ship.
In case of abandoning the ship, all the passengers must be rescued first using life jackets and life boats, or shifting them to another ship. The staff members should be the last ones to leave the ship and that even only after ensuring that no one is left on the abandoned ship. Modern ships are equipped with hi-tech and advanced life saving tools and with the help of mobile communication devices, or can easily contact off-shore rescue teams.

4.5 USE OF LEADERSHIP AND MANAGERIAL SKILLS

4.5.1 Shipboard personnel management and training

Organization of crew, authority structure responsibilities.

The crew is the staff who sails on board a ship and responsible for its operation, primarily while the ship is at sea; it also has certain responsibilities while the ship is in port. For the purpose of ship operation, traditionally, the crew of a ship in the merchant marine is divided into three departments:

- the deck department,
- engine department, and
- catering department.

The captain or master is the head of shipboard organization, who is responsible for supervising the efforts of these three departments, and coordinating their work so as to achieve the best results. He is also responsible for the safe navigation of the vessel from port to port and for the efficient loading, stowage and discharging of cargo. The master has other deck officers assisting him and usually has the advice of pilots while the ship is navigating in restricted waters, such as narrow or shallow channels. But it is the master who must ultimately answer for any fault found with operation of the ship. Since the master bears the maximum responsibility, be must be given absolute authority for control of the ship and its crew at sea. Since he takes care of each and every respect of the vessel, a captain is on duty almost twenty-four hours a day while in command of a ship.

Each shipboard department has a designated head who reports to the master. The deck department is headed by a chief officer, or first mate. As the head of the deck department, the chief officer supervises the crew members assigned to his department. He is assisted by two or more senior licensed deck officers or mates who stand the watches. Routine work on board ships is divided into daily watches. The usual schedule is two watches of four hours each within a twenty-four-hour workday. This department also includes petty or unlicensed crew members. The chief unlicensed man is known as a boatswain (bosun). The unlicensed watch standers are able-bodied seaman (A.B.) and ordinary seaman (O.S.). They stand wheel watches and lookout watches with the licensed deck officers when they are on watch. When they are not engaged in watch standing duties, they do maintenance chores under the supervision of the bosun.

The engine department is headed by a chief engineer. He has other licensed engineers to assist him with watch standing and the performance of maintenance and repair chores in the engine room. The unlicensed personnel of the engine department consist primarily of oilers, firemen, watertenders (F.W.T.), wipers and the electrician.

The chief steward or purser is the head of the catering department. He assists the captain in dealing with entering and leaving formalities and other administrative work if necessary. In port, he will take care of ordering and supervising the delivery of provisions. He also prepares daily menus, look after the supply and distribution of galley goods and is in charge of crew wages and the entertainment fund. The chief steward is assisted by a chief cook and his assistant cooks, messmen and assistant stewards.

Now with the development of shipping, the catering department is included in the deck department on some ships. So there are only two departments on board.

Ships may have other ratings in their crews, but the basic shipboard organization of a ship in the merchant marine remains standard and is easily recognizable on any ship.

Culture awareness, inheret traits, attitude, behavior, cross – cultural communication

Culture Awareness in the Workplace

With the globalization of business, increased diversity in the workplace and multicultural emphasis in society, cultural awareness has become one of the most important business tools in almost every industry. Understanding the cultures of those around you will enhance communication, productivity and unity in the workplace. Formal cross-cultural awareness training is very helpful for problem solving on multicultural business teams, but there are several cultural awareness techniques you can use in the meantime.

Cultural Knowledge

One of the easiest ways to understand your multicultural coworkers is by researching cultures on your free time and increasing your cultural knowledge. Reading books and searching the Internet are the most accessible sources of relevant information. Although you might not ever put to use most of the knowledge you accrue, you will still be able to better understand those you work with and international clients.

Put Cultural Knowledge to Use

If you learn something interesting about a coworker's culture, ask about it or mention it in a relevant situation. This might seem uncomfortable at first, but your coworkers will recognize your effort to educate yourself. Using acquired information as it comes up will serve to break down multicultural barriers, help everyone on your team to be more comfortable around each other and teach others about different cultures.

Listen Up

Effective listening is something that most cultures have in common. Listen to your coworkers actively, displaying positive body language and affirmation during the listening process. Listening intently allows you to read between the lines, pay attention to the way your coworkers say things and ask questions if anything is unclear. They will recognize your willingness to listen and appreciate being asked to explain an unclear point.

Overcome Stereotypes

Stereotypes and preconceived ideas are difficult to overcome, especially if they have been part of your thinking since childhood. Educate yourself about as many different cultures as you can and treat everyone the same. Your knowledge of their culture will give you the confidence you need to overcome the stereotypes that have been engraved in your memory. This newly found knowledge will replace your negative stereotypes with positive knowledge.

Shipboard situation, informal social structures on board

Preparing for and practicing responses for any shipboard emergency is a part of any ship's routine practices. Some Emergency measures adopted by mariners are the followings:

- Emergency Preparedness in Case of Ship Accidents

Whenever some incident of a serious or harmful nature happens suddenly, we classify it as an emergency. One of the most important factors in dealing with an emergency situation, apart from a sharp mind and the control of respectful fear, is the presence of a solid action plan. This is a general rule that is applicable to all situations whether on board a ship in the middle of the ocean or in a crowded city port amidst a sea of people and machinery.

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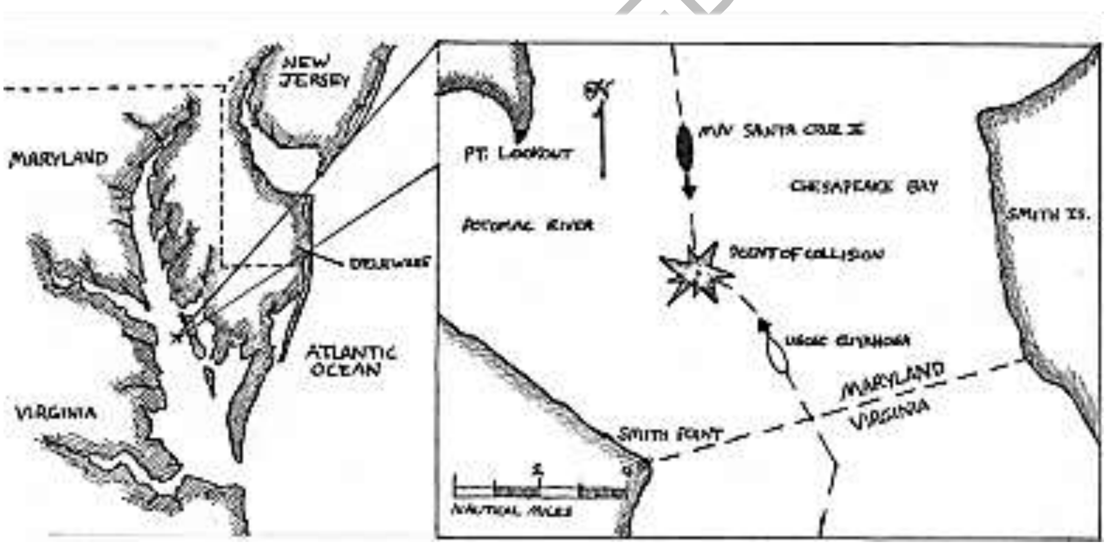
In case of abandoning the ship, all the passengers must be rescued first using life jackets and life boats, or shifting them to another ship. The staff members should be the last ones to leave the ship and that even only after ensuring that no one is left on the abandoned ship. Modern ships are equipped with hi-tech and advanced life saving tools and with the help of mobile communication devices, or can easily contact off-shore rescue teams.

Human errors, situation awareness, automation awareness, complacency, boredom

Types of Human Error

What do we mean by "human error"? Human error is sometimes described as being one of the following: an incorrect decision, an improperly performed action, or an improper lack of action (inaction). Probably a better way to explain human error is to provide examples from two real marine casualties.

The *first example* is the collision of the M/V SANTA CRUZ II and the USCGC CUYAHOGAvii, which occurred on a clear, calm night on the Chesapeake Bay. Both vessels saw each other visually and on radar. So what could possibly go wrong? Well, the CUYAHOGA turned in front of the SANTA CRUZ II. In the collision that ensued, 11 Coast Guardsmen lost their lives. What could have caused such a tragedy? Equipment malfunctions? Severe currents? A buoy off-station? No, the sole cause was human error.



There were two primary errors that were made. The first was on the part of the CUYAHOGA's captain: he misinterpreted the configuration of the running lights on the SANTA CRUZ II, and thus misperceived its size and heading. When he ordered that fateful turn, he thought he was well clear of the other vessel. The second error was on the part of the crew: they realized what was happening, but failed to inform or question the captain. They figured the captain's perception of the situation was the same as their own, and that the captain must have had a good reason to order the turn. So they just stood there and let it happen. Another type of human error that may have contributed to the casualty was insufficient manning (notice that this is not an error on the part of the captain or crew; rather, it is an error on the part of a "management" decision-maker who determined the cutter's minimum crew size). The vessel was undermanned, and the crew was overworked. Fatigue and excessive workload may have contributed to the captain's perceptual error and the crew's unresponsiveness.

The second example is the grounding of the TORREY CANYONviii. Again we have clear, calm weather--this time it was a daylight transit of the English Channel. While proceeding through the Scilly Islands, the ship ran aground, spilling 100,000 tons of oil.

At least four different human errors contributed to this accident. The first was economic pressure, that is, the pressure to keep to schedule (pressure exerted on the master by management). The TORREY CANYON was loaded with cargo and headed for its deep-water terminal in Wales. The shipping agent had contacted the captain to warn him of decreasing tides at Milford Haven, the entrance to the terminal. The captain knew that if he didn't make the next high tide, he might have to wait as much as five days before the water depth would be sufficient for the ship to enter. This pressure to keep to schedule was exacerbated by a second factor: the captain's vanity about his ship's appearance. He needed to transfer cargo in order to even out the ship's draft. He could have performed the transfer while underway, but that would have increased the probability that he might spill a little oil on the decks and come into port with a "sloppy" ship. So instead, he opted to rush to get past the Scillies and into Milford Haven in order to make the transfer, thus increasing the pressure to make good time.

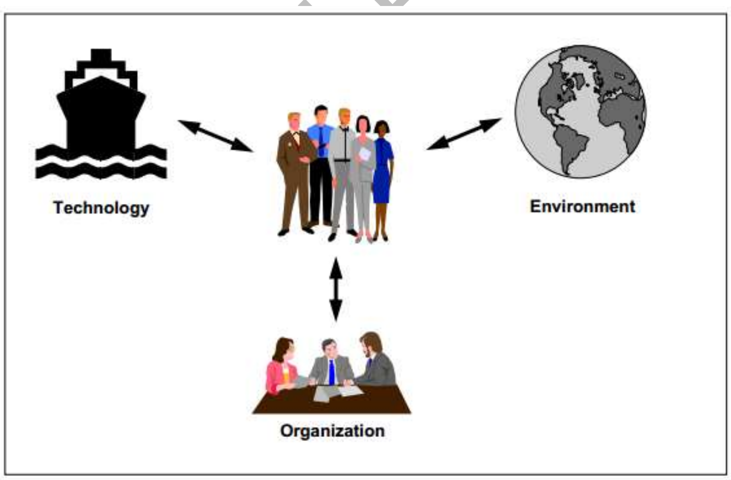
The third human error in this chain was another poor decision by the master. He decided, in order to save time, to go through the Scilly Islands, instead of around them as originally planned. He made this decision even though he did not have a copy of the Channel Pilot for that area, and even though he was not very familiar with the area.

The final human error was an equipment design error (made by the equipment manufacturer). The steering selector switch was in the wrong position: it had been left on autopilot. Unfortunately, the design of the steering selector unit did not give any indication of its setting at the helm. So when the captain ordered a turn into the western channel through the Scillies, the helmsman dutifully turned the wheel, but nothing happened. By the time they figured out the problem and got the steering selector back on "manual", it was too late to make the turn, and the TORREY CANYON ran aground.

As these two examples show, there are many different kinds of human error. It is important to recognize that "human error" encompasses much more than what is commonly called "operator error". In order to understand what causes human error, we need to consider how humans work within the maritime system.

The Maritime System: People, Technology, Environment, and Organizational Factors

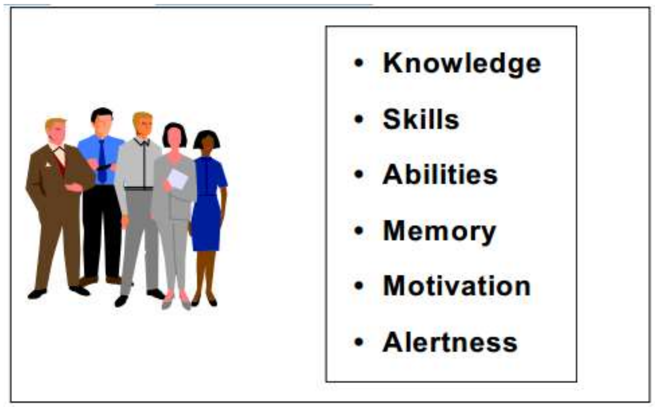
As was stated earlier, the maritime system is a people system (Fig. 1). People interact with technology, the environment, and organizational factors. Sometimes the weak link is with the people themselves; but more often the weak link is the way that technological, environmental, or organizational factors influence the way people perform. Let's look at each of these factors.



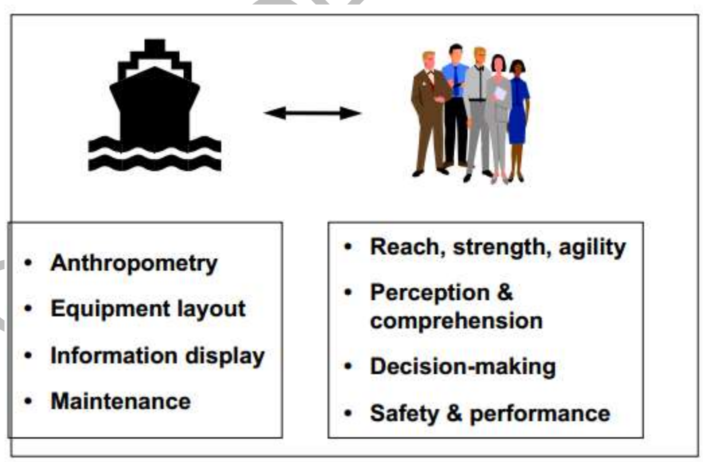
The Maritime System is a People System

First, the people. In the maritime system this could include the ship's crew, pilots, dock workers, Vessel Traffic Service operators, and others. The performance of these people will be dependent on many traits, both innate and learned (Fig. below). As human beings, we all have certain abilities and limitations. For example, human beings are great at pattern discrimination and recognition.

There isn't a machine in the world that can interpret a radar screen as well as a trained human being can. On the other hand, we are fairly limited in our memory capacity and in our ability to calculate numbers quickly and accurately--machines can do a much better job. In addition to these inborn characteristics, human performance is also influenced by the knowledge and skills we have acquired, as well as by internal regulators such as motivation and alertness.



The Maritime System: People



The Maritime System: Effect if Technology on People

The design of technology can have a big impact on how people perform (Fig. above). For example, people come in certain sizes and have limited strength. So when a piece of equipment meant to be used outside is designed with data entry keys that are too small and too close together to be operated by a gloved hand, or if a cutoff valve is positioned out of easy reach, these designs will have a detrimental effect on performance. Automation is often designed without much thought to the information that the user needs to access. Critical information is sometimes either not displayed at all or else displayed in a manner which is not easy to interpret. Such designs can lead to inadequate comprehension of the state of the system and to poor decision making.

The environment affects performance, too (Fig. above). By “environment” we are including not only weather and other aspects of the physical work environment (such as lighting, noise, and temperature), but also the regulatory and economic climates. The physical work environment directly affects one’s ability to perform. For example, the human body performs best in a fairly restricted temperature range. Performance will be degraded at temperatures outside that range, and fail altogether in extreme temperatures. High sea states and ship vibrations can affect locomotion and manual dexterity, as well as cause stress and fatigue. Tight economic conditions can increase the probability of risk-taking (e.g., making schedule at all costs).

Finally, organizational factors, both crew organization and company policies, affect human performance (Fig. below). Crew size and training decisions directly affect crew workload and their capabilities to perform safely and effectively. A strict hierarchical command structure can inhibit effective teamwork, whereas free, interactive communications can enhance it. Work schedules which do not provide the individual with regular and sufficient sleep time produce fatigue.

Company policies with respect to meeting schedules and working safely will directly influence the degree of risk-taking behavior and operational safety.

As you can see, while human errors are all too often blamed on “inattention” or “mistakes” on the part of the operator, more often than not they are symptomatic of deeper and more complicated problems in the total maritime system. Human errors are generally caused by technologies, environments, and organizations which are incompatible in some way with optimal human performance. These incompatible factors “set up” the human operator to make mistakes. So what is to be done to solve this problem? Traditionally, management has tried either to cajole or threaten its personnel into not making errors, as though proper motivation could somehow overcome inborn human limitations. In other words, the human has been expected to adapt to the system. This does not work. Instead, what needs to be done is to adapt the system to the human.

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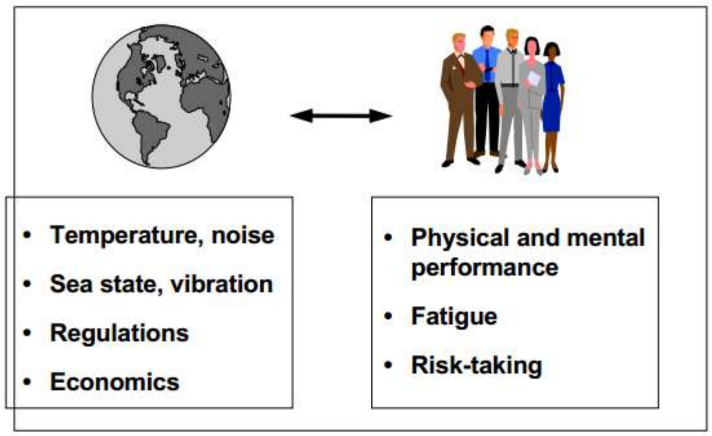
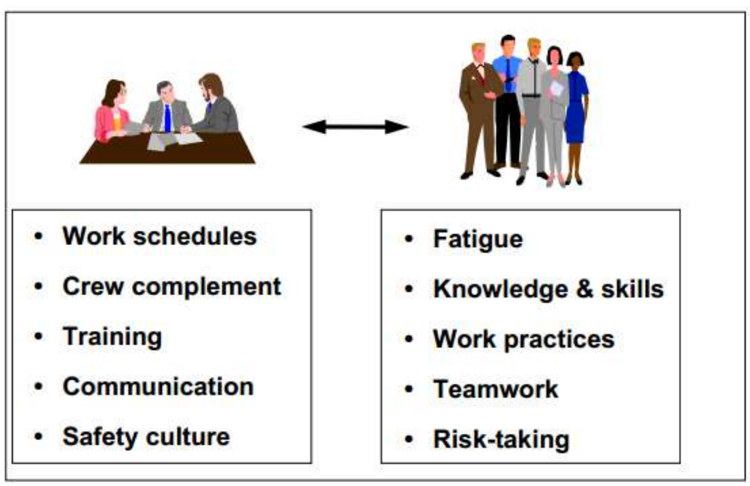


The maritime system: Effect of Environment on People



The maritime system: Effect of Organization on People

<u>Situation Awareness</u>

Situational awareness engendered more positive behaviors than ineffective ones which were clearly linked with other factors such as communication, leadership and team-working and the importance of seeing the bigger pictures:

'assuming roles have been given, then people talking about traffic... talking about where the vessel is in relation to track... about under-keel clearance...

about what's coming up ahead, tugs, hardly anyone being left out, and everybody feeding in and ensuring that others knew what the current status was'

For some, the effective attainment of situational awareness had a core component of technical capacity relating to an individual's ability to elicit information from equipment available to them.

There was also recognition from respondents about the cognitiva levels of situation awareness in line with the model develop by Endsley (1995). Endsley's model propose three levels of situation awareness, namely perception, comprehension and projection.

Perception is evidence by:

'You're getting it (information) from all sources...'

'seeking input from the various instruments, from the various people'

Comprehension is supported by:

'...an awareness of everything that's going on around you.'

'...he is stepping back and he can see everything...'

And the highest order level of projection is supported by:

'they will anticipate...'

'...calmness, concentration and by relevant concentration and information, i.e. talking about the task ahead...'

Why should you improve it?

It is important that you know how many problems you face and how serious they are. The temporary loss or lack of situational awareness is a causal factor in many construction accidents.

Often there is so much 'going on' in your working environment, or you become so absorbed in your own thoughts, that you fail to spot those things that could pose a serious threat to your health and safety.

Improve your situational awareness

Get in the habit of regularly pausing to make a quick mental assessment of your working environment. When doing so, consider the following questions:

- Is there anything around you that poses a threat to your health and safety and if so, to what extent?
- Is the threat big enough that you should stop working?
- Is there anything you can do to safely reduce that threat in order that you can carry on working safely?

Use the SLAM technique described next.

If you see something unsafe or spot a hazard, don't walk by – take responsibility to deal with it.

If you feel you are in any immediate danger to your health or safety STOP work immediately and inform your supervisor.

SLAM Technique

SLAM consists of four simple steps:

1. STOP Engage your mind before your hands. Look at the task in hand.
2. LOOK at your workplace and find the hazards to you and your team mates. Report these immediately to your supervisor.
3. ASSESS the effects that the hazards have on you, the people you work with, equipment, procedures, pressures and the environment. Ask yourself if you have the knowledge, training and tools to do the task safely. Do this with your supervisor.
4. MANAGE If you feel unsafe stop working. Tell your supervisor and workmates. Tell your supervisor what actions you think are necessary to make the situation safe.

You may wish to create your own SLAM prompt card for your workforce on site. Side A could contain the SLAM technique as above. Side B could include key areas of risk to be aware of on your site.

Where and when should situational awareness techniques be used?

Assessment of your working environment should occur continually, but especially in the following situations:

- When beginning work on a new project/contract.
- When you think the work environment has changed since a risk assessment or method statement was written.
- When working with new or different workmates.
- Before complacency has set in – it can be a silent killer!

Leadership and Team Working

The role of a manager

A team leader/manager's job is to get things done by using all resources available to them. One of the first and most famous management theorists was Henri Fayol. Based on observation and experience, he proposed that there were five main functions of management.

Fayol's work illustrated a good system to help managers to work effectively. For instance, a scenario might be that a team is given an objective to find a way of reducing waste. Fayol's five functions can be applied to this waste reduction scenario to illustrate the importance of each function.

Planning involves setting goals for future performance. For instance, achieving a 5% reduction in waste over the next two years. This will involve deciding what equipment, training and staff involvement will be needed to achieve this goal.

Organising involves assigning tasks to different departments or individuals to achieve the goal.

Commanding involves giving instructions to subordinates to carry out tasks. Such leadership is vital and CMI is committed to developing manager's skills in this area.

Co-ordinating involves bringing all departments together to achieve the goals. Achieving waste reduction will involve the operations team improving practices whilst the HR team will decide what training may be needed. The finance team will work out budgets available to finance any changes.

The final key function is controlling. Managers need to monitor progress against the goals, in this case reducing waste, and take appropriate corrective action as and when it is required.

<u>It's all about Teamwork</u>

It is encouraging to note 2010 Manila amendments to the STCW Code which mandates for training in bridge and engine room resource management and includes the application and use of leadership, managerial and team working skills for deck and engeering officer. The amendments recognise the need for effective communication onboard and ashore; and the importance of assertiveness and leadership, including motivation.

An analogy for the safe and efficient operation of a ship is that of the orchesta: The ultimate sucess of any orchestra lies with its musicians; each is higly trained and is part of a smaller team (string, brass, woodwinds, percussion etc) within the orchestra.

As a group they must be able to follow the score to the note. If one member of the orchestra makes a mistake, it will be evident not only to the rest of the orchestra but also the audience.

The conductor needs to understand the musical score as it is written and then lead a large and diverse group of musicians playing different instruments to achieve a harminious and sensitive delivery of the music.

He had to deal with the differing strengths, needs, sensitivities and communication style of the members of his orchestra. He is, of course, supported and directed by the board of directors.

In the ship context, the master is the conductor; the deck, engineer and hotel department represent the strings, the brass and the percussionists. The operations staff are, of course also a part of this team, whose ultimate aim is to ensure the safe conduct of the ship and the safe and timely arrival of the cargo.

<u>Training, structural shipboard training programme</u>

Structured Shipboard Training Programme or SSTP is also known as Distance learning Program or DLP for deck cadets. This simply means that the Cadets need to complete a structured training programme on board ship when they join as trainee (cadet) on board. Cadets undergoing training needs to complete SSTP projects and assignments and send the same in due course of time.

<u>The Importance of Shipboard Training</u>

"The progress of shipboard training for cadets is to develop with a planned training. The Master usually delegate his responsibility to his Chief Officer who assumes commitment for organization a proper training program. On board ship training is concerned with performance rather than with subject manner; person learn to perform the task required on the job in the actual job setting under the guidance of the Chief Officer and assistance from other navigating officers".

Learning process occurs as the result of interaction between the dealing with Chief Officer and cadets through feedback whether positive or negative. On board training when carefully planned is an organized method of training, designed to help the cadets, through Chief Officer's instruction, learn skills while actually working in an assigned job.

<u>Benefits of Training Onboard</u>

One of the most important benefits of shipboard practical is that cadet is able to learn things through practical exercises by doing various jobs onboard ships. The exposure of cadets to the working environment is able to help cadets realize and understand the job requirements onboard merchant vessels. They are able to show their capabilities, gain confidence, and test effectiveness and productivity upon training onboard.

The new seafarers learn through doing the job, experiencing the same problems that will face in the profession. Cadets are permitted to work at their own speed, thereby gaining confidence and a sense of productiveness. If they learn in the actual work environment, an understanding of the job and opportunity to correct errors before they become established is assured.

One of the potential benefits to be gained from a training regime which describes the outcomes required to undertake the various functions onboard, is flexibility. For cadets, the breaking down of the complex job of the watchkeeper into smaller elements allows flexibility of learning and timing and also provides the opportunity for skills gained onboard for truly multi-skilled officers in the future.

Knowledge of personal abilities and behavior characteristics

A Competency is an attribute, knowledge, skill, ability or other characteristic that contributes to successful job performance. Behavior competencies are observable and measurable behaviors, knowledge, skills, abilities, and other characteristics that contribute to individual success in the organization (e.g., teamwork and cooperation, communication). Behavioral Competencies can apply to all (or most) jobs in an organization or be specific to a job family, position, or career level. Behavioral competencies describe what is required to be successful in an Organization outside of a specific job. As such, behavioral competencies are specific to a person rather than to a job. Behavioral competencies describe how we do something, such as manage our jobs, our homes or our lives generally, and the behaviors we use, for example decision making, information gathering and wider thinking. Behavioral competencies clearly set out for staff and managers the behaviors that are required in each area of the organization in order to be successful. This helps people understand what is expected of them and gives them greater clarity about their team, and individual roles within it. Understanding the behavior that other areas of the organization see as essential to effective performance also helps us to improve how we work together. The behavioral competency is designed to be used by multiple Human Resource functions including Performance Management, Workforce Planning, Succession planning, Training and development, and Recruitment. The competencies and their "behavioral indicators" define what each employee needs to do to be successful and to contribute to the organization vision, mission, goals, objectives and strategies. The word behavioral competency is widely used in business and personnel psychology and refers to the behaviors that are necessary to achieve the objective of an Organization. Behavioral competency is also something you can measure and lists of competencies form a common language for describing how people perform in different situations. Every job or positions can be described in terms of hey behavioral competencies. This means that they can be used for all terms of Assessment, Including performance appraisals, training needs analysis and of course selection. Researchers measured the effect of organization advisors emotional, cognitive and other behavioral competencies on their clients' portfolio performances.

Classification

Types of Behavioral Competencies can be classified as follows:

1. Individual competencies – your personal attributes: Flexibility (personality), decisiveness, tenacity, independence, risk taking, personal integrity.

1. Managerial Competencies – Taking charge of other people: Leadership, Empowerment, Strategic planning, corporate sensitivity, Project Management and Management control.

2. Analytical Competencies – The elements of the decision making, Innovation, Analytical skills, numerical problem solving, practical learning, detail consciousness.

3. Interpersonal Competencies – Dealing with other people, communication, impact persuasiveness, personnel awareness, teamwork and openness.

4. Motivational Competencies – The things that drive you. Resilience (organizational), energy, motivation, achievement orientation, initiative, Quality Focus.

There are five competency groups given below and each group contain different behavioral competencies:

1. Achieving and delivery - Drive for results, Serving the customer, Quality focus and Integrity.
2. Personal effectiveness - Planning, organising and flexibility, Confidence and self-control, Problem solving and initiative and Critical information seeking.

3. Working together - Communicating with clarity, Embracing change, Collaborating with others and Influencing and relationship building.
4. Thinking and innovation - Innovation and creativity and Conceptual and strategic thinking.
5. Managing, leading and developing others - Managing and leading the team.

4.5.2 RELATED INTERNATIONAL MARITIME CONVENTIONS AND NATIONAL LEGISLATION

The maritime industry's most important concerns are safety of personnel and prevention of marine pollution for a smooth cargo transportation and marine operation at high seas. International Maritime Organization (IMO) introduced SOLAS – Safety of life at sea, MARPOL- The International Convention for Prevention of Marine Pollution from Ships, for safeguarding human life and marine environment from all kinds of pollutions & International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW).
SOLAS 74, the last adopted revised convention of 1974, includes a number of chapters which deals with safety precautions and safety procedures starting from the construction of ship to real emergency situation like – "Abandon Ship". The convention is updated so as to meet the safety norms in the modern shipping industry.
MARPOL 73/78, since it came into force in 1973 and later revised by the protocol in 1978, ensures that shipping remains the least environmentally damaging modes of transport. It

clearly highlights the points to ensure that marine environment is preserved by elimination of pollution by all harmful substance which can be discharged from ship.
The 1978 STCW Convention was the first to establish basic requirements on training, certification and watchkeeping for seafarers on an international level. Previously the standards of training, certification and watchkeeping of officers and ratings were established by individual governments, usually without reference to practices in other countries. As a result standards and procedures varied widely, even though shipping is the most international of all industries.
The Convention prescribes minimum standards relating to training, certification and watchkeeping for seafarers which countries are obliged to meet or exceed.

Thus, Safety of Life at Sea (SOLAS) and Convention for Prevention of Marine Pollution (MARPOL) and Standards of Training, Certification and Watchkeeping for Seafarers stands as three solid pillars that support the maritime industry by protecting the most important issues – marine pollution prevention and safety of human life and seafarers.
The entry into force of the MLC convention marks significant progress in the recognition of seafarers' roles and the need to safeguard their well-being and their working conditions. This is a truly important landmark for seafarers; and for shipping, on which the global economy relies.
The MLC treaty, which has been ratified by 48 countries, aims to achieve decent work for the world's seafarers and secure economic interests in fair competition for quality shipowners.
The MLC is considered the 'fourth pillar' of the most important maritime regulations covering international shipping, complementing three major conventions adopted by IMO: the International Convention for the Safety of Life at Sea (SOLAS); the International Convention for the Prevention of Pollution from Ships (MARPOL); and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). These three IMO treaties were first adopted in the 1970s and have each been ratified by more than 150 countries, representing more than 99 per cent of world merchant shipping.

IMO and ILO have a long history of co-operating on issues which come under the remit of both Organizations, insofar as they relate to seafarers, and have established joint ILO/IMO ad-hoc expert working groups on issues such as on hours of work and rest, seafarers' medical examinations, fair treatment of seafarers in the event of a maritime accident, and liability and compensation regarding claims for death, personal injury and abandonment of seafarers.
IMO's STCW Convention was revised in 2010 and includes mirror provisions to the MLC requirements on such issues as hours of work and rest, where the two treaties overlap
Mandatory IMO Instruments

- SOLAS 74
- SOLAS 74 + PROT 78
- SOLAS 74 + PROT 88
- MARPOL 73/78 + PROT 97

- STCW 78
- LOAD LINES 66
- LOAD LINES 66 + PROT 88
- Tonnage 69
- COLREG 72
- All instruments (Codes etc.) made mandatory through these conventions and protocol

Government Responsibility

The Government of a State Party to a mandatory IMO instrument must be in a position to implement and enforce its provisions through appropriate national legislation and to provide the necessary implementation and enforcement infrastructure.

4.5.3 APPLICATION OF TASK AND WORKLOAD MANAGEMENT

<u>Excessive workload</u>

Working consistently "heavy" workloads can cause fatigue. Workload is considered heavy when one works excessive hours or performs physically demanding or mentally stressful tasks. Excessive work hours and fatigue can result in negative effects such as the following:

- increased accident and fatality rates
- increased dependence upon drugs, tobacco or alcohol
- poor quality and disrupted sleep patterns
- higher frequency of cardiovascular, respiratory or digestive disorders
- increased risk of infection
- loss of appetite

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- loss of appetite

<u>How to Prevent and Mitigate Fatigue</u>

There are a number of steps that can be taken to prevent fatigue. Many of the measures that reduce fatigue are unfortunately beyond a single person's control, such as voyage scheduling, ship design, and work scheduling.

Guidelines

Steps such as the following are important in the prevention of fatigue on board ship, and are within the

Ship Officer's ability to influence and implement:

- Ensure compliance with maritime regulations (minimum hours of rest and/or maximum hours of work)
- Take strategic naps
- Develop and maintain good sleep habits, such as a pre-sleep routine (something that you always do to get you ready to sleep)
- Eat regular, well-balanced meals (including fruits and vegetables, as well as meat and starches)
- Exercise regularly
- Drink sufficient amount of water
- Use rested personnel to cover for those travelling long hours to join the ship and who are expected to go on watch as soon as they arrive on board (i.e. allowing proper time to overcome fatigue and become familiarised with the ship
- Create an open communication environment (e.g. by making it clear to crew members that it is important to inform supervisors when fatigue is impairing their performance and that there will be no recriminations for such reports
- Schedule drills in a manner that minimises the disturbance of rest/sleep periods
- Establish on board management techniques when scheduling shipboard work and rest periods, and using watch-keeping practices and assignment of duties in a more efficient manner (using, where appropriate, IMO and ILO recommended formats – "Model format for table of shipboard working arrangements" and "Model format for records of hours of work or hours of rest of seafarers")
- Assign work by mixing up tasks to break up monotony and combining work that requires high physical or mental demand with low-demand tasks (job rotation)
- Schedule potentially hazardous tasks for daytime hours
- Emphasis the relationship between work and rest periods to ensure that adequate rest is received; this can be accomplished by promoting individual record keeping of hours rested or worked. Using (where appropriate) IMO and ILO recommended formats in "IMO/ILO Guidelines for the
- Development of Tables of Seafarers' Shipboard Working Arrangements and Formats of Records of Seafarers' Hours of Work or Hours of Rest"
- Re-appraise traditional work patterns and areas of responsibility on board to establish the most efficient utilisation of resources (such as sharing the long cargo operations between all the deck officers instead of the traditional pattern and utilizing rested personnel to cover for those who have travelled long hours to join the ship and who may be expected to go on watch as soon as they arrive)

- Ensure that shipboard conditions, within the crew's ability to influence, are well maintained i (e.g., maintaining heating, ventilation and air-conditioning (HVAC) on schedule, replacing light bulbs, and contending with sources of unusual noise at the first possible opportunity)
- Establish shipboard practices for dealing with fatigue incidents and learning from the past (as part of safety meetings)
- Increase awareness of long term health benefits of appropriate lifestyle behaviour (e.g. exercise, relaxation, nutrition, avoiding smoking and low alcohol consumption)

Sleep

Sleep is the most effective strategy to fight fatigue. Sleep loss and sleepiness can degrade every aspect of a person's performance: physical, emotional and mental. To satisfy the needs of your body, you must acquire the following:

- deep sleep
- between 7 to 8 hours of sleep per 24-hour day
- uninterrupted sleep

Here is some general guidance on developing good sleep habits:

- develop and follow a pre-sleep routine to promote sleep at bedtime (examples are a warm shower or reading calming material)
- make the sleep environment conducive to sleep (a dark, quiet and cool environment and a comfortable bed encourages sleep)
- ensure that you will have no interruptions during your extended period of sleep
- satisfy any other physiological needs before trying to sleep (examples are, if hungry or thirsty before bed, eat or drink lightly to avoid being kept awake by digestive activity and always visit the toilet before trying to sleep)
- avoid alcohol and caffeine prior to sleep (keep in mind that coffee, tea, colas, chocolate, and some medications, including cold remedies and aspirin, may contain alcohol and/or caffeine)
- avoid caffeine at least six hours before bedtime
- consider relaxation techniques such as meditation and yoga, which can also be of great help if learned properly

Rest

Another important factor that can affect fatigue and performance is rest. Rest, apart from sleep, can be provided in the form of breaks or changes in activities. Rest pauses or breaks are indispensable as a physical requirement if performance is to be maintained. Factors influencing the need for rest are the length and intensity of activities prior to a break or a change in activity, the length of the break, or the nature or change of the new activity.

Strategic Napping

Research has identified "strategic napping" as a short term relief technique to help maintain performance levels during long periods of wakefulness. The most effective length for a nap is about 20 minutes. This means that if you have the opportunity to nap, you should take it.

However, there are some drawbacks associated with napping. One potential drawback is that naps longer than 30 minutes will cause sleep inertia, where situational awareness is impaired (grogginess and/or disorientation for up to 20 minutes after waking. A second is that the nap may disrupt later sleeping periods (you may not be tired when the time comes for an extended period of sleep).

Rules and Regulations

The following international organisations have issued various conventions and other instruments that deal with the fatigue aspects:

The following ILO instruments contain guidance on fatigue related aspects:

- Convention No. 180

This convention introduces provisions to establish limits on seafarers' maximum working hours or minimum rest periods so as to maintain safe ship operations and minimize fatigue. The text from the Convention is provided in the Appendix.

- Other Conventions

Other ILO Conventions related to fatigue include the following convention numbers: 92, 133, 140, 141 and 147. Each introduces minimum habitability requirements (e.g. noise control and air conditioning) on board ships.

The following IMO instruments contain guidance on fatigue related aspects:

- ISM Code

This Code introduces safety management requirements on shipowners to ensure that conditions, activities, and tasks (both ashore and afloat) that affect safety and environmental protection are planned, organized, executed and verified in accordance with company requirements. The fatigue related requirements include:

1. Manning of ships with qualified and medically fit personnel;
2. familiarisation and training for shipboard personnel; and
3. issuance of necessary support to ensure that the shipmaster's duties can be adequately
4. performed

- STCW Convention and STCW Code

The STCW Convention requires that Administrations, for the purpose of preventing fatigue, establishes and enforces rest period requirements for watchkeeping personnel. In addition, the

Convention sets minimum periods and frequencies of rest. Part A of the Code requires posting of the watch schedules. Part B of the Code recommends that record keeping is useful as a means of promoting compliance with rest requirements.

- Resolution A.772(18) – Fatigue Factors in Manning and Safety

This Resolution provides a general description of fatigue and identifies the factors of ship operations which may contribute to fatigue.

- MSC/Circ. 1014

A guidance on fatigue mitigation and management.

In addition to the international standards, company and flag administration policies, which may be more stringent in some cases, should be followed on board all ships.

4.5.4 EFFECTIVE RESOURCE MANAGEMENT

Maritime Resource Management (MRM) is a human factors training programme aimed at the maritime industry. The MRM training programme 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 behaviours 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 organisations who have an influence on safety at sea and the work on board a ship.

Overview

<u>Definition of MRM</u>

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.

<u>Target groups</u>

Ships' officers, engineers, pilots and shore-based personnel.

Objectives of MRM training

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

Technical vs. non-technical training.

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 Watchkeeping for Seafarers (STCW).

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 organisation.

Development of MRM

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 into the 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*. The main purpose was to increase attraction amongst other important target groups besides masters, bridge officers and maritime pilots. Such target groups included engineers and shore-based personnel.

Before that, the aviation industry had changed the meaning of *CRM* from *Cockpit Resource Management* to *Crew Resource Management*.

As of 2013, the further development of the Maritime Resource Management (MRM)™ training programme is assumed by the independent training development company ALL Academy International ABwith the main purpose of reaching out to an even wider audience, inside and outside of the maritime industry.

Focus of MRM training

Training of seafarers are regulated through the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). The STCW training requirements concern the seafarers, the people at the sharp end. At the sharp end we find the frontline operators, the people actually doing the task. The blunt end is further away from the action itself. The blunt end is the environment in which the seafarers work. Regulators, designers, shore-side owners and managers function at the blunt end.

Active errors and latent errors

Active errors occur at the sharp end of the process. The effect of active errors are felt almost immediately. Active errors could be; making a course change at the wrong position, pushing an incorrect button, forgetting to close a valve. Latent errors occur at the blunt end. These are errors, removed in both time and space from the operators at the sharp end, that may lie dormant within the system for a long time. Examples of latent errors may include; equipment design flaws that make the human-machine interface less than intuitive, or organizational flaws, such as staffing and training decisions made for fiscal reasons increasing the likelihood of errors. Latent errors are often unrecognized and have the capacity to result in multiple types of active errors. Analyses of major accidents involving many different areas of society indicate that latent errors pose the greatest risk to safety in a complex system. Such accidents include Three Mile Island accident, Heysel Stadium disaster,Bhopal disaster, Chernobyl disaster, Space Shuttle *Challenger* disaster, King's Cross fire, *Piper Alpha* and MS *Herald of Free Enterprise*.

4.5.5 DECISION-MAKING TECHNIQUES

“Risk includes any possible change of undesirable, adverse consequences to human life, health, property, or the environment.”

The threat or probability that an action or event will adversely or beneficially affect an organization's ability to achieve its objectives.

- Risk is a Combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that can be caused by the event or exposure(s)“

Definition of risk often simply is:

- RISK = (Probability of an accident) x (Losses per accident)

Or in more general terms:

- RISK = (Probability of event occurring) x (Impact of event occurring)

Risk assessment
Is the overall process of risk identification, risk analysis and risk evaluation.

Risk management
Is activity directed towards the assessing, mitigating (to an acceptable level) and monitoring of risks.

Risk Assessment now "Mandatory"

- ISM Code – Explicit as amended and entering into force on 1 July 2010
- EU Regulations
- IMO
- Flag Requirements
- Industry Best Practice – TMSA – Mandatory!

Company Responsibility
"Safety management objectives of the Company should assess all identified risks to its ships, personnel and the environment and establish appropriate safeguards". Ref. ISM Code 1.2 "Objectives" as Amended by Resolution MSC.273(85)

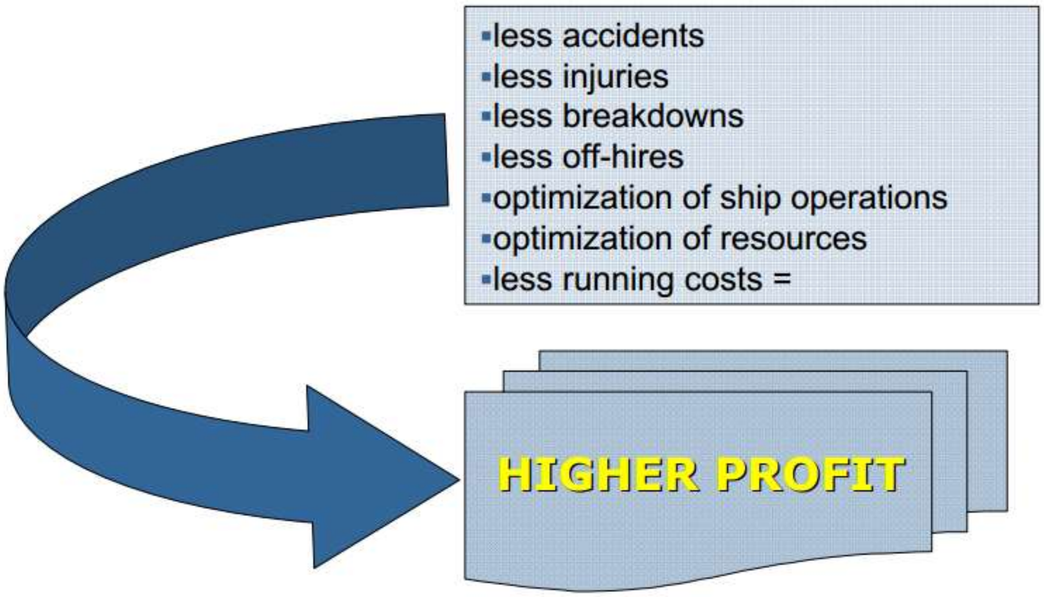
"Shipping Companies are required to ensure the health and safety of anyone working on the ship, by the application of certain principles, including the evaluation of risk and the taking of action to reduce them." Ref. ILO Conventions, MCA Code of Safe Working Practices for Merchant Seafarers, Flag state Occupational Health related Requirements, OSHAS 18001.

The Method
- There are different methods for hazard identification and assessment of the risks.
- Clients should adopt the most practical and effective method specific for the type of fleet and organization.
- Risk Assessment will take into consideration the ship's type & trading handled cargo(s), crew nationality and experience, historical data and statistics.
- Specific procedures shall be agreed upon and developed accordingly.

Benefits for Risk Management
- Risk management creates value
- Risk management is an integral part of the organizational process
- Risk management is part of the decision-making
- Risk management explicitly addresses uncertainty
- Risk management is systematic, structured and timely
- Risk management is based on the best available information
- Riks management takes human and cultural factors into account
- Risk management is dynamic, iterative and responsive to change

- Risk management facilitates continual improvement and enhancement of the organization

Benefits of Risk Management



4.5.6 DEVELOPMENT, IMPLEMENTATION AND OVERSIGHT OF STANDARD OPERATING PROCEDURES

Developing Standard Operating Procedures

SOP development is most effective when a well-planned, standardized, and comprehensive process is followed. By contrast, SOPs created quickly and without the use of a systematic approach are more likely to result in problems during implementation. Although the exact methods used to develop SOPs will vary, certain critical strategies help define any successful process. This chapter describes a standardized methodology for developing SOPs that can be useful whether preparing a complete SOP manual or a single written procedure.
It should be noted that the Needs Assessment process discussed establishes the foundation for the SOP development effort described here. The Needs Assessment identifies areas where SOPs are deficient and summarizes specific requirements for changes to existing guidelines. A thorough Needs Assessment also streamlines the actual SOP writing process since much of the necessary research and analysis has been completed. The concepts and techniques described are not repeated here; rather, they are built upon. Personnel responsible for writing SOPs should be familiar with the material in this chapter as well.

The SOP Development Process

The SOP development process can be viewed as essentially eight sequential steps that address the most important organizational and management considerations for department personnel. The methodology used for these steps can vary, depending on the scope of the project, local needs and resources, and other variables. The steps are listed below, with additional detail on each presented in the following sections:

1. Build the Development Team
2. Provide Organizational Support
3. Establish Team Procedures
4. Gather Information and Identify Alternatives
5. Analyze and Select Alternatives
6. Write the SOP
7. Review and Test the SOP
8. Ratify and Approve the SOP

The approach used to implement new or revised SOPs is critical to their success in helping agencies manage operational risks and enhance the actions of employees. Effective implementation generally involves preparation of a strategy and plan that is tailored to the requirement as necessary. Elements of the plan should address:

- Notification of members and others with a need to know
- Distribution of copies to potential users
- Placement and maintenance of reference copies
- Methods to identify and quantify training needs
- Training delivery and administration
- Competency testing and certification
- Ongoing performance monitoring and employee support

Without proper implementation, new SOPs may be ineffective, unused, or unsafe. Therefore, implementation planning should be a key component in any agency's approach when creating new SOPs or revising existing ones.

Implementation Planning

The development or modification of SOPs must be accompanied by a plan to implement the new procedure within the department. The implementation plan provides an opportunity to think through related tasks, assignments, schedules, and resource needs. The planning process may be formal or informal, depending on the requirement.

The first step is to decide on the purpose and scope of the task to be accomplished. Several important questions need to be considered:

- How many SOPs are being implemented? A whole new set of SOPs? A major portion of the SOPs? One or two SOPs?

- How significant are the changes to existing SOPs? What are the potential consequences if the SOPs are not implemented quickly or effectively?
- Who needs to know about the changes to the SOPs? Do different groups need different types of information?
- What are effective ways of disseminating information within the department? What methods have worked before and what methods have been unsuccessful?
- Is training necessary to ensure competence in the new SOPs? How will performance be monitored and enhanced?
- Would the SOPs be most effectively implemented by using a well-publicized changeover date or a defined phase-in period?

The answers to these questions determine the strategy and methods in the implementation plan. The approach might vary from simple notification during member meetings to on-the-job training for selected members to formal classroom sessions for the entire department. For example, a small volunteer fire department doing a minor updated of one or two SOPs affecting only the hazardous materials team.

Notification

The first step is making sure that all personnel are aware of the upcoming change in procedures.
In addition, outside groups that influence or coordinate with fire service emergency response operations should be notified as necessary, e.g., community officials, mutual aid Organizations, insurance carriers, employee groups, local hospitals, legal counsel, and state or regional regulatory bodies. Management might even consider informing citizens and special interest group, thereby taking advantage of the public relations and public education opportunities that arise when fire service operations are improved.

Besides informing people, the notification process has other objectives, such as identifying potential SOP implementation problems and encouraging compliance and personal accountability.
Therefore, when possible, managers should provide opportunities for members and outside group representatives to ask questions and give feedback. Departments may also wish to consider mechanisms that require personnel to acknowledge receipt of the notification and understanding of its content.

Notifications like this in career agencies are frequently covered during shift or division roll calls. Company officers are made responsible for disseminating information to their crews and documenting attendance / sing off at this section. This approach allows for “real time” questioning and opportunities for “customizing” the information, if necessary, for the personnel involved. In volunteer agencies, notifications may occur at monthly business meetings or training drills. Documentation of notification will be served in this case through attendance records or training rosters.

Distribution and accessibility

Distribution is the next topic to consider in the implementation plan. Employees cannot implement SOPs if they don't know what they are. Copies of new SOPs must be available to all personnel who may be affected. If personnel do not have access to new or revised procedures, they cannot necessarily be held accountable for carrying them out. SOPs should always be accessible.
Whether the organization is developing its first set of SOPs, reissuing sections of the existing SOP manual, or initiating a single new policy, it's best to provide a copy to every individual with related responsibilities. Some departments may not be able to provide copies of SOPs to every member. In these cases, the department leadership should make every effort to find creative ways of making the information available.

Whether or not a department can make individual copies available, the department should provide all employees with easy access to a complete copy of the SOP manual. This copy should be up-to-date and maintain in a location that is known and accessible to all. One method is to place a printed copy in a binder or cover that distinguishes it from other materials in a library or common access area. SOP Manuals should be in every fire station and administrative facility. Copies must be tamper-resistant and regularly checked against "master files" since mischief and sabotage in firehouses are possible. Responsibility for maintaining and updating these "official" copies should be given to a member of the leadership team.

Training

Effective implementation of SOPs often requires that personnel be trained in the new procedure.
Depending on the situation, instruction may be formal or informal, conducted in the classroom or on the job. As with any type of training, program design should follow accepted principles of adult education, taking into consideration four general components: motivation, transfer of information, opportunities to practice new skills, and demonstration of competence.

Performance Monitoring

As part of the implementation process, departments must establish a mechanism to monitor job performance and ensure that personnel carry out the new SOPs correctly. The process should be designed to 1) compare worker performance with expectations established by the new SOP, 2) identify potential problems, and 3) specify ways to improve implementation or provide additional support to personnel.

More subjective methods should also be included in the plan. These approaches are often easier to implement and, when interpreted correctly, provide a wealth of information. Examples include:

- Supervisor observations
- Interviews with personnel
- Interviews with members of the public
- Team meetings and discussions
- Incident debriefings
- Drills and exercises—observations and critiques
- Surveys

Evaluating Standard Operating Procedures

Evaluation, the feedback loop in the SOP management process, is designed to help fire service managers assess the adequacy of new or existing SOPs. The basic methodology is a comparison of operational actions and results with accepted standards or other measurable performance criteria and program objectives. Periodic evaluations provide a structured and ongoing mechanism to manage change in the fire services and community at large. Special evaluations, on the other hand, are studies intended to address a specific change, trend, operational deficiency, or opportunity identified by management.

SOP evaluation teams should represent the viewpoints of all affected groups, including individual members and emergency service customers. In addition, mechanisms should be established to gather input from other members of these groups as part of background research. Many different analytical and group decision-making techniques can be used, depending on the requirements of the study.

Poorly defined committee processes are almost always frustrating and rarely successful. However, a well-designed team strategy can harness the diverse talents of many individuals in a unified and creative effort that is greater than the sum of its parts. Management and team members must continually work together to establish this type of framework for SOP evaluations.