VEssel Construction and Maintenance

Learner’s Guide
Sections 1-14
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INTRODUCTION

PART A

This Learner’s Guide is compiled in 14 Sections to cover the construction and maintenance content up to Master 4 level.

There are self-test questions at the end of most Sections, to assist you to evaluate your understanding of the Section you have just completed.

An assignment has been included for Master 5 students.

A list of text and references is given later in this Introduction to help you to organise your lesson plan and study materials. You are encouraged to obtain the latest available editions of all study materials. Students from different States are required to study their own State legislative Acts in conjunction with those provided in this guide. All legislative Acts listed in this book are for your guidance only; you should always obtain an original copy of the respective Acts.

GENERAL AIMS OF THE CONSTRUCTION LEARNING MATERIAL

This is designed to make you familiar with the constructional arrangements and construction details found on small vessels, so that:

a) you will become familiar with the constructional terminology associated with small vessels

b) you will be able to recognize specific constructional arrangements and details found on small vessels, and are capable of drawing sketches to illustrate these arrangements and details

c) you will become familiar with the purpose of specific constructional arrangements found on small vessels

d) you can describe the major constructional differences found in the various types of vessels, and be able to explain why these differences occur.

SOME PRACTICAL CONSIDERATIONS

It is imperative that you realise that the time to learn about the way ships are built is while you are actually serving aboard. This is much more effective than merely studying from books while ashore.

As much of the construction of a vessel is only visible at survey or in drydock, you should take every advantage of these events to familiarise yourself with those parts of the ship that are normally inaccessible.

Each time you serve on a different type of vessel (trawlers, crayboats, charter boats, etc.), you should take special note of the general constructional arrangements so that it will be possible for you to compare the variations associated with ships built to serve different purposes.
TEXTBOOK

This learning resource is supplemented by the following text, obtainable from TAFE bookshops and boat bookshops:


Coxswains and master 5 students may not need to purchase EYRES, *Ship Construction* but it is compulsory for students at the master 4 level.

Where there are references in the text instructing you to read the relevant sections of EYRES, Coxswain and Master 5 students need not do so but it is essential for master 4 students to do so.

Reference

Copy of USL code sections 5, 7, 8, 10, 11, 13, 14

INSTRUCTIONS TO STUDENTS

Your work is divided into Sections and Units so that the material can be tackled in manageable portions. It will be in your best interest to do all the exercises - including the Self Tests.

In the instructions for the units certain words are intended to have a very precise meaning:

READ: means to read through the material to gain a general idea of the contents. Detailed understanding is not essential.

STUDY: means to examine the material very carefully, ensuring that you understand each paragraph, diagram and table before progressing to the following part. If you have to make notes and commit material to memory, now is the time to do it.

NOTE: means that this fact is very important.

REVISE: means to re-read your text; re-read your notes, and make a list of the important facts/details.

EXTERNAL STUDY

Remember that your tutor is there to help you, and you should have no hesitation in contacting him/her if you need help. Also remember, too, that your success in this course will largely depend on your own self discipline. You will need to set yourself goals and times for study.

When answering questions or working out problems for the assignments, remember that precision and neatness are important. In addition, all working for mathematical exercises should be shown so that if you make a mistake your tutor can see where you went wrong, and advise you accordingly.
STUDY AT SEA

Studying while at sea brings its own problems - and some advantages. The advantages include your being able to observe and be part of many shipboard jobs which you will have to learn as part of your studies. Also, when there are long periods of inactivity or you are off-watch, getting down to some study will lessen the boredom - and you will know that you are doing something positive to further your career.

The disadvantages may be considerable, too, especially if you are in cramped quarters and remain out for many weeks at a time. Nevertheless, you should persevere. Most seafaring folk realise that, in these days, you need qualifications to get anywhere, and although you may receive a little teasing about ‘going back to school’, most of your shipmates will respect your need for a bit of space and quiet - and most will be quite willing to help explain things to you if you ask.

Before we get into the main section of the learning resource, let’s first look at the basic construction of a vessel and some terminology. It is very important for all students to know this thoroughly; for those who know the following already think of it as useful revision.

Good luck with your study.
PART B

BASIC CONSTRUCTION OF A VESSEL AND TERMINOLOGY

Cross section of boats

When we actually start to look at the construction of boats we find there is a general similarity. They all tend to have a cross section similar to a box.

Now any box which is left unsupported will collapse, so we need to put some strengthening in it. A start is to put brackets into the corners. This will stop it from falling over.

If the box was put into the water, the sides and bottom would collapse from water pressure and the deck from any weight put on it.

So additional strengthening will need to be put in - framing.

Now we have a very simple cross section of every boat. All that needs to be added is a
bow and a stern and there is a basic hull. The way a vessel is constructed will vary from one hull to another. Sometimes the simplicity gets lost on small craft as one piece may serve several functions. Places of high stress (for example, under the engine) will need to have additional strengthening.

A vessel sitting in the water will have static forces acting.

![Figure 1](image1)

As soon as she starts moving dynamic forces come into play.

![Figure 2](image2)

This will result in stresses in the vessel which can either be structural, (that is, affect the whole ship) or local (that is, affect only a particular part of the ship). Fig. 5.17 shows two of the main structural stresses - *hogging* and *sagging*. Water pressure would be another stress operating over the whole hull.
Local Stresses

*Heavy weights:* require a structure that will spread the weight over a large area.

![Distortion of transverse section](image)

*Figure 3*

*Dry docking:* large stresses are put on the keel.

![Drydocking](image)

*Figure 4*

*Anchor:* local stress caused by the anchor and windlass.

*Propeller:* stress caused by vibration of propeller and thrust on the hull.

*Rudder:* additional weight and water pressure when used.

*Openings:* openings cut in bulkheads create a lack of continuity and particular stresses can build up in the corners.
The construction of vessels makes some sense when considered in terms of what stresses are present. In all of the above cases we can go to the particular part of the vessel where the stress is and see how in some form additional strengthening has been introduced. The engine is a good example - we can see how the weight of the engine is spread over as large an area as possible.

Structural components of a vessel

As the construction of ships has evolved from the early times of dugout canoes, through complex timber structures then on to fabricated metal vessels, terminology has also evolved to describe the various parts and components of the vessel. It is important to know and understand this terminology to avoid any misunderstanding when discussing or writing about a vessel or its structure. The following terms are some of those more commonly used. It is important to realize that diagrams are only meant to assist in understanding construction. Compare these with vessels of your own experience and relate the identified parts to steel, aluminium and fibreglass vessels. To have a good understanding requires you to actually go and look at the construction of different types of vessels and see, in each case, what the stresses are in a particular area and how they are overcome.
Abaft: towards the rear end or stem of the vessel.
Abeam: at right angles to the fore and aft line of the boat.
Aft: towards the stern.
Aloft: high up eg on the mast.
Ahead: straight in front of the vessel.
Amidships: in the middle section of the boat.
Aperture: the space allowed for the propeller to turn.
Apron: a thickening or strengthening piece fastened to the after side of the stem.
Asterne: behind the boat.
Athwartships: across the boat.
Ballast: a weight used to increase the draft or lower the ship’s centre of gravity.
Ballast Tanks: tanks in a vessel designed to be flooded from the sea to maintain the vessel’s draught.
Beam: maximum width of the ship.
Bow: the forward part of the vessel.
Bulkhead: a vertical division between sections of the vessel. It not only divides the vessel into compartments but is also an important strengthening component.
Butt block: a reinforcing piece placed behind and fastened to two planks when they are butt joined, ie joined end to end.
Camber: the transverse upward curvature of the deck.
Chine: the join of the side and bottom of the boat.

Figure 7

Collision Bulkhead: the forward most watertight bulkhead designed to prevent the vessel sinking in the event of collision.
Coaming: a raised lip around an opening to prevent inflow of water.
Companionway: an access hatch in the deck fitted with a ladder to allow access below decks.
Deadwood: a filler piece used at the fore or aft end of the keel to provide additional strength and thickness where additional timbers are fastened to the keel.

Deck beam: a traverse beam supporting the deck.

Deck girder: a longitudinal beam supporting the deck.

Engine beds: the heavy bases of timber or metal that carry the engine. They are securely fastened to the floors and other structural members to tie the vessel together and form a solid bed for the engine.

Flare: the outward curve of the bow from the waterline towards the deck.

Floor timbers: athwartships solid pieces which cross the hull in the keel section and are secured to the keel and the hull plating either side to tie the hull together. Floors may sometime be made from iron or steel.

Flush deck: a deck which has no raised or sunken sections.

Forecastle: the forward upper section of the vessel - used for accommodation or storage.

Forefoot: the forward end of the keel.

Freeboard: the distance from the waterline to the top of the hull.
**Figure 9**

**Gunwale:** the protective board fitted to the upper edge of a boat's side.

**Hog or hog piece:** a flat timber wider than, and secured to the upper surface of, the keel to provide additional strength and also a land for the first or garboard plank.

**Horn piece:** the timber secured to the aft deadwood and projecting aft to carry the planks for an overhanging stern.

Displacement and planing hulls are on opposite ends of the scale in relation to design features. Planning hulls are usually lighter for length than the displacement. This is one reason why they can move faster. It is the heavier nature of the displacement type, which is usually a deeper draft vessel, that makes it safer in terms of its sea qualities. (Fig. 10)

**Figure 10**

**Intercostal:** a term applied to longitudinal members fitted between frames or beams.

**Keel:** the backbone of the boat extending from fore to aft along the centreline at the lowest part of the vessel.

**Knees:** angled brackets made from grown bends or fabricated from the material of the structure to strengthen the join between beams and frames or at other joins in the vessel. In steel, aluminium or plywood construction they are sometimes replaced by gussets of the plating material.
Panting beams: athwartships beams in the forward part of the vessel to strengthen it against panting forces.

Panting Stringers: longitudinal stringers attached to the hull plating and the panting beams for strength as above.

Peaks: the areas at the extreme lower bow or stern.

Port side: the left hand side of the vessel looking forward.

Profile: the side elevation of the ship or part thereof.

Quarter: the after part of the vessel on either side of the stem.

Rabbet: a continuous groove cut along the backbone of a wooden vessel (eg the stem, keel, deadwood and horn piece) to form a land for the garboard plank.

Rake: the angle by which a mast, transom or funnel slopes from the vertical.

Ribs: the transverse timbers to which the planks are secured on a planked vessel. They may be steam bent or laminated. They may also be called frames or frame timbers.
Samson Post: a heavy strongly supported vertical post used for tying off mooring lines.

Scupper: a drain from the weather deck to carry away water.

Figure 13

Shaft log: the part of the aft deadwood through which the shaft passes.
Sheer: the fore and aft curvature of the deck line.
Sponson: wooden fenders fitted to the topside of a boat to protect it.
Starboard: the right hand side of the boat when looking forward.
Stem: the extreme forward part of the hull joining the two sides.
Stern: the rear end of the hull.
Stern post: the timber behind the deadwood connecting the keel to the horn piece.
Stoppers: softwood plugs in holes bored at the join of timbers crossed by the rabbet. They swell rapidly and help prevent leakage at these joints.
Stringers: longitudinal timbers inside and joined to the ribs of a carvel built vessel to further strengthen the vessel. On plywood vessels they are outside the frames and fastened to the plywood.
Topside: the side of the boat above the waterline.
Transom: the section across the stern of the boat.
Transverse: across, athwartships.
Wash bulkhead: a fore and aft bulkhead designed to reduce free surface effect.

Figure 14
Figure 19

Figure 20

xviii
SECTION 1

Basic Design and Development of Ship Types

INTRODUCTION

Throughout history, man has used the waters for transportation - the earliest vessels were rafts, simply made of logs tied together. The Polynesians used dugouts and outriggers - open boats in which they sailed many thousands of miles across the oceans, propelled by sail and paddle. It is believed that the Egyptians used papyrus boats, made by lashing bundles of reeds together. These, too, were propelled by oar and sail. The Eskimos used kayaks - canoes made of animal skins stretched over a frame. Man has never been slow or unimaginative in his use of available materials to build seagoing vessels to meet his needs.

In this Section, we are going to examine some of those needs, and how they have led to the modern design of vessels. We will look at some of the more common materials used in the construction of small vessels and, in particular, study the overall design of ships and the requirements they are intended to meet.

OBJECTIVES

By the end of Section 1 you should be able to:

• state why components of hull and outfit are in a particular location with consideration to the following:
  a) safety
  b) stress
  c) stability
  d) working practices
  e) commercial requirements
  f) inspection

• list the materials used in the construction of small vessels

• list various major components and state the material of which they are composed.

UNIT 1.1 DEVELOPMENT OF SHIP TYPES

READ Chapter 3 of Eyres Ship Construction, paying attention to Figure 3.1. Do not concern yourself with the portions of the rest on bulk carriers or oil tankers. As you read, make sure you are aware of the reasons given for the various design modifications.

UNIT 1.2

READ Chapter 2 ‘Ship Dimensions and Form’ and consult Figure 2.1 to identify each part.

Now STUDY the definitions of ‘Sheer’, ‘Camber’, ‘Tumblehome’, ‘Flair’ and ‘Rake’. You may already know them, but if you are not acquainted with the terms, take time to
look around the vessel you are serving on and identify the parts to which they refer. Now STUDY the explanations of these terms in the following notes in Unit 1.3.

UNIT 1.3 STRUCTURAL FEATURES

Flat of Bottom

(Sometimes called ‘Half Siding of Keel’.)

This is the part of the moulded surface which lies on the moulded base line. The flat of the bottom was essential in the case of riveted ships in order that the centre girder bottom bars were kept at 90°. In welded ships this is not a requirement, but a flat bottom is often retained - especially in larger vessels.

Rise of Floor

The bottom of a ship is usually flat, but not necessarily horizontal. The height of the bottom of the ship at the moulded beam above bottom of the ship on the centre line is called the rise of floor.

The amount of the rise of floor is dependent on ship form. Its purpose is to allow liquid in bottom tanks to drain to the centre for easy pumping.

Dockmasters need to know what the rise of floor is, in order to correctly determine the size of bilge blocks when ships drydock.

Sheer

Aids in water run off, promotes deck dryness and is also a consideration when freeboards are assigned, as it contributes to reserve buoyancy. It raises the height of the margin line above the keel. The margin line is an imaginary line drawn 75mm below the freeboard deck - the deck to which the watertight bulkheads extend. It is a requirement of design that, should a compartment in a vessel be bilged, the spacing between the watertight bulkheads should be such that (with the resulting loss of buoyancy) the margin line must not be submerged. Clearly, then, the higher the margin line is above the keel, the fewer watertight bulkheads are required. So, adequate sheer provides for increased buoyancy.

The load line regulations lay down standard sheer, and vessels not complying are penalised by having their freeboards increased.

The U.S.L. Code (Section 5D1.2) provides a table giving the number of watertight bulkheads which vessels of various lengths are required to have. The table was drawn up with the considerations we have just discussed, in mind. It is not necessary for you to trouble yourself with any of the calculations contained in the U.S.L. Code; you will learn more about it as you progress to higher grade certificates.

We will discuss watertight integrity of vessels later on in Section 3.

Camber

Aids in water run off. Also helps to reduce stresses in the upper deck.

Flair

Promotes dryness by forcing water outward and away from the ship’s deck when it is headed into rough seas. Helps lift the bow over waves.
**Stem Rake**

Similar to flair in that it also promotes deck dryness by forcing water forward when the bow strikes waves.

![Diagram of Stem Rake](image)

**Tumblehome**

Is not often found on ships today. It used to be included in design to prevent any small projections located at deck level from fouling the wharf. A better idea is to so design ships that there are no projections at all. Tumblehome has the undesirable effect of reducing stability as draft increases, since the stability of a vessel is a function of its water plane area.

If you have studied stability already, you may recall that the height of your GM determines how readily your vessel will right itself when heeled.

GM is a function of BM (height of metacentre above centre of buoyancy) and is found by the formula:

$$GM = KB + BM - KG$$

Clearly, if we reduce BM, we reduce GM.

Now, BM is calculated by the formula $BM = I/V$.

Where $V$ is the underwater volume of the vessel and $I$ is the second moment of area of the water plane about the fore and aft centre line of the vessel. $I$ is a function of Breadth$^3$.

What this all means is that, if you want to halve the breadth of the vessel at the water line, you would reduce BM to one eighth of what it previously was.

Clearly then, tumblehome, which reduces the breadth of a vessel with increase in draft, is an undesirable design feature.

You need not learn these formulae at this stage, but it is as well that you know them, since you will find them helpful in your career.
UNIT 1.4 GENERAL ARRANGEMENTS

STUDY the following plans and try to identify which parts of the vessels illustrated pertain to the six considerations stated in the first Performance Objective.

Figures 1.2, 1.3 and 1.4 (of this Learner’s Guide) relate to a landing craft, the ‘Cooma’.

NOTE the following:
1) The guard rails on the bridge deck
2) The location of the bow-door winch and controls - where the helmsman can control them and see what he is doing
3) The location of the crane for working cargo (can the ship berth Starboard side alongside?)
4) The freeing ports down the ship’s side (what are they for?)
5) Why the anchor is down aft
6) The location of the fuel, FW and ballast tanks (why is there a ballast tank in the bow?).

Figure 1.5 shows you a transverse midsection and the bow and stern profile sections of a small vessel.
- Identify the parts designed to counter stresses in seaway.

Figure 1.6 shows you the stern trawler ‘Junella’. NOTE the economic use of space, and how the whole design is geared towards efficient working.

Figure 1.7 shows the plan of K.F.V. Albatross.
- NOTE the Kort Nozzle on the propeller for better propulsion and manoeuvrability; the floodlights for lighting the working area and adequate freeing ports to drain water off the decks.

Figures 1.8, 1.9, 1.10 and 1.11 show various plans of a tug ‘Tammar’.

Figure 1.8 shows the profile plan.
- NOTE the location of fire fighting equipment, floodlights, fenders, life rafts, etc, with a view to the work the vessel will be expected to perform.

Figure 1.9 shows the wheelhouse and the wheelhouse top (Monkey Island). The location of all navigation equipment is clearly shown.

Figure 1.10 shows the main deck. It is an excellent plan and well detailed.
- NOTE the easy accessibility of the fire hydrants, life buoys and the good deck lighting.

Figure 1.11 shows the plan below the main deck, giving the engine room layout.
- NOTE this layout carefully, because we will be referring back to it later when we study the bilge and ballast systems, and steering gear arrangements.
Fig 1.2 "Cooma" Bridge Deck
Fig 1.3 "Cooma" Main Deck/Below Deck

GENERAL DESCRIPTION

LENGTH: 25.6 m
BREADTH: 7.25 m
DRAFT: 1.5 m
FUEL: 4,800 ltrs
CARGO: 14,300 ltrs
FRESH WATER: 16,000 ltrs
SPEED: 10 kn

ELDER PRINCE MARINE SERVICES P/L
25 m LANDING CRAFT COOMA
GENERAL ARRANGEMENT

DATE: 12-2-94
SCALE: 1:50
DRAWN: G. WATTS
Fig 1.4 "Cooma" Tank Location
Fig 1.5 Structural Parts
Fig. 1.6 Stem Trawler "Junella"

General arrangement of all-refrigerated Diesel-electric Stern-trawler "JUNELLA"

Dimensions:
- Length Overall: 460 ft
- Breadth Moulded: 58 ft
- Depth Mld. to Main Deck: 46 ft
- Depth Mld. to Lower Deck: 18 ft

General PARTICULARS:
- Gross Tonnage: 1,450
- Net Tonnage: 550
- Oil Bunkers: 300 tons
- Fresh Water: 105 tons
- Water Ballast: 70 tons
- Speed: 14 knots
- Max. Fuel Consumption: 10.8 tons per day
- Average Fuel Consumption: 7.2 tons per day

Builders: Hall, Russell & Co. Ltd.
Owners: J. Marr & Son Ltd.
Fig 1.7 K.F.V. Albatross
Fig 1.8 Profile: "Tammar"
PRINCIPAL PARTICULARS

LENGTH OVERALL (HULL) - 25.68 metres
LENGTH ON WATERLINE - 24.38 metres
BEAM - 8.22 metres
DEPTH (MLD.) - 4.16 metres
DRAFT (MAX.) - 3.58 metres
BOLLARD PULL - 35.30 tonnes
OIL FUEL - 48.33 k/litres
DOMESTIC FRESH WATER - 8.42 k/litres
FRESH WATER BALLAST - 68.09 k/litres
CREW - 6 Persons (8 Berths)

MAIN ENGINES
2-OFF G.M. 16V-14911: EACH DEVELOPING 1280 B.H.P AT 1900 R.P.M.

GEARBOX
2-OFF NIIGATA M.G.N. 1000 AZ × 8.86:1 REDUCTION RATIO

SCALE: - 1:50

Fig 1.9 Wheelhouse: “Tammar”
Fig 1.10 Main Deck: "Tammar"
Fig 1.11 Below Main Deck: "Tammar"
If you have studied the plans carefully, you should now have a good understanding of the parts of the vessel that provide stability, protection for the crew, safety, and aid in efficient working of the ship.

All tanks must have manholes so that periodic inspections can be carried out. In fact, all parts of the vessel must be accessible for survey, and those not normally accessible are made so when the vessel drydocks or is slipped.

UNIT 1.5 STRESS RESISTANCE

Because the sea environment is dynamic, the vessel is continuously experiencing many varying stresses. The ship must be capable of withstanding them.

The hull of a ship is not merely a watertight shell. The vessel is first built as a frame or skeleton (often upside down for easier welding) and then the shell plating is welded to the frame. (See Figures 1.12 and 1.13.) Normally there is a centre girder, sometimes called a *vertical keel*. Larger vessels may have side girders.

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Fig. 1.12
NOTE: Refer also to Figures 17.2 and 17.3 in Eyres.
Sharp corners are avoided - the bilge is normally rounded - and when hatch openings are cut into the deck, rounded gusset plates are used to reduce the stresses associated with the corner.

Refer to Figure 19.4 in Eyres.

The fore end of the ship is strengthened to cope with the panting and pounding forces in seaway.

**READ** the section on local stresses in Chapter 8 of Eyres.

**READ** also the section ‘Stem’ in Chapter 20 (Eyres) and **NOTE** the structures in Figures 20.1 and 20.2 which resist panting and pounding.

**READ** the sections on Bending and Shear forces in Chapter 8, but leave out ‘Bending Stresses’.

Most larger vessels are longitudinally framed to cope with the hogging and sagging forces. In smaller vessels, when these forces are not so great, transverse framing is common. Figure 16.3 (Eyres) shows the essential differences in these types of construction.

The aft end of most vessels also has additional stiffening to cope with the vibrations associated with the propeller.

**READ** Chapter 21 (Eyres) - the introduction and the part on ‘Stern Construction’.

**STUDY** Figures 21.1, 21.2 and look at Figures 21.3 and 21.4 in that chapter. Try to identify some of the considerations of design that have led to the types of construction shown in these drawings.

**UNIT 1.6 COMMERCIAL REQUIREMENTS**

Clearly, an investor who is going to go to the expense of building a ship must have some hope of making some return on the investment. There are many things before committing funds to a long-term investment such as a ship.

You wouldn’t buy a motor car without first considering:

- how much it is going to cost you to run it
- whether it will serve the purpose for which it is intended
- how long it will serve you (what is its expected serviceable life?)
- whether an alternative means of transport would be more viable (taxi, bus or train, etc.).

If you didn’t get satisfactory answers to all these questions, you wouldn’t buy the vehicle.

A ship owner is no different. If ship owners were denied the right to make a profit on their investment, they would invest their money elsewhere, and soon there would be no ships.

The same considerations are allowed for when equipping a vessel. Before any expensive gear is purchased, it must be determined if such gear will pay for itself.

Obviously, when safety of life at sea is concerned, expense is not a consideration, and the local and Commonwealth Authorities, such as the Department of Transport and Marine and Harbours, ensure by survey that an adequate safety standard is maintained.

The U.S.L. Code prescribes minimum manning levels for various sizes of ships. With the increase in the size of the ship, and the accompanying increase in the size of the ship’s complement, come additional constructional requirements.

More cabins, ablution facilities, safety gear, etc. All these added expenses must be balanced against the anticipated returns; that is, how much the ship will earn.
Salaries are not the only cost in running a ship. The size of the engines and the fuel bill are other considerations. Ships only earn money when they are underway; so, in port, turn-around is also important.

**FACTORS INFLUENCING OPERATORS’ REQUIREMENTS**

In deciding whether to enter a ship in a trade, some or all of the following factors will need to be considered in order to determine the type of vessel to employ.

**Physical factors:**
- Climatical - trade area e.g. ice regions (ICE STRENGTHENING), WNA (DECK WETNESS, BOW HEIGHTS)
- Ports, canals - depth, channel width, berth sizes, materials-handling equipment (ON BOARD CARGO GEAR)
- Ecological - IM0 tank size limitations (INTERNAL STRUCTURE)

**Trade factors:**
- Commodities - types e.g. dry bulk, liquid bulk, general, special - refrigerated, livestock, heavy lift, quantity (SHIP SIZE, HULL DIMENSIONS)
- Availability of opportunity - bi-lateral, UNCTAD 40-40-20, flag reservation (WHETHER OR NOT TO OPERATE VESSEL)

**Economic factors:**
- Market forces - trade cycles e.g. recession, boom (WHETHER OR NOT TO OPERATE VESSEL)
  - competition e.g. conferences, freight rates, delay e.g. strikes, congestion
- Costs - capital (WHETHER OR NOT TO OPERATE VESSEL)
  - operating

The physical and trade factors will determine the type and size of the vessel plus the type of materials-handling system required, while the economic factors determine whether or not the vessel should operate in a particular trade.

Quite clearly, when a decision to enter a trade has been taken, it becomes a question of designing the vessel for the function it is to perform. In terms of vessel functions, it is useful to consider these under five major headings:
- general cargo carriers
- dry bulk carriers
- liquid bulk carriers
- specialised cargo carriers
- support/service craft.

Further factors which influence vessel design and equipment, apart from the physical and trade factors previously mentioned, are the statutory requirements of the law.

**Legal factors:**

- Safe equipment - LSA, FFA
- Safe construction - watertight integrity
  - watertight sub-division
  - fire retardation
- Operational - load lines
  - stability
  - stress
  - pollution
- Health & hygiene - accommodation
  - noise levels
**DESIGN FEATURES**

Ships can be categorised in a variety of ways and the following diagram illustrates the way that ship types have developed over a period of time in order to cope with increasingly specialised trades.

![Diagram of ship types showing the development over time with a high degree of mechanisation and high adaptability leading to hybrid multipurpose ships, and low adaptability leading to highly specialised ships.](image)

**Fig. 1.15**
UNIT 1.7 MATERIALS USED IN CONSTRUCTION

There are five basic construction types of materials used in small ship construction.

Steel (most common)

Advantages:
- It is relatively cheap to build.
- It is very strong.
- It is immune to attack from marine life.
- It provides inherent ballast.
- It is easy to work.
- It never leaks (if welded).
- It is fire-proof - it does not burn.

Disadvantages:
- It rusts - needs considerable maintenance.
- It needs framing and stiffening.
- It distorts when welded, and needs considerable skill when welding.
- It is the heaviest type of hull (minimum plate thickness is 4mm) and fuel bill is the highest.
- It is very magnetic - affects compass.

Aluminium Alloy

Advantages:
- It is very light (almost as light as plywood).
- It does not rust.
- If welded, hulls do not leak.
- It is immune to attack from marine life.
- It is easy to work.
- It does not distort as much as steel when welded.
- It is non-magnetic.

Disadvantages:
- It is very expensive - up to 10 times the price of steel (weight for weight).
- While on its own it does not corrode; when in contact with steel, copper, brass or mercury in a marine environment it breaks down very rapidly due to electrolytic reaction. All connections between the aluminium and steel must be insulated. Copper and mercury based antifoulings should not be used.
- Because of its low melting point, it is not very resistant to fire and, as was shown in the Falklands War, if raised to a sufficiently high temperature, will burn very fiercely.

Ferro Cement

Advantages:
- It is a one-piece hull, and therefore very watertight.
- It does not rot.
- It is extremely fire resistant.
- It is odourless and toxic vapours do not develop while it is curing.
- It is stronger than glass-reinforced plastic or aluminium.
- It is reasonably cheap to build.

Disadvantages:
- It has low abrasion resistance - rubbing strakes are required.
- The surface chips easily.
- Construction is laborious and, if the mortar is not properly forced into and through the mesh, rusting of the inner steel can occur and thus manifest itself by staining the hull.
- It is highly magnetic and compass compensation is always necessary.

**GRP (Glass Reinforced Plastic)**

Advantages:
- It lends itself to mass reproduction: once the mould is made, the parts can be mass reproduced, and all parts will be true-to-form; that is, of the same dimensions.
- If multiple orders are made from the same mould, construction becomes very rapid and economical.
- It does not rot or rust and requires very little maintenance.
- It is flexible and withstands shock loads quite well. (NOTE: This feature can be a disadvantage, too - especially if large, flat sections are allowed to flex about a hard spot. Cracking can then occur at the hard spot.)
- It does not leak.
- Fuel and water tanks can be moulded in and included as part of the construction. This is not possible in wooden boats.

Disadvantages:
- It burns very easily.
- It requires a great deal of skill and care to ensure a good, strong construction.
- Styrene fumes are evolved when curing. These are flammable, and toxic when inhaled, after being drawn through a burning cigarette. The resins irritate the skin.
- It is easily damaged through abrasion. Any water that enters through abrasions will rapidly deteriorate the condition of the GRP in that vicinity. Rubbing strakes are therefore needed.

**Wood**

Advantages:
- It does not **sweat** inside as much as the other types.
- It absorbs engine vibrations better than steel or GRP.
- It has no odour like GRP.
- It has aesthetic appeal which is absent in all other types of construction.

Disadvantages:
- It is the weakest of all constructions.
- It leaks.
• It rots.
• It burns.
• It is becoming very expensive.

METALS USED IN MARINE CONSTRUCTION

The following is a list of some of the marine metals used today

Aluminium (READ Chapter 6 - Eyres)
Used for masts, fittings, booms, railings, doors, superstructures, and in small ships, engines and engine parts. Always used as an alloy - never on its own.

Copper
Used in electrical wiring, tubing and, on board, fresh water piping.

Brass
An alloy made mostly of copper with any or all of the following: lead, tin, manganese and iron. Some brasses are called bronze. The major difference between brass and bronze is usually the type of metal it is alloyed with; brasses are alloyed with zinc while bronzes are alloyed with tin, aluminium or silicon.

Brass is used for decorative fittings, (often in the wheelhouse): window frames, door knobs, window and porthole securing dogs, trimmings on companionways, navigation lights, megaphones, ships’ bells, etc.

Aluminium Bronze
Excellent corrosion, wear and fatigue resistance. Available as a wire rope.

Phosphor Bronze
A very tough bronze. Good elastic qualities. Resists cavitation erosion. Good fatigue and wear resistance. Often used to manufacture propellers.

Aluminium Silicon Bronze
Used for screws, nuts, bolts and forged turnbuckles (bottle screws).

Cupronickel
Used for tubing, piping and fittings. Excellent resistance to corrosion and does not require cathodic protection.

Magnesium
Makes a good sacrificial anode. Corrodes very easily, but is very light and has been used for deck fittings.

Monel
Two-thirds nickel, one-third copper alloy. Excellent resistance to corrosion. High tensile strength and ductility. Used for screws, nuts and bolts. Also excellent for propellers, prop shafts and wire rope.
Stainless Steel
Stronger than normal steel. Its chrome content makes it corrosion resistant provided that its surface is not chipped. Stainless steel will corrode faster than mild steel if its surface is continually being scratched. Used in blocks, tackles, fittings, small boat winches, etc. Cast stainless steels are used for tools.

Steel - Reinforcement
Used in ferrocement construction. Usually used in conjunction with poultry mesh or expanded metal mesh.

Expanded metal
Sheets of steel are slit and then stretched (expanded) to form a net-like pattern. Used in ferrocement boat construction.
Thicker plates are used to make catwalks.

Zinc
Corrodes slowly in air. Used to galvanise metals and protect them from rust.
In a sea environment, it corrodes faster than steel or bronze and is used to make sacrificial anodes.

**NOTE** the sacrificial anodes on the nozzles of the Z-props of the tug in Figure 1.16.

Fig. 1.16
The idea of the zinc anodes is that they will corrode and not the propellers or hull. New anodes are bolted on, each time the vessel dry docks.
UNIT 1.8 SELF-TEST EXERCISE

The answers to this self test can be found on the green pages at the end of this book.

1. What is the purpose of a raised quarterdeck in way of the after holds on a small vessel?
2. What problems arise when the machinery is right aft?
3. What is the most important reason for sheer when considering structural feature of a vessel?
4. Why is tumblehome undesirable?
5. Figure 1.6 shows a trawler with a 25 tonne water ballast capacity. Where would this ballast be stored?
SECTION 2

Basic Ship Construction

INTRODUCTION

As a ship’s officer you should have a sound knowledge of the general arrangement and terminology of the major parts of the vessel on which you are serving. You should be able to picture in your mind the general plan of the ship and reproduce sketches showing the location of the major components.

There is not much point in manning a ship with officers steeped in theory but unable to find the fixed foam installation for firefighting when the emergency arises.

Orientation is vitally important, especially when joining a new vessel.

It is essential that, when you join a ship, you quickly familiarise yourself with the firefighting equipment, its location and use, and then have a thorough knowledge of the layout of the ship so that you are able to move about the ship quickly, knowing where you are going and what you are likely to find there.

In this Section, we will be looking at the basic construction of small ships. We will refer back to the plans you were given in Section 1 and to the sketches of types of actual construction in Eyres. At the end of this Section, you will be asked to produce some sketches to show that you have attained the performance objectives.

OBJECTIVES

By the end of this Section you should be able to:

- produce a sketch (naming parts from memory) of the general longitudinal outline of a small vessel (up to 80 m)
- sketch (with labels) a transverse section of a vessel through the:
  a) forward end
  b) mid body
  c) aft end
- produce a sketch (naming parts) and giving a narrative explanation of a vessel showing the following components:
  a) outer shell
  b) frames
  c) crew accommodation
  d) engine spaces
  e) fuel tanks
  f) freshwater tanks
  g) power/generator/battery electrical supply
  h) steering gear
  i) navigation spaces, including bridge layout and equipment
  j) hold/cargo spaces
k) bilge pumps and sections  
l) collision bulkhead and subdivision bulkheads  
m) store rooms  
n) ice storage  
o) refrigeration plant  
p) deck equipment - mooring, docking, fishing  
q) anchoring arrangements (chain locker and windlass, hawser pipes and spurling pipes)  
r) ballast arrangements  
s) firefighting equipment  
t) openings in hull  
u) lifesaving appliances

UNIT 2.1  
STUDY all the plans and sketches reproduced in Section 1 with a view to identifying the parts listed in the performance objectives for this Section.

READ Chapter 21 (Eyres) and STUDY Figure 21.2 and Figure 21.5.

READ Chapter 21 (Eyres) from the paragraph headed 'Stern Frame' to the paragraph headed Stern Tube).

READ Chapter 17 (Eyres), the paragraphs on 'Framing'; 'Transverse Framing'; 'Longitudinal Framing'; 'Tank Side Brackets'; and 'Local Strengthening of Shell Plating'.

STUDY Figure 17.2 and Figure 17.3

UNIT 2.2 WATER TIGHT BULKHEADS  
NOTE, in the sketches of the fore end structure in Eyres, that the forward ballast tank is called the Fore Peak tank. The watertight bulkhead at the aft end of the Fore Peak tank is known as the first collision bulkhead. Remember that we briefly discussed watertight bulkheads in Unit 1.3 under the heading of 'Sheer'. It is also a requirement of the U.S.L. Code (and the load line convention) that there be a watertight bulkhead at each end of the engine room space.

The idea of these watertight bulkheads (and all other watertight bulkheads) is to ensure that, should the compartment be holed, the vessel would not sink. The spacing between the watertight bulkheads in the construction is worked out by multiplying the floodable length by a factor of subdivision. The engine room cannot be longer than this calculated 'permissible length', but if it is considerably shorter, it makes no difference - there still must be a watertight bulkhead at each end of the engine room.

The aftermost watertight bulkhead is called the aft peak bulkhead.

UNIT 2.3 SUBDIVISION  
Turn to Section 3.8 where the rules in the U.S.L. Code for watertight subdivision have been reproduced. Refer to Section 5D1.2, which includes a scale of the number of transverse watertight bulkheads required for vessels of various lengths. Where the machinery is located aft, the vessel is usually allowed one less bulkhead than when the machinery is located amidship.

In the case of machinery aft, the aft E.R. bulkhead becomes the Aft Peak Bulkhead as well. Let us consider the three ships - K.F.V Albatross, Tammar and Junella.
The *Albatross* is 24 metres long with machinery amidships. She must have 4 watertight bulkheads and she does. They are located in positions relative to the numbered base line as follows:

First collision bulkhead (Fore Peak Bulkhead) at No.4; watertight bulkhead at No.6; one on either side of the Engine Room at No’s 25 and 35; and an Aft Peak Bulkhead at 39.

The *Junella* is 72 metres long with machinery amidships. She must have at least 4 watertight bulkheads. In fact, she has 5. (See if you can locate them.)

The *Tammar* has 4.

**UNIT 2.4 OUTER SHELL AND FRAMES**

As was mentioned in the previous Section, the ship’s hull consists of not only the shell plating or the framing on their own, but a combination of the two. The framing provides the strength, while the shell provides the watertight skin.

Figure 1.12 in Section 2 shows the framework onto which the shell is being welded. Figure 2.1 below shows the finished object from the inside.

**NOTE** the transverse frames on the side, and the deck beams overhead.

You are looking through a doorway which has been cut in the bulkhead.

*Compare* this construction with the sketch in Figure 17.6 (Eyres).

![Fig. 2.1](image)

**UNIT 2.5 ANCHOR ARRANGEMENTS AND DECK EQUIPMENT**

Figure 1.7 in Section 1 gives adequate detail of the deck layout of a small trawler.

**STUDY** this plan to familiarise yourself with the general layout of the fishing gear - winches, booms, gantries, etc. As with all small vessels, mooring is not a problem, and winches for heaving the vessel alongside are not provided. The anchor winches could be used by disengaging the gypsy.
You should, however, familiarise yourself with the layout of the bollards for mooring. *Compare* the plan of the K.F.V. *Albatross* fore deck with the photograph of the fore deck of a small fishing boat shown in Figure 2.2 below.

![Fig. 2.2](image)

**Fig. 2.2**

The anchor windlass of the K.F.V. *Albatross* is not unlike the one shown in Figure 2.2. A closer look will make the relevant parts easier to identify. As you study Figure 2.3, below, refer to Figure 21.5 (Eyres).

![Fig. 2.3](image)

**Fig. 2.3**

*NOTE* the tongued hawse pipe and spurling pipe covers. It is important that hawse pipes and spurling pipes are closed when you put to sea. When the vessel is pounding, jets of water can shoot up the hawse pipe with great force and destructive power. The writer once sailed on a ship on which the ship’s carpenter was severely injured when a jet of water from the hawse pipe (caused by the vessel hitting a wave) threw him against the windlass! Closing the spurling pipes prevents water entering the chain locker - which, if it did in large quantities, could pose a serious stress and stability problem.
The steel plate covers shown in Figure 2.3 have sufficient strength to withstand the forces of the sea.

Figure 2.4 shows the same vessel with its anchor a’cockbill (hanging vertical just clear of the hawse pipe).

Fig. 2.4

NOTE the wooden striking boards where the flukes rest when the anchor is housed.

UNIT 2.6 OPENINGS IN THE HULL

There are numerous openings in the hull. Some of these are: ballast and cooling water, suctions and discharges; the stern tube; speed log probe; bow thruster units; rudder shaft; Z-prop housings; side scuttles (port holes); etc.

The above is by no means a comprehensive list, but all have to be made watertight. Side scuttles must have deadlights (steel plates which are secured by dogs on the inside of the ship and seal the porthole against the entrance of water should the glass break); water intakes and discharges have manually operated valves; and openings with moving parts are nearly always sealed by glands.

Refer to Eyres Chapter 21, Figures 21.5 and 21.6.

READ the Section headed ‘Stern tube’.
Fig. 2.5 Bow thrusters
Figure 2.5 shows the bow thrusters of an underwater research vessel. A similar gland seal is used on the moving shaft of the bow thruster to prevent water entering the gearing and gaining passage to the ship.

Fig. 2.6 Z-Prop housings
The Z-props can be rotated through 360° to enable them to point in any direction. This affords great manoeuvrability and does away with the need for a rudder.

Remember, if you are ever in command of a vessel with Z-props, you lose steerage if you stop engines. The Kort nozzle around the propeller directs water into the propeller disc in lines parallel to the shaft (reduces turbulence) causing an increase in thrust of between 20% and 50%. This allows an increase in the ship’s speed of up to 10% without
an increase in power; in other words, a 10% saving on the fuel bill (an important consideration nowadays).

Vibration is also reduced, and the nozzle affords some protection to the propeller blades, should the vessel take the ground.

Fig. 2.7

Figure 2.7 shows the cooling water intakes and outlets of the main engine of the vessel shown in Figure 2.2. The bulkhead through which the pipes pass is the forward watertight bulkhead of the engine room. Note how flanges are welded onto the bulkhead, and the valve bolted to the flange. This is the same type of arrangement for all inlets/discharges which pierce the hull below the margin line. Any inlet/discharge connected with machinery must have an easily accessible valve inserted in the pipeline between the hull and the machinery it is serving.
SECTION 3

Watertight Integrity

INTRODUCTION

Archimedes’ law of Flotation, simply stated, is: ‘Every body in a liquid experiences a reduction in weight equal to the weight of the liquid it displaces’.

When applied to floating bodies: ‘Every body floating in a liquid displaces an amount of liquid, the weight of which is equal to the weight of the floating body’.

A ship is a hollow vessel. It floats at a particular draft. If we were to calculate the volume of the underwater section and multiply it by the density of the water in which it was floating, we would find the weight of the volume of water displaced. According to Archimedes’ Law, this would be the weight of the ship. We call this the ship’s displacement.

The naval architect attempts to design a vessel that will safely displace its own weight in water through all conditions of loading and service. Ships will always float if:

1) they are not overloaded
2) water does not enter the ship.

The loading of the ship is the responsibility of the ship’s officers. Ensuring that it is so designed that under normal use water will not enter it in sufficient quantities to sink it, is the responsibility of the designer. The ship builder ensures that it is of sound construction to meet these requirements, and the initial survey verifies this.

We call this ability of a vessel to resist the entrance of water its watertight integrity.

OBJECTIVES

By the end of this Section you should be able to:

• demonstrate how the hull is made watertight
• demonstrate how the hull and deck connection is made watertight
• demonstrate how openings in the hull are made watertight

NOTE: Demonstrate is defined as being able to sketch a method employed with parts named and a descriptive explanation.

• describe the procedures to be followed for testing tanks and other watertight work
• define watertight and weathertight as contained in the U.S.L. Code
• state the nature of tests to be applied to the following:
  i) watertight bulkheads
  ii) watertight tanks
  iii) watertight doors set in and within the hull structure
  iv) weathertight hatchways
  v) weathertight accesses in superstructures.
UNIT 3.1 DEFINITIONS

Watertight means:

a) in relation to a fitting located above the margin line, that the fitting is so constructed as to effectively resist the passage of water, except for slight seepage, when subjected to a hose test with water at a pressure of 210 kPa from a nozzle of 18 mm bore, or to an equivalent test

b) in relation to the structure of the vessel, capable of preventing the passage of water through the structure in any direction under the head of water up to the margin line of the vessel.

A watertight door is any door that complies with the requirements set out below under the heading Watertight Doors (see Unit 3.2 below).

Weathertight, in relation to the structure of or a fitting in a vessel, means capable of preventing the passage of sea water through the structure or fitting in any ordinary sea conditions.

UNIT 3.2 WATERTIGHT DOORS

READ the following extracts from the U.S.L. Code.

C.26 All Openings in Watertight Bulkheads to be Closed by Means of Watertight Doors

C.26.1 An opening in a watertight bulkhead or other watertight structure shall be provided with a watertight door or other watertight covering by means of which the opening may be closed and made watertight.

C.26.2 The means of operation of any watertight door whether power operated or not, shall be capable of closing the door with the vessel listed to fifteen degrees either way.
C. 27  Sliding Doors to be Fitted

C.27.1 A door fitted to an opening referred to in the last preceding clause shall be a sliding door having a horizontal or a vertical motion, a hinged door or a door of an equivalent type, but shall not be a plate door secured only by bolts.

C.27.2 A hinged door may be fitted to an opening

a) in a bulkhead, not being a collision bulkhead, which divides one ‘tween-deck cargo space from another ‘tween-deck cargo space; or

b) in a bulkhead or other structure in a passenger space, crew space or working space above a deck the underside of which at its lowest point at side is at least 2.13 metres above the deepest sub-division load waterline.

but not otherwise.

C.27.3 A hinged door referred to in the last preceding sub-clause shall be fitted with catches or other quick action closing devices capable of being operated from each side of the bulkhead in which the door is fitted.

C.28  Construction and Fitting of Watertight Doors Generally

C.28.1 A watertight door shall be of such design, material and construction as will maintain the integrity of the watertight bulkhead in which it is fitted.

C.29  Material of Watertight Doors

C.29.1 Subject to the next succeeding sub-clause, a watertight door, and the frame of a watertight door, shall be made of cast steel, mild steel or cast iron.

C.29.2 A watertight door, and the frame of a watertight door, which gives direct access to a space which may contain bunker coal shall not be made of cast iron.

C.30  Closing of Watertight Doors

C.30.1 A watertight door shall be closed by means other than gravity or a dropping weight.

C.31  Rubbing Faces to be Fitted to Watertight Doors

C.31.1 A sliding watertight door, or the frame of a sliding watertight door, shall be fitted with rubbing faces of brass or similar material.

C.31.2 If the width of the rubbing faces is less than 25 mm, the rubbing faces shall be fitted in recesses.

C.32  Screw Gear on Watertight Doors

C.32.1 If a screw gear is used for operating a sliding watertight door, the nut in which the screw works shall be made of a suitable non-corrodible metal.

C.33  Frame of Watertight Doors

C.33.1 The frame of a watertight door shall be properly fitted to the bulkhead in which the door is situated and the jointing material between the
frame and the bulkhead shall be of a type which will not deteriorate or be injured when subject to heat.

C.33.2 The frame of a vertically sliding watertight door shall be so constructed
a) that there is no groove in the bottom of the frame in which dirt may lodge; and
b) if the frame is of skeleton form - that dirt cannot lodge in the frame.

C.34 Vertically Sliding Watertight Doors
C.34.1 The bottom edge of a vertically sliding watertight door shall be tapered or bevelled.
C.34.2 A vertically sliding watertight door which is operated by power shall be so constructed and fitted that, if the power supply ceases when the door is raised, the door will not drop.

C.35 Horizontally Sliding Watertight Doors
C.35.1 A horizontally sliding watertight door shall be so installed as to prevent it moving if the vessel rolls and, if necessary, a clip or other suitable device shall be provided to prevent the door from so moving.
C.35.2 A clip or device referred to in the last preceding sub-clause shall not interfere with the closing of the door when the door is required to be closed.

C.36 Coal-bunker Watertight Doors
C.36.1 A watertight door which is a coal-bunker door shall be provided with screens or other devices to prevent coal from interfering with the closing of the door.

C.37 Means of Operating Sliding Watertight Doors
C.37.1 Watertight doors the sills of which are above but not more than 2.13 m above the deepest sub-division load line shall be sliding doors, which may be hand operated.
C.37.2 Where, in a vessel -
   a) a trunkway which is part of a refrigeration, ventilation or forced draught system is carried through more than one transverse watertight bulkhead; and
   b) the sill of the opening by which the trunkway is carried through such a bulkhead is not more than 2.13 m above the deepest sub-division load water-line of the vessel,

   a power operated sliding door shall be fitted to that opening.
C.37.3 Watertight doors which may, in the normal working of the vessel, be required to be opened at sea, and the sills of which are below the deepest subdivision load line, shall be sliding doors.
C.37.4 Where the number of the doors referred to in the last preceding sub-clause (excluding doors at entrances to shaft tunnels) exceeds five, they shall be power operated and capable of being simultaneously closed from a central station on the bridge.
C.37.5 Subject to the next succeeding sub-clause, where:
   a) the number of doors referred to in sub-clause C.37.3 (excluding doors at entrances to shaft tunnels) is two or more but does not exceed five; and
   b) the vessel has passenger spaces below the bulkhead deck, those doors shall be power operated and shall be capable of being simultaneously closed from a central station situated on the bridge.

C.37.6 Where the number of doors referred to in sub-clause C.37.3 is two and they are into or within a machinery space, those doors may be hand operated.

C.37.7 All doors at the entrances to shaft tunnels or ventilation or forced draught ducts shall be power operated and capable of being simultaneously closed from a central station on the bridge.

C.37.8 A sliding watertight door -
   a) which is fitted between bunkers in the ‘tween-decks of a vessel below the bulkhead deck; and
   b) which may be required to be opened at sea for the purposes of trimming coal, shall be power operated.

C.38 Control of Power Operated Sliding Watertight Doors

C.38.1 Where sliding watertight doors in a vessel are required by this Sub-section to be power operated from a central station on the bridge -
   a) the gearing shall be so arranged that each door can be operated by power also at the door itself from both sides;
   b) the arrangement shall be such that each door will close automatically if opened by local control after being closed from the central station, and also such that each door can be kept closed by local systems which will prevent the door from being opened from the central station;
   c) local control handles in connection with the power gear shall be provided on each side of the bulkhead and shall be so arranged as to enable persons passing through the doorway to hold both handles in the open position without being able to set the closing mechanism in operation accidentally;
   d) the doors may have a horizontal or a vertical motion;
   e) the vessel shall be provided with at least two independent sources of power for opening and closing those doors;
   f) each of those sources of power shall be controlled from the central station on the bridge and shall be capable of operating all those doors simultaneously;
   g) indicators shall be fitted on the bridge of the vessel to show whether sufficient power is available from each of those sources for operating the doors;
   h) in the case of hydraulic operation, each power source shall consist of a pump capable of closing all the doors in not more than sixty seconds;
i) in the case of hydraulic operation, the whole installation shall have hydraulic accumulators of sufficient capacity to operate all the doors at least three times; that is to say, to close, open, and re-close the doors;

j) the fluid, if any, used for the purpose of operating the doors shall be incapable of freezing at temperature likely to be encountered on the voyages on which the vessel is, or will be, engaged; and

k) the mechanism for closing the doors shall be so timed that the time taken for a door to close is sufficient to ensure the safety of persons in or near the doorway.

C.38.2 All power operated watertight doors shall be provided with an approved hand gear workable at the door itself on either side and from an accessible position above the bulkhead deck.

C.39 Control of Sliding Watertight Doors not Power Operated

C.39.1 Where a sliding watertight door in a vessel is not required by this Sub-section to be operated by power, it may have a horizontal or a vertical motion and shall be provided with an approved hand operated mechanism at the door itself capable of being operated from either side, and from an accessible position above the bulkhead deck.

C.39.2 The requirement in the last preceding sub-clause that the mechanism at the door is to be capable of being operated from either side does not apply if the layout of the spaces on either side of the door makes compliance with that requirement impossible.

C.39.3 The mechanism referred to in sub-clause C.39.1 shall be capable of completely closing the door, with the vessel upright, in less than ninety seconds.

C.39.4 Where a sliding watertight door is in a machinery space of a vessel, the gear by which the door can be operated by hand from above the bulkhead deck shall be situated outside the machinery space unless there is no position outside that space in which the controls can be placed without interfering with the efficiency of that gear.

C.40 Watertight Doors - Indicators

C.40.1 Each watertight door in a vessel shall be connected with an indicator at each position at which the door may be operated, other than at the door itself, showing whether the door is open or closed.

C.41 Watertight Doors - Communication

C.41.1 A control of a sliding watertight door in a vessel being a control which operates the door by power, shall be connected to a warning device which, upon any movement of the control to close the door, will give an audible warning at the door in sufficient time before the closing of the door to enable the movement of person and articles away from the door.

C.41.2 If a watertight door in a vessel is not capable of being operated from a central control, there shall be installed in the vessel a telegraph, telephone or other means of communication by means of which an order to close the door may be promptly communicated from the bridge.
C.42  Openings - Generally

C.42.1  The number of openings, and the number of each class of opening in the shell plating of a vessel below the margin line shall be the minimum compatible with the design and proper working of the vessel.

C.42.2  Such an opening shall be provided with a watertight covering, or other device, by means of which the opening may be closed and made watertight.

C.42.3  In this clause ‘opening’ includes a side scuttle (whether opening or non opening), a port, a scupper and a sanitary discharge opening.

C.42.4  Side scuttles, their glasses and deadlights shall comply with the requirements of British Standard MA24.

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UNIT 3.3

Now READ the section on watertight doors in Eyres, Chapter 18; then STUDY Figure 18.3 (Eyres).

UNIT 3.4

Below is a photograph of a horizontally-sliding, watertight door in the aft engine room bulkhead of a tug.

Fig. 3.2

Weathertight doors are fitted above the margin line. They close accesses to holds, accommodation, stores, etc. They are usually hinged and secured by twist dogs which tighten against wedges.

A rubber seal (packing) in a channel around the rim of the door provides the ‘watertightness’. Figure 3.3 below shows a weathertight door. Note the raised coaming. This is a requirement under the U.S.L. Code.
Figure 3.4 shows the same door opened. **NOTE** the wedges on the inside of the coaming. To satisfy the requirements of the U.S.L. Code, this door should be marked on each side with bold permanent lettering: *THIS DOOR TO BE KEPT CLOSED AND SECURED.*

**UNIT 3.5 WATERTIGHT BULKHEADS**

**READ** Eyres, Chapter 18 as far as *Watertight Doors*. **STUDY** both Figures 18.1 and 18.2 and *identify* how the hull/deck connection is made watertight. Now **STUDY** the part on testing of watertight bulkheads.
UNIT 3.6   HULL WATERTIGHT INTEGRITY

The purpose of the shell plating is to keep the water out. The hull is a watertight skin. See Figure 1.13 in Section 1.

In steel and aluminium constructed ships, the hull is made watertight by welding the plates together. The application of heat in the process of welding fuses the plate edges together in a strong, watertight bond. In riveted ships the joints were made watertight by caulking. Caulking is carried out by splitting the plate edge close to the adjacent plate, then forcing the partly detached material against the adjacent plate. This is accomplished with a caulking tool. See Eyres, Chapter 9, Figure 9.2.

Welding is a much quicker and simpler process. READ the introduction to Chapter 9 (Eyres) for a comparison between welding and riveting.

GRP and ferrocement hulls are continuous with no joints and are inherently watertight, as is their deck/hull connection.

Timber - constructed vessels, whether carvel or clinker-type built, are not normally totally watertight but rely on seepage of water to swell the planking and thus make them watertight.

A clinker-built vessel, if taken from the water and allowed to totally dry out, will take considerable water when returned to the water, before the planking seals again.

STUDY Figure 19.1 (Eyres) to see how the deck plating is connected to the hull. This diagram shows the members which provide structural strength. The weld joining the deck plating to the side shell is a continuous weld.

UNIT 3.7   HATCHES

READ Chapter 19 - the part covering Hatches. STUDY Figures 19.4, 19.5 and 19.6. In each case, NOTE how the watertight integrity is maintained.

UNIT 3.8   WATERTIGHT SUBDIVISION - THE LAW

For your own reference, an extract of the U.S.L. Code has been reproduced in this Section. You should read through this material to familiarise yourself with the requirements of the Code.

It is strongly recommended that you obtain your own copy of the Australian Transport Advisory Council Uniform Shipping Laws Code if you have not already done so.

Copies are available from the Commonwealth Government Publishing office in your State.

Do not concern yourself with the calculations; merely gain an outline knowledge of what the rules cover. If you ever need to know precisely, you can consult the code then.
SUB-SECTION D

CONTENTS

Part I—Class 2 and Class 3 vessels 35 metres and over in measured length

<table>
<thead>
<tr>
<th>Clause</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.1</td>
<td>Number and Disposition of Transverse Bulkheads</td>
</tr>
<tr>
<td>D.2</td>
<td>Height of Bulkheads</td>
</tr>
<tr>
<td>D.3</td>
<td>Double Bottom</td>
</tr>
<tr>
<td>D.4</td>
<td>Inner Bottom of Double Bottom</td>
</tr>
<tr>
<td>D.5</td>
<td>Well Not to be Constructed in Double Bottom</td>
</tr>
<tr>
<td>D.6</td>
<td>Double Bottom not Required</td>
</tr>
<tr>
<td>D.7</td>
<td>Openings in Watertight Bulkheads</td>
</tr>
<tr>
<td>D.8</td>
<td>Doorways in Watertight Bulkheads</td>
</tr>
<tr>
<td>D.9</td>
<td>Openings Generally</td>
</tr>
<tr>
<td>D.10</td>
<td>Side Scuttles</td>
</tr>
<tr>
<td>D.11</td>
<td>Discharges, Inlets and Scuppers</td>
</tr>
<tr>
<td>D.12</td>
<td>Bolts Connecting Fittings to Shell Plating</td>
</tr>
<tr>
<td>D.13</td>
<td>Watertight Decks to be Drained</td>
</tr>
<tr>
<td>D.14</td>
<td>Rubbish-shoots</td>
</tr>
<tr>
<td>D.15</td>
<td>Gangway Ports</td>
</tr>
</tbody>
</table>

Part II—Class 2 and Class 3 vessel of less than 35 metres in measured length

<table>
<thead>
<tr>
<th>Clause</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.16</td>
<td>Number and Disposition of Transverse Bulkheads</td>
</tr>
<tr>
<td>D.17</td>
<td>Openings in Watertight Bulkheads</td>
</tr>
</tbody>
</table>

Part III—Special Provisions Applicable to Class 2 Vessels not subject to the provisions of the Load Lines Section and Class 3 Vessels other than such vessels to which Part IV applies

<table>
<thead>
<tr>
<th>Clause</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.18</td>
<td>Watertight Integrity</td>
</tr>
<tr>
<td>D.19</td>
<td>Weathertight Doors</td>
</tr>
<tr>
<td>D.20</td>
<td>Hatchway Coaminings</td>
</tr>
<tr>
<td>D.21</td>
<td>Hatchways Closed by Wood Covers</td>
</tr>
<tr>
<td>D.22</td>
<td>Hatchways Closed by Covers Other than Wood</td>
</tr>
<tr>
<td>D.23</td>
<td>Machinery Space Openings</td>
</tr>
<tr>
<td>D.24</td>
<td>Other Deck Openings</td>
</tr>
<tr>
<td>D.25</td>
<td>Ventilators</td>
</tr>
<tr>
<td>D.26</td>
<td>Air Pipes</td>
</tr>
<tr>
<td>D.27</td>
<td>Side Scuttles and Skylights</td>
</tr>
<tr>
<td>D.28</td>
<td>Scuppers, Inlets and Discharges</td>
</tr>
<tr>
<td>D.29</td>
<td>Freeing Ports</td>
</tr>
</tbody>
</table>

Part IV—Modifications applicable to Class 2B and Class 2C vessels less than 16 metres in measured length, Class 3B and Class 3C vessels less than 20 metres in measured length, Class 2D, Class 2E, Class 3D and Class 3E vessels

<table>
<thead>
<tr>
<th>Clause</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.30</td>
<td>Openings in Déckhouses or Superstructures in which there are Windows or Side Scuttles not fitted with Hinged Deadlights</td>
</tr>
<tr>
<td>D.31</td>
<td>Hatchway Coaminings</td>
</tr>
<tr>
<td>D.32</td>
<td>Hatchways on the Weatherdeck Closed by Wood Covers</td>
</tr>
<tr>
<td>D.33</td>
<td>Hatchways on the Weatherdeck Closed by Covers other than of Wood</td>
</tr>
<tr>
<td>D.34</td>
<td>Hatchways on a Deckhouse Top</td>
</tr>
<tr>
<td>D.35</td>
<td>(withdrawn)</td>
</tr>
</tbody>
</table>

Part V—Provisions applicable to all Class 2 and Class 3 vessels

<table>
<thead>
<tr>
<th>Clause</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.36</td>
<td>Wheelhouse and Deckhouse Windows</td>
</tr>
</tbody>
</table>
D.2 Height of bulkheads
D.2.1 The collision bulkhead is to extend to the uppermost continuous deck.
D.2.2 The after peak bulkhead may terminate at the first deck above the load waterline, provided that deck is made watertight to the stern or to a watertight transom floor.
D.2.3 The remaining bulkheads are to extend to the uppermost continuous deck except where the draught is not greater than that permitted with a superstructure extending for the full length of the vessel above the second deck, when the bulkheads may terminate at that deck provided it lies above the load waterline.

D.3 Double bottom
D.3.1 A vessel the length of which is 50 metres or more but less than 61 metres shall be fitted with a watertight double bottom extending from the machinery space to, or as near as is practicable to, the collision bulkhead.
D.3.2 Subject to the next succeeding sub-clause, a vessel the length of which is 61 metres or more shall be fitted with a watertight double bottom extending from, or from as near as is practicable to, the collision bulkhead to, or as near as is practicable to, the afterpeak bulkhead.
D.3.3 The last preceding sub-clause does not require a double bottom to be fitted in the machinery space of a vessel the length of which is less than 75 metres.

D.4 Inner bottom of double bottom
D.4.1 Where a double bottom is fitted to a vessel in pursuance of the last preceding clause its depth shall not be less than that determined by the formula and its inner bottom shall be continued out to the sides of the vessel in such a manner as to protect the vessel to the turn of the bilge.

The depth of the centre girders shall be not less than

\[ 32B + 190 \sqrt{d} \text{ mm} \]

where \( B \) = greatest moulded breadth \( \text{m} \).
\( d \) = draft for scantlings \( \text{m} \).

D.4.2 The inner bottom shall be deemed to comply with the last preceding sub-clause if the line of intersection of the outer edge of the margin plate of the inner bottom with the shell plating of the vessel is not lower at any point than a horizontal plane passing through the point of intersection of the frame line amidships with a line inclined at an angle of twenty-five degrees to the base line amidships and cutting that base line at a point one half of the vessel's moulded breadth from the middle line. See Figure 1.
D.5 Well not to be constructed in double bottom
D.5.1 Subject to sub-clause D.5.3, a well shall not be constructed in a double bottom fitted to a vessel in pursuance of this Sub-section unless the Authority exempts the vessel from the requirements of this sub-clause.
D.5.2 The Authority shall not exempt a vessel from the requirements of the last preceding sub-clause unless it is satisfied that the protection given to the vessel by the double bottom will not be diminished by reason of the exemption.
D.5.3 A well may be constructed in the double bottom of a vessel for the purposes of drainage in the after end of the shaft tunnel, if the vessel is a screw vessel and in any other position, if—
(a) the well is not larger, and does not extend downwards further, than necessary for that purpose;
(b) the depth of the well is not, except in the case of a well at the after end of the shaft tunnel, more than the depth less 457 mm of the double bottom at the centreline; and
(c) the well does not, except in the case of a well at the after end of the shaft tunnel, extend below the horizontal plane referred to in sub-clause D.4.2.
D.6 Double bottom not required
D.6.1 Nothing in this Sub-section requires a double bottom to be fitted in a part of a vessel in way of a watertight compartment used exclusively for the carriage of liquids if, in the event of bottom or side damage to that part of the vessel, the safety of the vessel will not be impaired by reason of the absence of the double bottom.
D.7 Openings in watertight bulkheads
D.7.1 The number of openings in watertight bulkheads shall be kept to the minimum compatible with the general arrangement and operational needs of the vessel.
D.7.2 A manhole may be fitted in a collision bulkhead provided it is located as high as practicable, is suitably compensated and closed with a bolted watertight cover.
D.7.3 If a pipe, scupper, electric cable or other equipment is carried through a watertight bulkhead it shall be located as high as is practicable and such provisions as are necessary to ensure that the bulkhead is watertight shall be made.
D.7.4 Where the Authority determines, a trunkway installed in connection with a ventilator or with a control or other system may be carried through a watertight bulkhead. The trunkway shall be located as high as is practicable in the bulkhead, be watertight over its entire length, be of equivalent strength to the bulkhead and have its upper opening not less than 4.3 metres above the weather deck or enclosed by a weathertight superstructure or deckhouse.
D.7.5 Heat-sensitive materials shall not be used in a system which penetrates a watertight bulkhead if deterioration in that system in event of a fire would impair the water-tightness of the bulkhead.
D.8 Door in watertight bulkheads
D.8.1 Watertight doors, in watertight bulkheads which may, in the normal working of the vessel, be required to be open at sea shall be sliding doors.
D.8.2 The sliding doors shall be of steel or, if the Authority has approved of the bulkhead being of another material may be of the same material as that approved for the bulkhead and shall be so constructed that when closed the watertight integrity of the bulkhead will not be impaired.
D.8.3 A sliding door may have a horizontal or vertical motion and shall be provided with a hand-operated mechanism capable of being operated from each side of the opening and from an accessible position above the bulkhead deck.
D.8.4 Where a sliding door is fitted in a machinery space bulkhead, the gear by which the door can be operated from above the bulkhead deck shall, unless the Authority otherwise approves, be situated outside the machinery space.
D.8.5 An access opening in a watertight shaft tunnel shall be fitted with a watertight sliding door which may be of the same material as the material of the shaft tunnel and the door shall be capable of being operated from both sides of the opening.
D.8.6 Where a sliding door is capable of being operated from a position above the bulkhead deck, means to indicate whether the door is opened or closed shall be provided at the place from which the door may be so operated.
D.8.7 Where a sliding door is capable of being power-operated, the control for the operating mechanism shall be connected to a warning device which upon any movement of the control will give an audible warning at the door.
D.8.8 A sliding door shall be so fitted that it is capable of being operated when the vessel is at an adverse list of 15 degrees.
D.9 Openings—generally
D.9.1 The number of openings, and the number of each class of opening in the shell plating of a vessel below the bulkhead deck shall be the minimum compatible with the design and proper working of the vessel.
D.9.2 Such an opening shall be provided with a watertight covering, or other device, by means of which the opening may be closed and made watertight.
D.9.3 In this clause 'opening' includes a side scuttle (whether opening or non-opening), a port, a scupper and a sanitary discharge opening.
D.10 Side scuttles
D.10.1 Side scuttles to spaces below the freeboard deck or to spaces within enclosed superstructures shall be fitted with efficient hinged inside deadlights arranged so that they can be effectively closed and secured watertight.
D.10.2 A side scuttle shall not be fitted in such a position that its sill is below a line drawn parallel to the freeboard deck at side and having its lowest point 2.5 per cent of the breadth or 500 mm above the load waterline, whichever is the greater distance.
D.10.3 Side scuttles, their glasses and deadlights shall comply with the requirements of British Standard MA24.
D.10.4 Where an opening in a superstructure deck or in the top of a deckhouse on the freeboard deck which gives access to a space below the freeboard deck or to a space within an enclosed superstructure is protected by an efficient deckhouse fitted with side scuttles, only those side scuttles that give direct access to an open stairway shall be fitted with deadlights in accordance with this clause.
D.11 Discharges, inlets and scuppers
D.11.1 Subject to sub-clause D.11.6 each discharge led through the shell either from spaces below the freeboard deck or from within superstructures and deckhouses on the freeboard deck fitted with doors complying with the requirements of sub-clauses 6.1 and 6.2 of the Load Lines Section shall be fitted with efficient and accessible means for preventing water from passing inboard.
D.11.2 Subject to sub-clause D.11.4 and D.11.5, the means for preventing water from passing inboard referred to in sub-clause D.11.1 shall consist of one automatic non-return valve with a positive means of closing from a position above the freeboard deck in respect of each separate discharge.
D.11.3 The means for closing the valve referred to in sub-clause D.11.2 shall be readily accessible at all times under service conditions and shall be provided with an indicator showing whether the valve is open or closed.
D.11.4 Where the vertical distance from the summer load waterline to the inboard end of a discharge pipe referred to in sub-clause D.11.1 exceeds 1 per cent of the length of the vessel, the discharge may have two automatic non-return valves without positive means of closing provided that the inboard valve shall be accessible for examination under service conditions.
D.11.5 Where the vertical distance from the summer load waterline to the inboard end of a discharge pipe referred to in sub-clause D.11.1 exceeds 2 per cent of the length of the vessel, the discharge may have a single automatic non-return valve without positive means of closing.

D.11.6 Where a discharge associated with the operation of machinery is connected to a ship side discharge valve that is located within the machinery space and is readily accessible at all times, the provisions of sub-clauses D.11.1 to D.11.5 inclusive do not apply to the discharge.

D.11.7 In manned machinery spaces, main and auxiliary sea inlets and discharges in connection with the operation of machinery may be controlled locally and, if they are controlled locally, the controls shall be readily accessible and provided with indicators showing whether the valves are open or closed.

D.11.8 In a machinery space which may be unmanned for any period during the normal operation of the vessel at sea:

(a) the main and auxiliary sea inlets and discharges in connection with the operation of machinery, in the spaces may be controlled locally and, if they are controlled locally, the controls shall be readily accessible and provided with indicators showing whether the valves are open or closed; and

(b) the machinery space shall be fitted with an efficient warning device to give warning at the position where the machinery is being monitored or controlled, of an entry of water into the machinery space other than water resulting from the normal operation of the machinery.

D.11.9 Scuppers and discharge pipes originating at any level and penetrating the shell either more than 450 mm below the freeboard deck or less than 600 mm above the summer load waterline shall be provided with a non-return valve at the shell.

D.11.10 The provisions of sub-clause D.11.9 do not apply to a scupper or discharge pipe:

(a) where the discharge pipe is associated with the operation of machinery and is connected to a ship side discharge valve that is located within the machinery space and that valve is readily accessible at all times, or

(b) except in the case of a discharge referred to in sub-clauses D.11.1 to D.11.6 inclusive, where the piping is of a thickness not less than:

\[
\text{Diameter of pipe in mm} = 2^{4} + 6.5 \text{ mm}
\]

but need not exceed 12.5mm.

D.11.11 Scuppers leading from superstructures or deckhouses not fitted with doors complying with the requirements of sub-clauses 6.1 and 6.2 of the Load Lines Section shall be led overboard.

D.11.12 All shell fittings and valves required by this clause shall be of steel, bronze or other approved ductile material and shall not be of ordinary cast iron.

D.11.13 All pipes referred to in this clause shall be of steel or other equivalent material.

D.12 Bolts connecting fittings to shell plating

D.12.1 A bolt which connects a cock, valve, discharge or inlet pipe, or other similar equipment to the shell plating of a vessel below the bulkhead deck of the vessel shall:

(a) have its head outside the shell plating of the vessel; and

(b) be either countersunk or cup-headed.

D.13 Watertight decks to be draised

D.13.1 A drainage system shall be provided for the drainage of each watertight deck of a vessel below the bulkhead deck of the vessel and, where drainage pipes are used for that purpose, they shall be fitted with valves, or otherwise so constructed, as to prevent the passage of water from one to another of the watertight compartments into which the vessel is sub-divided in pursuance of this Sub-section.

D.14 Rubbish-shoots

D.14.1 The inboard opening of a rubbish-shoot or other similar shoot in a vessel shall be fitted with

(a) a watertight cover; and

(b) where the opening is below the bulkhead deck of the vessel an automatic non-return valve in a readily accessible position above the deepest load waterline of the vessel.

D.14.2 The valve referred to in the last preceding sub-clause shall be of a horizontal balanced type which is normally closed and shall be provided with a control at the valve for securing it in a closed position.

D.15 Ports

D.15.1 Where a gangway port or cargo port is fitted below the bulkhead deck of a vessel

(a) the port shall be of adequate strength; and

(b) the lowest point of the port shall be above the deepest load waterline of the vessel.

Part II—Class 2 and Class 3 vessels of less than 35 metres in measured length

D.16 Number and disposition of transverse bulkheads

D.16.1 All vessels 125 metres and over in measured length shall have 2 machinery space bulkheads, except that where the machinery space is located at one end of the vessel then only the after or forward machinery space bulkhead as appropriate need be provided. In the case of sailing vessels with small machinery spaces, those spaces may be provided with partial transverse and longitudinal bulkheads forming an enclosure in lieu of the transverse bulkheads required above, provided that a collision bulkhead is fitted in accordance with provision D.16.2 (i).

D.16.2 All vessels of 16 metres in measured length and over, and under 25 metres measured length, shall be provided with bulkheads as follows:

(i) (a) where the rake of the stem does not exceed 15° the collision bulkhead shall be located not less than 5 per centum of the length or 750 mm whichever is the greater and not more than 15 per centum of the length abait the stem at the waterline assumed in sub-clause 3.16 of the Load Lines Section,

(b) where the rake of the stem exceeds 15° a stepped collision bulkhead may be fitted, the bulkhead to the step shall be positioned not less than 5 per centum of the length abait the stem at the load waterline, the top of the step shall be not less than 2.5 per centum of the length above the load waterline and the continuation of the bulkhead to the bulkhead deck shall be positioned at a distance not less than 1.5 per centum of the length abait the stem measured at the top of the step.

(ii) Bulkheads at each end of the machinery space, provided that where the machinery space is situated immediately aft of the collision bulkhead the after bulkhead only need be provided, and when the machinery space is at the extreme after end of the vessel the forward bulkhead only need be provided.

D.16.3 All vessels of 25 metres in length and over, and under 35 metres in length, shall, in addition to being provided with the bulkheads specified in D.16.2 be provided with an after bulkhead forward of the rudder stock. The bulkhead shall extend to the first deck above the load waterline.

D.17 Openings in watertight bulkheads

D.17.1 The number of openings in watertight bulkheads shall be kept to the minimum compatible with the general arrangement and operational needs of the vessel.
Section 5 Sub-section D

D.17.2 The openings shall be fitted with approved closing appliances. Watertight doors shall be of equivalent strength to the adjacent unpierced structure.

D.17.3 Subject to the next succeeding sub-clauses D.17.4, D.17.5 watertight doors shall not be fitted in the collision bulkhead below the weather deck.

D.17.4 A manhole may be provided in the collision bulkhead provided it is located as high as practicable, is suitably compensated, and fitted with a bolted watertight cover.

D.17.5 Watertight doors may be of the hinged type, which shall be capable of being operated locally from either side of the door.

D.17.6 Hinged doors shall be marked on each side, in bold and permanent lettering—"THIS DOOR TO BE KEPT CLOSED AND SECURED".

D.17.7 Sliding watertight doors shall be capable of being operated when the vessel is listed 15 degrees either way.

D.17.8 Sliding watertight doors whether manually operated or otherwise shall be capable of being operated locally from both sides of the door. Where the doors are capable of being operated by remote control means shall be provided at the remote operating positions to indicate when each door is open or closed.

Part III—Special provisions applicable to Class 2 vessels not subject to the provisions of the Load Lines Section and Class 3 vessels other than such vessels to which Part IV applies

D.18 Watertight integrity

D.18.1 Openings through which water can enter a vessel shall be provided with closing devices in accordance with the applicable provisions of this Sub-section.

D.18.2 All hatches exposed to the weather shall be of watertight construction.

D.18.3 Deck openings which may be open during fishing or other operations carried out at sea shall be arranged near to the centreline.

D.18.4 Fish flaps on stern trawlers shall be flush, watertight, power operated and capable of being closed from an adjacent position on the deck. Stern trawlers having a ramp or slip shall be fitted with a wave trap or door to prevent water flooding the deck.

D.19 Weathertight doors

D.19.1 All access openings in bulkheads of enclosed superstructures and other outer structures through which water could enter and endanger the vessel shall be fitted with doors permanently attached to the bulkhead, framed and stiffened so that the whole structure is of equivalent strength to the unpierced structure, and weathertight when closed. The means for securing the doors weathertight shall consist of gaskets and clamping devices or other equivalent means and shall be permanently attached to the bulkhead or to the doors themselves, and the doors shall be so arranged that they can be operated from both sides of the bulkhead.

D.19.2 Doors in deckhouses or superstructures giving access to spaces below the weather deck where those access ways are not fitted with coamings as required by sub-clause D.20.1 shall be of substantial construction and strongly attached to the deckhouse or superstructure and so framed stiffened and fitted that the whole structure of which they are part is of equivalent strength to the unpierced structure. They shall be capable of being closed weathertight.

D.19.3 The height of door sills in deckhouses or superstructures from inside which there is access to below the deck level shall not be less than given in the following table:

<table>
<thead>
<tr>
<th>Measured length (metres)</th>
<th>Sill height (millimetres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 12.5</td>
<td>200</td>
</tr>
<tr>
<td>12.5 or over but less than 20</td>
<td>300</td>
</tr>
<tr>
<td>20 or over but less than 30</td>
<td>450</td>
</tr>
<tr>
<td>30 and over</td>
<td>600</td>
</tr>
</tbody>
</table>

D.20 Hatchway coamings

D.20.1 Hatchway coamings shall be of substantial construction of equivalent strength to the deck or deckhead on which they are mounted. The height of the coaming above the deck shall be not less than that given in the table below:

<table>
<thead>
<tr>
<th>Measured length</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 12.5m</td>
</tr>
<tr>
<td>12.5m and over</td>
</tr>
<tr>
<td>20m and over</td>
</tr>
<tr>
<td>30m and over</td>
</tr>
<tr>
<td>Cargo hatches on weatherdeck</td>
</tr>
<tr>
<td>Hatches in weatherdeck giving direct access to machinery or accommodation spaces below deck</td>
</tr>
<tr>
<td>Hatches in weatherdeck providing direct access to machinery or accommodation spaces below the weatherdeck from inside deckhouses fitted with sills as provided in sub-clause D.19.3 or superstructures</td>
</tr>
</tbody>
</table>

D.20.2 The height of hatch coamings specified in sub-clause D.20.1 may be reduced where compliance with the requirements of that sub-clause is not reasonably practicable, provided that the hatches are:

(a) situated within the mid half beam of the vessel
(b) of a width less than half the beam of the vessel
(c) closed with efficient weathertight covers of steel or other equivalent material fitted with gaskets and clamping devices and capable of being rapidly closed and battened down, and
(d) the Authority is satisfied that the safety of the vessel in the service sea conditions will not be impaired by so doing.

D.21 Hatchways closed by wood covers

D.21.1 The finished thickness of wooden hatch covers shall be at least 4 mm for each 100 mm of unsupported span subject to a minimum of 40 mm and the width of their bearing surface shall be at least 65 mm.

D.21.2 Arrangements acceptable to the Authority shall be provided for securing wood hatch covers weathertight.

D.22 Hatchways closed by covers other than wood

D.22.1 For the purpose of strength calculations it shall be assumed that hatchway covers are subjected to the weight of cargo intended to be carried on them or to the following static loads, whichever is the greater:

(i) 0.75 tonnes per square metre for vessels of 18 metres in length or less,
(ii) 1.0 tonnes per square metre for vessels of 24 metres in length,
(iii) 1.75 tonnes per square metre for vessels of 100 metres in length and over.
For intermediate lengths the load values shall be determined by linear interpolation.

The loads may be reduced to not less than 75 per cent of the above values for covers to hatchways situated on the superstructure deck in a position aft, a point located 25 per cent of the vessel's length from the forward perpendicular.

D.22.2 Where covers are made of mild steel the maximum stress calculated according to D.22.1 multiplied by 4.25 shall not exceed the minimum ultimate strength of the material. Under these loads the deflections shall be not more than 0.002X times the span.

D.22.3 The strength and stiffness of covers made of materials other than mild steel shall be equivalent to those of mild steel.

D.22.4 Covers shall be fitted with approved clamping devices and gaskets sufficient to ensure weathertightness.

D.23 Machinery space openings

D.23.1 Machinery space openings shall be framed and enclosed by casings of equivalent strength to the superstructure. External access openings therein shall be fitted with doors complying with the requirements of clause D.19.

D.23.2 Openings other than access openings shall be fitted with covers of equivalent strength to the unperforated structure, permanently attached thereto and capable of being closed weathertight.

D.24 Other deck openings

D.24.1 Where it is essential for fishing or other operations, flush deck scuttles of the screw, bayonet or equivalent type may be fitted provided they are capable of being closed weathertight and are permanently attached to the adjacent structure. Having regard to the size and disposition of the openings and the design of the closing devices, metal to metal closures may be fitted if the Authority is satisfied that they are effectively weathertight.

D.24.2 Openings other than hatchways, machinery space openings, manholes and flush scuttles on the weather or superstructure deck shall be protected by enclosed structures fitted with weathertight doors or their equivalent. Companionways should be situated as close as practicable to the centreline of the vessel.

D.25 Ventilators

D.25.1 The height above deck of ventilator coamings, shall be as follows:

<table>
<thead>
<tr>
<th>Measured length</th>
<th>On weather deck (mm)</th>
<th>On superstructure deck (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 25 metres</td>
<td>...</td>
<td>600</td>
</tr>
<tr>
<td>25 metres and over but less than 45 metres</td>
<td>...</td>
<td>760</td>
</tr>
<tr>
<td>45 metres and over</td>
<td>...</td>
<td>900</td>
</tr>
</tbody>
</table>

Ventilators shall be of substantial construction and of equivalent strength to the structure to which they are attached and shall be capable of being closed weathertight by devices permanently attached to the ventilator or adjacent structure provided that closing appliances need not be fitted to ventilators:

(a) Where the length of the vessel is less than 10 metres and the vessel is a Class C vessel.

(b) Where the length of the vessel is less than 15 metres and the height of the ventilator is not less than 1.0 metres above the weather deck and positioned not more than 0.25 of the moulded breadth from the centreline of the vessel.

(c) Where the length of the vessel is less than 25 metres and the height of the ventilator is not less than 2.0 metres above the weather deck and positioned not more than 0.25 of the moulded breadth from the centre line of the vessel.

(d) Where the height of the ventilator exceeds 4.5 metres above the weather deck.

Wood plugs and canvas covers, or equally effective closing appliances may be used on all Class C vessels less than 15 metres.

Where the coaming of any ventilator exceeds 900 mm in height it shall be specially supported.

D.26 Air Pipes

D.26.1 Where air pipes to tanks and other spaces extend above the weather or superstructure deck the exposed parts of the pipes shall be of substantial construction. Where the diameter of the pipe exceeds 30 mm the pipe shall be provided with efficient means of closing water tight permanently attached to the pipe or adjacent structure.

D.26.2 The height of air pipes above deck to the point where water may have access below shall be at least 760 mm on the weatherdeck and at least 450 mm on the superstructure deck. The Authority may allow reduction of the height of an air pipe to avoid interference with fishing or similar operations.

D.27 Side Scuttles and Skylights

D.27.1 Side scuttles to spaces below the weather deck shall be fitted with hinged deadlights capable of being closed wetteright.

D.27.2 A side scuttle shall be fitted in a position such that its sill is above a line drawn parallel to the weather deck having its lowest point 500 mm above the load water line.

D.27.3 Side scuttles glasses and deadlights shall comply with the requirements of British Standard MA24.

D.27.4 Subject to sub-clause D.27.5 skylights leading to spaces below the weather deck shall be fitted with hinged metal covers capable of being closed weathertight by means of gaskets and suitable clamping devices.

D.27.5 Skylights leading to spaces below the weather deck, other than machinery spaces, may be fitted without deadlights if the skylights have a glazing material having sufficient strength to withstand the following appropriate assumed loads:

(a) where the skylight is in position 1
   (i) 1.75 tonnes per square metre for vessels of 100 metres measured length or over;
   (ii) 1.00 tonnes per square metre for vessels of 16 metres measured length or over but less than 24 metres measured length;
   (iii) for vessels of 24 metres measured length or over but less than 100 metres measured length and the space above the skylight is to be obtained by linear interpolation.

(b) where the skylight is in position 2
   (i) 1.30 tonnes per square metre for vessels of 100 metres measured length or over;
   (ii) 0.75 tonnes per square metre for vessels of 16 metres measured length or over but less than 24 metres measured length;
   (iii) for vessels of 24 metres measured length or over but less than 100 metres measured length and the space above the skylight is to be obtained by linear interpolation.

D.27.6 Deadlights are not required on fixed side scuttles and fixed skylights for vessels operating solely in smooth and partially smooth waters.
Section 5 Sub-section D

D.28 Scuppers, inlets and discharges
D.28.1 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.

D.28.2 Scuppers and discharge pipes which pass through the side of the vessel shall comply with the following:
Scupper and discharge pipes, excluding machinery exhaust systems, shall be fitted with valves or cocks in an easily accessible position against the vessel's side, except where approved bilge alarms are fitted. Such valves or cocks shall not be required in the case of a discharge not exceeding 50 mm internal diameter, the lowest point of which is not less than 250 mm above the load waterline.

Waste and soil discharges greater than 50 mm internal diameter from spaces above the freeboard deck which are led through the vessel's side more than 225 mm above the designed load waterline may be fitted with an automatic non-return valve in lieu of a valve or cock.

Main propulsion machinery exhaust systems shall be fitted with an approved hull fitting the lower edge of which shall be as high as practicable above the load waterline.

Such systems may pass through watertight bulkheads on the machinery space provided that:

(a) the system is passed through the bulkhead or bulkheads as close to the underside of the weather deck as practicable;

(b) an approved bulkhead fitting is provided at each watertight bulkhead through which the system passes.

Auxiliary propulsion machinery exhaust systems shall be fitted with an approved hull fitting the lower edge of which shall be as high as practicable but not less than 225 mm above the summer load waterline but shall not pass through watertight bulkheads without the approval of the Authority.

D.29 Freeing ports

D.29.1 Where bulwarks in the weather portion of the weather deck form walls, there shall be provided on each side of the vessel, at each well a minimum freeing port area of:

(a) Where the vessel is less than 12.5 metres measured length

\[ A = \frac{2 \times m \times h}{100} \]

where

- \( A \) = area in square metres
- \( m \) = length of well in metres
- \( h \) = height of bulwark in metres

(b) Where the vessel is 12.5 metres and over measured length

\[ A = \frac{(1.0 + 3.5h) \times m \times h}{100} \]

The area \( A \) may include:

(1) openings out in the transom

(2) in stern trawlers the apertures under the stern doors.

D.29.2 Freeing ports shall be so arranged throughout the length of the bulwark as to provide an effective means of freeing the deck of water. Lower edges of free ports shall be as near to the deck as is practicable. Freeing ports greater than 230 mm in depth shall be fitted with bars spaced not more than 230 mm apart.

D.29.3 If the Authority considers that the minimum freeing port area ascertained in accordance with D.29.1 is insufficient, then a greater minimum freeing port area shall be provided on each side of the vessel as determined by the Authority.

Commonwealth of Australia Gazette
No. P 17, 13 August 1984

Part IV—Modifications applicable to Class 2B and Class 2C vessels less than 16 metres in measured length, Class 3B and Class 3C vessels less than 20 metres in measured length Class D, Class 2E, Class 3D and Class 3E vessels

D.30 Openings in deckhouses or superstructures in which there are windows or side scuttles not fitted with hinged deadlights

D.30.1 Openings in deckhouses or superstructures in which there are windows or side scuttles not fitted with hinged deadlights shall be fitted with doors of substantial construction permanently attached to the deckhouse or superstructure and capable of preventing the ingress of spray. Openings in the after end of such deckhouses and superstructures may have sills not exceeding 100 mm in height. Openings in the sides of such deckhouses and superstructures shall have sills not exceeding 200 mm in height.

D.30.2 Accessways to spaces below the weatherdeck from inside deckhouses or superstructures referred to in D.30.1 shall be fitted with sills or hatchcoamings as given in Table 1.

D.30.3 Where the Authority is satisfied that the safety of the vessel in normal sea conditions will not be impaired by doing weathertight deck plugs or other approved flush closures may be fitted in lieu of coamings and covers.

D.31 Hatchway coamings

D.31.1 Hatchway coamings shall be of substantial construction of equivalent strength to the deck or head on which they are mounted. The height of the coaming above the deck in millimetres shall be not less than that given in Table 1.

<p>| TABLE 1 |
|-----------------|-----------------|
| Height of hatch coamings and door sills |</p>
<table>
<thead>
<tr>
<th>Vessel</th>
<th>Measured length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;12.5</td>
<td>12.5-20</td>
</tr>
<tr>
<td>Hatches in weatherdeck giving direct access to machinery or accommodation spaces or to spaces which are required to be opened for loading at sea</td>
<td>B &amp; C</td>
</tr>
<tr>
<td></td>
<td>D &amp; E</td>
</tr>
<tr>
<td>Hatches inside non weather-tight deckhouses giving direct access to spaces below the weatherdeck and having after doors only</td>
<td>B &amp; C</td>
</tr>
<tr>
<td></td>
<td>D &amp; E</td>
</tr>
<tr>
<td>Hatches inside non weather-tight deckhouses giving direct access to spaces below the weatherdeck and having side doors</td>
<td>B &amp; C</td>
</tr>
<tr>
<td></td>
<td>D &amp; E</td>
</tr>
<tr>
<td>Openings in deckheads not less than 1.5 metres above the weatherdeck</td>
<td>B &amp; C</td>
</tr>
<tr>
<td></td>
<td>D &amp; E</td>
</tr>
</tbody>
</table>

D.31.2 The height of the hatch coamings and sill specified in sub-clause D.31.1 may be reduced or omitted where compliance with the requirement of that sub-clause is not reasonably practicable provided that the openings are:

(a) situated within the mid half beam of the vessel;

(b) of a width less than half the beam of the vessel; and

(c) the Authority is satisfied that the safety of the vessel in service condition will not be impaired by so doing.
D.32 Hatchways on the weatherdeck closed by wood covers

D.32.1 The thickness of the cover shall be at least 4 mm for each 100 mm of unsupported span. The cover may be made in the form of an inverted box, the depth of the sides of the box being at least 0.4 times the height of the hatch coaming. The cover shall be secured to the deck by substantial retaining clips.

D.33 Hatchways on the weatherdeck closed by covers other than by wood

The cover shall comply with the requirements of clause D.22.

D.34 Hatchways on a deckhouse top

Hatchways on a deckhouse top shall be of substantial construction equal in strength to the strength of the deckhouse top, permanently attached to the deckhouse top and capable of preventing the ingress of spray under normal sea conditions.

D.35 (Withdrawn)

Part V—Provisions applicable to all Class 2 and Class 3 vessels

D.36 Wheelhouse and deckhouse windows

D.36.1 Wheelhouse windows should be so located as to afford, where practicable, an all round arc of visibility.

D.36.2 The maximum size of windows to be fitted in wheelhouses and deckhouses of seagoing vessels should not exceed 0.6 m² (and the length to width ratio should not exceed 2 to 1).

D.36.3 Window openings of wheelhouses and deckhouses shall be fitted with laminated or toughened safety glass. Wheelhouse window panes shall be of clear glass. Plate glass shall not be used.

\[
t = \sqrt{\frac{108 H b^2}{a}} \text{ mm}
\]

where

- \( t \) = thickness mm
- \( d \) = non-dimensional coefficient determined from Table 1
- \( H \) = design pressure head in metres determined from Table 2 and associated notes
- \( b \) = length in mm of the short dimension of the window
- \( a \) = allowable working stress of glass in kPa determined from Table 3

In no case should the glass thickness fitted be less than 6 mm.

### Table 1

<table>
<thead>
<tr>
<th>( a )</th>
<th>1.0</th>
<th>1.2</th>
<th>1.4</th>
<th>1.6</th>
<th>1.8</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>( b )</td>
<td>.0444</td>
<td>.0616</td>
<td>.0770</td>
<td>.0906</td>
<td>.1017</td>
<td>.1110</td>
<td>.1135</td>
<td>.1400</td>
<td>.1417</td>
</tr>
</tbody>
</table>

(Where \( a \) = long dimension of window, \( b \) = short dimension of window)

### Table 2

<table>
<thead>
<tr>
<th>L.W.L. (m)</th>
<th>Design Head (m)</th>
<th>L.W.L. (m)</th>
<th>Design Head (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.27</td>
<td>18</td>
<td>1.82</td>
</tr>
<tr>
<td>6</td>
<td>0.32</td>
<td>19</td>
<td>2.02</td>
</tr>
<tr>
<td>7</td>
<td>0.40</td>
<td>20</td>
<td>2.22</td>
</tr>
<tr>
<td>8</td>
<td>0.48</td>
<td>21</td>
<td>2.42</td>
</tr>
<tr>
<td>9</td>
<td>0.58</td>
<td>22</td>
<td>2.63</td>
</tr>
<tr>
<td>10</td>
<td>0.69</td>
<td>23</td>
<td>2.86</td>
</tr>
<tr>
<td>11</td>
<td>0.79</td>
<td>24</td>
<td>3.10</td>
</tr>
<tr>
<td>12</td>
<td>0.90</td>
<td>25</td>
<td>3.37</td>
</tr>
<tr>
<td>13</td>
<td>1.03</td>
<td>26</td>
<td>3.59</td>
</tr>
<tr>
<td>14</td>
<td>1.17</td>
<td>27</td>
<td>3.85</td>
</tr>
<tr>
<td>15</td>
<td>1.33</td>
<td>28</td>
<td>4.12</td>
</tr>
<tr>
<td>16</td>
<td>1.48</td>
<td>29</td>
<td>4.40</td>
</tr>
<tr>
<td>17</td>
<td>1.65</td>
<td>30</td>
<td>4.70</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Material</th>
<th>Design Head (m)</th>
<th>L.W.L. (m)</th>
<th>Allowable Working Stress (( \sigma ))</th>
<th>Young Modulus (( E ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminated float glass</td>
<td>27.6 x 10⁶</td>
<td>69 x 10⁶</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toughened glass</td>
<td>58 x 10⁶</td>
<td>69 x 10⁶</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deflection (\( d \)) determined in accordance with the following formula is not to exceed 1/100 span of short dimension of the pane.

\[
d = \frac{10 \alpha H b^2}{E \sigma} \text{ mm}
\]

where

- \( d \) = deflection mm
- \( \alpha \) = non-dimensional coefficient determined from Table 1
- \( H \) = design pressure head in metres determined from Table 2 and associated notes
- \( b \) = length in mm of the short dimension of the window
- \( E \) = Young's modulus of the material in kPa determined from Table 3
- \( t \) = thickness of window glass in mm

D.36.9 Window panes of material other than glass shall be specially considered by the Authority.

D.36.10 The following points concerning glazing of the windows are to be observed:
UNIT 3.9 SELF-TEST EXERCISE

The answers to the following questions are provided at the back of this book.

1. Describe the test for a watertight bulkhead.
2. Define *watertight* as given in the U.S.L. Code.
3. Describe the test for watertight tanks.
4. Describe the tests for watertight doors.
5. Describe the tests for weathertight hatchways.
6. Describe the tests for weathertight accesses in superstructures.

UNIT 3.10 SUMMARY

This summary will be very useful to you. STUDY it carefully.

The following table indicates the requirements of Lloyd’s Classification Society regarding the number of watertight bulkheads for cargo ships:

<table>
<thead>
<tr>
<th>V/c length (metres) above</th>
<th>Number of bulkheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not exceeding mach'y midships</td>
<td>Mach'y aft</td>
</tr>
<tr>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>105</td>
<td>115</td>
</tr>
<tr>
<td>115</td>
<td>125</td>
</tr>
<tr>
<td>125</td>
<td>145</td>
</tr>
<tr>
<td>145</td>
<td>165</td>
</tr>
<tr>
<td>165</td>
<td>190</td>
</tr>
<tr>
<td>190</td>
<td>To be considered individually</td>
</tr>
</tbody>
</table>
The distance apart of these bulkheads would be determined by the ‘floodable length’ calculation; however, there are some other basic requirements which must be complied with.

(a) There must be a collision bulkhead located between 0.05 and 0.075 L from the for’d end of the load waterline.

(b) There must be an after peak bulkhead which finally encloses the stern tube to contain any leakage where the propeller shafts pierce the hull.

(c) There must be watertight bulkheads at both ends of the machinery space.

This clearly implies that for a vessel with machinery amidships the minimum number of watertight bulkheads is 4, whilst for a vessel with machinery aft the minimum number of watertight bulkheads is 3.

**Bulkhead construction**

Watertight bulkheads are constructed by one of two distinct methods.

(a) Flat plates welded on horizontal strokes where plating thickness may increase with depth.

This type of bulkhead needs to be stiffened and this is usually achieved by a reasonable number of vertical stiffeners supported by a lesser number of horizontal stringers.

(b) Some bulkheads are constructed so as to be self-stiffening and this is achieved by corrugations or swedges.

In back cases, the corrugations or swedges are vertical to provide the stiffening required. Plates are cold bent to the desired shape and then welded together in order to form the bulkhead.

The plating used is of uniform thickness and, as such, will be heavier than equivalent flat plate bulkhead; however, this is affected by the weight savings made in not having to use stiffeners.

At this stage, students should ensure that they can produce realistic sketches of the various types of bulkhead construction. This should be done by making reference to various books as well as drawing on their own experiences.

A further point to consider is that, wherever possible, piping and ventilation trunks should not pass through watertight bulkheads. Where this cannot be avoided, the following measures must be adopted.

(a) Pipes must be flanged to the bulkhead, not pass through it.

(b) Ventilation trunks must be fitted with a watertight shutter.

(c) If the collision bulkhead is to be pierced by a pipe, a valve must be fitted at the collision bulkhead. This valve should normally be kept closed and may be operated by remote control and/or an extended spindle.

**Bulkhead testing**

The collision bulkhead, as the fore peak bulkhead, and the aft peak bulkhead are tested by filling the tanks to the level of the load waterline unless the tanks are used for a ballast when they are filled to their normal full condition and tested with a 2.45 metre head.

Other watertight bulkheads of compartments not forming the boundaries of liquid-carrying spaces are simply tested by hose testing.
**Watertight doors**

In some cases it is unavoidable that a larger hole is required in a watertight bulkhead; for example, between the engine room and a propeller shaft tunnel. In this case, the opening must be fitted with a watertight door which complies with the following basic rules.

(a) The opening must be framed and thicker plating used around the opening.
(b) The opening must be as small as possible.
(c) Below the load waterline, doors must be of the sliding type.
(d) Sliding doors must be capable of operating with a 15° list.
(e) Doors must be able to be operated both remotely and locally.
(f) Hydraulically-operated doors must be fitted with local alarms at each door to warn of closing/opening by remote control.
(g) Doors are tested by hose testing, except for passenger vessels where a pressure test, equal to the height of the bulkhead in which the door is to be fitted, is applied, usually before the door is fitted.
(h) Above the load waterline, hinged doors are permitted, provided that the hinges are made of suitable non-corrosive material.

**Drainage arrangements**

Watertight integrity should be such that little, if any, water should find its way into a watertight compartment. Experience shows that this is not always the case and thus it is necessary to provide drainage arrangements and means of removing the excess liquid.

Excess liquid within a compartment is usually channelled to bilges, wells or drain tanks by means of scuppers or drain channels. From the collection areas, a variety of pipe/pump systems is used to discharge the excess liquid overboard.

Frequently, engine room bilges and ro-ro drain tanks are fitted with high level alarms to alert personnel to the impending possibility of overflowing. Occasionally such alarms are designed in such a way that a pump is automatically activated to prevent overflows.
Tanks and Pumping Arrangements

INTRODUCTION

Apart from being a watertight container with its own means of propulsion and space for the carriage of cargoes, a vessel must also have means of carrying the fuel for its propulsion. In addition, to facilitate loading, it is necessary to include ballast tanks in order to counteract stresses induced by loading, correct lists and trims and provide a means of increasing or reducing stability as the conditions may require.

The crew on a vessel require fresh water, as do various parts of the ship’s machinery. It is not sufficient to have only fresh water generators, since these do not work in port when the main engines are not running. So there is a need for fresh water tanks. In addition, there is a need for lubrication oil tanks, daily service fuel oil tanks, sewerage tanks, and many others. These tanks all provide for the needs of various parts of the ship, and some efficient means of transporting the liquids to where they are required is needed. Gone are the days of a stoker manually shovelling coal into the furnace of a steam engine, or carrying water in a bucket. Nowadays, pumping and piping arrangements transport the liquids to where they are needed.

In this Section, we will be looking at the tanks and pumping arrangements in small vessels.

OBJECTIVES

By the end of this Section you should be able to:

- sketch or identify from shipboard plans the location and main features of the following components:
  i) fuel arrangements
  ii) fresh water arrangements
  iii) ballast arrangements
  iv) bilge pumping arrangements
- sketch and describe tank structure and pipeline layout with reference to the reasons for and methods of subdivision in tanks
- estimate the weight of fluid in a tank given the measurements of a regular shaped volume
- list the means by which a leaking or faulty tank can be recognised
- sketch and describe the position and purpose of various openings in a tank
- identify the colour code of pipework as found in the U.S.L. Code
- be familiar with the principles of, and give reasons for the ventilation and sounding of tanks and demonstrate correct methods of same
- identify from shipboard plans the position of sounding and vent pipes.
UNIT 4.1 LOCATION OF MAJOR COMPONENTS

In this Unit, we will look at the location in the ship of the tanks and pumps of the tug Tammar.

STUDY carefully Figures 1.8, 1.10 and 1.11, paying special attention to the location of all tanks and pumps. In Figure 1.8, NOTE the space between the fresh water tank and the fuel tanks. This space (frames 10-11) is labelled C/D which stands for cofferdam.

Cofferdams are void spaces fitted between oil tanks and fresh water tanks. The idea behind a cofferdam is that, if either bulkhead were to leak, adjacent tanks would not become contaminated.

Now STUDY carefully Figure 4.1 - this is the bilge/ballast plan for the same vessel. IDENTIFY the schematic pumps in this plan with their actual location on the vessel as shown in Figure 1.11.
Fig 4.1 Bilge & Ballast Schematic
Now do the same for the ballast and fresh water tanks. Identify also the types of valves used at the various locations. S.D.N.R. stands for “Screw down non-return”. You will learn more about the different types of valves in Section 5. Keep in mind the performance objectives and see how much you can achieve from your study of these plans.

Figure 4.3 (in this Study Guide) shows the fuel piping arrangements. Study this plan carefully with the same objectives in mind.
Fig 4.3  Fuel Oil Schematic
UNIT 4.2 TANK STRUCTURE

Just as ships are more than just a watertight container, so are tanks. Tanks, apart from storing liquids, perform another important task. When located in the bottom or sides, they provide a second skin. Should a vessel be bilged in way of a tank, the buoyancy of that compartment is lost, but the tank top maintains a watertight barrier against flooding. This is why most tanks (fuel included) are usually located in the bottom of the ship.

Vessels of 50 metres or more in length are required to have a double bottom extending from the machinery space to the first collision bulkhead. Vessels of more than 61 metres in length are required to have a double bottom extending from the aft peak bulkhead to the first collision bulkhead.

You might like to conduct a simple, practical experiment to demonstrate FSE for yourself.

a) Take a flat tray with raised sides and partially fill it with water. (A flat baking pan will work.)

b) Now hold it level, supported by the palms of your hands, held horizontal at arms length at shoulder height.

c) Now gently raise your right hand a few centimetres.

As the water runs to the left of the tray/pan you will feel a marked increase in weight, tending to push your left hand down further and so aggravate the condition.

This is free surface effect (FSE). A ship reacts in the same way. It first rolls slightly to a small angle of heel as a result of the wave forces. The internal forces of the shifting water in slack tanks then increases the list further as the liquid flows to the low side. If this FSE caused the vessel to list so that its deck edge was immersed below the waterline, it could well capsize.

By partitioning the tank longitudinally, the flow of liquids to the low side when the ship is heeled can be restricted. It is not removed completely, but the FSE can be reduced to acceptable limits. Obviously, correct loading and ballasting of the ship are also important, but this is an operational consideration, and not a design one.

Practically all tanks, with the exception of the fore peak ballast tank, are longitudinally subdivided for this reason. The tank location of the “Cooma” (Figure 1.3) shows this very clearly. Have a look at Figure 1.3 in Section 1.
Tank subdivision is affected by a continuous watertight divider extending in a fore and aft direction to each end of the tank, and vertically from the inner bottom of the tank to the underside of the tank top.

Usually this is the centre girder. If side tanks are also required, then side girders would be used for the same purpose.

Now STUDY Figure 20.2 (Eyres). This shows a typical fore peak tank construction.

NOTE how, even though there is no continuous watertight subdivision in this tank, the chain locker and the wash bulkhead form a partial divider which act as a baffle to retard the sideways motion of the water.

Fore peak tanks are usually narrow and do not present a very large free surface problem. For this reason, it is unusual to find any longitudinal subdivision.

UNIT 4.3 ESTIMATION OF WEIGHTS OF FLUIDS

It is always a good idea to know what the weight of the fluids in your tanks are. If you do not have precalculated tank tables, provided you know the measurements of your tanks (and they are reasonably regular), it is a relatively simple process to calculate or estimate the weight of fluid in a tank.

By weight we mean the kilogram or tonne (1000 kg) mass.

The weight of the liquid is simply the product of its density ($\delta$) and its volume.

The volume of a tank is approximately the product of its mean cross-sectional area and its length.

When calculating the volume of a liquid in a tank, we use the cross-sectional area of the liquid, and not the whole tank.

The density of a liquid is easily obtained with the use of a hydrometer, so the only problem is to find the volume of the liquid.

By taking a sounding, we can determine the height of the surface of the liquid in the tank above the bottom of the tank. More will be said about sounding later.

a) The prism-shaped tank

Consider the tank shown in Figure 4.4. If filled with water of a density 1.025 to a sounding of 1 m, what is the weight of the fluid in the tank?

First, we have to calculate the width of the water surface in the direction shown by the water level arrow. This is a simple proportion calculation. The ratio of width of the water level to the width of the top of the tank is in direct proportion to the ratio of the height of the water level to the height of the tank.
\[ \frac{W}{1.9} = \frac{1}{1.5} \]
\[ W = \frac{1.9}{1.5} \]
\[ \therefore W = 1.267 \]

The cross-sectional area = \( \frac{1}{2} \) base \( \times \) height
\[ = \frac{1.267}{2} \times 1 \]
\[ \text{Area} = 0.633 \text{ m}^3 \]

Multiply this by the length to find volume (V)
\[ V = 0.633 \times 1.2 \]
\[ \therefore \text{Volume} = 0.76 \text{ m}^3 \]

Multiply this by the density to find weight
\[ \text{Weight} = 0.76 \times 1.025 \]
\[ \therefore \text{Weight} = 0.779 \text{ tonne} \]

or Weight = 779 kg

b) The trapezoid-shaped tank

Consider the tank shown in Figure 4.5 sounding 0.6 m. Density of fuel 0.89 t.m\(^{-3}\). Calculate weight of fuel if the tank top is level.

This is a simpler calculation. First, we must calculate the longitudinal cross-sectional area (C.S.A.) of the fuel (the side running from aft to fwd).

The after depth of the fuel is 0.6m. The forward depth is 0.1m.
The formula for the C.S.A. of a trapezium is

\[
\frac{(h_1 + h_2)}{2} \times L = \left(\frac{0.6 + 0.1}{2}\right) \times 2
\]

\[
\text{CSA} = 0.7 \text{ m}^2
\]

Multiply this by the width of the tank to find the volume.

\[
V = 0.7 \text{ m}^2 \times 1 \text{ m}
\]

\[
V = 0.7 \text{ m}^3
\]

Multiply this by the density to find weight

\[
W = 0.7 \times 0.89
\]

\[
\therefore W = 0.623 \text{ tonnes}
\]

or \[
W = 623 \text{ kg}
\]

c) Block-shaped tanks

For a block-shaped tank, the formula for weight is simply Length x Breadth x Sounding x Density.
Figure 4.6 shows the typical fittings found in all tanks. The numbered parts are as follows:

1) Filling pipe cap (brass, threaded)
2) Air vent/filling pipe
3) Sounding pipe cap (brass, threaded)
4) Sounding pipe
5) Tank top
6) Suction pipe (for emptying tank)
7) Strumbox (bilges only)
8) Striker plate
9) Tank bottom/shell
10) Ball vent at highest point in tank (usually fuel).
When filling or emptying a tank, it is important to ensure that the air vents are open. This will prevent the build up of dangerous pressures, and will speed up the operation.

When filling tanks, they may either be filled by gravitating or pumping into the tank through the suction pipe. Gravitating means opening of the sea inlet valves and lines to the tank and bypassing the pump so that the water pressure, by virtue of the depth of the overboard discharge/suction, is the only force moving the water into the tank. This is always a good idea when pressing tanks up, so that the tank is not suddenly pressed up under the pressure provided by the ballast pump. Tanks have been ruptured by people using that bad practice.

**SOUNDING**

**Sounding** is the term used for measuring the depth of liquid in a tank. There are two methods of obtaining this information.

1) Lower a *sounding rod*, (usually a graduated rod — either long enough to reach the bottom of the tank from the sounding cap, or a shorter rod with rope attached by which the rod can be retrieved), down the sounding pipe till it taps the bottom of the tank. If using a short rod with rope attached, be sure not to let the rope become slack and fall into the tank so as to give a false reading.

   Then, withdraw the rod and measure of the length of the wetted part.

2) Use an *ullage tape*. (An ullage tape is, basically, a tape measure with a plumb weight on the ends).

   Lower the ullage tape till you hear the plum strike the surface of the liquid. Read off the reading at the sounding cap.

   Retrieve the ullage tape. The distance measured is that from the sounding cap to the surface of the liquid. By subtracting this distance from the height of the sounding cap above the bottom of the tank, the depth of liquid may be found.

**UNIT 4.5 LOCATION OF PUMPS**

Refer back to Figures 1.11 and 1.8 in Section 1.

**NOTE** that the general service pumps are located below the main deck. In all ships, it is common practice to have the pumps located as low as possible in the ship. This makes the emptying of tanks much easier. It means that the pumps do not have to suck the liquids up against gravity, or at least that the height of suction is kept to a minimum. If a ballast pump were located more than 8 metres above the tank it was to pump out, irrespective of the size or power of the pump, it would not be able to pump any water, even if it could develop a pure vacuum. Under our normal atmospheric conditions, the maximum head of water that a total vacuum could support is about 8 metres.

**UNIT 4.6 COLOUR CODING**

The Australian Standards Association prescribes a colour coding scheme for the identification of pipelines. The U.S.L. Code requires that all vessels adopt this colour scheme. It is a simple and effective way of identifying a pipeline without having to trace it to the source. If you wish to obtain a copy of the Australian Standard colour scheme, form AS 1345 is available from the Australian Standards Association.

The colours are basically as follows:

- Fresh Water - Royal Blue
- Salt Water - Emerald Green
- Steam - Silver Grey
UNIT 4.7 SELF-TEST EXERCISE

The answers to the following questions are to be found at the end of this book.

1. How could you identify a leaking or faulty tank?

2. The dimensions of a block-shaped tank are 3.38 m x 2.15 m x 1.65 m. If the ullage is 0.62 m, Density of fuel 0.92 t.m\(^{-3}\), calculate the weight of fuel in the tank (to the nearest kilogram).

3. Why is there an air pipe in a tank?

4. Why are tanks subdivided?
SECTION 5

Valves

INTRODUCTION

Having established tanks and piping systems, it becomes necessary for a means of regulating the flow of liquids in the system. It is for this purpose that valves were developed. In this Section, we will be looking at the more common types of valves in use on board ships.

OBJECTIVES

By the end of this Section you should be able to:

- list and sketch (schematically) the different types of valves used in pumping systems, viz:
  - Screw down/lift valves
  - Screw down non-return valves (S.D.N.R.)
  - Sluice/Gate valves
  - Quick release/drop valves (fuel)
  - Butterfly valves
  - Ball valves
- state the purpose and operation of each of the valves
- identify from a tank pumping plan the type of valves at the following locations:
  - Overside inlet
  - Overside discharge
  - Collision Bulkhead
  - Line crossover
- identify from a bilge pumping plan the valves at the following locations:
  - Overside discharge
  - Line backflooding
  - Line crossover
- describe the maintenance requirements of the different types of valves.

UNIT 5.1 VALVE TYPES

STUDY Figures 5.1 and 5.2 to identify when each type of valve is used.

a) The Screw Down/Lift Valve

This valve is designed to regulate the flow of liquid in either direction. Used for ballast lines, inlet and discharge, and collision bulkhead valve. May be used for fuel lines but gate valves are preferred.
Fig. 5.1 Screw Down/Lift Valve (globe type)

Labels

1) Handwheel  
2) Valve spindle  
3) Bridge  
4) Gland  
5) Gland packing  
6) Valve box cover  
7) Valve  
8) Valve guide  
9) Valve seating  
10) Valve box

The gland and gland packing seals the spindle so that liquid does not leak out of the top of the valve.

Turning the handwheel anti-clockwise will lift the valve spindle and consequently the valve from its seating. The valve guide prevents the valve being dislodged. Liquid can now flow past the valve and the line is open.

b) Screw-down Non-Return Valve (SDNR)

The S.D.N.R. is almost identical to the previous valve. The only difference is how the spindle connects to the valve itself. In the S.D.N.R. there is no actual connection. Lifting the spindle will not lift the valve; the valve will only lift against a pressure gradient when the high pressure is to the right as in Figure 5.2.

Fig.5.2 Screw-Down Non-Return Valve
Liquid cannot pass from left to right since the valve will seal itself against any backflow. S.D.N.R. valves are required for bilges, and should be opened up and maintained during drydocking and slipping. Figure 5.3a-e show various other N.R. valves. 

STUDY these to see how they work.

Figs. 5.3a-e
c) Sluice/Gate Valves

Fig. 5.4 Wedge-Gate Sluice Valve
Fig. 5.5 Wedge-Gate Sluice Valve
Figure 5.5 shows the major parts of a gate valve. By turning the hand wheel, the spindle threads itself into the gate which then lifts, allowing liquid to pass down the line. It is commonly used in fuel lines. See Figure 4.3.

**d) Quick Release Drop Valves**

These are the emergency fuel cut-off valves. By simply pulling the wire, the valve closes. They are very similar to the screw-down/lift valves and provided the trip lever is not operated, they can be used as such.

Quick release sluice valves operate on the same principle. In essence, all that happens, is that the bridge that holds the spindle is allowed to collapse, and the fuel pressure closes the valve, much like the non-return valve. Usually, the spindle is also spring-loaded so that it plunges down when the trip lever is released.

![Fig. 5.6 Quick Release Oil Fuel Tank Valve](image)

Figure 5.6 shows a schematic of a quick-release valve. When the trip wire is pulled, the elbow straightens and then bends to the left, allowing the valve to drop closed. The valve is opened by normal anti-clockwise turning of the handwheel.
Fig 5.7 Quick-Release Valves

Figure 5.7 shows the operation of the quick-release valve.

e) Butterfly Valves

Used in both fuel and ballast lines when regulation of flow is needed. They usually have only a lever-type handle with stops or settings marked on a 90° arc. The valve handle moves through 90° from open to shut and vice versa.

Fig. 5.8 Butterfly Valve

Figure 5.8 shows a butterfly valve. You would have seen this type of valve in the carburettor of your motor car. You can see how the valve has movement only through 90°.
Ball valves are used for isolating lines where bubble-tight shut off is required. The rotary stem sealing and quick action of the valve handle makes it ideal where you need to open or shut the valve quickly. The valve is also suitable for the operation of both viscous and dirty fluids (see Figure 5.8 (a) and (b)).

UNIT 5.2 FUEL INJECTION

A fuel injector is a highly specialised type of valve. Its purpose is to deliver a metered atomised spray of fuel into the cylinder of the engine just before maximum compression on the upward piston stroke is reached. The air above the piston will be very hot, and if the fuel injector works properly, the fuel spray will ignite and begin to burn. These burning vapours expand rapidly with the heat of combustion providing the power to drive the piston downwards on the power stroke. The following is a description of the Cummins Fuel Injection System.

THE CUMMINS P.T. FUEL INJECTION SYSTEM

The Cummins P.T. (Pressure-Time) system consists basically of an injector assembly containing a spring-loaded plunger, inlet and outlet ports and passages, and a metering orifice. Correct timing and operation of the plunger are accomplished mechanically by means of a cam-operated rocker assembly. A separate injector is used for each cylinder; fuel distribution and drain being obtained through drilled passages in the cylinder head in the case of the cylinder-type injector. An engine-driven gear pump, in conjunction with a governor-operated pressure control valve, supplies fuel oil continuously to the injectors at varying pressure, depending on engine speed and load conditions.
**Operation**

The operating sequence of a P.T. injector is illustrated in Figure 5.10. Fuel oil under pressure is delivered continuously from the pump to the inlet passage of the injector, but is unable to flow past point X during power, exhaust, and part of the induction stroke, because of the position of the plunger, which remains seated throughout this period. At a set point during the engine induction stroke, the plunger begins to move upward, uncovering port X in the process. Fuel may now circulate around a passage in the nozzle body and up through the drain passage for return to the supply tank. Further upward movement will cause the metering orifice, Y, to open, permitting a precisely metered quantity of fuel to enter the nozzle cup. Due to the action of the cam and rocker assembly, the plunger will now be forced downward, closing the metering port Y and trapping the fuel charge which has been delivered to the cup. The plunger will then generate whatever injection pressure is necessary to discharge this fuel through the spray holes of the nozzle into the combustion chamber.

Because of design variations, metering and circulation of drain fuel occur at the same time in the flange type injector, but at different times in the cylindrical type.

A cylindrical injector (PTD type) retains the basic principles of Pressure-Time fuel metering and camshaft controlled injection. It consists of a two-piece body called the adaptor and barrel, and the injector plunger and two-piece injector cup. The two-piece body reduces the cost of replacement components. The shorter barrel allows closer plunger-to-barrel fit and the use of greater wear-resistant materials in the wear area. This in turn helps to eliminate the possibility of plunger erosion and carboning, and minimises the danger of plunger seizure.

![Fig. 5.10 Operating sequence for flanged injector](attachment:image)
UNIT 5.3  SHIP'S FUEL SYSTEM

STUDY Figure 4.2 in this Section Book. Then compare the valve system with that in Figure 5.12 below.

You should now fully understand the purpose of all the components shown in Figure 5.12. If not, now is the time to refer back to your notes in this Section Book, and your text book (Eyres). Remember to use the index in the back of Eyres to help you find the information you require.
STORAGE

Typical fuel tank consists of:

a) Suction valve - three positions:
   (i) Shut - tank isolated.
   (ii) Fully open - when filling or transferring to tank.
   (iii) Non-return - when pumping from tank.

b) Manhole inspection door - allows access for cleaning and inspection.

c) Vent pipe - to weather deck or ‘tween decks, allows air into or out of tank. Wire gauze outlet anti-flash guard.

d) Sounding tube - flexible tape measures depth to determine amount in tank.

e) Tank heating steam coils - can pre-heat fuel in arctic conditions to make it ‘pumpable’. (FFO is viscous at low temperature.)

UNIT 5.4 SELF-TEST EXERCISE

The answers to these questions can be found at the end of this book.

1. What is the purpose of a screw-down valve?
2. What is the purpose of a S.D.N.R.?
3. When should all screw-down valves be opened up, checked and maintained?
4. What are the rules concerning collision bulkhead valves?
General Design Requirements

INTRODUCTION
A ship is nothing more than a watertight container with its own means of propulsion. Its purpose is to carry a cargo (be it fish, general cargo, bulk liquids, people, or smaller containers) or to perform specific tasks (warships, survey vessels, fishing vessels).

A vessel's viability is determined by how well it performs its tasks, or how much money it makes from the cargo it carries. In reality, all ships carry cargo - the survey vessel its instruments, the fishing vessel its catch, and the warship its weapons and troops.

Ship designers and naval architects are employed to find new ways for ships to perform the tasks appointed to them in a more efficient manner, but at the same time maintain adequate standards of safety.

In Part B we will discuss the general design requirements in ship building, and the need for and the intention of the Marine Survey Regulations.

OBJECTIVES
At the end of this Section you will be familiar with the purpose of the Survey Regulations and the basic design requirements that they ensure are met.

UNIT 6.1 WA MARINE ACT
The WA Marine Act, Division 5, contains the general laws pertaining to surveys and certificates of survey. The Act refers to the Regulations pursuant to the WA Marine Act for details of the survey requirements. The important points to note under Division 5 are:

a) If you ply your ship without a valid certificate of survey you could be fined up to $2,000. Ignorance of the Act is not an acceptable defence!

b) If you have a valid survey certificate but fail to display it, you could be fined up to $500.

c) If you carry more persons on board your vessel than your survey certificates allows, you could be fined up to $2,000 for a first offence and $3,000 for a second offence. In addition, you could be fined $20 for each person beyond the number that the vessel is allowed to carry.

However, in the case of emergency and trying to save life at sea, you can carry as many people as your ship will hold.
UNIT 6.2 MARINE (SURVEYS AND CERTIFICATES OF SURVEY) REGULATIONS

Below are reproduced extracts from the Survey Regulations covering initial and periodic surveys. Read through them and NOTE how they apply to you.

PART II—SURVEY REQUIREMENTS.

5. (1) Every new vessel constructed under the jurisdiction of the State and every existing vessel being brought under survey for the first time is required to undergo an initial survey for the purpose of satisfying the General Manager that the vessel complies with the laws of the State.

(2) An application for initial survey shall be made to the General Manager in the specified form and shall be accompanied by the appropriate survey fee set out in Schedule 1.

(3) An application for initial survey shall be accompanied by the following information—

(a) type and purpose of vessel;

(b) intended area of operations;

(c) whether vessel is to be classed and if so, name of the Classification Society (for existing vessel the details of any Classification);

(d) plans and details of hull, boilers and machinery, and equipment;

(e) such other information as the General Manager may require;

and

(f) where a vessel is, or is to be, classed, the owner shall forward to the General Manager only such plans and details as are relevant to the General Manager's own survey and the other plans and details shall be forwarded to the Classification Society.
(4) The information required to be provided to the Authority under subregulation (3) shall be submitted—

(a) in the case of a new vessel, prior to the commencement of construction (and construction shall not begin until the General Manager has given his approval); and

(b) in the case of an existing vessel, in such time as is provided by regulation 6(7) with respect to applications for periodic survey.

(5) Subject to subregulation (6), an initial survey shall be carried out in full by the Department’s surveyors who shall forward to the General Manager in writing, and in a form approved by the General Manager, a report of the condition of the hull and the boilers and machinery and equipment of the vessel.

(6) The General Manager may accept the performance of all or part of an initial survey by a survey authority.

6. (1) Subsequent to the initial survey, every vessel is required to undergo periodic surveys and inspections for the purpose of satisfying the General Manager that the vessel continues to comply with the laws of the State.

(2) The General Manager may accept the performance of all or part of a periodic survey or inspection by a survey authority.

(3) The intervals between surveys shall be as follows—

(a) a vessel’s equipment shall be surveyed at intervals not exceeding 1 year;

(b) a vessel’s hull, structure, boilers and machinery, and fittings shall be surveyed at the intervals specified in a survey programme approved by the General Manager or alternatively in accordance with the requirements of Schedule 2, except that the General Manager may in a particular case require lesser intervals than those in Schedule 2 if considered desirable because of—

(i) the age of the vessel;

(ii) the service of the vessel (passenger, cargo or fishing);

(iii) the area or proposed area of operation of the vessel;

(iv) the materials used in and the method of construction of the vessel;

(v) the type of underwater fittings of the vessel;

(vi) the size of the vessel; or

(vii) any other reason.

(4) The owner may submit a survey programme for a vessel to the General Manager for his approval. In drawing up such a programme, consideration shall be given to—

(a) the survey requirements and intervals in Schedule 2; and

(b) the specific requirements of the General Manager.

(5) Where a survey programme has been approved by the General Manager under this regulation, the survey of particular items shall be carried out in accordance with that programme, except where the General Manager directs otherwise or agrees to modify, defer, or cancel the programme.

(6) An application for periodic survey shall be made to the General Manager in the specified form and shall be accompanied by the appropriate survey fee set out in Schedule 1.
(7) An application for survey shall be made by the owner of a vessel—

(a) in the case of the survey of a vessel out of the water, not less than 7 days before the date on which the survey is to be performed;

(b) in respect of a survey of boilers and machinery or equipment or both—

(i) where the survey is to be made within the metropolitan area of Perth or at Geraldton, not less than 14 days before the date on which the survey is to be performed;

(ii) where the survey is to be made elsewhere than in the metropolitan area of Perth or at Geraldton, not less than 14 days before the date specified for surveys in that port or place in a programme of surveys issued by the Department and available at offices of the Department from 30 January in each year,

and the owner shall cause the vessel to be presented for survey at the port or place stated in the application at the time and date notified to him by the Department.

(8) Where a survey or inspection of a vessel’s hull is to be carried out, the owner shall cause the vessel to be withdrawn from the water and placed in a satisfactory manner to enable the surveyor to make an external examination of the hull, underwater fittings, shafting, propeller, rudder and any other appurtenances. Prior to such examination the hull shall have been washed and cleaned, but shall not have been painted.

(9) During the course of a survey or inspection the surveyor shall have discretion to require the opening up for examination of any other part or parts of the vessel including removal of linings and permanent ballast where applicable.

(10) After a survey or inspection the surveyor shall make in the manner or form required by the General Manager a duplicate List of Repairs and Deficiencies which shall be counter signed by the owner who shall retain one copy. The survey will not be completed until such repairs and deficiencies have been made good to the satisfaction of the surveyor.

(11) On completion of a survey or inspection, the surveyor shall make his report to the General Manager in writing and in a form approved by the General Manager.

(12) On completion of an item or stage of an approved survey programme, the surveyor shall sign the owner’s copy, the vessel’s copy and the General Manager’s copy of the programme documents and shall also make a report to the General Manager concerning the item or stage surveyed.

(13) When making a survey or inspection of a vessel, a surveyor shall be accompanied by the owner.
UNIT 6.3 INITIAL SURVEYS

These must be conducted before the vessel is brought into service. The main purpose of this survey is to ensure that the vessel will be able to perform the tasks for which it is intended. All aspects of the vessel’s construction are examined to ensure that it meets the requirements of Section 5 of the U.S.L. Code. A Load Line Certificate must accompany the application for an Initial Survey. The purpose of Load Lines, as will be discussed in Section 14, is to ensure that the vessel will have sufficient freeboard in all conditions of loading to avoid being overcome by the sea, in the normal weather conditions she would be expected to meet. Before Load Lines can be issued, all aspects of the vessel’s watertight integrity are examined to ensure that they meet the basic requirements as laid down in the U.S.L. Code.

When a person designs a vessel, there is little point in drawing a picture of what he thinks he wants, and then building it, hoping that the end result will be satisfactory. The ‘T.L.A.R. Method’ (that looks about right) is a dangerous one, to say the least.

The U.S.L. Code prescribes minimum sizes and strengths of materials to be used in construction of steel, aluminium GRP, ferrocement and wooden boats. Obviously, a designer wants to ensure that his vessel will be capable of withstanding all reasonable stresses due to weather and handling, that she is likely to be subjected to under operating conditions.

The purpose of the U.S.L. Code, and the survey regulations which enforce it, is to ensure that no cost-cutting measures employed by designers will sacrifice the safety and seaworthiness of the vessel. Equally obvious is the fact that the vessel should be sufficiently strong to cope with the seas/waters in which she is intended to operate, and that she should remain seaworthy at all times. The initial survey is simply to ensure that this principle has been adhered to by the designer.

The naval architect/designer is required to produce (with the initial survey application) plans giving full details of:

a) (i) transverse structure
   (ii) longitudinal structure
   (iii) stern frame, rudder and steering arrangements
   (iv) propeller shaft brackets
   (v) main engine seatings and main thrust seatings
   (vi) the structure and closing appliances of openings in any exposed decks, the superstructure, bulkheads, and in the vessel’s sides.

b) a General Arrangement Plan (See Section 1 Unit 1.7)

c) details showing arrangements for the protection of the crew

d) details showing the subdivision (watertight bulkheads) arrangements and calculations

e) intact and damaged stability data including:
   i) a capacity plan
   ii) hydrostatic curves
   iii) cross curves of stability.

From the detailed structural plans, the naval architect is able to calculate roughly how much material is to be used in the construction of the ship (lengths and dimensions of each member are known and hence its weight can be calculated) and thus calculate the weight distribution of the vessel. (All this can be worked out before the first piece of material is cut.)
From his plans it is also relatively simple, using Simpson’s rules and Bonjain curves (you will learn about these when you progress to higher grade certificates), to calculate the underwater volume of the vessel at different drafts. The weight of the vessel can be calculated for each of these drafts and the thrust of buoyancy about the waterplane area that the vessel will experience. This way the designer can verify that his vessel will float at an acceptable draft and trim.

The other consideration of design is to ensure that the vessel is capable of safely performing its design tasks.

For example, a barge or punt used for receiving cargo from vessels too large to berth should have sufficient stability to receive the cargoes it would have to carry. There should be sufficient lashing points on the deck to secure cargoes against shifting and thus upsetting the load. If the naval architect’s calculations show that the vessel will not have sufficient stability to safely perform its tasks, it should be redesigned - because it will not pass its surveys.

Reproduced below is the checklist used by the Department for Planning and Infrastructure when conducting the Initial Survey. (Also used for periodical surveys.)
### AUXILIARY MACHINERY

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>Make</th>
<th>Model</th>
<th>kW</th>
</tr>
</thead>
</table>

**Purpose of Auxiliary Engine:**

<table>
<thead>
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<th>No.</th>
<th>Type</th>
<th>Make</th>
<th>Model</th>
<th>kW</th>
</tr>
</thead>
</table>

**Purpose of Auxiliary Engine:**

<table>
<thead>
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<th>Refrigerant Gas Type</th>
<th>Qty/Volume</th>
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</thead>
</table>

### TANK LAYOUT

**Fuel Oil**

<table>
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<tr>
<th>No. &amp; Position of Tanks</th>
<th>Quantity of Oil</th>
</tr>
</thead>
</table>

| Fresh Water

<table>
<thead>
<tr>
<th>No. &amp; Position of Tanks</th>
<th>Quantity of Fresh Water</th>
</tr>
</thead>
</table>

### ELECTRICAL INSTALLATION

**Battery Details:**

---

### Marine Safety – Commercial Vessel Safety Branch

**MASTER SURVEY SHEET**

(This form is requested to be completed by the Builder before initial survey)

**Name of Vessel:**

**M/H No.:**

**Class(es) of Survey:**

**Description of Vessel:**

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>(m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>(m)</td>
</tr>
<tr>
<td>Max Beam at Deck Level</td>
<td>(m)</td>
</tr>
</tbody>
</table>

**Area of Operation:**

**Year Completed:**

**Date of Initial Survey:**

**Builder:**

**Classification Society Certification:**

**Stability Book Approval:**

**Load Line Issued:**

**Assigning Authority:**

### HULL DETAIL

**Vessel Construction Material:**

**Plating/Planking:**

**Frames and Frame spacing:**

**Stringer and Stringer spacing:**

**Bulwarks:**

**Bulwark/Guardrail Height:**

**Freeing Port Area:**

**FRP Sandwich or Single skin:**

**Laminate Detail:**

---

### STEERING GEAR (type):

**Tiller Arm Length:**

**Rudder stock (diameter and material):**

---

### PROPULSION MACHINERY DETAILS

<table>
<thead>
<tr>
<th>Type</th>
<th>Make</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max continuous kW</td>
<td>kW</td>
<td>r.p.m.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Cylinders</th>
<th>Two or Four Cycle</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Total Fuel Capacity</th>
<th>(Lt)</th>
<th>Approx. Range</th>
<th>(Nm)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Twin or single screw</th>
</tr>
</thead>
</table>

**Diameter & Pitch of Propellers:**

**Method of reversing:**

**Intermediate Shaft(s) Diameter:**

**Material:**

**Propeller Shaft(s) Diameter:**

**Material:**

---
UNIT 6.4 PERIODICAL SURVEYS

The Load Line Certificate issued under the WA Marine (Load Lines) Regulations is valid for five years but a Load Line Survey is to be conducted annually to ensure that the vessel is maintaining the standards upon which the certificate was issued. A Periodical Survey described in Section 7, part 7 of the U.S.L. Code is carried out at the same time. The first Periodical Survey is due one year from the date of the issue of the Initial Survey Certificate. A three-month period of grace is allowed but must be applied for. If the vessel will be at sea, or it would not be reasonable for it to undergo its Periodical Survey on the due date, then the owner may make an application for an extension of his Certificate of Survey. The application is made to the General Manager of the Department of Marine and Harbours in Fremantle.

The General Manager may require an inspection of the vessel before granting the extension. This is to ensure that the general condition of the vessel is not such as to render it unseaworthy. This requirement is only to protect the crew of the vessel in question.

It is in your own interest, as master, not to hide any deficiencies from the surveyors. Owners will be required to correct any deficiencies that are noted before the vessel passes its survey. Remember, no shipowner is risking his or her life when forcing you to sail an unseaworthy ship.

The periodical surveys are quite thorough. The schedule covering the items to be inspected is reproduced below. You should be familiar with what is covered in a Periodical Survey.

The following extract from the WA Marine Act (1982) is reproduced with the permission of the Attorney General. This is for reference only.

NOTE: Students should refer to USL Code for more detailed information.

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SCHEDULE 2.
SURVEY REQUIREMENTS AND INTERVALS.

Appendix II.

In this Appendix items listed shall be subjected to a survey unless otherwise indicated.

PART I—VESSELS LESS THAN 35 METRES IN LENGTH.

Annual Surveys.
1. Equipment.
2. Running trial of each main engine and associated gear box.
3. Operational test of bilge pumps, bilge alarms and bilge valves.
4. Operational test of all valves in the fire main systems.
5. Operational test of all sea injections and overboard discharge valves and cocks.
6. Operational test of main and emergency means of steering.
7. Running trial of all machinery essential to the safe operation of the vessel.
8. Inspection of all pipe arrangements.
9. General examination of machinery installation and electrical installation.
10. All safety and relief valves associated with the safe operation of the vessel to be set at the required working pressure.
11. Pressure vessels, and associated mountings used for the generation of steam under pressure or the heating of water to a temperature exceeding 99° C.
12. Inspection of the liquified petroleum gas installation.
13. Inspection of cargo handling, fishing and trawling gear.
15. Inspection of personnel protection arrangements in machinery spaces.
16. Inspection of casings, superstructures, skylights, hatchways, companionways, bulwarks and guard rails, ventilators and air pipes, together with all closing devices.
17. Inspection of ground tackle.

Two Yearly Surveys.
18. Hull externally and internally except in way of tanks forming part of the structure.
19. Sea injection and overboard discharge valves and cocks.
20. Inspection of propellers, rudders and underwater fittings.
21. Pressure vessel and associated mountings, of an air pressure/salt water system having a working pressure of more than 275 kPa.

Four Yearly Surveys.
22. Each screw and tube shaft.
23. Anchors and cables to range.
24. Chain locker internally.
25. Tanks forming part of the hull, other than oil tanks, internally.
27. Compressed air pressure vessels having a working pressure of more than 275 kPa and associated mountings.
28. Pressure vessel and associated mountings of an air pressure/fresh water system having a working pressure of more than 275 kPa.
29. Cargo handling, fishing and trawling gear.
30. Insulation tests of all electrical installations above 32V A.C. or D.C.

Eight Yearly Surveys.
31. Each rudder stock and rudder stock bearing.
32. Steering gear.
33. Hull in way of removable ballast.
34. Selected sections of internal structure in way of refrigerated space.

Twelve Yearly Surveys.
35. Fuel oil tanks internally.

Other Survey Periods.
36. The survey period for an item not specified in this Part shall be that period determined by the Authority.

PART II—VESSELS OF 35 METRES IN LENGTH AND OVER.

Annual Surveys.
1. Equipment.
2. Running trial of each main engine and associated gear box.
3. Operation test of all valves in the fire main system.
4. Operational test of all sea injection and overboard discharge valves and cocks.
5. Operational test of main and emergency means of steering.
6. Running trial of all machinery essential to the safe operation of the vessel.
7. Inspection of all pipe arrangements.
8. General inspection of machinery installation and electrical installation.
9. All safety and relief valves associated with the safe operation of the vessel to be set at the required working pressure.
10. Pressure vessels used for the generation of steam at a pressure not exceeding 345 kPa or for heating water to a temperature exceeding 99° C together with their associated mountings (not being a boiler referred to in items 16 and 23).
11. Inspection of the liquified petroleum gas installation.
12. Inspection of cargo handling, fishing and trawling gear.
13. Inspection of escapes from engine room and accommodation spaces.
15. Inspection of casings, superstructures, skylights, hatchways, companionways, bulwarks and guard rails, ventilators and air pipes, together with all closing devices.
16. A boiler and its mountings where the boiler has been in service for more than eight years (not being a pressure vessel referred to in item 10).
17. An evaporator and its mountings which has been in service for more than eight years, and in which the operating pressure is above atmospheric.
Two Year Surveys.
18. Hull externally and internally except in way of tanks forming part of the structure.
19. Sea cocks and valves, bilge injection valves and overboard discharge valves, of ferrous construction.
20. Inspection of propellers, rudders and under water fittings.
22. Pressure vessel and associate mountings of an air pressure/salt system having a working pressure of more than 275 kPa.
23. A boiler and its mountings where the boiler has been in service for less than eight years (not being a pressure vessel referred to in item 10).
24. An evaporator and its mountings, which has been in service for less than eight years, and in which the operating pressure is above atmospheric.

Four Yearly Surveys.
25. Sea cocks and valves, bilge injection valves and overboard discharge valves, of non ferrous construction.
27. Independent pumps used for pumping sea water, fresh water, fuel oil, condensate and boiler feed.
28. Air receivers and mountings, selected sections of air piping and explosion protection devices.
29. Main propulsion intermediate shafting.
30. Evaporators and mountings in which the operating pressure is at or below atmospheric pressure.
31. Anchors and cables and all links and joining shackles.
32. Windlass.
33. Condensers, lubricating oil coolers, jacket water coolers, drain coolers, distillers and air ejectors.
34. Boiler feed water heaters.
35. Oil fuel heaters.
36. Gear boxes to such extent necessary to ensure satisfactory condition.
37. Screw and tube shafts.
38. Internal combustion engined auxiliary generators other than emergency generators.
40. Main engine, steam turbines.
41. Main engine, internal combustion engines.
42. Selected lengths of steel steam pipes having bolted joints and carrying steam at a temperature exceeding 455° C. Also hydraulic test of those lengths.
43. Steel pipes having welded joints carrying steam at a temperature exceeding 455° C. Also hydraulic test of those lengths.
44. Pressure vessel and associated mountings of an air pressure/fresh water system having a working pressure of more than 275 kPa.
45. After the twelfth year in service all solid drawn copper steam pipes having an internal diameter exceeding 75 mm are to be annealed and hydraulically tested.

46. After the twelfth year in service selected lengths of steel steam pipes having an internal diameter exceeding 75 mm and carrying steam not exceeding 455° C are to be hydraulically tested.

Five Yearly Surveys.

47. Peak tanks internally. Peak tanks are to be tested to a head sufficient to give the maximum pressure than can be experienced in service.

48. Deep tanks (except those tanks used exclusively for oil fuel) internally. All deep tanks are to be tested to a head sufficient to give the maximum pressure that can be experienced in service. Deep tanks used exclusively for oil fuel need not be examined internally subject to satisfactory external survey and hydraulic test.

49. Double bottom tanks (except those tanks used exclusively for oil fuel) internally. All double bottom tanks are to be tested to a head sufficient to give the maximum pressure that can be experienced in service. Double bottom tanks used exclusively for oil fuel need not be examined internally subject to satisfactory external survey and hydraulic test.

50. Ballast tanks and tanks forming part of the ship’s main structure internally. Ballast tanks and tanks forming part of the ship’s structure are to be hydraulically tested to a head sufficient to give the maximum pressure that can be experienced in service.

Six Yearly Survey.

51. Independent pumps used solely for pumping lubricating oil (except those pumps used for the supply of oil under pressure to hydraulically operated machinery).

Eight Yearly Surveys.

52. Independent pumps used for the supply of lubricating oil under pressure to hydraulically operated machinery.

53. Electrically operated or hydraulically operated steering gear.

54. All solid drawn copper steam pipes having an internal diameter exceeding 75 mm are to be annealed and hydraulically tested.

55. Selected lengths of steel steam pipes having an internal diameter exceeding 75 mm and carrying steam at a temperature not exceeding 455° C are to be hydraulically tested.

Other Survey Periods.

56. Emergency generator i.e. generator used normally for emergency purposes shall be surveyed once in the first 12 years and thereafter once in every subsequent period of eight years.

57. One deep tank that is used exclusively for fuel oil to be surveyed internally every five years starting when the ship is 10 years old and all such deep tanks to be surveyed by the time the ship is 25 years old.

58. At least one double bottom tank that is used exclusively for fuel oil to be surveyed internally every five years starting when the ship is 10 years old and all such double bottom tanks to be surveyed by the time the ship is 25 years old.

59. The survey period for an item not specified in this Part shall be that period determined by the Authority.

By His Excellency’s Command,

J. E. A. PRITCHARD,
Clerk of the Council.
For an initial Survey Certificate to be issued (and a Load Line Certificate) it must first be ascertained that the vessel has sufficient structural strength for it to be loaded to its freeboard drafts. In addition, it is to have sufficient stability in all conditions of loading, right down to the draft at the assigned freeboard.

The main purpose of the Periodical Survey is to ascertain that the structural strength has not deteriorated to such an extent that she no longer complies with this requirement. It is also to determine if any alterations have been made to the hull or superstructures which would alter the conditions upon which its summer freeboard was assigned. Also, the fittings and appliances for the protection of openings, guard rails, freeing ports, and means of access to the crew’s quarters are inspected to ensure that they are maintained in an effective condition.

The surveyor should also inspect the stability information, loading information (for avoiding dangerous stresses) and the freeboard assigning authority’s statement setting out the conditions of assignment as required in Section 7, Part 2 of the U.S.L. Code.

UNIT 6.5 CLASSIFICATION SOCIETIES

FUNCTIONS

There are eight classification societies throughout the world:

- Lloyds Register of Shipping (LR)
- American Bureau of Shipping (ABS)
- Bureau Veritas (BV)
- Der Norske Veritas (NV)
- Germanischer Lloyd (GL)
- Registro Italiano (RI)
- Registrar of Shipping (USSR)
- Nippon Kaiji Kyokai (NKK)

Apart from the Russian Register, they operate in a similar fashion and the following remarks could apply equally well to any of them. A classification society’s main function is that of an information bureau for insurers. The insurance of ships and their cargoes is a truly international business, and there is clearly no way that an insurer could have personal knowledge of the ships in which they are financially concerned. It was from this basic need of knowledge by insurers, so that they could assess the risk, that classification societies grew. They classify, or arrange in order of merit, such ships as are built to their rules or are subsequently offered for classification, and a classed ship can then be considered by all interested parties to have a particular standard of seaworthiness.

Nowadays, the classification society is closely involved with a ship on its register from the initial design stage, through construction and then regular surveys throughout its working life. For a new ship to be classed at Lloyds, for example, approval is necessary for the constructional plans (the design would have been based on Lloyd’s table of scantlings), the materials used (samples of the steel, for example, are tested and then marked when approved) and the constructional methods and standards (construction is observed throughout by a society surveyor). When construction is complete, the general committee (on the basis of the surveyor’s report) will award a class to the ship,
and the ship is then entered on the register. This information is then available to insurers, chatterers, skippers, potential purchasers and other interested parties, throughout the sea transport industry. Not only the hull is surveyed, of course; the ship’s equipment and machinery are also classed. The symbols used are important. For example: + 100 A 1 LMC UMS.

This means:

- + vessel built under supervision of Society’s surveyor.
- 100 hull built to highest standard laid down in the rules.
- 1 equipment, such as anchors and cables, in good and efficient condition.
- LMC Lloyd’s Machinery Certificate. Machinery built according to society rules and proved satisfactory in sea trials.
- UMS Machinery installation satisfied the rules for unattended machinery spaces.

Once a ship is classed, it is inspected regularly by the Society’s surveyors to ensure that it is maintained to the required standard to retain its class. It is not essential to use a classification society when using a state or federal authority.

**Benefits to Shipowners**

A shipowner is not legally required to class his or her ship and, in fact, some vessels are not classed. However, in most cases, it is in the owner’s interest to class his or her vessel and to maintain it with the requirements of the class through its working life. Advantages are:

- approval of plans ensures that the design will produce a vessel of sufficient strength and incorporating all the features necessary for its planned role
- supervision of construction by the society’s surveyor ensures the use of appropriate materials and required standard of workmanship
- reduced insurance premium for a vessel in class
- charterers and shippers will readily accept that a classed vessel has the required seaworthiness to carry their cargoes
- potential buyers will be aware that, to have retained class, a vessel must have been maintained at a certain minimum standard
- vessel can be sold or resold for delivery anywhere.

**Surveys to Retain Class**

After the initial classification of a ship, periodic surveys are required in order that it may retain class. They are:

- Annual survey (Load Line Survey).
- Docking survey. Generally every 12 months but certainly no more than two years. General condition of vessel is assessed, particularly shell plates, stern frame, rudder, etc.
- Special survey. Every four years, although a period of grace for an extra 12 months may be granted. Special surveys are categorised A, B, C and D - A being the first one and D being the first after the vessel is 20 years old - and the amount on inspection gradually increases.
- Damage repair surveys. Any repairs to damaged hull or equipment must be carried out to the specifications of the Society’s surveyor.
UNIT 6.6 SELF-TEST EXERCISE

The answers to these questions can be found at the end of this Section Book.

1. What is the purpose of the Survey Regulations?
2. What are the basic design requirements?
3. Which vessels are required to have an Initial Survey?
4. What is the purpose of an Initial Survey?
5. When are Periodical Surveys due, and what extension period may be granted if it is not possible to have a Periodical Survey on the due date?
SECTION 7

Steering Gear

INTRODUCTION

Mark Twain, who had been a Mississippi river pilot, once said ‘Steering gear is nothing more than an oar with a college education’.

Although rudders and steering gears have replaced the steering oar, it is still recognised as a valid method of steering a small vessel. Life boats, today, are still equipped with a steering oar, in addition to the normal rudder and tiller.

The early Egyptian rudder was essentially a broad-bladed oar, lashed loosely to the vessel’s side and to a support post on the deck. A tiller bit was fastened to the handle of the oar and, by pushing the tiller back and forth transversely, a torque was applied and steering was effected. The oar could be raised or lowered, depending on the depth of water, or as required.

The Vikings used a similar method of steering. Metal rings replaced the rope lashings. A large tiller was mounted athwartships and the helmsman could grasp this and put his whole weight behind it, using his back and leg muscles. The stock (shaft of the oar) of this simple rudder was held in place by a broad, plaited strap and the blade was kept aligned by an elastic cord woven from pine roots. The oar was always mounted on the right-hand side, which became known as the steering side. In Norse it was ‘Styonbord’, from which we derive the English starboard.

Around the time of William the conqueror, alterations in the design of ships included a vertical stern post to carry a true rudder, and the tiller became a fore-and-aft lever directly attached to the rudder - as we know and use it today. Ships were small enough to allow the rudder to be controlled by one man or by a few men. As ships became larger, and decks were added above, the tiller became submerged and an alternative method of controlling it from above was sought.

The Whipstaff appeared towards the end of the 15th century. This device was a long pole with a ring at the end. The ring fitted over the end of the tiller. The pole passed through a hole in a platform above the tiller where it was hinged, and up through an athwartship’s slot in the main deck, which allowed the whipstaff to be swung from side to side. The helmsman held the upper end and steered the ship by moving the whipstaff. Because of the fulcrum, if he wished to turn the ship to starboard, he moved the whipstaff to starboard (See Figure 7.1).

This system was inefficient as the helm movement was restricted to a small arc. Large rudders were required to provide manoeuvrability, and these often became unmanageable in rough weather.
Rope tackles were later fitted to the tiller, doing away with the whipstaff. The hauling parts of the tackles were led through blocks to the steering position and joined together. When the rope was heaved in one direction, it would slack away in the other. Finally, the hauling part was wound around a drum and the steering wheel was born.

Small craft still use this method of steering, but usually the tackle is done away with since the rudders are very light (See Figure 7.2).
As ships became larger, manpower was not sufficient to operate the helm and other methods were designed, using powerful machines to turn the rudder.

The steering wheel now became the control which operated the steering motors. Many types of steam engines were tried as steering gear, but finally the electric motor replaced the steam engine. With the development of hydraulics, the electrohydraulic steering gear came into being. An electric motor drives a hydraulic oil pump, which powers two (sometimes four) hydraulic rams connected to the tiller. The direction of flow of the hydraulic oil in the system (and hence, the direction in which the rudder moves) is nowadays controlled by a Telemotor.

Fine proportional control is now possible, and 200,000 tonne ore carriers can be swung around by the effort of one finger.

In this Section we will study the various types of steering gear found in small vessels.

OBJECTIVES

By the end of this Section you should be able to:

- list the main components of a steering gear
- sketch a block diagram of the main components of a steering gear
- using the block diagram, explain how rudder control is effected.

UNIT 7.1 U.S.L. CODE REQUIREMENTS

All vessels, except twin-screw vessels (they can steer by changing revs on one or both screws) must have two effective independent means of steering. Small craft with only a hand tiller do not have to comply.

The second or emergency steering gear must be capable of being brought speedily into action. The steering gear must be strong enough to cope with the forces experienced at maximum speed without experiencing any damage. Rudder movement must be $35^\circ$ in each direction, unless otherwise authorised.

In vessels of more than 12.5 m in length, the steering gear must be able to move the rudder from $35^\circ$ helm on one side to $30^\circ$ helm on the other in less than 30 seconds, when the vessel is at maximum service speed. The wheel must not recoil violently.

Hydraulic systems must have a pressure relief valve. The wheel must be positioned so that the helmsman has a clear view ahead.

UNIT 7.2 TYPES OF STEERING GEAR

Today, hydraulic steering gear is by far the most popular. For any vessel other than a small pleasure craft, some form of power assisted steering is used.

Hydraulic systems can be scaled right down to suit the smallest vessel, or right up to the largest ones afloat.

Electric steering gears are still found, but they too are being superseded by the electro hydraulic.

A refinement on the gear shown in Figure 7.3 is the use of a quadrant to which the steering cables are attached.
Fig. 7.3 Quadrant Tiller

Under this system the angle of lead from the quadrant to the lead blocks remains the same. The quadrant is not rigidly attached to the tiller but by the buffer springs. This way, any wave shocks on the rudder are not transferred directly to the steering cables.

In an electric steering system, the quadrant would have gear teeth on the upper radius and the electric steering motor would drive the gears. The direction in which the motor would turn is linked by electrical circuit to the steering wheel in the wheelhouse. The amount of deflection of the rudder is measured by a follow-up potentiometer connected to the steering wheel.

UNIT 7.3 HYDRAULIC STEERING NOTES

READ the following notes and STUDY the diagrams.

BASIC SYSTEM

Hydraulic control for steering systems is used on almost all modern-day vessels. The systems vary in their construction and components used, but the basic theory and principle of operations remain unchanged. Provided that normal care and maintenance schedules are followed, very little, if any, trouble will be experienced from the modern hydraulically controlled system.

The system is designed on the use of hydraulic fluid under pressure to control the movement and position of the steering rudder. Fluid is moved in the system by means of a pump. The movement of the rudder is controlled by the use of a hydraulic cylinder or actuator, the movement of which is controlled by directional control valves.

One or two systems are found in most small vessels.

The first is a hand-operated system where the turning of the wheel actually turns an axial piston pump and delivers the fluid direct to the cylinder.

The second method is where a pump is driven off the main engine. The wheel turn delivers the amount of fluid needed to move the cylinder a set amount. More turns allow more movement to the cylinder.
HAND OPERATED SYSTEM

If the wheel is turned to starboard (RIGHT) hydraulic fluid is pumped by the axial pump, into the right side of the cylinder. While this is happening pressure is reduced on the left side of the cylinder and the cylinder rod is moved to the left. This causes the short tiller to follow to the left, moving the tip of the rudder right. The vessel then turns to the right (STARBOARD).

Fig. 7.4 Hand Operated Hydraulic Steering
UNIT 7.4 THE HYDRAULIC SYSTEM: DETAILED EXPLANATION

READ ‘Steering Gear’ in Chapter 21 of Eyres.

Now STUDY Figure 7.6 (in this study guide). It is a diagram of the hydraulic steering gear circuit of the tug ‘Tammar’.

Fig. 7.5 Pump Driven Steering System
Fig 7.6 Hydraulic Circuit

STOPS SET AT 37°
P & S

LEGEND

Piping supplied with steering gear.
Flexible hose supplied with steering gear.
Piping to be supplied by shipbuilder.
Use steel tubing, do not use black pipe.
Avoid goosenecks.
Flexible Hose to be supplied by shipbuilder.
Must have equivalent internal flow area and pressure rating as tubing.
Shut-off Valves supplied with steering gear.
Shut-off Valves supplied by shipbuilder,
for servicing purposes.
Bleed Fittings to be supplied by shipbuilder.
Add to highest points in all hydraulic lines for venting purposes.
Piping Tee's to be supplied by shipbuilder.

GENERAL NOTES

Outside Diameter of TUBING in millimetres.
Wall thickness to be determined by shipbuilder.
Maximum Pressure in Pascals.
Port Size - all connections NPT unless otherwise noted - see table code.
Additional Equipment - as noted.
Components supplied as one assembly.
This hydraulic steering gear has two hydraulic pumps. It can operate quite satisfactorily if only one pump is running. However, it is normal practice to use two pumps when high manoeuvrability is required.

Now, follow the numbers (circled) on the diagram as you read the following explanation on how the system works. We will assume that only pump no 1 is working. This pump is driven by a 3 hp electric motor. Oil is driven to the uniblock #1 (2) where it is directed along the hydraulic lines 3 and 10, depending on which way the rudder is to be turned.

Directional control may be obtained in one of two ways. When the wheel is turned, a signal is sent either electrically or via a telemotor to the steering gear, indicating the way that the helm is to be turned. If the pump is a two-way pump (one which can deliver oil in different directions such as the radial or axial piston pumps) then the hydraulic fluid will be pumped in the required direction along the correct line. On the other hand, the signal could operate a two-way valve in the uniblock. Let’s assume that we want to turn to starboard. Oil is then directed down line (3) to the base of the lower hydraulic ram at (4), and at the same time up the T joint (5) to the top of the upper (Port) ram at (6). This causes the starboard ram to extend and the port ram to retract, turning the tillers (13) in an anti-clockwise direction and giving the initial starboard helm.

Fluid now moves out of the base of the port ram (7) down the T joint (8) to return, together with the fluid leaving the stb ram (9) along the return line (10) to the uniblock.

Should there be any sudden shock pressures caused by waves, etc., the two-way pressure release valve (11) will open and relieve the shock pressure. This is a spring-loaded relief valve designed to lift at a pressure above the normal working pressures created when turning the rudders.

The follow-up connection at (12) measures exactly how far the rudder has moved. This amount is compared by an electronic comparator and, when the deflection equals that ordered by the signal from the steering wheel, the pump or two-way valve controls return to the neutral position and the correct amount of helm is applied.

Now trace out with a pencil on Figure 7.7 below how the fluid would flow if a port helm were ordered.
Fig 7.7 Hydraulic Circuit

STOP SET AT 37°
P & S

TIE ROD

HEADER TANK

FOLLOW UP WITH CONNECTIONS FOR RUDDER ANGLE INDICATOR SYSTEM

PUMP MODEL V110-1S

2kw Motor

UNI BLOCK #1

STOP

AFT
In Figure 7.7 all the auxiliary lines not concerned with the immediate problem have been removed.

Should the system leak hydraulic fluid (as all hydraulic systems do from time to time) the header tank is filled with fluid to top the system up, and to bleed off any air that might get into it.

Should there be a power failure, the helmsman can operate a lever (which is a valve) at the steering position and use the steering wheel as a hand pump. That is, oil can be manually pumped into the lines and the rudders still operated in an emergency. The other two valves (14) which are normally closed, will have to be opened before the helm pump could work.

UNIT 7.5 BRIDGE CONTROL - THE HELM

There are two methods of communicating the helm order to the steering gear: Mechanical and Electrical.

Electrical is the preferred method nowadays, since modern electronics has made the communication and interpretation of electrical signals very easy. Electrical systems are cheaper, easier to install and require practically no maintenance.

The principle is very simple.

Turning the wheel moves the potential divider of a potentiometer. This creates a positive (let’s say for starboard) or a negative voltage (let’s say for port). The further the wheel is turned, the greater the voltage, and hence the greater the current flow. The current is a direct current which is relayed to the steering gear. This current is identified, amplified and used to drive the control that directs the oil flow in the hydraulic lines.

The follow-up system is so designed that, when the movement of the wheel causes a current in one direction, the follow-up causes an opposite current which increases as the rudder moves. When the two currents are of equal magnitude, they cancel each other out, and the hydraulic pump/fluid directional control returns to its neutral position.

The mechanical type of steering motor control is usually a hydraulic telemotor. It consists of two hydraulic fluid-filled pistons mounted at the steering wheel. Assume a starboard helm order is given. The wheel is turned to starboard and the starboard piston is depressed while the port piston is raised.

The fluid is piped to the steering gear control where it moves one end of a floating lever in the correct direction. The control lever of the hydraulic steering gear pump is connected to the middle of this lever and the other end is connected to an arm attached to the tiller. See Figure 7.8 below.
Fig. 7.8 Telemotor control

When the telemotor ram moves, the floating lever also moves, driving the bell crank and the steering gear control. When the rudder moves in the right direction, it draws the floating lever with it which in turn moves the bell crank in the opposite direction and the control lever returns to the neutral position when the desired angle of helm is reached.

The whole telemotor system could then be summed up as:
1) A transmitter (the wheel).
2) A receiver (the telemotor ram and linkage via bell crank to the controller).
3) A controller (the actual pump control or fluid control).
4) A comparator (the floating lever and connection to the tiller).
UNIT 7.6 SUMMARY

The whole steering gear assembly could be summarised in a block diagram as follows. (See Figure 7.9.)

![Block Diagram of Steering Gear Assembly](image)

UNIT 7.7 SMALL CRAFT STEERING

There are many different types of steering mechanisms available, but they can be grouped into four main categories when all the sophisticated trimmings are removed. All have the same function to perform - namely, to turn the tiller and in so doing, steer the vessel. There are not many boats which still rely upon the tiller alone.

In some cases the tiller would need to be of great length in order to develop the leverage necessary to make the steering easy. This would create a hazard aboard the boat - fouling ropes, tripping busy crew, etc.

Many years ago this wheel was developed and coupled to the tiller via ropes, wires and chains. The mechanical advantage gained depends upon the diameter of the wheel, the diameter of the drum holding the wire or rope, and the length of the tiller.

Modern gear still uses the basic design with improved connections between wheel and tiller.

The main types are described below.

**Wire and Pulley**

For efficient operation, the pulleys should be as large as practical, to permit the wire to bend without undue pressure being exerted, and to minimise the actual bending of the
strands.

The diameter of these pulleys could range between 50 mm and 100 mm if 16 millimetre wire is being used. These sizes are suggested as this type of steering is found in the smaller yacht or powered dinghy. Figures 7.10(a) and 7.10(b) show some typical arrangements.

**Fig. 7.10(a) Yacht**

**Fig. 7.10(b) Launch**

*Chain and Steering Box*

This consists of two gears mounted behind the steering bulkhead, and connected with chain. A rod or tube leads from the lower gear to the stern of the vessel and is attached to the steering box. The box may be an automobile type or an expensive reduction gear, if the occasion demands. (Figure 7.11)

**Fig. 7.11**

The movement of the tiller is again of prime importance. It should be of sufficient length to give good leverage. Remember that the length will also have an effect upon the movement of the steering wheel.

Other points to consider:

(a) The gear diameter ratios must be selected to give correct revolutions to the steering box, which in turn will move the tiller the required amount, usually 35 degrees each side of centre.
(b) The steering arm length is normally the same as the tiller although this can be varied slightly if more or less movement is needed on rudder.

(c) The steering arm should be pointing in the same direction as the tiller - both aft or both forward - or a lock-up can result. If one is reversed to change rudder direction, as is sometimes necessary if the steering box is in an awkward position, extreme care must be taken.

(d) As the chain may stretch, the gear spacing should be made adjustable.

**Push-Pull Cable**

This type is purchased from the chandlers ready to install. The flexible inner and outer cable are easily attached to the steering wheel, which is precision-engineered and ready to mount.

It will suit most craft up to about ten metres in length, having a positive movement with no slack, as is sometimes found in the previous two types. (Figures 7.12(a) and 7.12(b)).

![Fig. 7.12 (a) TYPE ‘A’](image1)

![Fig. 7.12(b) TYPE ‘B’](image2)

Again, the main point to consider is the tiller length. The cable movement will be related to rudder angle. This type is most suitable for outboard motors.

**Hydraulic**

Hydraulic systems are available to suit a large range of craft. However they are rarely installed in dinghies or other small craft as weight and cost favour the other types.

Hydraulics are often used in medium to large boats because:

(a) several steering positions can be set up more neatly and easily, than the other types allow

(b) there is no backlash on to the wheel during bad weather, giving effortless handling

(c) there is very little maintenance, as hydraulic systems have few wearing parts

(d) hydraulic systems can be easily attached to an automatic steering device.

Yachtsmen do not usually favour this manner of steering as there is no ‘feel’ on the wheel. (Figure 7.13)
UNIT 7.8  SELF-TEST EXERCISE

The answers to this self test are provided at the back of the book.

1. Figure 7.14 shows a schematic layout of a steering gear (hydraulic) system. Supply the missing labels.

2. What are the requirements regarding the performance of steering gear?
SECTION 8

Electrical Distribution Systems

INTRODUCTION

Nowadays, a person entering a darkened room flips a switch and the lights come on. We take the modern miracle of electrical power for granted. Electrical power is also used at sea, and has replaced most other forms of power.

It is rare to find oil navigation lamps, or steam winches - even on steam-powered vessels, where obtaining steam is not a problem. It is far easier to transfer power down an electrical cable than to use the pipes and hoses that are required for steam and compressed air.

However, with the boon that electricity has brought, various problems have also arisen. Electricity can spark, burn, cause fires and electrocute. Electrical appliances often generate toxic fumes, and electrical currents cause corrosion. But, having stated the dangers and disadvantages of electrical power, when they are balanced against the tasks that it can perform, the benefits far outweigh its complications.

In this Section we will look at the distribution of electrical power on board ships in general, and on the tug ‘Tammar’ in particular.

OBJECTIVES

By the end of Section 8 you should be able to:

• describe the safety devices and arrangements associated with electrical distribution systems
• describe the safety procedures to be followed in the use of electrical distribution systems.

UNIT 8.1 DISTRIBUTION - DESIGN

In order to conduct the electrical energy safely to the parts of the vessel where it is required, a distribution system must be designed to meet these requirements. It was once the practice to use the hull as a return circuit and wire for the delivery. The dangers of this type of system become apparent immediately, and after several fires and accidents, such a system of distribution was no longer allowed.

The use of the hull for return of lighting or power has been replaced by an insulated two-wire system. The hull is now used as an earth.

All electrical conductors provide some resistance, and the distribution systems must be so designed that there is a voltage drop of no more than 10% of the design voltage. The reason for this requirement is that electrical motors and appliances will always draw the power needed to operate them, and electrical generators will always produce the current required by the load. If the voltage drops, then, to maintain the same power, the current will increase, with a corresponding increase in heating of the conductors. It is imperative, then, that cable manufacturers’ recommended maximum permissible current ratings are never exceeded.
Fuses are incorporated into the circuits to ensure that they are not overloaded. In order to calculate the suitable size of fuses (fuses are rated according to the maximum current they will conduct before blowing) a detailed knowledge is required of the maximum power that a service needs for its operation. The conducting cables must have current rating equal to or greater than this amount. The fuses which protect a circuit should have the same rating as the connected load. Conducting cables are so designed that they can safely carry their rated current without excessive heating.

All motors for essential services must be provided with their own circuits, so that their operation will not be interrupted should another motor overload its circuit.

UNIT 8.2 SWITCHBOARDS

Switchboards must be constructed of non-hygroscopic (non-water absorbing) insulating materials. They should be located in accessible positions that are well ventilated and free from flammable gases and acid fumes. They should be well clear of moving parts, so that they will not suffer mechanical damage. They should also be well clear of splashing water. All the switches and switch gear on the distribution panels should be provided with clear identification.

UNIT 8.3 CIRCUIT PROTECTION

Electrical wiring and equipment are very susceptible to conditions that affect their operation. The moist, marine environment encourages damage to circuits. Even though every precaution is taken when designing them to keep the circuits dry and protected from sources of mechanical damage, accidents do happen.

Various devices are employed to protect the circuits against overload, either of moderate value or those high enough to cause extensive damage to wiring, as may occur under short-circuit conditions, or voltage surges. The most commonly-used protection devices are fuses and circuit breakers.

All circuits have a calculated maximum safe working current. When this current is exceeded, excessive heating of the conductor can occur. This can result in the melting of insulation or in arcing and fire may result. There is also the possibility of shock hazard due to the leakage of current.

The requirements for the protection of a circuit, by either fuse or circuit breaker are:

- the device should be able to carry its rated current continuously without overheating
- small overloads of short duration should not cause the device to operate
- the device must operate when the overload (even if small) exists long enough to cause overheating of the circuits
- the device must open the circuit before damage occurs
- the device must isolate only the faulty circuit, and other circuits remain unaffected and operative.

UNIT 8.4 FUSES

A fuse is a device which protects a circuit from an excessive current by breaking the circuit when that current melts the fuse element.

Because the semi-enclosed wire fuse (found in most household switchboards) is not airtight, there is a minor fire hazard as the fuse arcs when it blows. For this reason, such types of fuse are not commonly found on board ships. A sealed cartridge-type fuse is usual. These are known as HRC fuses (high rupturing capacity).

8.2
The element of the HRC fuse is enclosed in a ceramic cylinder filled with a special quartz having arc-extinguishing properties, which reduce the fire hazard when the fuse blows.

HRC fuses can safely interrupt high values of fault current. They have a high operating speed, and thus limit the short-circuit energy that can damage the circuit they are protecting. They do not deteriorate in service, and, as a result, their characteristics are constant, and their performance is consistent. They also are more accurate than the semi-enclosed fuse, in that they operate at their design overload.

HRC fuses are much more expensive than semi-enclosed fuses but this is not normally a consideration.

**Location and Replacement of Fuses**

A fuse must be replaced only by one of a similar type (assuming that the original was the correct one) as the fuse that had blown. Because HRC fuses are so accurate, are manufactured to precise standards and are in a circuit for a specific purpose, they must be replaced only by an exact copy. If there is any doubt as to which fuse should be used, the circuit diagram should be consulted. (See Figures 8.3 and 8.4.)

Under no circumstances should a fuse be replaced by one with a higher rating than the original. If the replacement fuses keep blowing, the service so isolated must be discontinued and only reinstated by a licensed electrician. Indeed, all fittings should be installed only by a licensed electrician.

If a fuse keeps blowing, try to identify why the circuit is being overloaded. You may have too many services operating, so that simply discontinuing one of them may rectify the problem. If nothing you do solves the problem, you have a short circuit and, as mentioned above, the services of a licensed electrician must then be sought.

**UNIT 8.5  CIRCUIT BREAKERS**

The primary function of a circuit breaker is protection - like that of a fuse. It is usually provided with a switching facility, and is not *sacrificial* like a fuse. Circuit breakers are often used instead of fuses, or in conjunction with them.

There are four basic types of circuit breakers.

1) **Thermal** (Figure 8.2(a))

   The load, or part of it, passes through the bi-metal strip. If the circuit is overloaded, the bi-metal strip heats up. The metals expand at different rates, causing the strip to bend and operate the trip lever, thus opening the circuit.
Because the strip takes time to heat up, overloads of short duration will not cause the device to operate.

2)  *Magnetic* (Figure 8.2(b))

The load, or part of it, passes through the electro-magnet. If the circuit is overloaded, the magnetic element attracts the iron armature and the trip lever opens the circuit.

If the armature is not restrained (usually by a spring) the circuit breaker will trip with normal load current.

The magnetic trip provides near instantaneous operation on short circuits, but does not have the time-delay characteristics of the thermal breaker.

3)  *Thermal Magnetic* (Figure 8.2(c))

This breaker combines the characteristics of the first two. The bi-metal strip will trip on a continuous small overload, while the magnetic element requires a higher current to cause it to operate, but then it operates instantaneously – as in the case of a short circuit.

4)  *The Solid State* (Electronic)

This breaker does not have moving parts and the associated problems of mechanical circuit-breakers, nor does it arc when operating, but generally does not handle currents as high as can the mechanical types.

**Arcing**

As with all electrical contacts, circuit breakers arc when they open. This arc must be extinguished if the device is to perform its design function. In large circuit breakers, blasts of air or oil are used to blow out the arc. The arc may also be extinguished by de-ionising grids, which break up the magnetic field caused by the arc.

If a circuit breaker trips, the same considerations apply as for a blown fuse. A circuit breaker should never be held closed in order to force the system to work.

Fig. 8.2 shows a diagram of the Thermal-magnetic action

![Diagram](a)

*Small overload for short period of time*

![Diagram](b)

*Small overload for long period of time (bi-thermal spring)*
UNIT 8.6 THE DISTRIBUTION BOARD

Study Figure 8.3

Note how the essential services required for the manoeuvring of the vessel, the navigational instruments and bridge/engine-room communications are all protected with circuit breakers, while those circuits for the lighting of the accommodation are all protected by fuses only.

Note also how the rating of the cables is, in every case, higher than that of the fuses protecting the circuit. This feature provides an additional safety factor, and is a sign of good practice.

From Figure 8.3 it is possible to know exactly what rating of fuses must be used for replacements. There is no need to guess!

Such diagrams are always available on board ship.

Figure 8.4 shows the main electrical diagram, with two diesel-driven alternators, each providing 240 V two-phase and 415 V three-phase electricity. The main alternator provides 45 kw power, while the second alternator provides 25 kw.

It is possible to run the two alternators together, thus providing 70 kw, if needed.

The output power of each alternator is monitored by the protection relay circuits. The U/V trip coil is an energised solenoid switch which holds the circuits closed (switched on). Should there be a significant voltage drop (current surge brought on by too many services in operation) which indicates a ‘system overload’ the U/V coil becomes de-energised and the spring-loaded switch opens the circuit on all three phases, causing a blackout. Should there be a short circuit, the short-circuit protection relay contacts will open the switch numbered 7 and 8, and the U/V coil will once again become de-energised and the three-phase switch will open.

It is also possible to connect the power to a shore supply through the shore supply connection box.

This allows all the alternators to be shut down while alongside, but, at the same time, to maintain all the electrical on-board services. The phase rotation meter allows the phase of the onboard alternators to be matched to that of the shore supply. When both systems are exactly in phase, the shore circuits are opened, and the ship’s alternators may be shut down without interrupting supply.
Fig 8.4 Main Electrical Diagram
The lower part of Figure 8.4 shows the main switchboard. Note that all the switches are 3-pole switches. Because the polarity is always changing in alternating circuits, all poles are periodically live. For this reason it is necessary to isolate all poles to effectively switch the system off.

In a two-phase system, such as the lighting system, it is possible to switch a light off by using a single pole switch. The circuit has been broken, but because there is no live and neutral wire in an a/c system, it is still possible to be electrocuted if one accidentally touches the non-isolated wire while one is earthed (in contact with the ship's hull).

UNIT 8.7  EARTH LAMPS

An earth lamp or meter is usually included on the switchboard to indicate if current is leaking to earth from bad insulation. A schematic diagram of the earth lamp circuit is shown below.

![Diagram of earth lamp circuit]

If current is allowed to leak to earth, more current will be drawn from the generator and the continued overload may result in damage and extra expense. Clearly, parts of the hull may become live, and thus dangerous. To detect earth leakage, earth lamps are used.

In normal cases, with no earths, the voltage across bulb X and bulb Y is equal, and thus the bulbs glow with equal brightness. ( ).

If the negative wire is earthing, for example, at point C in the figure, the current will flow through the path of least resistance, A BCEYG. The voltage drop across bulb X will be small, most of the 240 volts being dropped across bulb Y. Thus X will be dim and Y will be bright. ( ).

If the positive wire is earthing, for example, at point D in the sketch, the current will flow through the path of least resistance AB x EDFG. The voltage drop across bulb Y will be small, most of the 240 volts being dropped across bulb X. Thus X will be bright and Y dim. ( ).

The relative brightness of each of the two lamps thus shows in which line the earth is occurring. The electrician must then find where the earth is and cure it.
The U.S.L. Code Section 9, Clause 27.4.4:

A vessel with a metal hull which has overload protection provided in both conductors, the installation shall be provided with lamps or suitable equipment to indicate earth faults.

UNIT 8.8 SUMMARY

1) The purpose of an electrical distribution system is to safely distribute electrical power to all parts of the vessel.
2) The safe distribution of electrical power can be achieved by ensuring that all fittings are installed by a licensed electrician.
3) Under no circumstances should a circuit be overloaded.
4) Blown fuses must never be replaced with other than those for which the circuit is rated.
5) Circuit breakers must never be forcibly held closed.
6) Before entering an enclosed electrical distribution area, ensure that the space has been thoroughly ventilated.

UNIT 8.9 SELF-TEST EXERCISE

The answers to this self-test can be found at the end of the book.

1. Would it be safe to use a single wire to carry current to a motor and use the hull as a return? Explain your answer.
2. Where would you expect a switchboard to be located?
3. In order to ensure that there is no hazard associated with circuits, what is the prime consideration when selecting gear and equipment for the distribution of power?
4. What is the purpose of an electrical distribution system, and how can one ensure that it will perform its required tasks?
5. What type of material do you expect would be used for lining the enclosures for switch gear and fuse gear?
6. Where should electrical equipment be located?
SECTION 9

Maintenance

INTRODUCTION

The marine environment is especially harsh on the materials in use for the construction of water craft and vessels.

All the major materials used in ship construction, whether they are metal, GRP or timber, experience deterioration. This deterioration - corrosion in the case of metal ships, destruction of the gel coat and glass fibre laminations in GRP vessels, and rot in timber vessels - in all cases, will lead eventually to the failure of the components suffering the attack, if it is not arrested.

In this Section we will look at some of the causes of these problems, and how, through a programme of maintenance and inspection, their effects can be minimised.

OBJECTIVES

By the end of Section 9 you should be able to:

• state the ways in which corrosion occurs
• describe how chemical corrosion occurs
• describe how galvanic action causes corrosion
• state which metals, commonly used in ship building, are liable to be anodic in the marine environment
• state how zinc or other similar metals can be employed to produce cathodic protection of the vessel
• describe how surfaces can be prepared and protected to reduce corrosion
• state the uses of the various types of paints - primers, undercoats, top coats, anti-corrosion and anti-foulings
• describe the methods of maintaining timber in good condition
• describe the maintenance required for GRP hulls
• identify the components most likely to corrode, and describe the inspections required to monitor this.

UNIT 9.1  CORROSION IN METALS

Study Chapter 27 in your text as far as ‘Corrosion Control’. Make sure you identify and understand the electrical nature of metallic and chemical corrosion. In unit 9.4, there is a list of anodic and cathodic metals used in ship building. What this list tells us is that if any two metals listed are in contact with each other, and with an electrolyte (such as sea water), then the metal which is lower down in the list will corrode.

Make sure you understand the various causes of corrosion.
UNIT 9.2 CORROSION CONTROL

Study the paragraphs in Chapter 27, dealing with corrosion control. Note how the principle of corrosion control is either to reverse the current that flows in the corrosion cell, or to attach to the hull metal anodes that will corrode faster than the hull and components. If protection by sacrificial anodes is to be attained, the anodes must be made of a metal which appears lower down in Table 26.1 than the metal it is to protect.

UNIT 9.3 PAINTS

As we discussed in Unit 9.2, corrosion can be prevented if the corrosion current can be stopped. This countering of the corrosion current is called cathodic protection. There is another way to stop corrosion, and this is by excluding the electrolyte (the current-carrying liquid). The most common way of preventing the electrolyte from coming into contact with the metal which needs protecting is by painting the exposed metal.

a) Now study the paragraphs in Chapter 27 under the heading Paints.
b) Read the following notes on paint systems.

UNIT 9.4 PAINT SYSTEMS

Study the following notes:

PRIMERS - ANTI-CORROSIVE

CORROSION MECHANISM FOR SHIPS’ HULLS:

Salt water is an alkaline medium (typical pH 8.82) and contains, in addition to the large amount of dissolved salts, quantities of dissolved free oxygen. This means then, that when it comes into contact with unprotected steel, conditions are ideal for corrosion to begin. The reaction is basically simple, when considering just the oxygenated water:
Fig. 9.2

Corrosion cell at a break in millscale or steel immersed in seawater. Note that rust is formed away from the anode (scale-free) and the cathode (scale-covered), so that it does not stifle the corrosion reaction.

However, the presence in sea water of dissolved metallic salts not only complicates the reaction, but produces a medium which makes certain types of paint unsuitable for use in those areas of the ship continually exposed to sea water. For example, sodium chloride (common salt) ionises and some of the sodium ions will combine with free hydroxyl ions to form sodium hydroxide. This forms at the cathodes of the corrosion cells, makes the medium very alkaline and quickly destroys any paint that has a natural oil medium.

The chemical reaction involves the following:

\[
\text{iron + oxygen + water + salt} \rightarrow \text{iron oxides + iron salts + sodium hydroxide}
\]

The sodium hydroxide (caustic soda) saponifies the oil medium (turns it into soap), leaving the surface completely unprotected.

The essence of a paint system is to prevent the onset of the corrosion mechanism. Ideally, this could be achieved by sealing the steel completely from air and water, but paints are porous, even the most sophisticated types, so the problem must be solved in another way. Current technology uses anti-corrosive paints to prevent the onset of corrosion. Anti-corrosives are paints which are formulated with an electrolytic inhibitor in the mix. There are two ways this is done:

(a) Anodic Inhibition

(b) Resistance Inhibition

ANODIC INHIBITION

GALVANIC SERIES OF METALS

Anodic End:

(Greater tendency to corrode)

1. Magnesium
2. Zinc
3. Aluminium
Cathodic End:

(Less tendency to corrode)

(A) Active Metal Surface

(P) Passive Metal Surface

This method makes use of the fact that, if two dissimilar metals sufficiently far apart in the electro-chemical series are placed in an electrolyte, a current will flow between them. The paint becomes anodic and the steel cathodic, with the result that the paint film, rather than the steel, is wasted. Basically, these paints are a zinc rich type of primer. Manganese can also be used, but is generally too expensive for large-scale commercial use. With this type of primer, the content of zinc must be heavy, so that not only is there metallic contact between the zinc and the steel, but also between the zinc particles in the paint. Typically, one of these paints will have a zinc pigment content of between 80-95% by weight (dried film).

These paints are porous and therefore only work anodically in the presence of an electrolyte (sea water). As the reaction progresses it can be seen that, rather than (as one would expect) the life of the paint being limited to the electrical activity between the zinc and the steel, what happens is that there is a formation (through the reaction of the H₂O and O₂) of hydroxyl ions which combine with the zinc and other metallic salts to
form the hydroxides (and carbonates by a similar reaction). These form a film on the steel surface which clogs the pores in the paint and makes it impervious.

One disadvantage of this type of paint is that the outer-surface becomes coated with zinc oxides which are water soluble. Therefore, over-coating times are critical. The paint must not be allowed to stand for too long before overcoating, unless the user is prepared to clean off the oxide film prior to overcoating (a lengthy and expensive process, reducing the thickness of the paint film).

As has been previously mentioned, exposed steel becomes covered with a film of oxide. If this film can be thickened and maintained, corrosion will not occur. There are two methods of achieving this. The first is to make use of the saponification reaction. Thus these paints have a natural (usually linseed) oil base. The oil breaks down and the long-chain fatty acids formed combine with the metallic salts to form the reinforcing pigment. (Most usual reaction is with azelaic acid to form azelates.) Red lead is the common pigment. However, because of the saponification process, these paints are not suitable for use where continual immersion is involved.

The other method is by the use of water-soluble pigments. Chromates are the most effective here, with an iron/chromium oxide film being formed by the action of the chromate ion with the existing iron oxide film. Zinc chromate is the most usual, but, again, water solubility has its drawbacks in immersion situations.

**RESISTANCE INHIBITION**

As corrosion is an electrolytic reaction, a substance introduced into the mechanism which has the effect of putting a resistance in the circuit will prevent corrosion.

However, to achieve this, the following conditions apply:

- the thicker the coating, the more resistance inhibitor in the film, and thus the greater the protection
- water soluble impurities in the paint must be minimised to prevent the formation of electrolytes in the film
- there must be no electrolytes underneath the film
- the paint must have a formulation such that it is impervious to water.

Chlorinated rubber and coal-tar epoxy paints are examples of this type of anti-corrosive.

**CHOICE OF ANTI-CORROSIVE**

Dependent upon:

(a) Area of intended use. Points to watch are:
   - use of oil-based paints underwater
   - type of metal being coated. e.g. the results of priming aluminium with a lead-based primer are disastrous. (Why?)

(b) The type of galvanic protection used is important, because the characteristics of the paint may have to be modified because of the highly alkaline environment created in such systems. (Current causes electrolysis of water, formation of hydroxyl ions and subsequently corrosive metallic hydroxides.) Types of damage that occur are: softening and blistering (attack upon paint binder) and, of course, saponification in oil-based paints.

(c) Compatibility: the anti-corrosive should be chosen so that no problems arise when over-coating. A zinc silicate primer is highly alkaline when dry, so unless the undercoat and topcoat used are alkali resistant, they will then break down and negate all previous work.
OTHER PRIMERS

In the initial preparation of steel in the shipyard, the plate is treated to remove millscale (pickling, sand or shot blasting) washed, dried and coated with what is referred to as a shop or blast primer. While this is, in essence, an anti-corrosive primer, it has to possess properties not required in more normal primers.

• It must be highly resistant to the abrasion and mechanical damage caused during fabrication.
• It must not affect weld quality (no gases to cause porosity or matter inclusions in weld bead). (Lloyds Certificate necessary for blast primers.)
• It must not give off toxic gases when heated.
• It must resist high temperatures involved in welding or burning.
• It must not affect speed of automatic welding, or cutting machines.
• It must dry quickly, to enable handling within minutes of treatment.

Blast primers are usually required to protect the steel for a limited period and are not subject to immersion. Possibly 60-80% of a blast primer consists of low boiling point solvents such as methyl-ethyl-ketone and isopropanal which flash off to leave a touch-dry film - curing completely in a couple of hours.

These primers are referred to by four names:

(a) shop
(b) blast
(c) wash
(d) etch

but all describe the same thing.

BARRIERS AND UNDERCOATS:

Underwater Sections

Antifouling paints produce their effects by the action of the poisons in them. These are usually copper or mercury salts. The consequences of applying antifouling direct to steel or to a metal rich anti-corrosive should be obvious. Thus a barrier coat is needed. They should cover well, provide a good base for the topcoat and not be subject to decomposition by the solvents and other chemicals in the topcoat.

In the case of repainting the underwater section with a new coat of antifouling, it is essential that a barrier is used between the old and the new. This is because the solvents in the new paint will react with the old and some of the poison etc., will leach down through the old paint thereby reducing the amount available to come out of the new coat to seaward and thus lowering its effectiveness. Barrier coats do not usually contain rust-inhibitive pigments. The function of an undercoat is to provide three things necessary for a good paint finish.

These are

(1) film build - to increase the overall thickness of the paint system
(2) opacity - this ensures proper colour coverage so that the primer does not show through or discolour the topcoat
(3) intercoat bonding - the finished surface of the undercoat must be such that the topcoat adheres properly.

They may be oleo-resinous (above waterline) as the presence of oil in the medium (particularly linseed) makes brushing easier, but usually today undercoats are made with an alkyd media.
ANTIFOULING

Antifoulings are probably the most expensive and important paints used on a ship. Foul hulls require more power for the same speed. This is due to the roughness caused by the attachment of weed, barnacles, etc., to the underwater sections. Typical values for this are: 1% more fuel for a 10% increase in roughness, or if the same consumption is maintained, a fall off of about 0.3%K per 10µ. Hull roughness is not something we will discuss at length in this subject except insofar as it affects paint technology.

Marine organisms propagate by releasing miniscule larvae or spores into the water. To change into adult forms they must attach themselves to something solid. So, if a paint which is so formulated that substances poisonous to the organisms are released (in a controlled manner) is applied to the hull, these organisms will be killed before attachment. The most common compound is cuprous oxide, but this may be reinforced by mercury, arsenic, tin, lead or zinc salts (effective against plant growth). Most effective of these are organo-tin or organo-lead compounds such as triphenyl lead acetate.

There are two basic types of conventional Antifouling:

- Soluble-matrix
- Contact

![Fig. 9.3 Soluble-matrix antifouling](image)

(a) Soluble Matrix antifoulings

Soluble Matrix antifoulings are those in which the poisons are combined in a sea water soluble binder. This binder is composed of acidic rosins which react with the alkaline sea water and slowly dissolve, releasing the poisons.

With these paints the leach rate (rate at which poison is released) is critical and is controlled by the amount of poison in the paint and the ratio of rosin to plasticiser (plasticisers adjust rate of dissolution of rosin). A leach rate of about 20mg/cm²/day is needed to prevent all growth including microscopic algae but this is rather wasteful and a rate of about 10mg/cm²/day (which prevents settlement of barnacles) is more usual.
(b) Contact Antifouling

As the name suggests, in this type of paint the particles of poison are in contact throughout the film. Thus, as the poison leaches out, a *honey comb* structure is left, enabling the sea water to enter and reach poison particles deeper in the film. In effect, the paint has an insoluble binder as opposed to the other type of paint where the binder dissolves exposing the poison. The poison content and its geometry are the factors here. In the dry film, the total soluble content (poison, rosin, etc.) must exceed 52% by volume to ensure continued leaching. Below that figure, it is possible for the poison particles to become totally encased in the matrix, rendering the paint useless. Similarly, concentrations exceeding 74% by volume, there will be enough matrix to fill the particle interstices, with the result that the film is underbound and will leach away too quickly. The life for these conventional antifoulings is about 8-14 months for soluble matrix types and 12-20 months for insoluble matrix types.

**Figure 9.5**

*HIGH PERFORMANCE ANTIFOULINGS*

In a lot of trades the incidence of fouling and the shipping schedules make annual drydocking an expensive luxury, so coatings have been developed which claim to extend the interdocking period to 3 or 4 years.

In tankers, where the in-port period is usually less than 48 hours, barnacle fouling is not a problem, but weed growth, needing only a few hours to begin, is of major importance.

The antifoulings developed for these cases use either cuprous oxide reinforced with organo-tin compounds in a chlorinated rubber medium (contact antifouling) or the more sophisticated organic poisons in an acrylic or vinyl medium where the poison is leached by molecular diffusion. As the poisons come away from the surface, they are replenished by diffusion of the poison molecules deeper in the paint film. One major advantage of this type of antifouling is that the particles are of molecule size and evenly dispersed throughout the binder, thus eliminating the chance of algae spores
(about 0.1µ) settling on the matrix between the poison particles. Also, because the poison
is in such small particles, the paint surface remains smooth.

The roughness that eventuates from the leaching of other antifoulings means that (as
mentioned previously) before re-coating, a barrier coat must be applied in order to
smooth out the surface as well as prevent the hullward movement of the poisons.

Coal-Tar epoxy paints impregnated with organic poisons are sometimes used; the benefit
of which lies with the extreme thickness of the coating; hence, large amounts of poison
and, it is claimed, a service life of over 3 years.

The major development in recent years has been the use of self-polishing coatings and
reactivating antifoulings. Reactivating antifoulings are thick coats of a chlorinated rubber
paint, highly charged with poison (usually cuprous oxide), which, because of their
thickness, lend themselves to re-activation. The procedure is that when the vessel would
normally be docked, the ship has her hull scrubbed down in the water, removing the
top layer of used paint and exposing a new film which is then (supposedly) good for
another couple of years. Generally this type of antifouling is red in colour, changing to
grey as the surface leaches out. Therefore, a check on the thoroughness of the reactivation
can be done by observing the colour change back from grey to red during the scrubbing
operation.

It is claimed by manufacturers that, on the completion of scrubbing, the leach rate returns
to the original figure.

The self-polishing antifoulings are the most sophisticated types of paints so far discussed.
The principle makes use of the turbulence of the water flow along the hull. The poisons,
which are of the organo-tin type, are copolymerised into an acrylic resin. Thus the resin
binder of the paint is toxic and, as this is eroded or polished away by the ship's movement
through the water, the poison is released. These paints are expensive, require costly
pre-treatment of hulls and are highly toxic. Several shipping companies, among them
ANL, are using them on elements of their fleets with apparent success; resulting in
substantial savings in fuel.

Finally, a word on the toxins in antifoulings. With the increasing use of organic metallic
poisons, paint manufacturers and environmental authorities have to keep a very careful
watch on the amounts of poison released into the water. Already, some of these poisons
have been banned. The use of organo-mercury and organo-arsenic compounds has
already been banned as they are also toxic to humans, and, in Japan, certain organo-tin
compounds are restricted on health grounds. It follows that, when using or working
near antifoulings, stringent precautions must be taken to preserve the health of the
operators and others in the vicinity. This involves safety equipment - respirators, goggles,
gloves etc., as well as precautions to see that there is no overspray or spillage that can
contaminate the environment.
UNIT 9.5 PROTECTION BY MEANS OF PAINTS

Study the remainder of Chapter 26 and the following notes on the preparation and painting of surfaces.

PREPARATION OF SURFACES

Paint should NEVER be removed back to bare metal unless it is absolutely necessary; i.e., if corrosion is evident or the paint is peeling off due to poor preparation, initially. This applies to both steel and alloys.

To prepare any surface for painting:
• all defective paint (flaking, cracking, etc.), has to be removed
• all corrosion has to be removed
• then, all grease and oil have to be removed.

The method used to prepare a surface differs according to the material used in its construction.

The hull of a ship and any strong points (e.g., bollards) are usually constructed of steel for strength. The upper works are usually constructed of galvanised steel or aluminium alloy for easy maintenance.

A badly-prepared surface will result in a poorly finished job and cause extra work, in the long run, because of corrosion.

PREPARING A STEEL SURFACE

Steel is a hard metal and, to prepare it, you will require the following tools and equipment:
• needle gun (Jason pistol)
• chipping hammer
• disc sander
• wire brush
• metal scraper
• scaling machine/growler
• goggles, ear defenders and protective clothing.

Because steel is hard, you will need to apply force when scraping or using a wire brush. Remember to wear your goggles and to fit your ear defenders when using the hammer, pistol or scaling machine.

PREPARING AN ALUMINIUM AND GALVANISED SURFACE

Aluminium and galvanised surfaces are softer than steel surfaces and so greater care needs to be taken when preparing them; otherwise, damage may result.

You will require the following tools and equipment:
• paint remover
• wooden scrapers
• goggles and gloves
• rags.

NOTE the use of wooden scrapers and NOT chipping hammers!
Again, remember to wear gloves, goggles and protective clothing when applying paint remover.

In the majority of cases, aluminium surfaces can be prepared for repainting by sanding off the surface layer of paint and applying one coat of ‘top coat’.

PREPARING A WOODEN SURFACE
Wood, of course, is the softest surface you will have to prepare and so requires the greatest of care.

You will require the following tools and equipment:
- scraper
- paint remover
- goggles
- protective clothing
- sandpaper
- warm soapy water
- scrubbing brush.

MIXING OF PAINT
1. Invariably, prior to a can or drum of paint being opened for use, it will have rested on a shelf both in stores and in the ship’s paint store. This causes a thick layer (cake) of pigment to settle on the bottom of the container.

2. It is essential that this settled cake be incorporated into the paint before use. Storing the drum upside down may be partially successful, but in many cases the settled pigment cakes firmly and is not readily detached from the bottom by gravity.

3. The most satisfactory method of mixing paint is to remove the top of the container completely, and pour the liquid portion into a suitably sized clean container. The paste-like pigment is then stirred into a smooth creamy consistency using a broad bladed paddle or similar implement - NOT THE USUAL BROOM HANDLE.

4. When the pigment is fully stirred and no lumps remain, gradually add the poured-off liquid a little at a time, stirring after each addition until all the liquid has been thoroughly mixed into the paste.

5. Multi-pack paints need to be thoroughly mixed separately prior to being added together in their correct mixing ratio and again being thoroughly mixed.

PAINTING
Stirring the Paint
The paint should always be stirred well before use. This ensures that any sediment which has separated to the bottom of the paint is remixed, thereby giving the paint body.

Your paint should be stirred periodically while in use. Failure to stir the paint will result in a poor finished appearance and the paint will also take longer to dry.

Stages of Painting
PRIMARY STAGE - to seal the surface against corrosion
UNDERCOATING STAGE - to give a base for the top coat
TOP-COATING STAGE - to give the surface its hard-wearing properties and finished appearance
UNIT 9.6  CORROSION AND SHIP MAINTENANCE

Causes of Corrosion
(a)  Oxidation (chemical action).
(b)  Electrolytic action owing to differences of electric potential between dissimilar materials.
(c)  Galvanic Action when two different metals form a corrosion cell.
(d)  Mechanical and thermal treatment to which the metal is or has been subjected.
(e)  Variations in stress or vibration.

Effects of corrosion
•  Progressive corrosion will reduce steel to a mass of rust.
•  Increases the total weight and bulk of the part attacked by the absorption of oxygen and the retention of moisture.

Mill Scale
Formation of scale on wrought iron or mild steel in the process of manufacture. It is bluish-black in colour if the material is finished hot, but reddish in colour if the plate leaves the rolls at low temperature.

Removal of millscale is by either:
•  pickling in dilute hydrochloric acid (very expensive), or
•  shotblasting.

Means of surface preparation for removal of scale on steel
1.  blast cleaning
2.  pickling
3.  flame cleaning
4.  preparation by hand.

FORMS OF CORROSION
Oxidation: A chemical process of rusting where oxygen is consumed from the atmosphere and combines with moisture to form rust. The rate of rusting is determined mainly by the pollution of the air through smoke/sea salts.

Electrolytic Action: When two metals have dissimilar characteristics, a difference of electric potential exists, and an electric current is produced. It is not necessary for the metals to be different. For instance, a difference in electric potential will exist between a well-painted steel plate and a defectively-painted steel plate. An electric current will be produced and corrosion will take place at the defectively-painted plate. Thus, electrolytic action will take place between any two surfaces with physical differences, provided that there is present a solution through which conduction of an electric current can occur (that is, moisture).

Galvanic Action: This is really an electrolytic action, but when the two metals are distinctly different (for example bronze and steel), a galvanic cell is set up with sea water as the electrolyte. It is then known as Galvanic action.

Stress Corrosion: Corrosion is active where stresses have been set up, such as when steel is cold worked; that is, flanging, punching, riveting. Corrosion is therefore evident at cold-flanged brackets, punched rivet holes, etc.
**Vibration:** Where corrosion has occurred, the scale forms a protective layer for the steel beneath it. However, where there is vibration, the scale is continuously vibrated off, leaving the bare steel beneath to be further attacked by corrosive forces.

**Cavitation (Pitting):** In a rapidly-flowing liquid environment, such as a ship at sea, vapour cavities (partial vacuums) are continuously formed along the ship’s side. When pressure is increased, the vapour cavities collapse, or *implode*, bombarding the steel plating. This breaks down the paintwork and further imploding causes pitting in the shell plating.

**Erosion:** This takes place at the waterline or in the vicinity of overboard discharges. Air bubbles in the water bombard the paintwork continuously. This breaks down the paintwork in these areas, after which electrolytic action takes place, causing corrosion.

**Cathodic Protection:** Where Galvanic action takes place, particularly in the stern region, and especially in the vicinity of the propeller, protection against corrosion is supplied by the use of anodes on the stern plating. Anodes may be of zinc, aluminium or magnesium (magnesium anodes NOT to be used in the cargo tanks of tankers or where inflammable gases exist). The galvanic cell is then formed between the anode and propeller and the anode is wasted away instead of the ship’s steel plating.

Anodes may be used for cathodic protection in petroleum and other tanks, but magnesium anodes are not to be used where inflammable gases exist - because, should they fall off, they will create a spark sufficient to cause an explosion! Zinc and aluminium anodes are safe to use in tankers’ cargo tanks.

Note: Anodes for cathodic protection MUST NOT BE PAINTED.

**Connections of aluminium to steel:** Electrolytic action will take place with two different metals joined together, unless moisture can be completely excluded from the joint. It is imperative, therefore, that when different metals are joined together, there should be insulating material (for example, neoprene) between the materials, and the edges of the joint should be sealed with sealing compound to prevent the admission of moisture.

**Explosion ‘Bonding’:** This is a method of joining aluminium to steel whereby the joint is free of any crevices and the exposed part of the *aluminium/steel* joint is protected by paint.

**Impressed Current System:** This is a form of cathodic protection for the whole of the immersed external hull.

**Modern treatment of steel in shipbuilding yards**

Immediately steel leaves the stockyard and before moving to shops for cutting, forming etc, steel is:
- shotblasted
- washed
- dried
- painted with special primer.

The primer used must meet the following requirements:
- it must dry quickly (within a few minutes)
- be non toxic
- should not produce porosity in welds when welded
- must withstand heat from burning etc.
- must not give off obnoxious fumes during welding, cutting, etc.
- must be compatible with other paints to be applied later.

An example of such a primer is one consisting of zinc dust in an epoxy resin.
Parts of the ship especially liable to corrosion

- Plating and framing in lower part of machinery spaces
- Boiler casing tops
- Peak tanks
- Double Bottom tanks
- Storerooms
- Between the light and load waterline
- In vicinity of deck scuppers and overboard discharges
- Bilges (highly corrosive area)
- Below wood deck sheathing
- Under leaky sidelights
- Parts of bottom plating which were sitting on blocks during last drydock and were not treated at that time
- Between any two steel surfaces which are insufficiently closed to exclude moisture
- Any part of the ship where space is so restricted that it is difficult to work in
- Any steel which has been stressed during cold working (e.g., flanges of brackets)
- Any flat projections where water can accumulate (e.g., stringers used for stiffening)
- Ship’s stern in vicinity of propeller (galvanic action)

Means adopted during ship construction to prevent or minimise corrosion (design and workmanship)

1. Steel treatment immediately steel leaves stockyard.
2. Scantlings are designed with a ‘margin of safety’; that is, scantlings are sufficient to allow a margin for corrosion.
3. Well thought out design reduces to a minimum the number of small or awkward spaces which will be neglected in future maintenance.
4. All small closed-in spaces to have means of access for maintenance.
5. For spaces occurring where it is impossible to leave room for maintenance, it is better to fill them solid with an air-excluding substance such as cement (e.g., very narrow spaces at extreme ends of ship).
6. Reduce the area of surface and number of parts exposed to corrosive influences. That is, where design permits, a thicker and smaller section is better than a thinner but larger surface. It is better to have heavier frames spaced further apart than lighter frames closer together.
7. Avoid construction techniques which permit gathering of moisture and dirt.
8. Avoid projections (e.g., hold stringers), which form lodgements for water.
9. Deck plating should be well sloped to allow water to drain off quickly (including lower decks and flats).
10. Heat promotes rapid corrosion; therefore, steam pipes for winches, etc., should be kept well clear of exposed steel decks, hatchways, coamings and deck erections.
11. Drains and scupper carefully arranged to clear decks of water as quickly as possible.
12. Limber holes should be of large size and placed at low part of the floor plates to prevent accumulation of water at plates.
UNIT 9.7 FIBREGLASS BOATS (GRP)

Study the following notes.

**IS GRP A MAINTENANCE-FREE MATERIAL?**

GRP, like any other material, needs the correct protection throughout its service life. It is certainly a low maintenance material, but usage will ultimately affect the degree of maintenance required.

**WHAT CAN BE DONE TO PROTECT GRP AGAINST WEATHERING?**

Weathering is a slow process, which, eventually (if unchecked) erodes the surface of gel coat, making it rough and pitted and subject to accelerated attack. Eventually the gel coat will become porous; thus, no longer protecting the underlying laminate. This process normally takes many years. However, if the gel coat is of poor quality or is subject to excessive atmospheric pollution, it can occur relatively quickly. The most effective safeguard is regular waxing of the gel coat, which then acts as a barrier between it and the weather. Furthermore, the wax also provides a measure of protection against scuffs and abrasions and sea-borne oil.

**WHAT TYPE OF WAX MAY BE USED WITH GRP?**

The choice of polish is important. Obviously, it must be weather-resistant, but considering the eventuality of repair work and ultimately repainting, the polish needs to be of a type which can be easily removed. The choice lies between two types: silicones and wax. Silicone polish readily gives a high gloss finish which is water-repellent. However, it has a major disadvantage in being extremely difficult to remove. Wax polish is thicker and easier to remove, but requires more buffing to produce a high gloss.

**WHAT ARE THE MAIN CAUSES OF GEL COAT DETERIORATION?**

Apart from general weathering, the most common cause of minor gel coat damage is abrasion from the rubbing of fenders or mooring warps. Boats lying to piles or tied up alongside other craft at crowded pontoons are particularly prone to abrasion from the continual rubbing motion between vessels. Even new fenders will eventually lose their smooth surface and abrade the gel coat, while rough or badly-worn fenders (particularly car tyres and old-fashioned rope fenders) will remove the smooth surface of the gel coat very rapidly.

Bad anchoring practice is also a cause of trouble, and the well-handled craft should always be allowed to lose way through the water before the anchor cable is paid out. Wind-against-tide conditions will tend to drive a tide-rode (usually deep keeled) boat over her chain, causing rapid damage to the topside gel coat. Plastic pipe can be used to protect the topside from the chain, though, in less severe wind conditions, a bucket streamed astern will tend to prevent the craft from riding over its chain.

**HOW IS LOSS OF GEL COAT GLOSS RECTIFIED?**

If abrasion is only superficial, it can be polished out using one of the proprietary boat maintenance products, though mild cutting compounds and polishes sold for car refinishing have been found satisfactory.

If the abraded gel coat includes some areas of deeper abrasion which have not actually penetrated the gel coat a very fine wet and dry paper can be used initially, to be followed by the above procedure.
**SHOULD A GRP HULL BE PAINTED?**

If properly cared for, and excepting the possibility of a disfiguring repair, a GRP hull should maintain its appearance for five years or more, depending on the extent and conditions of use. A well maintained dinghy, for example, may never need painting, assuming the owner has the sense not to drag his craft along the foreshore or across a sandy beach. A workboat or fishing boat, on the other hand, is bound to suffer wear and tear and should be repainted as much for protection as for appearance.

**WHAT IS THE PROCEDURE FOR PAINTING THE TOPSIDE OF A GRP BOAT?**

Follow the paint manufacturer’s instructions implicitly. Paints for GRP hulls have been carefully formulated and generally need more careful application than do those for wooden or steel hulls. Also, the more perfect surface of a GRP hull accentuates any faults in paint application, emphasising brush marks, runs and *holidays* (dry patches).

The first essential is a perfectly clean surface, with all traces of wax polish removed. Particular care should be taken to remove stubborn silicone waxes if these have been used, as well as traces of varnish dropped from toe rails or rubbing strakes. Do not use strong abrasives, and on no account remove varnish or conventional paint with paint stripper, unless it is one of the specially formulated kind that will not attack the gel coat.

The hull is best cleaned with water and mild detergent, and more persistent marks can be removed with methylated spirit.

The topside can then be mechanically abraded using a fine grade of wet and dry paper used wet (with a little detergent to stop clogging), or a key for the paint can be provided by using an etching primer.

**WHAT TYPES OF PAINT ARE AVAILABLE?**

The main types available are:

- conventional yacht enamels, usually based on an alkyd resin
- single-pot polyurethanes
- two-pot (catalytically cured) polyurethanes.

**WHAT ARE THE ADVANTAGES OF THE PARTICULAR SYSTEMS?**

Conventional yacht enamels are cheaper and easy to apply. Because they are slower drying, brush marks can be worked out more easily and the risk of a dry edge is minimised. They are, however, softer, less resistant to abrasion and are generally less durable. A conventional enamel will usually require re-painting after two or three years. One-pot polyurethanes offer a good compromise, are harder and tougher than enamels, and are relatively quick drying. Most dry by reaction with moisture in the air and will dry well on calm, humid days (when dust is not raised by ground and wind). A good painting technique must be mastered, and the painter should work in vertical strokes from one end of the hull to the other, without stopping. Avoid overloading the brush as runs can rarely be brushed out, and ensure that each successive stroke meets the wet edge of the previous one. A dry patch, or *holidays*, cannot easily be rectified.

Two-pot polyurethanes give the greatest strength, resistance to salt water and chemical attack, and impermeability. They will also give the finest finish if applied with skill. Two-pot polyurethanes can be smoothed off and buffed to produce a very fine finish, free from all traces of brush marks. Like one-pot polyurethanes, these paints are quick drying, and a similar technique should be adopted. Drying rate, however, depends not on humidity but temperature.
**WHY MUST GRP BOATS BE PAINTED BELOW THE WATERLINE?**

Primarily, to prevent marine organisms such as barnacles and weed attaching themselves to the hull and thereby increasing the resistance of the hull to movement through the water, and secondly, to form a relatively impervious layer over the gel coat, and so reduce the possibility of water absorption by the hull and consequent osmotic blistering. Special paints with low permeability and antifouling qualities have been developed for underwater use.

**WHAT IS THE PROCEDURE FOR PAINTING A NEWLY MOULDED HULL BELOW THE WATERLINE?**

Before painting the hull, sufficient time must be allowed for it to cure (about 3 weeks at 16°C) and any surface imperfections, blisters, etc, must be removed and filled.

The hull is then mechanically abraded using abrasive wet and dry paper, or other process which will key the surface of the gel coat without removing an excessive thickness.

Many different materials have been evolved for painting below the waterline, and it is essential that the paint manufacturer’s instructions are carefully followed. One method is to prime the surface with two-pot polyurethane thinned by the addition of 154 thinners. Subsequent coats are then applied, unthinned, until an adequate thickness has been built up.

Alternatively, undercoats and antifoulings based on epoxy resins can be used. These have a very high resistance to porosity, and generally require fewer coats than polyurethane.

If the traditional type of porous soft antifouling is to be used, sufficient coats of an approved underwater undercoat must be applied to protect the gel coat from ingress of water.

**HOW SHOULD THE BOTTOM BE RE-PAINTED?**

Loose antifouling should be removed if the craft is already painted. This is best done with a coatset grade of wet and dry paper, used with a plentiful supply of water. Rubber gloves should be worn, or the hands protected with barrier cream. Goggles, mask and hat should also be worn and the face and arms thoroughly washed as soon as the job is completed, and certainly before food is taken. Antifouling compounds contain poisons which present a real hazard and are a frequent cause of dermatitis, eye damage and respiratory troubles.

When the antifouling is cut back to sound paint, a further coat or two can be applied - but only if the new material is compatible with the existing antifouling. If in any doubt, consult the manufacturer, or cut back the old antifouling to undercoat or primer.

**UNIT 9.8 TIMBER SHIPS**

Timber is one of the easiest to work, and is the most aesthetically pleasing of all the materials used in ship building. It used to be the main ship-building material, but, with the more efficient methods of working metals, and later, with the introduction of synthetic materials (such as GRP), wood has largely been superseded.

Timber nowadays is used primarily in ship-building for aesthetic purposes only. The reasons for its replacement by metals and synthetic materials are many, but the major consideration has been the economic factor. Wood does not lend itself to mass-production methods as easily as metals and GRP products do. Strength is another important factor to be considered.
However, in spite of this, timber-constructed vessels are still being built, although these are usually small craft, or pleasure craft. Timber is still used on board nearly all vessels for internal furnishings, deck planking, taff rails etc.

Timber requires special attention to keep it in its best condition.

If the wood is used for decorative purposes, it is usually varnished. There are many types of transparent coatings, but a good marine-quality varnish will give woodwork a beautiful finish if applied properly. The varnish coating of all woodwork exposed to the elements eventually blisters and becomes brittle, requiring a light sanding and recoating periodically. If the wood is left for a lengthy period and the varnish is allowed to break down completely, the wood will be weather-stained with grey streaks and patches.

In this case, it will be necessary to completely remove the old varnish and prepare the surface for recoating.

Do it this way.

1. All the old varnish should be scraped off, using a wood scraper, taking care not to gouge into the wood.
2. Any varnish not removed by the scraping, should be sanded with a coarse sandpaper. Take care to always sand with the grain of the wood.
3. The wood should be finished by sanding to a smooth finish with a fine sandpaper.
4. All sanding dust and wood powder should be removed and then the wood should be lightly coated with raw linseed oil.
5. Twenty-four hours should be allowed for the oil to soak in and then a second coat should be applied, again allowing 24 hours for soaking.
6. The wood should be dry, but if it feels sticky where too much oil has accumulated, it should be wiped down with a cloth impregnated with mineral turpentine. This will prepare the surface for receiving the first varnish coat, and will dry it out.
7. The first coat of varnish should be diluted with mineral turpentine (or whatever solvent the manufacturers recommend). A mixture of one part turps to one part varnish usually will suffice.

The first coat is a sealer, and should be thinly applied, taking care that the wood is totally coated. It is always best to allow overnight drying between successive coats.

8. A light sanding with a fine sandpaper is necessary before applying the second coat. This should also be a diluted mixture. Overnight drying and a light sanding before the third coat are necessary.
9. The third, fourth and fifth coats should be applied full strength, but as thinly as possible. Pouring the varnish in a clean tin and standing the tin in boiling water until the varnish is hot and then applying it will make the job much easier as the varnish flows very smoothly when hot.
10. Care should be taken during the application of these coats to avoid any bubbles appearing on the surface of the wood. Any that do appear should be smoothed out. The wood should be allowed to dry out of direct sunlight, especially in the heat of the day, as this will cause blistering and unsightly bubbles. A good time to varnish is the late afternoon.
11. The intermediate coats should be rubbed down with a very fine waterpaper to give a glass-like finish. Before applying the next coat sufficient time should be allowed for the previous coat to dry out and harden properly. Sometimes 24 hours drying time is not sufficient.
12. Great care should be taken with the final coat, and this should be very gently brushed on, floating the brush over the surface to give a high-gloss finish.

13. If these steps have been followed, your woodwork will have a beautiful appearance and its full aesthetic value can be appreciated. All that will now be necessary to maintain its appearance is a light sanding followed by water-papering and finish-coating every 4-6 months. Any salt water that dries on the woodwork should be washed down with fresh water to remove the salt.

**Wet and dry rot**

Essentially these terms describe the same thing, which is wood decay as a result of fungal attack, the only difference being that dry rot is a drier version of wet rot. The term is somewhat misleading, because even though the wood has a dry, cracked appearance, the trouble always occurs in damp, badly ventilated areas. The prevention is obvious. It is caused by a fungus which feeds on the timber, gradually eating away the fibres, producing a cubical, cracked effect.

The fungus itself, is a white growth which sends out lace-like strands that attack the timber in the vicinity. Dry rot usually does not occur if the moisture content of the wood is less than 20%.

Soft woods are especially susceptible to dry rot attack; hard woods to a lesser extent.

Dry rot can be introduced in many ways. The spores are often carried by the wind, or come on board with stores from warehouses. They can penetrate mortar. If they land on a piece of uncoated timber, and the conditions are right, they will germinate.

Wet rot is a different fungus that attacks very wet timbers, but not those continually immersed. Although the fungus thrives in very moist conditions, it does not grow under water.

**UNIT 9.9 WOODEN HULLS: ADDITIONAL POINTS ON MAINTENANCE**

Attention should be paid to two main factors:

- use of a suitable paint to minimise weed (algae) growth
- protection from the borer teredo.

Both these organisms can be successfully repelled by anti-fouling paint. Such paints contain toxins, like copper oxides, and must be kept in good condition (no broken surfaces) to remain effective. They are formulated to control marine growth by leaching of the toxins (poison) into the immediate vicinity.

To increase the protection available, it is advisable to coat bare wood with copper naphthanate or a similar solution. A new wooden hull can be treated inside and out with such a solution before painting is carried out.

The interior of the craft, particularly if it has many enclosed areas, can be affected by dry rot. Copper-based preservatives will protect these areas as well as the hull.
The teredo is difficult to detect. It enters the wood, leaving a mere pinhole which is hard to see when cleaning down. Once entering the timber, the teredo quickly grows. If it is possible to leave the boat out of the water for about three weeks, the borer will die of dehydration. However, if it has caused serious damage, the wood will have to be replaced. Holes running along the planking have been known to measure fifteen millimetres in diameter. See Figure 9.7.

UNIT 9.10 SCHEDULED MAINTENANCE

The way maintenance is approached on the vessel you own or operate is the most important function that will contribute to the safe operation, value and operational life of the vessel.

A recreational or commercial vessel is not unlike a motor car in many ways-just a bunch of systems, both mechanical and electrical, put together to provide a means of transporting goods and/or people. The major difference between a vessel and a car is the environment that it has to operate in. The marine environment makes the requirement of maintenance all the more critical to the safe operation, value and life of the vessel.

Maintenance on any vessel, whether it be a four metre aluminium dinghy or a one hundred thousand tonne super tanker, should be approached in the same way. A plan of scheduled maintenance should be set up using manufacturers hand books of all machinery and systems onboard the vessel. As the crew become familiar with the vessel’s operation, items peculiar to that vessel will become apparent and should be added to the plan of scheduled maintenance.

The best way to set up the plan of scheduled maintenance is to divide the vessel up into components and systems as follows:

HULL AND SUPERSTRUCTURE

Depending on the size of the vessel this also can be divided into separate components eg Decks, Upper Deck Screens, Internal Compartments, and Watertight Doors etc. The main consideration in the maintenance of the vessel’s structure is the type of preservation system used. GRP vessels in most cases, will have a Gelcoat finish on all surfaces above the waterline and will only require regular washing and periodic polishing. In just about all other types of construction, the vessel’s structure is protected by an appropriate paint system. Over the years, a lot of research and development has gone into marine paint systems to a point where the application, repair and maintenance of the systems require some degree of expertise. Taking this into consideration, detailed documentation
should be kept of all the paint systems used on the vessel and in what areas they are applied. Any paint used in the day-to-day maintenance of the vessel should be stowed in a separate, well ventilated space and clearly labelled as to its type and use.

The next most important requirement in maintaining the vessel’s structure is the watertight integrity of all upper deck openings. These will vary from vessel to vessel. In vessels that have patent hatches and doors, the manufacturers specifications should be referred to to ensure that the correct maintenance procedures are carried out and enough appropriate spares are carried onboard to carry out any repairs. Where the vessel relies on the hinged and dogged type of watertight closures to maintain watertight integrity, a good supply of sealing rubber, hinge pins and dogs should be provided onboard.

**MACHINERY**

This is a rather broad term and the amount of machinery will vary greatly onboard a vessel depending on its type and function. The best way to address the maintenance requirements of all the machinery onboard the vessel is to refer to the manufacturers handbook and then separate the required maintenance procedures into daily, weekly, monthly, three monthly, six monthly and yearly routines. In the case of internal combustion engines, the maintenance is carried out after so many hours run. A log of all services and major overhauls carried out on main propulsion and auxiliary internal combustion engines should be kept to allow a history of the engines performance to be built up. This will help the ship’s crew in predicting running costs and spares requirements. Most engine manufacturers have an engine lubricating oil analysis service. It is highly recommended that this is taken advantage of due to its ability to forecast catastrophic failure of major engine components. This allows for the planning of major overhauls at a time that is convenient to the vessel’s programme.

Where possible, engine and machinery type should be kept the same. This helps in the training of the vessel’s crew and their operation of the engines and machinery and also decreases the amount of emergency spares carried onboard the vessel. This also increases the redundancy of the vessel’s systems; eg starter motors of auxiliary machinery can be interchanged with main engines.

A typical internal combustion engine service and maintenance plan follows.
<table>
<thead>
<tr>
<th>Inspection</th>
<th>Running Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily</td>
</tr>
<tr>
<td><strong>Lubricate System</strong></td>
<td></td>
</tr>
<tr>
<td>Check oil levels (engine and gear unit)</td>
<td>✓</td>
</tr>
<tr>
<td>Check for oil leaks</td>
<td>✓</td>
</tr>
<tr>
<td>Lubricate reducing gear aft oil seal</td>
<td>✓</td>
</tr>
<tr>
<td>Change engine oil</td>
<td></td>
</tr>
<tr>
<td>Clean delivery filter element (engine)</td>
<td>✓</td>
</tr>
<tr>
<td>Clean crankcase breather filter</td>
<td>✓</td>
</tr>
<tr>
<td>Lubricate plunger type water pump</td>
<td></td>
</tr>
<tr>
<td>Renew delivery filter element (engine)</td>
<td>✓</td>
</tr>
<tr>
<td>Drain flywheel and dirt sumps (reverse gear)</td>
<td>✓</td>
</tr>
<tr>
<td>Change reducing gear oil</td>
<td>✓</td>
</tr>
<tr>
<td>Change Reverse gear oil</td>
<td></td>
</tr>
<tr>
<td>Renew crankcase breather filter</td>
<td>✓</td>
</tr>
<tr>
<td>Lubricate centrifugal water pump</td>
<td></td>
</tr>
<tr>
<td>Inspect oil cooler corrosion element</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Fuel System</strong></td>
<td></td>
</tr>
<tr>
<td>Fill fuel tank/s</td>
<td>✓</td>
</tr>
<tr>
<td>Check for fuel leaks</td>
<td>✓</td>
</tr>
<tr>
<td>Clean Duplex filter elements</td>
<td>✓</td>
</tr>
<tr>
<td>Clean second filter element on engine</td>
<td>✓</td>
</tr>
<tr>
<td>Test sprayers, clean if necessary</td>
<td>✓</td>
</tr>
<tr>
<td>Renew Duplex filter elements</td>
<td>✓</td>
</tr>
<tr>
<td>Renew second filter element on engine</td>
<td>✓</td>
</tr>
<tr>
<td>Check fuel pump output (calibrate)</td>
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</tr>
<tr>
<td><strong>Cooling System</strong></td>
<td></td>
</tr>
<tr>
<td>Check level of coolant</td>
<td>✓</td>
</tr>
<tr>
<td>Check for coolant leaks</td>
<td>✓</td>
</tr>
<tr>
<td>Clean sea water strainer</td>
<td>✓</td>
</tr>
<tr>
<td>Drain and replenish cooling system</td>
<td>✓</td>
</tr>
<tr>
<td>Clean pipes and water jackets etc</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Engine And Gear Controls</strong></td>
<td></td>
</tr>
<tr>
<td>Lubricate governor cam and spring lever spindles where exposed</td>
<td>✓</td>
</tr>
<tr>
<td>Lubricate single lever control pulleys etc</td>
<td>✓</td>
</tr>
<tr>
<td>Lubricate reverse gear selector mechanism</td>
<td>✓</td>
</tr>
<tr>
<td>Lubricate F.P. slider bar and quadrants</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Misc. Checks and Adjustments</strong></td>
<td></td>
</tr>
<tr>
<td>Check oil level in handwheel hydraulic pump (if fitted)</td>
<td>✓</td>
</tr>
<tr>
<td>Check tension of single lever control cables</td>
<td>✓</td>
</tr>
<tr>
<td>Check slow running adjustment</td>
<td>✓</td>
</tr>
<tr>
<td>Check timing chain tension</td>
<td>✓</td>
</tr>
<tr>
<td>Check engine and propeller shaft alignment</td>
<td>✓</td>
</tr>
<tr>
<td>Check tightness of engine bearer bolts</td>
<td>✓</td>
</tr>
<tr>
<td>Check valve tappet clearances</td>
<td>✓</td>
</tr>
<tr>
<td>Check F.P. slide bar 1/33” end clearance</td>
<td>✓</td>
</tr>
<tr>
<td>Check injection control friction adjustment</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Top Overhaul</strong></td>
<td></td>
</tr>
<tr>
<td>Decarbonise</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 9.1
**FUEL SYSTEMS**

The most important requirement of this system is the delivery of clean fuel to the engines on board the vessel. The first procedure to meeting this requirement is to ensure that the fuel being supplied is of the highest quality available at the time of bunkering. The next most important item in the fuel system is the cleanliness of the fuel storage tanks. All fuel storage tanks onboard vessels will at some stage be exposed to moisture inside the tanks. This is due to the tanks being vented to the atmosphere and condensation build up caused by temperature changes inside and outside the tanks. The presence of moisture in diesel fuel tanks causes a fungus to form between the interface of the fuel and water and will continue to increase until the whole fuel system becomes contaminated. The only proven method of eliminating this fungus is the regular cleaning of all fuel storage tanks. Commercial fuel additives are available to dose fuel tanks at the time of bunkering but despite the manufacturers claims, these additives will not eliminate the problem. All fuel systems on the vessel should be fitted with filtration, usually consisting of a primary and secondary filter. The primary filter is usually fitted in the main fuel supply line and the secondary filter fitted at the engine before the fuel lift pump. A good supply of filter cartridges for all fuel filtration systems should be carried onboard the vessel at all times. The fuel system will be fitted with valves to isolate and direct the flow of fuel. These should be regularly serviced and checked for correct operation. Commercial vessels will be fitted with some method of isolating the main fuel supply to all engines in the case of fire. This should be regularly checked for correct operation. Fuel piping and joints should be checked at regular intervals for general condition and leaks.

**BILGE SYSTEMS**

The main function of this system is the rapid removal of unwanted water from the vessel’s bilges. The most common method of achieving this in a commercial vessel is by using manually operated or engine driven pumps. In most cases, these pumps will come with manufacturers recommendations for periodic maintenance and should be integrated into the scheduled maintenance plan. The size of the vessel will dictate the complexity of the bilge system. In just about all cases, there will be isolating valves and piping making up the system. All valves in the system should be regularly opened and closed and serviced when necessary. Piping and joints should be regularly checked for condition and leaks.

Set out on the following page is a simple schematic drawing of a typical bilge / fire main pumping arrangement in a small commercial vessel.
FIRE MAIN SYSTEM

This system will only be found on larger vessels. On some vessels that do not have a dedicated fire pump, the engine driven bilge pump is used to provide salt water to the fire main. When this is the case an “L” ported cock is fitted between the sea water suction and the bilge suction or non return valves are fitted to all the bilge suctions, to prevent back flooding of the bilges. Taking this into consideration, the correct functioning and maintenance of the “L” ported cock and or the non return valves is critical to the watertight integrity of the vessel and therefore they should be operated and serviced on a regular basis. All associated pipes, valves and joints should be regularly checked for condition and leaks.
SALTWATER SYSTEMS

On most vessels, the function of this system is to provide cooling water to heat exchangers on main and auxiliary machinery and to air-conditioning and refrigeration. Saltwater intakes and hull valves are subject to the build-up of marine growth. To stop this marine growth contaminating the rest of the system, strainer boxes should be fitted as close as possible to the intake valves. These should be cleaned at regular intervals, the frequency being dictated by the vessel's area of operation. Regular cleaning of heat exchangers should be factored into the plan of scheduled maintenance and carried out in conjunction with the servicing of other associated machinery. All associated piping, valves and joints should regularly be checked for condition and leaks.

FRESHWATER SYSTEMS

The purpose of this system, in most vessels, is to provide drinking and washing water to the crew and passengers. The main requirement in maintaining potable freshwater onboard the vessel is to ensure the quality of the water at the time of bunkering. The next most important item is the cleanliness of the freshwater storage tanks. These should be cleaned periodically and dosed with chlorine. In vessels that are fitted with manual or electric pumps, maintenance should be carried out in accordance with the manufacturers recommendations. Particular attention should be paid to the maintenance of taps on sinks and hand basins to ensure they do not leak; this should be incorporated into a daily maintenance routine. All piping, valves and joints should be checked regularly for condition and leaks.
HYDRAULIC SYSTEMS
Most vessels will have some form of hydraulic system fitted onboard. On small vessels it may only be a simple steering system. The same principles apply to the maintenance of small, simple systems as apply to large, complicated systems. The main requirement is that the oil system is maintained at the correct level and that the oil remains clean. On systems operating at high pressures, the maintenance is obviously a lot higher due to the load put on the piping, connections and seals. Regular inspection of all hydraulic hoses and fittings should be factored into the plan of scheduled maintenance. All hydraulic machinery should be maintained in accordance with the manufacturers guidelines.

COMPRESSED AIR SYSTEMS
The compressed air system onboard a vessel may only consist of a small portable combined air compressor and air receiver to provide air to pneumatic tools, up to high pressure air compressors providing air to directly start main and auxiliary engines. No matter what the size or complexity of the system, compressed air should be treated with a great deal of care. This is why the maintenance of compressed air systems is critical to the safety of the vessel and the personnel on board. Air receivers should be drained of water on a regular basis to stop accumulation of water in the receiver causing corrosion. This should be done at least daily and during continuous use more frequently. Air compressors should be maintained in accordance with the manufacturer’s requirements and the oil should be checked at least daily. The most important safety device fitted to any compressor is the pressure relief valve-this is to be set at a pressure no higher than 10% of the working pressure of the compressor. This should be checked for correct operation at regular intervals and these checks should be incorporated into the plan of scheduled maintenance. All associated piping, fittings and valves should be checked regularly for corrosion and for correct operation.

D.C. ELECTRICAL SYSTEMS
On most vessels low voltage electrical current is provided by storage batteries; the most common of these are lead acid, low maintenance lead acid, nickel cadmium or gel cell type batteries. These are kept charged usually by alternators driven by the main engines, auxiliary engines or by battery chargers powered from the vessels A.C. electrical system. Most well found commercial vessels will have numerous battery banks consisting of a number of large capacity batteries. The heavy cabling to starter motors and switch gear carry very high amperages which can cause a very rapid heat build up at any dirty or loose connections, posing a very high fire risk. It is essential that particular attention be paid to these connections during checks and maintenance procedures. All cabling should be checked regularly for any damage or deterioration of the insulation and that the cabling is well supported in cable trays or conduit. A log of battery maintenance should be kept and the battery maintenance routines incorporated in the plan of scheduled maintenance.

Figure 9.10 indicates points that should be observed during visual checks of lead acid batteries.
A.C. ELECTRICAL SYSTEMS

Medium to high voltage power on board vessels is usually provided by diesel driven alternators providing either 240 volts single phase power or 415 volts three phase power. In some vessels an inverter is used to provide a limited 240 volt single phase power source from the D.C. battery power system. After this system is installed in the vessel, very little maintenance is required other than the routine maintenance on the alternator prime movers and a full insulation test on all circuits above 32 volts every 2 years. A regular inspection of all cabling should be made for any damage or deterioration and this should be incorporated into the plan of scheduled maintenance. At all times, a great deal of care must be taken when working on any medium or high voltage electrical system to ensure that the power is isolated and the appropriate test equipment is available to check the system is not live. If in doubt disconnect shore power, shutdown all power generating machinery and isolate all battery power and work by torch light.

FIXED AND PORTABLE FIRE FIGHTING EQUIPMENT

All vessels should have some form of portable fire fighting equipment onboard. This will consist of portable fire extinguishers only on smaller vessels. Larger vessels will carry not only portable fire extinguishers but also engine room fixed fire system, non portable fire extinguishers and fire hoses and nozzles at each fire hydrant. Fire extinguishers should be stowed in readily accessible positions on board the vessel and, when not clearly visible, a sign clearly indicating their position should be provided. The general condition and physical presence of all fire extinguishers should be checked on a daily basis to ensure they have not been removed from their correct stowage and they have not been discharged accidentally. Fire extinguishers and fixed fire systems should be serviced by an approved servicing agent every 12 months and a certificate
provided by the servicing agent that all fire extinguishers are in good working order and the pressure test on storage cylinders is in date. Fixed fire systems should be provided with a service certificate indicating the fire extinguishing medium is fully charged, the activating mechanism is functioning correctly and that all heat and/or smoke sensors and alarms both audible and visual are operating correctly. Every month, all fire hoses and nozzles should be removed from their stowages, connected to fire hydrants and fully charged from the vessel's fire main. Hoses should be checked for leaks and nozzles checked for correct operation.

SAFETY EQUIPMENT

An up-to-date list of the safety equipment required onboard the vessel for its different survey classes should be displayed in a prominent position in the wheelhouse/bridge. The safety equipment should be checked on a weekly basis from the list to ensure that it is in its correct stowage and that it is in good condition; this also helps the crew become familiar with the location and type of equipment onboard the vessel in the case of an emergency.

LIQUID PETROLEUM GAS (LPG) SYSTEMS

LPG is a very convenient form of energy. Unfortunately, it is highly dangerous. It is heavier than air and will, therefore, accumulate in a vessel's bilge. It can take as little as a static spark from your clothing, to cause an explosion.

LPG is non toxic but can cause suffocation if inhaled in sufficient quantity. The USL code specifies requirements for LPG fittings and installations; they include:

- LPG burning appliances require a certificate of compliance and should be installed and serviced by a licensed gas fitter.
- All appliances should be installed firmly in place to ensure no movement.

LPG gas cylinders must be:

- Hot dip galvanized
- Fitted with a pressure safety relief device
- Fitted with a stop valve with a permanent handle
- Secured valve uppermost on open deck
- Positioned at least one metre horizontally from any opening leading below decks
- Protected from climatic extremes
- If the cylinder is housed in a cabinet, it must be vented top and bottom
- Fitted with a low pressure regulator.

LPG cylinders MUST NOT be:

- Installed or stowed even temporarily below decks or in a deck house.

All LPG appliances must be above decks (stoves exempted with stringent conditions) and must have flame failure shut offs.

All appliances should have flame failure devices fitted to all burners or, where this is
not the case, an approved gas detector is to be installed with sensors at each of the LPG appliances and in the engine room bilge. An isolating valve is to be fitted as close as possible to all appliances in the gas supply line in a position that does not require leaning over the equipment to operate the valve. The operation of the flame failure devices and/or the gas detection system is to be checked for correct operation on a regular basis. Gas bottles are to be stowed in a separate locker that is gas tight from the interior of the vessel and vented at the bottom of the locker over the side of the vessel. It must be emphasised that LPG is extremely flammable and explosive and is heavier than air. This makes LPG an extremely dangerous substance to have onboard a vessel and the utmost care should be taken in handling LPG and the regular maintenance of all associated piping and safety devices fitted to the system.

The above list of systems onboard a vessel is by no means exhaustive and, as indicated earlier, will depend on the vessel’s size and function. Set out below is a typical plan of scheduled maintenance for a large, sheltered waters passenger carrying vessel.

UNIT 9.11 PLAN OF SCHEDULED MAINTENANCE (large, passenger carrying vessel operating in sheltered waters)

HULL AND SUPERSTRUCTURE

DAILY ROUTINES

1. Check operation of all watertight doors, hatches and vent flaps.
2. Check all guard rails and access closures are secure.
3. Check the operation of all navigation lights and sound signals.
4. Clean all windows.

WEEKLY ROUTINES

1. Check anchors and cables and operation of anchor winch.
2. Descale and paint any corroded deck fittings.
3. Check all safety and fire fighting equipment for condition and correct stowage.

MONTHLY ROUTINES

1. Descale and touch up any corroded areas on hull.
2. Check operation of engine room intake and exhaust vent flaps.
3. Check condition of sealing rubber on all watertight doors, hatches and vent flaps and carry out chalk test on all watertight closures.

THREE MONTHLY ROUTINES

• Repaint decks in high traffic and gangway areas where necessary.

SIX MONTHLY ROUTINES

• Assess condition of all paint work on upper deck superstructure and repaint where necessary
TWELVE MONTHLY ROUTINES
1. Prepare vessel for slipping. Order paint required, create work list for work to be carried out during slipping and arrange any contractors required to carry out work.
2. Prepare and arrange for vessels annual survey. Check all safety equipment before survey is carried out.

MACHINERY AND SYSTEMS

DAILY ROUTINES
1. Check oil levels in main engine sumps and gear boxes.
2. Check oil levels in alternator prime mover engine sumps.
3. Check coolant level in closed circuit cooling systems on both main and alternator engines.
4. Start and run main engines and alternator prime mover engines and visually check for any oil or water leaks. Check oil pressure is correct on all engines and temperature gauges are functioning correctly.
5. Operate main engines ahead and astern from wheel house control stations to ensure they are functioning correctly.
6. Run all vessels alternators on ships load and check for correct operation.
7. Record all engines hours in engine maintenance logs. Check fuel levels in all fuel tanks.
8. Run all freshwater and toilet flushing pumps and visually check for any leaks
9. Check taps at all sinks and hand basins on board the vessel for leaks and correct operation.
10. Flush all toilets and urinals and check for correct operation.
11. Fill freshwater tanks and toilet flushing tanks.
12. Check operation of sullage pumps and pump sullage tanks dry.

WEEKLY ROUTINES
1. Check engine hours on all main engines and alternator prime movers and arrange to carry out any service items that are due.
2. Check electrolyte level on all lead acid battery banks and record in maintenance log.
3. Check for loose cable connections at battery terminals, starter motors and change over/isolating switches.
4. Check the operation of all bilge level alarms.
5. Clean all seawater intake strainers.

MONTHLY ROUTINES
1. Run all engine driven bilge/fire pumps and provide water to all fire hydrants.
2. Charge all fire hoses and check for leaks and check nozzles for correct operation.
3. Fully open and close all valves and “L” ported cocks associated with the bilge/fire system and prove bilge suction system by sucking out a bilge.

4. Check correct operation of all emergency fuel shut off valves

5. Check correct operation of engine room ventilation closures.

6. Check condition of hydraulic steering hoses and fittings.

7. Check manual release for engine room fixed fire system is connected and in good condition. Check contents gauge on storage cylinder is reading fully charged.

8. Check the condition and contents of all fire extinguishers located in the engine room.

THREE MONTHLY ROUTINES

• Lift engine room deck plating and check condition of piping and operate any associated valves deck engine room local control stations and communications for correct operation.

TWELVE MONTHLY ROUTINES

• Two weeks before slipping start running down a designated fuel tank ready to be opened and vented gas free to allow cleaning during the vessel’s slipping.

UNIT 9.12 SELF-TEST EXERCISE

The answers to this self test can be found at the end of the book.

1. What is corrosion?

2. List 6 types of corrosion, giving brief notes to explain the nature of each.

3. Lead is a soft metal, which is easier to mould. Do you think it is a good metal to use for the manufacture of sacrificial anodes? Explain your answer.

4. What precautions should you take when in dry dock, with respect to the sacrificial anodes and impressed current electrodes?

5. What are some of the advantages/disadvantages of the sacrificial anode system, compared to the impressed current system?

6. Why do GRP hulls need weather protection?

7. What is meant by wet and dry rot?

8. List three ways that good maintenance can benefit a vessel.

9. What is the biggest contributing factor to the deterioration of a vessel’s structure and systems?

10. What is the best way to ensure that periodic maintenance is carried out on the vessel’s structure and systems?

11. What is the best way to ensure the correct paint systems are used on the vessel’s structure?

12. On a commercial vessel, what safety device is fitted to the fuel system?
13. What critical spares should be carried onboard the vessel for the fuel system?

14. What is the only proven method of removing fungus build up from a diesel fuel tank?

15. What simple maintenance routine can be carried out on the bilge system to ensure that the system will operate correctly in an emergency?

16. On a vessel that has a combined bilge/fire pump, what type of cock is fitted between the sea suction and the bilge manifold suction to prevent back flooding of the bilges?

17. What daily maintenance routine should be carried out on the vessel’s freshwater system?

18. What is the most important safety device fitted to an air compressor and what parameter should this device be set?

19. Why is it necessary to pay close attention to the cable connections at batteries, starter motors and change over switches on DC electrical systems onboard the vessel?

20. What is the best way to ensure that AC electrical circuits are not live when carrying out maintenance or repairs?

21. List the fire fighting appliances and equipment found on a large, well found vessel?

22. Where should a list of the safety equipment required by the vessel’s survey classes be displayed?

23. What safety devices should be fitted to all LPG appliances installed below decks onboard the vessel?

24. Describe the requirements of LPG bottle stowage.

25. Create a plan of scheduled maintenance for a vessel that you are familiar with.
SECTION 10

Dry docking and Slipping

INTRODUCTION

The U.S.L. Code requires that all vessels under the jurisdiction of the Surveying Authority in your State, shall undergo periodic surveys. (Refer back to Section 3 in this Section Book.)

Every two years the hull must be externally and internally inspected. All steel sea cocks and valves, bilge injection valves and overboard discharge valves have to be inspected for any deterioration or excessive corrosion. To conduct these surveys it is necessary to withdraw the vessel from the water and place it ‘in a satisfactory manner to enable the surveyor to make an external examination of the hull, underwater fittings, shafting propeller(s), rudder(s) and any other appurtenances’.

Prior to such examination, the hull shall have been washed and cleaned, but not painted.

In this Section we will examine the methods of, and precautions associated with, the drydocking and slipping of vessels.

OBJECTIVES

By the end of Section 10 you should be able to:

• describe the different methods of slipping and drydocking
• describe the action of bringing a vessel to a slipway or dock, and the precautions necessary while doing so.

UNIT 10.1 DOCKING METHODS

1) Careening

This is not actually docking in the true sense of the word, but it does give the crew an opportunity to clean the hull without the expense of using docking facilities.

The vessel is run close in shore over a suitable gently-sloping sandy beach, at high tide, preferably the lower of the two high tides. About three to four boat lengths from the point where the vessel can be expected to touch the bottom, the seaward anchor is released and the vessel is allowed to drift gently sideways to the beach till she touches bottom. This can be controlled by running mooring lines ashore and securing them on the beach. (See Figure 10.1)
Using a Baltic type moor, while paying out the anchor will ensure total control over the vessel as she is beached.

As soon as she touches bottom all the moorings are pulled up tight. It is necessary then to wait for the tide to run out.

At low tide the vessel will be grounded and heeled over towards the shore. This method is widely used for small craft, and while cheap, it does have its attendant problems and dangers.

The time when work can be carried out on the hull is limited to the period between the time that the beach in the locality of the vessel dries on the falling tide, and the time that it floods on the rising tide.

There are not many surveyors who would be prepared to conduct a periodic survey under such conditions, so this method of exposing the hull is not satisfactory in that respect.

If there are any rocks or sharp objects that the skipper has not noticed when beaching the vessel, a very real danger of bilging her can exist. If the beach is sloping too steeply she can roll over, and that usually means the loss of the vessel.

If she is beached at the higher high tide, there is a real danger that she will not be able to be refloated at the next high tide.

A large range of tides is, of course, necessary for successfully carrying out this operation.

When the tide comes in, the shore moorings are slipped and, by heaving on the windlass, the vessel is guided into the deeper waters as the rising water level lifts her.

Other methods of careening are to approach the beach bow first or stern first, and heel the vessel over using ballast, to expose the side to be worked on. Ground tackle must be rigged to hold her securely while work is being done on the hull.

Using these methods, it is quite likely that the seaward end is always afloat and it will be necessary to turn her around on the next tide to complete the job of hull cleaning. Beaching bow-on or stern-on does reduce the danger of the vessel falling over if the beach sloped too steeply for a broadside beaching; nevertheless, there is the stability problem of an upthrust on one end of the keel which is common to all drydocking procedures. More about this will be discussed later.
2) **Heaving Down**

Here, a vessel is heeled over, while afloat, by means of tackles set up between her masts and another ship, hulk or shore attachments. Her masts are rigged with extra preventer shrouds to distribute the additional stresses involved.

Crewmen on rafts can then conduct work on the exposed part of the hull. This method is not as successful as careening in exposing the hull, but, since the vessel is afloat, there is little hull stress, and the dangers, through touching the bottom, of damage to the hull and the intakes, are minimal. It must be remembered that by heeling a vessel you increase its draft, and you should be sure that there is sufficient under-keel clearance for the job.

3) **The graving dock**

This is one which is excavated from the land and closed to the sea by means of a large watertight gate. The edge of the dock bottom beneath the gate is referred to as the sill. This dock is a large, robustly built tank with concrete terraced sides into which shores can be heeled if required. Along the centre line of the dock, huge baulks of timber are built up into keel blocks. In the larger docks, two parallel lines of bilge blocks (one on either side of the keel blocks) are placed to give additional support. The blocks are usually fastened down to prevent them toppling, or being tripped when the vessel is being sewn or refloated. The line of the tops of the blocks usually presents a slight gradient, the front end of the line of blocks being slightly higher than the gate end. This is known as the declivity of the dock (trim). The dock is filled from the river or the sea; the gates being opened when the inner and outer water levels are the same. The ship is then floated in and positioned over the blocks. The gates are closed and the dock pumped dry. The top edge of the gate, usually wide enough for vehicles to be driven along it and people to walk across it, is often 15 m above the dock bottom. It is of academic interest to note that if the water level were 3 m below the top of the gate, the gate would have to withstand pressure in excess of 12 tonnes per square metre!

![Fig. 10.2 The graving dock](image-url)
4) The floating dock

This is virtually a huge flat pontoon tank with subdivisions (similar in construction to a ship’s double bottom). Down its centreline on the top of the tank is the row of keel blocks. Bilge blocks may also be present.

Two vertical wing tanks are also constructed at the sides of the dock.

![Fig. 10.3 Floating dock](image)

The whole dock forms a floating, watertight structure which can be submerged by flooding the bottom tanks.

The vessel to be docked is simply floated into the dock and is positioned above the keel blocks by use of mooring lines. Shores are fitted to provide support and the pontoon tanks are pumped out, until the pontoon deck is dry.

The shores serve two purposes.
1) They prevent the vessel toppling off the keel blocks.
2) They prevent the sides of the dock deflecting inwards because of the weight of the ship resting on the blocks.

Before floating the vessel into the dock, the docking manager will require the vessel’s stability details, including list and trim, loading condition, and ballast. These may have to be altered. Each section of the dock must be capable of supporting that portion of the ship’s length that rests on it, and the weight that lies within it. To avoid subjecting the dock to severe bending stresses, the vessel must therefore be evenly loaded.

To keep the dock properly trimmed, it is important to position the ship so that the ship’s Centre of Gravity is located vertically above the dock’s centre of buoyancy. These positions are marked (by painting) on the sides of both dock and ship.
5) *The floating cradle (Patent Slip)*

This consists of a sloping, reinforced-concrete runway, on which is built a railway, carrying a heavy cradle. The runway extends well below the low-water mark. The cradle, fitted to a wheeled carriage, is run out to receive the vessel when there is sufficient water. The vessel is floated into position and secured in the cradle. The cradle is then drawn out of the water, bringing the ship with it. When the keel rests on the bottom of the cradle, the securing beams are drawn tight and any shores, if required, are fitted. The vessel, now being secure, is drawn clear of the water onto the slip.

![Fig. 10.4 Patent slip](image)

Figure 10.5 shows a photograph of a vessel in a cradle. The supporting beams which take the place of keel blocks can be clearly seen. As the keel is sewn, these beams are drawn up to hold the vessel snugly in a V.

![Fig. 10.5](image)
Figure 10.6 gives a closer look at the keel and the support beams and how the vessel is supported while in the cradle.

UNIT 10.2 STABILITY CONSIDERATIONS

A vessel entering dry dock should be upright. It is desirable that she has a slight trim by the stern so that she will initially rest on the blocks at the aftermost point of her keel. She will then pivot about this point in a vertical plane as the water level falls, and may also be pivoted in a horizontal plane by means of her forward breast lines so that her keel may be aligned with the keel blocks. A problem does arise, however, while the water level is falling. The upthrust on her keel has the effect of reducing her stability and causing an apparent rise in the Centre of Gravity. The value of this upthrust can be found by the formula:

\[ P = \frac{\text{Trim} \times \text{MTC}}{d} \]

Where:
- \( P \) is the upthrust at the keel in tonnes
- \( \text{Trim} \) is the vessel’s trim in centimetres
- \( \text{MTC} \) is the moment to change trim by 1 centimetre
- \( d \) is the distance in centimetres of the centre of flotation from aft.

Fig. 10.6 The cradle
By placing a weight in the bottom of a ship, you effectively lower its Centre of Gravity, and by removing a similar weight, you would effectively raise the Centre of Gravity. The effect of the upthrust on the keel is exactly the same as removing a weight equal to $P$.

This causes a virtual rise in your Centre of Gravity (loss of GM) of

$$\frac{(P \times KG)}{W - P}$$

where $W$ is the original displacement of the vessel.

Once the keel is sewn, and shores can be rigged, the stability of the vessel is not a problem. But it should be obvious that in order to ensure that the vessel does not topple off the blocks as the water level falls, GM must be greater than

$$\frac{(5 \times KG)}{(W - P)}$$

and the greater the GM the better.

Whatever method of docking or slipping is used, this requirement should be met, as it is the only way of ensuring there is sufficient stability to safely sew the keel.

There is a second critical moment to be considered when using a floating dock.

Although it is beyond your control and is the responsibility of the docking manager, it is included in this Unit for your interest.

When the keel is sewn and the floating dock begins to lift the vessel out of the water, the vessel and dock become one floating craft or system, the stability of which depends on the water plane area of the craft.

As the water level falls below the ship’s keel, and is between the keel and the dock bottom, the water plane area is restricted to that of the two narrow side tanks. The floating dock’s stability is greatest when the dock bottom is dry.

Free surfaces in the ship’s and dock’s tanks also affect the system.

**NOTE:** This topic will be studied in greater detail in your stability learning resource.

**UNIT 10.3 GENERAL PROCEDURES**

**Repair Lists**

Prior to docking or slipping, a complete repair list of all work to be done while in dock should be made up.

Several copies should be made so that all those directly involved in the work can monitor the progress being made and cross off the completed jobs.

**Draft and Trim**

We have already discussed the stability problems associated with trim. The dock-master or slip manager should be informed of the draft and trim as soon as possible, so that any alterations, if required, can be made.
**Structural features**

It should be remembered that the echo-sounder transducer, the log, sonar transducers and keel coolers are a primary consideration before any dry docking or slipping is carried out.

The deck master should be notified of the locations of these, so that the positioning of the keel blocks can be arranged to prevent any damage. He should also be informed of the bilge keels (if any), the rake of the stem and the type and number of propellers.

Any protruding logs should be withdrawn into the hull.

After the dock is drained, transducers and impressed current anodes should be covered with grease and then masking tape to ensure that they are not painted over. Prior to flooding, the tape should be removed and the transducers be wiped clean.

All tanks that need draining should have their plugs removed from their recesses in the shell plating and placed in safe custody.

A written record should be made, identifying the location from which the plugs have been removed. Prior to flooding the dock, the plugs must be replaced, and the record checked off as each plug is replaced. A signed certificate should be given to the dock-master or slip-manager, stating that a competent officer has inspected the hull and that all drain plugs have been replaced.

**Cargo and movable weights**

If possible, the vessel should have discharged all cargo prior to dry docking or slipping.

When a vessel is dry-docked or slipped, the whole weight of the vessel must be supported by the keel and bilge blocks. This results in considerable localised stresses being exerted on the hull, and particularly large bending stresses in way of the garboard strake. While the vessel is afloat, the hull is uniformly supported by the water pressure and buoyancy forces. To help relieve the stresses described above, shores or cradle support beams, as shown in Figures 10.10 to 10.13, are placed on the frame lines. It is important that the shoring or supports are not placed between the frames, as this will result in the shell plating being set in.

If the vessel has cargo on board, the ship is likely to be subjected to very severe stresses and be strained. The double bottom tanks should be pressed up beneath the holds carrying cargo. This will help to distribute the weight of the cargo evenly over the inner bottom.

When the keel is sewn, bilge blocks should be built up (if not already correctly in place) to ensure that the vessel is well supported before too much of her weight is transferred to the keel blocks. The bilge blocks should be placed under longitudinal side girders to prevent plate buckling.

Extra shores should be placed throughout the ship’s length, and especially at her ends. The dock-master must be given detailed loading plans prior to dry-docking.

All movable weights should be secured. Since it is desired that the vessel should be in the same conditions of trim (large stability and zero list), both on entering and leaving the dock, tanks should be either full or empty, so that no free surfaces exist. The fore and aft peak tanks are difficult to support with shores, and should, if possible, be empty.

As soon as the keel is sewn, all tanks and bilges should be sounded, and the soundings recorded. If any tanks have to be drained while in dock, these soundings can be duplicated prior to refloating.

There is an advantage of docking with tanks full - leaks can be readily noticed.
**Derricks, gangways and anchors**

All scaffolding, ladders and gangways must be properly secured, and guard rails must be fitted, to provide safe access between the vessel and the shore.

The anchors should be secured. It is a good practice to rotate the shackles of the anchor chain while in dock. This is done by lowering the anchor with the windlass in gear and ranging the cable on the dock.

The joining links are broken and the first two shackles of cable are placed in the chain locker at the bitter end. This way, after some five dry-docking periods, the entire anchor chain has been rotated and all parts of the chain experience more even wear.

**UNIT 10.4 SELF-TEST EXERCISE**

The answers to the following questions can be found at the end of the book.

1. What is the *critical moment* when using a floating dock?
2. How can a *Baltic* type moor be used for controlling the beaching of a vessel for careening her to clean the hull?
3. What are the dangers of careening?
4. What precautions should you take to ensure that the echo sounder transducer, sonar transducers, the log and keel coolers are not damaged during docking?
5. What steps would you take when preparing a double bottom ballast tank for inspection in dry dock?
SECTION 11

Safety During Maintenance Operations

INTRODUCTION

Perhaps the most hazardous period on board any ship, in terms of personal injury or damage to the ship itself, is during dry-docking or slipping operation. Many people not usually associated with the running of the ship are on board; welding is normally being done - with the attendant fire hazards; men may be working aloft and the chances of being hit by a falling hammer or tool are much greater; sandblasting and painting activities are going on, each with its own potential hazards. It is a time for the intelligent seaman to be especially aware and alert.

OBJECTIVES

By the end of Section 11 you should be able to:

• describe the dangers associated with the use of a sand-blasting facility and the safety equipment required during its use
• describe the dangers associated with welding operations and the precautions necessary before and during the welding operation
• describe the precautions necessary in the prevention of fire during repairs and maintenance.

UNIT 11.1 FIRE PRECAUTIONS IN DRY DOCK

Often the time in dry dock is used to overhaul and maintain the vessel’s fire-fighting appliances (F.F.A.). Fire extinguishers are sent ashore to be tested and recharged, fire pumps are overhauled, fire detection systems are tested and blown through. While these activities are going on, the vessel cannot make use of her own F.F.A. in the event of fire. Full fire-fighting precautions should therefore be taken as soon as the vessel docks. It is difficult to run hoses from the dock to the ship, and, in an emergency, considerable time can be lost. A shore hose from a shore hydrant should be connected to the fire mains on board, and pressure maintained all the time.

Wherever hot work is being carried out (welding, cutting), hoses fitted with combination jet/spray nozzles should be rigged. All flammable materials should be removed from the vicinity of ignition sources (such as welding, grinding or acetylene torch cutting).

No F.F.A. should be sent ashore or dismantled without first ensuring that it is replaced with a suitable alternative.

No-smoking signs should be posted, and observance enforced in high-fire-risk areas.

During dry dock, extensive painting is usually taking place. All paint vapours are flammable, and the need for thorough ventilation is paramount. The spillage of solvents and thinners used in the painting process presents an additional fire hazard, not to mention the flammable liquid, soaked rags and waste inevitably littered about the ship. These should not be allowed to accumulate. The possible causes of fire while in dry dock are too numerous to list, but it is enough to say that all concerned should be especially conscious of the hazardous situation.
UNIT 11.2 OXY-GAS CUTTING AND ARC WELDING

OXY-GAS CUTTING

The first requirement for safety with the oxygen gas plant and its use, is the need for protective clothing.

GOGGLES are essential and must be worn to protect the eyes from the heat and glare, and from the possible spatter of hot metal and scale. The goggles are available in a range of filter lenses to suit the various gas welding and cutting operations.

NOTE: These are NOT suitable for arc welding.

LEATHER GLOVES should be worn for all cutting operations.

SAFETY BOOTS are necessary to protect the feet from hot slag and from off-cuts falling from the plate being cut.

A LEATHER APRON is recommended for all welding and cutting operations.

FIRE HAZARDS with gas cylinders and equipment can be avoided by:

• positioning cylinders away from area where sparks or slag can be expected
• avoiding working on wooden floors, and if there is no alternative, making sure they are wetted or covered with sand
• ensuring that all combustible materials, grease or oil are well away from the working area
• always being aware of the location of fire-fighting equipment in the workshop
• ensuring that the other side of any metal bulkhead or deck undergoing hot work is free from flammable materials, and maintaining a constant watch throughout the operation if it is not.

EXPLOSION RISKS are always possible when acetylene gas is present in the air. It is essential, therefore, that the following requirements are followed:

• ensure that there is adequate ventilation in work areas
• inspect the equipment carefully before use for any leaks in the system; a soap and water solution painted on to all connections will readily indicate any faulty joints.

GAS CYLINDERS must be treated with care and with proper regard for their potential hazard by:

• always keeping them upright and secure to avoid mechanical damage
• always keeping them cool, away from heat sources and naked flames
• storing the cylinders in well-ventilated surroundings and by not smoking in a cylinder storage area
• keeping the cylinder valves closed when not in use or when changing equipment. (Correct pressure regulators must be fitted prior to use.)
• keeping cylinders free from grease, oil and dirt. (Oils and greases can ignite spontaneously in the presence of oxygen.)

ARC WELDING

PROTECTIVE CLOTHING is essential with this process, and, although some of the equipment is the same as that recommended for gas cutting, much of it is not, and should never be considered to be adequate without first checking carefully.
**EYE PROTECTION** is probably the main consideration. The electric arcs produced by both a.c. and d.c. machines are extremely injurious to the naked eye. **Infra-red** radiation causes a noticeable heat on the face and, without adequate protection, causes serious eye problems. **Ultra-violet** radiation can cause a **sunburn** on the skin, and a condition known as **arc-eye** to anyone in the vicinity without eye shielding. The intense **visible light** or glare from the arc can cause eye strain and headaches.

The consequent need for eye protection is obvious, and this is obtained by the use of special filters, which are of such a colour and density as to adequately protect the eyes from this visible and invisible radiation.

However, the tint of the glass is of such a density that normal working vision is very restricted, and eye shields and goggles cannot be worn when doing operations other than welding. Removal of slag by means of a chipping hammer is one such an operation. This is itself an eye hazard, so clear glass goggles, safety glass or a shield fitted with a change-over device should be worn.

**BODY PROTECTION** is afforded by leather gloves, apron and leggings, to protect the clothes and body of the operator from the weld splatter.

**SCREENS** must be placed around a welding area to protect other workers from the radiation from the arc. Even a casual few seconds glance, from several metres away, is sufficient to cause eye problems.

**FIRE HAZARDS** are just as great with arc welding as they are with oxy-gas. The area around the welding position must be clear of refuse, rags, paper, etc., and a sand bin should be available for the disposal of spent electrodes. Wooden floors must be protected by spread sand or metal sheeting.

One of the most common injuries suffered around welding operations is burning to the hands from freshly-welded work pieces being picked up by other personnel, unaware of the hot condition of the metal. These hot objects should be clearly marked HOT with chalk.

**VENTILATION** in the arc welding area must be of a reasonable standard. Although not as essential as in gas welding and cutting, the fumes given off by the burning of the electrode coating can be injurious if they are not dispersed by reasonable ventilation. For enclosed cubicles, fume **extractors** should be employed at all times.

**ELECTRICAL HAZARDS** accompany the use of electric arc welding. The high voltage (415 v) from the mains supply necessitates that equipment be safely installed and carefully maintained by a qualified electrician.

Damaged insulation, incorrect (oversize) fuses or lack of adequate earthing, can cause fire, overheating, damage to the equipment or serious injury to the operator.

The secondary (or working side) of the circuit is of low voltage but high current (typically 70 V, 400 A), and has a similar potential for creating dangerous conditions if not properly maintained and operated. The equipment must always have: a good earthing connection; undamaged insulation; adequate capacity cable and connections, and a positive return path - all to avoid fire damage and serious injury to the operator.

**Electrode holders** should be positively connected to the welding lead and should be of an approved adequately insulated, heat-resistant, non-ignitable type.

**Return current clamps** provide the connection between the work and the power source, and must be in good condition, firmly jointed and positively connected to the return cable.
The proper selection and care of welding cables is an essential safety requirement. A variety of faults can usually be traced to the neglect of the precautions necessary for safe and efficient working conditions, the most common faults being:

- bad connections
- excessive voltage drop through the use of over-long cables
- insulation being allowed to become defective
- the use of cables of inadequate current-carrying capacity.

When overhead welding is carried out, adequate protection must be provided for equipment and personnel beneath the welding position. A fire-resistant blanket should be hung so that all welding slag and spatter is caught, and not showered onto the area below.

**GENERAL CLEANLINESS** in the work area is an essential method of ensuring a safe workshop. Waste material, cleaning rags, paper and spent electrode stubs should all be placed in appropriate rubbish containers. Note that the electrode stubs should not be discarded in the normal waste/rubbish bins. They can cause fires. A sand surrounded metal bin in the immediate vicinity of the welding area should be provided for this purpose. A discarded electrode, lying on the floor, can burn through normal footwear - and can provide a rolling surface for others to step on - with disastrous results!

Remember that a welding area has the three potential major hazards:

- heat
- radiation
- high electrical risk

If behaviour is generally conducted to avoid these hazards, common sense actions will prevent most, if not all, personal injury and damage to equipment.

With reference to mechanical equipment, most of the precautions followed in the engine room can be applied directly to the dry dock.

Over-long hair must be contained by a cap or hair net to prevent entanglement in moving parts of machinery.

Footwear must always be of a substantial impact-proof type.

Clothing should be close-fitting to prevent entanglement with revolving equipment.

Clear safety glass spectacles or goggles must always be worn in drilling, grinding and cutting-off machine operations.

The setting, adjustment and preparation of machinery should always be carried out with the power isolated from the machine.

All protective guards must be securely and properly fitted before attempting to use any equipment.

If there is a failure in the electrical or mechanical operation of any equipment, the appropriate authority should be notified and no attempt to repair the machine is to be made, other than by suitably-trained and qualified personnel.

**UNIT 11.3 WELDING AND THE COMPASS**

The U.S.L. Code requires that all vessels, prior to the initial survey, should have their compasses adjusted by a licensed compass adjuster, and thereafter at intervals not exceeding three years.
The purpose of adjusting the compass is to identify any large deviations that the compass is experiencing because of the magnetic properties of the ship and hull, to compensate them, (if possible), and also to draw up a deviation table suitable for use in navigation.

Any extensive welding operations or alterations to the ship’s hull and components are going to have effect on the ship’s deviation. Depending on the extent of the work, and the proximity to the compass position, the effect can be various.

Obviously, if any magnetic properties of the ship are altered sufficiently to have a noticeable effect on the ship’s deviation, it will be necessary to have the compass adjusted, and any new errors compensated for.

The U.S.L. Code provides for the re-adjusting of the compasses ‘if the vessel has undergone repairs or alterations of such a nature as in the opinion of the authority are likely to affect the accuracy of the compass or compasses’.

The prudent seaman will ensure that his compasses are adjusted in such a case, without being instructed to do so by a Departmental Surveyor.

UNIT 11.4  HULL CLEANING

The principal reason for dry-docking or slipping is to remove the marine growth on the hull, and so allow the vessel to run more efficiently, with greatly-reduced fuel costs. There are four methods commonly used, each with its own advantages and disadvantages.

These are:
1) hand scraping and mechanical scaling
2) flame cleaning
3) shot blasting or sand blasting
4) high-pressure water washing, with or without the use of grit.

Fig. 11.1 Hand scraping
Hand scraping and mechanical scaling. These are relatively safe. Head and eye protection must always be worn by the workers. With mechanical scaling machines, ear protection should be worn, as the noise level is very high.

The major disadvantage of using these methods of hull cleaning is that they are very slow, rather inefficient, and (with current labour costs) very expensive.

Flame cleaning. This is faster. An oxy-acetylene torch with several jets to produce a wide flame, quickly burns off paint, however thick or old, and rust flakes off, because of the different rates of expansion of the rust and the steel plate. The plate is immediately brushed by another man following with a wire brush. The hull is now warm and dry and can be primed immediately.

Flame cleaning does have serious hazards, some of which are immediately apparent. The danger of fire outbreak inside the hull is real. The heating of the hull could result in the evolution of dangerous vapours which would be hazardous to any persons entering the tanks should they need to be surveyed. These suffocating fumes, which are also often flammable, must be completely removed by ventilation before the tanks can be entered.

The process of burning the antifouling and boot topping will release toxic fumes, so that the use of breathing apparatus and protective clothing should be considered essential, if not prescriptive.

Opinions vary as to the efficiency of flame cleaning. Some ship owners have had excellent results, but it seems to be less popular nowadays.

Shot blasting. Shot blasting is perhaps the most efficient means of steel preparation. Steel shot is projected at the area being cleaned (usually via compressed air). The hull is quickly stripped to the bare metal, removing all rust, paint and grease. The process leaves a slightly rough surface which enables good adhesion of the paint. Sand-blasting is similar to shot-blasting, but uses sand grit instead of steel shot.

Both the grit and the shot can be swept up and re-used, thus minimising the wastage to some extent.

The process is very noisy, very dusty, and has many attendant health hazards. Totally protective clothing must be worn by all operators. Goggles must be worn to protect the eyes from the fine dust, and the dust masks worn must totally filter out all dust, as the dust will contain particles of paint, which, if coming from the antifouling, will be toxic.

All persons not required to be on board should leave the vessel. The ship’s ventilation should be stopped during the process, unless adequate filtering of the air intakes is possible. Any machinery with air intakes not suitably filtered should not be used.

Severe injuries can occur to personnel if the nozzle of the sand blaster is directed at any unprotected parts of the body, so it is obvious that only trained operators should be allowed to use the facility.

Sand-blasting is unpopular, because of the massive clean-up job required after the operation. There is dust everywhere. Some dockyards do not allow sand-blasting for this reason.

High-pressure water hosing

This is a highly efficient system of cleaning. An extremely high-pressure jet of water is directed at the area to be cleaned. Grit may be used, but the pressure is usually so great that the paint is quickly stripped off. If grit is used, the hull is stripped to the bare metal.

The nozzle used is very fine, and the jet of water extremely concentrated. This method of cleaning is not nearly as fast as sand-blasting, but it does not create the dust hazard.
These jets of water that can cut through paint and rust to expose bare metal, are just as efficient at removing human flesh. Such a facility is highly dangerous in the hands of an unskilled operator.

UNIT 11.5 SELF-TEST EXERCISE

The answers to these questions can be found at the end of the book.

1. Describe the safety equipment required for sand-blasting.
2. Describe the dangers associated with a welding operation.
3. What are the requirements concerning the ship’s compass after extensive welding operations and repairs?
4. List the safety equipment you would use during an oxy-acetylene torch cutting operation.
5. When would you wear a hard hat while in dry dock?
Fumigation and Pest Control

INTRODUCTION

All ships, no matter where they are trading, will periodically be invaded by pests and vermin. Port health controls are strict and aim at restricting the movement of vermin to and from ships in port, and thereby to contain as far as possible, the spread of the diseases that the vermin carry.

In the past, it was quite common for ships to carry a cat, ostensibly to control the level of rat infestation. This worked to some degree, insofar as the cat had access to the entire ship and could hunt out the rats. The construction and regulations for modern ships prevents such freedom and the ship’s cat has gone ashore. Pets also carry diseases and quarantine regulations require that all pets on board any vessels that arrive in Australian ports remain on board, and must be sighted by an official before outward clearance will be given.

OBJECTIVES

By the end of Section 12 you should be aware of the methods employed in pest control on board ships, and the hazards associated with fumigation.

NOTE: The information in this Section should be read as a guide only. Students should refer to Marine Notices from AMSA, the Regulations relating to quarantine from AQIS and the relevant section in the USL Code for the latest requirements. All the latest information on Fumigation can be found in those publications.

Visit Website: www.aqis.gov.au

UNIT 12.1 INSECTS

There are many types of insects that carry disease, but to the mariner the most common are flies, mosquitoes and cockroaches.

Mosquitoes

Mosquitoes are different from flies and cockroaches in that they are parasites - they derive their sustenance from living animals, whereas flies and cockroaches generally thrive on dead animal and vegetable matter.

The mosquito is the carrier of malaria, a tropical disease which can be, and is often, fatal. The term malaria is derived from mal and aria, meaning bad air.

Before modern science identified the disease as being caused by the parasite protozoan of genus Plasmodium, it was thought to be caused by the inhalation of the foul-smelling air from the swamps and marshes in the areas where the disease was common. People used to keep indoors, with doors and windows closed, to prevent the breathing of the bad air. While these precautions did reduce the incidence of the disease, it was largely a result of ‘the right action for the wrong reason’.
The World Health Organisation (WHO) has designated the areas between 20° North Latitude and 20° South Latitude as the high-risk malarial areas. For vessels trading in these areas, special precautions should be taken for the protection of the crew. A check with the local health authorities will let you know if there is a danger of infection.

In these areas, insect screens should be fitted to all doors, windows and ports. The crew should be issued with supplies of insect repellent and cans of insecticide to use in their cabins. A course of anti-malarial tablets should be taken, in accordance with the manufacturer’s instructions.

Malaria frequently shows itself soon after infection, but may take several months. Any shivering fits, fever or headaches should be regarded as possible early symptoms, and if they persist, medical attention should be sought.

**Flies and Cockroaches**

Wherever food scraps or refuse is allowed to accumulate, flies and cockroaches will be there, uninvited guests at a disgusting meal. Cockroaches, while fundamentally crawling insects, do fly when mature, and thus gain easy access to ships. Like flies, they love warm, smelly corners where food is found. The smell of decaying food readily attracts them, and any bacteria they pick up, will be transferred to the ship’s food supply if they gain access to it.

Scrupulous cleanliness in the galley, mess room and cabins is the only way to combat these pests. Regular spraying by pest control officers will reduce the incidence of infestation, but the ship’s complement must do their part in ensuring that good hygiene is maintained.

Food scraps and crumbs must not be allowed to accumulate. The galley should be scrubbed down every day, special attention being paid to the areas under benches and in hard-to-reach corners.

Fly screens should be used, and always in good condition. Aerosol insecticide sprays may be used, but all foodstuffs should be covered when spraying is in process.

Other pests such as beetles and weevils attack food cargoes, and surveyors may require that the vessel be treated for insect infestation.

**UNIT 12.2 TREATMENT FOR INSECT INFESTATION**

The following is a Marine Notice issued by the Commonwealth Department of Transport. Study it carefully. Methyl Bromide is used by pest control agencies in WA for the control of insects.

**Notice No. 8/1972**

**SURVEYS OF GRAIN SHIPS AFTER CHEMICAL TREATMENT FOR INSECT INFESTATION**

The Navigation (Grain) Regulations require that ships loading bulk grain in Australian ports shall undergo inspection by surveyors of this Department in order to ensure that the fittings and stowage arrangements within the ship are sufficient to ensure safe carriage.

These surveys necessitate inspection of the holds and bilges before loading of grain and customarily take place soon after the ship’s arrival at the loading port.

In addition to the surveys outlined above, the Department of Primary Industry requires the holds to be inspected prior to loading under the Export (Grain) Regulations in order to ensure freedom from infestation or other contamination which might adversely affect the grain cargo. In order to eliminate infestation, either gas fumigation or treatment with pesticides (or organic insecticides) is employed and the following sections of this
notice detail the precautions that are required before entry to the hold after such fumigation or treatment has been carried out:

(i) in the port of loading in Australia,
(ii) at sea whilst en route to Australia, or
(iii) at a port of call en route to Australia.

In all such cases the Master is to provide details of the substance used and the date of fumigation or treatment.

(A) PRECAUTIONS REQUIRED AFTER GAS FUMIGATION

Fumigation of grain in Australian ports as a measure to eliminate insect infestation is normally carried out by means of Methyl Bromide gas. Minimum recommended dosages for this gas are contained in the Department of Primary Industry Pamphlet ‘Notes for General Guidance - Fumigation of Grain Loading Vessels for Insect Pests’. Safety measures required during fumigation are detailed in the ‘Code of Practice for Fumigation of Ships’ Cargo Spaces with Methyl Bromide’ which has been produced by the Australian National Health and Medical Research Council and will shortly be available from all State Health Departments.

Methyl Bromide gas is poisonous to man and entry into a space where a residue of gas has collected can have serious or fatal consequences. Fumigation should only be carried out by experienced personnel who have a sound knowledge of good fumigation practice including the properties and safe handling of Methyl Bromide, and the following procedure is required before commencement of hold inspections under the Navigation (Grain) Regulations:

(a) Tests are to be carried out in all parts of the ship and a certificate issued indicating the maximum concentration of gas remaining. This procedure may be performed either by a fumigator who is licensed by a State Authority or by a qualified State Occupational Health Officer.

(b) If neither of the above persons is available, the Master and fumigator are jointly to inspect all parts of the vessel, carry out the necessary tests and sign the certificate indicating the maximum concentration of gas remaining. Alternatively, a medical practitioner or an industrial chemist who is experienced in fumigation and is in possession of the necessary equipment may act in lieu of the fumigator in this case.

In all cases this inspection and testing must be carried out as nearly as possible to the time that the survey of the ship is to be undertaken.

Entry into a hold or space that is found to have a remaining concentration of over 20 parts per million of Methyl Bromide must not be permitted.

It should also be noted that Methyl Bromide is odourless and that a proportion of Chloropicrin is frequently added at the time of packaging to act as warning agent.

Entry into a hold or space must also be prohibited if Chloropicrin is found to be present.

(The following details from the national Health and Medical Research Council Code of Safe Practice may be used for detection of the presence of this gas.)

CHLOROPICRIN

The first effects of excessive exposure to its vapour are irritation of eyes, nose and throat with coughing and lachrymation and later vomiting. These effects are reversible and symptoms subside rapidly if exposure is quickly terminated.

Failure to heed these early warning signs may lead, with continued exposure, to serious lung irritation.
(B) PRECAUTIONS REQUIRED AFTER TREATMENT WITH ORGANIC INSECTICIDES OR OTHER PESTICIDES

Pesticides and organic insecticides such as Malathion, Lindane and Dichlorvos, which may be applied either as a spray or from a smoke generator, may leave traces of vapour in the atmosphere.

These substances can cause discomforting but not permanently harmful effects. Basic instructions for use and a list of the substances commonly used are contained in the Department of Primary Industry pamphlet ‘Notes for General Guidance - Spraying and Fogging of Grain Loading Vessels Against Insect Pests’.

Where this method of treatment has been employed, the holds concerned must be thoroughly ventilated before the hold is entered for survey in order to remove any accumulated concentration of vapour. As a general guide, the opening of all hatch covers and ventilators for a period of about three hours is sufficient to achieve the purpose.

UNIT 12.3 RATS AND MICE

There are basically two types of rats - the country burrowing type, and the climbing type which dwells in the dock areas feeding on spilled grain and food-stuffs that litter the dock areas. The latter is often a disease carrier. In order to stop the passage to and from the ship, rat guards should be fitted to all lines. These are circular galvanised iron plates that fit over the mooring rope. They are lashed in position and, when properly secured, prevent any rats or mice passing to or from the ship.

![Fig. 12.1 Rat guard](image)

If it is not possible to fit a metal rat-guard, canvas paralled over the moorings both at the ship and at the shore bollards, well tarred or heavily coated with grease, extending 0.6 m up the line, will suffice.

The gangway should be well lighted at night, as rats avoid brightly illuminated areas.
Stores should be moved regularly to discover whether they are harbouring rats, and, as said before, refuse should not be allowed to collect.

Rats may be caught on board by using traps, either break-back or live-capturing traps. Rats caught alive should be drowned, and all dead rats burned.

Rat baits can be profitably used to keep a ship rat free. Most baits are anti-coagulants which kill the rat only after several meals. They are generally safe to use and contamination risk to humans handling the bait is minimal. Obviously, hands should be washed after using the rat-bait. And while we are talking about washing hands, dead rats should never be handled.

If it becomes necessary to fumigate a vessel, certain precautions must be taken. Usually, gases like sodium fluoracetate are used, and occasionally, hydrogen cyanide gas. The latter is extremely dangerous, and people have been killed as a result of the failure to observe the necessary precautions.

The British Department of Trade issues merchant shipping notices, giving information to mariners, mainly relating to safety aboard ship. The following is M. Notice 115.

NOTE TO SHIPMASTERS No.115

FUMIGATION OF SHIPS WITH HYDROGEN CYANIDE

Fumigation with hydrogen cyanide is a dangerous process which should be undertaken only by responsible persons with full knowledge of the nature of the gas and of the necessary precautions.

The Nature of the Gas

Hydrogen cyanide - which is also known as hydrocyanic acid gas or prussic acid gas - is an invisible and highly poisonous gas. It has a faint almond-like odour. Many people however cannot smell it, and in some cases the sense of smell becomes deadened. It is therefore highly dangerous to rely on the sense of smell for detecting the presence of the gas.

It is a fallacy to imagine that because the gas is a little lighter than air it can be induced to escape upwards merely by opening port holes or hatches of ships. When once mixed with air it cannot thus easily be got rid of. The whole atmosphere of a compartment or ship must be changed, and this can be done only by applying the well-known principles of ventilation. The circulation of air may be assisted by mechanical means, and special attention must be paid to places where ventilation is obviously difficult or slow, e.g., forepeaks, deep holds with small hatches, etc.

Warning Notices

Warning notices should be displayed on every gangway and other means of access to the ship before the fumigation is started, and they should be kept in position until the operation is over and ventilation is complete.

Preliminary Search for Unauthorised Persons

Before any part of a ship is put under gas steps should be taken to see that no unauthorised person is on board.

Clearance after Fumigation

The ship must be properly ventilated and the fumigant operators must ascertain by test that in no part of the risk area is the fumigant concentrated by more than one part by volume in one hundred-thousand parts of air.
Bedding, blankets, pillows, cushions, thick carpets, etc., must be thoroughly beaten in the open air.

*Special attention should be paid to cabins and sleeping compartments. It is often advisable, after they are apparently free from gas, to close them for one hour and again test the air.*

In cold weather ventilation is slow and repeated tests may be necessary. As the temperature rises gas may be liberated from materials which have retained it. In such circumstances it may be necessary to heat compartments and then re-test them before they are declared free of gas.

Special attention should be paid to cold storage chambers.

The crew’s quarters or cabins must not be occupied during the night following a fumigation. If, however, this is unavoidable, all doors, port holes and other openings of spaces must be kept open and special attention must be paid to the previous beating - *in the open air* - of bedding, blankets, pillows, etc.

If the vessel has been fumigated with the cargo on board, special care is necessary, and the atmosphere should be kept under observation when unloading is in progress.

**Symptoms of Poisoning**

Hydrogen cyanide is extremely poisonous and poisoning may result from breathing the gas or absorbing it through the skin. The warning signs are irritation of the throat, dizziness, nausea, general weakness and headache, palpitation, a feeling of suffocation, pallor, deep breathing, sudden unconsciousness followed by a cessation of breathing, in that order.

A person showing these symptoms must be immediately removed to a pure atmosphere, laid down with his head into the wind and first aid must be given without delay. Speed is essential. A doctor must be summoned at once. The first aid procedure, if the patient is conscious, is as follows:

1. Break a capsule of amyl nitrite on to a piece of cloth and allow the patient to inhale the vapour.
2. Remove or cut away splashed clothing.

If the patient is unconscious, then in addition to (1) above, artificial respiration should be started simultaneously with (2) above. The patient should be kept warm and not walked about.

The reader’s attention is drawn to the Hydrogen Cyanide (Fumigation of Ships) Regulations, 1951, in which precautions are laid down regarding the treatment of ships by this gas. Notice of the forthcoming fumigation must be given to the Medical Officer of Health; operators are required to be adequately trained and equipped with respirators. The Rules explain how unauthorised persons are permitted to enter the risk area in the event of emergency such as fire.

In the Port of London in 1959, 112 vessels were deratted by the use of sodium fluoracetate (1080) compared with only thirteen by the use of HCN. The use of 1080 has proved popular with ship owners as it presents no fire risk or danger to humans. It does not give off poisonous fumes and it cannot be absorbed through the unbroken skin. It is odourless and tasteless in use and presents no repellent effect. Rats drink a lot of water and will approach the solution confidently.

While deratting with 1080, the crew may remain on board and work can proceed in those parts of the ship not under treatment.

Article 52 of the International Sanitary Regulations requires that a vessel shall be kept in a condition such that the number of rodents on board is negligible. Such a ship can exist on Deratting Exemption. This is achieved using the anti-coagulation baits,
distributed through the ship in polythene sachets which are broken by the rats. These sachets help to keep the bait fresh. Ships with past records of rodent infestation have been kept completely clear by the use of these baits.

In the Port of London, 100 ships are deratted nearly every year. Over 2000 rats are destroyed on vessels in the port each year.

Cargoes which are especially likely to contain rats are bagged grains, bagged bone-meal and fish meal, or in short, any bagged food-stuffs.
SECTION 13

Life Saving (LSA) and Fire-fighting (FFA) Appliances

INTRODUCTION

In 1960 and again in 1974 the articles and regulations of the International Convention for Safety of Life at Sea were drawn up. Australia was a signatory government to these articles, and undertook to enact legislation enforcing the standards required by this convention. This was done in due course and the minimum standards required in Australia pertaining to L.S.A. and F.F.A. can be found in the U.S.L. Code in Sections 10, 11 and 13.

Equipment which complies with the requirements of the convention has been loosely termed SOLAS equipment.

OBJECTIVES

By the end of this section you will be able to describe the methods of, and the necessity for, the inspection and maintenance of all fire-fighting and life saving appliances.

Students should refer to Section 10 of the USL Code for the latest requirements.

UNIT 13.1 INSPECTION

The W.A. Marine Act requires that the Master ensure that his vessel does not proceed to sea unless it is furnished with L.S.A. and F.F.A. in accordance with the regulations (a copy of which is reproduced below). All the L.S.A. and F.F.A. must be in good working order, and, if damaged, must be repaired or replaced immediately. Failure to do so can result in a fine of $2000 being imposed (as at January 2000).

In order to monitor the standard of F.F.A. and L.S.A. on board vessels, they are required to undergo yearly inspections. It is in the interest of all concerned to ensure that every piece of equipment is functional and operational, not only at the time of the annual surveyor’s inspection, but at all times.

There is little point in having a vessel equipped with elaborate fire fighting equipment, or life saving equipment, and then never inspecting it to ensure that it is correctly maintained.

A regular program of inspection should include the sighting of all L.S.A. and F.F.A., and the testing of some of them. A good time to conduct the inspection and tests is during the emergency fire and survival training drills held on board for the crew’s training.

- Fire hoses should be rigged and tested. They should be drained of any water and hung out to dry before being rolled and returned to their positions.
- Fire nozzles should be tested, and all moving parts on the spray/compression nozzles tested to ensure that they are not jammed.
- Fire extinguishers should be inspected to see that the correct fire extinguisher is in each location. Its securing straps should be in good condition and be able to be
quickly released in an emergency; extinguishers should never be tied down! Nozzles should be clear and free from any blockages. Pressure gauges should indicate the correct operational pressures.

- Breathing apparatus and firemen’s suits should be inspected for any signs of deterioration.
- All hydrants should be tested to ensure that they are not jammed. They should never be screwed down too tightly, so that they cannot be opened in an emergency. If they leak, the seals in the valve should be replaced.
- Fire alarms should be tested.
- Automatic fire detection units should be tested to ensure that they are operating effectively.
- Fixed fire fighting installations should be inspected to ensure that all parts are working.
- All life jackets should be closely inspected for signs of damage or deterioration. Check the straps, stitching, whistle, light, retro-reflection tape and flotation.
- Check the life buoys - each in its correct location. Test the self-igniting lights. Examine the lines bucketed around the buoy for any deterioration or lack of strength; where they have pyrotechnic smoke signals, check the expiry date, and replace where necessary.
- Check the pyrotechnics kept on board (usually in the wheelhouse); those with expired dates must be replaced.
- Check all fittings securing life boats or life rafts. Boarding ladders must be in good condition.
- Emergency lighting systems should be tested, and repaired where necessary.
- All liferafts should be sent for inspection to an authorised liferaft-servicing depot. Liferafts should not be tampered with while on board. The seals should not be broken. If they are, the raft must go ashore to be serviced by trained personnel. Often, liferafts are tampered with by irresponsible people thinking there are drugs contained in the first aid kit. While morphine used to be kept in lifeboats and liferafts, this is no longer the case, and the strongest pain-killer kept in the first aid kits nowadays is codeine-phosphate. These are readily available at chemists, and it seems a pity that valuable equipment such as a liferaft should be destroyed for this ridiculous reason.
- The magnetic compass should be clean, and local magnetic influences kept to a minimum. The light must be working, and a valid compass adjuster’s certificate kept on board.
- Depth-sounding equipment should be checked that it is satisfactory. The hand lead-line should be checked to ensure that it has the correct markings.
- Signalling lamp/s should be tested. Clean mirrors where necessary and replace any burnt-out bulbs.
- Nautical publications should be current and corrected up to date.
- Accommodation ladders, gangways and safety nets should be inspected and repaired where necessary.
- Pilot ladders should always be in good condition and comply with the requirements of Section 13 of the U.S.L. Code.
- Medicines and medical stores should be checked to ensure that the minimum scales are maintained.

UNIT 13.2 EXTRACTS FROM THE U.S.L. CODE

The following are extracts from the U.S.L. Code, covering the requirements as far as L.S.A. and F.F.A. is concerned.
STUDY them carefully, and identify the equipment on board the vessel on which you are serving. It goes without saying that all the equipment listed should be inspected to ensure that it is in a good working order and condition.

NOTE: Students should refer to the latest edition of the USL Code for any recent change in Regulation. This extract should be used as a guide only.
PART 3—SCALES OF LIFE-SAVING APPLIANCES
CLASS 1A

PASSENGER VESSELS—UNLIMITED SEAGOING

Reference should be made to Part 2 for marking, stowage, etc., and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>All lengths</td>
<td>The requirements for provision of LIFEBOATS, RESCUE BOATS, LIFEBOATS, BUOYANT APPARATUS, PORTABLE AND FIXED SURVIVAL CRAFT RADIO EQUIPMENT, TWO WAY RADIO EQUIPMENT, DISTRESS SIGNALS, LIFEBOYS, LIFEJACKETS, LINE THROWING APPLIANCES, IMMERSION SUITS, THERMAL PROTECTIVE AIDS, GENERAL EMERGENCY ALARM SYSTEMS, and EMERGENCY COMMUNICATIONS SYSTEMS are contained in Marine Orders Part 25. The requirements for EMERGENCY ELECTRICAL INSTALLATIONS are contained in Marine Orders Part 20. The requirements for MUSTER STATIONS are contained in Marine Orders Part 25 and 29.</td>
</tr>
</tbody>
</table>
CLASS 1B
PASSENGER VESSELS—LIMITED SEAGOING

Note:
Consistent with the type of vessel and the area of operations, a suitable scaling down of equipment may be permitted by the Authority.
Reference should be made to Part 2 for marking, stowage, etc., and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
</table>
| 25 metres and over | LIFEBOATS AND LIFERAFTS  
(1) Coastal lifeboat(s) for 100% complement on each side, or  
(2) A coastal lifeboat for 100% complement capable of being launched from either side of vessel, or  
(3) Coastal liferaft(s) for 100% complement plus rescue boat  
*Note*: Coastal lifeboat(s) for 50% complement on each side may be permitted by the Authority in vessels that are subdivided in accordance with the Construction Section of the Code. |
| Less than 25 metres | Coastal liferaft(s) for 100% complement |
| 60 metres and over  
45 metres and over but less than 60 metres  
25 metres and over but less than 45 metres  
10 metres and over but less than 25 metres  
Less than 10 metres | LIFEBOATS  
12 lifebuoys  
8 lifebuoys  
6 lifebuoys  
2 lifebuoys, one with light and one with line  
1 lifebuoy with light  
LIFEJACKETS  
(1) A SOLAS lifejacket fitted with a light and whistle for each person of mass of 32 kg and over that the vessel is certified to carry, plus  
(2) A SOLAS lifejacket suitable for each person aboard the vessel of mass of less than 32 kg, plus  
(3) 5% of (1) and 5% of (2) above stowed in a conspicuous place on deck  
DISTRESS SIGNALS  
12 parachute distress rockets  
6 parachute distress rockets  
4 red hand flares  
2 hand held orange smoke signals  
3 parachute distress rockets  
2 red hand flares  
1 hand held orange smoke signal |  
At least 50% with self-igniting lights, including 2 with smoke signals. 2 of remainder fitted with buoyant lines |
### Section 10

<table>
<thead>
<tr>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
</table>
| 45 metres and over | **LINE THROWING APPLIANCE**  
Line throwing appliance with 4 rockets and lines |
| 25 metres and over | **ELECTRICAL ALARM SIGNAL**  
Electrical alarm signal for mustering crew and passengers  
(where efficient mustering cannot be carried out by voice) |
| All lengths     | **EMERGENCY ELECTRICAL INSTALLATION**  
A self-contained emergency electrical installation, in addition to main generating set, able to simultaneously operate emergency bilge pump (where electrically operated), watertight doors (where electrically operated), indicators and sound signals for power operated doors, fire protection system, emergency lighting, emergency signals, navigation lights and communications equipment and capable of providing continuous operation for 12 hours  
(For voyages of short duration, a shorter period of continuous operation may be permitted by the Authority) |
## CLASS 1C

**PASSENGER VESSELS—RESTRICTED SEAGOING**

Reference should be made to Part 2 for marking, stowage, etc., and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
</table>
| 25 metres and over | **LIFEBOATS AND LIFERAFTS**  
(1) Coastal lifeboat(s) for 100% complement on each side, or  
(2) A coastal lifeboat for 100% complement capable of being launched from either side, or  
(3) Coastal liferaft(s) for 100% complement plus rescue boat  
*Note*: Coastal lifeboat(s) for 50% complement on each side may be permitted by the Authority in vessels that are subdivided in accordance with the Construction Section. Coastal liferaft(s) for 100% complement |
| Less than 25 metres | **LIFEBOATS**  
8 lifebuoys  
6 lifebuoys  
4 lifebuoys  
2 lifebuoys, one with light and one with buoyant line  
1 lifebuoy with light |
| 60 metres and over  
45 metres and over but less than 60 metres  
25 metres and over but less than 45 metres  
10 metres and over but less than 25 metres  
Less than 10 metres | **LIFEBOYS**  
At least 50% to have self-igniting lights, including 2 with smoke signals. 2 of remaining lifebuoys fitted with buoyant lines |
| All lengths | **LIFEJACKETS**  
A Coastal lifejacket with whistle for each adult or child aboard the vessel (each crew lifejacket shall be fitted with a light and a whistle) |
| 45 metres and over | **LINE THROWING APPLIANCE**  
Line throwing appliance with 4 rockets and lines |
| 25 metres and over  
Less than 25 metres | **DISTRESS SIGNALS**  
6 parachute distress rockets  
4 red hand flares  
2 hand held orange smoke signals  
3 parachute distress rockets  
2 red hand flares  
1 hand held orange smoke signal |
| 25 metres and over | **ELECTRIC ALARM SIGNAL**  
Electric alarm signal for mustering crew and passengers (where efficient mustering cannot be carried out by voice) |
| All lengths | **EMERGENCY ELECTRICAL INSTALLATION/EQUIPMENT**  
(1) a number of electric torches or hand lamps as determined by the Authority  
(2) emergency installation capable of operating navigation lights (where they are solely electric) for 3 hours, and  
(3) emergency installation capable of operating signalling lamps (where they are normally operated from main electrical power source) and communication equipment for 3 hours  
*Note*: In relation to (2) and (3) above the emergency installation can be the normal starting batteries provided that they are suitably placed in the vessel |
### CLASS 1D

**PASSENGER VESSELS—PARTIALLY SMOOTH WATERS**

*Note:*

In the tables following—

1. in vessels fitted with internal buoyancy as prescribed by Appendix N, or
2. in vessels that are subdivided in accordance with the Construction Section

the buoyant appliances and/or lifebuoys listed below may be reduced by a percentage not exceeding 40% as approved by the Authority.

3. Reference should be made to Part 2 for marking, stowage, etc., and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUOYANT APPLIANCES</td>
<td>(1) A dinghy, plus</td>
</tr>
<tr>
<td></td>
<td>(2) sufficient buoyant appliances and/or lifebuoys to provide float-off buoyancy for 100% complement, provided that—</td>
</tr>
<tr>
<td></td>
<td>(a) each lifebuoy is assumed to provide support for two persons,</td>
</tr>
<tr>
<td></td>
<td>(b) the following minimum number of lifebuoys shall be included in the above appliances:</td>
</tr>
<tr>
<td></td>
<td>6 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>4 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>2 lifebuoys</td>
</tr>
<tr>
<td>25 metres and over</td>
<td>Sufficient buoyant appliances and/or lifebuoys to provide float-off buoyancy for 100% complement, provided that—</td>
</tr>
<tr>
<td></td>
<td>(a) each lifebuoy is assumed to provide support for 2 persons,</td>
</tr>
<tr>
<td></td>
<td>(b) a dinghy may be included in the above appliances</td>
</tr>
<tr>
<td>60 metres and over</td>
<td>LIFEBUOYS</td>
</tr>
<tr>
<td>45 metres and over but less than 60 metres</td>
<td>Additional to any lifebuoys included in 100% buoyancy above</td>
</tr>
<tr>
<td>25 metres and over but less than 45 metres</td>
<td>2 lifebuoys, one with light and one with buoyant line</td>
</tr>
<tr>
<td>Less than 25 metres</td>
<td>1 lifebuoy with light</td>
</tr>
<tr>
<td>10 metres and over</td>
<td>LIFEJACKETS</td>
</tr>
<tr>
<td>less than 10 metres</td>
<td>A coastal lifejacket for each adult and child aboard the vessel</td>
</tr>
<tr>
<td>All lengths</td>
<td>DISTRESS SIGNALS</td>
</tr>
<tr>
<td></td>
<td>3 parachute distress rockets</td>
</tr>
<tr>
<td></td>
<td>2 red hand flares</td>
</tr>
<tr>
<td></td>
<td>1 hand held orange smoke signal</td>
</tr>
<tr>
<td></td>
<td>(A reduction in distress signals may be permitted by the Authority consistent with the area of operations allocated to the vessel)</td>
</tr>
<tr>
<td>All lengths</td>
<td>ELECTRIC ALARM SIGNAL</td>
</tr>
<tr>
<td></td>
<td>Electric alarm signal for mustering crew and passengers (where sufficient mustering cannot be carried out by voice)</td>
</tr>
<tr>
<td>25 metres and over</td>
<td>EMERGENCY ELECTRICAL EQUIPMENT</td>
</tr>
<tr>
<td>All lengths</td>
<td>A number of electric torches or hand lamps as determined by the Authority</td>
</tr>
</tbody>
</table>
CLASS 1E

PASSENGER VESSELS—SMOOTH WATERS

Reference should be made to Part 2 for marking, stowage, etc., and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All lengths</strong></td>
<td><strong>BUOYANT APPLIANCES</strong></td>
</tr>
<tr>
<td></td>
<td>Consistent with the area of operations allocated, the Authority may determine the percentage of lifejackets to be included in the buoyant appliances</td>
</tr>
<tr>
<td></td>
<td>Sufficient buoyant appliances, lifebuoys and/or coastal lifejackets to provide for 115% complement, provided that—</td>
</tr>
<tr>
<td>60 metres and over</td>
<td>(a) each lifebuoy is assumed to provide support for two persons,</td>
</tr>
<tr>
<td>45 metres and over but less than 60 metres</td>
<td>(b) the following minimum number of lifebuoys shall be included in the above appliances:</td>
</tr>
<tr>
<td>25 metres and over but less than 45 metres</td>
<td>6 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>4 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>2 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>(c) a dinghy may be included in the above appliances.</td>
</tr>
<tr>
<td><strong>10 metres and over less than 10 metres</strong></td>
<td><strong>LIFEBUOYS</strong></td>
</tr>
<tr>
<td></td>
<td>Additional to any lifebuoys included in 115% buoyancy above</td>
</tr>
<tr>
<td></td>
<td>2 lifebuoys, one with light and one with line</td>
</tr>
<tr>
<td></td>
<td>1 lifebuoy with light</td>
</tr>
<tr>
<td><strong>All lengths</strong></td>
<td><strong>DISTRESS SIGNALS</strong></td>
</tr>
<tr>
<td></td>
<td>Distress signals, consistent with the area of operations allocated, as determined by the Authority</td>
</tr>
<tr>
<td><strong>All lengths</strong></td>
<td><strong>EMERGENCY ELECTRICAL EQUIPMENT</strong></td>
</tr>
<tr>
<td></td>
<td>Electric torches or hand lamps as determined by the Authority</td>
</tr>
</tbody>
</table>

CLASS 2A

NON-PASSENGER VESSELS—UNLIMITED SEAGOING

Reference should be made to Part 2 for marking, stowage, etc. and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All lengths</strong></td>
<td><strong>Refer to Table for Class 1A Vessels</strong></td>
</tr>
</tbody>
</table>
## CLASS 2B

**NON-PASSENGER VESSELS—LIMITED SEAGOING**

**Note:**
Consistent with type of vessel and the area of operations, a suitable scaling down of equipment may be permitted by the Authority. Reference should be made to Part 2 for stowage, marking, etc., and to Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 metres and over</td>
<td>LIFEBOATS AND LIFERAFTS</td>
</tr>
<tr>
<td></td>
<td>(1) Coastal lifeboat(s) for 100% complement on each side of vessel, or</td>
</tr>
<tr>
<td></td>
<td>(2) A Coastal lifeboat for 100% complement capable of being launched from either side of the vessel, or</td>
</tr>
<tr>
<td></td>
<td>(3) Coastal liferaft(s) for 100% complement plus rescue boat Coastal liferaft(s) for 100% complement</td>
</tr>
<tr>
<td>Less than 25 metres</td>
<td>LIFEBUOYS</td>
</tr>
<tr>
<td></td>
<td>8 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>6 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>4 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>2 lifebuoys, one with light and one with buoyant line</td>
</tr>
<tr>
<td></td>
<td>1 lifebuoy with light</td>
</tr>
<tr>
<td></td>
<td>Note: All self-igniting lights in tankers to be electric battery type</td>
</tr>
<tr>
<td>60 metres and over</td>
<td>LIFEJACKETS</td>
</tr>
<tr>
<td>45 metres and over but less than 60 metres</td>
<td></td>
</tr>
<tr>
<td>25 metres and over but less than 45 metres</td>
<td></td>
</tr>
<tr>
<td>15 metres and over but less than 25 metres</td>
<td></td>
</tr>
<tr>
<td>Less than 15 metres</td>
<td></td>
</tr>
<tr>
<td>All lengths</td>
<td></td>
</tr>
<tr>
<td>45 metres and over</td>
<td>DISTRESS SIGNALS</td>
</tr>
<tr>
<td>25 metres and over but less than 45 metres</td>
<td></td>
</tr>
<tr>
<td>Less than 25 metres</td>
<td></td>
</tr>
<tr>
<td>12 parachute distress rockets</td>
<td></td>
</tr>
<tr>
<td>6 parachute distress rockets</td>
<td></td>
</tr>
<tr>
<td>4 red hand flares</td>
<td></td>
</tr>
<tr>
<td>2 hand held orange smoke signals</td>
<td></td>
</tr>
<tr>
<td>3 parachute distress rockets</td>
<td></td>
</tr>
<tr>
<td>2 red hand flares</td>
<td></td>
</tr>
<tr>
<td>1 hand held orange smoke signal</td>
<td></td>
</tr>
</tbody>
</table>
## Section 10

### CLASS 2B—continued

**NON-PASSENGER VESSELS—LIMITED SEAGOING**—continued

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
</table>
| 25 metres and over | ELECTRIC ALARM SIGNAL  
Electric alarm signal for mustering crew (where efficient mustering cannot be carried out by voice) |
| 50 metres and over, or less than 50 metres but not less than 500 tons | EMERGENCY ELECTRICAL INSTALLATION/EQUIPMENT  
A self-contained emergency electrical installation, in addition to the main generating set, able to simultaneously operate lighting, alarm signals, navigation lights and communications equipment and capable of continuous operation for:  
(1) vessels 125 metres and over, or (2) less than 125 metres but not less than 5000 tons | 6 hours  
(3) less than 125 metres and less than 5000 tons | 3 hours |
| Less than 50 metres and less than 500 tons | (1) a number of electric torches or hand lamps as determined by the Authority,  
(2) emergency installation capable of operating navigation lights (where they are solely electric) for 3 hours, and  
(3) emergency installation capable of operating signalling lamps (where they are normally operated from main electrical power source) and communication equipment for 3 hours |

*Note: In relation to (2) and (3) above the emergency installation can be the normal starting batteries provided that they are suitably placed in the vessel*
## CLASS 2C

### NON-PASSENGER VESSELS—RESTRICTED SEAGOING

Reference should be made to Part 2 for marking, stowage, etc., and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>25 metres and over</strong></td>
<td>LIFEBOATS, LIFERAFTS AND INTERNAL BUOYANCY</td>
</tr>
<tr>
<td></td>
<td>(1) Coastal lifeboat(s) for 100% complement on each side of vessel, or</td>
</tr>
<tr>
<td></td>
<td>(2) One coastal lifeboat for 100% complement capable of being launched from either side of vessel, or</td>
</tr>
<tr>
<td></td>
<td>(3) Coastal liferaft(s) for 100% complement plus rescue boat</td>
</tr>
<tr>
<td></td>
<td>(1) Coastal liferaft(s) for 100% complement, or</td>
</tr>
<tr>
<td></td>
<td>(2) Coastal lifeboat(s) as detailed above for 25 metres and over, or</td>
</tr>
<tr>
<td></td>
<td>(3) In the case of a vessel of less than 15 metres measured length, internal buoyancy as prescribed by Appendix N</td>
</tr>
<tr>
<td><strong>Less than 25 metres</strong></td>
<td>LIFEBOYS</td>
</tr>
<tr>
<td></td>
<td>8 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>6 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>4 lifebuoys</td>
</tr>
<tr>
<td></td>
<td>2 lifebuoys, one with light and one with line</td>
</tr>
<tr>
<td></td>
<td>At least 50% to have self-igniting lights, including 2 with smoke signals. 2 of remaining lifebuoys fitted with buoyant lines</td>
</tr>
<tr>
<td></td>
<td>One lifebuoy with light provided that these items are not required in:</td>
</tr>
<tr>
<td></td>
<td>(1) a vessel under 10 metres length which carries only one person, or</td>
</tr>
<tr>
<td></td>
<td>(2) a vessel less than 5 metres length which is fitted with internal buoyancy as prescribed by Appendix N</td>
</tr>
<tr>
<td><strong>Note:</strong> All self-igniting lights in tankers to be electric battery type</td>
<td></td>
</tr>
<tr>
<td><strong>60 metres and over</strong></td>
<td>LIFEJACKETS</td>
</tr>
<tr>
<td>45 metres and over but less than 60 metres</td>
<td>A coastal lifejacket with a light and whistle for each person that the vessel is certified to carry</td>
</tr>
<tr>
<td>25 metres and over but less than 45 metres</td>
<td>DISTRESS SIGNALS</td>
</tr>
<tr>
<td>15 metres and over but less than 25 metres</td>
<td>6 parachute distress rockets</td>
</tr>
<tr>
<td>Less than 25 metres</td>
<td>4 red hand flares</td>
</tr>
<tr>
<td></td>
<td>2 hand held orange smoke signals</td>
</tr>
<tr>
<td></td>
<td>3 parachute distress rockets</td>
</tr>
<tr>
<td></td>
<td>2 red hand flares</td>
</tr>
<tr>
<td></td>
<td>1 hand held orange smoke signal</td>
</tr>
<tr>
<td><strong>25 metres and over</strong></td>
<td>ELECTRIC ALARM SIGNAL</td>
</tr>
<tr>
<td></td>
<td>Electric alarm signal for mustering crew (where efficient mustering cannot be carried out by voice)</td>
</tr>
<tr>
<td><strong>All lengths</strong></td>
<td>EMERGENCY ELECTRICAL INSTALLATION/EQUIPMENT</td>
</tr>
<tr>
<td></td>
<td>(1) A number of electrical torches or hand lamps as determined by the Authority</td>
</tr>
<tr>
<td></td>
<td>(2) An emergency installation capable of operating navigation lights (where they are solely electric) for 3 hours, and</td>
</tr>
<tr>
<td></td>
<td>(3) An emergency installation capable of operating signalling lamps (where they are normally operated from main electrical power source) and communication equipment for 3 hours</td>
</tr>
<tr>
<td><strong>Note:</strong> In relation to (2) and (3) above the emergency installation can be the normal starting batteries provided that they are suitably placed in the vessel</td>
<td></td>
</tr>
</tbody>
</table>
# CLASS 2D

**NON-PASSENGER VESSELS—PARTIALLY SMOOTH WATERS**

Reference should be made to Part 2 for stowage, marking, etc., and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 metres and over</td>
<td>BUOYANT APPLIANCES</td>
</tr>
<tr>
<td></td>
<td>Sufficient buoyant appliances and/or lifebuoys to provide a total float-off capacity for 100% complement, provided that—</td>
</tr>
<tr>
<td></td>
<td>(a) each lifebuoy is assumed to provide support for two persons,</td>
</tr>
<tr>
<td></td>
<td>(b) a dinghy shall be included in the above appliances</td>
</tr>
<tr>
<td>10 metres and over but less than 25 metres</td>
<td>Sufficient buoyant appliances and/or lifebuoys to provide a total float-off capacity for 100% complement, provided that—</td>
</tr>
<tr>
<td></td>
<td>(a) each lifebuoy is assumed to provide support for two persons,</td>
</tr>
<tr>
<td></td>
<td>(b) a dinghy may be included in the above appliances</td>
</tr>
<tr>
<td></td>
<td>(1) buoyant appliances and/or lifebuoys for 100% complement, or</td>
</tr>
<tr>
<td></td>
<td>(2) a dinghy for 100% complement, or</td>
</tr>
<tr>
<td></td>
<td>(3) internal buoyancy as prescribed in Appendix N</td>
</tr>
<tr>
<td>Less than 10 metres</td>
<td>LIFEBUOYS</td>
</tr>
<tr>
<td></td>
<td>Additional to any lifebuoys included in 100% buoyancy above</td>
</tr>
<tr>
<td></td>
<td>2 lifebuoys, one with light and one with buoyant line</td>
</tr>
<tr>
<td></td>
<td>1 lifebuoy with light</td>
</tr>
<tr>
<td>15 metres and over</td>
<td>LIFEJACKETS</td>
</tr>
<tr>
<td>Less than 15 metres</td>
<td>A coastal lifejacket for each person that the vessel is certified to carry</td>
</tr>
<tr>
<td>All lengths</td>
<td>DISTRESS SIGNALS</td>
</tr>
<tr>
<td></td>
<td>3 parachute distress rockets</td>
</tr>
<tr>
<td></td>
<td>2 red hand flares</td>
</tr>
<tr>
<td></td>
<td>1 hand held orange smoke signal</td>
</tr>
<tr>
<td>Note: Consistent with the area of operations allocated to the vessel, a reduction in distress signals may be permitted by the Authority</td>
<td></td>
</tr>
<tr>
<td>All lengths</td>
<td>EMERGENCY ELECTRICAL EQUIPMENT</td>
</tr>
<tr>
<td></td>
<td>A number of electric torches or hand lamps as determined by the Authority</td>
</tr>
</tbody>
</table>
### CLASS 2E

**NON-PASSENGER VESSELS—SMOOTH WATERS**

Reference should be made to Part 2 for stowage, marking, etc., and Part 4 for specifications of equipment.

<table>
<thead>
<tr>
<th>Measured Length</th>
<th>L.S.A. Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 metres and over</td>
<td>BUOYANT APPLIANCES</td>
</tr>
<tr>
<td></td>
<td>Sufficient buoyant appliances and/or lifebuoys to provide a total float-off capacity for 100% complement provided that—</td>
</tr>
<tr>
<td></td>
<td>(a) each lifebuoy is assumed to provide support for two persons,</td>
</tr>
<tr>
<td></td>
<td>(b) a dinghy may be included in the above appliances.</td>
</tr>
<tr>
<td>Less than 15 metres</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1) buoyant appliances and/or lifebuoys as for 15 metres and over (above), or</td>
</tr>
<tr>
<td></td>
<td>(2) fitted with internal buoyancy as prescribed by Appendix N</td>
</tr>
<tr>
<td>15 metres and over less than 15 metres</td>
<td>LIFEBUOYS</td>
</tr>
<tr>
<td></td>
<td>Included in 100% buoyancy above</td>
</tr>
<tr>
<td></td>
<td>2 lifebuoys, at least one with light</td>
</tr>
<tr>
<td></td>
<td>One lifebuoy with light</td>
</tr>
<tr>
<td>All lengths</td>
<td>LIFEJACKETS</td>
</tr>
<tr>
<td></td>
<td>A coastal lifejacket for each person that the vessel is certified to carry</td>
</tr>
<tr>
<td>All lengths</td>
<td>DISTRESS SIGNALS</td>
</tr>
<tr>
<td></td>
<td>Distress signals, consistent with the area of operations as determined by the Authority</td>
</tr>
<tr>
<td>All lengths</td>
<td>EMERGENCY ELECTRICAL EQUIPMENT</td>
</tr>
<tr>
<td></td>
<td>Electric torches or hand lamps as determined by the Authority</td>
</tr>
</tbody>
</table>
UNIT 13.3 MAINTENANCE

A system of planned maintenance should be set up and operated on board all vessels. The idea of planned maintenance should consist of a regular programme of inspecting and overhauling all equipment. As each item is inspected and overhauled, it is ticked off on the list and the date of maintenance recorded. Ideally, a schedule should be set up whereby all L.S.A. and F.F.A. is inspected and maintained at least once every three months. Conscientious behaviour in this regard saves lives! Any equipment that is judged to have deteriorated below an acceptable standard should be repaired or replaced. Of course, it must be borne in mind that the standard of operation for equipment can be determined only by using it in the capacity for which it was designed. This does not apply to fire extinguishers. They should not be discharged unless they can be immediately replaced with recharged ones. Dry chemical fire extinguishers should be regularly inverted, and given a shake, to prevent the powder packing down inside the extinguisher.
SECTION 14

Loadlines - Conditions of Assignment

INTRODUCTION

In 1824, a man was born in England whose influence was destined to produce a major change in the safety of shipping. His name was Samuel Plimsoll.

In those days, there were no regulatory bodies controlling the loading of ships. The shipowner (often the Captain) would arrive in port, and then attempt to sell his cargo space to would-be shippers. Having procured a cargo or cargoes, he would then proceed to load his ship, stuffing as much in as he could. When all the free space was used up, his vessel would sail into the open sea, headed for its - perhaps - far away destination. Often, it never made it. Being overloaded, and well down in the water, many such vessels never had sufficient freeboard to cope with the seas they encountered. Many were overcome and sank, with great loss of life.

Plimsoll, concerned with the loss of life and property that was occurring, actively campaigned for the introduction of legislation that would limit the amount of cargo that ships could carry, in order to ensure they had sufficient freeboard to meet the expected weather conditions of their trading areas.

When he was 52, he finally saw his goal realised, with the inclusion of the loadline rules into the Merchant Shipping Act of 1876.

Plimsoll died in 1898, but he will always be remembered as the man whose single contribution to shipping has saved the lives (or prevented the loss) of more people than any other man of his century or ours.

In recognition of Plimsoll’s enormous contribution to maritime safety, the line or mark required to be placed on the hull of all British merchant vessels, showing the depth to which they may be submerged through loading, became known as the Plimsoll Line or Plimsoll Mark. This is now more commonly referred to as the Summer Loadline.

What then are loadlines, and what are the conditions that must be met before loadlines can be assigned? We will address these questions in this Section.

OBJECTIVES

By the end of Section 14 you should be able to:

• state the difference between type A and type B vessels
• identify the factors that influence the position of the loadlines
• state the factors upon which the conditions of assignment depend
• detail the information in the possession of the ship owner after loadlines have been assigned
• state the types of ships to which the loadline rules apply.
UNIT 14.1 DEFINITIONS

Below are some of the definitions used in the U.S.L. Code. You should read through them and familiarise yourself with the terms, and especially note the definitions of Type A and Type B vessels. You should know these. NOTE the comments under ‘Vessel’. These are the vessels to which the conditions of assignment DO NOT apply.

‘After perpendicular’ means a line drawn at the after end of the vessel parallel to, and at a distance equal to the length of the vessel from, the forward perpendicular for the vessel.

‘Amidships’ means the vertical plane situated halfway between the perpendiculars of the vessel and at right angles to the centre line plane of the vessel.

‘Flush deck vessel’ means a vessel that has no superstructure on the freeboard deck.

‘Forward perpendicular’ means a line drawn at right angles to the waterline and for the purpose of ascertaining the length of the vessel at the intersection of the waterline with the fore side of the stem of the vessel.

‘Perpendiculars’ means the forward and after perpendiculars.

‘Summer moulded draught’ means the distance equal to the difference between: the actual depth of the deck line position of the vessel; and the summer freeboard assigned to the vessel.

‘Superstructure deck’ means a deck forming the top of a superstructure.

‘The actual depth of the deck line position’ means the distance measured vertically amidships from the line from which the moulded depth of the vessel is measured to the deck line position.

‘The deck line position’ means the position of the line that constitutes the deck line for the vessel.

‘Type A vessel’ means a vessel:

(a) that is designed to carry only liquid cargoes in bulk

(b) that has a high integrity of the exposed deck by reason of the fact that its cargo tanks have only small access openings closed by weathertight gasketed covers of steel or equivalent material; and

(c) that has a high degree of safety against flooding, resulting from the low permeability of loaded cargo spaces and the degree of sub-division.

‘Type B vessel’ means a vessel other than a Type A vessel.

‘Weathertight’, in relation to a fitting in a vessel, means that in any sea conditions water will not penetrate into the vessel through that fitting.

‘Vessel’ does not include:

(a) a vessel of less than 16 metres measured length

(b) a fishing vessel

(c) a vessel operating solely on the basis of the maximum number of passengers permitted to be carried being a smooth water vessel or a partially smooth water vessel.

‘Length’: the distance measured from the fore side of the stem to the axis of the rudder stock on the waterline.

‘Breadth of a vessel’: its maximum breadth measured amidships to the moulded line of the frame if the vessel has a metal shell or to the outer surface of the hull if the vessel has a shell of any other material.
‘Moulded depth’: the vertical distance measured from the top of the keel to the top of the freeboard deck beam.

‘Depth for freeboard’ shall be the moulded depth amidships of the vessel.

‘Block coefficient’ of a vessel shall be read as a reference to the number \( C_b \) ascertained in accordance with the formula:

\[
C_b = \frac{V}{L \cdot B \cdot d_1}
\]

where:

B is the breadth of the vessel in metres.

d_1 is 85 per cent of the least moulded depth of the vessel in metres.

L is the length of the vessel in metres; and

\( V \) is:

(a) if the vessel is a vessel with a metal shell the volume in cubic metres of the moulded displacement of the vessel, excluding bossing; or

(b) if the vessel is a vessel with a shell of any other material, the volume in cubic metres of displacement to the outer surface of the hull, both taken at a moulded draught of \( d_1 \).

‘Freeboard deck’: the freeboard deck of a vessel shall be the uppermost complete deck, exposed to weather and sea, which has permanent means of closing all openings in the part exposed to the weather and below which all openings in the sides of the vessel are fitted with permanent means of watertight closing.

‘Superstructure’: a superstructure of a vessel shall be a decked structure (including a raised quarter deck) on the freeboard deck extending from side to side of the vessel or with the side plating of the structure not being inboard of the shell plating by more than 4 per cent of the breadth of the vessel.

Where, a lower deck is specified as the freeboard deck of a vessel, any part of the hull which extends above the deck so specified shall be deemed to be a superstructure.

‘Enclosed superstructure’: an enclosed superstructure shall be a superstructure with:

(a) enclosing bulkheads of efficient construction

(b) access openings, if any, in the bulkheads fitted with doors complying with the requirements for watertight doors

(c) all other openings in the sides or ends of the superstructure fitted with efficient weathertight means of closing.

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UNIT 14.2

It is interesting to note the difference in definitions of weathertight given in the U.S.L. Code.

Under the construction Section 5A.4.20, weathertight means capable of preventing the passage of sea water in any ordinary sea conditions, while under the loadline Section 7.3.14, it means that in any sea conditions water will not penetrate. Clearly then, if loadlines are to be assigned, a higher standard is required than if they are not to be assigned.
UNIT 14.3 CONDITIONS OF ASSIGNMENT

The International Conference on loadlines in 1966 produced the basis for our present legislation. A minimum freeboard is required to ensure that the ship is seaworthy when loaded.

Before assigning a freeboard to a ship, the Government Department or Classification Society must satisfy itself that the vessel is structurally sound. In addition, there is a whole series of conditions that must be met, relating particularly to the watertightness of openings and hatchways before freeboards can be assigned.

The loadlines are merely marks cut into the side of the vessel (or painted on) showing the depths to which the vessel may be loaded while in a particular loadline zone or in salt or fresh water. The distances from these marks to the deckline are the assigned freeboards for the various zones.

The subjects covered under the conditions of assignment are as follows:

1) Stability Information
   To be supplied to the master and carried on board at all times.

2) Construction of Bulkheads at exposed ends of Superstructures

3) Access openings in Bulkheads - not to weaken bulkhead and must be capable of being made weathertight.

4) Cargo and Other Hatchways - must be capable of being secured and made weathertight.

5) Coamings - to be of a minimum height prescribed in the U.S.L. Code.

6) Hatchways - must be capable of withstanding certain assumed loads.

7) Hatchway covers - must be 4.25 times stronger than the maximum assumed load that the hatchway could be required to carry.

8) Pontoon covers must have a strength factor of 5.

9) Tarpaulin hatchway covers - must be strong and have satisfactory means of securing and making hatch watertight.

10) Protection of openings - any openings in a vessel are to be strengthened with a rim plate or the like so as to prevent any weakening of the structure as a result of the opening.

11) Ventilator coamings- minimum heights and method of closing are prescribed.

12) Air pipes - minimum heights prescribed and satisfactory means of closing required.

13) Cargo Ports and similar openings to have watertight doors.

14) Discharges, inlets and scuppers. All to have means of isolating and closing, inserted in the line between them and the parts that they service.

15) Freeing ports - must be sufficient to allow the rapid draining of the decks of any water that comes on board. The percentage area of the bulwarks that the freeing ports must provide is prescribed, with a reduction if above standard sheer is provided.

16) Protection for crew
   - Deckhouses used for the accommodation of the crew shall be of adequate strength.
   - Efficient guard rails, or bulwarks, having a height of not less than 1 metre above the deck or such lesser height as is approved shall be fitted on all exposed parts of the freeboard and superstructure decks, first tier deckhouses and superstructure ends.
• The opening below the lowest course of the guard rails shall not exceed 230 mm, the other courses being not more than 380 mm apart and, in the case of vessels with rounded gunwales, the guard rail supports shall be placed on the flat of the deck.

• Guard rails, life lines, gangways or underdeck passages shall be provided for the protection of the crew in getting to and from their quarters, the machinery space and all other parts used in the working of the vessel.

• Deck cargo carried on any vessel shall be so stowed that any opening which is in way of the cargo and which gives access to and from the crew’s quarters, the machinery space and all other parts used in the necessary work of the vessel can be properly closed and secured against the admission of water, effective protection of the crew in the form of guard rails or life lines being provided above the deck cargo if there is no convenient passage on or below the deck of the vessel.

• This does not apply to an unmanned barge.

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If you wish to have a more detailed knowledge of the conditions of assignment, consult Part 2 of Section 7 of the U.S.L. Code, clauses 4 to 26.

It is not necessary for the purposes of this course that you should know all the minor details of the conditions of assignment, but you should have a practical knowledge of the subjects covered.

The assignment of the loadlines is dependent upon the Conditions of Assignment. If these conditions are not met, freeboards will not be assigned. However, the conditions of assignment do not affect, in any way, the amount of freeboard assigned to a vessel. This is calculated according to a set of simple formulae based on the construction of the vessel. The conditions of assignment are generally dependent upon reserve buoyancy, watertight integrity, and stability of the ship and its crew. That it continues to comply with these conditions of assignment is verified by the periodical surveys.

UNIT 14.4 LOADLINE RULES
READ Chapter 31 in Eyres.

NOTE how the constructional considerations increase or reduce freeboard. Freeboards are assigned to vessels purely according to their length. These freeboards are tabulated in Appendix B (Type A vessels) and Appendix C (Type B vessels) of the U.S.L. Code. These tabular freeboard are then increased or reduced according to the calculations given in the Loadline Rules you have just read.

UNIT 14.5 THE LOADLINES

![Fig. 14.1 Loadlines]
Figure 14.1 shows the typical loadlines for a vessel trading solely in Australia. The abbreviations are as follows:

- TF Tropical Fresh Water Mark
- F Fresh Water Mark
- T Tropical Mark
- S Summer (Plimsoll) Mark
- W Winter Mark

The Tropical, Summer and Winter are the Marks which must not be submerged when the vessel is trading in a designated Tropic Zone, Summer Zone or Winter Zone.

The names of the zones have no meaning related to the seasons of the year. It is possible to have summer zones in winter and vice versa.

Bad sea and weather conditions are associated with winter zones; better weather with summer zones, and good conditions with tropical zones. As a result, a greater freeboard is required for the bad weather zones than for the good weather zones.

A seasonal zone is one which changes its name according to different times of the year.

UNIT 14.6 LLOYDS’ REGISTER (LR)

When LR appears on the loadline marks, it means that the vessel is classified by Lloyds’ Classification Society. (Note that this is not Lloyds of London, the underwriters, but a separate body.)

For example, if the letters were AB the Classification Society would be the American Bureau of Shipping.

The loadline marks on the left of the diagram are those you would find on a vessel designed to carry timber. The L stands for lumber. The freeboard required is slightly less than that of a normal vessel because of the buoyancy offered by the timber. The assumption is made that the logs will be lashed on deck in a solid unit (using chains at one metre intervals), thus effectively raising the deck level.

The assigned freeboard is the distance between the deckline and the Summer Mark. The Summer Mark is also called the Load Waterline.

The distance between the Summer and Fresh Water Marks is called the fresh water allowance and is found by the formula:

\[
FPA = \frac{W}{4TPC}
\]

This is the same distance as that between T and TF. The distance from S to the keel is known as the Summer Draft. The distance between T and S, and between S and W is 1/48 of the Summer Draft.

If the loadlines were assigned by a State Authority without working with a Classification Society, then the letters at the loadline mark would be:

- VA Victoria
- TA Tasmania
- WA Western Australia
- NA New South Wales
- QA Queensland
- SA South Australia
- NTA Northern Territories
- CA ACT
When loadlines have been assigned, a Loadline Certificate will be issued giving particulars of the vessel, its official number, port of registry and length.

In addition, the assigned Tropical Summer and Winter freeboards will be recorded (in millimetres). A statement setting out the conditions of assignment as applicable to the vessel will also be issued to the owner. This statement must be carried on board.

Figure 14.2 shows the Seasonal Zones around Australia.

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*Fig. 14.2 Seasonal zones*

NOTE how the zones change during the year.
Figure 14.3 is a copy of a loadline certificate.
UNIT 14.7 PENALTIES

The W.A. Marine Act provides some heavy penalties for overloading. If your vessel is in a zone where the appropriate loadline is submerged, then for every 25 mm that the mark is submerged, you, as master, could be fined as follows:

<table>
<thead>
<tr>
<th>Deadweight tonnage</th>
<th>Fine $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1000</td>
<td>500</td>
</tr>
<tr>
<td>Less than 5000</td>
<td>1000</td>
</tr>
</tbody>
</table>

It is unlikely that you will be in command of a vessel with over 5000 tonnes dwt.

If you put to sea in a vessel which is uncertified, but should be, you - as master - could be fined $2000. You could face the same fine if you did not keep your vessel marked, or allowed the loadline marks to be concealed, removed, altered, defaced or obliterated.

However, if you can prove that any non-compliance on your part was caused by a deviation or delay as a result of stress of weather or other circumstances beyond your control, you would not be guilty of an offence.

UNIT 14.8 SELF-TEST EXERCISE

The answers to the following questions are provided at the back of the book.

1. To which vessels do the conditions of assignment not apply?
2. What is the difference between a Type A vessel and a Type B vessel, as far as the loadline rules are concerned?
3. What are the components that the conditions of assignment take into account, and what do these affect?
4. What documentation is given to the owner/master of a vessel after loadlines have been assigned?
Vessel construction and maintenance assignment

This assignment can be submitted as soon as you have studied the construction and maintenance topics.

**QUESTION 1**

On the enclosed plans of a vessel less than 35 metres in length identify or list separately:

- Parts of the vessel that will be surveyed at an annual survey.
- Parts of the vessel that will be surveyed at a Two Yearly Survey.

Itemise the equipment that would be required to be surveyed.
QUESTION 2

Identify the potential for corrosion / deterioration in the three structures below as indicated. In each case, indicate the key areas for consideration; the type of deterioration you would expect to find; what preventive and corrective measures should be undertaken.

Timber hull. Areas under deck and around the keels area.

Steel ship Anchor Locker

Steel ship. Areas around keel and stern frame
QUESTION 3

What is meant by the term Galvanic corrosion?

Give two examples of anodic and cathodic materials.

Give two examples on a vessel where galvanic corrosion could take place.

On vessel hulls metal blocks are attached:

- What are these blocks for?
- Where do you usually find them?

QUESTION 4

Describe how a vessel is docked when using:

i. a graving dock
ii. a slipway

and discuss the precautions necessary when doing so.
**QUESTION 5**

Describe the types of stresses a vessel will be subject to when dry docking.

How may some of these stresses be relieved?

Your answer should be illustrated.

**QUESTION 6**

Your 20 metre steel vessel has been holed below the water line in an empty forward fuel tank. Temporary repairs have been carried out. The vessel is to go into dock for full repairs.

Write a report for the owners indicating the damaged areas, plate and frame numbers, a cross section drawing and your requirements in dock.

What safety precautions will have to be taken?
ANSWERS TO SELF-TEST QUESTIONS
UNIT 1.8
1. With the machinery space aft which is proportionately large in a small vessel, there is a tendency to trim by the bow when fully loaded. A raised quarter deck in way of the after holds eliminates this tendency.

2. In ballast, a large trim by the stern can occur, resulting in large bending moments.

3. It gives reserve buoyancy forward and aft.

4. It tends to reduce stability with increase in draft.

5. In the fore Peak Tank.

UNIT 3.9
1. The collision bulkheads, for peak and aft peak bulkheads, are tested by filling the peaks with water to the level of the load waterline. All other bulkheads, provided that they do not form boundaries of a tank, are hose tested. It is not considered prudent to test ordinary w/t bulkheads by filling the cargo hold. The surveyors usually examine the strength calculations upon which the bulkhead was constructed, to ensure that adequate strength has been provided.

2. See Unit 3.1

3. See Chapter 22 Eyres – the heading Testing Tanks. The tank is tested to a pressure equivalent to the maximum head of pressure that the tank could be subjected to: usually, by filling the tank with water until it overflows from the sounding pipe.

4. See Unit 3.10 – Summary.

5. Hatch covers are hose tested. Hatchways into oil-tight compartments are air-pressure tested.

6. Hose tested as per U.S.L. Code (Unit 3.2).

UNIT 4.7
1. (a) Close off all valves and pipe lines to the tank in question, after having filled the tank up with water.

   (b) Take soundings at regular intervals. If the level does not change, the tank is sound. If the level changes, one of two things may be wrong:

   i) The tank itself is holed internally or externally.

   ii) The pipes through the tank are holed and water is escaping into other tanks/valves are leaking.

To verify, sound adjacent tanks at regular intervals. If there is no change in the level of adjacent tanks, or the bilges of adjacent compartments, the vessel is holed externally.

If the levels change, the tank is holed internally, or has leaking lines or valves.
To verify, systematically air-pressure test the line and valves. If the pressure drops, there is a leak in the lines or valves. If it does not, there is a leak at the bulkhead between the tanks.

2. Sounding  =  1.65 - 0.62  =  1.03 m

\[
\text{Weight} = L \times B \times D \times \delta
\]

\[
= 3.38 \times 2115 \times 1.03 \times 0.92
\]

\[
= 6 \text{ tonnes} \times 886 \text{ kg}
\]

3. Air pipes prevent air being trapped under pressure in a tank when it is filled, or a vacuum being created when it is emptied.

4. To reduce the free surface effect of liquids in slack tanks. This is a design consideration and not an operational one. The master should invariably ensure that safe working practices are observed when ballasting tanks to prevent dangerous free surface moments developing.

**UNIT 5.4**

1. To regulate the flow of liquid in either direction.

2. To stop the flow of liquid in one direction if not screwed down, and to stop flow in both directions if it is screwed down.

3. During drydocking and slipping, when the systems are not in use.

4. A pipe piercing a collision bulkhead shall be fitted with a screwdown valve or lock at the bulkhead. This shall be controllable from the bulkhead deck and an appropriate open/closed indicator shall be provided.

**UNIT 6.6**

1. They are to ensure that the basic design requirements are met with under reasonable/expected conditions, and while competently performing the design tasks.

2. (a) To float at an acceptable draft and trim.

(b) To be stable at all design drafts and trim.

(c) To be capable of withstanding reasonable stresses due to weather and loading/handling conditions.

(d) To be capable of maintaining watertight integrity.

(e) To be seaworthy in the sea/water in which the vessel is to be operated.

(f) To be capable of safely performing the design tasks.
3. Every new vessel constructed under the jurisdiction of the state and every existing vessel being brought under survey for the first time.

4. To satisfy the General Manager that the vessel complies with the laws of the state.

5. The first Periodical Survey is due one year from the date of initial survey, and thereafter annually. An extension period of 3 months may be granted.

UNIT 7.8

1. 

![Fig. Hydraulic Steering Gear](image)

2. Two means of steering required. The emergency steering must be capable of being brought speedily into action. The normal steering gear must be capable of putting the rudder over from $35^\circ$ on one side to $30^\circ$ on the other in 30 seconds when the vessel is at maximum service speed, with the rudder totally submerged. No violent recoil of steering wheel.

UNIT 8.9

1. No, it would not be safe and such practice is not allowed under Clause 27.2.1 of Section 9 in the U.S.L. Code which states ‘The distribution of electrical power shall be by the two wire insulated system. The use of a hull return for lighting or power distribution is not permitted.’

The use of a two-wire system allows the hull to be used as an earth, thus providing a safety feature in the event of a short-circuit. If the hull were used as part of an AC distribution circuit, it would, in reality, become a live wire and the dangers of electrocution to personnel, when the vessel is alongside, would be high.
2. Switchboards should be placed in easily accessible, well-ventilated positions that are free from flammable gases and acid fumes, and where they are not exposed to the risk of mechanical injury or damage from water.

3. All conductors, switchgear and accessories should be of such size and construction as to be suitable for the purpose intended, and capable of carrying, without their respective ratings being exceeded, the maximum in service current.

4. The purpose of an electrical distribution system is to distribute electrical power safely to all parts of the vessel. The safest way to achieve this is to ensure that all fittings are installed by a licensed electrician and that unqualified persons do not tamper with, or try to effect, repairs to the system.

5. Preferably non-combustible, but, in any case, a fire-resistant non-hygroscopic material.

6. In dry, accessible and well ventilated positions. All nuts and screws used in connection with current-carrying parts and working parts should be effectively locked.

UNIT 9.12
1. Corrosion is the spontaneous chemical transformation of useful metal into useless chemical compounds.

2. (a) Oxidation – chemical action.
(b) Atmospheric corrosion – caused by pollution.
(c) Immersion corrosion – forms around the waterline where the hull is intermittently immersed.
(d) Galvanic corrosion – when two dissimilar metals form a corrosion cell.
(e) Stress corrosion – wherever internal stresses exist in a metal.
(f) Erosion – occurs where cavitation exists – usually on the propeller and bow regions.

3. Lead is a more noble metal than either steel or aluminium and is not suitable as a sacrificial anode – the steel would corrode and the lead would be protected.

4. Ensure that they are not overpainted; because this would provide a barrier between the anode/electrode and the sea-water electrolyte, thus interrupting the current providing the cathodic protection.

5. Advantages
(a) requires no power source
(b) current cannot be supplied in the wrong direction
(c) installation and supervision are simple
Disadvantages
(a) available current depends on anodes
(b) if power is available, it is usually much cheaper than anodes
(c) maintenance is tedious.

6. GRP is not a maintenance-free material. Weathering, although slow, if unchecked, eventually leads to the erosion of the surface of the gel coat, making it rough, pitted and porous. Water is then able to penetrate the laminate and cause the layers to separate. When this happens, repairs can be quite expensive.

7. Wet and dry rot are terms used to describe the decay of timber by fungal attack. Dry rot is really only a drier version of wet rot. It is caused by a different fungus, and the wood has a dry cracked appearance. Nevertheless, dry rot will occur only in damp, poorly-ventilated areas. Soft woods are more susceptible to attack than hard woods. Wet rot occurs when the wood is visibly wet.

No rot will occur if the moisture content of the wood is less than 20%

8. By contributing to the value, safe operation and operational life of the vessel.

9. The maritime environment that the vessel is operating.

10. By setting up a plan of scheduled maintenance.

11. By keeping detailed documentation of the type of paint systems used onboard the vessel and what areas they are used.

12. An isolating valve located or operated outside the machinery space.

13. A good supply of replacement fuel filter elements for the primary and secondary fuel tank.

14. Emptying the fuel tank of fuel and physically cleaning all internal surfaces of the fuel tank.

15. Open and close all associated valves on a regular basis to ensure their correct operation.

16. An “L” ported cock and/or non return valves.

17. Check all taps on all sinks and basins throughout the vessel.

18. The most important safety device fitted to an air compressor is the pressure relief valve and this should be set at no more than 10% above the working pressure of the compressor.

19. The high currents that these cables carry can cause extremely high heat build up at any loose connections, creating a very high fire risk.

20. Disconnect shore power, shut down all power generating machinery, isolate all batteries and work by torch light.

21. Portable fire extinguishers; Non portable fire extinguishers; Engine room fixed fire systems; Fire hoses and nozzles.

22. In a prominent position in the wheel house or bridge.

23. Flame failure devices and/or gas detectors.

24. The stowage should be gas tight from the inside of the vessel and be vented over the vessel’s side.
UNIT 10.4

1. When the keel is sewn, the vessel and the floating dock become one floating craft or system, the stability of which, like any craft, is determined by the beam of the area of its waterplane. This is least when the water level is between the keel of the vessel and the dock bottom. At this moment, the waterplane area is provided only by the narrow side tanks of the floating dock. This is known as the critical moment of docking.

2. Essential to the safe operation of this manoeuvre is a well protected beach with a gently-sloping sand shore.

A wire spring is run from aft outside all obstructions and shackled on to the anchor shackle of the seaward anchor. About 3 or 4 boat lengths from where you expect to touch bottom, you let go your seaward anchor and pay out the cable until about one boat length cable has been paid out. The vessel will now lie to the anchor with the spring holding her in a bridle type fashion.

Mooring lines can be taken ashore and secured on the beach.

Baltic Type Moor
The vessel is now controlled as she drifts ashore and is allowed to touch the bottom. The whole procedure should be timed so that she touches bottom around the lower high tide.

3. Because the vessel is going to rest on the shore, damage to the hull is a possibility, especially if she settles on any unnoticed rocks. Also she could topple over, if the beach slopes too steeply, or if she does not have sufficient stability. Working time is limited to the period that the tide is low enough to dry around the vessel.

4. The dock master or slip manager should be notified of the position of all the fittings so that they will not be damaged by the keel blocks, bilge blocks or support beams as they take the weight. Logs should be withdrawn into the hull. All transducers should be covered with grease and masking tape after the dock has been drained.

All cooling intakes and discharges should be plugged. The plugs and coverings should be removed prior to refloating.

5. (a) Ensure that the tank has been pumped dry.
(b) Remove man-hole covers, and ventilate thoroughly.
(c) Remove drain plugs and place in safe custody.
(d) Ensure that the tank has been boxed up after inspection and that drain plugs have been replaced.

UNIT 11.5

1. For the operators in all cases
(a) Full protective clothing
(b) Headgear – hard hats
(c) Ear muffs
(d) Dust-proof goggles
(e) Gloves
(f) Dust masks. If the material being sandblasted develops toxic fumes, then full breathing apparatus should be considered.

Additionally, for work at heights, and over the side in dry dock, a stage with railings at least 1m high, and operators should be wearing safety harnesses.

Ventilation systems should have filters fitted, to avoid drawing the dust into the system and damaging machinery etc.

All personnel not involved, should be ashore, or, at least, away from the immediate vicinity.

2. Electrical hazard – in the marine environment, the moisture level is high. Welding should not be conducted by people wearing wet or sweaty clothing. Gloves (preferably leather) should be worn, and the electrodes handled only with insulated tools when connecting them to the electrode holder. Earthing of the unit should be good, and all leads and connections maintained in the best condition.

Radiation hazard: Arc welding generates intense U.V. radiation. This can cause severe skin burns and damage to the eyes. Welding helmets should always be worn. By-standers should never look at the arc. No parts of the body should be exposed to the radiation and all clothing should be properly closed and buttoned.
Burn injury: Bits of melting metal always spray from or fall from the point being welded. Leather gloves should be worn, with the cuffs of overalls secured, so that hot metal cannot fall down the sleeves.

The same applies to boot-tops and trouser legs.

Fire-hazard – All flammable materials should be removed from the scene of welding. A passenger ship, the *Normandic*, was burnt out during lay-up when welders did not remove a pile of life jackets that they were welding next to. A spark ignited the life jackets, no fire extinguisher was at hand, and the ship was lost as a result.

If a bulkhead or deck is being welded, the other side should be inspected during the operation to ensure that fire does not break out there.

3. “The compass or compasses of a vessel shall be adjusted if … the vessel has undergone repairs or alterations of such nature as in the opinion of the authority are likely to affect the accuracy of the compass or compasses.”

4. (a) Goggles  
   (b) Leather gloves  
   (c) Safety boots  
   (d) Leather apron  
   (e) Fire extinguishers and fire hoses rigged for use.

5. At all times, when outside of the ship’s accommodation.

UNIT 14.8

1. Vessels of less than 16 metres in length, fishing vessels and passenger ferries operating in smooth or partially smooth waters, which do not carry cargo but operate on a basis of a specific number of passengers carried.

2. Type A vessels are those that are designed to carry only liquid cargoes in bulk. Type B vessels are any other vessels.

3. The components covered by the loadline conditions of assignment are: stability information; superstructure and bulkheads; doors, position of hatchways, doorways and ventilators; cargo and other hatchways; hatchways closed by portable covers, tarpaulins etc; hatchways closed by steel weathertight covers, etc; machinery space openings; miscellaneous openings in freeboard and superstructure decks; ventilators; air pipes; cargo ports and similar openings; scuppers, inlets and discharges; side scuttles; freeing ports; protection of the crew. These components affect the reserve buoyancy, watertight integrity, and the safety of the ship and its crew. These components are inspected during the periodical surveys.

4. A loadline certificate and a statement outlining the conditions of assignment applicable to the vessel.
VESSEL CONSTRUCTION AND MAINTENANCE

Learner’s Guide
Sections 1-14

DESCRIPTION
This learner’s guide is compiled in 14 sections to cover the construction and maintenance content up to Master 4 level.

CATEGORY
Maritime Studies