Indian Register of Shipping

Rules and Regulations for the Construction and Classification of High Speed Crafts and Light Crafts

July 2016

General Information

This consolidated version of the 'Rules and Regulations for the Construction and Classification of High Speed Crafts and Light Crafts' (July, 2016) supersedes the July, 2015 edition of the Rules and includes amendments published in the ‘Rule Change Notice No.1 of January, 2016’.

A summary of additions and amendments incorporated in this consolidated version (further to amendments in ‘Rule Change Notice No.1 of January, 2016’) are indicated in Table No.1.

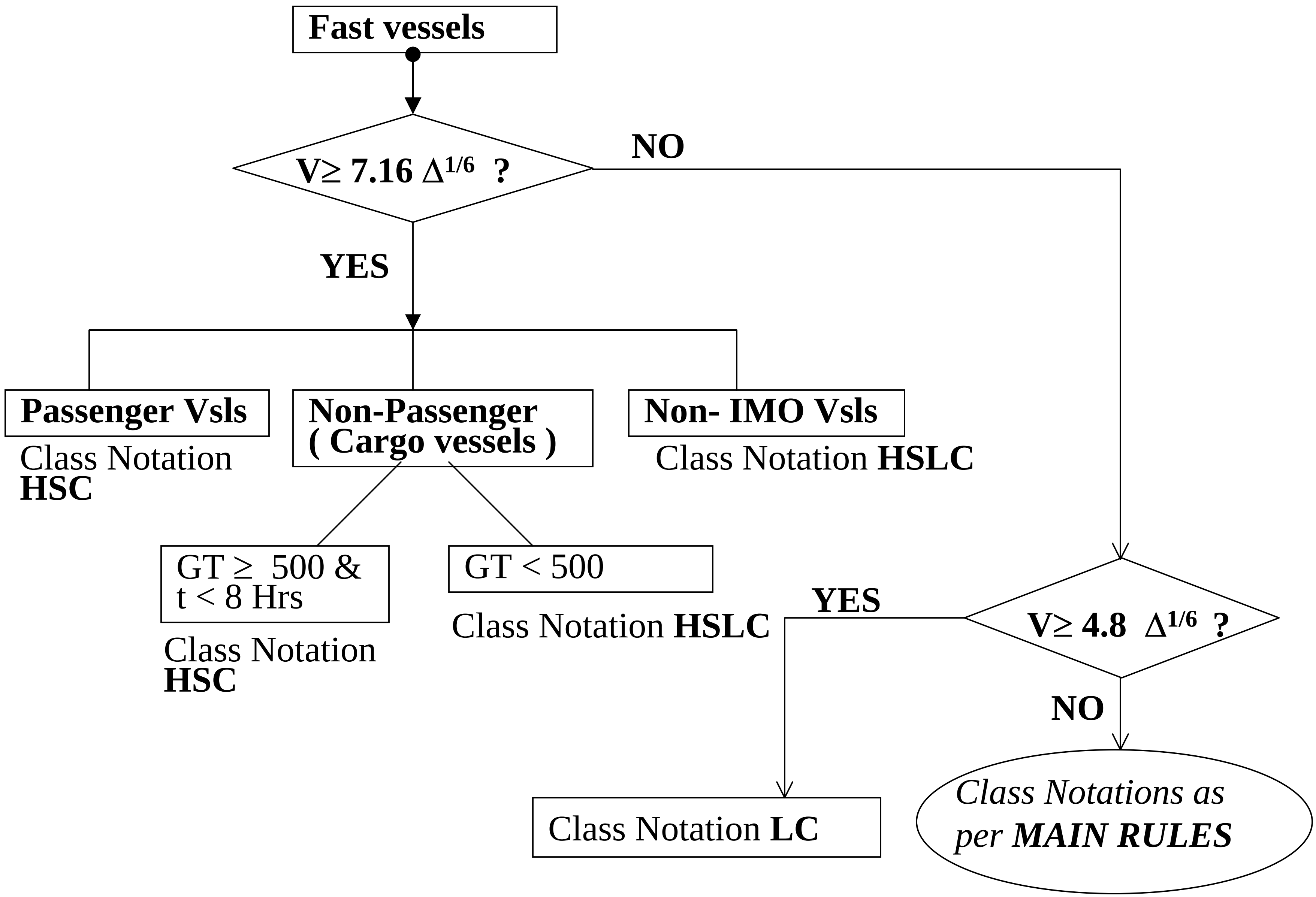
RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF HIGH SPEED CRAFTS AND LIGHT CRAFTS, JULY 2016

TABLE 1 – AMENDMENTS INCORPORATED IN THIS EDITION

These amendments will come into force as indicated in the Table

Section / Clause	**Subject / Amendment**
Chapter 1 : General *The amendments are effective from 1 July 2016*	
1/1.11	The term “surveys” is changed to appropriate term “inspections”. Requirement of verification of performance of service providers is added.
3/3.8, 3.10, 3.11, 3.12, 3.13, 3.16, 3.18, 4/4.1	Updated in accordance with the existing requirements given in Rules for Construction and Classification of Steel Ships (Main Rules) .

Regime of application of HSC & LC Rules (See Chapter 1)



Indian Register of Shipping

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Section 1

General Information

1.1 Indian Register of Shipping

1.1.1 Indian Register of Shipping (hereinafter referred to as “IRS) was incorporated in 1975 as a Public Limited Company under Section 25 of the Indian Companies Act, 1956 for the purpose of providing amongst other things a faithful and accurate classification of mercantile shipping classed with it, to approve designs of, to survey and to issue reports on mercantile and non-mercantile ships, hovercrafts, hydrofoils etc; all within the scope of classification described in the Rules. This Section contains General regulations which have been adopted by IRS for its governance.

1.1.2 The management of the affairs of IRS are carried out under the direction and control of the Board of Directors (hereinafter referred to as the ‘Board’), in accordance with the provisions of its Memorandum and Articles of Association.

1.1.3 The Board of Directors shall consist of representative of the interests of various members of the Company and those concerned with shipping in general as under:

3	Directors representing Indian Shipowners
2	Directors representing Indian Shipbuilders
1	Director representing General Insurance Corporation of India and other Indian underwriters
1	Director being the Director General of Shipping, Ministry of Surface Transport, Govt. of India
1	Director representing Ship Design Research and Development Institutions
1	Director representing Manufacturers of Marine Engines/General Engineering Goods
1	Director representing Indian Navy/Coast Guard
1	Director being a person of eminence from the field of Law
3	Directors being persons of eminence from any industry allied with maritime activities
1	Managing Director being full-time employee appointed by the Board of Directors.

The composition of the Board as above is to be in accordance with the Articles of Association of IRS (as may be amended from time to time).

1.1.4 The Board shall consist of not less than six and not more than fifteen Directors. The Board of Directors shall elect one of its members to be Chairman of the Board of Directors.

1.1.5 The Board is to appoint a Sub-Committee of Classification representing concerned interests.

1.1.6 The Board is to appoint the Chairman of the Sub-Committee of Classification and the Managing Director, IRS to be 'ex- officio' member of the Sub-Committee of Classification.

1.1.7 The employees of IRS are to be appointed by and be under the direction of the Board.

1.1.8 The Surveyors of IRS are not to be permitted without the special sanction of the Board of Directors to receive any fee, gratuity or reward whatsoever, for their own use or benefit, for any service performed by them in their capacity as Surveyors to IRS, except on pain of immediate dismissal.

1.1.9 The Funds and Accounts are to be under the authority and control of the Board of Directors.

1.2 Fees

1.2.1 Fees will be charged for all surveys and for other services rendered by IRS or any of its publications in accordance with established scales. Traveling expenses incurred by the Surveyors in connection with such services are also chargeable.

1.3 Technical committee

1.3.1 The Board is to appoint a Technical Committee whose function will be to consider:

a) Formulation of Technical Rules for Classification Surveys, building of ships, their machinery and equipment.

b) Important alterations to Rules once framed as may be required from time to time.

1.3.2 All decisions of the Technical Committee including amendments and/or additions to the Rules for classification surveys and building of ships' hull, their machinery and equipment to be reported to the Board of Directors.

1.3.3 The Technical Committee to be constituted as follows:

Number of Members	**Nominees/Representatives of**
3	Board of Directors of IRS
1	Marine Engine Unit of M/s. Garden Reach Ship-builders and Engineers Ltd.
1	Other Marine Engine Builders
6	Shipbuilders
2	Indian Institution of Naval Architects
2	Institute of Marine Engineers (India)
1	Company of Master Mariners
2	Directorate General of Shipping
1	IMU (Earlier NSDRC)
4	Indian National Shipowners Association
1	Institution of Engineers (India)
1	Ex-Officio - Managing Director of IRS or his nominee
1	Indian Coastal Conference Shipping Association
1	Oil Industry Safety Directorate
5	Indian Navy
2	Indian Coast Guard
1	Research Institutes
2	Indian Institute of Technology/ National Institute of Technology
2	Maritime Training Institutes
3	Other Flag Administrations
1	Inland Waterways Authority of India.

1.3.4 In addition to the foregoing, the Technical Committee may co-opt to the main body other members of high managerial positions in Ship Building and Engineering, Naval Architecture, Marine Insurance, Steel Making, etc.

1.3.5 Nomination of all members to the Technical Committee to be subject to confirmation by the Board.

1.3.6 The Technical Committee can appoint panels from amongst its body to which representatives of any organisation or industry or individuals specialised in relevant disciplines could be co-opted for the purpose of considering any particular Technical problem or area of Rules.

1.3.7 The Board of Directors to appoint biennially, the Chairman of the Technical Committee and the Technical Committee to appoint from their own body biennially a Vice-Chairman.. The appointment of Vice-Chairman to be confirmed by the Board of Directors.

1.3.8 The terms of office of all members to be not more than four years, one-fourth of all members (including those co-opted) to retire at the end of each calender year. The members so retiring being those who have been longest in office since their last nomination and such members to be eligible for re-nomination for a second term. Unless specially so authorised by the Board of Directors, no member other than Chairman and/or Vice- Chairman, who has served for two periods of nomination, to be eligible for re-nomination. In the event of any vacancy occurring before the expiration of the normal term of office, a representative to be nominated to fill the vacancy from the same group/body/institution and for such nominee the date of his nomination by the respective body to be considered as date of his joining the Technical Committee for purposes of his retirement by rotation.

1.3.9 The meeting of the Technical Committee to be convened as often and at such time and place as may appear necessary, but there shall be at least two meetings in each year.

1.3.10 The members desiring to propose alterations in, or additions to the Rules for the classification, survey or building of ship (hull and machinery) shall give notice of such proposals to the Secretary. Every meeting to be convened by notice from the Secretary, if possible one month before the date of the meeting and the Secretary to send to each member an Agenda paper as soon as possible thereafter.

Proposals for changes to rules may also be given by Flag Administrations, shipowners, shipbuilders and other interested parties who may not be represented in the Technical Committee.

1.3.11 The quorum for any meeting of Technical committee will be six members, with at least 50% of the members present being those who do not have or represent any interest in commercial shipping.

1.3.12 In the event that any matter is not decided by unanimity, the same may be decided by a majority of votes cast in favor, with each member, including co-opted members, having one vote only. In the event of a parity of votes, the Chairman of the Technical Committee would be entitled to an additional casting vote.

1.3.13 When any discussion relates to an item of interest to those connected with commercial shipping (representatives of commercial ship owning or ship building organizations), such representatives would not be entitled to vote, if such matter is to be decided by voting.

1.3.14 In the event that any member of the Technical Committee absents himself for 3 consecutive meetings of the Technical Committee without seeking leave of absence, he would be deemed to have vacated office and his vacancy would be filled by seeking fresh nomination from concerned interest represented.

1.3.15 In the absence of the Chairman & the Vice Chairman of the Technical Committee, the members of the Technical committee shall elect a Chairman, by majority vote, to preside over that particular meeting only.

1.3.16 The Board of Directors reserves to themselves the right of altering, adding to or rescinding any/or all of the above terms of reference including the dissolution of the Technical Committee.

1.4 Survey reports

1.4.1 All reports of survey are to be made by the Surveyors according to the form prescribed and submitted for consideration of the Board or the Sub-Committee of Classification, but the character assigned by the latter is to be reported to the Board. The Board may, in specified instances, vest in the Managing Director discretionary powers to act on its behalf, and all such actions being reported to the Board at its subsequent meeting.

1.4.2 The reports of the Surveyors shall, subject to the approval of the Managing Director, be open to inspection of the Owner and any other person authorised in writing by the Owner. Copies of the reports will, subject to the approval of the Managing Director, be supplied to Owners or their representatives.

1.5 Register of Ships

1.5.1 A Register Of Ships is available on-line on IRCLASS Website which contains the names of ships, character of class and notations assigned together with other relevant useful information for ships classed with IRS.

1.6 Liability

1.6.1 Whilst Indian Register of Shipping (hereinafter referred to as IRS) and its Committees use their best endeavours to ensure that the functions of IRS are properly carried out, in providing services, information or advice, neither IRS nor any of its servants or agents warrants the accuracy of any information or advice supplied. Except as set out herein, neither IRS nor any of its servants or agents (on behalf of each of whom IRS has agreed this clause) shall be liable for any loss damage or expense whatever sustained by any person due to any act or omission or error of whatsoever nature and howsoever caused of IRS, its servants or agents or due to any inaccuracy of whatsoever nature and howsoever caused in any information or advice given in any any way whatsoever by or on behalf of IRS, even if held to amount to a breach of warranty. Nevertheless, if any person uses services of IRS, or relies on any information or advice given by or on behalf of IRS and suffers loss, damage or expenses thereby which is proved to have been due to any negligent act, omission or error of IRS, its servants or agents or any negligent inaccuracy in information or advice given by or on behalf of IRS then IRS will pay compensation to such person for his proved loss upto but not exceeding the amount of the fee charged by IRS for that particular service, information or advice.

1.6.2 Any notice of claim for loss, damage or expense as referred to in 1.6.1 shall be made in writing to IRS Head Office within six months of the date when the service, information or advice was first provided, failing which all the rights to any such claim shall be forfeited and IRS shall be relieved and discharged from all liabilities.

1.7 Audits and assessments by external organizations

1.7.1 The surveys required by the regulations, and conducted by IRS may be subject to Audit by an independent Accredited Certification Body (ACB) as per the requirements of ISO-9001:2008 standard and Quality Management System Certification Scheme (QSCS) of IACS. For this purpose, ACB auditors are to be given the necessary access to the craft, shipyard or works when requested by IRS.

Access is also to be given to auditors or inspectors accompanying the Surveyors as required by other external organizations.

1.8 Access of Surveyor to crafts, shipyards or works

1.8.1 The Surveyors are to be given free access to crafts classed with the Society as well as to shipyards, works, etc. so as to perform their duties, and are to receive adequate assistance for this purpose.

1.9 Compliance with statutory requirements

1.9.1 Whilst the requirements of these Rules are considered to meet the related requirements of the International Code of Safety of High Speed Craft (HSC Code), 1995, consideration should be given to any relevant requirements of the National Authority of the country in which the craft is to be registered.

1.10 Responding to Port State Control

1.10.1 When requested by Port State and upon concurrence by the vessel’s owner/master IRS Surveyors would attend onboard a ship in order to assist in the rectification of reported deficiencies or other discrepancies that affect or may affect classification or the statutory certificates issued by IRS. The owner and the vessel’s flag state will be notified of such attendance and survey. IRS Surveyors will also cooperate with Port States by providing inspectors with background information.

1.11 Requirements for service suppliers

1.11.1 In general, the following categories of service suppliers are to be approved:

a) Classification and / or statutory services

- Firms engaged in thickness measurements on ships

- Firms engaged in tightness testing of closing appliances such as hatches, doors etc. with ultrasonic equipment

- Firms carrying out in-water survey of ships and mobile offshore units

- Firms engaged in the examination of Ro-ro ships, bow, stern, side and inner doors

- Firms engaged in the measurement of noise levels onboard ships

- Firms engaged in inspections and maintenance of fire extinguishing equipment and systems

- Firms engaged in testing of coating systems in accordance with the requirements of IMO performance standards for protective coatings.

b) Statutory services

- Firms engaged in servicing inflatable liferafts, inflatable lifejackets, hydrostatic release units, inflatable rescue boats, marine evacuation systems etc.

- Firms engaged in the inspections and testing of radio communication equipment

- Firms engaged in inspections and maintenance of self contained breathing apparatus

- Firms engaged in the annual performance testing of voyage data recorder and simplified voyage data recorders

- Firms engaged in the inspections of low location lighting systems using photo luminescent materials and evacuation guidance systems used as an alternative to low location lighting systems

- Firms engaged in sound pressure level measurements of public address and general alarm systems on board ships

- Firms engaged in the servicing and maintenance of lifeboats, launching appliances, on-load release gear and davit-launched liferaft automatic release hooks

- Firms engaged in the inspection, performance testing and maintenance of Automatic Identification Systems (AIS).

1.11.2 Where the results of the following service providers are used by a Surveyor of IRS in making decisions affecting Classification services, then that service provider is to be approved and service performance verified by IRS:

- Firms engaged in thickness measurements on ships

- Firms carrying out in-water survey of ships and mobile offshore units

- Firms engaged in tightness testing of closing appliances such as hatches, doors etc with ultrasonic equipment.

IRS may also accept the services of firms approved by other IACS member classification societies for such services other than those listed above.

1.11.3 Where services are used by the Surveyors in making decisions affecting statutory certifications and service, the firms are subject to approval and performance verifications by IRS, where IRS is so authorized by the relevant Flag Administration (i.e. the Flag of the ship on which the servicing is to be done or the service equipment is to be used). For such services, IRS may accept approvals done by:

I. The Flag Administration itself,
II. Duly authorized organisation acting on behalf of the Flag Administration, or
III. Other organizations those are acceptable to the Flag Administration (e.g. other governments etc).

1.11.4 Use of the approved service suppliers is not mandatory for the following services, unless instructed otherwise by the flag Administration with respect to statutory certification:

- Firms engaged in the inspections of low location lighting systems using photo luminescent materials and evacuation guidance systems used as an alternative to low location lighting systems

- Firms engaged in sound pressure level measurements of public address and general alarm systems on board ships

- Firms engaged in measurement of noise levels onboard ships

- Firms engaged in testing of coating systems in accordance with the requirements of IMO performance standards for protective coatings.

- Firms engaged in the examination of bow, stern, side and inner doors.

Section 2

Application and Definitions

2.1 Application

2.1.1 These Rules apply to:

a) Crafts for which the 'International Code of Safety of High Speed Craft (HSC Code), 2000; applies i.e.:

   – High speed passenger crafts which do not proceed in the course of their voyage more than 4 hours at 90% of maximum speed from a place of refuge, and

   – High speed cargo crafts of 500 tons gross tonnage and over which do not proceed in the course of their voyage more than 8 hours at 90% of maximum speed from a place of refuge, when fully laden.

b) Other fast crafts of light construction which do not fall under a) above, but having a maximum speed V equal to or more than $4.8\ \Delta^{1/6}$.

(See Sec.2.2 for definitions of high speed craft, passenger craft, cargo craft, maximum speed V and Length L).

2.1.2 It may be noted that for crafts as defined in 2.1.1a, to which the HSC Code applies, the Administration would generally require that the following requirements of the code (See Note below) are complied with:

a) the Code will be applied in its entirety;
b) the management of the company operating the craft exercises strict control over its operation and maintenance, by a quality management system as per the ISM Code adopted by Resolution A.741(18);
c) the management ensures that only persons qualified to operate the specific type of craft used on the intended route are employed;
d) the distances covered and the worst intended conditions in which operations are permitted will be restricted by the imposition of operational limits;
e) the craft will at all times be in reasonable proximity to a place of refuge;
f) adequate communications facilities, weather forecasts and maintenance facilities are available within the area of operation;
g) in the intended area of operation there will be suitable rescue facilities readily available;
h) areas of high fire risk such as machinery spaces and special category spaces are protected with fire-resistant materials and fire-extinguishing systems to ensure, as far as is practicable, containment and rapid extinguishing of fire;
i) efficient facilities are provided for the rapid and safe evacuation of all persons on board into survival craft;
j) that all passengers and crew are provided with seats;
k) that no enclosed sleeping berths for passengers are provided;

Note : For the background and safety philosophy of the HSC Code 2000, refer to the Preamble to the Code reproduced as Annexure 1 to these Rules.

2.1.3 For all crafts, the limitations on the area of operation and environmental conditions indicated in 2.1.2(d) & (e) would be reflected in the appropriate class notation assigned to the craft as defined in Sec.3.

2.1.4 These Rules include all requirements of the HSC Code 2000 except those given in the following chapters/annexes of the Code, which relate to purely statutory matters. However, it may be noted that compliance with these statutory requirements would be necessary for certification by the Administration for operation as high speed craft under the HSC Code 2000.

a) Chapter 4 : Accommodation and Escape
b) Chapter 8 : Life Saving Appliances and Arrangements
c) Chapter 13 : Navigational Equipment
d) Chapter 14 : Radio Communication
e) Chapter 15 : Operating Compartment Layout
f) Chapter 17 : Handling Controllability and Performance
g) Chapter 18 : Operational Requirements
h) Annex 1 : Form of High Speed Craft Safety Certificate
i) Annex 2 : Permit to operate High Speed Craft
j) Annex 5 : Ice accretion applicable to all types of crafts
k) Annex 10 : Criteria for testing and evaluation of revenue and crew seats
l) Annex 11 : Open reversible liferafts.

Where relevant, the Rule requirements which are applicable only to crafts with HSC notation (See 3.6.2) and need not be applied to crafts with LC or HSLC notation, have been indicated separately.

2.1.5 On all craft, new installation of materials containing asbestos used for the structure, machinery, electrical installations and equipment is prohibited except for:

.1 vanes used in rotary vane compressors and rotary vane vacuum pumps;

.2 watertight joints and linings used for the circulation of fluids when, at high temperature (in excess of 350°C) or pressure (in excess of 7×10^6 Pa), there is a risk of fire, corrosion or toxicity; and

.3 supple and flexible thermal insulation assemblies used for temperatures above 1000°C.

2.2 Definitions

2.2.1 ***Administration*** means the Government of the State whose flag the craft is entitled to fly.

2.2.2 ***Air-cushion vehicle (ACV)*** is a craft such that the whole or a significant part of its weight can be supported, whether at rest or in motion, by a continuously generated cushion of air dependent for its effectiveness on the proximity of the surface over which the craft operates.

2.2.3 ***Assembly station*** is an area where passengers can be gathered in the event of an emergency, given instructions and prepared to abandon the craft, if necessary. The passenger spaces may serve as assembly stations if all passengers can be instructed there and prepared to abandon the craft.

2.2.4 ***Auxiliary machinery spaces*** are spaces containing internal combustion engines of power output upto and including 110 kW driving generators, sprinkler, drencher or fire pumps, bilge pumps, etc., oil filling stations, switchboards of aggregate capacity exceeding 800 kW, similar spaces and trunks to such spaces.

2.2.5 ***Auxiliary machinery spaces having little or no fire risk*** are spaces containing refrigerating, stabilizing, ventilation and air conditioning machinery, switchboards of aggregate capacity 800 kW or less, similar spaces and trunks to such spaces.

2.2.6 ***Base port*** is a specific port identified in the route operational manual and provided with:

a) appropriate facilities providing continuous radio communications with the craft at all times while in port and at sea;
b) means for obtaining a reliable weather forecast for the corresponding region and its due transmission to all craft in operation;
c) for a category A craft, access to facilities provided with appropriate rescue and survival equipment; and
d) access to craft maintenance services with appropriate equipment.

2.2.7 ***Base port state*** means the State in which the base port is located.

2.2.8 ***Breadth (B)*** means breadth [m] of the broadest part of the moulded watertight envelope of the rigid hull, excluding appendages, at or below the design waterline in the displacement mode with no lift or propulsion machinery active.

2.2.9 ***Cargo craft***, for the application of the HSC Code, is any high speed craft other than passenger craft and which is capable of maintaining the main functions and safety systems of unaffected spaces, after damage in any one compartment on board.

2.2.10 ***Cargo spaces*** are all spaces other than special category spaces used for cargo and trunks to such spaces.

2.2.11 ***Category A craft*** is any high speed passenger craft:

a) Operating on a route where it has been demonstrated to the satisfaction of the flag and port states that there is a high probability that in the event of an evacuation at any point of the route, all passengers and crew can be rescued safely within the least of:

   – The time to prevent persons in survival craft from exposure causing hypothermia in the worst intended conditions.
   – The time appropriate with respect to environmental conditions and geographical features of the route, or
   – 4 hours, and

b) Carrying not more than 450 passengers.

2.2.12 ***Category B craft*** is any high speed passenger craft, other than a category A craft, with machinery and safety systems arranged such that, in the event of damage disabling any essential machinery and safety systems in one compartment, the craft retains the capability to navigate safely i.e. to reach the port of refuge within the period of weather forecast validity.

2.2.13 ***Continuously manned control station*** is a control station which is continuously manned by a responsible member of the crew while the craft is in normal service.

2.2.14 ***Control stations*** are those spaces in which the craft's radio or navigating equipment (main displays and controls for equipment) or the emergency source of power and emergency switchboard are located, or where the fire recording or fire control equipment is centralized, or where other functions essential to the safe operation of the craft such as propulsion control, public address, stabilization systems, etc., are located.

2.2.15 ***Crew accommodation*** are those spaces allocated for the use of the crew, and include cabins, sick bays, offices, lavatories, lounges and similar spaces.

2.2.16 ***Critical design conditions*** means the limiting specified conditions chosen for design purposes, which the craft should keep in displacement mode. Such conditions should be more severe than the worst intended conditions by a suitable margin to provide for adequate safety in survival condition.

2.2.17 ***Datum means*** a watertight deck or equivalent structure of a non-watertight deck covered by a weathertight structure of adequate strength to maintain the weathertight integrity and fitted with weathertight closing appliances.

2.2.18 ***Design waterline*** means the waterline corresponding to the maximum operational weight of the craft with no lift or propulsion machinery active and is limited by the stability and strength requirements in the Rules.

2.2.19 ***Displacement mode*** means the regime, whether at rest or in motion, where the weight of the craft is fully or predominantly supported by hydrostatic forces.

2.2.20 ***Failure mode and effect analysis (FMEA)*** is an examination in accordance with HSC Code annex 4 of the craft's systems and equipment to determine whether any reasonably probable failure or improper operation can result in a hazardous or catastrophic effect.

2.2.21 ***Fire Test Procedures Code (FTP Code)*** means the International Code for Application of Fire Test Procedures, as defined in chapter II-2 of the SOLAS Convention.

2.2.22 ***Flap*** means an element formed as integrated part of, or an extension of, a foil, used to adjust the hydro or aerodynamic lift of the foil.

2.2.23 ***Flash-point*** means a flash-point determined by a test using the closed cup apparatus referenced in the International Maritime Dangerous Goods (IMDG) Code.

2.2.24 ***Foil*** means a profiled plate or three dimensional construction at which hydrodynamic lift is generated when the craft is under way.

2.2.25 ***Fully submerged foil*** means a foil having no lift components piercing the surface of the water in the foil-borne mode.

2.2.26 ***Galleys*** are those enclosed spaces containing cooking facilities with exposed heating surfaces, or which have any cooking or food heating appliances each having a power of more than 5 kW.

2.2.27 ***High speed craft*** is a craft capable of maximum speed equal to or exceeding:

$7.16\ \Delta^{0.1667}$ [knots]

where,

Δ = displacement corresponding to the design waterline [t].

2.2.28 ***Hydrofoil boat*** is a craft which is supported above the water surface in non-displacement mode by hydrodynamic forces generated on foils.

2.2.29 ***IMDG*** Code means the International Maritime Dangerous Goods (IMDG) Code as defined in chapter VII of the SOLAS Convention.

2.2.30 ***IMO*** means the International Maritime Organisation.

2.2.31 ***Length (L)*** means the overall length [m] of the underwater watertight envelope of the rigid hull, excluding appendages, at or below the design waterline in the displacement mode with no lift or propulsion machinery active.

2.2.32 ***Lightweight*** is the displacement of the craft [t] without cargo, fuel, lubricating oil, ballast water, fresh water and feed-water in tanks, consumable stores, passengers and crew and their effects.

2.2.33 ***Machinery spaces*** are spaces containing internal combustion engines either used for main propulsion or having an aggregate total power output of more than 110 kW, generators, oil fuel units, major electrical machinery and similar spaces and trunks to such spaces.

2.2.34 ***Maximum operational weight*** means the overall weight upto which the craft will be operated in the intended mode. In the case of crafts where HSC Code applies this is the weight permitted by the Administration.

2.2.35 ***Maximum speed*** V [knots] is the speed achieved at the maximum continuous propulsion power for which the craft is certified at maximum operational weight and in smooth water.

2.2.36 ***Non-displacement mode*** means the normal operational regime of a craft when non hydrostatic forces substantially or predominantly support the weight of the craft.

2.2.37 ***Oil fuel unit*** is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0.18 N/mm^2.

2.2.38 ***Open ro-ro spaces*** are spaces:

a) to which any passengers carried have access; and

b) which either:

i) are open at both ends, or

ii) have an opening at one end and are provided with permanent openings distributed in the side plating or deckhead or from above, having a total area of at least 10% of the total area of the space sides.

2.2.39 ***Operating compartment*** means the enclosed area from which the navigation and control of the craft is exercised.

2.2.40 ***Operating station*** means a confined area of the operating compartment equipped with necessary means for navigation, manoeuvring and communication, and from where the functions of navigating, manoeuvring, communication, commanding, conning and lookout are carried out.

2.2.41 ***Passenger*** is every person other than:

a) the master and members of the crew or other persons employed or engaged in any capacity on board a craft on the business of that craft; and
b) a child under one year of age.

2.2.42 ***Passenger craft*** is a craft which carries more than twelve passengers.

2.2.43 ***Place of refuge*** is any naturally or artificially sheltered area which may be used as a shelter by a craft under conditions likely to endanger its safety.

2.2.44 ***Public spaces*** are those spaces allocated for the passengers and include bars, kiosks, smoke rooms, main seating areas, lounges, dining rooms, recreation rooms, lobbies, lavatories and similar permanently enclosed spaces allocated to passengers.

2.2.45 ***Refreshment kiosks*** are those spaces which are not enclosed, serving refreshments and containing food warming equipment having a total power of 5 [kW] or less and with an exposed heating surface temperature not above 150°C.

2.2.46 ***Ro-ro craft*** is a craft fitted with one or more ro-ro spaces.

2.2.47 ***Ro-ro spaces*** are spaces not normally subdivided in any way and normally extending to either a substantial length or the entire length of the craft in which motor vehicles with fuel in their tanks for their own propulsion and/or goods (packaged or in bulk, in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded, normally in a horizontal direction.

2.2.48 ***Service spaces*** are those enclosed spaces used for pantries containing food warming equipment but not cooking facilities with exposed heating surfaces, lockers, sales shops, storerooms and enclosed baggage rooms.

Such spaces containing no cooking appliances may contain:

.1 coffee automats, toasters, dish washers, microwave ovens, water boilers and similar appliances, each of them with a maximum power of 5 kW; and

.2 electrically heated cooking plates and hot plates for keeping food warm, each of them with a maximum power of 2 kW and a surface temperature not above 150°C.

2.2.49 ***Significant wave height*** is the average crest-to-trough height of the highest one third of the zero-upcrossing waves in a specified period

2.2.50 ***SOLAS 74*** means the International Convention for Safety of Life at Sea, 1974, as amended.

2.2.51 ***Special category spaces*** are those enclosed ro-ro spaces to which passengers have access. Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 [m].

2.2.52 ***Surface effect ship (SES)*** is an air-cushion vehicle whose cushion is totally or partially retained by permanently immersed hard structures.

2.2.53 ***Transitional mode*** means the regime between displacement and non-displacement modes.

2.2.54 ***Watertight in relation to a structure*** means capable of preventing the passage of water through the structure in any direction under the head of water likely to occur in the intact or damaged condition.

2.2.55 ***Weather deck*** is a deck which is completely exposed to the weather from above and at least two sides.

2.2.56 ***Weathertight*** means that water will not penetrate into the craft in any wind and wave conditions up to those specified as critical design conditions.

2.2.57 ***Worst intended conditions*** means the specified environmental conditions within which the craft is intended to be operated as provided for in the certification of the craft. This should take into account parameters such as the worst conditions of wind force allowable, significant wave height (including unfavourable combinations of length and direction of waves), minimum air temperature, visibility and depth of water for safe operation and such other parameters as the Administration may require in considering the type of craft in the area of operation.

Section 3

Classification Regulations

3.1 General

3.1.1 When a craft is assigned a specific Character of Class by Indian Register of Shipping, it implies that IRS has been satisfied that the said craft meets, for this particular class, with these Rules and Regulations or requirements equivalent thereto. The craft will continue to be classed with IRS so long as it is found, upon examination at the prescribed annual and periodical surveys, to be maintained in a fit and efficient condition and in accordance with the Periodical Survey requirements of these Rules. Classification will be conditional upon compliance with IRS requirements and assignment of character of class for both hull and machinery.

3.1.2 The Rules are framed on the understanding that:

– the crafts will be properly loaded, they do not, unless stated in the class notation, provide for special distributions or concentrations of loading.

– the crafts will not be operated outside the design parameters corresponding to the class notation assigned as per 3.6 and 3.7.

– the crafts will be properly handled, in particular the reduction of speed in heavy weather which has been assumed during design, incorporated in the operational manual and appended to the certificate of class, is applied. See Chapter 4 ‘Design Loads’ for details.

3.1.3 Compliance to the following International Conventions and Codes of IMO, as applicable, and any National requirements is a prerequisite of classification:

- International Code of Safety of High Speed Craft (HSC Code);
- International Convention for the Safety of Life at Sea (SOLAS);
- International Convention for the Prevention of Pollution from Ships (MARPOL);
- International Convention on Loadlines (ILLC);
- Fire Test Procedures Code (FTP Code)
- International Convention on the Control of Harmful Antifouling Systems on Ships (AFS Convention).

In addition, the Unified Interpretations of IACS (International Association of Classification Societies) related to the above IMO Conventions and Codes are also to be complied with, unless the flag Administration has provided its own interpretation in writing. For the purposes of the application of the IMO Conventions and Codes for Fibre-Reinforced Plastic (FRP) Craft, the term “the keels of which are laid or which are at a similar stage of construction” should be interpreted as the date that the first structural reinforcement of the complete thickness of the approved hull laminate schedule is laid either in or on the mould.

3.1.4 Where a craft holds dual classification with IRS and another Society and the periodical survey requirements of the corresponding Society differ from IRS Rule requirements, IRS may permit the requirements of the corresponding Society being applied, in so far as they are equivalent in purpose or are no less stringent than the IRS rule requirements.

3.1.5 The classification of a craft with IRS does not exempt the owners from compliance with any additional and/or more stringent requirements issued by the Administration of the state whose flag the craft is entitled to fly and provision for their application.

3.1.6 It is the responsibility of the Owners to ensure that the operating and maintenance instructions / manuals for the crafts machinery equipment essential to the safe operation of the crafts are available in a language understandable by those officers and crew members who are required to understand such information / instructions in the performance of their duties.

3.1.7 Operating manuals - For vessels required to comply with the HSC Code, the Administration would require that the management of the company operating the craft has provided the craft with adequate information and guidance in the form of manuals to enable the craft to be operated and maintained safely. These manuals should include a route operational manual, craft operating manual, maintenance manual, servicing schedule and as a minimum the information specified in Chapter 18 of the HSC Code.

3.2 Application of Rules

3.2.1 Unless directed otherwise by IRS, no new Regulation or amendment to the existing regulation relating to the character of classification or class notation is to be applied to existing crafts.

3.2.2 Unless directed otherwise by IRS, no new Rules and Regulations or amendments to the existing Rules & Regulations become applicable within 6 months after the date of issue nor after the approval of original midship section or equivalent structural plans. Where it is proposed to use existing previously approved plans for a new contract, written application is to be made to IRS.

3.3 Scope of classification

3.3.1 Classification covers craft’s hull, appendages and machinery including electrical systems to the extent as specified in these Rules and Regulations.

3.4 Interpretation of the Rules

3.4.1 The correct interpretation of the requirements contained in the Rules and Regulations is the sole responsibility and at the sole discretion of IRS.

3.5 Character of classification

3.5.1 The following Characters and symbols are assigned by IRS to indicate classification of High Speed Crafts and Light Crafts.

a) Character **SUL** assigned to sea-going crafts indicates that the hull and its appendages and equipment (i.e. anchors, chain cable and hawsers) meet the Rule requirements for assignment of this Character of Class.

   Guidance Note : Appendages to the hull referred to in 3.5.1 a), b) and c) means the rudder & rudder stock, rudder horn, sole pieces, propeller nozzles, shaft brackets, skeg etc. which are covered by the rule requirements.

b) Character **SU-** assigned to sea-going crafts indicates that the hull and its appendages meet the Rule requirements but equipment (i.e. anchors, chain cable and hawsers) is not supplied or maintained as per the relevant Rules but is considered by the Board to be acceptable for their particular service.

c) Character **SU** assigned to sea-going crafts indicates that the hull and its appendages meet the Rule requirements but in respect of the equipment, IRS has agreed that the normal equipment is not necessary in view of their particular service.

d) Character **IY** assigned to self-propelled seagoing crafts indicates that the machinery meets the rule requirements for assignment of this Character of Class.

3.5.2 The distinguishing mark 卐 inserted before Characters of Class (SUL, SU-, SU, IY as appropriate) is assigned to new crafts where the hull and its appendages, equipment and the machinery, as appropriate are constructed under special survey of IRS in compliance with the Rules to the satisfaction of IRS.

3.6 Class notations – Hull

3.6.1 When requested by an Owner and agreed to by IRS or when considered necessary by IRS, relevant class notation(s) as detailed in 3.6.2 to 3.6.4 below will be appended to the character of classification assigned to the craft e.g.
卐 SUL, HSC, RS 0, Patrol.

3.6.2 Main Notations:

Depending on the type of craft one of the following main notations would be assigned:

a) Notation ‘**HSC’** – to crafts for which the HSC Code is applicable as defined in 2.1.1a.

b) Notation **‘LC’** – to other fast crafts of light construction as defined in 2.1.1b. Where such crafts satisfy the high speed criteria given in 2.2.27, notation ‘**HSLC**’ would be assigned.

3.6.3 Service area restriction notations:

a) Depending on the sea conditions in service area for which the craft has been approved and constructed, or appropriate service restriction notation would be assigned from those given in the Table 3.6.3.

Table 3.6.3

Notation	**Design significant wave height [m]**
RS 0	$H_s \geq 4.0$ m
RS 1	$2.5 \leq H_s < 4.0$ m
RS 2	$0.6 < H_s < 2.5$ m
RS 3	$H_s \leq 0.6$ m

b) In addition to the above, crafts may be assigned a service range notation limiting the distance in nautical miles from the place of refuge or coast, if requested : for example 'for operation within 20 Nm from place of refuge' or 'for operation within 20 Nm from the coast'.

3.6.4 Service type notation:

Depending on the primary nature of service provided by the crafts, one of the following notations would be assigned:

a) Passenger
b) Cargo
c) Supply
d) Workboat
e) Pilot
f) Patrol
g) Rescue.

3.7 Class notations – Machinery

3.7.1 The notation **SYJ** assigned to crafts indicates that the control engineering equipment required for unattended machinery spaces has been provided, installed and tested in accordance with the requirements given in Chapter 14.

3.8 Materials, components, equipment and machinery

3.8.1 The materials used in the construction of hull and machinery of crafts intended for classification, or in the repair of crafts already classed, are to be of good quality and free from defects and are to be tested in accordance with the relevant Rules. The materials are to be manufactured at works recognized* by IRS for the type of product being supplied. Alternatively, tests to the satisfaction of IRS will be required to demonstrate the suitability of the proposed material.

Consideration may be given by IRS to accept the works approved by IACS Member Societies with whom IRS currently has Cooperation Agreements for this purpose.

3.8.2 Certification of materials, components, equipment and machinery is carried out on basis of the following, considering IRS and/or IMO requirements, as applicable:

a) Type approval carried out by IRS

b) Unit certification by IRS,

c) Alternative Certification Scheme by IRS (Refer to *IRS Rules and Regulations for the Construction and Classification of Steel Ships Pt 1, Ch 1, Sec 4*),

d) Mutual recognition of certificates, if type approved by an IACS Member Society or European Union recognized organization based on commonly agreed design requirements between IRS and the recognized organization.

3.9 Request for surveys

3.9.1 It is the responsibility of the Builders or Owners, as applicable, to inform the Surveyors of IRS in the port at which the surveys for supervision during new construction or crafts in service are to be undertaken and to ensure that all surveys for issue of class certificate for new construction, and maintenance of class for crafts in service are carried out.

3.10 Repairs

3.10.1 Any repairs to the hull, machinery and equipment either as a result of damage or wear and tear which are required for the maintenance of the craft's class are to be carried out under the inspection of and to the satisfaction of the Surveyors.

3.10.2 Where a craft is damaged to an extent resulting in towage outside port limits, it shall be

Owner's responsibility to notify IRS at the first practicable opportunity.

3.10.3 Where such repairs are effected at a port where there is no Surveyor of IRS, the craft is to be surveyed by one of its Surveyors at the earliest opportunity.

3.10.4 Where repairs to hull, machinery or equipment, which affect or may affect classification, are to be carried out by a riding crew, they are to be planned in advance. A complete repair procedure including the extent of proposed repairs and the need for Surveyor's attendance during the voyage is to be submitted to and agreed upon by the Surveyor reasonably in advance. Failure to notify IRS, in advance of the repairs, may result in suspension of the craft's class.

Where in any emergency circumstance, emergency repairs are to be effected immediately, the repairs should be documented in the craft's log and submitted thereafter to IRS for use in determining further survey requirements.

3.11 Alterations

3.11.1 Any alterations proposed to be carried out to approved scantlings and arrangements of the hull, machinery or equipment are to meet with the approval of IRS and for this purpose plans and technical particulars are to be submitted for approval in advance. Such approved alterations are to be carried out under the inspection of, and to the satisfaction of the Surveyors. If such alterations are carried out on items which may affect the classification of the craft without informing IRS, the class of the craft will be liable to be suspended except in the case of emergency repairs mentioned in 3.10.4

3.12 Date of contract for construction

3.12.1 The date of "contract for construction" of a craft is the date on which the contract to build the craft is signed between the prospective owner and the builder. This date and the construction numbers (i.e. hull numbers) of all the crafts included in the contract are to be declared to IRS by the party applying for the assignment of class to a new building. (Also refer to *Rules and Regulations for the Construction and Classification of Steel Ships Pt1, Ch 1, 2.14*).

3.13 Date of build

3.13.1 The date of completion of the special survey inspection will normally be taken as the date of build to be entered in the Register Book.

Where there is a substantial delay between completion of construction survey and the craft commencing service, the date of commissioning may be specified on the classification certificate.

When modifications are carried out on a craft, the initial date of build remains assigned to the craft.

3.13.2 When a complete replacement or addition of a major portion of the craft (e.g. fwd.section, midship section or aft section) is involved, the following applies:

- Date of build assigned to each portion of the craft will be indicated on the classification certificate, and the date of modification will be indicated in the Register Book.

- Survey requirements shall be based on the date of build associated with each major portion of the craft.

3.14 Appeal from Surveyor's recommendations

3.14.1 If the recommendations of the Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to IRS, who may direct a special examination to be held.

3.15 Certificates

3.15.1 Certificates of Class will be issued to Builders or Owners when the required reports on completion of Special Surveys of new crafts or of existing crafts submitted for classification have been received from the Surveyors and approved by IRS.

3.15.2 Certificates of class maintenance in respect of completed periodical special surveys of hull and machinery will also be issued to Owners.

3.15.3 The Surveyors are permitted to issue Interim Certificates to enable a craft, classed with IRS, to proceed on her voyage provided that, in their opinion, it is in a fit and efficient condition. Such Certificates will contain Surveyors' recommendations for continuance of Class, but in all cases are subject to confirmation by IRS.

3.15.4 Individual Certificates can also be issued for propelling machinery, boilers, equipments and fittings which have been manufactured under IRS Survey and in accordance with these Regulations.

3.16 Suspension, withdrawal and deletion of class

3.16.1 Suspension

3.16.1.1 The class of a craft will be automatically suspended from the expiry date of the Certificate of Class or by the expiry date of any extension granted, if the special survey has not been completed by the due date and an extension has not been agreed to, or the vessel is not under attendance by the Surveyor with a view to complete the surveys prior to resuming service.

3.16.1.2 The class of a craft will also be automatically suspended if the annual, intermediate survey become overdue.

3.16.1.3 Classification will be reinstated upon satisfactory completion of overdue survey. The scope of the overdue surveys will be based on the survey requirements applicable to the craft at the original due date and not based on the age of the vessel when the survey is carried out. Such surveys will be credited from the date originally due. However, the craft will remain dis-classed from the date of suspension until the date class is reinstated.

The Owners and the Flag State, where applicable, would be informed in writing, of the suspension and reinstatement of Classification.

3.16.1.4 When the surveys relating to specific additional notations of hull or equipment or machinery have not been complied with and thereby the craft is not entitled to retain that notation, then the specific notation will be suspended till the related surveys are completed.

3.16.1.5 The class of craft will be subject to a suspension procedure if an item of continuous survey is overdue at the time of annual survey, unless the item is dealt with or postponed by agreement.

3.16.1.6 The class of the craft will also be subject to a suspension procedure if recommendations and/or conditions of class are not dealt with by the due date or postponed by agreement, by the due date.

3.16.1.7 The class of a craft is liable to be withheld or, if already granted, may be withdrawn in case of any nonpayment of fees or expenses chargeable for the service rendered.

3.16.1.8 Where any craft proceeds to sea with a less freeboard than that approved by IRS or when the freeboard marks are placed higher on the ship's sides than the position assigned or approved by IRS, the ship's class will be suspended.

3.16.1.9 When it is found that a craft is being operated in a manner contrary to that agreed at the time of classification, or is being operated in conditions or in areas more onerous than those agreed, the class will be suspended.

3.16.1.10 The class of a craft will be liable to be suspended if the Owner fails to notify IRS of any damage to the craft's hull, machinery or equipment, which may adversely affect classification of the vessel or subsequently fails to arrange for the survey as may be advised by IRS.

3.16.1.11 The class of a craft will be suspended after a major casualty to the craft, such as grounding, sinking or breaking up, if the Owner is unable to arrange for the craft's survey by IRS and commence repairs within a reasonable period of the occurrence of the casualty, unless otherwise agreed to with IRS.

3.16.1.12 Crafts laid up in accordance with the Rules prior to surveys becoming overdue will not be suspended when surveys addressed above become overdue.
However, crafts which are laid up after being suspended as a result of surveys becoming overdue, will remain suspended until the overdue surveys are completed.

3.16.2 Withdrawal

3.16.2.1 Craft's class will be withdrawn, at the end of six months of suspension, if the Owner has not commenced any action to reinstate the craft's class. A longer suspension period may be granted when the craft is not trading or in cases of lay-up awaiting attendance for reinstatement or disposition, in the event of a casualty.

3.16.2.2 When the class of a craft holding IRS class, is withdrawn by IRS in consequence of a request from the Owners, the notation "Class withdrawn at Owners' request" (with date) will be made in the subsequent reprints of the Register Of Ships. This entry will continue till the craft's class is reinstated or deleted.

3.16.2.3 When the Regulations as regards surveys on the hull or equipment or machinery have not been complied with and the craft thereby is not entitled to retain her class, the class will be withdrawn and the notation "Class withdrawn" (with date) will be made in the subsequent reprints of the Register Of Ships. This entry will continue till the craft's class is reinstated or deleted.

3.16.2.4 The withdrawal of a craft will be confirmed in writing to the Owner and the Flag State, where applicable

3.16.3 Deletion of Class

3.16.3.1 A craft will be considered to "cease to exist" when it is destroyed by scrapping or by sinking to unsalvageable depths or abandoned by the owner.

3.16.3.2 A craft can also be considered to "cease to exist" when it is broken up either by grounding or due to structural failure or due to actions of war or sabotage.

3.16.3.3 Craft's class will be deleted when it ceases to exist.

3.17 Reclassification of crafts

3.17.1 When Owners request for reclassification of a craft for which the class previously assigned has been withdrawn, IRS will require a Special Survey for Reclassification to be held by the IRS Surveyors. The extent of the survey will depend upon the age of the craft and the circumstances of each case.

3.17.2 If the craft is found or placed in good and efficient condition in accordance with the requirements of the Rules and Regulations at the Special Survey for Reclassification, IRS may decide to reinstate her original class or assign such other class as considered appropriate.

3.17.3 The date of reclassification will appear in the supplement to the Register Of Ships and the subsequent issue of Register Of Ships.

3.18 Transparency of Classification and Statutory information

3.18.1 The classification and statutory information which may be released to Shipowners, Flag State, Port State, Insurance company and Shipyards as relevant and the conditions for their release are indicated in Rules and Regulations for the Construction and Classification of Steel Ships, Pt1, Ch1, Table 2.21.1.

Section 4

Classification of Crafts Built under the Survey of Indian Register of Shipping

4.1 Classification of new construction

4.1.1 The request for classification of new constructions is to be submitted to IRS by the shipyard or shipowner in the form provided by IRS. The request is to include complete details regarding class notation and statutory certificates required, where applicable.

The IRS Rules in force on the date of contract for construction of the craft (See 3.12) will be applicable for classification, in general. However, statutory requirements coming into force after the date of contract for construction may have to be complied with if they become applicable based on any other criteria such as the date on which craft is constructed (keel laid).

4.1.2 When the shipyard places orders for major machinery and equipment on manufacturer or suppliers, IRS will have to be informed. Responsibility for compliance with IRS Rules and Regulations shall be with the manufacturers/suppliers.

Where relevant, the date of application for certification of specific major machinery will also be considered in addition to the date of contract for construction of the craft, for determining the applicable rules for such machinery.

4.1.3 Plans and particulars as specified in the Rules will have to be submitted to IRS in triplicate sufficiently in advance of commencement of construction. One copy with stamp of approval will be returned. Any deviation from approved drawings will require to be approved by IRS prior to execution of work.

IRS reserves the right to request for additional plans, information or particulars to be submitted.

Where it is proposed to use existing previously approved plans for a new contract, written application is to be made to IRS.

Approval of plans and calculations by IRS does not relieve the Builders of their responsibility for the design, construction and installation of the various parts, nor does it absolve the Builders from their duty of carrying out any alterations or additions to the various parts on board deemed necessary by IRS during construction or installation on board or trials.

4.1.4 IRS will assess the production facilities and procedures of the shipyard and other manufacturers as to whether they meet the requirements of the construction Rules.

4.1.5 During construction of a craft, IRS will ensure by surveys that parts of hull and machinery requiring approval have been constructed in compliance with approved drawings, all required tests and trials are performed satisfactorily, workmanship is in compliance with current engineering practices and welded parts are produced by qualified welders.

4.1.6 All hull, machinery and electrical installations will be subjected to operational trials in the presence of IRS Surveyor.

4.1.7 On completion of the craft, copies of as fitted plans showing the craft as built, essential certificates and records, loading manual etc. are to be submitted by the Builder generally prior to issuance of the Interim Certificate of Class.

4.2 Scope

4.2.1 The items listed below, where applicable, are covered by these requirements and are subject to approval by IRS:

- Materials
- Structural strength
- Stability – intact and damaged
- Weathertight / watertight integrity
- Anchoring and mooring equipment
- Propulsion machinery, including shafts and propellers
- Steering gear and rudders
- Auxiliary machinery
- Remote control systems
- Pumping and piping systems, including valves
- Boilers and pressure vessels
- Electrical installations
- Fire safety.

Section 5

Classification of Crafts not Built under the Survey of Indian Register of Shipping

5.1 General procedure for classification of crafts not built under survey of IRS

5.1.1 Plans of hull and machinery in duplicate, together with torsional vibration calculations, where applicable, as specified in 5.2 are to be submitted for approval. It is preferable to have the plans approved before the classification survey is commenced.

5.1.2 Full special classification surveys would require to be carried out by IRS Surveyors in order to satisfy themselves regarding the workmanship and to verify the approved scantlings and arrangements. The scope of these surveys may, however, be modified in the case of crafts built under the Special Survey and holding valid certificates of class of established classification societies, if prior to commencement of survey by IRS, documentary evidence of all hull and machinery classification surveys held by the other society subsequent to last special survey carried out by them could be produced. In such cases, a special survey notation will not be assigned in conjunction with the classification survey. The next special survey therefore would become due five years from the special survey held by the other society and not five years from classification with IRS.

In cases of transfer of class from another society to single class of IRS, the interim certificate of class or any other documents enabling the craft to trade, can be issued:

a) In case of vessels less than 15 years of age

   – only after IRS has completed all overdue surveys and overdue recommendations/ conditions of class issued earlier against the vessel, as specified to the Owner by the previous society.

b) In case of vessels 15 years of age and over

   – only after the previous society has completed all overdue surveys and all overdue recommendations / conditions of class issued earlier against the vessel.

5.1.3 For crafts not built under survey of IRS but subsequently taken in class with the above procedure, the mark signifying the survey during construction will be omitted.

5.1.4 Once a craft has been taken into IRS class, periodical surveys are subsequently to be held as per these rules.

5.2 Plans and data to be furnished as required in 5.1.1

5.2.1 Plans of hull and equipment showing the main scantlings and arrangements of the actual craft and any proposed alterations are to be submitted for approval. These should normally comprise of the following plans:

For information

- General arrangement
- Capacity plan
- Hydrostatic curves
- Loading manual
- Lightweight distribution
- Operating manual.

For approval

- Midship section
- Longitudinal section and decks
- Cross deck structure
- Shell expansion plan
- Transverse bulkheads
- Fore body structure
- Aft body structure
- Rudder and rudder stock
- Hatch covers
- Fire detection, fighting and extinction and such other plans as may be requested.

5.2.2 It would normally be expected that particulars of the process of manufacture and testing of material of construction are furnished. Consideration will however be given to waiving this where such particulars are not readily available, provided it can be established that the relevant craft has been originally built under special survey of an established classification society and continues to be so classed with an established classification society. In case of crafts, which have been originally built under the special survey of an established classification society but subsequently not maintaining class, it should additionally be possible to ascertain reasonably that no changes that would significantly affect the material specifications, have taken place.

5.2.3 Following machinery plans together with the particulars of the materials used in the construction of the boilers, air receivers and important forgings should be furnished.

For information

- General machinery lay-out

For approval

- Thrust, intermediate and propeller shafting
- Propeller
- Main engines, propulsion gears and clutch systems (or manufacturer, make, model and rating information)
- Bilge and ballast piping system
- Wiring diagram
- Steering gear systems, piping and arrangements and steering gear manufacturer make and model information
- Additional plans for vessels with unattended machinery spaces

- Description and/or block diagram of method of operation of the control system.

Line diagrams of the control system for:

- Main propelling machinery and essential auxiliaries
- Bilge level systems
- Boiler controls
- Fire detection
- Fire prevention, including details in way of fuel oil pressure pipes
- Overall alarm system including test schedule.

5.2.4 Calculations of torsional vibration characteristics of the main propelling machinery are to be furnished specially for crafts which have been in service for less than about 2 years.

End Of Chapter

Chapter 2

Periodical Surveys

Contents

Section	
1	General Requirements
2	Annual Surveys
3	Intermediate Surveys
4	Docking Surveys
5	Special Surveys – Hull
6	Special Surveys – Machinery
7	Surveys of Propeller Shafts, Tube Shafts and Propellers
8	Planned Maintenance System

Section 1

General Requirements

1.1 General

1.1.1 All crafts are to be subjected to periodical surveys for the purpose of ascertaining the condition of the structure, machinery, installations and equipment. Survey notations and survey intervals corresponding to the main class are given in Table 1.1.1. Where additional class notations have been assigned, surveys are to be carried out at intervals given in Table 1.1.2.

Where boilers, steam generators, steam pipes and condensers are fitted onboard, they are to be surveyed in accordance with the requirements given in *Rules and Regulations for the Construction and Classification of Steel Ships* Pt.1 Ch.2.

1.1.2 Crafts with additional class notations for which there are no specific survey requirements defined in this chapter are to have the equipment and/or construction related to this additional class notation examined to the surveyor's satisfaction at each special survey. However, at the time of annual surveys, the continued effectiveness of operational features, safety devices and control systems are to be verified.

1.2 Definitions

1.2.1 A **Ballast tank** is a tank which is being used solely for water ballast. A tank which is used for both cargo and ballast will be treated as a ballast tank when substantial corrosion has been found in that tank.

1.2.2 A **Transverse section** includes all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom, inner bottom and hopper side plating, longitudinal bulkheads and bottom plating in top wing tanks.

1.2.3 **Representative spaces/tanks** are those which are expected to reflect the condition of other spaces/tanks of similar type and service and with similar corrosion protection systems. When selecting Representative Spaces/Tanks account is be taken of the service and repair history onboard and identifiable Critical Areas and/or Suspect Areas.

1.2.4 **Suspect areas** are locations showing Substantial Corrosion and/or considered by the Surveyor to be prone to rapid wastage.

1.2.5 **Critical areas** are locations which have been identified from calculations to require monitoring or from the service history of the subject ship or sister ships (if available) to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship.

Table 1.1.1 : Periodical survey and intervals for main class survey notations		
Survey	**Survey Notation Main Class**	**Survey interval in years**
Hull : special survey	SSH	5
Hull : continuous survey	CSH	5
Machinery : special survey	SSM	5
Machinery : continuous survey	CSM	5
Intermediate survey	IS	2 or 3 [1)]
Annual survey	AS	1 [2)]
Docking survey for crafts with HSC notation for crafts other than with HSC notation	DS	1 2.5[4)]
Shaft Survey		
Oil Lubricated	SH (OL)	See Notes 3 & 5
Fresh Water Lubricated Closed Loop System	SH (FW-C)	
Single Shaft Fresh Water Lubricated Open System	SH (S-FW-O)	
Single Shaft Corrosion Protected or Corrosion Resistant Material, Water Lubricated Open System	SH (S-CP-O)	
Multiple Shaft, Water Lubricated Open System	SH (M-O)	
Single Shaft, Water Lubricated Open System	SH (S-O)	
Directional propellers, water jet units, or athwartship thrust propellers	DP	5[5)]

Table 1.1.1 Notes :

1) May be carried out along with 2nd or 3rd AS, or in between.
2) May be carried out within 3 months on either side of the due date.
3) See Tables 7.2.1.3 and 7.2.2.3 for survey intervals of closed and open systems respectively.
4) At least 2 surveys are to be carried out within any 5 years, of which one survey is to be in conjunction with the special survey. The interval between two consecutive surveys is not to exceed 3 years.
5) Upon request, IRS may extend the survey period to harmonise with docking survey and in accordance with the requirements of Section 7.

Table 1.1.2 : Periodical survey intervals for additional class survey notations

Survey	Survey Notation Additional Class	Survey interval in years
Unattended machinery spaces Special Survey Annual Survey	 SS(SYJ) AS(SYJ)	 5 1 [1]
Planned Maintenance System of Machinery Annual Audit	AA(PMS)	1[2]
Note : 1) May be carried out within 3 months on either side of due date. 2) To be carried out in conjunction with annual survey.		

1.2.6 **Protective coatings** are to be usually epoxy coating or equivalent. Other coating systems may be considered acceptable as alternatives provided they are applied and maintained in compliance with the manufacturer's specifications.

1.2.7 **Soft coatings** Where soft coatings have been applied, safe access is to be provided for the Surveyor to verify the effectiveness of the coating and to carry out an assessment of the conditions of the internal structures which may include spot removal of the coating. When safe access cannot be provided, the soft coating is to be removed.

1.2.8 **Coating condition** is defined as follows :

GOOD - Condition with only minor spot rusting;
FAIR - Condition with local breakdown at edges and weld connections and/or light rusting over 20 per cent or more of areas under consideration, but less than as defined for POOR condition;
POOR - Condition with general breakdown of coating over 20 per cent or more of areas or hard scale at 10 per cent or more of areas under consideration.

1.2.9 **Spaces** are separate compartments including holds and tanks

1.2.10 **A prompt and thorough repair** is a permanent repair completed at the time of survey to the satisfaction of the Surveyor, therein removing the need for the imposition of any associated condition of classification.

1.2.11 **Anniversary date** means the day and month of each year corresponding to the expiry date of the classification certificate.

1.3 Survey preplanning and record keeping

1.3.1 Plans and procedures for special periodical surveys, special continuous surveys and dry docking surveys are to be submitted for review in advance of the survey and made available on board. These are to include drawings or forms for identifying the areas to be surveyed, the extent of hull cleaning, non-destructive testing locations (including NDT methods), nomenclature and for the recording of any damage or deterioration found. Submitted data, after review by the Surveyor will be subject to review if found to be necessary in light of experience.

1.4 Laid up vessels

1.4.1 Survey during lay-up

1.4.2 When a vessel is laid up and IRS is so informed and the attending surveyor has so recommended, the periodical surveys required by 1.1.1, except Annual Surveys, may be postponed at the discretion of IRS depending upon the vessel's lay-up location, the maintenance and preservative measures taken during the lay-up. During lay-up, the vessel is to comply with the following:-

a) The vessel is to be adequately manned in accordance with the statutory requirements prevailing at the location of lay-up.

b) Adequate power is to be available on board to meet the following requirements:-

- fire fighting;
- bilge pumping;
- lighting;
- communication with shore;
- needs of crew on board, and
- operating anchor and mooring winches within a reasonable time.

c) All Conditions of Class have been suitably dealt with or have been postponed till the next scheduled general examination.

1.4.3 During lay-up, vessels are to be subjected to a general examination every year.

1.5 Reactivation survey

1.5.1 In the case of crafts which have been out of service for an extended period, the requirements for reactivation surveys will be specially considered in each case with due regard given to the status of surveys at the time of commencements of the lay-up period, the lengths of the period and conditions under which the craft had been maintained during the period, but will at least include a sea trial for function testing of machinery installation.

1.6 Surveys by Chief Engineers

1.6.1 Continuous machinery Surveys of some machinery items may be carried out, subject to certain conditions, under the supervision of the Chief Engineer of the ship at ports where IRS is not represented and where practicable, at sea.

1.6.2 A limited confirmatory Survey should be carried out at the next port of call by an exclusive Surveyor of IRS. Where IRS Surveyor is not available, such Survey may be carried out by the exclusive Surveyor of a Society with whom IRS has collaboration agreement in force.

1.6.3 Where an Owner wishes to make use of this type of Survey an application will have to be made by the Owner stating the name, age, qualifications and experience of the Chief Engineer for the consideration of IRS.

Further particulars of this scheme may be obtained from IRS Head Office

1.7 Surveys for damage

1.7.1 It is the responsibility of the owner/operator of the craft to report to IRS without delay any damage, defect or breakdown, which could invalidate the conditions for which a classification has been assigned so that it may be examined at the earliest opportunity by IRS Surveyor(s). All repairs found necessary by the Surveyor are to be carried out to his satisfaction.

1.8 Repairs

1.8.1 Any damage and / or wastage over the allowable limits (including buckling, grooving, detachment or fracture), which affects or, in the opinion of the Surveyor, will affect the vessel's structural, watertight or weathertight integrity, is to be repaired promptly and thoroughly as defined in 1.2.10. Areas to be considered as relevant, include:

- side structure and side plating;
- deck structure and deck plating;
- bottom structure and bottom plating;
- inner bottom structure and inner bottom plating;
- inner side structure and inner side plating;
- longitudinal bulkhead(s) plating and structure;
- transverse watertight or oiltight bulkheads, plating and structure; and
- hatch covers or hatch coamings.

Where adequate repair facilities are not available, consideration may be given to allow the vessel to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage.
Additionally, when a survey results in the identification of substantial corrosion or structural defects, either of which, in the opinion of the Surveyor, will impair the vessel's fitness for continued service, remedial measures are to be implemented before the ship continues in service.

1.9 Alterations

1.9.1 No alterations which may affect classification are to be made to the hull or machinery of a classed craft unless plans of proposed alterations are submitted and approved by IRS before the work of alterations is commenced. Such work is to be carried out in accordance with approved plans and tested on completion as required by the Rules and to the satisfaction of the Surveyor(s).

1.10 Unscheduled surveys

1.10.1 On the event that IRS has reason to believe that it Rules and Regulations are not being complied with IRS reserves the right to perform unscheduled surveys of the hull or machinery.

1.11 Provisions for hull surveys

1.11.1 The Surveyors are to be provided with necessary facilities for a safe execution of survey.

1.11.2 The surveys at sea or at anchorages may be carried out provided necessary precautions are taken while carrying out the survey and adequate assistance is provided.

1.11.3 Tanks and spaces are to be safe for access, i.e. gas freed, ventilated, etc. Tanks and spaces are to be reasonably clean and free from water, scale, dirt, oil residues, etc. to reveal significant corrosion, deformation, fractures, damages and other structural deterioration.

1.11.4 Adequate illumination is to be provided to reveal significant corrosion, deformation, fractures, damages or other structural deterioration.

1.11.5 For overall examination, means are to be provided to enable the Surveyor to examine the structure in a safe and practical way.

Section 2

Annual Surveys

2.1 General

2.1.1 Annual class surveys are to be carried out within 3 months on either side of the due date. These are to be held concurrently with statutory annual or other relevant statutory surveys, where practicable.

2.1.2 Satisfactory completion of annual survey will be confirmed by endorsement of the class certificate.

2.1.3 Annual surveys are normally visual examination to ascertain the general condition of the craft or that relevant requirements are complied with. A more thorough annual survey may be specified for particular structure, machinery installations or equipment due to consequences of failure or age.

2.2 Survey requirements for all vessels

2.2.1 The efficient condition of the following is to be verified:

a) Complete overall examination of craft structure including all internal void spaces and critical structure behind fire insulation as deemed necessary by the Surveyor.
b) Hatchways on freeboard and superstructure decks.
c) Weather decks.
d) Ventilation coamings and ventilation ducts for engine or boiler rooms with dampers.
e) Air pipes.
f) Windows, deadlights and side scuttles.
g) Watertight doors in craft’s bow, sides and stern.
h) Scuppers, discharges and valves with hull attachments (so far as practicable).
i) Exposed casings and skylights.
j) Deckhouses and companionways.
k) Superstructure bulkheads and W.T. doors and penetrations.
l) Chutes and other openings.
m) Bilge level detection and alarm systems on crafts with SYJ notation.
n) Anchoring and mooring arrangement.
o) Guardrails, bulwark, gangways, lifelines, freeing ports and shutters.
p) Main and auxiliary steering arrangement, including their associated equipment and control equipment and verification that log book entries have been made in accordance with statutory requirements when applicable.
q) Machinery spaces, with particular attention being given to the propulsion system, and to the existence of any fire and explosion hazards. Where applicable, emergency escape routes to be checked.

r) Means of communication between the bridge and the machinery control position as well as the bridge and the alternative steering position, if fitted.

s) The bilge pumping systems and bilge wells, including operations of extended spindles, self closing drain cocks and level alarms, where fitted, are to be examined so far is practicable. Satisfactory operation of the bilge pumps including any hand pumps, is to be tested.

t) Any pressure vessels including safety devices, foundations, controls, relieving gear, associated piping systems, insulation and gauges are to be generally examined.

u) The electrical equipment and cabling forming the main and emergency installations are to be generally examined under operating conditions so far as is practicable. The satisfactory operation of the main and emergency sources of power and electrical services essential for safety in an emergency is to be verified. Where the sources of power are automatically controlled, they are to be tested in the automatic mode. Bonding straps for the control of static electricity and earthing arrangements are to be examined where fitted.

v) Remote control on quick closing or stop of valves, pumps, fans, fire dampers.

2.3 Additional requirements for vessel with class notation HSC

2.3.1 In addition to the requirements of 2.2, following is to be complied with:

a) Following documentation is to be available on board:

- High speed craft safety certificate according to the HSC code (passenger or cargo craft as applicable) OR
  - Dynamically supported craft construction and equipment certificate according to DSC code; OR
  - Passenger ship safety certificate referring to the DSC code;
- Permit to operate high speed craft; OR
  - Permit to operate dynamically supported craft;
- Record of assignment of loadline (if applicable);
- Speed versus significant wave height operational restrictions;
- Operational manual.

b) An external examination of the craft's bottom. If permitted by Flag State, bottom survey may be carried out afloat, as per 4.2.

Section 3

Intermediate Surveys

3.1 General

3.1.1 Intermediate surveys are to be held concurrently with statutory annual on other relevant statutory surveys wherever practical, at or between the second or third annual survey.

3.1.2 The following requirements are in addition to those for annual survey and are applicable to crafts over five years of age. For crafts below 5 years of age, additional examination over and above the requirements of annual survey may be required at the discretion of the Surveyors.

3.2 Survey requirements for all vessels

3.2.1 For steel crafts, a general examination of salt water ballast tanks, integral sanitary tanks and bilges is to be carried out as required below. If such inspections reveal no visible structural defects then the examination may be limited to a verification that the protective coating remains in good condition. When considered necessary by the Surveyor thickness measurement of the structure is to be carried out. Where the protective coating is found to be other than in good condition and it has not been repaired, maintenance of class will be subject to the spaces in question being internally examined and gauged as necessary at annual surveys.

a) For all crafts over five years of age and upto ten years of age, representative salt water ballast tanks, integral sanitary tanks and bilges are to be generally examined. Where the protective coating is found to be other than in good condition, or other defects are found, the examination is to be extended to other spaces of the same type.

b) For crafts over ten years of age all salt water ballast tanks, integral sanitary tanks and bilges are to be generally examined.

3.2.2 For crafts over ten years of age, anchors are to be partially lowered and raised using the windlass.

3.2.3 The electrical generating sets are to be examined under working condition.

3.2.4 Representative internal spaces including fore and aft peak spaces, machinery spaces, bilges, etc. are to be generally examined, including any suspect areas.

Section 4

Docking Surveys

4.1 General

4.1.1 At docking or in-water surveys, an examination of the craft's hull and machinery, as far as necessary and practicable is to be carried out to ascertain the general condition.

4.1.2 Attention is to also be given to any relevant statutory requirements of the Administration of the country in which the craft is registered. Consideration may be given at the discretion of IRS, to any special circumstances justifying an extension or reduction of the docking survey interval specified in Table 1.1.1.

4.1.3 The craft is to be placed on blocks of sufficient height in a drydock or on a slipway and proper staging is to be erected as may be necessary, for the examination of the outside of the hull, rudder(s) and underwater fittings. The outside surface of the hull is to be cleaned as may be required by the Surveyor.

Particular attention is to be given to the part of the external hull structure liable to structural deterioration from causes such as high stresses, chafing, lying on the ground, areas of structural discontinuity and shell plating in way of side, bow and stern doors.

4.1.4 The following parts of the external hull structure are to be specially examined:

a) For steel hulls attention is to be given to parts of the structure particularly liable to excessive corrosion and to any undue distortion of the plating of the bottom. The coating system is to be examined and made good as necessary.
b) For aluminium alloy hulls attention is to be given to areas adjacent to any bimetallic connections at skin fittings etc.
c) For composite hulls, the gelcoat or other protective finish is to be examined for surface cracking, blistering or other damage which may impair the efficiency of the protection to the underlying laminate.

4.1.5 The clearances in the rudder bearings are to be ascertained. The rudder is to be lifted for examination of the pintles, if considered necessary by the Surveyor. The securing of the rudder couplings and/or pintle fastenings is to be confirmed.

4.1.6 When chain cables are ranged, the anchors and cables are to be examined by the Surveyor.

4.1.7 The sea connections and overboard discharge valves, their attachments to the hull and the gratings at the sea inlets are to be examined.

4.1.8 The propeller and fastenings are to be examined for erosion, fitting, cracking of blades or possible contact damage. The clearances in the stern bush is to be measured. In the case of oil glands, this requirement may be waived if an approved oil gland is fitted so that the oil gland is not disturbed, provided the sealing arrangement appears satisfactory. If poker gauges or other devices are provided for ascertaining the wear in an oil lubricated stern bush, the clearance in the bush is to be measured.

4.1.9 The inboard shaft seals or glands are to be examined. Where flexible stern glands are fitted, the satisfactory condition of the rubber hose and securing clips is to be confirmed.

4.1.10 For variable pitch propellers, tightness of hub and blade sealing is to be verified and locking arrangements for bolts to be checked. Dismantling may be required to the extent found necessary by the Surveyor.

4.1.11 Special attention is to be given to the hull in way of underwater fittings such as transverse thrusters, stabilizers etc.

4.1.12 For water jets, steering gear external to the transom is to be surveyed and function tested. Impeller, hull ducting, grating, nozzle steering and reversing arrangements are to be examined as far as possible.

4.1.13 When transom mounted propulsion units are fitted, the steering arrangements and any flexible transom seal are to be examined.

4.1.14 When applicable, attention is to be given to the connecting and/or intersection of the cross deck structure to the hulls of multi hull craft.

4.1.15 For hydrofoil or foil assisted crafts, the attachment of the foils is to be examined.

4.1.16 Corrosion protection systems or coatings are to be surveyed. Any deterioration is to be repaired or renewed.

4.1.17 Earth fault detection equipment for craft built in aluminium is to be checked for proper functioning.

4.2 In-water surveys

4.2.1 IRS may accept an in-water survey in lieu of the annual or intermediate docking between special surveys required in a five-year period, provided the interval between two examinations in drydock or on slipway does not exceed five years.

4.2.2 The in-water survey is to provide the information normally obtained from a docking survey, so far as practicable. Proposals for in-water survey are to be submitted in advance so that satisfactory arrangements can be agreed with IRS.

4.2.3 The in-water survey is to be carried out at agreed location under the surveillance of a surveyor, with the craft in sheltered waters, the in-water visibility is to be good and the hull below waterline is to be sufficiently clean to permit meaningful examination. The surveyor is to be satisfied that the method of pictorial presentation is satisfactory. IRS is to be satisfied with the method of localization of the divers on the plating, which is to make use of, where necessary, permanent markings on the plating at selected points. A good two way communication between surveyor and diver is to be provided.

4.2.4 Diving and in-water survey operations are to be carried out by firms recognized by IRS, using qualified and trained divers.

4.2.5 If the in-water survey reveals damage or deterioration that requires early attention, the surveyor may require the craft to be drydocked in order that a detailed survey can be undertaken and necessary repairs carried out.

Section 5

Special Surveys – Hull

5.1 General

5.1.1 All crafts classed with IRS are to undergo Special Surveys at 5 yearly intervals. The first special survey is to be completed within 5 years from the date of the initial classification survey and thereafter 5 years from the assigned date of the previous special survey. However, an extension of class of 3 months maximum beyond the 5th year may be granted in exceptional circumstances. In such cases, the next period of class will start from the expiry date of the special survey before extension was granted.

5.1.2 The interval between the special surveys may be reduced at the request of the parties concerned or by IRS if considered appropriate.

5.1.3 For surveys completed within 3 months before the expiry date of the special survey, the next period of class will start from the expiry date of the special survey. For surveys completed more than 3 months before the expiry date of the special survey, the period of class will start from the survey completion date.

5.1.4 The special survey may be commenced at the 4th annual survey and be progressed with a view to completion by the 5th anniversary date. Special surveys which are commenced prior to the due date are not to extend over a period greater than twelve months, except with prior approval of IRS.

5.1.5 As part of the preparation for special survey, the thickness measurement and survey programme is to be dealt with, in advance of the special survey. The thickness measurement is not to be held before the 4th annual survey.

5.1.6 Record of special survey will not be assigned until the machinery survey has been completed or postponed in agreement with IRS.

5.1.7 Crafts which have satisfactorily passed a special survey will have a record entered in the supplement to the Register Book indicating the assigned date of special survey.

5.1.8 IRS may, at the request of the owners, accept a special survey of the hull on a continuous basis spread over a period of 5 years. Proposals for such continuous surveys are to be submitted for the consideration of IRS. In general, approximately one fifth of the special survey is to be completed every year. All compartments of the hull are to be opened for survey and testing in rotation such that not more than 5 years elapse between consecutive examination of each part.

Crafts which have completed satisfactorily the survey of all the items on the above basis will have a record entered in the supplement to the Register of Ships indicating the date of completion of the survey.

5.1.9 The requirements of Sec.2 and 3, as applicable, are to be complied with for all ships.

5.1.10 A docking survey in accordance with the requirements of Sec.4 is to be carried out as part of the special survey.

5.2 Preparation for survey

5.2.1 The ship is to be prepared for overall survey in accordance with the requirements of Table 5.2.1. The preparation is to be of sufficient extent to facilitate an examination to ascertain any excessive corrosion, deformation, fractures, damages and other structural deterioration.

5.3 Examination and testing, general requirement for all crafts

5.3.1 All spaces within the hull and superstructure are to be examined.

5.3.2 Double bottom compartments and all integral tanks are to be tested by a head, which gives the maximum pressure expected in service.

Tanks, forming part of the underwater shell plating, may be tested afloat provided their internal examination is also carried out afloat.

5.3.3 All watertight bulkheads are to be examined.

5.3.4 All decks, casings and superstructures are to be examined. Attention is to be given to the corners of openings and other discontinuities in the hull structure.

5.3.5 The masts, standing rigging and anchors are to be examined.

5.3.6 The steering gear, and its connections and control systems (main and alternative) are to be examined. The various parts of the auxiliary steering gear are to be assembled and examined.

5.3.7 The hand pumps and suctions, watertight doors, air and sounding pipes are to be examined.

5.3.8 The Surveyor is to satisfy himself regarding the efficient condition of the following:

- Means of escape from machinery spaces, crew and passenger spaces and spaces where crew are normally employed;
- Means of communication between bridge and engine room and between bridge and alternative steering position;
- Helm indicator.

5.3.9 The chain cables are to be ranged and anchors and the chain cables are to be examined.

5.3.10 Any length of chain cable which is found to have reduced in mean diameter at its most worn part by more than 12 per cent of its original rule diameter is to be renewed. The windlass is to be examined

5.4 Examination and testing – Additional items for steel craft

5.4.1 All tanks are to be examined internally in accordance with the requirements of Table 5.4.1.

5.4.2 For spaces used for salt water ballast, excluding double bottom tanks, where a protective coating is found in POOR condition (See Table 5.5.6 for definition) and it is not renewed or where a protective coating was not applied from the time of construction, maintenance of class will be subject to the space in question being internally examined and gauged as necessary at annual surveys.

When extensive corrosion is found, thickness gauging is to be carried out.

Table 5.2.1 : Survey preparation		
Special Survey I (Craft 5 years old)	**Special Survey II (Craft 10 years old)**	**Special Survey III (Craft 15 years old) and subsequent special surveys**
i) The interior of the craft is to be sufficiently opened out by the removal of lining, ceiling/cabin sole, portable tanks and ballast, etc. as required in order that the Surveyor may be satisfied as to the condition of suspect areas of the structure. A record is to be made of those areas where lining, ceiling/cabin sole etc., were opened out and where equipment was removed during the survey. This record is to be retained for reference during subsequent surveys. ii) Machinery compartments, fore and aft peaks and other spaces as directed by the Surveyor, are to be cleared and cleaned as necessary, and the bilges and limbers all fore and aft are to be cleaned and prepared for examination. Platform plates in engine spaces are to be lifted as may be necessary for the examination of the structure below. Where necessary, pipework may be required to be removed for examination of the structure. iii) In way of the single and/or double bottom areas, a sufficient amount of ceiling/cabin sole is to be lifted to permit examination of the bilges and/or tanktops below. iv) All integral tanks are to be cleaned as necessary to permit examination (for steel craft see Table 3.5.2).	In addition to the requirements for Special Survey I, the following are to be complied with: i) The chain locker is to be cleared and cleaned internally for examination of the structure and examination of the cable securing arrangements. The rudder is to be unshipped for examination of the rudder stock and trunk at the discretion of the Surveyor.	In addition to the requirements for Special Survey II the following are to be complied with: i) Linings, ceiling/cabin soles, etc. are to be removed as required in order that the Surveyor may be satisfied as to the condition of the structure. For steel craft: ii) Portions of wood sheathing, or other covering, on steel decks are to be removed, as considered necessary by the Surveyor, in order to ascertain the condition of the plating. iii) Where spaces are insulated, sufficient insulation is to be removed in each space to enable the Surveyors to be satisfied with the condition of the structure. iv) Linings are to be removed in way of shell plating immediately above tank top connections to the side shell, in way of galleys/washrooms and beneath portlights and windows.

Table 5.4.1 : Tank internal examination requirements for steel craft

Tank	Special Survey I (Craft 5 years old)	Special Survey II (Craft 10 years old)	Special Survey III (Craft 15 years old)	Special Survey IV (Craft 20 years old)	All subsequent Special Surveys
Peaks	All tanks	All tanks	All tanks	All tanks	All tanks
Salt water ballast	All tanks	All tanks	All tanks	All tanks	All tanks
Lubricating oil	None	None	See Note 2	See Note 3	All tanks
Fresh water	None	See Note 1	See Note 2	See Note 3	All tanks
Oil fuel	None	See Note 1	See Note 2	See Note 3	All tanks
Sanitary	All tanks	All tanks	All tanks	All tanks	All tanks

NOTES:
1. Tanks (excluding peak tanks) used exclusively for oil fuel or fresh water need not all be examined internally provided that the Surveyor is satisfied with the condition, after both external examination and testing and from an internal examination of the after end of one forward double bottom tank and of one selected deep tank.
2. Tanks (excluding peak tanks) used exclusively for oil fuel, oil fuel and fresh water ballast, or lubricating oil, need not all be examined internally provided that the Surveyor is satisfied with the condition, after both external examination and testing and from an internal examination of one double bottom tank forward and one aft and one deep tank.
3. Tanks (excluding peak tanks) used exclusively for oil fuel, oil fuel and fresh water ballast, or lubricating oil, need not all be examined internally provided that the Surveyor is satisfied with the condition, after both external examination and testing and from internal examination of a least one double bottom tank amidships, one forward and one aft and one deep tank.
4. When examining tanks internally the Surveyor is to verify that striking plates or other additional reinforcement is fitted under sounding pipes. In the case of tanks fitted only with remote gauging facilities, the satisfactory operation of the gauges is to be confirmed.

5.4.3 For salt water double bottom tanks where a protective coating is found in POOR condition and it has not been repaired or where a protective coating was not applied from the time of construction, the maintenance of class may, at the discretion of IRS, be subject to the spaces in question being examined and gauged as necessary at annual surveys.

When extensive corrosion is found, thickness gauging is to be carried out.

5.4.4 Wooden decks or sheathings are to be examined and if decay or rot is found or the wood is excessively worn, the wood is to be renewed.

Attention is to be given to the condition of the plating under wood decks, sheathing or other deck coverings. Removal of such coverings may be dispensed with if they are found to be sound and adhering satisfactorily to the plating.

5.4.5 The structure in way of bimetallic connections e.g. to aluminium alloy deckhouses is to be examined.

5.4.6 The Surveyors may require to measure the thickness of the material in any portion of the structure where signs of wastage are evident or wastage is normally found. Any parts of the structure which are found defective or excessively reduced in scantlings are to be made good by materials of the approved scantlings and quality. The minimum requirements for thickness measurements are given in 5.5.

5.5 Thickness measurement for steel craft

5.5.1 The surveyor may require to determine thickness of the material by drilling or other approved means where wastage is evident. Particular attention is to be paid to structure in way of discontinuities. Where thickness measurements are taken by approved means other than drilling, the accuracy of such measurements are to be verified by drilling in a few locations.

5.5.2 Thickness measurements are to be taken at the forward and aft areas of all plates. In all cases the measurements are to represent the average of the multiple measurements taken on each plate. The number of measurement is to be increased where necessary to determine the extent of local substantial corrosion. Where measured plates are renewed, the thickness of adjacent plates in the same strake are to be reported.

5.5.3 The thickness measurements are normally to be by means of ultrasonic test equipment and are to be carried out by an approved firm.

5.5.4 Thickness measurements may be carried out within the 12 months prior to the due date of the special survey.

5.5.5 For areas in tanks where coating are found to be in a GOOD condition, the extent of thickness measurements may be specially considered by the Surveyor.

5.5.6 The minimum requirements for thickness measurements are indicated in Table 5.5.6.

5.5.7 Thickness measurements are normally to be carried out under the supervision of the Surveyor. However, the Surveyor may accept thickness measurements not carried out under his supervision subject to re-checking the measurements as deemed necessary to ensure acceptable accuracy.

5.5.8 A thickness measurement report is to be prepared. The report is to give the location of measurements, the thickness measured as well as corresponding original thickness. Furthermore, the report is to give the date when the measurements were carried out type of measurement equipment, names of personnel and their qualifications and has to be signed by the operator. The report is to be verified and countersigned by the Surveyor.

5.6 Examination and testing – Additional items for aluminium alloy craft

5.6.1 The structure in way of any bimetallic connections is to be examined and the efficiency of the insulation arrangements confirmed.

5.6.2 The Surveyor may require to measure the thickness of the material in any portion of the structure where signs of deterioration are evident or may normally be found. Any parts of the structure which are found defective or excessively reduced in scantlings are to be made good by materials of the approved scantlings and quality.

5.7 Examination and testing – Additional items for composite craft

5.7.1 The bonded attachments of frames, floors, bulkheads, structural joinery, engine bearers, stern-tubes, rudder tubes and integral tank boundaries are to be examined.

5.7.2 The hull to deck joint together with any joints between the deck and deckhouses or superstructures are to be examined.

5.7.3 The structure in way of the bolted attachment of fittings including guardrail stanchions, windlass, shaft brackets, fendering, mooring bitts, etc. is to be examined.

Table 5.5.6 : Thickness measurement of steel craft

Special Survey I (Craft 5 years old)	**Special Survey II (Craft 10 years old)**	**Special Survey III (Craft 15 years old)**	**Special Survey IV and subsequent (Craft 20 years old and over)**
Suspect areas, as required by the Surveyor and may include areas where the coatings are found to be other than in GOOD condition (see note 1)	Suspect areas, as required by the Surveyor and may include areas where the coatings are found to be other than in GOOD condition (see note 1)	1) Any exposed plating throughout the main deck 2) Shell plating in way of the waterline throughout the length of the craft 3) Suspect areas, as required by the Surveyor and may include areas where the coatings are found to be other than in GOOD condition (see note 1)	1) All main deck plating outside deckhouses or superstructures and including plating in way of wood deck planking or sheathing 2) Shell plating in way of and below, the waterline throughout the length of the craft 3) 2 transverse sections of deck and shell plating within 0.5L amidships 4) Suspect areas, as required by the Surveyor and to include as applicable: a) Areas where the coatings are found to be other than in GOOD condition. b) Shell and tanktop plating immediately adjacent to tank top margins. c) Bottom shell in way of any cement, asphalt or other composition. d) Shell plating below portlights and windows. e) Tanktop plating below ceiling or cabin soles. f) Deck plating and side shell plating in way of galleys, washrooms and refrigerated store spaces. g) Structure in way of integral sanitary tanks.

NOTES:

1. Suspect areas are locations within the hull structure vulnerable to increased likelihood of structural deterioration and may include, for steel hulls, areas of substantial corrosion and/or fatigue cracking.
2. Coating condition for steel craft is defined as follows:
   Good : Condition with only minor spot rusting;
   Fair : Condition with local breakdown at edges and weld connections and/or light rusting over 20 percent or more of areas under consideration, but less than as defined for POOR condition;
   Poor : Condition with general breakdown of coating over 20 percent or more of areas or hard scale at 10 percent or more of areas under consideration.

Section 6

Special Surveys – Machinery

6.1 General

6.1.1 The machinery special survey becomes due five years from the date of build or from the last assigned machinery special survey (SSM) date.

6.1.2 When due to special circumstances a special survey is commenced prior to its due date, the survey is to be completed within a period not exceeding 9 months and not later than the expiry date of the classification certificate including any postponement that may be granted by IRS.

6.1.3 If a craft at the time classification certificate expires is not in a port in which it is to be surveyed, IRS may upon owners request extend the validity of the classification certificate for a period not exceeding 3 months. Such requests will only be considered to enable the vessel to complete its voyage to the port of survey and only in cases where it is considered proper and reasonable to do so.

6.1.4 Upon satisfactory completion of the machinery special survey an appropriate record will be entered in the supplement of Register of Ships.

6.2 Continuous survey of machinery (CSM)

6.2.1 At the request of the Owners and upon approval of the proposed arrangement a system of continuous survey of machinery (CSM) may be undertaken whereby the requirements of special survey of machinery are completed within a five year period. The survey cycle is to be such as would ensure that the interval between consecutive examination of each item does not exceed five years and it is expected that approximately an equal proportion of the machinery would be subjected for survey each year.

6.2.2 Further parts of machinery may require to be opened if any defects are found during the course of Survey of any item and the defects made good to the satisfaction of the Surveyor.

6.2.3 Upon satisfactory completion of the continuous machinery survey cycle, a record indicating the date of completion of the cycle will be shown in the supplement to the Register of Ships.

6.3 Survey requirements: Auxiliary engines

6.3.1 All auxiliary engines driving the generators and other essential machinery together with their coolers and attached pumps are to be opened up and examined as considered necessary by the Surveyor. Alarms and safety devices fitted on these units are to be included in this survey.

6.4 Survey requirements: Air compressors, receivers and starting air pipes

6.4.1 All air receivers and other pressure vessels for essential services together with their mountings and safety devices are to be cleaned internally and examined internally and externally. If an internal examination of an air receiver is not practicable it is to be tested hydraulically to 1.3 times the working pressure.

6.4.2 Air compressors are to be opened up and coolers tested as considered necessary by the Surveyor. Selected pipes in the starting air systems are to be removed for internal examination and hammer tested. If an appreciable amount of lubricating oil is found in the pipes the starting air system is to be thoroughly cleaned by steaming or other suitable means. Some of the pipes selected are to be those adjacent to the starting air valves at the cylinders and to the discharges from the air compressors.

6.5 Survey requirements: Propulsion system

6.5.1 Athwartships thrust propellers are to be generally examined so far as is possible in dry dock and tested under working conditions afloat for satisfactory operation.

6.5.2 All shafts (except screwshafts and tube shafts, for which special arrangements are detailed in Section 7), thrust block and all bearings are to be examined. The lower halves of bearings need not be exposed if alignment and wear are found to be acceptable.

6.5.3 An examination is to be made as far as practicable of all propulsion gears complete with all wheels, pinions, shafts, bearings and gear teeth, thrust bearings and incorporated clutch arrangements.

6.6 Survey requirements: Independent fuel tanks

6.6.1 Fuel tanks which do not form part of the ship's structure are to be examined internally and externally and, if considered necessary by the Surveyor, they are to be tested. These need not be examined at the first engine survey if they are found satisfactory on external examination. All mountings, fittings and remote control devices are to be examined as far as practicable.

6.7 Survey requirements: Pumps, heat exchangers, forced draught fans, etc.

6.7.1 All pumps, heat exchangers, forced draught fans, etc. used for essential purposes are to be opened up and examined as considered necessary by the Surveyor.

6.8 Survey requirements: Pumping and piping system

6.8.1 The valves, cocks and strainers of the bilge system including bilge injection are to be opened up as considered necessary by the Surveyor and together with pipes, are to be examined and tested under working conditions. If non-return valves are fitted in hold bilges, these are to be opened up for examination.

6.8.2 The oil fuel, feed and lubricating systems and ballast connections together with all pressure filters, heaters and coolers used for essential service, are to be opened up and examined or tested as considered necessary by the Surveyor. All safety devices for the foregoing are to be examined.

6.8.3 Non-metallic expansion joints in piping systems, if located in system which penetrates the ship's side and both the penetration and the non-metallic expansion joint are located below the deepest load waterline, are to be examined and replaced as necessary or at an interval recommended by the manufacturer.

6.9 Survey requirements: Reduction gears, flexible couplings and clutch arrangements

6.9.1 Reduction gears, flexible couplings and clutch arrangements are to be opened as considered by the Surveyor in order to permit the examination of the gears, gear teeth, spiders, pinions, shafts and bearings, reversing gears, etc. Essential parts of other power transmission arrangements are to be opened up and examined as considered necessary by the Surveyor.

6.10 Survey requirements: Securing arrangements

6.10.1 Holding down bolts and chocks of main and auxiliary engines, gear cases, thrust blocks and tunnel bearings are to be checked.

6.11 Survey requirements: Shafting

6.11.1 Intermediate shafts and bearings, thrust bearings and their seating are to be examined. The lower halves of bearings need not be exposed if alignment and wear are found acceptable.

6.12 Survey requirements: Sea connections

6.12.1 All openings to the sea including sanitary and other overboard discharges in the machinery spaces and pump rooms together with valves and cocks are to be examined internally and externally. The fastenings of valves and cocks to the hull are to be examined and are to be renewed when considered necessary by the Surveyor.

6.13 Survey requirements: Windlass and steering machinery

6.13.1 These are to be examined to ascertain that they are in good working order. Any relief valves fitted are to be included in the above examination.

6.14 Survey requirements: Internal combustion engines for propulsion

6.14.1 All working parts of the engines and their attached pumps are to be opened and examined. These are to include all cylinders, cylinder heads, valves and valve gear, pistons, piston rods, cross-heads, guides, connecting rods, crankshafts, vibration dampers and all bearings, camshafts and driving gear, fuel pumps and fittings, scavenge pumps, scavenge blowers and their prime movers, superchargers, air compressors, inter coolers, clutches, reverse gears, crankcase door fastenings and explosion relief devices and such other parts of the machinery as may be considered necessary. Integral piping systems are to be examined. The maneuvering of engines is to be tested under working condition.

6.15 Survey requirements: Gas turbines and free piston gas generators for propulsion

6.15.1 The survey is to include opening and examination of the following parts:

- The blading, rotors and casings of the turbines, the impellers or blading, rotors and casing of air compressors, the combustion chambers, burners, inter coolers, heat exchangers, gas and air pressure piping and fittings and reversing arrangements. When gas turbines operate in conjunction with free piston gas generators, the following parts of the free piston gas generators are to be opened and examined: the gas and air compressor cylinders and pistons and the compressor end covers, the valves and valve gear, fuel pumps and fittings, synchronizing and control gear, cooling system explosion relief devices, gas and air piping, receivers and valves including by-pass. The maneuvering of engines is to be tested under working conditions.

6.16 Survey requirements: Unattended machinery spaces/Remote control systems

6.16.1 Where remote and/or automatic controls such as bridge controls, bilge controls and bilge level alarms, local hand controls, fire detection and prevention, alarms warning systems and shut-offs, electric supply, main controls station, are fitted for essential machinery, they are to be examined and tested to demonstrate that they are in good working order.

6.16.2 During such trials the proper operation of the safety devices will be checked, in particular, such as emergency stops, emergency astern movement, standby control of the propelling gear, fire alarm.

6.16.3 The log recording the operating conditions is to be checked. If such scrutiny reveals that certain portion of the automated equipment has behaved abnormally the cause of such failure is to be investigated and appropriate remedies determined.

6.17 Electrical equipment survey requirements

6.17.1 An electrical insulation resistance test is to be made on the electrical equipment and cables. The installation may be sub-divided or equipment, which may be damaged, disconnected for the purpose of this test.

6.17.2 The fittings on the main and emergency switchboards, section boards and distribution boards are to be examined and over-current protective devices and fuses inspected to verify that they provide suitable protection for their respective circuits.

6.17.3 Generator circuit-breakers are to be tested, so far as is practicable, to verify that protective devices including preference tripping relays, if fitted, operate satisfactorily.

6.17.4 The electric cables and their securing arrangements are to be examined, so far as is practicable, without undue disturbance of fixtures or casings unless opening up is considered necessary as a result of observation or of the tests required by 6.17.1.

6.17.5 The generator prime movers are to be surveyed and the governing of the engines tested. The motors concerned with essential services together with associated control and switch gear are to be examined and if considered necessary, are to be operated, so far as is practicable, under working conditions. All generators and steering gear motors are to be examined and are to be operated under working conditions, though not necessarily under full load or simultaneously.

6.17.6 Where transformers or electrical apparatus associated with supplies to essential services are liquid filled or cooled by a liquid in direct contact with current carrying parts, the owner is to arrange for samples of the liquid to be taken and tested, by a competent authority, in accordance with the equipment manufacturer’s requirements, and a certificate giving the test results is to be furnished to the Surveyor.

6.17.7 Navigation light indicators are to be tried under working conditions, and correct operation on the failure of supply or failure of navigation lights verified.

6.17.8 The emergency sources of electrical power, where fitted, together with their automatic arrangements and associated circuits are to be tested.

6.17.9 Emergency lighting, transitional emergency lighting, supplementary emergency lighting, general emergency alarm and pump address systems are to be tested as far as practicable.

6.17.10 Where the craft is electrically propelled, the propulsion motors, generators, cables and all ancillary electrical gear, exciters and ventilating plant (including coolers) associated therewith are to be examined, and the insulation resistance to earth is to be tested. Special attention is to be given to windings, commutators and slip-rings. The operation of protective gear and alarm devices is to be checked, so far as is practicable. Liquids for filling and cooling, if used, are to be tested in accordance with 6.17.6. Interlocks intended to prevent unsafe operations or unauthorized access are to be checked to verify that they are functioning correctly. Emergency over-speed governors are to be tested.

6.17.11 Where batteries provide the source of power for any essential services, their installation, including charging and ventilation arrangements, is to be examined.

Section 7

Surveys of Propeller Shafts, Tube Shafts and Propellers

7.1 General

7.1.1 At shaft surveys, propeller shafts and tube shafts if any, are to be withdrawn for examination, at intervals as detailed in Section 1of this chapter.

7.1.2 Unless alternative means are provided to ensure the condition of the propeller shaft assembly, these requirements apply to all vessels with conventional shafting fitted with a propeller as follows:

.1 from 1 Jan 2016 for ships delivered on or after 1 Jan 2016;

.2 after the first shaft survey scheduled on or after 1 Jan 2016, for ships delivered before 1 Jan 2016. Upon completion of the first shaft survey scheduled on or after 1 Jan 2016, the designation of dates for the next shaft survey is to be made based on the requirements in this section.

7.1.3 For the purpose of these requirements, the following definitions are applicable:

.1 *Shaft* is a general definition that could mean :

Propeller shaft
Tube shaft

The definition does not include the intermediate shaft(s) which is (are) considered part of the propulsion shafting inside the vessel.

.2 *Propeller Shaft*. Propeller shaft is the part of the propulsion shaft to which the propeller is fitted. It may also be called screwshaft or tailshaft. Where a separate tube shaft is not fitted, the propeller shaft runs through the stern tube and is connected to the intermediate shaft within the ship. In this case, only the propeller shaft and intermediate shaft are fitted and there is no tube shaft.

.3 *Tube Shaft*. Tube shaft is a shaft placed between the intermediate shaft and propeller shaft, normally arranged within a stern tube or running in open water. It may also be called Stern Tube Shaft.

.4 *Stern Tube*. Tube or pipe fitted in the shell of a ship at the stern (or rear part of the ship), below the water-line, through which passes the tube shaft or the propeller-shaft. Stern tube is the housing of the shaft bearings, generally two (one aft and one fore), that sustain the shaft and allows its rotation with less frictional resistance. The stern tube also accommodates the shaft sealing arrangement.

.5 *Close Loop (system) Oil Lubricated Bearing*. Closed loop oil lubricating systems use oil to lubricate the bearings and are sealed against the environment (seawater) by adequate sealing / gland devices.

.6 *Water Lubricated Bearing*. Water lubricated bearings are bearings cooled / lubricated by water (fresh or salt).

.7 *Closed Loop System Fresh Water Lubricated Bearing*. Closed loop water lubricating systems use fresh water to lubricate the bearings and are sealed against the environment (such as seawater) by adequate sealing / gland devices.

.8 *Open Systems (water)*. Open water lubricating systems use water to lubricate the bearings and are exposed to the environment.

.9 *Adequate means for protection against corrosion*. An adequate means for protection against corrosion is an approved means for full protection of the core shaft against sea water intrusion and subsequent corrosion attack. Such means are used for the protection of common steel material against corrosion particularly in combination with water lubricated bearings. Typical means are for example:

- continuous metallic, corrosion resistant liners,
- continuous cladding,
- multiple layer synthetic coating,
- multiple layer of fiberglass,
- combinations of above mentioned,
- rubber / elastomer covering coating.

The means for protection against corrosion are installed/ applied according to IRS approved procedures.

.10 *Corrosion Resistant Shaft*. Corrosion resistant shaft is made in approved corrosion resistant steel as core material for the shaft.

.11 *Sterntube Sealing System*. Sterntube sealing system is the equipment installed on the inboard extremity and, for closed systems, at outboard extremity of the stern tube.

Inboard Seal is the device fitted on the fore part of the stern tube that achieve the sealing against the possible leakage of the lubricant media in to the ship internal.
Outboard seal is the device fitted on the aft part of the stern tube that achieve the sealing against the possible sea water ingress and the leakage of the lubricant media.

.12 *Service Records*. Service records are regularly recorded data showing in-service conditions of the shaft(s) and may include, as applicable: lubricating oil temperature, bearing temperature and oil consumption records (for oil lubricated bearings) or water flow, water temperature, salinity, pH, make-up water and water pressure (for closed loop fresh water lubricated bearings depending on design).

.13 *Oil sample examination*. An oil sample examination is a visual examination of the stern tube lubricating oil taken in presence of the surveyor with a focus on water contamination.

.14 *Lubricating oil analysis*. Lubricating oil analysis is to be carried out at regular intervals not exceeding six (6) months .The documentation on lubricating oil analysis is to be available on board.

Oil samples, to be submitted for the analysis, are to be taken under service conditions.

.15 *Fresh water sample test*. Fresh water sample test is to be carried out at regular intervals not exceeding six (6) months

Samples are to be taken under service conditions and are to be representative of the water circulating within the sterntube. Analysis results are to be retained on board and made available to the surveyor. At time of survey the sample for the test is to be taken in the presence of the surveyor.

Fresh water sample test is to include the following parameters:
- chlorides content,
- pH value,
- presence of bearing particles or other particles (only for laboratory analysis, not required for tests carried out in presence of the surveyor).

.16 *Keyless Connection*. Keyless connection is the forced coupling methodology between the shaft and the propeller without a key achieved through interference fit of the propeller boss on the shaft tapered end.

.17 *Keyed Connection*. Keyed connection is the forced coupling methodology between the shaft and the propeller with a key and keyway achieved through the interference fit of the propeller boss on the shaft tapered end.

.18 *Flanged Connection*. Flanged connection is the coupling methodology, between the shaft and the propeller, achieved by a flange, built in at the shaft aft end, bolted to propeller boss.

.19 *Alternative Means*. Alternative means are shafting arrangements with configuration other than those described in these requirements.

7.2 Scope of survey

7.2.1 Oil Lubricated Shafts or Closed Loop System Fresh Water Lubricated Shafts (Closed System)

7.2.1.1 Shaft Survey Methods

7.2.1.1.1 **METHOD 1**

.1 The survey is to consist of:

- Drawing the shaft and examining the entire shaft, seals system and bearings;

- For keyed and keyless connections:

  • Removing the propeller to expose the forward end of the taper,

  • Performing a non-destructive examination (NDE) by an approved surface crack-detection method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted).
  For shaft provided with liners the NDE is to extend to the after edge of the liner.

- For flanged connection:

  • Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the surveyor, the coupling bolts and flange radius are to be examined by means of an approved surface crack detection method.

- Checking and recording the bearing clearances;

- Verification that the propeller is free of damages which may cause the propeller to be out of balance;

- Verification of the satisfactory conditions of inboard and outboard seals during the re- installation of the shaft and propeller;

- Recording the bearing wear down measurements (after re-installation)

7.2.1.1.2 **METHOD 2**

.1 The following are to be verified and found satisfactory as a pre-requisite for application of Method 2:

- Review of service records;

- Review of test records of:

  • Lubricating Oil analysis (for oil lubricated shafts), or

  • Fresh water sample test (for closed system fresh water lubricated shafts);

- Oil sample examination (for oil lubricated shafts), or fresh water sample test (for closed system fresh water lubricated);

- Verification that there are no repairs by grinding or welding of shaft and/or propeller.

.2 The survey is to consist of:

- For keyed and keyless connections:

  • Removing the propeller to expose the forward end of the taper;
  • Performing a non-destructive examination (NDE) by an approved surface crack-detection Method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted).

- For flanged connection:

  • Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the surveyor, the coupling bolts and flange radius are to be examined by means of a an approved surface crack detection Method.

- Checking and recording the bearing wear down measurements;

- Visual Inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damages which may cause the propeller to be out of balance;

- Seal liner found to be or placed in a satisfactory condition;

- Verification of the satisfactory re-installation of the propeller including verification of satisfactory conditions of inboard and outboard seals.

7.2.1.1.3 **METHOD 3**

.1 The pre-requisites for application of Method 3, are the same as those given in 7.2.1.1.2.1

.2 The survey is to consist of

- Checking and recording the bearing wear down measurements;

- Visual Inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damage which may cause the propeller to be out of balance;

- Seal liner found to be or placed in a satisfactory condition;

- Verification of the satisfactory conditions of inboard and outboard seals.

7.2.1.2 Shaft Extension Surveys -Extension Types

7.2.1.2.1 *Extension up to 2.5 years*

.1 In addition to the pre-requisites listed in 7.2.1.1.2.1, the Chief Engineer is to confirm that the shafting arrangement is in good working condition, for extension up to 2.5 years to be applied.

.2 The survey is to consist of:

- Checking and recording the bearing wear down measurements, as far as practicable;

- Visual inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damages which may cause the propeller to be out of balance;

- Verification of the effectiveness of inboard seal and outboard seals.

7.2.1.2.2 *Extension up to 1 year*

.1 In addition to the pre-requisites listed in 7.2.1.1.2.1, the previous wear down and/ or clearance recordings are also to be reviewed, for extension up to 1 year to be applied.

.2 The survey is to consist of:

- Visual inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damage which may cause the propeller to be out of balance;

- Verification of the effectiveness of inboard seal and outboard seals.

7.2.1.2.3 *Extension up to 3 months*

.1 The pre-requisites listed in 7.2.1.1.2.1 above is to be verified and found satisfactory for extension up to 3 months to be applied.

.2 The survey is to consist of:

- Visual inspection of all accessible parts of the shafting system;

- Verification of the effectiveness of the inboard seal.

7.2.1.3 Methods for oil lubricated shafts and fresh water lubricated shafts (closed loop systems) and shaft survey intervals.

Details of the applicable methods for flanged propeller connection, keyless propeller connection and keyed propeller connection and survey intervals are listed in Table 7.2.1.3. The types of survey extensions applicable are also listed in Table 7.2.1.3.

7.2.2 Water Lubricated Shafts (Open Systems)

7.2.2.1 Shaft Survey Methods

7.2.2.1.1 **METHOD 4**

The survey is to consist of

- Drawing the shaft and examining the entire shaft (including liners, corrosion protection system and stress reducing features, where provided), inboard seal system and bearings.

- For keyed and keyless connections:

  • removing the propeller to expose the forward end of the taper,

  • performing a non-destructive examination (NDE) by an approved surface crack detection method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted). For shaft provided with liners the NDE is to be extended to the after edge of the liner

- For flanged connection:

    • Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the surveyor, the coupling bolts and flange radius are to be examined by means of an approved surface crack detection method.

- Checking and recording the bearing clearances.

- Verification that the propeller is free of damage which may cause the propeller to be out of balance.

- Verification of the satisfactory conditions of inboard seal during re-installation of the shaft and propeller.

7.2.2.2 Shaft Extension Surveys– Extension Types

7.2.2.2.1 *Extension up to 1 year*

.1 Pre-requisites to be verified and found satisfactory in order to apply extension up to 1 year are as follows:

- Review of the previous clearance recordings;

- Service records;

- Verification that there are no repairs by grinding or welding of shaft and/or propeller;

- Confirmation from the Chief Engineer that the shafting arrangement is in good working condition.

.2 The survey is to consist of:

- Visual Inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damages which may cause the propeller to be out of balance;

- Checking and recording the clearances of bearing;

- Verification of the effectiveness of the inboard seal.

7.2.2.2.2 *Extension up to 3 months*

.1 The pre-requisites listed in 7.2.2.2.1.1 is to be satisfactorily verified, for extension up to 3 months to be applied.

.2 The survey is to consist of:

- Visual Inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damage which may cause the propeller to be out of balance;

- Verification of the effectiveness of the inboard seal.

7.2.2.3 Methods for water lubricated shafts (open loop systems) and shaft survey intervals, along with applicable details are given in Table 7.2.2.3.

7.2.2.3.1 For single shaft operating exclusively in fresh water, single shaft provided with adequate means of corrosion protection, corrosion resistant shafts and multiple shaft arrangements; survey intervals up to 5 years may be allowed. Applicable details along with maximum permissible survey intervals are given in Table 7.2.2.3.

7.2.2.3.2 Shaft arrangements, other than the configurations listed in 7.2.2.3.1, are to be surveyed according to Method 4, every 3 years. Applicable details along with maximum permissible survey intervals are also given in Table 7.2.2.3.

Table 7.2.1.3 Survey Intervals (Closed Systems)

Oil Lubricated [Survey Notation SH (OL)]			
	Flanged Propeller Coupling	Keyless Propeller Coupling	Keyed Propeller Coupling[c]
Every five years[a]	Method 1 or Method 2 or Method 3	Method 1 or Method 2 or Method 3[d]	Method 1 or Method 2
Extension 2.5 Y[b]	Yes[e]	Yes[e]	Yes[e]
Extension 1 Y[b]	Yes[f]	Yes[f]	Yes[f]
Extension 3 M[d]	Yes[g]	Yes[g]	Yes[g]
Fresh Water Lubricated [Survey Notation SH (FW-C)]			
	Flanged Propeller Coupling	Keyless Propeller Coupling	Keyed Propeller Coupling[c]
Every five years[a]	Method 1[h] or Method 2 or Method 3	Method 1[h] or Method 2 or Method 3	Method 1[h] or Method 2
Extension 2.5 Y[b]	Yes[e]	Yes[e]	Yes[e]
Extension 1 Y[b]	Yes[f]	Yes[f]	Yes[f]
Extension 3 M[d]	Yes[g]	Yes[g]	Yes[g]

General Notes :

For surveys (Method 1, or Method 2, or Method 3) completed within 3 months before the shaft survey due date, the next period is to start from the shaft survey due date.

The extension survey is normally to be carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date. If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension counts from the date on which the extension survey was completed.

Methods 1, 2 & 3 are described in 7.2.1.1.1, 7.2.1.1.2 and 7.2.1.1.3 respectively. The pre-requisites for each Method are to be satisfactorily verified, prior surveys.

Survey methods 1, 2 and 3 would normally require drydocking of the vessel. Extension surveys may be carried out without dry-docking by in water surveys"

Notes :

a) Unless an Extension type (Extension 2.5 Y, Extension 1 Y, Extension 3 M) is applied in between.

b) Only one Extension type can be applied in between of two Methods (Extension 2.5 Y, or Extension 1 Y) except for what concerns the Extension 3 M (see further note g).

c) Method 3 is not allowed.

d) Maximum of two consecutive Method 3 surveys. The maximum interval between two surveys carried out according to Method 1 or Method 2 is not to exceed 15 years, except in the case when one extension for no more than three months is granted.

e) No more than one extension can be granted. No further extension of other type can be granted.

f) No more than two consecutive "one year extensions" can be granted. No further extension of other type can be granted.

g) No more than one "three months extension" can be granted. In the event an additional extension is requested, the requirements of "one year extension" are to be carried out and the shaft survey due date prior to the previous extension is to be extended for a maximum of one year.

h) The maximum interval between two surveys carried out according to Method 1 is not to be more than 15 years. An extension for no more than three months can be granted.

<table>
<tr><th colspan="4">Table 7.2.2.3 Survey Intervals (Open Systems)</th></tr>
<tr><td colspan="2">Single shaft operating exclusively in fresh water
[Survey Notation SH (S-FW-O)]
Single shaft provided with adequate means of corrosion protection, single corrosion resistant shaft
[Survey Notation SH (S-CP-O)]
All kinds of multiple shaft configurations
[Survey Notation SH (M-O)]</td><td colspan="2">Other Shaft Configurations
[Survey Notation SH (S-O)]</td></tr>
<tr><td colspan="4">All kinds of propeller couplings[d]</td></tr>
<tr><td>Every five years[a]</td><td>Method 4</td><td>Every three years[a]</td><td>Method 4</td></tr>
<tr><td>Extension 1 Y</td><td>Yes[b]</td><td>Extension 1 Y</td><td>Yes[b]</td></tr>
<tr><td>Extension 3 M</td><td>Yes[c]</td><td>Extension 3 M</td><td>Yes[c]</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">General Notes :

For surveys (Method 4) completed within 3 months before the shaft survey due date, the next period will start from the shaft survey due date.

The extension survey is to be normally carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date. If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension is to count from the date on which the extension survey was completed.

Method 4 is described in 7.2.2.1.1. The pre-requisites for the Method are to be satisfactorily verified, prior survey.

Survey method 4 would normally require dry docking of the vessel. Extension surveys may be carried out without dry-docking by in water surveys.

In case of multiple shaft configurations, if there is a failure to one shaft system, vessel is to be dry-docked for carrying out surveys of all shaft systems, and repairs as necessary”</td></tr>
<tr><td colspan="4">Notes :

a) Unless an Extension type (Extension 1 Y, Extension 3 M) is applied in between.

b) No more than one extension can be granted. No further extension, of other type, can be granted.

c) No more than one extension can be granted. In the event an additional extension is requested the requirements of the one year extension are to be carried out and the shaft survey due date prior to the previous extension is to be extended for a maximum of one year.

d) For keyless propeller connections the maximum interval between two consecutive dismantling and verifications of the shaft cone by means of non-destructive examination (NDE) is not to exceed 15 years</td></tr>
</table>

7.2.3 Steerable and azimuth thrusters

The survey is to normally comprise of examination of the following:

a) Exposed parts including attachment to the hull.

b) The following items upon removal of propeller:

- propeller shaft threaded end and nut;
- cone, key and keyway including examination by an efficient crack detection method of fore part of the shaft cone;
- sealing glands.

c) Lubricating oil analysis (to include wear particle analysis) records to detect possible wear of internal gears and bearings.

d) Internal gears and control gears as far as practicable through hand holes or limited opening of controlling device.

If the above checks are not satisfactory, complete dismantling of the internal parts may be required.

7.2.4 Vertical axis propellers

The survey is to normally comprise of examination of the following:

a) Exposed parts.
b) Tightness of the oil glands and the backlash of the gears from outside by action on the blades.
c) Gears, as far as practicable through hand holes and observation ports.
d) Control gear for proper functioning.
e) Lubricating oil analysis (to include wear particle analysis) records to detect possible wear of internal gears and bearings.

If the above checks are not satisfactory, complete dismantling of the internal parts may be required.

7.2.5 Water jet system

The survey is to normally comprise of examination of the following:

a) Impeller, shaft and bearing clearances.
b) Sealing glands.
c) Nozzle assembly.
d) Control and reversing gear.
e) Suction grids.

If the above checks are not satisfactory further dismantling may be required.

7.2.6 Controllable pitch propellers

Where controllable pitch propellers are fitted, in addition to the survey requirements of the shafts, the working parts and control gear are to be opened up sufficiently to enable Surveyors to examine them at each shaft survey. The survey is to include the following:

a) Analysis of hydraulic oil including wear particle analysis.

b) Propeller blades and hub including crack detection of blade root, flange and blade securing arrangements.

c) Examination of seals, carrier bearings, crank pin ring, fillets, blade openings in the boss and blade bolts, upon removal of at lest one blade.

d) Examination of distribution box seal and bearings.

e) Verification upon re-assembly of, servomechanism and hydraulic test of hub and hydraulic piping including pitch controls together with limit stops.

Section 8

Planned Maintenance System

8.1 General

8.1.1 An approved Planned Maintenance System on board a ship may be accepted in lieu of the regular surveys by IRS Surveyors on CSM basis provided the requirements of this section are complied with.

Any item not covered by PMS is to be surveyed and credited in the usual way. In general the intervals for PMS is not to exceed those specified for CSM survey. PMS is to be programmed and maintained by a computerised system.

8.1.2 A vessel complying with the requirements of section will be assigned the PMS survey notation.

8.1.3 The survey system (PMS) is to be approved by IRS before being implemented. When the system is implemented machinery inspection may be based on calendar or running hours calling for items to be opened for inspection and overhaul at specified periods, or the machinery may be monitored for condition and performance whereby items need only be opened for examination when readings indicate a deterioration. Schemes could be made up of a combination of two or more methods of maintenance control, such as:

- A switchboard is surveyed based on regular 5 yearly intervals.

- A diesel engine is surveyed based on running hours.

- A lubricating oil pump is surveyed based on calendar interval.

- A turbine may be surveyed based on condition monitoring.

8.1.4 When any machinery and components are approved under PMS for condition monitoring and when their condition and performance is within acceptable limits, no overhaul is necessary, unless otherwise specified by the manufacturer.

8.1.5 Other items of machinery and components, which are not subjected to an approved condition monitoring system and part of PMS are required to be surveyed at intervals not greater than those specified for CSM.

8.1.6 Chief Engineer of the vessel will be responsible and in-charge of PMS and is to be approved by IRS as per Sec.1, 1.6 of this Chapter.

8.1.7 The survey of machinery and components (defined at 8.2) & covered by the PMS may be carried out by the Chief Engineer. Survey of machinery and components defined in 8.3 is not eligible to be surveyed by the Chief Engineer.

8.1.8 At the time of the Annual Classification Survey an audit of the planned maintenance system will be carried out to ensure that the system is being correctly operated in accordance with the conditions of approval.

8.1.9 When the annual audit is held, a confirmatory survey will be carried out for those items to be credited which have been examined by the Chief Engineer under the planned maintenance system during the preceding year.

8.2 Machinery acceptable for survey by Chief Engineers under Planned Maintenance System

8.2.1 The following machinery may be surveyed by the Chief Engineer under PMS:

- Main engine cylinder covers.
- Main engine valves and valve gears.
- Main engine cylinder liners.
- Main engine pistons and piston rods.
- Main engine connecting rods, crossheads, top end bearings, guides, gudgeon pins and bushes.
- Main engine crankshafts and bearings (multiple engine installations only).
- Main engine fuel injection pumps and fuel booster pumps.
- M.E. Scavenge pumps, blowers and air coolers.
- Main engine detuners, dampers and balancer units.
- Main engine camshaft and camshaft drive.
- Main propulsion gas turbines (casing, rotor and blading) at alternate surveys provided the monitoring defined in 8.8.1.2 is provided and vibration measurements and full power trials are carried out at the time of the survey in the presence of a Surveyor.
- M.E. driven pumps, e.g. bilge, lubricating oil, cooling water.
- Independently driven pumps and associated motors and cables where insulation resistance readings are supplied e.g. bilge, ballast, fresh water cooling, sea water cooling, lubricating oil, oil fuel transfer.
- M.E. fresh water and lubricating oil coolers.
- Low pressure heaters used in fuel oil systems of internal combustion engines
- Main and auxiliary condensers/drain coolers.
- Air compressors including their safety devices.
- Windlass and windlass machinery.
- Auxiliary oil and steam engines including their coolers and pumps (provided the number of generating sets is such that all services essential to the propulsion and safety of the ship, also the preservation of refrigerated cargo, can be supplied when any two sets are not working. One of these sets can be overhauled while the other remains as "stand-by").
- Intermediate shafts.
- Main engine thrust bearing.
- Engine room tanks with boundaries not forming part of ship’s structure

Note : In cases where torsional vibration characteristics indicate that there is no susceptibility to damage as a result of uneven firing and the condition monitoring equipment defined in 8.8.1.1 is installed, a special arrangement may be granted whereby the Chief Engineer is permitted to survey the main engine crankshafts and bearings on single engine installations provided a modified confirmatory survey is carried out by IRS Surveyors at the time of the annual audit as follows:

- Check condition-monitoring records. (See 8.8.1.1)
- Check bearing clearances where possible.
- Check for signs of wiped or broken white metal in crankcase.
- Check witness marks of shrink fits.
- Check bed plate structure inside and outside.
- Obtain Chief Engineer's statements regarding crankpins, journals and bearings.

8.3 Machinery not acceptable for Survey by Chief Engineers

- Main engine crankshaft and bearings in single engine installations where special requirements in 8.2.1 are not complied with
- Reduction/increase gearing, flexible couplings and clutches.
- Holding down bolts and chocks
- Crankcase doors, crankcase and scavenge relief devices
- Maneuvering valves and main stop valves
- Steering machinery
- Pumping arrangements for Bilge/Ballast/ Fuel Oil/Fresh Water/Sea water/Lub.Oil/ Fire
- Electrical equipment other than that defined in 8.2.1
- Propellers
- Screwshafts
- Sea connections
- M.E. controls, bridge, centralised or automatic and controls in unmanned machinery spaces
- Engine trial
- First start arrangements trial.
- Starting Air bottles and their relief devices

8.4 System Administration

8.4.1 The Owner is to make a formal request to IRS providing the documentation and information detailed in 8.4.2 below for approval of the system.

8.4.2 The documentation and information to be submitted is to include the following:

a) A description of the system and its application onboard and organizational interface identifying the areas of responsibility ashore and the people responsible for the PMS onboard.

b) The list of items of machinery, equipment and components to be considered for inclusion in the PMS. The list is to be same in terms of description and identification with the identification system adopted by IRS.

c) Time schedules and scope of the maintenance procedures for each item listed in b), including acceptable limit conditions of the parameters to be monitored on items of opened up machinery, based on the manufacturer's recommendations or recognized standards. These are to be laid down in appropriate PMS sheets.

d) For machinery identified to be maintained under condition monitoring, maintenance and condition monitoring methods to be used, the time intervals for monitoring and maintenance of each item, the original reference data where applicable, the list and specifications of the condition monitoring equipment.

The acceptable limits of deteriorated condition should be stated and these are to be derived from manufacturer’s recommendations, applicable severity criteria as defined in applicable Standards, or the Owners requirements when these are more severe.

e) The documentation flow and filing procedure.

This is to include a system for reporting to Owners, records to be maintained onboard and at Owner’s head quarters.

f) A list of all personnel likely to be in-charge of the PMS system.

8.4.3 Computerized system requirement

8.4.3.1 The access to and updating the maintenance documentation and the maintenance program is to be permitted by the Chief Engineer or other authorized person only.

8.4.3.2 The system is to be suitably protected by suitable password access w.r.t. alterations to maintenance schedules, list of items under PMS and noting of damages.

8.4.3.3 The computerized system is to include a backup procedure, which is activated at regular intervals.

8.4.3.4 The functional applications of these computerized systems are to be approved by IRS.

8.4.4 Information to be available onboard.

a) All the documentation listed in 8.4.2, duly updated.

b) Maintenance instructions for each machinery, as applicable (supplied by the manufacturer or the shipyard).

c) The condition monitoring data including all data since last opening of the machinery and where applicable the original reference data.

d) Reference documentation (trend investigation procedures etc.).

e) The records of the maintenance performed, including conditions found, repairs and renewals carried out.

8.5 System Implementation

8.5.1 After the PMS documentation has been approved, an Initial Survey is to be carried out by IRS Surveyors.

8.5.2 Upon successful completion of the Confirmatory Survey, the PMS is considered approved and the survey notation PMS is assigned to the vessel and entered in the Register of Ships.

8.5.3 The PMS is retained throughout the class period of the vessel provided that :

a) An annual report covering the year's service is submitted to IRS detailing the list of items of machinery and components which were subjected to preventive maintenance in the period under review, together with preventive maintenance sheets, the condition monitoring data including all data since last dismantling and any changes to PMS documentation.

b) An annual audit of the PMS is carried out by IRS.

c) Any change to the PMS is submitted to IRS for approval.

8.5.4 The survey agreement for machinery according to PMS will be withdrawn by IRS if the PMS is not satisfactorily operated in terms of improperly maintained records or unsatisfactory condition of machinery or failure to observe the agreed intervals between overhauls.

8.5.5 The Owner may discontinue the PMS at any time by informing IRS in writing. In such a case the items that have been inspected under the PMS since last annual audit may be credited for IRS records at the discretion of the attending surveyor carrying out confirmatory surveys.

8.5.6 In case of change of management of the ship the PMS will require to be re-approved.

8.6 System Surveys

8.6.1 Initial Survey is to be carried out by an IRS Surveyor within one year from the date of the documentation approval. The scope of this survey is to verify that :

a) The PMS is implemented as per the approved documentation and is suitable to the type and complexity of machinery and systems onboard.

b) The documentation required for the annual audit is available and the adopted system is able to produce such a report.

c) The requirements of surveys and testing for continuing the class status are complied with.

d) The shipboard personnel are familiar with the PMS procedures including documentation.

8.6.2 **Annual Audit** is to be carried out once the PMS is implemented and approved, to verify the continued compliance with the documented PMS. The annual audit is carried out in conjunction with the annual class surveys. The scope of the audit is to be as given in the following :

a) The Surveyor is to verify that the PMS is correctly operated and that all items (due for survey in the relevant period) have actually been surveyed in due time.

b) The Surveyor is to verify that the machinery has been functioning satisfactorily upon review of the maintenance and performance records since the previous survey or audit and where needed necessary measures have been taken in response to machinery operating parameters exceeding acceptable limits and that the overhaul intervals have been observed.

c) A report detailing overhaul/repairs carried out and spare parts used on items in the list of surveyable items is to be presented by the Chief Engineer. Any machinery part or component, which has been replaced by a spare due to damage, is to be retained onboard and submitted to the attending surveyor's examination.

d) The attending surveyor after verification of records on board for the identification details of the Chief Engineers who have undertaken the maintenance activity and prepared the reports given in c), for compliance with the approved PMS, and upon satisfactory general examination and confirmatory surveys will credit the items for survey.

e) Scope of the confirmatory surveys

– Where condition monitoring equipment is in use, function tests, confirmatory inspections and random check readings are to be carried out as far as practicable and reasonable at the discretion of the surveyor. Where the condition and performance of the items are within specified approved limits, these items can be credited for survey without opening up.
– Where calendar based or running hour based maintenance is used function tests, review of records for operational parameters and maintenance records are to be carried out as far as practicable and reasonable at the discretion of the surveyor. Where the condition and performance of the items are within specified approved limits, these items can be credited for survey.

f) Written reports of break down or malfunction are to be made available.

g) If the surveyor is not satisfied with results of the PMS i.e. with degree of accuracy as regards the maintenance records and/or the general condition of the machinery, a report will be forwarded to IRS recommending that the special arrangements dealing with machinery surveys be suspended.

h) Upon satisfactory completion of the annual audit the surveyor confirms the validity of the PMS by crediting the PMS Annual audit.

8.7 Damage and repairs

8.7.1 Damage to components or items of machinery covered by the PMS which may affect the class is to be reported to IRS immediately. A surveyor will attend on board, survey the damage and on the basis of the survey results decide whether condition of class is to be recommended.

8.7.2 All parts of machinery or components, which need to undergo substantial repairs, are to be surveyed by IRS before, during and after the repairs, as deemed appropriate by the attending surveyor.

8.7.3 In the case of outstanding conditions of class or records of unrepaired damage, which may affect the PMS, the relevant items are to be taken out of the PMS until the conditions of class are dealt with or the repairs are carried out.

8.8 Guidelines for machinery items surveyed on the basis of condition monitoring

8.8.1 The extent of condition based maintenance and associated monitoring of equipment; to be included in the PMS is decided by the owner. The minimum parameters to be checked in order to monitor the condition of the various machinery for which this type of maintenance is accepted are indicated in 8.8.1.1 to 8.8.1.4.

8.8.1.1 For the main propulsion diesel engine the following parameters are to be monitored.

- Shaft horse power
- Engine and shaft RPM
- Indicator diagrams (both power and injection timing), where applicable
- Fuel oil temperature and/or viscosity
- Charge air pressure
- Exhaust gas temperatures for each cylinder and before and after turbochargers
- Engine cooling system temperatures and pressures
- Engine lubricating oil system temperatures and pressures

- Turbocharger RPM and vibration
- Lubricating oil analysis data
- Crankshaft deflections
- Main bearing temperatures.

8.8.1.2 For the main and auxiliary steam turbines the following parameters are to be monitored.

- Turbine rotor/bearing vibration
- Turbine rotor axial displacement
- Shaft horsepower
- Shaft and turbine rotor RPM
- Plant performance data i.e. steam conditions at the inlet and outlet of each turbine, boiler performance data, condenser vacuum, sea temperatures.

8.8.1.3 For the auxiliary diesel engines the following parameters are to be monitored.

- Exhaust gas temperatures for each cylinder and before and after turbochargers
- Engine cooling system temperatures and pressures
- Engine lubricating oil system temperatures and pressures
- Turbocharger RPM and vibration
- Lubricating oil analysis data
- Crankshaft deflections.

8.8.1.4 For other auxiliary machinery the following parameters are to be monitored.

- Cooler inlet and outlet temperatures and efficiencies
- Inlet and outlet temperatures of heaters
- Pumps and fans vibration and performance data
- Differential pressures across filters serving essential systems.

End Of Chapter

Chapter 3

Materials of Construction

Contents	
Section	
1	General
2	Structural Steel
3	Structural Aluminium Alloy
4	Glass Reinforced Plastic Materials

Section 1

General

1.1 Scope

1.1.1 These Rules provide for use of steel, marine grade aluminium alloys and glass fibre reinforced plastics in the construction or repair of hull structures. These materials are to be tested and inspected according to the requirements given in Sections 2, 3 and 4 respectively.

1.1.2 Materials used for the construction or repair of machinery systems or components are to be manufactured tested and inspected according to the relevant requirements given in Part 2 of the *Rules and Regulations for the Construction and Classification of Steel Ships.*

1.1.3 Materials complying with recognised national or international standards giving equivalent requirements may also be accepted.

Section 2

Structural Steel

2.1 Manufacture, inspection and testing

2.1.1 All steel rolled products, castings and forgings used in the construction or repairs of the hull structures are to be manufactured and tested in accordance with the requirements of Chapters 3, 4 and 5, respectively of Part 2 of the *Rules and Regulations for the Construction and Classification of Steel Ships.*

2.2 Material factor ‘k’ for steel

2.2.1 Ordinary hull structural steel is a hull structural steel with a minimum yield stress of 235 [N/mm^2] and a tensile strength generally in the range of 400-490 [N/mm^2].

For ordinary hull structural steel, the material factor ‘k’ is to be taken as 1.0.

2.2.2 Steels having a yield stress of 265 [N/mm^2] and higher, are regarded as higher tensile steels. Where higher tensile steel is used, the hull girder section modulus and the local scantlings may be reduced in accordance with the relevant requirement of the Rules. For this purpose, a material factor ‘k’, is to be taken as follows:

k = 0.78 for steel with a minimum yield stress of 315 [N/mm^2].

k = 0.72 for steel with a minimum yield stress of 355 [N/mm^2].

2.3 Grades of steel

2.3.1 In general, grade A or AH steel would be acceptable. Where the thickness of material exceeds 15 mm, the required grade of steel would be specially considered depending on the thickness and the proposed use.

Section 3

Structural Aluminium Alloy

3.1 Manufacture, inspection and testing

3.1.1 All aluminium alloy rolled or extruded products, castings or aluminium/steel transition joints used in the construction or repairs of the hull structure are to be manufactured and tested in accordance with the requirements of Chapter 9 of Part 2, of the *Rules and Regulations for the construction and Classification of Steel Ships.*

3.1.2 Wrought aluminium alloys are to have a satisfactory resistance to corrosion in marine environment. Grades for welded structures are to be weldable, applying one of the welding methods approved by IRS.

3.1.3 The alloy grades 6005A, 6061 of the 6000 series should not be used in direct contact with sea water unless protected by anodes and/or paint system.

3.2 Material factor 'k' for aluminium alloys

3.2.1 The material factor 'k' to be used for determination of required scantlings of aluminium structures is to be taken as:

$$k = 235/\sigma_y$$

where,

σy = guaranteed minimum 0.2% proof stress of the alloy in the welded condition or 70% of the ultimate strength in the welded condition, whichever is the lesser [N/mm^2].

Section 4

Glass Reinforced Plastic Materials

4.1 General

4.1.1 The requirements given in this section are based on the use of an unsaturated polyester resin system with glass fibre reinforcement and employing hand lay-up or spray lay-up contact moulding production techniques. Other types of resin systems and reinforcements may be accepted based on testing and approval in each individual case.

4.1.2 The following base materials used in the construction or repair of GRP crafts are to be approved in accordance with the approval procedure given in this sub-section and the requirements of sub-sections 4.3, 4.4 and 4.5, as relevant.

- Glass fibre reinforcements
- Polyester resins
- Sandwich core materials
- Sandwich adhesives.

4.1.3 Materials other than GRP, are to be of good quality, suitable for the purpose intended and where applicable, are to comply with the Rule requirements appropriate to the material. Where these materials are attached to, or encapsulated within the GRP construction, they are to be such as not to affect adversely the cure of plastic materials.

4.2 Procedure for approval of base materials

4.2.1 The following information is to be submitted by the manufacturer for each base material product for which the approval is sought.

a) Detailed specifications for each grade, giving Manufacturer's Nominal Values (MNV) and corresponding acceptable tolerances.

b) An outline of the production process giving details of all important stages in production.

c) A brief description of the plant and equipments.

d) Details of systems employed for production and quality control.

e) Details of the systems used for the identification of raw materials, semi-finished and finished products.

f) The number and qualifications of all staff engaged in quality control duties.

g) Details of test equipment, testing procedures, stages at which tests are carried out by the Manufacturer and frequency of testing.

h) Manufacturer's test results for a period of at least 3 months covering testing on at least 10 production batches.

The Manufacturer's works and equipment are to be inspected to examine all aspects of production and quality control as per the above mentioned details and the actual testing for approval of product may commence only after they have been found satisfactory.

4.2.2 The base material products are to be tested in accordance with the recommended test methods given in 4.3, 4.4 and 4.5, as relevant. Other equivalent test methods may be individually considered. The test equipment used is to be kept in a satisfactory and accurate condition and calibrated annually. The tests are to be carried out by competent personnel and are generally to be witnessed by Surveyors. In case of testing by reputed independent test house, the witnessing may be waived at the discretion of the attending Surveyor.

4.2.3 The test samples and specimens are to be prepared in accordance with the manufacturer's recommendations and the relevant recommended test methods. When tests on GRP laminates are required, the laminates are to be moulded by the hand lay-up method at an angle of 45 deg. to the horizontal and under environmental conditions specified in Chapter 7, Section 2.

4.2.4 On the satisfactory completion of all testing a type approval certificate valid for a period of five years shall be issued which shall be subject to the conditions of approval given in 4.2.5 and 4.2.6 and satisfactory annual inspections as per 4.2.7. Any alteration in the composition of the product or in any of the production details which affect the quality may warrant new approval testing.

4.2.5 The type approval is given on the condition that the product material, when correctly examined will give test results reasonably close to the submitted properties. Should the properties of the base materials or those of well made laminates using these materials be found to deviate significantly from the submitted properties, or should the quality control procedures not be adhered to consistently, approval will be withdrawn.

4.2.6 Each delivery of raw materials is to be suitably marked with following details:

- Approval Certificate No. and date
- Designation of product
- Batch No.

Properties to be tested for each delivery or batch to which the delivery belongs are specified in Tables 4.3.4, 4.4.2 and 4.5.4 (marked (D)). The values resulting from testing are to be recorded and made available for inspection.

4.2.7 Manufacturers' works and quality control systems are to be subjected to annual inspection. The scope of inspection and testing at the annual inspection is limited to ensuring that the conditions of approval given in 4.2.4 to 4.2.6 remain valid.

Quality control records and Manufacturer's test results are to be made available to the Surveyor and random tests are to be carried out in the Surveyors' presence to adequately demonstrate that the consistency of the approved grade is satisfactorily maintained.

4.3 Glass fibre reinforcements

4.3.1 The Rule requirements in respect of the following types of glass fibre reinforcements are given in this section.

- Chopped strand mat
- Unidirectional
- Woven roving
- Woven cloth

Other types of glass fibre reinforcements will be individually considered.

4.3.2 Reinforcement features

The following details are to be provided as applicable, for each type of reinforcements:

a) Reinforcement type

b) Fibre tex value

c) Fibre finish and/or treatment

d) Yarn count in each direction

e) Width of manufactured reinforcement

f) Weight per unit area of manufactured reinforcement

g) Weight per linear metre of manufactured reinforcement

h) Compatibility (e.g. suitable for polyesters, epoxides, etc)

i) Constructional stitching (details of yarn, type, frequency and direction)

j) Weave type

k) Binder type and content.

4.3.3 The glass fibre reinforcements are to be manufactured from low-alkali borosilicate "E" glass. A chemical analysis is to be carried out and the chemical composition (%) is to comply with the following requirements:

S_iO_2	C_aO	AL_2O_3	B_2O_3	M_gO	$Na_2O + K_2O$
52-56	16-25	12-16	6-12	0-6	0-1

Binders where used are to be soluble polyester resin. Sizes and finishes are to be of the silane type, and are to be compatible with the laminating resins.

4.3.4 The glass fibre reinforcements and laminates prepared from them are to be tested in accordance with Table 4.3.4 and are to comply with the requirements specified therein.

For the purpose of this approval testing, the laminates are to be prepared as follows:

a) An approved resin of suitable type is to be used.

b) A minimum of three layers of the reinforcement is to be laid with parallel ply to give a laminate not less than 4 mm thick.

c) The weights of resin and reinforcements used are to be recorded together with the measured thickness of the laminate.

d) The following glass/resin ratios by weight, are to be used:

Reinforcement type	Glass fraction
Chopped Strand-mat	0.3
Unidirectional	0.6
Woven Roving	0.5
Woven Cloth	0.5

The laminates are to be tested in air in the directions indicated below:

Type of reinforcement	**Test orientation**
Unidirectional	0^o
Chopped Strand Mat	any direction
Woven Roving Woven Cloth	0^o and 90^o 0^o and 90^o

4.4 Polyester resins

4.4.1 Scope

The Rule requirements in respect of the following unsaturated polyester resins suitable for lamination by hand lay-up are given in this section.

- Isophthalic polyester resins
- Orthophthalic polyester resins.

It may be noted that orthophthalic polyester resins are not to be used in the main hull.

The resins are to have good wetting properties and are to cure satisfactorily under environmental conditions specified in Chapter 7.

4.4.2 Properties

For each grade of resin to be approved, resin in liquid and cast conditions and the laminates prepared from it are to be tested in accordance with the Table 4.4.2 and are to comply with the requirements specified therein.

For the purpose of approval testing, the laminates are to be prepared in accordance with 4.3.4 using the resin under consideration and an approved chopped strand mat reinforcement.

4.4.3 The resins to be approved for application in gelcoats are to satisfy the requirements for isophthalic polyester resin given in Table 4.4.2 for liquid and cast conditions. Testing of laminates prepared using the resins need not be carried out.

Table 4.3.4 : Properties for acceptance purposes : Glass fibre reinforcements

Property	Required values	Recommended Test Methods
(A) GLASS FIBRE REINFORCEMENTS		
Moisture content (D)	Max. 0.2% (max. 0.3% for emulsion bonded CSM)	ISO 3344
Av. weight per unit area (D)	MNV ± 8%	BS 3749 BS EN 14118
% max. variation in weight per unit area (D)	19% of MNV	BS 3749 BS EN 14118
Loss on ignition (D)	MNV*	ISO/R 1887
Mat binder solubility (for CSM only)	MNV*	BS EN 14118
Wet-out time	MNV*	BS EN 14118
(B) LAMINATES		
Ultimate Tensile Strength Tensile Modulus	Subject to approval in each separate case	ISO 527-4
Ultimate Bending Strength Bending Modulus	- do -	ISO 178
Glass Content	- do -	ISO 1172

Notes:

MNV : Manufacturers Nominal Value (As given in the product specifications)
D : To be tested for each delivery/batch
* : Tolerance limits are subject to approval in each separate case.

Table 4.4.2 : Properties for acceptance purposes : Polyester resins

Property	Required values		Recommended Test Method
	ISOPHTHALIC	ORTHOPHTHALIC	
(A) LIQUID RESIN			
Density (D)	MNV		ISO 1675
Viscosity (D)	MNV ± 20%		ISO 2555 OR ISO 2884
Acid value (D)	MNV ± 10%		ISO 2114
Monomer content (D)	MNV ± 10%		ISO 3251
Gel time (D)	MNV ± 20%		ISO 2535
Shrinkage during cure (D)	MNV		ISO 3521
(B) CAST RESIN			
Density	MNV	MNV	
Hardness (Barcol)	35	35	ASTM D2583
Heat deflection temp.	75 (°C)	62 (°C)	ISO 75
Water absorption (mg) (28 days immersion)	80 (mg) max.	100 (mg) max.	Method A ISO62
Ultimate tensile strength	45 [N/mm^2]	45 [N/mm^2]	ISO 527-4
Tensile modulus	3000 [N/mm^2]	3000 [N/mm^2]	ISO 527-4
Elongation at fracture	2% (2.5% for gelcoat)	1.5%	
Ultimate bending strength	80 [N/mm^2]	80 [N/mm^2]	ISO 178

Table 4.4.2 : (Continued …)			
Property	**Required values**		**Recommended Test Method**
	ISOPHTHALIC	**ORTHOPHTHALIC**	
(C) LAMINATE			
Ultimate tensile strength	85 [N/mm^2]		ISO 527-4
Tensile modulus	6500 [N/mm^2]		ISO 527-4
Ultimate bending strength	152 [N/mm^2]		ISO 178
Bending modulus	5206 [N/mm^2]		ISO 178
Glass content (by weight)	0.3		ISO 1172
Notes: MNV : Manufacturer's Nominal Value (as given on the product specifications) D : To be tested for each delivery/batch			

4.5 Sandwich core materials

4.5.1 The Rule requirements in respect of the following core materials to be used in sandwich constructions are given in this section.

- Rigid expanded PVC foam
- Balsa wood.

Where plywood is proposed to be used as core, it is to be of a marine grade meeting the requirements of Chapter 7.

Other core materials such as honeycombs, etc., will be individually considered. Expanded polystyrene foam is attacked by the styrene in the polyester resin and is not recommended for use as core.

4.5.2 Rigid expanded PVC foams are to have closed-cell structure and be impervious to water, fuel and oils and are to be compatible with the polyester resin. The foam is not to shrink with time, the shrinkage strains if any, not exceeding the tolerances on linear dimensions.

4.5.3 Balsa wood is to be end-grain and to have moisture content not exceeding 12%. Where manufactured into formable sheets of small blocks, the open weave backing material and adhesive are to be compatible and soluble, respectively, with the polyester laminating resin.

4.5.4 The core materials and the sandwich panels prepared with the core material under consideration are to be tested in accordance with Table 4.5.4 and are to comply with the requirements specified therein. The skin laminates used in the construction of the sandwich panel are to be prepared from approved resin and CSM reinforcements.

Table 4.5.4 : Properties for acceptance purposes : Sandwich core materials		
Property	**Required values**	**Recommended Test Method**
(A) CORE		
Density [Kg/m^3] (D)	MNV + 15% - 0%	ASTM C-271 specimen 1000 x 1000 x thickness of sheet [mm]
Compressive strength [N/mm^2] (D)	0.7 0.53 (after 4 weeks immersion in salt water)	ISO 844
Compressive modulus [N/mm^2]	30 22.5 (after 4 weeks immersion in salt water)	ISO 844
Shear strength [N/mm^2]	0.69	ISO 1922
Shear modulus [N/mm^2]	12	ISO 1922
Water absorption [Kg/m^2] (1 week immersion in salt water)	1.5 max.	ASTM C272 40 deg. C
Styrene resistance	Resistance	ISO 175
(B) SANDWICH PANEL		
Shear strength [N/mm^2]	0.69 Failure not to occur in bond between skins and core	ISO 1922
Shear modulus [N/mm^2]	12	ISO 1922
Notes: MNV : Manufacturer’s Nominal Value (as given in the product specification) D : To be tested for each delivery/batch.		

End Of Chapter

Chapter 4

Design Loads

Contents	
Section	
1	General, Definitions, Documentation
2	Design Accelerations
3	Local Loads
4	Global Loads

Section 1

General, Definitions, Documentation

1.1 Scope and application

1.1.1 The scantlings of various hull members are to be based on the design values of accelerations given in Section 2 and the local loads due to lateral pressures, impact pressures, liquid pressures in tanks, dry cargo, stores etc. given in Section 3. Longitudinal strength when required to be investigated as per Chapter 6 and 7 and the transverse strength of connecting structure in case of twin-hulls is to based on global loads given in Section 4.

1.1.2 Speed reduction may be considered in heavy seas to limit the accelerations to the design values. A table giving the allowable speeds versus significant wave heights may require to be appended to the class certificate and also to be posted in the wheelhouse.

1.1.3 Installation of an accelerometer may be required (for high speed craft) at the LCG giving indication of acceleration values in the wheel house.

1.1.4 Alternative methods of load estimation based on model tests, full scale measurements or accepted theories may be specially considered.

1.2 Definitions

1.2.1 The forward perpendicular, F.P., is the perpendicular drawn at the forward end of the length defined in chapter 1, 2.2.31.

1.2.2 The after perpendicular, A.P. is the perpendicular drawn at the aft end of the length defined in Chapter 1, 2.2.31.

1.2.3 “Amidship” is at 0.5L aft of the F.P.

1.2.4 Depth, D, is the moulded depth [m], measured amidships from top of the keel to the moulded deck line of the uppermost continuous deck at side.

1.2.5 Draught, T, is the moulded draught amidships corresponding to the fully loaded waterline with the craft floating at rest, [m].

1.2.6 The block coefficient, C_b, is the moulded block co-efficient calculated as follows:

$$C_b = \frac{moulded\ \ displacement\ [m^3]\ at\ \ draught\ \ T}{L\ \ B_w\ \ T}$$

1.2.7 B_w is the greatest moulded breadth of the hull(s) in m at the fully loaded waterline, with the craft at rest. In the case of multi-hull crafts B_w is the sum of the waterline breadths.

1.2.8 Wave factor

C_W = 0.0856 L for L ≤ 90 m
= 10.75 - $[(300-L)/100]^{3/2}$ for L > 90 m

Wave factor C_W for service area notations would be reduced as follows:

Notation	Reduction factor
RS0	1.0
RS1	0.8
RS2	0.6
RS3	0.35

1.2.9 For definitions of breadth B, maximum service speed V, displacement Δ and other terms see Chapter 1, Sec.2.2

1.3 Structural terms

1.3.1 The general terms used in the Rules for various structural components of the crafts are defined as under:

Strength Deck : In general, the uppermost continuous deck. Where a superstructure deck has within 0.4L amidships, a continuous length equal to or greater than (1.5B + 3H) for mono-hull vessels and (0.2L + 3H) for twin hull vessels, it is to be regarded as the strength deck instead of the covered part of the uppermost continuous deck. (H is the height of the superstructure [m]).

Freeboard Deck : The freeboard deck is normally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all openings in the weather part and below which all openings on the sides of the ship are fitted with means for watertight closing.

Superstructure : A decked structure on freeboard deck extending from side to side of the ship or with the side plating not inboard of shell plating by more than 4 percent of the breadth B.

Deckhouse : A decked structure above the freeboard deck with the side plating being inboard of the shell plating by more than 4 percent of the breadth B.

Girder : A collective term for the primary supporting members, other terms include:

- Transverse – transverse girder under the deck
- Web frame – side vertical girder
- Stringer – horizontal girder
- Floor – bottom transverse girder.

Stiffener : A collective term for secondary supporting members, other terms being

- Frame
- Reverse frame – transverse stiffener on the inner bottom
- Horizontal or vertical bulkhead stiffener.

Flat Cross Structure : is a structure having exposed, down facing horizontal surface above the waterline.

1.4 Documentation

1.4.1 Documents as listed in 1.4.2 to 1.4.4 below are to be submitted in triplicate, one copy of which shall be returned.

1.4.2 The following supporting plans and calculations are to be submitted for information:

- General arrangement
- Capacity plan
- Lines plan and hydrostatic curves or tables
- Docking plan
- Operating manual.

1.4.3 The following additional information is to be submitted for the purpose of strength calculations:

- Maximum values of still water bending moments and shear forces
- Lightship weight and its longitudinal distribution
- Bonjeans data
- Masses and unbalanced moments of heavy machinery components e.g. engines, cranes, winches etc.

1.4.4 Plans as indicated in Table 1.4.4 are to be submitted for approval, as relevant.

Table 1.4.4 : Hull plans for approval

Plan	Including information on
Loading manual	Details of loading in all contemplated loading conditions and resulting SWBM, SF and Torsional Moments (TM)
Midship section Other transverse sections Longitudinal sections and decks Cross deck structure in case of multi-hull vessels Shell expansion and frame plan	Main dimensions, displacements, maximum speed Design values of vertical accelerations at c.g and wave height, speed reductions, if any Equipment specification Complete class notation applied for Spacing of stiffeners Deck loads, if other than those specified in the Rules Opening on the deck Minimum ballast draught(s) Extent of flat part of bottom forward Openings of the shell Material grades
Double bottom	Indication of access Height and location of overflows Loading on inner bottom
Watertight subdivision bulkheads and watertight tunnels	Openings and their closing appliances
Aft-end structure Propeller shaft brackets Aftpeak structure	Propeller outline Propeller thrust Structural details in way of rudder and propeller bearings
Engine room structure Machinery foundations	Type, power and r.p.m. of propulsion machinery Weight of machinery, boilers, etc.
Fore-end construction Fore peak structure	Openings on non-watertight bulkheads and diaphragm plates
Oil tight/water tight and partition bulkheads in tanks	Intended tank contents and their densities Height and location of overflow/air pipes Tanks intended to be partially filled Corrosion protection, if any
Superstructures deckhouses and machinery casings	Height of sills from deck and closing appliances for companion ways
Hatchways Hatch covers Bow and stern doors Side ports	Position and type Loads if different from those specified in the rules Sealing and securing arrangement, spacing of bolts or wedges
Rudder stock and tiller Steering gear arrangement	Speed of the ship (ahead and astern) Material of bearings, coupling bolts, stock and the locking device rudder carrier
Trim flaps or foils structure	Details of attachment to hull
Bilge keel	Material grade
Testing plan of tanks and bulkheads	
Welding details	
Note : 1) One drawing may contain more than one of the items from each group	

Section 2

Design Accelerations

2.1 Vertical acceleration

2.1.1 The design value of vertical acceleration at LCG which corresponds to the average of the 1 percent highest accelerations in the most severe operating conditions is to be specified by the designer. The relationship between the vertical accelerations at the centre of gravity, the significant wave height, speed and dimensions of the craft given in 2.1.2 is to be used. Normally, the design value of vertical acceleration at LCG greater than those given in Table 2.1.1 may not be adopted. Where relevant, the relationship between allowable speed and significant wave height will be appended to the classification certificate and the same is to be incorporated in the operational manual of the craft.

Table 2.1.1

Type of service	Limit of a_{cg} (g)
Passenger Cargo	1.0
Supply, Workboat	1.5
Pilot	2.0
Rescue, Patrol	2.5

2.1.2 Unless other values are justified by calculations carried out according to accepted theories, model tests or full scale measurements, the vertical acceleration at LCG, 'a_{cg}', is to be taken as:

$$a_{cg} = C_H \left[\frac{12H_s}{B_w} + 1\right] \left[50 - \theta_d\right] \left[\frac{V}{\sqrt{L}}\right]^2 \cdot \frac{B_w \,.10^{-5}}{C_b\ T}$$

where,

H_s = significant wave height in m, for monohull crafts H_s is not to be taken as less than 0.2 B_w

θ_d = dead rise angle at LCG in degrees, not to be taken less than 10^o nor more than 30^o.

θ_t = running trim angle in degrees, but not to be taken less than 3^o.

$C_H = \theta_t$ for monohulls and catamarans
= 3.0 for SWATHS and foil assisted crafts
= 3.2 for SES and ACV crafts.

2.1.3 The longitudinal distribution of vertical acceleration along the hull may be taken as:

$$a_v = k_v\ a_{cg}$$

where,

$k_v = 0.8$ for $x/L \leq 0.4$

= 2.0 at FP

at intermediate values k_v to be linearly interpolated

x = distance from AP [m].

Section 3

Local Loads

3.1 General

3.1.1 The scantlings of shell and weather deck panels are to be based on the external sea pressures given in 3.5. Internal pressure, in way of tanks (See 3.6.2) should be considered if that be greater. The scantlings of bulkhead structures are to based on design pressures given in 3.6.

The bottom structure, forebody and flat cross deck structures are to withstand the effect of slamming and impact pressures given in 3.2, 3.3 and 3.4.

Inner bottom and decks supporting dry cargoes, stores and accommodation spaces are to be based on design pressure given in 3.7.

3.2 Slamming pressure on bottom

3.2.1 The design slamming pressure due to high speed slamming on the bottom of the craft is to be taken as:

$$P_{sl} = \frac{125\,\Delta}{LB_w}\left[\frac{50-\theta_{dl}}{50-\theta_d}\right].K_A.K_L.\left(\frac{a_{cg}}{C_b}\right)\ [kN/m^2]$$

K_A = Area factor as given in Fig.3.2.1

where, A_R = reference area = 0.7 L B_w C_b and

A = design load area for the element under consideration [m^2].

for plating, 'A' is not to be greater than $3s^2$ where s is the spacing of stiffeners.

for stiffeners, 'A' is to be taken as the stiffener span x spacing.

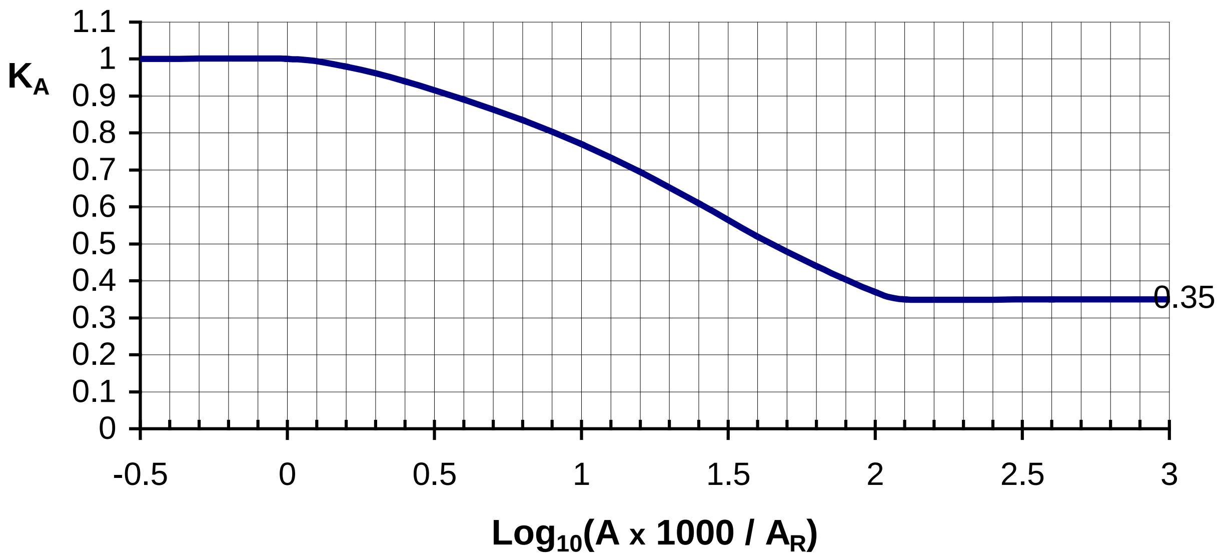


Fig. 3.2.1 : Area factor for slamming pressure

K_L = longitudinal distribution factor

= 0.5 at A.P.

= 0.5 + x/L for $x/L \leq 0.5$

= 1.0 for $0.5 \leq x/L \leq 0.8$

= 3.0 – 2.5 x/L for $x/L > 0.8$

where x = distance of load point from the A.P.

θ_{dl} = deadrise angle in degrees at the section under consideration

θ_d = deadrise angle at l.c.g.

3.3 Forebody side and bow impact pressure

3.3.1 Forebody side and bow in the region forward 0.25L from the F.P is to be strengthened for bow impact pressure P_i, is to be taken as:

$$P_i = C_L\,(2.2 + 1.5 \tan\alpha)\,(0.4\,V \sin\beta + 0.6\sqrt{L})^2\ .\ x/L\ \ [kN/m^2]$$

where,

V = maximum speed (knots)
β = angle made by the tangent to water line with the centre line of the ship at the point under consideration as shown in Fig.3.3.1

C_L = 0.0125L, not to be taken more than 1.0
α = angle between the side shell and the vertical as shown in Fig.3.3.1
x = distance from A.P.

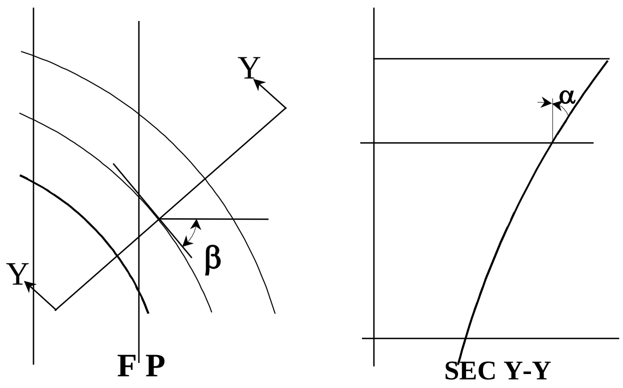


Fig.3.3.1 : Bow flare details

3.4 Impact pressure on flat cross deck

3.4.1 The impact pressure due to slamming on bottom of flat cross deck of multi hull vessels is to be not less than:

$$P_d = \frac{125\Delta}{(0.66\, LB_w + 0.33 L_d\, B_d)} \text{ x}$$

$$\left(\frac{a_{cg}}{C_b}\right) K_A \left(1 - \frac{G_A}{H_s}\right) [\text{kN/m}^2]$$

where,

K_A = area factor as given in 3.2.1,

L_d = length of wet cross deck [m]

B_d = breadth of wet cross deck [m]

G_A = Vertical distance from the fully loaded water line to bottom of cross deck [m].

3.5 Sea pressure

3.5.1 The pressure ‘p’ acting on the craft’s side, bottom and weather decks is to be taken as:

- For load point below design waterline:

  $p = 10\ h_o + (k_s - 1.5\ h_o/T)\ C_w$ [kN/m^2]

- For load point above design waterline:

  $p = k_s\ (C_w - 0.8\ h_o)$ [kN/m^2]

h_o = vertical distance [m] from fully loaded waterline to the loadpoint

k_s = 7.5 aft of amidships

= $5/C_B$ forward of F.P.

elsewhere, the value of k_s may be obtained by linear interpolation.

‘p’ is not to be taken less than:

10 [kN/m^2] for craft’s sides,

5 [kN/m^2] for weather decks

For vessels with service restriction notation ‘**RS3**’ the above values may be reduced to 5 [kN/m^2] and 3 [kN/m^2] respectively.

3.5.2 For decks forming crown of tanks, loads due to liquids in tanks should be considered as for bulkheads given in 3.6.

3.5.3 The design pressure on superstructure and bulkheads and deckhouses is not to be taken less than:

$p = a\ k_s\ (C_w - 0.8\ h_o)$ [kN/m^2]

where, h_o is as defined in 3.5.1

a = factor for location:

= 2.0 for lowest tier of unprotected fronts

= 1.5 for 2nd tier unprotected fronts

= 1.0 for deckhouse sides

= 0.8 elsewhere.

The design pressure 'p', should not be less than:

$10 + 0.05L$ [kN/m^2] for lowest tier of unprotected fronts and

5 [kN/m^2] elsewhere.

For crafts with notation '**RS3**' the above values may be reduced to 5 [kN/m^2] and 3 [kN/m^2] respectively.

3.6 Loads on bulkheads

3.6.1 The design pressure for ordinary watertight bulkheads is given by

$$p = 10\ h \quad [\mathrm{kN/m^2}]$$

where,

h = the vertical distance from the centre of loading to the top of bulkhead or to the flooded waterline if it is higher.

3.6.2 The design pressure for tank bulkheads are normally to be taken as the greater of:

$p = (10 + 5\ a_v)\ h_s$ [kN/m^2]

$p = 6.7\ h_p$ [kN/m^2]

$p = 10\ h_s + p_o$ [kN/m^2]

where,

a_v = vertical acceleration at the load point as given in 2.1.3

h_s = vertical distance from the load point to top of tank [m].

h_p = vertical distance from the load point to top of air pipe [m].

$p_o = (0.2L + 6)$ [kN/m^2] for $L \leq 90$ m

$= 24$ [kN/m^2] for $L > 90$ m.

3.6.3 The design pressure on wash bulkheads is to be taken not less than:

$p = (4 - 0.005L)\ l_t$ [kN/m^2] for transverse bulkheads

$= (3 - 0.01B)\ b_t$ [kN/m^2] for longitudinal bulkheads

where,

l_t = greater of the distances between the adjacent transverse bulkheads

b_t = greater of the distances between adjacent longitudinal bulkheads.

3.7 Pressure due to dry cargo, stores and equipment

3.7.1 The design pressure on inner bottom, decks and hatchcovers due to dry cargo, stores or equipment is to be taken as the following:

$p = q\ (10 + 5\ a_v)$ [kN/m^2]

a_v is as given in 2.1.3

q = deck cargo load [t/m^2]

= 1 [t/m^2] for weather decks and hatchcovers with cargo loading, in general
= 1.6 [t/m^2] for platform deck in machinery spaces

= ρ H [t/m^2] for tween decks or inner bottom

where,

ρ = density of cargo [t/m^3] and H is the stowage height [m]

q = 0.35 [t/m^2] for accommodation decks.

Section 4

Global Loads

4.1 Longitudinal hull girder bending and shear loads

4.1.1 The longitudinal bending and shear strength of the hull girder is to be based on

i) the combination of still water and wave bending moments and shear forces as given in 4.1.2, or
ii) the dynamic bending moments and shear forces due to slamming effects as given in 4.1.3, whichever is higher.

4.1.2 The total longitudinal bending moment amidships is given by:

$$M_L = M_s + M_w$$

where,

M_s = the still water bending moment [kN-m]

M_w = $-0.11\ C_w\ L^2\ B\ (C_b + 0.7)$ [kN-m]
– for sagging condition

= $+\ 0.19\ C_w\ L^2\ B\ C_b$ [kN-m]
- for hogging condition

In the above formula C_b is not to taken less than 0.6.

For multi-hull crafts 'B' is to be replaced by 'B_w' as defined in 1.2.4.

The total shear force on longitudinal hull girder:

$$Q_L = Q_s + Q_w$$

where,

Q_s = still water shear force [kN]

$Q_w = 0.3\ k_{wq}\ .\ C_w\ L\ .\ B\ (C_b + 0.7)$ [kN]

K_{wq} = the distribution factor for +ve and –ve shear forces given in Table 4.1.2.

Table 4.1.2

Location from A.P	**Positive shear force (+)**	**Negative shear force (-)**
A.P	0	0
0.2L to 0.3L	$\frac{1.589\ C_b}{C_b + 0.7}$	-0.92
0.4L to 0.6L	0.7	-0.70
0.7L to 0.85L	1.0	$-\frac{1.727\ C_b}{(C_b + 0.7)}$
F.P	0	0

4.1.3 The total longitudinal bending moment amidships due to slamming is to be taken as:

$$M_{sl} = 0.33\ \Delta\ L\ (1 + a_{cg})\ \ [\text{kN-m}]$$

The corresponding shear force due to slamming is to be taken as:

$$Q_{sl} = \frac{4M_{sl}}{L}\quad [kN]$$

4.2 Twin hull loads

4.2.1 The strength of the cross deck structure connecting twin hull is to be analysed for forces and moments as indicated below unless other values verified by model tests or full scale measurements are submitted.

4.2.2 For crafts with partially submerged hulls such as catamarans the twin hull transverse bending moment, M_T, and the corresponding shear force 'Q_T' at centre line between the twin hull are taken as:

$$M_T = \frac{9.81\Delta\ b\ \ a_{cg}}{4}\quad [\text{kN} - \text{m}]$$

and

$$Q_T = \frac{9.81 \Delta a_{cg}}{3} \ [kN]$$

where 'b' is the transverse distance between the centre of the two hulls. (See Fig.4.2.3).

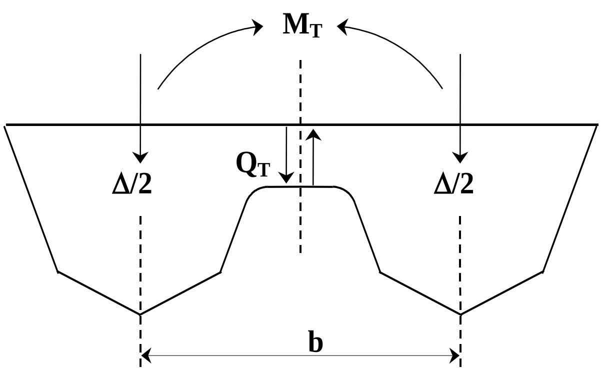


Fig. 4.2.3 : Twin hull transverse BM and SF

4.2.3 The twin hull pitch connection moment 'M_p' about the transverse axis, is to be taken as: (See Fig.4.2.4)

$$M_p = \frac{9.81 \Delta a_{cg} L}{8} \ [kN - m]$$

4.2.4 For crafts with fully submerged hulls such as SWATH the transverse bending moment M_t is to be taken as:

$M_T = F_{ST} \cdot h_{ST}$ [kN-m]

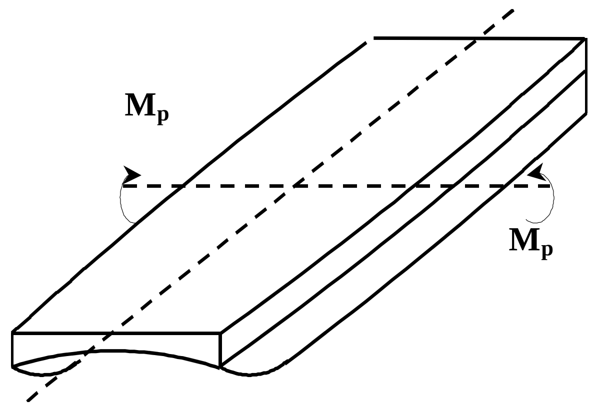


Fig. 4.2.4 : Twin hull pitch connection moment

where,

F_{ST} = Side force at mid draught of hull =
$9.56 \cdot T \cdot \Delta^{2/3} \cdot K_1 K_2$ [kN]

$K_1 = 2.07 - \tanh(\Delta/1100)$

$K_2 = 1 + 0.47 \tanh[1.64 L_s/(\Delta^{1/3}) - 6]$

h_{ST} = distance from mid draught to the midpoint of cross deck structure [m].

L_s = the length of the struts [m].

End Of Chapter

Chapter 5

Stability, Subdivision, Watertight and Weathertight Integrity

Contents

Section	
1	General, Definitions, Documentation
2	General Stability Requirements
3	Requirements for Stability of Passenger Craft
4	Requirements for Stability of Cargo Craft
5	Watertight and Weathertight Integrity
6	Subdivision and Arrangement
7	Weathertight Integrity and Loadline for Craft with **‘LC’** or **‘HSLC’** Notation

Section 1

General, Definitions, Documentation

1.1 Scope

1.1.1 Crafts for which HSC code is applicable i.e. which are assigned class notation ‘**HSC**’ are to satisfy the requirements given in Sections 2, 3, 4, 5 and the applicable requirements of Section 6 of this chapter.

Other fast crafts for which class notation ‘**LC**’ or **‘HSLC’** is assigned should satisfy the applicable stability requirements of Part 3, Chapter 1, Section 1.4 in ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

Crafts with class notation **'LC'** or **‘HSLC’** shall also satisfy the requirements related to subdivision and arrangement, weathertight integrity and loadline indicated in Sections 6 and 7

1.1.2 In addition to 1.1.1 above, all craft should satisfy any other stability requirements specified by the Administration.

1.1.3 Other general requirements in respect of subdivision and arrangement, weathertight integrity and loadline are given in Section 5 and 6.

1.2 Definitions

1.2.1 For the purpose of this and other chapters, unless expressly defined otherwise, the following definitions apply.

1.2.2 **Down flooding point** means any opening, irrespective of size, that would permit passage of water through a water/weathertight structure (e.g. opening windows), but excludes any opening kept closed to an appropriate standard of water/weathertightness at all times other than when required for access or for operation of portable submersible bilge pumps in an emergency (e.g. non-opening windows of similar strength and weathertight integrity to the structure in which they are installed).

1.2.3 **Elsewhere** when applied to sill and coaming heights in 5.6 and 5.7 is taken as applying to all weathertight and watertight closures located on or below the datum.

1.2.4 **Fully submerged foil** means a foil having no lift components piercing the surface of the water in the foil borne mode.

1.2.5 **Monohull craft** means any craft which is not a multihull craft.

1.2.6 **Multihull craft** means a craft which in any normally achievable operating trim or heel angle, has a rigid hull structure which penetrates the surface of the sea over more than one discrete area.

1.2.7 **Permeability** of a space means the percentage of the volume of that space which can be occupied by water.

1.2.8 **Skirt** means a downwardly extending, flexible structure used to contain or divide an air cushion.

1.2.9 ∇ = volume of displacement corresponding to the design waterline [m^3].

1.3 Documentation

1.3.1 The following plans or documents are to be submitted for examination or approval of stability, as applicable:

a) Lines plan and offset table.

b) Hydrostatic tables, cross curve tables.

c) Data of all compartment and sub-compartment boundaries.

d) Position of all non-watertight and non-weathertight openings.

e) Stability investigation with input and output data including initial loading conditions.

f) Inclining test report.

g) Intact stability report, damage stability computations

h) Damage control plan.

Section 2

General Stability Requirements

2.1 General

2.1.1 A craft is to have:

a) Buoyancy and stability characteristics adequate for safety where the craft is operated in the displacement mode both in the intact condition and damaged condition;

b) Stability characteristics and stabilization system adequate for safety when the craft is operated in the non-displacement mode and during the transient mode;

c) Stability characteristics in the non-displacement and transient modes adequate to transfer the craft safely to displacement mode in case of any system malfunction.

2.1.2 Other means of demonstrating compliance with the requirements of any part of this chapter may be accepted, provided that the method chosen can be shown to provide an equivalent level of safety. Such methods may include:

a) mathematical simulation of dynamic behaviour;
b) scale model testing; and
c) full-scale trials.

The adequacy of mathematical simulations must first be demonstrated by correlation with full-scale or model tests for the appropriate type of craft. It may be appropriate to use mathematical simulations to help to identify the more critical scenarios for subsequent physical testing.

The model or full-scale tests and/or calculations (as appropriate) shall also include consideration of the following known stability hazards to which high-speed craft are known to be liable, according to craft type.

a) directional instability, which is often coupled with roll and pitch instabilities;

b) broaching and bow diving in following seas at speeds near to wave speed, applicable to most types;

c) bow diving of planing monohulls and catamarans due to dynamic loss of longitudinal stability in relatively calm seas;

d) reduction in transverse stability with increasing speed of monohulls;

e) porpoising of planing monohulls, being coupled pitch and heave oscillations, which can become violent;

f) chine tripping, being a phenomenon of planing monohulls occurring when the immersion of a chine generates a strong capsizing moment;

g) plough-in of air-cushion vehicles, either longitudinal or transverse, as a result of bow or side skirt tuck-under or sudden collapse of skirt geometry, which, in extreme cases, can result in capsize;

h) pitch instability of SWATH (small waterplane area twin hull) craft due to the hydrodynamic moment developed as a result of the water flow over the submerged lower hulls;

i) reduction in effective metacentric height (roll stiffness) of surface effect ships (SES) in high-speed turns compared to that on a straight course, which can result in sudden increases in heel angle and/or coupled roll and pitch oscillations; and

j) resonant rolling of SES in beam seas, which, in extreme cases, can result in capsize.

2.1.3 Suitable calculations shall be carried out and/or tests conducted to demonstrate that, when operating within approved operational limitations, the craft will, after a disturbance causing roll, pitch, heave or heel due to turning or any combination thereof, return to the original attitude.

Where calculations are employed, it shall first be shown that they correctly represent dynamic behaviour within the operational limitations of the craft.

2.2 Buoyant spaces

2.2.1 All crafts are to have a sufficient reserve of buoyancy at the design waterline to meet the intact and damage stability requirements of this chapter. The Administration may require a larger reserve of buoyancy to permit the craft to operate in any of its intended modes. This reserve of buoyancy should be calculated by considering:

a) watertight compartments situated below the datum, and;

b) watertight or weathertight compartments situated above the datum.

In considering the stability after damage, flooding shall be assumed to occur until limited by

(a) watertight boundaries in the equilibrium condition and

(b) weathertight boundaries in intermediate stages of flooding and within the range of positive righting lever required to satisfy the residual stability requirements.

Where a buoyant space is subjected to increased fluid pressure in the equilibrium position after damage, the boundaries and associated openings and penetrations of that space are to be designed and constructed to prevent the passage of fluid under that pressure.

2.2.2 Arrangements are to be provided for checking the watertight or weathertight integrity of all compartments considered for calculation of reserve buoyancy in paragraph 2.2.1.

2.3 Intact stability in the displacement mode

2.3.1 Hydrofoil craft fitted with surface-piercing foils and/or fully submerged foils are to have sufficient stability under all permitted cases of loading to comply with the relevant provisions of HSC Code Annex 6 (Annexure 4 of these rules) and specifically maintain a heel angle of less than 10^{o} when subjected to the greater of the heeling moments given in 1.1.2 and 1.1.4 of that annex.

2.3.2 Subject to 2.3.4, multihull craft should meet the relevant requirements of HSC Code Annex 7 (Annexure 5 of these rules) for all permitted conditions of loading.

2.3.3 Subject to 2.3.4 monohull craft other than hydrofoil craft are to meet the relevant requirements of HSC Code Annex 8 (Annexure 6 of these rules) in all permitted conditions of loading.

2.3.4 Where the characteristics of multihull craft are inappropriate for application of HSC Code annex 7 (annexure 5 of these rules) or the characteristics of monohull craft are inappropriate for application of HSC Code Annex 8 (Annexure 6 of these rules), alternative criteria equivalent to those stipulated as appropriate to the type of craft and area of operation may be accepted subject to the approval of the

Administration. The requirements of HSC Code Annexures 7 and 8 may be applied as indicated in the table below:

Table 2.3.4 : Application of HSC Code annexes 7 and 8 (annexures 5 and 6 of these rules) to monohull and multihull craft

GM_T	Angle of maximum GZ	
	≤ 25°	> 25°
≤ 3 m	annex 7 or annex 8	annex 8
> 3 m	annex 7	annex 7 or annex 8

where,

GZ = righting lever;

GM_T = transverse metacentric height in the loading condition corresponding to the design waterline, corrected for free surface effects [m].

2.4 Intact stability in the non-displacement mode

2.4.1 The requirements of this section and section 3.3 should be applied on the assumption that any stabilization systems fitted are fully operational.

2.4.2 The roll and the pitch stability on the first and/or any other craft of a series should be qualitatively assessed during operational safety trials as required by HSC Code - Chapter 18 and Annex 8. The result of such trials may indicate the need to impose operational limitations.

2.4.3 Where crafts are fitted with surface piercing structure or appendages, precautions should be taken against dangerous attitudes or inclinations and loss of stability subsequent to a collision with a submerged or floating object.

2.4.4 In designs where periodic use of cushion deformation is employed as a means of assisting craft control, or periodic use of cushion air exhausting to atmosphere for purposes of craft manoeuvring, the effects upon cushion-borne stability should be determined, and the limitations on the use by virtue of craft speed or attitude should be established.

2.4.5 In the case of an air cushion vehicle fitted with flexible skirts, it should be demonstrated that the skirts remain stable under operational conditions.

2.5 Intact stability in the transitional mode

2.5.1 For all weather conditions upto the worst intended conditions, the time to pass from the displacement mode to the non-displacement mode and vice versa should be minimal unless it is demonstrated that no substantial reduction of stability occurs during this transition.

2.5.2 Hydrofoil crafts are also to comply with the relevant provisions of HSC Code Annex 6 (Annexure 3 of these Rules).

2.6 Buoyancy and stability in the displacement mode following damage

2.6.1 The requirements of this section apply to all permitted conditions of loading.

2.6.2 For the purpose of making damage stability calculations the following volume and surface permeabilities are to be assumed in general.

Spaces	Permeability
Appropriated to cargo or stores	60
Occupied by accommodation	95
Occupied by machinery	85
Intended for liquids	0 or 95*
Appropriated for cargo vehicles	90
Voids spaces	95
* whichever results in the more severe requirements.	

2.6.3 Notwithstanding 2.6.2, permeability determined by direct calculation should be used where a more onerous condition results, and may be used where a less onerous condition results from that provided according to 2.6.2.

2.6.4 Administrations may permit the use of low density foam or other media to provide buoyancy in void spaces, provided that there is satisfactory evidence to show that any such proposed medium is the most suitable alternative and is:

a) of closed cell form if foam, or otherwise impervious to water absorption;

b) structurally stable under service conditions;

c) chemically inert in relation to structural materials with which it is in contact or other substances with which the medium is likely to be in contact (reference is made to Chapter 10, Clause 2.6.3.7);

d) properly secured in place and easily removable for inspection of the void spaces.

2.6.5 Void bottom spaces may be fitted within the watertight envelope of the hull without the provision of a bilge system or air pipes, subject to the approval of the Administration, provided that:

a) the structure is capable of withstanding the pressure head after any of the damages required by this section;

b) when carrying out a damage stability calculation in accordance with the requirements of this section, any void space adjacent to the damaged zone shall be included in the calculation and the criteria in 2.6, 3.4 and 4.1 are complied with;

c) the means by which water which has leaked into the void space is to be removed shall be included in the craft operating manual required by HSC Code chapter 18; and

d) adequate ventilation is provided for inspection of the space under consideration as required by 2.2.2.

Void spaces filled with foam or modular buoyancy elements are considered to be void spaces for the purposes of this paragraph, provided such foam or elements fully comply with 2.6.4.

2.6.6 Any damage of a lesser extent than that postulated in 2.6.7 to 2.6.10, as applicable, which would result in a more severe condition, should be also investigated.

2.6.7 The following side damages are to be assumed anywhere on the periphery of the craft:

a) the longitudinal extent of damage is to be 0.75 $\nabla^{1/3}$, or (3m + 0.225 $\nabla^{1/3}$) or 11 m, whichever is the least;

b) the transverse extent of penetration into the craft is to be 0.2 $\nabla^{1/3}$. However, where the craft is fitted with inflated skirts or with non-buoyant side structures, the transverse extent of penetration is to be at least 0.12 $\nabla^{1/3}$ into the main buoyancy hull or tank structure; and

c) the vertical extent of damage is to be taken for the full vertical extent of the craft.

The damages described in this paragraph shall be assumed to have the shape of a parallelepiped. Applying this to Fig.2.6.7a, the inboard face at its mid-length shall be tangential to, or otherwise touching in at least 2 places, the surface corresponding to the specified transverse extent of penetration, as illustrated in Fig.2.6.7.a.

Side damage shall not transversely penetrate a greater distance than the extent of 0.2$\nabla^{1/3}$ at the design waterline or the lesser extent given in 2.6.7b. (Refer to Fig. 2.6.7b and Fig.2.6.7c).

If considering a multihull, the periphery of the craft is considered to only be the surface of the shell encompassed by the outboard surface of the outermost hull at any given section.

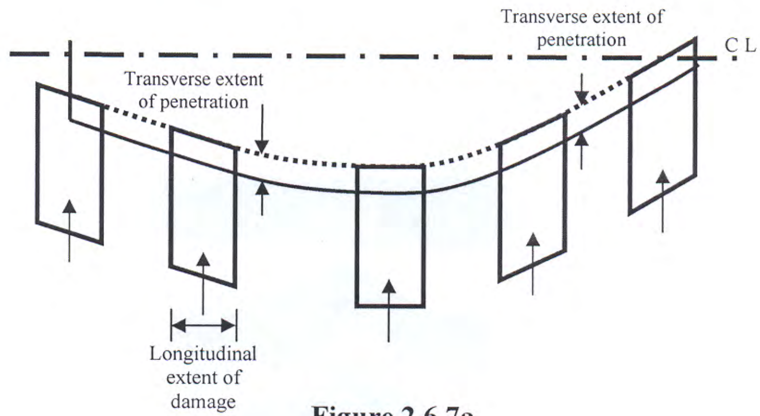


Figure 2.6.7a

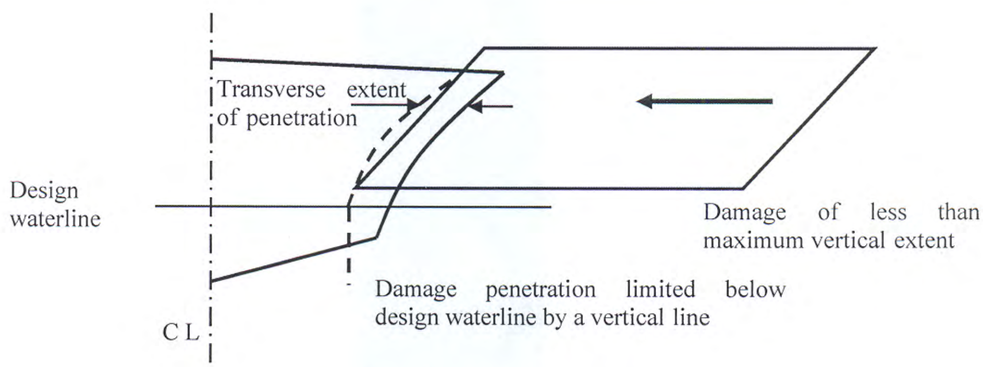


Figure 2.6.7 b

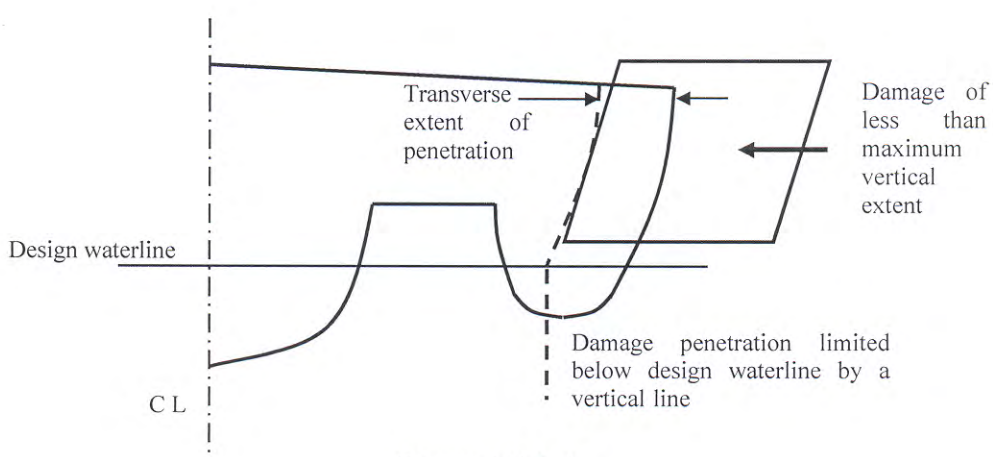


Figure 2.6.7 c"

2.6.8 Extent of bow and stern damage

2.6.8.1 The following extents of damage are to be applied to bow and stern, as illustrated in Fig.2.6.8:

a) at the fore end, damage to the area defined as A_{bow}, the aft limit of which being a transverse vertical plane, provided that this area need not extend further aft from the forward extremity of the craft's watertight envelope than the distance defined in 2.6.7a) and

b) at the aft end, damage to the area aft of a transverse vertical plane at a distance $0.2\nabla^{1/3}$ forward of the aft extremity of the watertight envelope of the hull.

A_{bow} = 0.0035 A m f V, but not les than 0.04A

where,

A_{bow} is the plan projected area of craft energy absorbing structure forward of the transverse plane [m^2] (See Fig.2.6.8).

A = total plan projected area for the full length of the craft [m^2]

m = material factor = 0.95/M

M = 1.3 for high-tensile steel

= 1.0 for aluminium alloy

= 0.95 for mild steel

= 0.8 for fibre reinforced plastics.

Where materials are mixed, the material factor is to be taken as a weighted mean, weighted according to the mass of material in the area defined by A_{bow}.

f = framing factor

= 0.8 for longitudinal deck and shell stiffening

= 0.9 for mixed longitudinal and transverse stiffening

= 1.0 for transverse deck and shell stiffening

V = 90% of maximum speed [knots].

2.6.8.2 The provisions of 2.6.6 in relation to damage of lesser extent remain applicable to such damage.

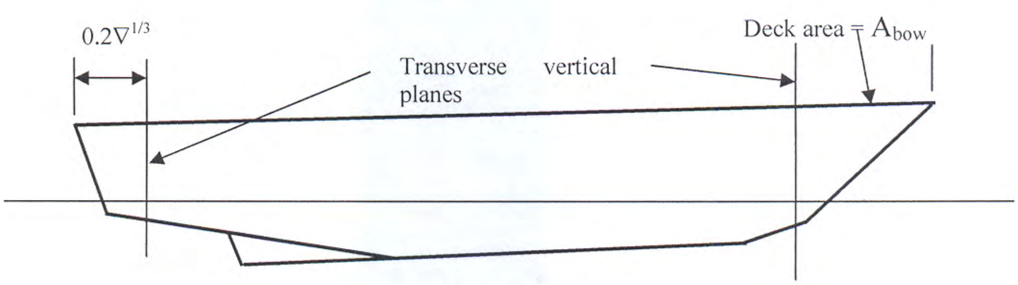


Figure 2.6.8"

2.6.9 Extent of bottom damage in areas vulnerable to raking damage

2.6.9.1

a) Any part of the surface of the hull(s) is considered to be vulnerable to raking damage if:

i) it is in contact with the water at 90% of maximum speed in smooth water, and

ii) it also lies below two planes represented by lines AB and BC in Fig.2.6.9.1, which are perpendicular to the craft centreline plane and at heights as shown in the figure.

For multihulls, individual hulls shall be considered separately.

b) Raking damage shall be assumed to occur along any fore-and-aft line on the surface of the hull(s) between the keel and the upper limit defined in the Figure 2.6.9.1:

where,

T = maximum draught of the hull (each hull considered individually in the case of multihulls) to the design waterline, excluding any non-buoyant structure.

Structures such as single plate skegs or solid metal appendages are to be considered to be non-buoyant and thus excluded.

c) Damage shall not be applied at the same time as that defined in 2.6.7 or 2.6.9.

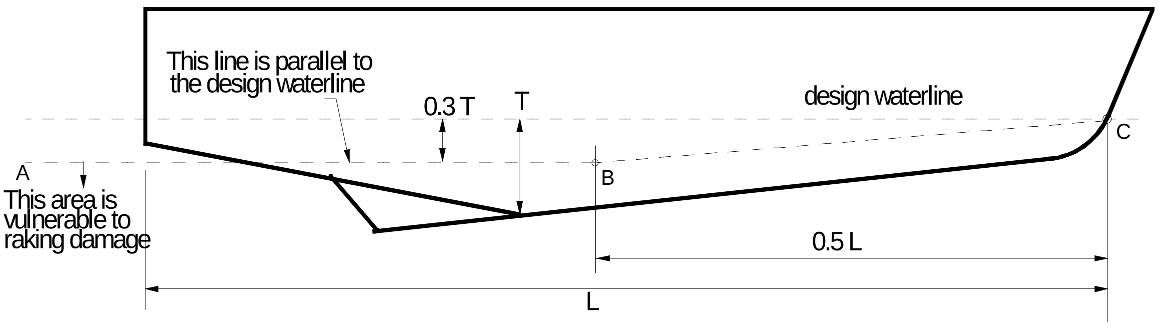


Fig.2.6.9.1

2.6.9.2 Extent

a) Two different longitudinal extents shall be considered separately:

i) 55% of the length L, measured from the most forward point of the underwater buoyant volume of each hull; and

ii) a percentage of the length L, applied anywhere in the length of the craft, equal to 35% for craft where L = 50 m and over and equal to (L/2+10)% for craft where L is less than 50 m.

b) Except as provided below, the penetration normal to the shell shall be 0.04 $\nabla^{1/3}$, or 0.5 m, whichever is the lesser, in association with an athwartship girth along the shell equal to 0.1 $\nabla^{1/3}$, where ∇ is the volume of displacement corresponding to the design waterline [m^3]. However, this penetration or girth shall under no circumstances extend above the vertical extent of the vulnerable area as specified in 2.6.9.1 a).

c) The shape of damage is to be assumed to be rectangular in the transverse plane as illustrated in Fig.2.6.9.2. Damage is to be assumed at a series of sections within the defined longitudinal extent in accordance with Fig.2.6.9.2, the mid-point of the damaged girth being maintained at a constant distance from the centerline throughout that longitudinal extent.

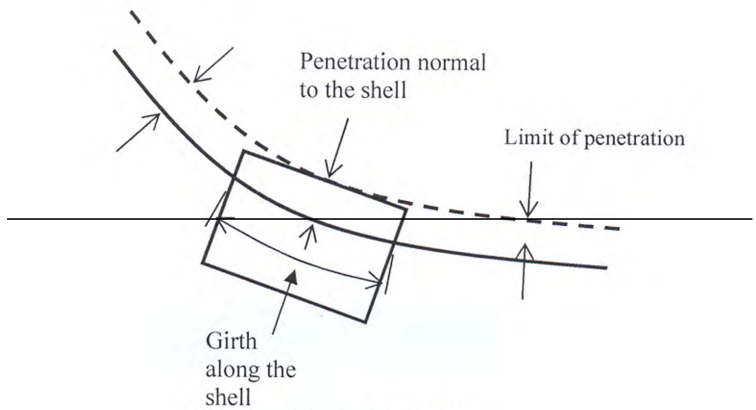


Figure 2.6.9.2"

2.6.10 Extent of bottom damage in areas not vulnerable to raking damage

2.6.10.1

This applies to all parts of the hull(s) below the design waterline which are not defined as vulnerable to raking damage in 2.6.9.1. Damage shall not be applied at the same time as that defined in 2.6.7, 2.6.8 or 2.6.9.

2.6.10.2 Extent

The following extent of damage shall be assumed:

a) the length of damage in the fore-and-aft direction shall be $0.75\nabla^{1/3}$ or (3 m $+ 0.225\ \nabla^{1/3}$), or 11 m whichever is the least;

b) the athwartships girth of damage shall be $0.2\nabla^{1/3}$; and

c) the depth of penetration normal to the shell shall be $0.02\nabla^{1/3}$.

d) the shape of damage shall be assumed to be rectangular in the plane of the shell of the craft and rectangular in the transverse plane as illustrated in Fig.2.6.9.2.

2.6.11 In applying 2.6.9 and 2.6.10 to multihull craft, an obstruction at or below the design waterline of upto 7 [m] width shall be considered in determining the number of hulls damaged at any one time. The requirement of 2.6.6 shall also be applied.

2.6.12 Following any of the postulated damages detailed in 2.6.6 to 2.6.11, the craft in still water shall have sufficient buoyancy and positive stability to simultaneously ensure that:

a) for all craft other than amphibious air-cushion vehicles, after flooding has ceased and state of equilibrium has been reached, the final waterline is below the level of any opening through which further flooding could take place by at least 50% of the significant wave height corresponding to the worst intended conditions;

b) for amphibious air-cushion vehicles, after flooding has ceased and a state of equilibrium has been reached, the final waterline is below the level of any opening through which further flooding could take place by at least 25% of the significant wave height corresponding to the worst intended conditions;

c) there is a positive freeboard from the damage waterline to survival craft embarkation positions;

d) essential emergency equipment, emergency radios, power supplies and public address systems needed for organising the evacuation remain accessible and operational; and

e) the residual stability of craft meets the appropriate criteria as laid out in HSC Code annexes 7 and 8 according to Table 2.3.4.

2.6.13 Downflooding openings referred to in 2.6.12 a) and 2.6.12. b) shall include doors and hatches which are used for damage control or evacuation procedures, but may exclude those which are closed by means of weathertight doors and hatch covers and not used for damage control or evacuation procedures.

2.7 Inclining and stability information

2.7.1 Every craft on completion of build is to be inclined and the elements of its stability determined. When an accurate inclining is not practical the lightship displacement and centre of gravity may be determined by a lightweight survey and accurate calculation subject to agreement by the Statutory Authority.

2.7.2 On all craft, where an accurate inclining experiment is impractical owing to the height of the center of gravity (VCG or KG) being less than one third of the transverse metacentric height (GM_T), the Administration may accept estimation of KG by detailed calculation in place of an inclining experiment. In such cases, a displacement check shall be undertaken to confirm the calculated lightship characteristics, including LCG, which may be accepted if the measured lightship displacement and LCG are respectively within 2% and 1% L relative to the estimate.

2.7.3 The master is to be supplied by the owner with reliable information relating to the stability of the craft which has been approved by the Administration incorporating such additions and amendments as the Administration may in any particular case may have required.

2.7.4 Where any alterations are made to a craft so as materially to affect the stability information supplied to the master, amended stability information is to be provided. If necessary, the craft is to be re-inclined.

2.7.5 A report of each inclining or lightweight survey carried out in accordance with this Chapter and of the calculation therefrom of the lightship condition particulars is to be submitted to the Administration for approval, together with a copy for their retention. The approved report is to be placed on board the craft by the owner in the custody of the master and is to incorporate such additions and amendments as the Administration may in any particular case require. The amended lightship condition particulars so obtained from time to time is to be used by the master in substitution for such previously approved particulars when calculating the craft's stability.

2.7.6 The above mentioned stability information demonstrating compliance with this chapter is to be furnished in the form of a stability information book to be kept on board the craft at all times in the custody of the master. The information is to include particulars appropriate to the craft and must reflect the craft's loading conditions and mode of operation. Any enclosed superstructures or deckhouses included in the cross curves of stability and the critical downflooding points and angles is to be identified.

2.7.7 Every craft is to have scales of draughts marked permanently and clearly at the bow and stern. Accuracy of the draught marks should be demonstrated to the Administration prior to the inclining experiment. In the case where the draught marks are not located where they are easily readable, or operational constraints for a particular trade make it difficult to read the draught marks, then the craft is also be fitted with a reliable draught indicating system by which the bow and stern draughts can be determined.

For amphibious air-cushion vehicles this may be achieved by the use of draught gauges in conjunction with deck datum plates.

2.8 Loading and stability assessment

On completion of loading of the craft and prior to its departure on a voyage, the craft's trim and stability is to be determined and recorded by the master in order to ascertain that the craft is in compliance with stability criteria of the relevant requirements. The Administration may accept the use of an electronic loading and stability computer or equivalent means for this purpose.

2.9 Damage control plan

2.9.1 A damage control plan is to be permanently exhibited or readily available on the navigating bridge and is to include inboard profile, plan views of each deck and transverse section necessary to show the following:

a) the watertight boundaries of the ship,

b) the locations and arrangements of cross flooding systems if any,

c) the locations of all internal watertight closing appliances and their local and remote controls, position indicators and alarms. Information regarding the usage of doors such as ‘open while at sea’, ‘not used while at sea’ etc. should be clearly indicated,

d) the locations of all doors on the shell of the craft, position indicators, leakage detectors and surveillance devices,

e) the locations of all weathertight closing appliances in local subdivision boundaries above the bulkhead deck and on the lowest exposed weather decks, their controls and position indicators if any,

f) the locations of all bilge and ballast pumps, their control positions and associated valves.

2.9.2 The above information is to be repeated in a damage control booklet to be kept on board the craft. The damage control booklet is to also include instructions for controlling the effects of damage in detail.

2.10 Marking and recording of the design waterline

2.10.1 The design waterline shall be clearly and permanently marked on the craft's outer sides by the load line mark described below. This and the reference line described in 2.10.2.2 below shall be recorded in the High Speed Craft Safety Certificate. For craft where this is not practical, e.g. amphibious air-cushion vehicles fitted with peripheral skirts, defined deck reference points shall be provided from which the freeboard can be measured and hence the draughts obtained.

2.10.2 Loadline mark

2.10.2.1 The loadline mark shall consist of a ring with an outside diameter of 300 [mm] and width of 25 [mm] which is intersected by a horizontal line of length 450 mm and having a breadth of 25 [mm], the upper edge of which passes through the centre of the ring. The centre of the ring shall be placed at the longitudinal centre of flotation in the displacement mode and at a height corresponding to the design waterline.

2.10.2.2 To assist in verifying the position of the load line mark, a reference line shall be marked on the hull at the longitudinal centre of flotation by a horizontal bar having a length of 300 mm and a breadth of 25 [mm] and having the upper edge corresponding to the reference line.

2.10.2.3 Where practicable, the reference line shall be related to the uppermost deck at side. Where it is not possible, the position of the reference line shall be defined from the underside of keel at the longitudinal centre of flotation.

2.10.2.4 The mark of the Authority by whom the load lines, are assigned may be indicated alongside the load line ring above the horizontal line which passes through the centre of the ring, or above and below it. This mark shall consist of not more than four initials to identify the Authority's name, each measuring approximately 115 mm in height and 75 mm in width.

2.10.2.5 The ring, lines and letters shall be painted in white or yellow on a dark ground or in black on a light ground and permanently marked. The marks shall be plainly visible.

2.10.3 Verification

The High Speed Craft Safety Certificate would not be issued until it is verified that the marks are correctly and permanently indicated on the sides of the craft.

Section 3

Requirements for Stability of Passenger Craft

3.1 General

For determination of the effects of passenger weight, on stability, the following information is to be assumed:

a) The distribution of passengers is 4 persons per square metre.
b) Each passenger has a mass of 75 kg.
c) Vertical centre of gravity of seated passengers is 0.3 m above seat.
d) Vertical centre of gravity of standing passengers is 1.0 m above deck.
e) Passengers and luggage are considered to be in the space normally at their disposal.
f) Passengers are distributed on available deck areas towards one side of the craft on the decks where assembly stations are located and in such a way that they produce the most adverse heeling moment.
g) Passengers assumed to be occupying seats are to be taken as having a vertical center of gravity corresponding to being seated, with all others standing.
h) On the decks where assembly stations are located, the number of passengers on each deck shall be that which generates the maximum heeling moment. Any remaining passengers shall be assumed to occupy decks adjacent to those on which the assembly stations are located and positioned such that the combination of number on each deck and total heeling moment generate the maximum static heel angle.
i) Passengers are not to be assumed to gain access to the weather deck nor be assumed to crowd abnormally towards either end of the craft unless this is a necessary part of the planned evacuation procedure.
j) Where there are seats in areas occupied by passengers, one passenger per seat shall be assumed, passengers being assigned to the remaining free areas of the deck (including stairways, if appropriate) at the rate of four per square meter.

3.2 Intact stability in the displacement mode

The craft is to have sufficient intact stability that, when in still water conditions, the inclination of the craft from the horizontal would not exceed 10^o under all permitted cases of loading and uncontrolled passenger movements as may occur.

3.3 Intact stability in the non-displacement mode

3.3.1 The total heel angle in still water due to be effect of passenger movements and due to beam wind pressure as per 1.1.4 of HSC Code (Annexure 4 of these rules) Annex 6 is not to exceed 10^o. Passenger movement need not be considered where passengers are required to be seated whenever the craft is operating in the non-displacement mode.

3.3.2 In all loading conditions, the outward heel due to turning is not to exceed 8^o, and the total heel due to beam wind pressure as per 1.1.4 of HSC Code Annex 6 (Annexure 4 of these Rules) and due to turning is not to exceed 12^o outward.

3.3.3 Demonstrating the effect of the passenger heeling moment calculated as given in 3.1 above, or a defined beam wind pressure when at speed, shall be established by conducting a trial or model test with an equivalent heeling moment applied by test weights. Passenger movement may only be neglected on craft where the safety announcement expressly requires passengers to remain seated throughout the voyage.

3.4 Buoyancy and stability in the displacement mode following damage

3.4.1 Following any of the postulated damages detailed in 2.6.6 to 2.6.10, in addition to satisfying the requirements in 2.6.11 and 2.6.12, the craft in still water is to have sufficient buoyancy and positive stability to simultaneously ensure that:

a) the angle of inclination of the craft from the horizontal does not normally exceed 10^o in any direction. However, where this is clearly impractical angles of inclination up to 15^o immediately after damage but reducing to 10^o within 15 min. may be permitted provided that efficient non-slip deck surfaces and suitable holding points, e.g. holes, bars, etc., are provided; and

b) any flooding of passenger compartments or escape route which might occur will not significantly impede the evacuation of passengers;

3.4.2 In addition to the requirements in 3.4.1, category B craft shall also satisfy the following criteria after sustaining raking damage of 100% of length L, having the girth and penetration given in 2.6.8.2 b) to any part of the surface of the hull(s) defined in 2.6.8.1:

a) the angle of inclination of the craft from the horizontal shall not exceed 20° in the equilibrium condition;

b) the range of positive righting lever shall be at least 15° in the equilibrium condition;

c) the positive area under the righting lever curve shall be at least 0.015 m-rad in the equilibrium condition;

d) the requirements of 2.6.11c) and 3.4.1b) are satisfied; and

e) in intermediate stages of flooding, the maximum righting lever shall be at least 0.05 m and the range of positive righting lever shall be at least 7°.

In complying with the above, the righting lever curve shall be terminated at the angle of downflooding and only one free surface need be assumed.

3.5 Inclining and stability information

3.5.1 At periodical intervals not exceeding five years, a lightweight survey is to be carried out on all passenger craft to verify any changes in lightweight displacement and longitudinal centre of gravity. The passenger craft is to be re-inclined whenever, in comparison with the approved stability information, a deviation from the lightweight displacement exceeding 2% or a deviation of the longitudinal centre of gravity exceeding 1% of L is found or anticipated.

Section 4

Requirements for Stability of Cargo Craft

4.1 Buoyancy and stability in the displacement mode following damage

Following any of the postulated damages detailed in 2.6.6 to 2.6.10, in addition to satisfying the requirements of 2.6.11 and 2.6.12, the craft in still water is to have sufficient buoyancy and positive stability to simultaneously ensure that the angle of inclination of the craft from the horizontal does not normally exceed 15^o in any direction. However, where this is clearly impractical, angles of inclination upto 20^o immediately after damage but reducing to 15^o within 15 min. may be permitted provided that efficient non-slip deck surface and suitable holding points, e.g. holes, bars, etc., are provided.

4.2 Inclining

Where it is satisfied by lightweight survey, weighting or other demonstration, that the lightweight of a craft is closely similar to that of another craft of the series to which 2.7.1 has been applied, the Administration may waive the requirement of 2.7.1 for craft to be inclined. In this regard, a craft which lies within the parameters of 3.5.1, when compared with a craft of the series which has been inclined, is to be regarded as being closely similar to that craft.

Section 5

Watertight and Weathertight Integrity

5.1 Openings in watertight divisions

5.1.1 The number of openings in watertight bulkheads shall be kept at the minimum compatible with the design and proper working of the craft and all such doors shall be closed prior to departure of the craft from the berth.

5.1.2 Doors in watertight bulkheads may be hinged or sliding. They shall be shown by suitable testing to be capable of maintaining the watertight integrity of the bulkhead. Such testing shall be carried out for both sides of the door and shall apply a pressure head 10% greater than that determined from the minimum permissible height of a downflooding opening. (Refer to 2.6.12) Testing may be carried out either before or after the door is fitted into the craft but, where shore testing is adopted, satisfactory installation in the craft shall be verified by inspection and hose testing.

5.1.3 Type approval may be accepted in lieu of testing individual doors, provided the approval process includes pressure testing to a head equal to, or grater than, the required head (Refer to 5.1.2).

5.1.4 All watertight doors shall be capable of being operated when the craft is inclined upto 15°, and shall be fitted with means of indication in the operating compartment showing whether they are open or closed. All such doors shall be capable of being opened and closed locally from each side of the bulkhead.

5.1.5 Watertight doors shall remain closed when the craft is at sea, except that they may be opened for access. A notice shall be attached to each door to the effect that it is not to be left open.

5.1.6 Watertight doors shall be capable of being closed by remote control from the operating compartment in not less than 20s and not more than 40s, and shall be provided with an audible alarm, distinct from other alarms in the area, which will sound for at least 5s but no more than 10s before the doors begin to move whenever the door is closed remotely by power and continue sounding until the door is completely closed. The power, control and indicators shall be operable in the event of main power failure, as required by regulation II-1/15.7.3 of SOLAS. In passenger areas and areas where the ambient noise exceeds 85 dB(A) the audible alarm shall be supplemented by an intermittent visual signal at the door. Where such doors are essential for the safe work of the craft, hinged watertight doors having only local control may be accepted for areas to which crew only have access, provided they are fitted with remote indicators as required by 5.1.4.

5.1.7 Where pipes, scuppers, electric cables, etc. are carried through watertight divisions, the arrangements for creating a watertight penetration shall be of a type which has been prototype tested under hydrostatic pressure equal to or greater than that required to be withstood for the actual location in the craft in which they are to be installed. The test pressure shall be maintained for at least 30 min and there must be no leakage through the penetration arrangement during this period. The test pressure head shall be 10% greater than that determined from the minimum permissible height of a downflooding opening. Watertight bulkhead penetrations which are effected by continuous welding do not require prototype testing.

5.1.8 Where a ventilation trunk forms part of a watertight boundary, the trunk shall be capable of withstanding the water pressure that may be present, taking into account the maximum inclination angle allowable during all stages of flooding.

5.2 Inner bow doors

5.2.1 Where ro-ro craft are fitted with bow loading openings, an inner bow door shall be fitted abaft such openings to restrict the extent of flooding in the event of failure of the outer closure. This inner bow door, where fitted, shall be:

a) weathertight to the deck above, which deck shall itself be weathertight forward to the bow loading opening;

b) so arranged as to preclude the possibility of a bow loading door causing damage to it in the case of damage to, or detachment of, the bow loading door;

c) forward of all positions on the vehicle deck in which vehicles are intended to be carried; and

d) part of a boundary designed to prevent flooding into the remainder of the craft.

5.2.2 A craft may be exempted from the requirement of fitting such an inner bow door where requirements given in at least one of the following clauses 5.2.2.1 to 5.2.2.4, are complied with.

5.2.2.1 The vehicle loading deck at the inner bow door position is above the design waterline by a height more than the significant wave height corresponding to the worst intended conditions.

5.2.2.2 It is demonstrated, using model tests or mathematical simulations, that when the craft is proceeding at a range of speeds upto the maximum attainable speed in the loaded condition at all headings in long crested seas of the greatest significant wave height corresponding to the worst intended conditions, either:

a) the bow loading door is not reached by waves; or

b) having been tested with the bow loading door open to determine the maximum steady-state volume of water which accumulates, it is shown by static analysis that, with the same volume of water on the vehicle deck(s), the residual stability requirements are satisfied. If the model tests or mathematical simulations are unable to show that the volume of water accumulated reaches a steady state, the craft shall be considered not to have satisfied the conditions of this exemption.

   Details of mathematical simulation methods employed are to be submitted alongwith validations made against full-scale or model testing.

5.2.2.3 Bow loading openings lead to open ro-ro spaces that are provided with guardrails or freeing ports complying with 5.2.2.4.

5.2.2.4 The deck of the lowest ro-ro space above the design waterline is fitted on each side of the deck with freeing ports evenly distributed along the sides of the compartment. These shall either be proven to be acceptable using tests according to 5.2.2.2 above or comply with a) to d) below:

a) $A \geq 0.3l$

where,

A = the total area of freeing ports on each side of the deck in m^2; and

l = the length of the compartment [m];

b) the craft shall maintain a residual freeboard to the deck of the ro-ro space of at least 1 [m] in the worst condition;

c) such freeing ports shall be located within the height of 0.6 [m] above the deck of the ro-ro space and the lower edge of the ports shall be within 0.02 [m] above the deck of the ro-ro space; and

d) such freeing ports shall be fitted with closing devices or flaps to prevent water entering the deck of the ro-ro space whilst allowing water which may accumulate on the deck of the ro-ro space to drain.

5.3 Other provisions for ro-ro craft

5.3.1 The distance of the lowest point of all accesses in the ro-ro space that lead to spaces below the deck, measured above the design waterline, is not to be less than the height required from the tests conducted according to 5.2.2.2 or 3 m, whichever is higher.

5.3.2 Where vehicle ramps are installed to give access to spaces below the deck for the ro-ro space, their openings shall be capable of being closed weathertight to prevent ingress of water below.

5.3.3 Accesses situated at distances lower than that required by 5.3.1 may be accepted provided they are watertight and are closed before the craft leaves the berth on any voyage and remain closed until the craft is at its next berth.

5.3.4 The accesses accessed as per 5.3.2 and 5.3.3 above shall be fitted with alarm indicators in the operating compartment.

5.3.5 Special category spaces and ro-ro spaces shall be patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access by passengers thereto can be detected whilst the craft is under way (Refer Ch.10, 2.10.3).

5.4 Indicators and surveillance

5.4.1 Indicators

Indicators shall be provided in the operating compartment for all shell doors, loading doors and other closing appliances which, if left open or not properly secured, could lead to major flooding in the intact and damage conditions. The indicator system shall be designed on the fail-safe principle and shall show by visual alarms if the door is not fully closed or if any of the securing arrangements are not in place and fully locked and by audible alarms if such door or closing appliance becomes open or the securing arrangements become unsecured. The indicator panel in the operating compartment shall be equipped with a mode-selection function 'harbour / sea voyage' so arranged that an audible alarm is given in the operating compartment if the craft leaves harbour with the bow doors, inner doors, stern ramp or any other side shell doors not closed or any closing device not in the correct position. The power supply for the indicator system shall be independent of the power supply for operating and securing the doors.

5.4.2 Television surveillance

Television surveillance and a water leakage detection system shall be arranged to provide an indication to the operating compartment and to the engine control station of any leakage through inner and outer bow doors, stern doors or any other shell doors which could lead to major flooding.

5.5 Integrity of superstructure

5.5.1 Where entry of water into structures above the datum would significantly influence the stability and buoyancy of the craft, such structures shall be:

a) of adequate strength to maintain the weathertight integrity and fitted with weathertight closing appliances; or
b) provided with adequate drainage arrangements; or
c) an equivalent combination of both measures.

5.5.2 Weathertight superstructures and deckhouses located above the datum shall, in the outside boundaries, have means of closing openings with sufficient strength such as to maintain weathertight integrity in all damage conditions where the space in question is not damaged. Furthermore, the means of closing shall be such as to maintain weathertight integrity in all operational conditions.

5.6 Doors, windows, etc. in boundaries of weathertight spaces

5.6.1 Doors, windows, etc. and any associated frames and mullions in weathertight superstructures and deckhouses shall be weathertight and shall not leak or fail at a uniformly applied pressure less than that at which the adjacent structure would experience permanent set or fail.

5.6.2 For doors in weathertight superstructures, hose tests shall be carried out with a minimum pressure of in the hose of at least 0.2 [N/mm^2] applied at a maximum distance of 1.5 [m]. The nozzle diameter of the hose is not to be less than 12 [mm].

5.6.3 The height above the deck of sills to doorways leading to exposed decks shall be as high above the deck as is reasonable and practicable, particularly those located in exposed positions. Such sill heights shall in general not be less than 100 [mm] for doors to weathertight spaces on decks above the datum and 250 [mm] elsewhere. For craft of 30 [m] in length and under and having service area notation RS3, smaller values of sill height may be specially considered.

5.6.4 Windows are not acceptable in the boundaries of special category spaces or ro-ro spaces or below the datum. If required by restrictions in the Permit to Operate, forward-facing windows, or windows which may be submerged at any stage of flooding, shall be fitted with hinged or sliding storm shutters ready for immediate use.

5.6.5 Sidescuttles to spaces below the datum shall be fitted with efficient hinged deadlights arranged inside so that they can be effectively closed and secured watertight.

5.6.6 No sidescuttles shall be fitted in a position so that its sill is below a line drawn parallel to and one metre above the design waterline.

5.7 Hatchways and other openings

5.7.1 Hatchways closed by weathertight covers

The construction and the means for securing the weathertightness of cargo and other hatchways shall comply with the following:

a) coaming heights shall in general not be less than 100 [mm] for hatches to weathertight spaces on decks above the datum and 250 [mm] elsewhere. For craft of 30 [m] in length and under and having service area notation RS3, smaller values of coaming height may be specially considered.

b) the height of these coamings may be reduced, or the coamings omitted entirely, on condition that the safety of the ship is not thereby impaired in any sea conditions upto the worst intended conditions subject to approval of the Administration. Where coamings are provided, they shall be of substantial construction; and

c) the arrangements for securing and maintaining weathertightness shall ensure that the tightness can be maintained in any sea conditions upto the worst intended conditions.

5.7.2 Machinery space openings

5.7.2.1 Machinery space openings shall be properly framed and efficiently enclosed by casings of ample strength. Where the casings are not protected by other structures, their strength shall meet the requirements for exposed deck house bulkheads. Access openings in such casings shall be fitted with weathertight doors.

5.7.2.2 Heights of sills and coaming shall, in general, not be less than 100 [mm] for openings to weathertight spaces on decks above the datum and 380 [mm] elsewhere. For craft of 30 [m] in length and under and having service area notation RS3, smaller values of sill and coaming heights may be specially considered.

5.7.2.3 Machinery space ventilator openings shall comply with the requirements of 5.7.4.2.

5.7.3 Miscellaneous openings in exposed decks

5.7.3.1 Manholes and flush scuttles on the datum or within superstructures other than enclosed superstructures shall be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers shall be permanently attached.

5.7.3.2 Service hatches to machinery, etc. may be arranged as flush hatches provided that the covers are secured by closely spaced bolts, are kept closed at sea and are equipped with arrangements for portable guardrails.

5.7.3.3 Openings in exposed decks leading to spaces below the datum or enclosed superstructures other than hatchways, machinery space openings, manholes and flush scuttles shall be protected by an enclosed superstructure or by a deckhouse or companionway of equivalent strength and weathertightness.

5.7.3.4 The height above the deck of sills to the doorways in companionways shall, in general, not be less than 100 [mm] for doors to weathertight spaces on decks above the datum and 250 [mm] elsewhere. For craft of 30 [m] in length and under and having service area notation RS3, smaller values of sill height may be specially considered.

5.7.4 Ventilators

5.7.4.1 Ventilators to spaces below the datum or decks of enclosed superstructures shall have substantially constructed coamings efficiently connected to the deck. Coaming heights shall in general not be less than 100 [mm] for ventilators to weathertight spaces on decks above the datum and 380 [mm] elsewhere. For craft of 30 [m] in length and under and having service area notation RS3, smaller values of coaming height may be specially considered.

5.7.4.2 Ventilators the coamings of which extend to more than one metre above the deck or which are fitted to decks above the datum need not be fitted with closing arrangements unless they face forward or are specifically required by the Administration.

5.7.4.3 Except as provided in 5.7.4.2, ventilator openings shall be provided with efficient weathertight closing appliances.

5.7.4.4 Ventilator openings shall face aft or athwartships whenever practicable.

5.8 Scuppers, inlets and discharges

5.8.1 Discharges led through the shell either from spaces below the datum or from within superstructures and deckhouses fitted above the datum shall be fitted with efficient and accessible means for preventing water from passing inboard. Normally each separate discharge shall have one automatic non-return valve with a positive means of closing it from a position above the datum. Where however, the vertical distance from the design waterline to the inboard end of the discharge pipe exceeds 0.01L, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions. Where the vertical distance exceeds 0.02L, a single automatic non-return valve without positive means of closing may be accepted. The means for operating the positive-action valve shall be readily accessible and provided with an indicator showing whether the valve is open or closed.

5.8.2 Valves on scuppers from weathertight compartments included in the stability calculations shall be operable from the operating compartment.

5.8.3 In manned machinery spaces, main and auxiliary sea inlets and discharges in connection with the operation of machinery may be controlled locally. Such controls shall be readily accessible and shall be provided with indicators showing whether the valves are open or closed. In unmanned machinery spaces, main and auxiliary sea inlets and discharge controls in connection with the operation of machinery shall either:

a) be located at least 50% of the significant wave height corresponding to the worst intended conditions above the deepest flooded waterline following damage specified in 2.6.6 to 2.6.10; or

b) be operable from the operating compartment.

5.8.4 Scuppers leading from superstructures or deckhouses not fitted with weathertight doors shall be led overboard.

5.8.5 All shell fittings and the valves required above shall be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable. Materials are to satisfy the requirements given in Pt.2 of *Rules and Regulations for the Construction and Classification of Steel Ships.*

5.9 Air pipes

5.9.1 Main storage tanks containing flammable liquids or tanks which can be pumped or filled from the sea shall have air pipes which do not terminate in enclosed spaces.

5.9.2 All air pipes extending to exposed decks shall have a minimum height measured from the deck to the point where water may have access below as follows:

– 300 [mm] where the deck is less than 0.05L above the design waterline; and

– 150 [mm] on all other decks.

5.9.3 Air pipes may discharge through the side of the superstructure provided that this is at a height of at least 0.02L above any waterline when the intact craft is heeled to an angle of 15°, or 0.02L above the highest waterline at all stages of flooding as determined by the damage stability calculations, whichever is higher.

5.9.4 All air pipes shall be equipped with weathertight closing appliances of approved automatic type.

5.10 Freeing ports

5.10.1 Where bulwarks on weather decks form wells, ample provision shall be made for rapidly freeing the decks of water and for draining them. The minimum freeing port area (A) one each side of the craft for each well on the weather deck of the main hull(s) shall be:

a) where the length of bulwark (l) in the well is 20 [m] or less:

$A = 0.7 + 0.035l$ [m^2]; and

b) where l exceeds 20 [m]:

$A = 0.07l$ [m^2],

and, in no case, l need be taken as greater than 0.7L.

If the bulwark is more than 1.2 [m] in average height, the required area shall be increased by 0.004 [m^2] per [m] of length of well for each 0.1 [m] difference in height. If the bulwark is less than 0.9 [m] in average height, the required area shall be decreased by 0.004 [m^2] per metre of length of well for each 0.1 [m] difference in height.

5.10.2 Such freeing ports shall be located within the height of 0.6 [m] above the deck and the lower edge shall be within 0.02 [m] above the deck.

5.10.3 All such openings in the bulwarks shall be protected by rails or bars spaced approximately 230 [mm] apart. If shutters are fitted to freeing ports, ample clearance shall be provided to prevent jamming. Hinges shall have pins or bearings of non-corrodible material. If shutters are fitted with securing appliances, these appliances shall be of approved construction.

5.10.4 In crafts having superstructures which are open at front or both ends, the minimum freeing port area shall be as required by 5.10.1. In crafts having superstructures which are open at the aft end, the minimum freeing port area shall be:

$A = 0.3\ b\ [m^2]$

where,

b = the breadth of the craft at the exposed deck [m].

5.10.5 Ro-ro craft fitted with bow loading openings leading to open vehicle spaces shall comply with the provisions of 5.2.

Section 6

Subdivision and Arrangement

6.1 Applicability

6.1.1 The requirements of 6.2 and 6.3 applies to crafts with class notation **'LC'** or **'HSLC'** only. Other requirements in the section apply to all crafts.

6.2 Transverse bulkheads for craft with 'LC' or 'HSLC' notation

6.2.1 The following transverse watertight bulkheads are to be fitted in all ships:

- A collision bulkhead
- An aftpeak bulkhead
- A bulkhead at each end of the machinery space.

Additional bulkheads, as necessary to satisfy any applicable Damage Stability requirements are to be fitted at suitable locations.

6.2.2 The watertight bulkheads are in general to extend to the freeboard deck. The afterpeak bulkhead may terminate at the fore deck above the loadwater line provided that the deck is made watertight to the stern or to a watertight transom floor.

6.2.3 The collision bulkhead is normally to extend to the uppermost continuous deck or, in the case of ships with a long superstructure that includes a forecastle, to the superstructure deck.

6.2.4 For craft with two continuous decks and a large freeboard to the uppermost deck with the second deck above design waterline, all bulkheads except the collision bulkhead may be terminated at the second deck.

6.2.5 The distance x_c from the forward perpendicular to the collision bulkhead is to be between the following limits:

x_c (minimum) = 0.05L [m]
x_c (maximum) = 3.0 + 0.05L [m]

However, positioning of collision bulkhead aft of the above limits may be considered if calculation showing that with the craft loaded to design waterline, flooding of the space forward of the collision bulkhead will not result in any part of the freeboard deck becoming submerged or result in any unacceptable loss of stability.

6.2.6 Any recesses or steps in collision bulkheads are to fall within the limits of bulkhead positions given in 5.1.5.

6.3 Openings in watertight divisions and closing appliances for craft with 'LC' or 'HSLC' notation

6.3.1 Openings may be accepted in watertight bulkheads except for that part of the collision bulkhead below the freeboard deck. The number of openings in watertight bulkheads is to be reduced to the minimum compatible with the design and proper working of the craft.

6.3.2 Doors in watertight bulkheads shall be shown by suitable testing to be capable of maintaining the watertight integrity of the bulkhead. Such testing is to be carried out for both sides of the door. Testing may be carried out either before or after the door is fitted; where shore testing is adopted, satisfactory installation shall be verified by inspection and hose testing.

6.3.3 Watertight doors are to be kept closed at sea, except that they may be opened for access. A notice should be attached to each door to the effect that it is not to be left open.

6.3.4 Where pipes, scuppers, electrical cables etc. are carried through watertight divisions, the arrangements for creating a watertight penetration shall be of a type which has been prototype tested under hydraulic pressure for the intended head.

6.4 Cofferdams

6.4.1 Fuel oil, lubricating oil and freshwater tanks are to be separated from each other by cofferdams. However, cofferdams need not be fitted between fuel oil and lubricating oil tanks provided that the common boundaries have full penetration welds and the head of fuel oil is generally not in excess of that in the adjacent lubricating oil tanks.

6.5 Shell doors

6.5.1 The scantlings and arrangements of any side shell doors, stern or bow doors are to be as given in Part 3, Chapter 12 of the Rules and Regulations for the Construction and Classification of Steel Ships; with appropriate value of design loads given in Chapter 4 of these rules for high speed crafts and light crafts. In the case of aluminium doors, appropriate material factor is to be used in the formulations.

6.6 Testing of hull structure

6.6.1 In general the testing of tanks, watertight bulkheads, weathertight hatchcovers and closing appliances is to be carried out in accordance with the requirements given in Part 3, Chapter 18, Section 3 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

In the case of vessels with 'HSC' notation the references to 'freeboard deck' in the above rules are to be taken as references to 'Datum'.

(See also 5.1.2 and 5.1.7 for crafts with 'HSC' notation).

Section 7

Weathertight Integrity and Loadline for craft with ‘LC’ or ‘HSLC’ notation

7.1 General

7.1.1 Where applicable loadline markings for craft with **'LC'** or **‘HSLC’** notation are to be made as per the requirements of the International Loadline Convention 1966 and the Protocol of 1988 thereto.

7.1.2 The requirements given in the following chapters of ‘Rules and Regulations for the Construction and Classification of steel Ships’ are to be satisfied, in general.

Part 3, Chapter 12 : Openings and Closing Appliances
Part 3, Chapter 13 : Ventilation, Air Pipes and Discharges

Part 3, Chapter 11, Section 5 : Bulwarks and Guard Rails.

7.1.3 Where it is not practicable to satisfy the above requirements due to operational or design considerations, relaxation on specific requirements may be considered subject to approval of the Administration.

End Of Chapter

Chapter 6

Structures : Steel and Aluminium

Contents	
Section	
1	Principles of Scantlings and Structural Details
2	Hull Girder Strength
3	Plating
4	Secondary Stiffeners
5	Primary Girders and Pillars
6	Welding

Section 1

Principles of Scantlings and Structural Details

1.1 Application

1.1.1 Scantlings of various platings, stiffeners and girders satisfying the local strength requirements are to be determined in accordance with the general principles given in the chapter.

Scantlings of hull members contributing to the longitudinal strength are also to comply with the requirements of Section 2.

1.1.2 The design values of loads to be considered are given in Chapter 4 and further detailed reference of the applicable loads is given in individual sections of this chapter.

1.1.3 Scantlings of hull members subjected to compressive stresses are also to comply with the requirements to resist buckling given in 'Rules and Regulations for the Construction and Classification of Steel Ships' Part 3, Chapter 3, Section 6.

1.2 Symbols

p = design pressure [kN/m^2] as per 1.1.2.

s = spacing of stiffeners [m], measured along the plating

l = span of the stiffener [m], in accordance with 1.4

S = span of girder [m] or primary supporting member, in accordance with 1.4.

b = mean breadth [m] of the load area supported by the girder

σ_a = allowable bending stress [N/mm^2], as given in relevant sections

σ_y = minimum yield stress of material [N/mm^2] may be taken as 235 [N/mm^2] for normal strength steel. For aluminium alloys the guaranteed minimum 0.2% proof stress [N/mm^2] of the alloy in welded condition or 70% of the ultimate strength in the welded condition, whichever is lesser, is to be used.

k = material factor given in Chapter 3, Sections 2.2 and 3.2.

E = modulus of elasticity:

= 2.06 x 10^5 [N/mm^2] for steel and 0.7 x 10^5 [N/mm^2] for aluminium alloy.

1.3 Frame spacing

1.3.1 The standard frame spacing 's_r' may be taken as 480 + 2L [mm].

1.3.2 Where the actual frame spacing differs from the standard frame spacing given in 1.3.1 the minimum thickness requirement for various structural members is to be corrected in direct proportion

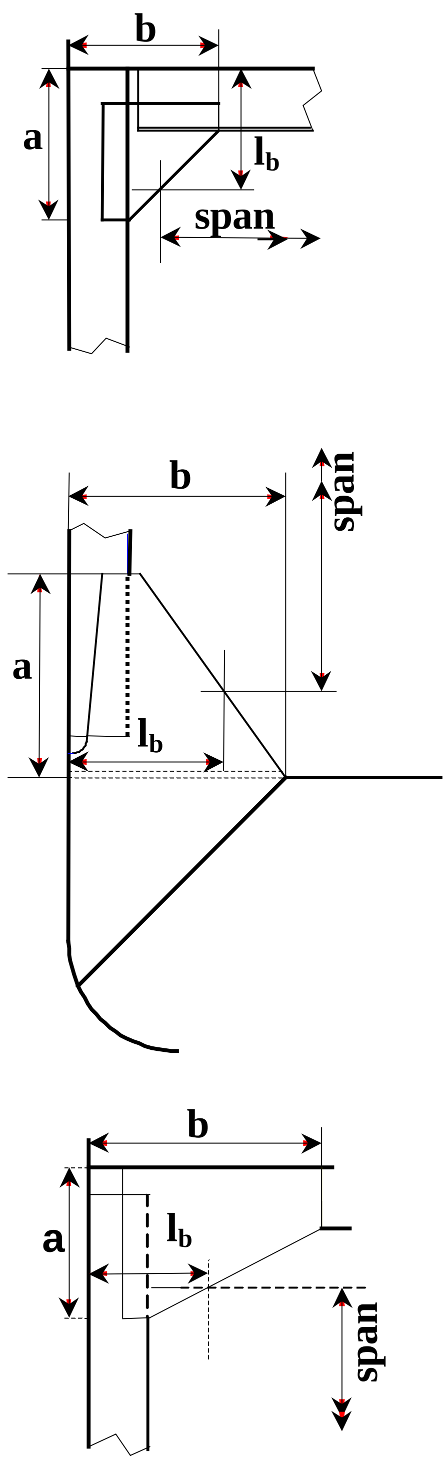
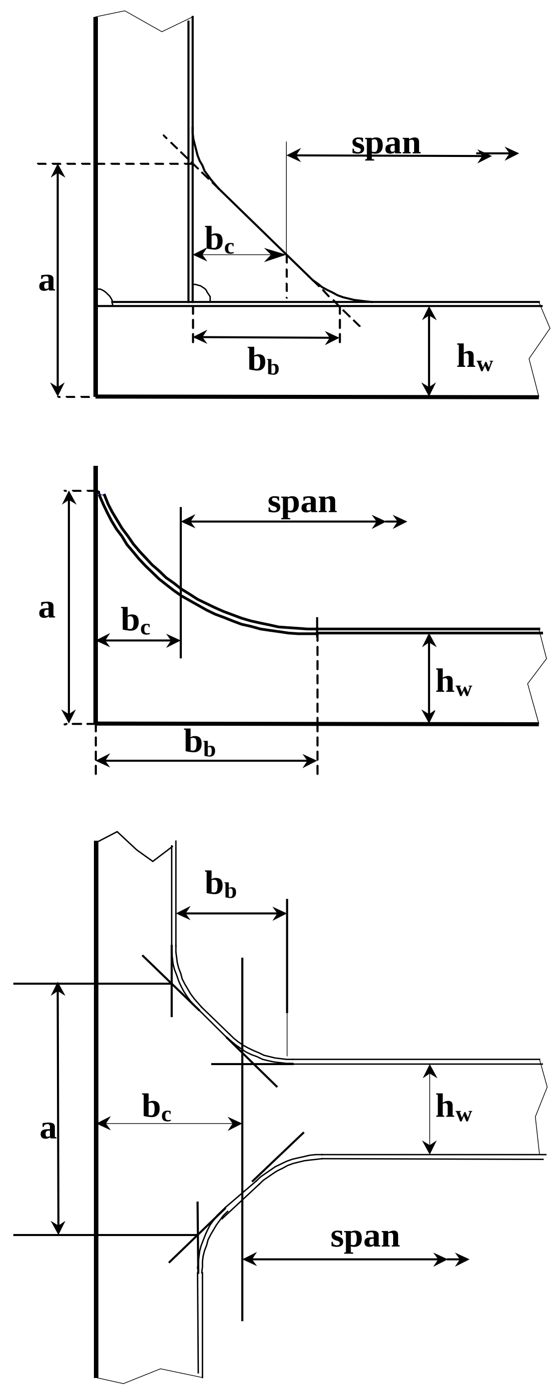


Fig. 1.4.1 : Stiffener end connections



$$b_c = b_b\,(1 - h_w/a)$$

Fig. 1.4.2 : Girder end details

1.4 Stiffeners and girders

1.4.1 For stiffeners, the span 'l' [m] is to be taken as the length of the stiffener between the two supporting members less the depth of stiffener on crossing panel if any. Where brackets larger than those required in 1.5.1 are fitted, the span may be determined as shown in Fig.1.4.1.

For curved stiffeners, 'l' may be based on the chord length.

1.4.2 For girders, the span 'S' [m] is to be taken as the length of the girder between the two supporting members, less the web height of in-plane girder if any and the correction for bracket 'b_c', as shown in Fig.1.4.2.

1.4.3 The area of the attached plating to be used in the calculation of sectional properties of the stiffeners and girders, is to be taken as the cross sectional area within the effective width of the attached plating.

1.4.4 The effective width of plating attached to a stiffener may be taken as the mean of spacings on either side of the stiffener.

1.4.5 The effective width of plating attached to a girder, 'b_e' is to be taken as per the following:

$$b_e = c \cdot b$$

where,

$c = c_1$, for girders with uniformly distributed loads or with six or more evenly spaced point loads

$= c_2$, for girders with three or less evenly spaced point loads.

Table 1.4.5 : Values of "c"

a/b	0.5	1.0	2.0	3.0	4.0	5.0	6.0	≥ 7.0
c1	0.19	0.38	0.67	0.84	0.93	0.97	0.99	1.00
c2	0.11	0.22	0.40	0.52	0.65	0.73	0.78	0.80

For intermediate values of a/b and number of point loads, values of 'c' may be obtained by interpolation.

a = span of the girder, for simply supported girders [m]

= 60 per cent of span of the girder, for girders fixed at both ends [m].

1.4.6 In case of girders on corrugated bulkheads which run across the corrugations, the effective width of attached plating is to be taken as 10% of that obtained from 1.4.5.

1.4.7 The effective cross sectional area of the attached plating is not to be less than that of the face plate.

1.4.8 The effective cross sectional area of the girder web is to be taken as:

$$A_w = 0.01\, h_n\, t_w \quad [cm^2]$$

where,

h_n = net girder height [mm], after deduction of cutouts at the section under consideration.

Where an opening is located at a distance less than $h_w/3$ from the cross section under consideration, h_n is to be taken as the smaller of the net height and the distance through the opening (h_{n1} + h_{n2}) (See Fig. 1.4.8).

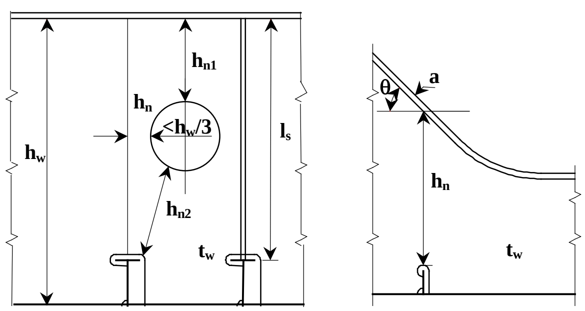


Fig. 1.4.8 : Effective web area of girders

Where the girder flange is at angle θ to the length of the girder, A_w may be taken as:

$$A_w = 0.01\, h_n\, t_w + 1.3\, a \sin 2\theta \, \sin\theta \quad [cm^2]$$

where,

a = area of flange [cm^2]

The requirement of effective web area of various girders are given in the 5.1.

1.4.9 The thickness of the girder web t_w is not to be less than:

$$t_W = \frac{S_W}{65} \text{ [mm]}$$

where,

S_w = web depth or spacing [mm], of the first web stiffener parallel to the face plate.

The web stiffeners may be flat bars of same thickness as that of the web and 1/10 of the height of girder, in depth.

1.4.10 Where openings are cut in the girder web, they are to be away from the girder ends and scallops for stiffeners; with their centre location as near to the neutral axis of the girder as practicable. Openings of depth exceeding 25% of the girder depth or 300 [mm] and of length exceeding the depth of the girder or 60% of the secondary stiffener spacing, are to be reinforced all around at the edge; or alternatively by providing horizontal and vertical stiffeners.

1.4.11 Girders are to be provided with adequate lateral stability by tripping brackets fitted generally at every alternate stiffener in case of asymmetrical section or at every fourth stiffener in case of symmetrical section. Tripping brackets are also to be fitted at the toes of end brackets and in way of concentrated loads such as heels of pillars or cross ties.

Where the width of face plate on one side of the web exceeds 15 t_f, the tripping brackets are to be connected to the face plate.

The tripping brackets are to be adequately dimensioned at base and are to have a smooth transition to the adjoining stiffeners. The free edge of the tripping bracket is to be stiffened if it’s length exceeds 60 t [mm]. Additional stiffeners are to be fitted parallel to the free edge to ensure that the arm length of an unstiffened triangular end panel does not exceed 100 t [mm].

1.5 End attachments

a) End attachments of stiffeners

1.5.1 Scantlings of brackets fitted on stiffeners not participating in the longitudinal strength are not to be less than the following:

- The arm lengths, ‘a’ and ‘b’ (See Fig.1.4.1) are to be such that:

  i) $a, b \geq 0.8\ l_b$

  and

  ii) $a + b \geq 2.0\ l_b$

where,

$l_b = 24\ \sqrt{Z} + 75$ [mm]

- Thickness of unflanged bracket is to be not less than:

  $t = (4.0 + 0.3\ \sqrt{Z})\ \sqrt{(k_b / k_s)}$ [mm]

- Thickness of flanged bracket is to be not less than:

  $t = (3.0 + 0.25\ \sqrt{Z})\ \sqrt{(k_b / k_s)}$ [mm]

  but need not be taken greater than 13.5 [mm].

- Width of flange, $w \geq 40 + Z/25$ [mm], but not to be less than 50 [mm].

  where,

  Z is the section modulus [cm^3], of the smaller stiffener, being connected.

  k_b, k_s are the material factors for the bracket and the stiffener, respectively.

b) End attachments of girders

1.5.2 The end attachments and supporting structure of the girders are to provide adequate resistance against rotation and displacement of the joint and effective distribution of the load from the member. Supporting members to which the girders are being connected, may require additional strengthening to provide adequate stiffness to resist rotation of the joint. Where the end attachment provides only a low degree of restraint against rotation, the girder is generally to be extended beyond the point of support by at least two frame spaces before being gradually tapered.

Connections between girders forming a ring system are to be such as to minimize stress concentrations at the junctions. Integral brackets are generally to be radiused or well rounded at the toes.

Where the face plate of the girder is not continuous over the bracket, the free edge of the bracket is to be stiffened and the face plate of the girder is to be extended well beyond the toe of the bracket.

1.5.3 The thickness 't' of brackets on girder is not to be less than that of the girder web.

The arm length 'a' including the depth of girder is not to be less than:

$A = 83 \sqrt{(Z/t)}$ [mm];

where,

Z = the section modulus [cm^3], of the girder to which the bracket is connected.

The cross sectional area 'A_f' of the face plate on the girder bracket is not to be less than:

$$A_f = 0.001\ l_f\ t\ [cm^2]$$

where, l_f is the length [mm], of the free edge of the bracket.

Additional stiffeners parallel to the bracket face plate are to be fitted on webs of large brackets. The arm length of an unstiffened triangular end panel of bracket is generally not to exceed 100 t [mm].

1.6 Corrosion protection

1.6.1 The scantlings determined from the formulae provided in the Rules assume that the materials used are selected, manufactured and protected in such a way that there is negligible loss in strength by corrosion.

Where the materials are not adequately protected against corrosion, by painting or other approved means, the scantlings may require to be further considered.

1.6.2 Where bimetallic connections are made, involving dissimilar metals, measures are to be incorporated to preclude galvanic corrosion. In order to prevent galvanic corrosion, special attention is to be given to the penetrations of and connections to the hull, bulkheads and decks by piping and equipment where dissimilar materials are involved.

The design is to ensure that the location of all bimetallic connections allows for regular inspection and maintenance of the joints and penetrations during service.

1.6.3 The hull, deck and all surfaces exposed to the marine environment are to be suitably protected against corrosion. This may be by coating and/or by a system of cathodic protection in accordance with the requirements detailed below.

1.6.4 In case of steel crafts, all internal spaces except the integral fuel tanks are to be suitably protected against corrosion. In case of aluminium crafts the internal spaces need not in general be coated provided they are built of suitable grades as per Chapter 3.

1.6.5 Paints or other coatings are to be suitable for the intended purpose in the locations where they are to be used and are generally to be hard coatings. Coatings are to be of adequate film thickness, applied in accordance with the paint manufacturer's specification and are to be compatible with any previously applied primer. Primers used are to be of a type approved in accordance with Part 3, Chapter 2 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

Paints, varnishes and similar preparations having a nitro-cellulous or other highly flammable base are not to be used in accommodation or machinery spaces.

In case of aluminium crafts, paints containing lead, mercury or copper are not to be used.

1.6.6 All steel structures are to be suitably cleaned and cleared of millscale before the application of any coating. It is recommended that blast cleaning, or other equally effective means, be employed for this purpose. All aluminium structures are to be suitably cleaned, cleared of oxide and degreased before the application of any coating.

1.6.7 Where an impressed current cathodic protection system is fitted, plans showing the proposed layout of anodes, reference cells, wiring diagram and the means of bonding-in of the rudder and propeller are to be submitted.

The arrangements for glands, where cables pass through the shell, are to include a small cofferdam. Cables to anodes are not to be led through tanks containing low flash point oils.

1.6.8 Anodes to be used for protection of ballast spaces are to be of an approved type and fitted in accordance with the requirements of Part 3, Chapter 2 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’. In case of aluminium crafts, particular attention is to be paid to the electric potential of aluminium alloys used in the construction during selection of the anodes, anodes containing mercury however, are not to be used.

1.6.9 Where plated decks are sheathed with wood, the sheathing is to be efficiently attached to the deck, caulked and sealed, to the satisfaction of the Surveyor in accordance with the approved drawings.

Deck coverings in the following positions are to be of a type, which will not readily ignite where used on decks:

a) Forming the crown of machinery or cargo spaces within accommodation spaces of cargo craft.
b) Within accommodation spaces, control stations, stairways and corridors of passenger craft.

Section 2

Hull Girder Strength

2.1 General

2.1.1 Scantlings of hull members contributing to longitudinal strength are to comply with the requirements given in the section. These members are also to comply with the requirement of buckling strength as mentioned in 1.1.3.

2.1.2 In general, the longitudinal strength is to be checked for all crafts where L/D > 12 and/or L > 50 m. For other vessels longitudinal strength calculations may be required based on the form, construction arrangement and loading.

2.1.3 For new designs of large and structurally complicated craft the rule scantling calculations are to be complemented by a direct calculation using 3D finite element analysis. The design loads are to be based on model tests or full scale measurements where available or required.

2.2 Hull section modulus

2.2.1 The required section modulus of the hull is given by:

$$Z = \frac{M}{\sigma} \text{ x } 1000 \ [\text{cm}^3]$$

where,

M is the longitudinal bending moment, which is greater of:

a) Bending Moment due to slamming M_{sl} given in Chapter 4, Section 4.1.3 and

b) Total Bending Moment $M_t = (M_s + M_w)$ given in Chapter 4, Section 4.1.2.

$\sigma = 175/k$ {N/mm^2}.

2.3 Openings in longitudinal strength members

2.3.1 The effective sectional area of continuous longitudinal members considered in the calculation of section modulus should be the net area after deduction of openings. Shadow areas representing the imaginary longitudinal extension of an opening is to be deducted by drawing two tangent lines with an opening angle of 30^o as shown in Fig.2.3.1.

2.3.2 The keel plate is normally not to have any openings. In the bilge plate within 0.6L amidships openings are to be avoided as far as practicable. Openings in strength deck are to be kept well clear of craft’s side and hatch corners.

2.3.3 Circular openings with diameter equal to or more than 0.325 m are to have edge reinforcement. Elliptical openings are to have their major area in the fore and aft direction. Where the ratio of the major axis to the minor axis is less than 2 the openings are to have edge reinforcement.

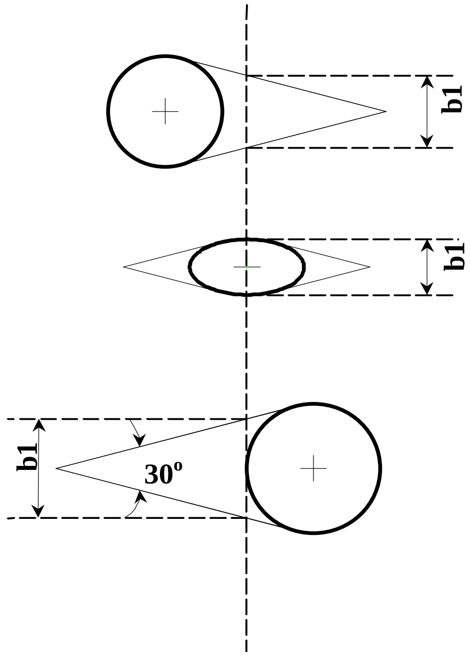


Fig. 2.3.1 : Shadow areas

2.3.4 Rectangular openings are to have their corners well rounded. Where corners are of circular shape, the radius is not to be less than 20 percent of the breadth of the opening and the edges are to be reinforced.

2.4 Transverse strength of twin hull craft

2.4.1 The twin hull connecting structure is to have adequate strength related to the design loads and moments given in Chapter 4, Section 4.2.

2.4.2 The following stress levels are normally acceptable:

Bending	σ	= 175/k [N/mm^2]
Shear	τ	= 90/k [N/mm^2]
Equivalent stress	σ_c	= 190/k [N/mm^2]

Section 3

Plating

3.1 General

3.1.1 The thickness 't' of plating subjected to lateral pressure given by:

$$t = \frac{0.0158\, f_a \,.\, f_r \;\; s\sqrt{p}}{\sqrt{\sigma_a}} \;\; [\mathrm{mm}]$$

where,

's' is the frame spacing [mm]

p = lateral pressure [kN/m^2]

σ_a = permissible stress [N/mm^2] given in Table 3.1.1

f_a = correction factor for aspect ratio of plate field

= $(1.10 – 0.5 (s/1000\, l)^2)^{1/2}$; not to be taken more than 1.0.

f_r = correction factor for curvature perpendicular to the stiffeners

= (1 – 0.5 s/r)

r = radius of curvature of plating [mm]

k = material factor given in Chapter 3, Section 2.2 and 3.2 for steel and aluminium respectively.

3.2 Bottom and bilge plating

3.2.1 The thickness of bottom plating corresponding to lateral pressure or impact loads is given by 3.1.1.

where,

p = lateral pressure in Chapter 4, Section 3.5 or impact pressure due to slamming given in Chapter 4, Section 3.2

3.2.2 The thickness is also be not less than:

t = (5 + 0.04L) s/s_r [mm] for steel, and

t = (6.5 + 0.05L) s/s_r [mm] for aluminium

3.2.3 The thickness of bilge plating is not to be less than the adjacent bottom or side plates whichever is greater.

3.2.4 The thickness of plates in way of shaft brackets is to be increased by 50%.

3.2.5 Sea chests are to have scantlings as required for watertight tank bulkheads with design pressure equal to sea pressure in Chapter 4, Section 3.5 plus half the slam impact pressure given in Chapter 4, Section 3.2.

3.3 Side plating

3.3.1 The thickness of side plating corresponding to lateral pressures or impact is given by 3.1.1.

where,

p = sea pressure as in Chapter 4, Section 3.5 or forebody side and bow impact pressure as per Chapter 4, Section 3.3.

Table 3.1.1 : Allowable local bending stress σ_a [N/mm^2]

Item		Framing system Trans.:T Long.:L	For plating	For secondary stiffeners	For primary girders and web frames
Bottom shell	Slamming/ Impact	Both	235/k	235/k	215/k
	Sea load	T	100/k*	160/k	160/k Trans. girder
		L	120/k *	140/k*	120/k* Longl. girder
Side shell & longl. Bhds.	Bow impact load	Both	235/k	235/k	215/k
	Sea load	T	55/k* at deck 120/k* below D/3 from deck	160/k	160/k Trans. Girder
		L	85/k* at deck 120/k* below D/3 from deck	80/k* at deck 150/k* below D/3 from deck	120/k* Long. Girder
Main/strength deck		T	55/k*	160/k	160/k Trans. Girder
		L	85/k*	80/k*	65/k* Long. Girder
Superstructure / deck houses : decks/house tops. Short decks		-	160/k	160/k	160/k
Transverse tank bulkheads and collision bulkhead		-	160/k	160/k	160/k
Transverse watertight / bulkheads		-	220/k	220/k	220/k
Superstructure and bulkheads Deckhouse side / end bulkheads		-	235/k	220/k	220/k
* Stress values, at 0.4L amidships. To be increased to 160/k at ends and at intermediate locations values to be linearly interpolated					

3.3.2 The thickness should also be not less than:

t = (5 + 0.025L) s/s_r for steel
t = (6.0 + 0.03L) s/s_r for aluminium

3.3.3 The thickness of sheer strake should be not less than the adjacent side or stringer plate.

3.3.4 The thickness of sheer strake is to be increased by 30% on each side of a superstructure end bulkhead located within 0.5L amidships if the superstructure deck is a partial strength deck. The side plating of the superstructure should be given a smooth transition to the sheer strake below and its thickness is to be increased by 25% at the transition.

3.3.5 For vessels with L > 50 m where the sheer strake extends above the deck stringer plate, the top edge of the sheer strake is to be kept free from notches and isolated weld fittings and is to be ground smooth with round edges. Drainage openings with smooth transition in the longitudinal direction may be allowed.

3.4 Deck plating

3.4.1 The thickness of deck plating to be designed to withstand lateral pressure as given by 3.1.1.

where,

p = weather load given in Chapter 4, Section 3.5.1 or other loads as applicable

3.4.2 The thickness of deck plating is also be not less than the following:

a) For strength deck

$t = (5 + 0.02L)\, s/s_r$ [mm] for steel, and
$t = (6 + 0.03L)\, s/s_r$ [mm] for aluminium.

b) For other decks

$t = (4.5 + 0.01L)\, s/s_r$ [mm] for steel
$t = (6 + 0.01L)\, s/s_r$ for aluminium.

3.4.3 Adequate transverse buckling strength is to be provided for deck plating by increased thickness or by providing intercoastal transverse stiffeners.

3.4.4 Where corners of openings in the strength deck are not of streamlined shape, inserts plates are to be fitted at the corners. The insert plates are to be 25 percent thicker than the deck plating outside the line of openings and are to extend as shown in Fig.3.4.4.

3.5 Bulkhead plating

3.5.1 The thickness requirement corresponding to lateral pressure is given by 3.1.1.

where,

p = pressure as per Chapter 4, Section 3.6

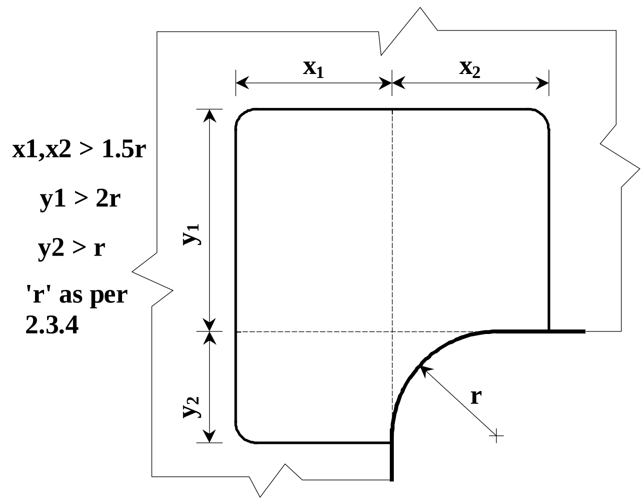


Fig.3.4.4 : Extent of insert plate

3.5.2 The plate thickness is also not be less than the following:

a) Tank bulkheads

$t = (5 + 0.02L)\, s/s_r$ for steel
$t = (6 + 0.03L)\, s/s_r$ for aluminium.

b) Ordinary watertight bulkheads

$t = (4 + 0.02L)\, s/s_r$ for steel
$t = (5 + 0.025L)\, s/s_r$ for aluminium.

3.5.3 The thickness of upper and lower strakes of longitudinal bulkheads are also to satisfy the buckling strength requirements given in 1.1.3.

3.6 Superstructure and deckhouse bulkheads, bulwarks

3.6.1 The thickness requirement for plating of superstructure end bulkheads, deckhouse sides and ends corresponding to lateral pressure is given in 3.1.1.

where,

p is the lateral pressure given in Chapter 4, Section 3.5.

3.6.2 The thickness is also be not less than the following:

a) For lowest tiers

$t = (5 + 0.01L)\ s/s_r$ [mm] for Steel
$t = (6.5 + 0.01L)\ s/s_r$ [mm] for Aluminium

b) For other tiers

$t = (4 + 0.01L)\ s/s_r$ [mm] for Steel
$t = (5.5 + 0.01L)\ s/s_r$ [mm] for Aluminium

3.6.3 The thickness of the bulwark plating is not to be less than that required for the superstructure side plating in the same location if the height of the bulwark is equal to or greater than 1.8 [m]. Where the height of the bulwark is 1.0 [m], the thickness is not to be less than 6.0 s/s_r [mm] with a minimum of 3.0 [mm].

3.7 Hatch covers

3.7.1 Hatch cover plating should have same strength as the adjacent deck plating.

Section 4

Secondary Stiffeners

4.1 General

4.1.1 This section gives the requirements for secondary stiffeners of the bottom, sides and decks.

4.1.2 The section modulus of stiffeners subject to lateral loading is given by:

$$Z = \frac{l^2 sp}{m\sigma_a}\ [cm^3]$$

l = span of stiffener [m]

s = spacing of stiffener [mm]

p = lateral pressure [kN/m^2] as given in Chapter 4, Section 3.

m = bending moment factor given for each item in Table 4.1.1.

σ_a = allowable stress [N/mm^2] given for each item, in Table 3.1.1

k = material factor as given in Chapter 3, Section 2.2 and 3.2 for steel and aluminium respectively.

4.2 Longitudinals

4.2.1 The section modulus of longitudinal stiffeners are to be as given in 4.1.2.

4.2.2 The bottom longitudinals are to be preferably continuous through the transverse members. Where they are interrupted at a transverse watertight bulkhead continuous brackets are to be fitted through the bulkhead connecting the ends of longitudinals, in general.

4.3 Frames

4.3.1 In general the section modulus of transverse frames and deck beams are to be not less than given in 4.1.2.

4.3.2 The section modulus of side shell frames below freeboard deck is also not be less than:

$Z = 6.5\ \sqrt{(Lk)}\ .\ s/s_r\ [cm^3]$.

4.3.3 The side frame brackets are to be as follows:

Length of bracket:

- upper 70 l [mm]
- lower 120 l [mm]

Section modulus at end including bracket :

- upper 1.7 Z [cm^3]
- lower 2.0 Z [cm^3]

where,

Z = section modulus of side frame.

Where the free edge of the bracket exceeds 40 times the bracket thickness, the brackets are to be flanged. The flange is to be at least 1/15 of the length of the free edge.

Table 4.1.1 : Bending moment factor ‘m’

Item		**Framing: Trans:T Longitudinal:L**	**For secondary stiffeners**	**For primary girders and transverses**
Bottom shell	Slamming/impact	Both	16	16
	Sea load	T	10	10
		L	12	12
Side shell & longl. bulkheads	Bow impact	Both	16	16
	Sea load	T	15 [1]	15 [1]
		L	12	12
Main/strength deck		T	10	10
		L	12	12
Short decks, ss/deckhouse tops		T	10	10
		L	12	12
Transverse tank bulkheads & collision bulkhead			10	10
Trans. Watertight bulkhead	Fixed ends		16	10
	Simply supported ends		8	
	One end fixed		12	
Superstructure / deckhouse end bulkheads			12	10
[1] with rule brackets at end of span as given in 4.3.2				

4.3.4 Brackets at the ends of the side frame may be omitted provided the frame is carried through the supporting members and the section modulus of the frame increased by 75 percent.

4.4 Bulkhead stiffeners

4.4.1 The section modulus of vertical and horizontal stiffeners on bulkheads is given by 5.1.2.

where,

p is lateral pressure from Chapter 4, Section 3.6

4.4.2 Brackets are to be fitted at the ends of stiffeners for tank bulkheads and collision bulkhead. For other bulkheads where stiffeners are sniped at ends, the thickness of the plating supported by the stiffeners is not to be less than:

$$t = 0.04 . \sqrt{[(l - 0.0005s)s.p.k.]} \ \text{[mm]}$$

where l, s and p are as defined in 5.1.2.

4.5 Superstructure and deckhouse bulkhead frames

4.5.1 The section modulus of frames of superstructure and deckhouse end bulkheads and exposed side bulkheads of deckhouses is given by 4.1.2.

where,

‘p’ is the lateral pressure as per Chapter 4, Section 3.5.3.

4.5.2 Stiffeners on fronts are to be connected to deck at both ends with a connection area ‘a’ not less than:

a = 0.07 s p l k [cm^2]

Webs of stiffeners on sides and after ends of the lowest tiers of all erections are to be welded to the deck at both ends.

4.5.3 The section modulus 'Z' at the bottom of the bulwark stay is not to be less than:

$Z = (33 + 0.44\ L)\ h^2\ s \quad [cm^3]$

where,

h = height of the bulwark [m]

s = spacing of bulwark stays [m]

In the calculation of section modulus 'Z' only the material connected to the deck is to be included.

4.6 Weather deck hatch cover stiffeners

4.6.1 The section modulus of weather deck hatch cover stiffeners and girders is not to be less than that given by 4.1.2.

where,

p = lateral pressure based on deck load given in Chapter 4

$\sigma_a = 135\ [N/mm^2]$

m = 8.

4.6.2 The moment of inertia of stiffeners and girders of weather deck, hatch covers supported at side or end coamings only, is not to be less than:

$I = 1.7\ Z\ l \quad [cm^4]$

where,

Z is the rule section modulus of the stiffener or girder [cm^3], and

l is the span [m].

Section 5

Primary Girders and Pillars

5.1 General

5.1.1 In general the section modulus of girders and web frames supporting transverse beams, longitudinals, vertical frames or bulkhead stiffeners is not to be less than:

where,

$$Z = \frac{1000\ b\ p\ S^2}{m\ \sigma_a} \quad [cm^3]$$

b = breadth of area supported by the girder [m]

p = lateral pressure [kN/m^2] as given in Chapter 4, Section 3

S = span of girder [m]

σ_a = allowable stress from Table 3.1.1.

m = bending moment factor from Table 4.1.1.

k = material factor as given in Chapter 3, Section 2.2 and 3.2 for steel and aluminium respectively.

5.1.2 The effective web area of girders and web frames is not to be less than:

$A_w = 0.07\ S\ b\ p\ k \quad [cm^2]$

5.2 Bottom transverses and girders

5.2.1 A single bottom construction is assumed, in these Rules in general. Double bottom construction would be specially considered, if provided. In general, the scantlings of double bottom structure is not to be less than that for tank boundaries.

5.2.2 A centreline girder is to be fitted normally on all ships for docking purposes. This girder should have web thickness, depth and flange area suitable for the load from the docking block. In addition, side girders are to be fitted with their spacing not exceeding 2.5 m, in general.

5.2.3 In machinery spaces, floors are to be fitted at every frame, in general. Under the main engine, girders extending from the bottom to the top plate of the engine seating are to be fitted.

5.2.4 Floors are to be positioned in way of side and deck transverses.

5.2.5 The scantlings of bottom girders are to be based on section modulus given in 5.1.1 where the allowable stress 'σ_a' and bending moment factor 'm' are given in Tables 3.1.1 and 4.1.1 respectively.

5.3 Side webframes and stringers

5.3.1 Web frames are to be fitted in way of hatch end beams and deck transverses. In the engine room, web frames are to be fitted at the forward and aft end of the engine and every 5th frame, in general.

5.3.2 In peak spaces, side stringers supporting vertical peak frames are normally to be fitted at every 2.6 [m].

5.3.3 The scantlings of simple stringers and web frames supporting frames and longitudinals are to be in accordance with 5.1.1 and 5.1.2 where 'σ_a' and 'm' are to be obtained from Table 3.1.1 and Table 4.1.1 respectively.

5.3.4 The scantlings of webs supporting fully effective side stringers are to be based on point loadings and σ_a values in Table 3.1.1. The scantlings of complex girder systems are to be based on direct stress analysis.

5.4 Deck transverses and girders

5.4.1 Deck girders and transverses are to be arranged in line with vertical members of scantlings sufficient to provide adequate support.

5.4.2 The scantlings of simple girders and transverses are to be in accordance with 5.1.1 and 5.1.2 where 'σ_a' and 'm' are to be obtained from Table 3.1.1 and Table 4.1.1 respectively.

5.4.3 The scantlings of a complex girder system are to be based on a direct stress analysis. The girders are to be satisfactorily stiffened against buckling.

5.5 Pillars

5.5.1 Scantlings of pillars are to be in accordance with the requirements to prevent buckling given in 'Rules and Regulations for the Construction and Classification of Steel Ships' Part 3, Chapter 3, Section 6 with appropriate material properties for steel or aluminium as applicable. Axial loads, if any from pillars above is to be added to the load from deck girders.

5.5.2 Pillars are to be fitted in the same vertical line wherever possible and arrangements are to be made to effectively distribute the load at the heads and heels. Where pillars support eccentric loads, they are to be strengthened for the additional bending moments imposed on them. Doubling or insert plates are generally to be fitted at the head and heel of pillars.

5.5.3 The pillars are to have a bearing fit and are to be attached to the head and heel plates by continuous welding.

5.5.4 Structural reinforcement below pillars will be considered in individual cases.

5.5.5 Inside tanks, hollow pillars are not to be used and strengthening at the heads and heels of pillars is not to be obtained by means of doublers. Where hydrostatic pressure may give rise to tensile stresses in the pillars, the sectional area 'A' is not to be less than:

$$A = .07\ A_L \cdot p \quad [cm^2]$$

where,

A_L = load area of deck [m^2] supported by pillar

p = design pressure causing tensile stress pillar [kN/m^2].

Section 6

Welding

6.1 General

6.1.1 Welding in steel and aluminium hull construction of all types of craft is to comply with the requirements of this section.

6.1.2 Connection details of the welded structural members including type and size of welds are to be clearly indicated on the plans submitted for approval. An explanation of all symbols or abbreviations used in detailing the weld connections should be included on the plans.

Details of proposed welding procedures is to be submitted indicating preheating temperature and any post-welding heat treatment, if employed. Extent to which automatic welding, including deep penetration welding, is to be employed should also be indicated.

6.1.3 Welders are to be proficient in the type of work on which they are to be engaged. The records of their tests and qualifications are to be kept by the builders and made available to the Surveyors. A sufficient number of skilled supervisors are to be employed to ensure effective control at all stags of assembly and welding operations.

6.1.4 Electrodes and welding consumables approved by IRS in accordance with the requirements of 'Rules and Regulations for the Construction and Classification of Steel Ships', Part 2, Chapter 11 and suitable for the type of joint and grade of steel or aluminium, are to be used.

6.1.5 For the connection of two different grades of the same tensile strength properties, electrodes suitable for the lower grade will be generally acceptable except at structural discontinuities or other points of stress concentration.

6.1.6 For the connection of steel or aluminium of different tensile strengths, the electrodes are to be suitable for the tensile strength of the component, on the basis of which the weld fillet size has been determined.

6.2 Preparation for welding

6.2.1 The parts to be welded are to be fitted in accordance with the approved joint detail. The edge preparation is to be accurate and uniform. Means are to be provided for maintaining the parts to be welded, in correct position during the welding operations. Excessive force is not to be employed in aligning the parts before welding and the means employed in maintaining the alignment are to be so arranged as to allow for expansion and contraction during the welding operation. All methods employed in correcting improper alignment are to be to the satisfaction of the Surveyor.

6.2.2 All surfaces to be welded are to be clean, dry and free from rust, scale and grease. The surface and boundaries of each run of deposit are to be thoroughly cleaned and freed from slag before the next run is applied. Before a manual sealing run is applied to the back of a weld, the original root material is to be gouged out to sound metal.

6.2.3 Tack welding is to be kept to a minimum, and where used, should be equal in quality to that of the finished welds. Any defective tack weld is to be cut out before completing the finished welds. Care is to be taken in removing the tack welds to ensure that the structure is not damaged in doing so.

6.3 Weld procedures and their approval

6.3.1 Only approved welding procedures are to be used, as described in 6.3.5.

6.3.2 Structural arrangements are to be such as to allow adequate access for satisfactory completion of all welding operations. Welded joints are to be so arranged so as to facilitate downhand welding wherever possible.

6.3.3 The sequence of welding is to be so planned that any restraint during welding operations is reduced to a minimum. The ends of the frames and stiffeners should be left unattached to the plating at the subassembly stage until connecting welds are made, in the intersecting systems of plating, framing and stiffeners, at the erection stage.

Where a butt meets a seam, the welding of the seam should be interrupted well clear of the junction and not be continued until the butt is completed. Welding of the butt should continue past the open seam and the weld be chipped out for the seam to be welded straight through.

6.3.4 Adequate precautions are to be taken to ensure that the welding site is protected from the deleterious effects of high moisture, severe wind and extreme cold.

6.3.5 Unless previously approved, welding procedures are to be established by the yard and forwarded to IRS for approval. The welding procedure specifications are to include detailed description of the base material, primer, plate thickness range, joint/groove design, welding consumable, welding position, welding techniques, welding parameters, preheating / interpass temperature and post heat treatment if any.

The welding for procedure qualification and subsequent testing, are to be witnessed by the IRS Surveyor.

6.4 Inspection of welds

6.4.1 Effective arrangements are to be provided for the inspection of finished welds to ensure that all welding has been satisfactorily completed.

6.4.2 All finished welds are to be visually inspected and are to be sound, uniform and substantially free from slag inclusions, porosity, undercutting or other defects. Welds and adjacent base metal are to be free from injurious arc strikes.

6.4.3 For the examination of important structural welds, visual inspection is to be supplemented by radiography or other acceptable non- destructive crack or flaw detection methods. The extent of such examination is to be to the Surveyors' satisfaction, but particular attention is to be given to the following locations:

a) Junction and crossings of seams and butts in strength deck, sheer strake, side and bottom shell within 0.4L amidships.

b) Butts of keel plating and rounded sheerstrake within 0.4L amidships.

c) Insert plates in way of hatch openings on the strength deck.

d) Butts of longitudinal framing and longitudinal bulkhead stiffeners within 0.4L amidships.

6.4.4 Defective sections of welds as found by visual or non- destructive examination or leakages under hydrostatic tests, are to be gouged out as necessary and carefully rewelded.

6.5 Butt welds

6.5.1 Plates of equal thickness may be manually butt welded as per Fig. 6.5.1. For automatic welding procedures and special welding techniques, the welding procedure will be specially considered.

6.5.2 For joints of plates with difference in thickness of more than 4 [mm], the thicker plate is to be tapered. The taper is not to exceed 1:3. Edge preparation after the tapering is to be as indicated in 6.5.1 above.

6.5.3 All manual butt welds are normally to be welded from both sides. Where a back ceiling run is not practicable or in certain cases when the stress level in the members is very low, welding on one side may be permitted provided the welding process is found satisfactory.

6.5.4 Where stiffening members, attached by continuous fillet welds, cross the finished butt or seam welds, these welds are to be made flush in way of the faying surface. Similarly for butt welds in webs of stiffening members, the butt weld is to be first completed and made flush with the stiffening member before the stiffener is connected to the plating by fillet weld. The ends of the flush portion are to run out smoothly without notches or any sudden change of section. Where such conditions can not be complied with, a scallop is to be arranged in the web of the stiffening member. Scallops are to be of such size and in such a position, that a satisfactory weld can be made.

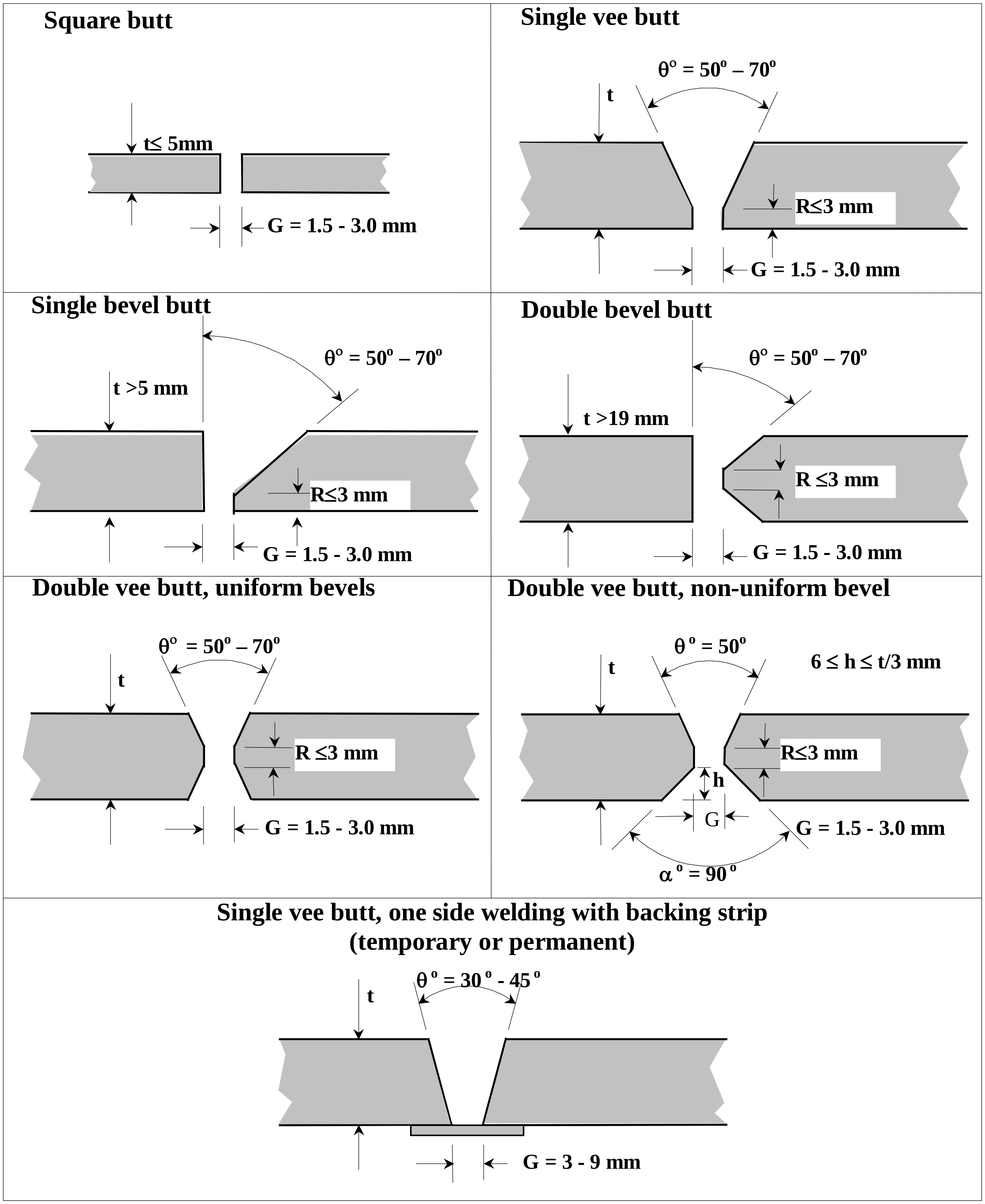


Fig.6.5.1 : Typical manually welded butt joints

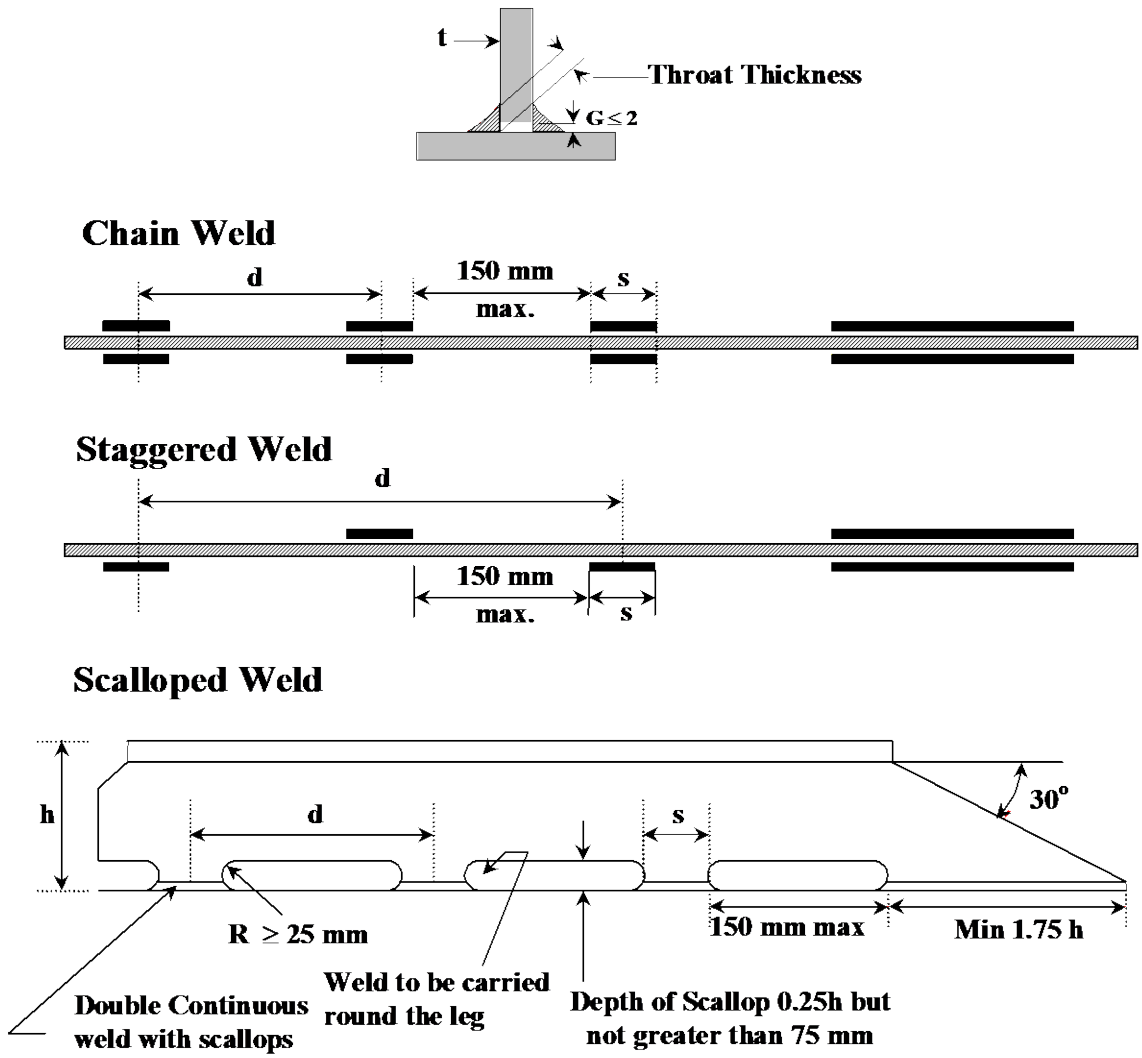


Fig.6.6.1 : Intermittent fillet welds

6.6 'T' connections

6.6.1 The throat thickness (See Fig.6.6.1) of the fillet welds is given by:

throat thickness = t_p . weld factor. d/s

where,

t_p = thickness [mm], of the thinner of the two parts being connected.

d = distance [mm], between the successive weld fillets.

s = length [mm], of the correctly proportioned weld fillets, clear of end craters
s is not to be less than 75 [mm].

The weld factors for various connections are generally to be as given in Table 6.6.1.

Where an approved automatic deep penetration procedure is used, the weld factors may be reduced by 15 per cent.

6.6.2 The throat thickness is not to be less than 3.0 [mm] for t_p upto 8.0 [mm] and 0.21 t_p or 3.25 [mm], whichever is greater, for t_p over 8 [mm]. The throat thickness is also generally not to be greater than 0.44 t_p for double continuous welds and the greater of 0.44 t_p or 4.5 [mm] for intermittent welds.

6.6.3 The leg length is not to be less than √2 times the specified throat thickness

6.6.4 Where the connection is highly stressed, deep penetration or full penetration welding may be required. Where full penetration welding is required, the abutting plate may require to be beveled. (See Fig. 6.6.4).

6.6.5 Continuous welding is to be adopted in the following locations and may be used elsewhere if desired.

a) Boundaries of weathertight decks and erections, including hatch coamings, companionways and other openings.

b) Boundaries of tanks and watertight compartments.

c) All structures in the afterpeak and the afterpeak bulkhead stiffeners.

d) All welding inside tanks intended for chemicals or edible liquids if any.

e) All lap welds in tanks.

f) Bottom framing structure in machinery spaces.

g) Where loading is mainly of dynamic nature e.g. bottom plating subjected to slamming and forebody side or bow impact area.

h) Under side of cross deck structure in case of multi-hull craft.

i) Primary and secondary members to plating in way of end connection and end brackets to plating in the case of lap connection.

j) Where the thickness of the abutting member (i.e. stiffener web) is greater than 15 [mm] and also exceeds the thickness of the table member (e.g. plating).

k) Other connections as given in Table 6.6.1.

6.6.6 Where intermittent welding is used, the welding is to be made continuous around the ends of brackets, lugs, scallops and at other orthogonal connections with other members. Where intermittent welding is permitted as per Table 6.6.1, only scalloped welding is to be used in tanks for water ballast, cargo oil or freshwater.

Chain or staggered intermittent welding may be used in dry spaces or tanks arranged for fuel oil only.

6.6.7 Where structural members pass through the boundary of a tank, and leakage into the adjacent space could be hazardous or undesirable, full penetration welding is to be adopted for the members for at least 150 [mm] on each side of the boundary. Alternatively, a small scallop of suitable shape may be cut in the member close to the boundary outside the compartment, and carefully welded all round.

6.7 Lap connections

6.7.1 Overlaps are not to be used to connect plates which may be subjected to high tensile or compressive loading. However, where they are adopted, the width of overlap is to be adequate to ensure a good weld, the surfaces are to be in close contact and the joints should be closed all round by continuous fillet weld.

6.8 Slot weld

6.8.1 For the connection of plating to internal webs, where access for welding is not practicable, the closing plating is to be attached by continuous full penetration or slot welds to flat bars fitted to the webs. Slots are to be well rounded at ends, to have a minimum length of 75 [mm] and in general, a minimum width of twice the plating thickness. The distance between the slots is not to exceed 150 [mm]. Complete filling of the slots is normally not permitted.

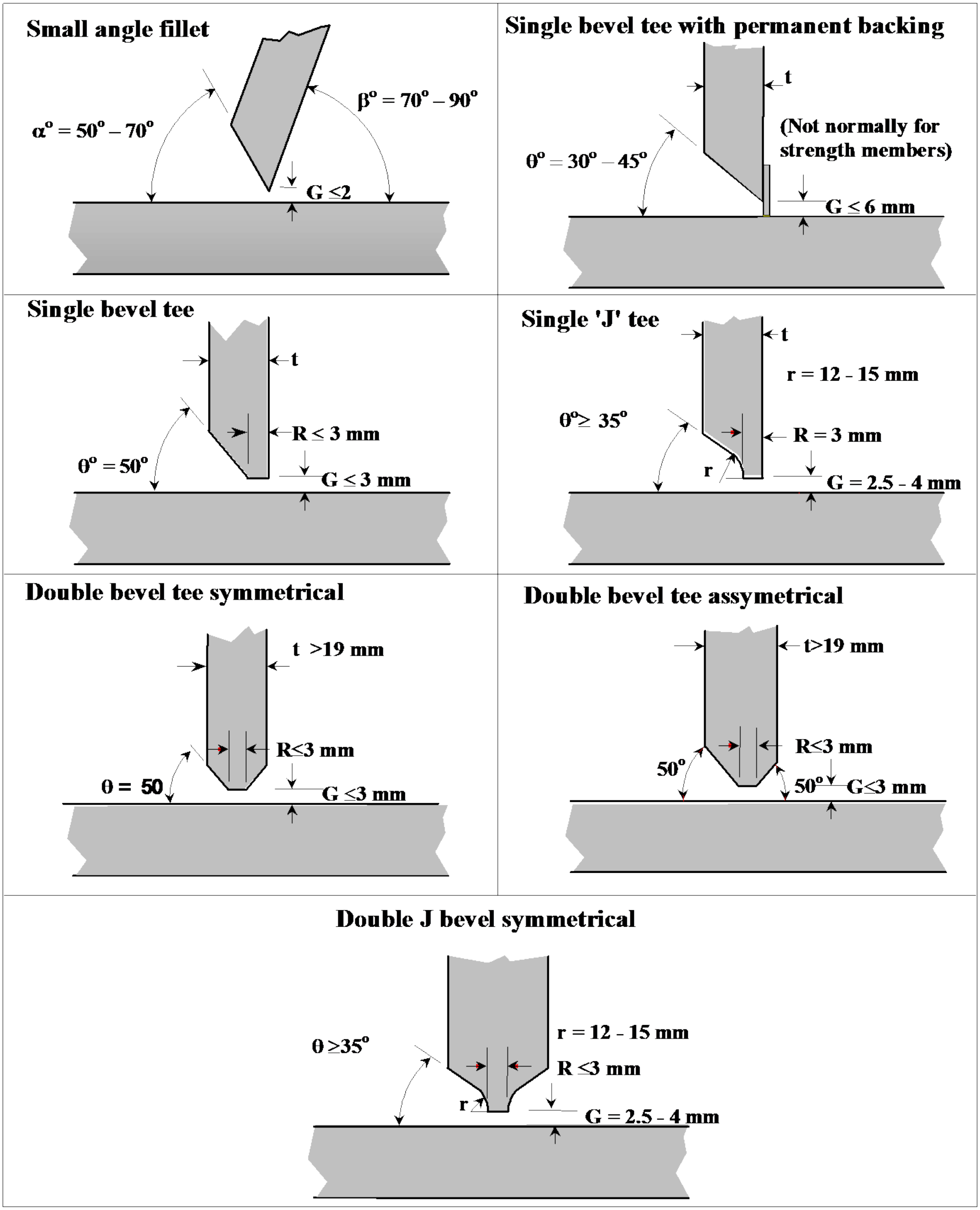


Fig. 6.6.4 : Typical edge preparations for manually welded 'T' or cross joints

6.9 End connection

6.9.1 In way of the end connections of girders double continuous welding is to be used all around. The weld area is not to be less than the cross-sectional area of the member, and the throat thickness not less than that given by Table 6.6.1 for girder ends.

6.9.2 Where stiffeners have bracketed end connections, bracket arms are to be welded all around and the throat thickness is not to be less than 0.35 times the thickness of bracket.

6.9.3 Where stiffeners are continuous at girder, they are to be connected to the webs, either directly and/or by means of lugs. The weld area is to be such that the shear stress does not exceed 80/k [N/mm^2]. Where the shear forces are high, a double sided connection to the web and/or a web stiffener welded on top of the continuous stiffener may be required.

6.10 Butt straps for aluminium alloy

6.10.1 In general the scantlings of welded structures are to be determined using the mechanical properties of aluminium alloy in the welded condition. However, where stiffeners are butt welded, consideration would be given to the use of suitable butt straps on the flanges which sufficiently reinforce the area of the weld to allow the scantlings to be determined using unwelded mechanical properties. The butt weld is to be completed and made flush with the flange of the stiffening member before the butt strap is fitted and the butt strap weld is to be continuous. The scantlings, arrangements and locations of all joints and butt straps are to be submitted for approval in such cases. Mechanical tests may also be required to be carried out to demonstrate the effectiveness of such arrangements.

Table 6.6.1 : Weld factors for fillet welds

	Structural items	Weld factors	Permitted type of weld		Remarks
			Double Cont.	Intermi-ttent	
Bottom Structure					
Center girder	To keel plate or bar keel	0.3	*		Double continuous welding is required in bottom impact area. See 6.6.5(g)
	To face plate	0.15		*	
	To inner bottom	0.25		*	
Side girder	To bottom shell	0.15		*	
	To face plate	0.13		*	
	To floors	0.20		*	
	To inner bottom	0.15		*	
Floors	To keel plate	0.15	*		
	To shell plating	0.15		*	
	To centre girder	0.35	*		
	To longitudinal bulkheads	0.35	*		
	To inner bottom	0.15		*	
	To face plate	0.15		*	
	Stern-tube covering	0.15	*		
Bottom and inner bottom longitudinals, frames	To shell plating	0.13		*	
Inner bottom	To side shell	0.4	*		
Stiffeners	To floors and girders	0.13		*	
Structure in Machinery Space					
Floors and girders	To shell and inner bottom	0.3	*		See Note 1
	To face plate	0.2	*		
Transverse and longitudinal frames	To shell plating	0.15	*		
Floors	To centre girder in way of engine, thrust blocks and boiler seatings				
	- In single bottom	0.50	*		
	- In double bottom	0.30	*		
Main engine foundation	To top plate	0.5	*		
Girders	To hull structure	0.4	*		
Floors	To engine girder	0.4	*		
Brackets etc.	To engine girders	0.3	*		
Side Structure					
Transverse frames	To side shell				
	- In tanks	0.13		*	
	- Elsewhere	0.11		*	
Side longitudinals	To shell plating	0.13		*	
Web frames and side stringers	To shell plating				
	- Within 0.2 x span from ends	0.35	*		
	- Elsewhere	0.20		*	
	To face plate and tripping bracket	0.15		*	
Web frames	To side stringers	0.3	*		

Table 6.6.1 : Weld factors for fillet welds (Continued….)

	Structural items	Weld factors	Permitted type of weld		Remarks
			Double Cont.	Intermi-ttent	
Deck Structure					
Strength deck	To shell	F.P.			See Note 2 Generally
Other decks	To shell and bulkheads	0.3	*		
Deck beams	To deck plating				
	- In tanks	0.13		*	
	- elsewhere	0.11		*	
Deck longitudinals	To decks	0.13		*	
Deck girders	To deck plating				
	- Within 0.2 x span from ends	0.35	*		
	- Elsewhere	0.20		*	
	- To face plating and tripping brackets	0.15		*	
Cantilever webs	To shell, decks, face plates and longitudinal girders at ends	0.35	*		
Pillars	To deck, inner bottom and pillar brackets	0.40	*		
Bulkheads and Partitions					
Boundaries of	Watertight, oiltight and wash bulkheads and shaft tunnels	0.4	*		
Stiffeners	On tank and wash bulkheads	0.13		*	
	On pillar bulkheads	0.13		*	
	On ordinary bulkheads	0.11		*	
Vertical and horizontal girders in tanks and wash bulkheads	To bulkhead plating				
	- Within 0.2 x span from ends	0.40	*		
	- Elsewhere	0.30		*	
	- To faceplate	0.30		*	
	- To tripping brackets	0.15		*	
Vertical and horizontal girders elsewhere	To bulkhead plating				
	- Within 0.2 x span from ends	0.35	*		
	- Elsewhere	0.20		*	
	To faceplate and tripping brackets	0.15		*	
Superstructures and Deckhouses					
External bulkheads	To deck				See Note 3
	- On 1st and 2nd tiers	0.40	*		
	- Elsewhere	0.25	*		
Internal bulkheads	Boundaries	0.13		*	
stiffeners	To external bulkheads	0.10		*	
Rudders and Nozzles					
Rudders					See Note 4
Main piece members	To coupling flange	F.P.	*		
	To each other	0.44	*		
Rudder plating	To rudder webs, elsewhere	0.20	*		
Nozzles	Generally as for rudders				

Table 6.6.1 : Weld factors for fillet welds (Continued….)

<table>
<tr><td colspan="6">Miscellaneous Fittings and Equipment</td></tr>
<tr><td>Framing ring for manhole type covers</td><td>To deck and bulkhead</td><td>0.4</td><td>*</td><td></td><td rowspan="12">Continuous fillet weld of minimum 4 [mm] throat thickness</td></tr>
<tr><td>Framing around ports and W.T./oiltight doors</td><td>To plating</td><td>0.4</td><td>*</td><td></td></tr>
<tr><td rowspan="2">Sea-chest boundary welds</td><td>Exposed to sea</td><td>0.5</td><td>*</td><td></td></tr>
<tr><td>- Elsewhere</td><td>0.4</td><td>*</td><td></td></tr>
<tr><td>Ventilators air pipes etc.</td><td>To deck</td><td>0.4</td><td>*</td><td></td></tr>
<tr><td rowspan="2">Bulwark stays</td><td>To deck</td><td>0.4</td><td>*</td><td></td></tr>
<tr><td>To bulwark plating</td><td>0.2</td><td></td><td>*</td></tr>
<tr><td>Bilge keel</td><td>To ground bars</td><td>0.2</td><td>*</td><td>*</td></tr>
<tr><td>Bilge keel ground bar</td><td>To side shell</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>0.35</td><td>*</td><td></td></tr>
<tr><td>Fabricated anchors</td><td></td><td>F.P.</td><td></td><td></td></tr>
<tr><td colspan="2">Masts derrick posts, crane pedestals, deck machinery and mooring equipment seating to deck etc.</td><td colspan="4">To be considered in each individual case</td></tr>
<tr><td colspan="6">Intermittent welding means chain intermittent, staggered intermittent or scalloped welding with rounded ends.
For permitted use see 6.6.6.

F.P. means full penetration weld

Note 1 : Preferably to be deep penetration or full penetration weld depending on the thickness of the engine girders.
Note 2 : Generally full penetration, but alternative proposals may be considered depending on t_p.
Note 3 : For end connections see 4.5.
Note 4 : See Chapter 8.</td></tr>
</table>

End Of Chapter

Chapter 7

General Hull Requirements for Fibre Composite and Sandwich Constructions

Contents

Section 1

Principles of Scantlings and Structural Details

1.1 Application

1.1.1 The Rules in this chapter apply to glass reinforced unsaturated polyester (GRP) structures of single skin construction and sandwich construction. Structures using fibre-reinforced plastics other than GRP may be accepted upon special consideration.

1.12 Scantlings of various laminates, stiffeners and girders satisfying the local strength requirements are to be determined in accordance with the general principles given in this chapter.

Scantlings of hull members contributing to the longitudinal strength are also to comply with the requirements of Section 6.

1.1.3 The design values of loads to be considered are given in Chapter 4.

1.1.4 In certain cases additional check to investigate the buckling strength of hull members subjected to compressive stresses may be required.

1.2 Symbols

s = spacing of stiffener [mm]

b = unsupported panel breadth [mm], See Fig. 7.3.2.

l = span of stiffener or girder [m]

p = design pressure [kN/m^2] as per 1.1.3

G_c = the glass content by weight of the reinforcement within the laminate

G = shear modulus of sandwich core material [N/mm^2]

σ_u = ultimate tensile or compressive stress, as applicable, for the laminate under consideration [N/mm^2]

E_i = tensile modulus of individual laminate, [N/mm^2]

t_c = core thickness [mm]

τ_u = ultimate shear stress of the laminate under consideration [N/mm^2].

1.3 Frame spacing

1.3.1 The normal frame spacing 's_r' may be taken as 350 + 5L [mm].

1.3.2 Where the actual spacing of stiffeners differs from the normal frame spacing s_r, the minimum thickness requirements specified in this Chapter for various structural members is to be corrected in direct proportion to the frame spacing, however, any reduction in thickness is not to be more than 30%.

1.4 Stiffeners and girders

1.4.1 For girders and stiffeners, the span ‘l’ [m] is to be taken as the length of the girder or stiffener between the two supporting members less the depth of girder or stiffener on crossing panel if any, with correction for end brackets as shown in Fig. 1.4.1(a) and 1.4.1(b).

For curved or knuckled stiffeners, ‘l’ may be based on the chord length.

1.4.2 The area of the attached plating to be used in the calculation of sectional properties of the stiffeners and girders, is to be taken as the cross sectional area within the effective width of the attached plating as given in 1.4.3

1.4.3 In case of single-skin laminates, the effective width ‘w’ of plating attached to a stiffener or girder is to be taken as the mean stiffener or girder spacing in [mm] or (18 t + b_w) [mm], whichever is less where, t = thickness of plating [mm] and b_w = net width of stiffener [mm]. See Fig. 1.4.3.

Where FRP sandwich laminate plating with an effective (balsa or marine plywood or plastic) core is used, “t” in the above equation is to be taken as the thickness of a single-skin laminate having the same moment of inertia per unit width as the two skins of the sandwich.

For a stiffener along an opening, the effective plating width is to be taken as either half the stiffener spacing in [mm] or (9t + b) [mm], whichever is less.

1.4.4 The effective cross sectional area of the attached plating is not to be less than that of the faceplate.

1.4.5 The effective cross sectional area of the girder web A_w is to be taken as per Chapter 6, Section 1.4.8.

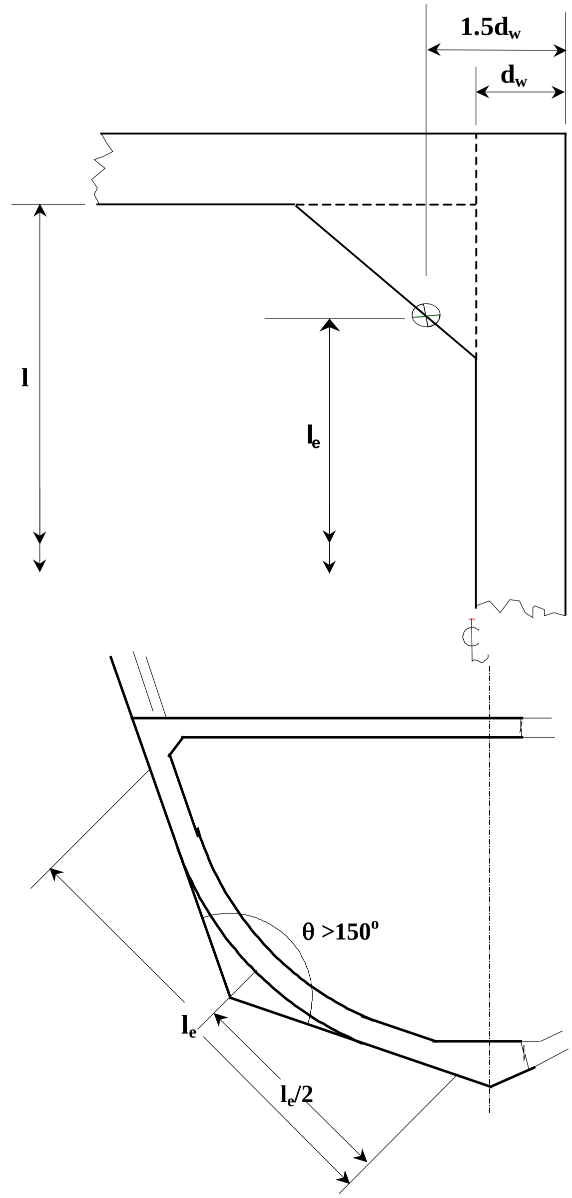


Fig. 1.4.1 (a) and (b)

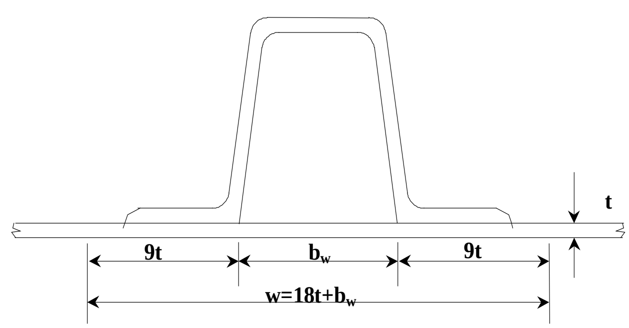


Fig. 1.4.3

1.4.6 The proportions of stiffeners and girders with hollow form or nonstructural cores or forms, including ineffective wood cores (softwoods used below the waterline are considered to be ineffective), are to conform with Fig.1.4.6. The widths and heights of the stiffeners are to be not greater than:

$w = 20\ t_1$ [mm] $h = 30\ t_w$ [mm]

Where,

w = width of stiffener face [mm]
h = height of stiffener webs [mm]
t_1 = thickness of stiffeners face [mm]
t_w = thickness of stiffener webs and flanges [mm].

The thickness of the web of an inverted angle or T bar stiffener or girder is not to be less than twice the web thickness specified for hollow forms.

For encapsulated effective wood or plywood core, webs and faces are not subjected to the above mentioned thickness limitations, however, minimum thickness of the web and face is to be 3 [mm].

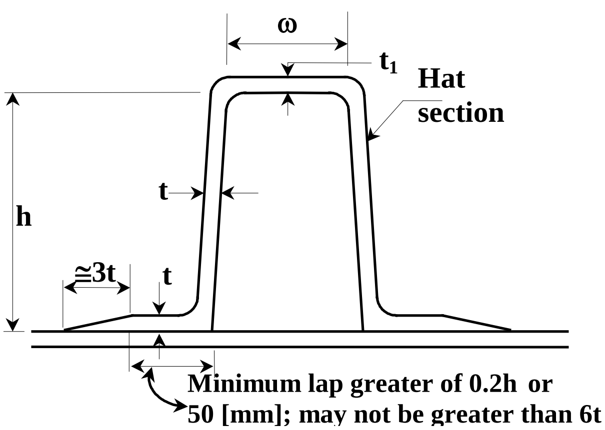


Fig. 1.4.6 : Proportions and connections of stiffeners

1.4.7 Shear ties (stiffeners)

Where the total web depth to thickness ratio requirement in 1.4.6 for buckling of stiffener webs is not complied with, cross linking of the stiffener webs at the Rule depth to thickness ratio is to be provided by the use of shear ties, as indicated in Fig.1.4.7.

Alternative arrangements will be subject to individual consideration in conjunction with submitted direct calculations.

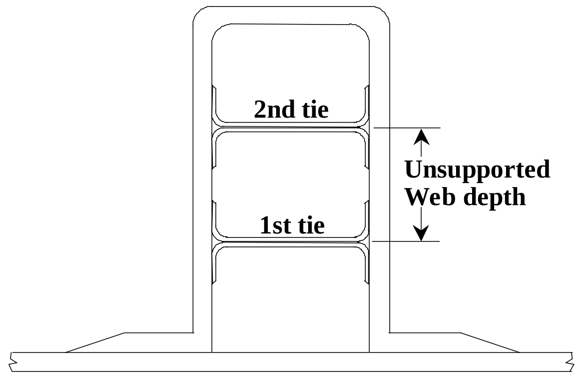


Fig. 1.4.7 : Arrangement of shear ties (stiffeners)

1.4.8 Where openings are cut in the girder web, they are to be away from the girder ends and scallops for stiffeners, with their centre location as near to the neutral axis of the girder as practicable. Openings of depth exceeding 25% of the girder depth or 300 [mm] and of length exceeding the depth of the girder or 60% of the secondary stiffener spacing, are to be suitably reinforced all around at the edge

1.4.9 Girders are to be provided with adequate lateral stability by tripping brackets fitted generally at every alternate stiffener in case of asymmetrical section or at every fourth stiffener in case of symmetrical section. Tripping brackets are also to be fitted at the toes of end brackets and in way of concentrated loads such as heels of pillars or cross ties.

1.5 End attachments

1.5.1 The end attachment of stiffeners and girders are to ensure good structural continuity. As far as practicable the stiffeners and girders are to be continuous through and adequately supported at the supporting members. In case of connections side frame to deck beams or where it is not feasible to provide the continuity, the stiffeners and girders may be abutted provided brackets as required by 1.5.2 are fitted. Typical acceptable arrangements are shown in Fig.1.5.1.

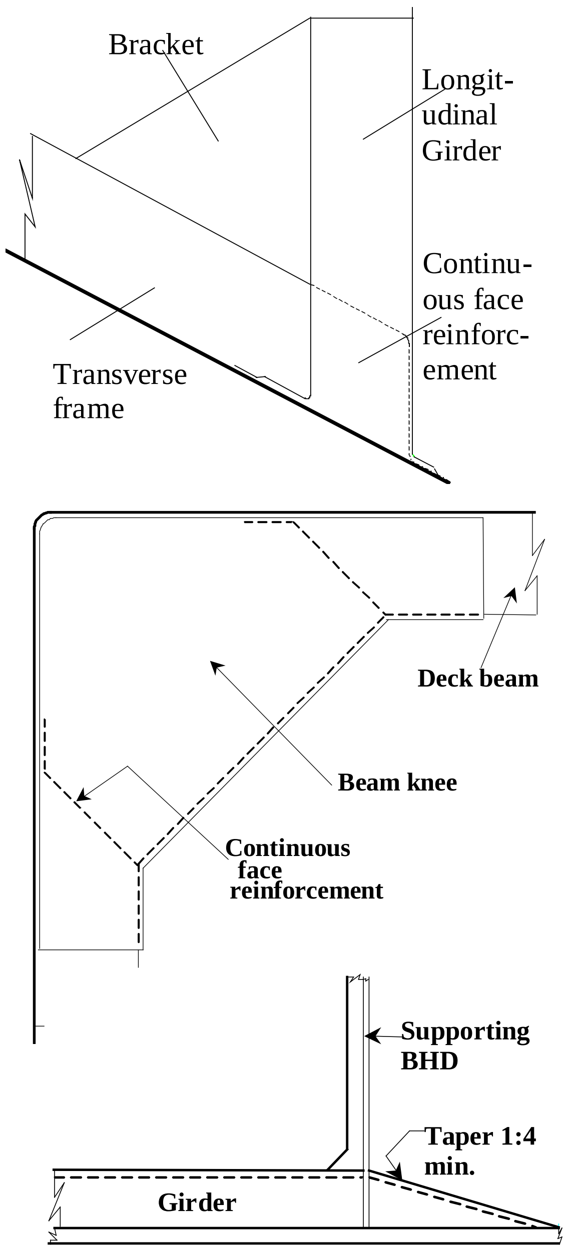


Fig. 1.5.1 : End attachments

1.5.2 In general, the thickness of webs and flanges of the stiffeners or girders is to be continued over the bracket region. The bracket arm length (including the depth of the stiffener or girder) is not to be less than 1.5 times the depth of the stiffener or girder.

1.6 Bottom structures

1.6.1 In crafts of single skin construction, the bottom structures are normally to be longitudinally stiffened. In crafts with sandwich construction, adequate longitudinals or longitudinal girders are to be provided in way of shear ties see 7.2.3 and may also be provided to support the bottom panels.

The bottom longitudinals are to be supported by bottom transverses or bulkheads spaced not more than 2 metres apart.

1.6.2 Web frame rings continuous around the transverse cross section of the craft are to be arranged in line with the bottom transverses. Where intermediate floors are fitted for additional bottom support, their ends are to be well tapered or connected to local panel stiffening.

1.6.3 In the engine room, floors are generally to be fitted at every frame. The floors are preferably to be carried continuously through the engine girders. In way of thrust bearings additional strengthening is to be provided.

1.6.4 Bottom longitudinal girders in general, are to spaced 2.5 m and are to be carried continuously through bulkheads.

A centre girder is to be fitted for docking purposes if the external keel or bottom shape does not give sufficient strength and stiffness.

1.6.5 Main engines are to be supported by longitudinal girders with suitable local reinforcement to take the engine and gear mounting bolts. Rigid core materials are to be applied in all through bolt connections. Also see 4.7 for inserts.

1.6.6 Adequate number of manholes are to be provided for easy access to all parts of the double bottom. Exposed edges of openings in sandwich constructions are to be sealed with resin impregnated mat see 4.8 for details. All openings are to have well-rounded corners.

1.7 Side structures

1.7.1 The craft sides may be longitudinally or vertically stiffened.

1.7.2 In open deck crafts, the top ends of the stiffeners are to be efficiently connected to fore and aft gunwale at deck line.

1.8 Deck structure

1.8.1 Decks of single skin construction are normally to be longitudinally stiffened.

1.8.2 In areas subjected to high compressive stresses additional transverse intermediate stiffeners may have to be fitted to ensure adequate buckling strength.

1.8.3 Hull to deck connections details are to be as per 4.10.

1.9 Bulkhead structures

1.9.1 Number and location of transverse watertight bulkheads are to be in accordance with the requirements given in Chapter 5, Section 5.

1.9.2 Bulkheads are to be suitably strengthened at the ends of deck girders and where subjected to concentrated loads.

1.10 Bow protection

1.10.1 For craft of composite sandwich construction the fore foot region upto atleast one frame spacing abaft of the stem, is to be so designed that in the event of local impact the effect of damage will be limited. This may be achieved by providing an additional sacrificial nose or sheathing or by arranging the individual plies of the laminate such that any delamination due to the impact will be directed to the outer surface of the laminate.

1.11 Superstructures and deckhouses

1.11.1 In superstructures and deckhouses, the front bulkhead is to be in line with a transverse bulkhead in the hull below or be supported by a combination of girders and pillars. The after end bulkhead is also to be effectively supported. As far as practicable, exposed sides and internal longitudinal and transverse bulkheads are to be located above girders and frames in the hull structure and are to be in line in the various tiers of accommodation. Where such structural arrangement in line is not possible other effective supports are to be arranged.

1.11.2 Sufficient transverse strength is to be provided by means of transverse bulkheads or girders supported by web frames.

1.11.3 At the break of superstructures, which have not set-in from the ship’s side, the side plating is to extend beyond the ends of the superstructure and is to be gradually reduced in height down to the deck or bulwark. The transition is to be smooth and without local discontinuities.

1.11.4 Openings in the sides of deckhouses are to have well-rounded corners. Large openings in sides of deckhouses are to be substantially stiffened along the edges.

1.11.5 Machinery casings supporting one or more decks above are to be adequately strengthened.

1.12 Bulwarks

1.12.1 Bulwark sides shall have the same scantlings as required for a superstructure in the same position.

1.12.2 A strong flange is to be made along the upper edge of the bulwark. Bulwark stays are to be arranged in line with transverse beams or local stiffening. The stays are to have sufficient width at deck level. If the deck is of sandwich construction solid core inserts are to be fitted at the foot of the bulwark stays. Stays of increased strength are to be fitted at ends of bulwark openings. Openings in bulwarks are not to be situated near the ends of superstructures.

1.12.3 Where bulwarks on exposed decks form wells, ample provision is to be made to facilitate freeing the decks of water.

Section 2

Requirements for Manufacturing Facilities

2.1 Storage of raw materials

2.1.1 Storage premises are to be so equipped and arranged that the respective material supplier's recommendations for correct storage and handling of the raw materials are complied with.

2.1.2 Storage premises for glassfibre are to be kept clean and as free from dust as possible, so that the raw material is not contaminated. Glassfibre parcels are also to be protected against rain and moisture.

2.1.3 The glass fibre materials are to be stored for at least two days in storage premises where the relative humidity of air is not higher and the air temperature is not lower than that in the moulding shop.

2.1.4 The resins are to be stored under dry, well-ventilated conditions, in accordance with the material supplier's recommendations. Resins which are stored at temperatures lower than + 18^{o}C are to be pre-conditioned to the moulding shop temperature prior to use.

2.1.5 Core materials are to be stored dry and protected against mechanical damage.

2.2 Manufacturing conditions

2.2.1 Manufacturing premises are to be so equipped and arranged that the material supplier's directions for handling the materials, the laminating process and curing conditions can be followed.

2.2.2 The air temperature in the moulding shops is not to be less than + 18^{o}C and in general, not more than 30^{o}C. The air temperature is to be attained at least 24 hours before commencement of lamination and is to be maintained within ±3^{o}C throughout the moulding area during the lay-up and curing period.

2.2.3 The relative humidity of the air is to be kept below the dew point to avoid condensation and is in any case not to exceed 75%. In areas where spray moulding is taking place, the relative humidity is not to be less than 40%.

2.2.4 Air temperature and relative humidity are to be recorded at all necessary locations regularly.

2.2.5 Arrangements are to be made to prevent draught and direct sunlight in places where lamination and curing are in progress.

2.2.6 Sufficient scaffoldings are to be arranged so that all lamination work can be carried out without operators standing on the core or on surfaces on which lamination work is taking place.

2.2.7 Fabrication of flat panels is to be carried out on a support lifted from the workshop floor level.

Section 3

Production Procedures, Workmanship and Manufacturing Control

3.1 General

3.1.1 Fabrication of all major structural parts is to be carried out in accordance with the approved production plan and by skilled operators. Any deviations from this plan are required to be approved by the surveyor prior to commencement of the work.

3.1.2 Raw materials for all structural members covered by the Rules are to be of approved type in accordance with Chapter 3. The supplier's directions for application of the materials are to be followed.

3.2 Manual lamination

3.2.1 The reinforcement material is to be applied in the approved sequence.

3.2.2 Changes in laminate thickness are to be made using a gradual taper. The length of such taper is, in general, not to be less than 20 times the difference in thickness. Where the construction changes from sandwich laminate to a solid laminate, the thickness of the core material is, in general, to be reduced by a gradual taper of not less than 2:1. Also see Fig.7.1.3.

3.2.3 When the laminate is applied in a mould a chopped strand mat of max. 450 g/m^2 is to be applied next to the gelcoat.

3.2.4 Polyester resin is to be applied on each layer of reinforcement. Gas and air pockets are to be worked out of the laminate by regular rolling, generally before the next layer is applied. Rolling of the layers are to be made carefully, paying special attention to sharp corners and transitions.

3.2.5 The time interval between applications of each layer of reinforcement is to be within the limits specified by the material supplier. For thicker laminates care is to be taken to ensure a time interval sufficiently large to avoid excessive heat generation.

3.2.6 Curing systems are to be selected with due regard to the reactivity of the polyester and in accordance with the supplier’s directions. Heat development during curing is to be kept at a safe level. The quantity of curing agents is to be kept within the limits specified by the supplier.

3.2.7 After completion of lamination the laminates are to cure for at least 48 hours at an air temperature of not less than 18^{o}C. Curing at a higher temperature and a shorter curing time may be accepted on the basis of control of the curing rate.

3.3 Spray moulding

3.3.1 The term spray moulding is understood to mean the simultaneous deposit of polyester resin and fibreglass reinforcement. Manufacturers using this method are subject to special approval.

3.3.2 When approval of the spray moulding process is considered, special attention will be paid to production arrangement, ventilation equipment, the manufacturer's own quality control systems and other factors of significance to the quality of the finished product.

3.3.3 Spray moulding of structural members is to be carried out only by specially approved operators.

3.3.4 The equipment used for spray moulding is to give an even and homogenous build-up of the laminate. Any dosage devices are to ensure an even application of additives to the polyester resin. No fibres are to be shorter than 20 mm in length.

3.3.5 In addition to ensuring an even application during the spray moulding over the entire surface, regular rolling out of the sprayed-on layers is to be carried out. Immediately next to the gelcoat, the rolling out is to be done before the thickness of finished laminate reaches 1.5 mm and thereafter for every 2.5 mm of thickness of subsequent layers. The rolling out is to be done thoroughly to ensure adequate compression and removal of gas and air pockets. Special care is to be taken at sharp transitions and corners.

3.4 Sandwich lay-up

3.4.1Sandwich constructions can be fabricated either by lamination on the core (e.g. plug moulding), application of the core against a wet laminate or by gluing the core against a cured skin laminate.

3.4.2 Efficient bond is to be obtained between the skin laminates and the core and between the individual core elements. Approved tools for cutting, grinding etc. of various types of core material are to be specified in the production procedure. The bond is to be verified by shear or tensile testing.

3.4.3 All joints between skin laminates and core and between the individual core elements are to be completely filled with resin, glue or filler material.

3.4.4 Core materials with open cells in the surface are normally to be impregnated with resin before it is applied to a wet laminate or before lamination on the core is commenced.

3.4.5 When the core is applied manually to a wet laminate the surface is to be reinforced with a chopped strand mat of 450 g/m^2 on plane surface and 600 g/m^2 on curved surfaces. The core material is to be laid onto the pre-moulded skin as soon as possible after the laminate cure has passed the exothermic stage.

3.4.6 Frameworks for core build up are to give the core sufficient support to ensure stable geometrical shape of the construction and a rigid basis for the lamination work.

3.4.7 When a prefabricated skin laminate is glued to a sandwich core, measures are to be taken to evacuate air from the surface between skin and core.

3.4.8 The core material is to be free from dust and other contamination before the skin laminates are applied or core elements are glued together.

3.4.9 Where a core is to be applied to an uneven surface, the Surveyor may request additional building up of the surface or contouring of the core to suit.

3.4.10 In general laminates are to be staggered by 50 mm per layer of reinforcement. Where very thin sandwich skins are adopted the rate of laminate stagger will be individually considered. The plans are to clearly show the staggering of successive plies in both the transverse and longitudinal directions.

3.4.11 Thermoforming of core materials is to be carried out in accordance with the manufacturer's recommendations. Maximum temperature limits are to be strictly observed.

3.5 Secondary bonding

3.5.1 A secondary bonding is any bond between two GRP structures which is made after one or both of the individual structures has effectively cured.

Normally, the laminating is to proceed as a continuous process, as far as practicable, with the minimum of delay between successive plies. Where a secondary bond is required to be made, it is to be carried out in accordance with the resin manufacturer's recommendation, details of which are to be incorporated in the builder's quality control documentation. This will, in general, take the form of the area being lightly abraded and wiped with a suitable solvent, which is to be allowed to dry prior to laminating.

3.5.2 The surface ply of a laminate subject to secondary bonding and the first ply of the bonding laminate is normally to be of chopped strand mat to enhance the interlaminar strength of the laminate.

3.5.3 Surfaces in way of secondary bonding are to be clean and free from dust.

3.5.4 If a laminate subject to secondary bonding has cured for more than 5 days the surface is to be ground. If resin containing wax is used, grinding is required if the curing time exceeds 24 hours.

3.5.5 Consideration is to be given, especially in highly stressed areas, to the application of peel ply materials to obviate contamination of the exposed surface, and thereby reducing the abrading required to obtain a good secondary bond. If "peel strips" are used in the bonding surface the required surface treatment may be dispensed with.

3.6 Faults

3.6.1 All faults are to be classified according to their severity and recorded, together with the remedial action taken, under the requirements of the quality control systems. The documentation is to be made available during surveys and for works approval.

3.6.2 Production faults are to be brought to the attention of the attending Surveyor and a rectification scheme agreed upon.

3.7 Repair

3.7.1 Minor repairs are to be agreed with the attending Surveyor prior to being carried out. The builder is to incorporate details of the agreed repair procedures in the quality control system for the craft.

3.7.2 Where required, plans giving details of the proposed structural modifications or repairs are to be submitted for approval, prior to execution.

3.8 Inspection

3.8.1 It is the builder's responsibility to carry out the inspections required in accordance with the accepted quality control system.

3.8.2 The Surveyors will monitor the builder's quality control records and carry out inspections of work in progress during their periodical visits.

3.8.3 During inspections, all deviations are to be dealt with under the builder's agreed quality procedures.

3.9 Acceptance criteria

3.9.1 Classification is dependent upon the work being carried out in accordance with the approved plans and the requirements of an accepted quality system.

3.9.2 The workmanship is to be to the satisfaction of the attending Surveyor. This will include the verification of the quality control documentation and the remedial action associated with all defects and deficiencies recorded.

3.9.3 Proposed deviations from the approved plans are subject to IRS approval. An amended plan is to be submitted for approval prior to any such changes being introduced.

Section 4

Details and Fastenings

4.1 General

4.1.1 The general requirements in respect of details and fastenings given in this section are in addition to the accepted good building practices. Alternative details may be accepted against evidence of satisfactory service experience or test data.

4.2 Alignment

4.2.1 Details of alignment and building tolerances are to be laid down in the builder's production plan.

4.2.2 Where details of alignment and building tolerances are not included on the construction plans, or submitted separately for consideration with the plan submission, they may, subject to individual consideration, be agreed locally with the attending Surveyor.

4.2.3 Particular attention is to be given to the accurate alignment of the following:

a) girder abutting single skin bulkhead,
b) girder webs with tank sides,
c) frames with beams,
d) deck and bottom girders with bulkhead or transom stiffeners,
e) tank baffles with floors,
f) longitudinals where broken at tank ends, and

4.2.4 For larger crafts, the hull breakage sight line is to be progressively monitored during the construction of the craft and is to form part of the quality control documentation. The production plan is to identify maximum breakage limits dependent upon the size of the craft.

4.2.5 The production plan is to identify allowable tolerances for the alignment of the primary structural components.

4.2.6 To ensure efficient load transmission, intercostals, single skin bulkheads are to be aligned to within half the thickness of the thinner bulkhead. In the case of sandwich construction the tolerance requirements will be individually considered dependent upon the sandwich panel dimensions and the construction of the continuous member. In general, the webs of the intercoastal sandwich panel member are to be aligned within 5 mm. Where poor alignment has been identified, additional boundary bonding reinforcements are to be applied as agreed with the attending Surveyor. Any deviations and details of the remedial action taken are to be recorded in the builder's quality control documentation.

4.2.7 To ensure efficient transmission of shear loads, the alignment tolerance of intercoastal ‘top hat’ stiffener webs is, in general, to be within half of the web thickness. Where poor alignment is identified, additional reinforcements are, in general, to be incorporated into the stiffener webs as agreed with the attending Surveyor. Such deviations and details of the remedial action taken are to be recorded in the builder's quality control documentation.

4.3 Continuity

4.3.1 Continuity of all primary structural members is to be maintained and abrupt changes of section are to be avoided. All longitudinal girders and stiffeners are to be continuous through their supporting members.

Brackets ending at unsupported sandwich panels are to be tapered smoothly to zero and the panels skin laminate to be locally reinforced at the end of the bracket.

Girders are to be fitted with bracket or tapered gradually at ends. See Fig. 1.5.1

4.3.2 Special consideration is to be given to the inter-section of longitudinal and transverse members. In general the ratio between the depths of the intersecting members is to be 2:1. The shallower member is to be continuous under the supporting members.

4.3.3 Alternative proposals to the requirements given in 4.3.2 will be subject to special consideration alongwith details for maintaining the continuity of reinforcements at intersections in both directions which are to be submitted. Where stiffeners are of similar dimensions the primary member is to be continuous. In general, the section modulus of the continuous material is to be maintained.

4.4 Openings

4.4.1 All openings are to have well rounded corners and are to be supported on all sides. Cut edges of openings are to be sealed to prevent the ingress of moisture.

4.4.2 All hatch openings are to be supported by a system of transverse and longitudinal stiffeners, the details of which are to be submitted for approval.

4.4.3 The requirements for closing arrangements and outfit are given in Chapter 5, Section 6.

4.4.4 All deck openings are to have corner radii as specified in Section 6.4.3.

4.4.5 For details of sealing the edges of openings and sandwich panels, see 4.9.

4.5 Through bolting and bolted connections

4.5.1 Bolting arrangements are, in general, to be in accordance with 4.5 to 4.7. The details of all through bolted structural connections including bolt material, proposed number and spacing are to be indicated on the relevant construction plans submitted for approval. The design of the joint is to be suitable for its intended purpose with a sufficient number of bolts to satisfactorily close the joint.

4.5.2 All fastenings are to be of a suitable marine grade and are to be of a non-corrosive material or protected against corrosion.

4.5.3 In general, large headed bolts or large diameter thick washers are to be used to prevent localised crushing damage during tightening.

4.5.4 Where mechanical fastenings are used, the torque is to be indicated on the plans submitted for approval.

4.5.5 In sandwich constructions, inserts of a material capable of resisting crushing are to be fitted in accordance with 4.7.

4.5.6 The diameter of a fastening is not to be less than the thickness of the thinner component being fastened, with a minimum of 6 mm.

4.5.7 Bolted connections are, in general, to be bonded along all mating surfaces using an accepted structural adhesive, applied in accordance with the manufacturer's requirements. Where connections rely solely on the shear resistance of the connecting bolts the spacing is not to exceed 3 x the bolt diameter. In areas where subsequent access will either be limited or not possible, self-locking nuts are to be provided.

4.5.8 In general, all structural, bolted connections are to use reeled lines of bolts in accordance with the requirements given in Table 4.5.8.

Table 4.5.8 : Minimum bolt pitch requirements in bonded and bolted connections

Location	Pitch
Watertight connections - below static load waterline	$10\ d_b$
Connections in hull above static load waterline to deck	$15\ d_b$
Hull to deck connections - bonded with structural adhesive - bolted with mastic sealant (see note 2)	$15\ d_b$ $8\ d_b$
Connections in deckhouses	$20\ d_b$
Deckhouse to deck connections - bonded with structural adhesive - bolted with mastic sealant (see note 2)	$15\ d_b$ $8\ d_b$
Minimum distance between reeled lines of bolts	$3\ d_b$
Minimum distance from centreline of line of bolts to free edge	$2\ d_b$

Notes:
1. d_b is the diameter of the bolt
2. Internal boundary sealing angle to be provided.

4.5.9 All structural, single line, bolted connections without adhesive bonding are to be in accordance with the requirements given in Table 4.5.9.

Table 4.5.9 : Minimum bolt pitch requirements in bolted structural connections

Location	Pitch
Manhole covers to fuel tanks	6 d_b
Manhole covers to water tanks	8 d_b
Covers over void tanks/cofferdams	10 d_b
Bolted access hatches in decks	10 d_b
Bolted watertight door frames	8 d_b
Window frames	8 d_b

Notes:
1. d_b is the diameter of the bolt.
2. Internal boundary sealing angle to be provided.

4.5.10 Care is to be taken to avoid distortion of the frame when window frames are bolted into the structure of the craft. Where necessary, uneven surfaces are to be locally built upto the satisfaction of the attending Surveyor.

4.5.11 Bolt holes are to be drilled, without undue pressure at break through, having a diametric tolerance of two percent of the bolt diameter. Where bolted connections are to be made watertight the hole is to be sealed with resin and allowed to cure before the bolt is inserted.

4.5.12 In areas of high stress or where unusual bolting configurations are proposed, testing on the basis of equivalence with the above Rules, may be required.

4.6 Through hull fittings

4.6.1 Where fittings penetrate the hull envelope, care is to be taken to seal the hull laminate with resin or other suitable compound. See 4.9.

4.6.2 The areas in way of penetrations for fittings in sandwich construction are, in general, to comply with the requirements of 4.7. Where the requirements cannot be complied with, the core is to be replaced locally with a solid core or very high density foam core with compressive properties commensurate with the loads imposed by the securing arrangements. In areas where localised crushing of a sandwich core is likely to occur, large diameter washers, compression tubes or inserts or a combination of these may to be provided.

4.6.3 All bolted fittings are to be bedded down using a suitable mastic, details of which are to be indicated on the plans for approval.

4.7 Backing bars (inserts) and tapping plates

4.7.1 The requirements for backing plates and bars will be individually considered, on the basis of the loading imposed, details of which are to be indicated on the submitted plans.

4.7.2 Metallic plates and bars are to be suitably protected against corrosion.

4.7.3 Tapping plates may be encapsulated within the laminate, laminated to or bolted to the structure. Where tapping plate edges or corners are likely to give rise to hard spots or stress concentrations the edges are to be suitably rounded.

4.7.4 Where tapping plates are placed on foam cores the plate is to be mounted on a suitable foundation to prevent the movement of the tapping plate during drilling operations.

4.7.5 Direct calculations regarding the scantlings of tapping plates are to be provided at the plan appraisal stage.

4.8 Exposed edges

4.8.1 The exposed edges of all openings cut in single skin laminate panels are to be suitably sealed. Where such edges are in wet spaces or under water the edges of such openings are to have rounded edges and are to be sealed by two plies of 450 g/m^2 chopped strand mat (or equivalent) reinforcements.

4.8.2 Exposed edges of openings cut in sandwich panels are to be suitably sealed. The cut edges are, in general, to be sealed with a weight of reinforcement not less than that required for the outer skin of the sandwich. Where other than an epoxy resin system is used the first layer of such reinforcement is to be chopped strand mat with a weight not exceeding 450 g/m^2.

4.9 Local reinforcement

4.9.1 Areas subject to local loads or increased stress are to be suitably reinforced, details of which are to be indicated on the submitted plans.

4.9.2 The hull is to be locally increased by minimum 50% in thickness in way of rudder tubes, propeller brackets, etc. Details of such reinforcements are to be submitted. Local reinforcement is in general to extend under the adjacent supporting structure and then tapered gradually to the base laminate thickness over a distance of minimum 20 times the difference in thickness.

4.10 Hull to deck connections

4.10.1 Details of the hull to deck connection, the method of bonding and the tolerances are to be indicated on the submitted plans.

4.10.2 Hull to deck connections are to be, in general, bolted and over-bonded. A suitable mastic or sealing compound is to be incorporated within the joint.

4.10.3 The bolting details are to be reeled lines of bolts pitched as specified in Tables 4.5.8 and 4.5.9, as applicable. Suitable large diameter thick washers are to be used under both the head and the nut.

4.10.4 Where a mastic is not used, sealing plies are to be applied on the inside of the hull.

4.10.5 The weight of the over-bonding reinforcement is, in general, not to be taken as less than equivalent to the lighter of the component members being connected, and in no case less than equivalent to three plies of 600 g/m^2 chopped strand mat.

4.10.6 Substantial beam knees are to be provided to maintain structural continuity between the transverse deck and hull stiffening.

4.10.7 The watertight integrity, continuity and strength of the connection is not to be impaired by the attachment of the hull fender.

4.11 Exhaust systems

4.11.1 Exhaust systems, manufactured from FRP, are to be of the water injected type with a normal operating temperature of 60^o to 70^{o}C.

4.11.2 Exhaust pipes, silencers and water separators are to be of a type approved design, installed strictly in accordance with the manufacturer's requirements.

4.11.3 Where a type approved system is not used, the arrangement will be considered on an individual basis. Resins used in the manufacture of exhaust systems are to be of a type approved by IRS and are to have good heat and chemical resistance properties with a high deflection temperature under load. A vinylester resin is to be used, but a fire retardant polyester resin, having a high heat distortion temperature, will be considered. Test samples may be required dependent upon the proposed arrangement, temperatures and materials.

4.11.4 It is recommended that pigments and additives are not used unless it can be demonstrated that the mechanical properties of the resin system remain unaffected. Resins used are not to show any embrittlement with age.

4.11.5 Special consideration is to be given to post curing of such systems to obtain optimal characteristics.

4.11.6 Due to the weight of water contained within the system, exhaust pipes and fittings are to be efficiently supported.

4.11.7 Exhaust boxes are to be lined with a minimum of two plies of 600 g/m^2 chopped strand mat (or equivalent) using a suitable fire retardant/high temperature resin.

4.11.8 For engineering aspects of exhaust systems reference is to be made to Chapter 12, Section 3.1.4.

4.12 Ballast

4.12.1 The provision of permanent ballast is not to adversely affect the surrounding structure.

4.12.2 Where a resin compound is to be poured into a void space, care is to be taken to minimise the generation of heat that may affect the mechanical and weathering characteristics of the structural laminate.

4.12.3 Details of all ballast materials and the proposed method of installation are to be indicated on the submitted plans.

4.13 Limber holes

4.13.1 Provision is to be made to drain areas likely to accumulate liquids, details of which are to be indicated on the submitted plans.

4.13.2 The size, shape and position of limber holes are not to affect the structural strength of the stiffening members in which they are fitted. Limber holes are, in general, to be positioned at the quarter span of the stiffener.

4.13.3 In way of limber holes, “Top Hat” stiffeners are to be boxed, so that, water does not pass through stiffener hollows to other parts of the vessel.

4.14 Integral tanks (requirements for coatings)

4.14.1 The surfaces of integral tanks are to be provided with a barrier to reduce the ingress of liquid. The details of the proposed system are to be indicated on the submitted plans.

4.14.2 Fresh water tanks are to be coated with a non-toxic and non-tainting coat of resin that is recommended by the resin manufacturer for potable water tanks.

4.14.3 The design and arrangement of oil fuel tanks is to be such that there is no exposed horizontal section at the bottom that could be exposed to a fire. Other fire protection arrangements for oil fuel tanks will be specially considered. For details of fire protection requirements see Chapter 10.

4.14.4 Where plywood bulkheads form part of a tank boundary, the surface is to be completely protected against the ingress of moisture with a minimum of 5 mm thickness of laminate to provide an effective fluid barrier.

4.14.5 Where outfit items are to be laminated to the tank surface, the heavy coating of resin is to be applied afterwards and the laminated brackets sealed to prevent the ingress of moisture.

4.14.6 The scantlings of integral oil fuel and water tanks are to be in accordance with Sections 7, 8 and 9.

4.14.7 Integral tanks are to be tested in accordance with Chapter 5, Section 5.5.

4.15 Reserve buoyancy

4.15.1 Details of materials to be used and the method of installation of reserve buoyancy are to be indicated on the submitted plans.

4.15.2 Where necessary, buoyancy materials are to be over-laminated in-situ to prevent the ingress of moisture.

Section 5

Material Properties and Testing

5.1 Material properties

5.1.1 The mechanical properties of materials which are assumed for determination of scantlings as per Sections 6, 7 and 8, are to be clearly indicated on the structural plans submitted for approval.

5.1.2 The reinforcements are to be thoroughly impregnated with resin. The maximum glass content by weight of reinforcement is in general, not to exceed the following:

In case of chopped strand mat or sprayed fibres	0.34
In case of Woven rovings	0.50

5.1.3 In the absence of suitable test data, the assumed mechanical properties of laminates may be based on the properties given in Tables 5.1.4 (a) and (b). In case of laminates using alternate layers of chopped strand mat and woven roving reinforcements, the estimation of properties of the composite laminates is to be based on the mechanical properties of individual layers, their thickness and location in the laminate etc.

5.1.4 The approval of plans is subject to proof, by testing as per 5.2, that the assumed mechanical properties are within the following limits :

– 90 percent of the mean first ply/resin cracking failure values determined from accepted mechanical tests,
– or the mean values minus two times the standard deviation for the five samples.

Table 5.1.4 (a) : Mechanical properties for chopped strand mat (CSM) reinforcements

Mechanical property	[N/mm^2]
Ultimate tensile strength	$200\ G_c + 25$
Tensile modulus	$(15\ G_c + 2) \times 10^3$
Ultimate compressive strength	$150\ G_c + 72$
Compressive modulus	$(40\ G_c – 6) \times 10^3$
Ultimate shear strength	$80\ G_c + 38$
Shear modulus	$(1.7\ G_c + 2.24) \times 10^3$
Ultimate flexural strength	$502\ G_c^2 + 106.8$
Flexural modulus	$(33.4\ G_c^2 + 2.2) \times 10^3$
Note: G_c is the glass content by weight of the reinforcement within the laminate.	

Table 5.1.4 (b) : Mechanical properties for woven roving (WR) reinforcements

Mechanical property	[N/mm^2]
Ultimate tensile strength	$400\ G_c - 10$
Tensile modulus	$(30\ G_c - 0.5) \times 10^3$
Ultimate compressive strength	$150\ G_c + 72$
Compressive modulus	$(40\ G_c – 6) \times 10^3$
Ultimate shear strength	$80\ G_c + 38$
Shear modulus	$(1.7\ G_c + 2.24) \times 10^3$
Ultimate flexural strength	$502\ G_c^2 + 106.8$
Flexural modulus	$(33.4\ G_c^2 + 2.2) \times 10^3$
Note: G_c is the glass content by weight of the reinforcement within the laminate.	

5.1.5 The total thickness of a cured laminate is given by:

$$t = \Sigma t_i \text{, (excluding the gel coat)}$$

where,

t_i = the thickness of i_{th} layer

$$= \frac{w_i}{3072} \times \left(\frac{2.56}{G_c} - 1.36 \right) \text{ [mm]}$$

w_i = the weight of the reinforcement in the i_{th} layer, [g/m^2]

G_c = glass content by weight in the i_{th} layer.

5.2 Testing

5.2.1 The test pieces of sandwich panels and laminates are to represent the actual construction in respect of the raw materials used (reinforcements, resins, additives and fillers), lay-up sequence, production procedures, workshop conditions, etc.

The shear strength and shear modulus properties of type approved core materials as tested and certified by the supplier may be accepted subject to satisfactory supporting documentation.

5.2.2 The testing is to be carried out as per the test methods specified in Chapter 3,section 4.

5.2.3 The extent of material testing will be considered in each individual case but shall normally include the following, as a minimum :

In case of single skin laminates :

– the tensile strength, tensile modulus, bending strength and bending modulus and glass content

In case of sandwich panels :

– the tensile strength and tensile modulus of the skin laminates
– the bending strength and modulus of the sandwich panel as a whole
– shear test for core materials and test for bond between the skin and core

In case of flange laminates of stiffeners and girders :

– the tensile strength and tensile modulus of the skin laminates

5.2.4 The testing is normally to be carried out at the temperatures mentioned in the relevant standards indicated in Chapter 3, Section 4. For structural members which may be subjected to elevated temperatures, e. g. in way of engine exhaust pipes, it may be necessary to carry out the tests at the relevant operating temperatures.

Section 6

Hull Girder Strength

6.1 General

6.1.1 Scantlings of hull members contributing to longitudinal and transverse hull girder strength are to comply with the requirements given in this section. In addition, members subjected to large compressive stress may also need to be checked for buckling strength.

6.1.2 In general, the longitudinal strength is to be checked for all crafts where L/D > 12 or L > 24 m. For other vessels, longitudinal strength calculations may be required based on the deck flange area, form, construction arrangement and loading.

6.2 Longitudinal bending strength

6.2.1 The resultant longitudinal bending tensile or compressive stress within any laminate is not to exceed the allowable hull girder bending stress σ_a = 0.33 x σ_u {N/mm^2], where σ_u is the ultimate tensile strength of the laminate.

6.2.2 The resultant tensile or compressive stress, σ, within any laminate is given by :

$$\sigma = \frac{E_i y_i M}{\Sigma(E_i I_i)} \text{ x } 10 \quad [\text{N/mm}^2]$$

Where,

M = the Rule longitudinal bending moment [kN-m], which is the greater of :

a) Total Bending Moment M_t = (M_s + M_w) given in Chapter 4, Section 4.1.2.

b) Bending Moment due to slamming M_{sl} given in Chapter 4, Section 4.1.3

E_i = tensile modulus of the laminate under consideration [N/mm^2]

y_i = the vertical distance to the furthest point within the laminate under consideration from the neutral axis [m]

I_i = the moment of inertia of the laminate under consideration, about the neutral axis [cm^2- m^2]

The distance of the neutral axis, Y_{na}, from keel is given by :

$$Y_{na} = \frac{\Sigma(E_i a_i z_i)}{\Sigma(E_i a_i)} \text{ [m]}$$

Where,

a_i, = the cross sectional area of individual laminate [cm^2]

z_i = the distance to the centre of area of individual laminate from keel [m]

6.3 Calculation of effective sectional properties and longitudinal bending stress

6.3.1 The effective sectional properties of a transverse section are to be calculated using the net area of all continuous longitudinal members after deduction of openings in accordance with Chapter 6, Section 2.3.

6.3.2 In case of sandwich panels, area of only the skin laminates are to be considered, ignoring the core material.

6.4 Openings in longitudinal strength members

6.4.1 The keel plate is normally not to have any openings. In the bilge plate within 0.6L amidships openings are to be avoided as far as practicable. Openings in strength deck are to be kept well clear of craft’s side and hatch corners.

6.4.2 Circular openings with diameter equal to or more than 0.325 m are to have edge reinforcement. Elliptical openings are to have their major axis in the fore and aft direction. Where the ratio of the major axis to the minor axis is less than 2, the openings are to have edge reinforcement.

6.4.3 Rectangular openings are to have their corners well rounded. Where corners are of circular shape, the radius is not to be less than 20 percent of the breadth of the opening and the edges are to be reinforced.

6.5 Shear Strength

6.5.1 The shear stress, τ, at mid depth at any position along the length is not to exceed the allowable hull shear stress $\sigma_a = 0.33 \times \tau_u$ {N/mm^2], where τ_u is the ultimate shear strength of the laminate.

6.5.2 The shear stress τ, is to be taken as :

$$\tau = \frac{10Q}{A_S} \text{ [N/mm}^2\text{]}$$

Where,

Q = the Rule shear force [kN], which is the greater of :

a) Total shear force $Q_L = (Q_s + Q_w)$ given in Chapter 4, Section 4.1.2.

b) Shear force due to slamming Q_{sl} given in Chapter 4, Section 4.1.3.

As = net sectional area of laminates of side shell plating and longitudinal bulkheads, if any [cm^2]

6.6 Transverse strength of twin hull craft

6.6.1 The twin hull connecting structure is to have adequate strength considering the design loads and moments given in Chapter 4, Section 4.2.

6.6.2 The following stress levels are normally acceptable:

Tensile or compressive stress : $0.25\ \sigma_u$ [N/mm^2]
Shear stress : $0.25\ \tau_u$ [N/mm^2].

Section 7

Sandwich Plate Panels

7.1 General

7.1.1 In this section general requirements for local strength of sandwich panels are given.

7.1.2 The reinforcement of skin laminates is to be containing at least 40% continuous fibres.

7.1.3 In way of keel, stem and knuckles, single skin construction is to be locally adopted with scantlings as specified in Section 8.1. Similarly, in way of rudder tubes and shaft brackets etc; the reinforced areas are generally to be of single skin construction. See Section 4.9 for details.

The design in way of attachment of other fittings or equipment is to be such that the load can be transmitted into the structure by bending and not by shear. Suitably reinforced single skin construction is generally to be provided in these areas.

The recommended arrangement of reinforcement in way of the transition from sandwich construction to single skin laminate is to be in accordance with Fig. 7.1.3.

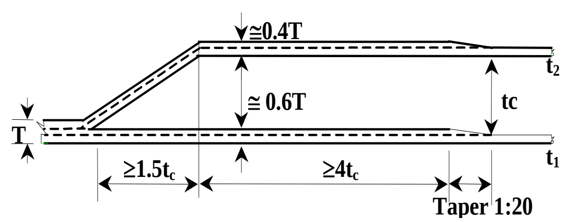


Fig. 7.1.3

7.2 Sandwich core thickness

7.2.1 The thickness of the sandwich core, t_c, is not to be less than :

(i) $t_c = \frac{f_{cs}\ p.b \times 10^{-3}}{2.\tau_a}$ [mm], and

(ii) $t_c = \frac{f_{cd}\ p.b \times 10^{-2}}{G}$ [mm]

where,

$f_{cs} = 320\,(l/b) + 0.36$, with $0.68 \le f_{cs} \le 1.0$

$f_{cd} = 0.56 + \ln(1000\, l/b)$, with $f_{cd} \le 1.0$

τ_a = allowable shear stress for the core material, as per Table 7.2.1, [N/mm^2]

Table 7.2.1		
Sandwich panel comprising:	$\boldsymbol{\sigma_a}$	$\boldsymbol{\tau_a}$
Bottom, side and cross deck structures when slamming loads are considered and all ordinary w.t. bulkheads	0.40 σ_u	0.40 τ_c
Bottom, side, cross deck structures in all other cases and inner bottoms, decks, tank bulkheads, superstructures, deckhouses etc.	0.30 σ_u	0.30 τ_c
σ_u = the ultimate tensile or compressive strength of the laminates τ_c = the ultimate shear strength of the core material		

7.2.2 Where shear ties as per 7.2.3 are provided in the direction of the panel breadth, the allowable shear stress τ_a may be determined using the increased effective shear strength, τ_{eff}, of the core material as given below, in lieu of τ_c. See equation in 7.2.1 (i).

$$\tau_{\text{eff}} = \tau_c + \left(\frac{t_t}{s_t}.\,\tau_t\right) \quad [\text{N/mm}^2]$$

where,

τ_{eff} = effective shear strength of the core material given by:

τ_c = shear strength of basic core material [N/mm^2]

t_t = thickness of shear tie material [N/mm^2]

τ_t = ultimate shear strength of the shear tie material [N/mm^2]

s_t = spacing or mean spacing of the shear ties [mm].

7.2.3 Where shear ties are to be fitted, the maximum spacing between the shear ties is to be not greater than the maximum panel breadth that can be achieved with the basic core material. Shear ties are also, in general, to be fitted in the sandwich structure beneath primary longitudinal members.

Shear ties fitted between the sandwich skins are to be angled at 45^o. The width of shear tie bonding to the sandwich skins is to be 2.5 t_c or 50 mm whichever is the greater, see Fig.7.2.3.

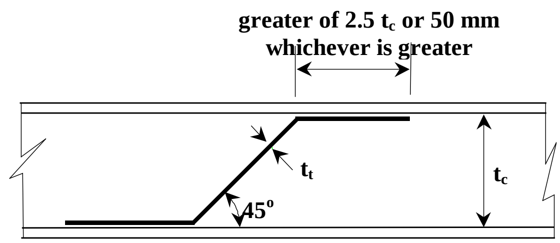


Fig.7.2.3 : Arrangement of shear ties

7.3 Sandwich laminate thickness

7.3.1 The minimum thickness requirement of each skin laminate of sandwich panels is given by :

$$t = (t_o + c\,L) \quad [\text{mm}]$$

t_o and c are to be taken from Table 7.3.1.

Table 7.3.1			
Sandwich panel comprising:	$\boldsymbol{t_o}$ **Outer skin**	**Inner skin**	**c**
Hull below WL	2.5	2.0	0.07
Hull above WL, inner bottom, tank bulkheads	2.3	1.8	0.05
Weather deck	2.0	1.5	0.04
Other structures	1.8	1.5	0.03

7.3.2 The effective section modulus of the sandwich panel, mm^3 per mm of breadth, at the extreme surface of the outer or inner skin laminates is not to be less than :

$$Z = \frac{M.(f_a)^2.(f_r)^2}{\sigma a} \quad [\text{N/mm}^2]$$

Where,

$$M = \frac{m\,p\,b^2}{12} \cdot 10^{-3} \text{ [N - mm]}$$

$$m = \frac{\gamma^3 + 1}{\gamma + 1}$$

$$\gamma = \frac{b_w}{b}$$

b = unsupported panel breadth [mm]. See Fig. 7.3.2

b_w = base width of stiffener [mm]

fa , fr = the correction factors for the aspect ratio of plate field and curvature respectively, as given in Chapter 6, Section3.1.1.

σ_a = allowable stress as per Table 7.2.1.

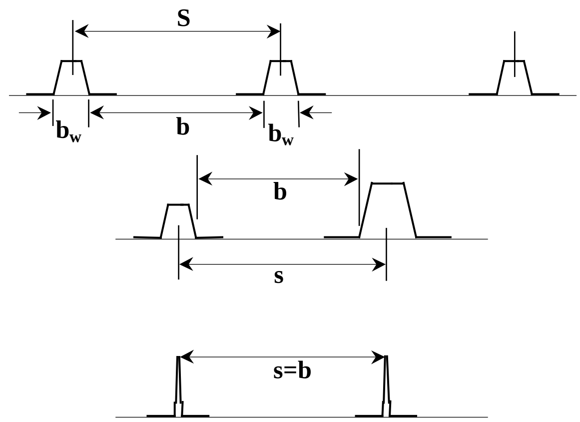


Fig. 7.3.2 : Panel dimensions

Section 8

Single Skin Plate Panels

8.1 General

8.1.1 In this section the general requirements for local strength of laminates in stiffened single skin constructions are given.

8.1.2 The reinforcement of skin laminates is to contain at least 40% continuous fibres.

8.1.3 The width and thickness of laminates in way of stem, keel and knuckles is not to be less than that specified in 8.2.1. The thickness of these laminates is also not to be less than 50% in excess of the thickness required as per 8.2.2 considering the actual frame spacing in the area.

8.1.4 For reinforcements in way of attachment of fittings or equipment see Section 4.9.

8.2 Single skin laminate thickness

8.2.1 The minimum thickness requirement of single skin laminates is given by :

$$t = (t_o + c\,L) \quad \text{[mm]}$$

t_o and c are to be taken from Table 8.2.1.

8.2.2 The laminate thickness is also not to be less than the following requirements based on allowable bending stress and deflection :

(i) $t = f_a . f_r . \sqrt{\frac{6M}{\sigma_a}}$ [mm]

(ii) $t = 0.146\ b\ \sqrt[3]{\frac{p}{E_{tp}}}$ [mm]

Where,

M, f_a, f_r, b as given in 7.3

σ_a = allowable stress as per Table 8.2.2

E_{tp} = tensile modulus of plate laminate [N/mm^2].

Table 8.2.1

Single skin laminate comprising:	t_o	**c**
Stem and keel, for a distance of (100+8L) mm on either side of centre line	9.0	0.10
Chine and transom corners, for a distance of (10L) mm on either side of the corner	7.0	0.06
Hull below WL	5.0	0.10
Hull above WL, inner bottom, tank bulkheads	5.0	0.05
Weather deck	4.5	0.05
Other structures	3.5	0.05

Table 8.2.2

Single skin laminate comprising:	σ_a
Bottom, side and cross deck structures when slamming loads are considered and all ordinary w.t. bulkheads	0.40 σ_u
Bottom, side, cross deck structures in all other cases and inner bottoms, decks, tank bulkheads, superstructures, deckhouses etc.	0.30 σ_u
σ_u = the ultimate tensile or compressive strength of the laminates	

Section 9

Stiffeners, Primary Girders and Pillars

9.1 Applications

9.1.1 In this section general requirements for local strength of stiffeners and primary girders (i.e. longitudinal and transverse girders, web frames etc.) and pillars based on the lateral pressure on plating they support are given.

9.2 Strength requirements of stiffeners and girders

9.2.1 The required section modulus of each stiffener and girder, based on the lateral pressure is given by:

$$Z = \frac{l^2 s p}{m \sigma_a} \ [\mathrm{cm}^3]$$

where,

m = 12 in case of stiffeners and girders which can be considered as fixed at ends, i.e. those which are continuous through the supporting members and are adequately supported or which are provided with end attachments in accordance with Sec 1.5.

m = 8 where the ends are simply supported

σ_a = allowable stress [N/mm^2] given for each item in Table 9.2.1.

Table 9.2.1

Stiffeners and Girders on	σ_a
Bottom, side and cross deck structures when slamming loads are considered and all ordinary w.t. bulkheads	0.40 σ_u
Bottom, side, cross deck structures in all other cases and inner bottoms, decks, tank bulkheads, superstructures, deckhouses etc.	0.30 σ_u
σ_u = the ultimate tensile or compressive strength of the laminates	

9.2.2 The effective web area of girders, determined in accordance with Chapter 6, Section 1.4.7, is not to be less than the required area A_r :

$$A_r = \frac{l s p}{200 \tau} \ [\mathrm{cm}^2]$$

where,

l, s and p are as defined in 1.2.

$\tau = 0.25 \times \tau_u$

where,

τ_u is as defined in 1.2.

9.2.3 The end attachments of stiffeners and girders are to be in accordance with 1.5.

9.2.4 Where girders are attached to the supporting structural members by secondary bonding, the effective bond area, $A_{e,}$ is not to be less than:

$$A_B = \frac{l\,s\,p}{200\,\tau_b} \ [\mathrm{cm}^2]$$

where,

l, s and p are defined in 1.2.

$\tau_b = 0.25\ \tau_{bu}$

τ_{bu} = the ultimate bond shear stress for the secondary bonding.

$A_e = B\,H - b\,h$ (See Fig.9.2.4).

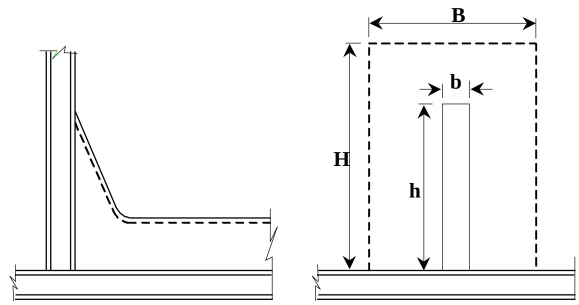


Fig. 9.2.4: Effective bond area

9.3 Pillars

9.3.1 The scantlings of pillars or pillar bulkheads are to be based on the axial load to be carried and the maximum permissible load considering buckling criterion as specified in Chapter 6, Section 5.5, using appropriate material properties.

9.3.2 As far as practicable, deck pillars are to be located in line with pillars above. High density core inserts are to be fitted at the head and foot of pillars.

End Of Chapter

Chapter 8

Hull Appendages, Rudders and Steering Arrangement

Contents	
Section	
1	General Requirements
2	Bar Keel, Stem and Stern Frames
3	Shaft Brackets
4	Rudders
5	Steering Gear Systems
6	Waterjet Installations

Section 1

General Requirements

1.1 Scope

1.1.1 This chapter applies to all the craft types detailed in the Rules. Requirements are given for stem, stern frame, shaft brackets, rudders and steering gears.

1.1.2 Further, the requirements include structural strength of hull foundations of above items and appended propulsion units such as waterjets.

1.1.3 The details of other appendages e.g. hydrofoils, wings etc. will be specially considered.

1.2 Materials

1.2.1 All plates and sections, castings and forgings used in the constructions are to be tested and approved in accordance with the requirements of Part 2 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

1.2.2 Use of other materials not covered above will be individually considered.

Section 2

Bar Keel, Stem and Stern Frames

2.1 General

2.1.1 Bar keel, stem and stern frames are to be designed such that they are effectively integrated into the ship's structure.

2.1.2 It is recommended that the after body of the ship be so shaped as to ensure adequate flow of water to the propeller so as to prevent uneven formation of eddies, as far as possible.

2.1.3 The scantlings are indicated based on normal mild steel as per Part 2 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’. Aluminium stern frames and stems will be specially considered based on the proposed material grades.

2.2 Bar keel and stem

2.2.1 Details and scantlings of bar keel and stem are to be as per Section 2 and Section 3 respectively of Part 3, Chapter 6 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

2.2.2 The thickness of the plate stem is not to be lower than the rule side shell plate thickness in way. However, the thickness ‘t’ of the plate stem below the summer load water line need not be more than:

$$t = (0.1L + 3)\ k^{1/2}$$

2.2.3 The thickness of the plate stem may be gradually reduced to that of the side shell at the stem head.

2.2.4 The plate stems are to be supported by horizontal diaphragms spaced not more than 1.0 [m] apart. When the stem plate radius is large, a centerline stiffener or web is to be provided.

2.3 Stern frames

2.3.1 For a moderately cavitating propeller the minimum values of propeller-hull clearances may be as per Part 3, Chapter 6, Section 4 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'. For propellers that are heavily loaded, the propeller-hull clearances will be specially considered individually based on detailed analysis.

2.3.2 The scantlings and details of the stern frames are to be as per Part 3, Chapter 6, Section 4 of the Rules as mentioned in 2.3.1 above.

2.3.3 The scantlings and details of rudderposts are to be as per Part 3, Chapter 6 of the Rules mentioned in 2.3.1 above.

2.4 Sole piece

2.4.1 The details and scantlings of sole-pieces if fitted are to be as per Part 3, Chapter 6, Section 4 of the Rules mentioned in 2.3.1 above.

Section 3

Shaft Brackets

3.1 Details of shaft bracket struts and reinforcements in way are to be as per Part 3, Chapter 6, Section 4 of the Rules as mentioned in 2.3.1 above.

3.2 For the shaft and the shaft bracket boss made of the same material the length and thickness [mm] of the shaft bracket boss are to be not less than ($4d_p$) and ($d_p/4$), respectively, where d_p is the tail shaft diameter [mm]. For shaft and shaft bracket boss made of different materials d_p [mm] is to be based on bracket boss material. For calculating d_p see Chapter 12, Section 2.

Section 4

Rudders

4.1 The details and scantlings of rudder blade, rudder stock, pintles and rudder couplings are to be as per Part 3, Chapter 14 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

Section 5

Steering Gear Systems

5.1 Scope

5.1.1 The requirements of this chapter apply to the design and construction of Directional Control systems. This section gives the general requirements applicable to steering gear of crafts with HSC notation. The requirements applicable to crafts with LC or HSLC notation are given in subsection 5.18.

5.1.2 A Directional Control System includes all steering devices, all mechanical, electrical and hydraulic linkages, all power devices, including manual devices, all controls and all actuating systems. Steering may be achieved by means of air or water rudders, foils, flaps, steerable propellers or jets, yaw control ports or transverse thrusters, differential propulsive thrust, variable geometry of the craft or its lift system components or by a combination of these devices.

5.2 General

5.2.1 Craft should be provided with means for directional control of adequate strength and suitable design to enable the craft's heading and direction of travel to be effectively controlled to the maximum extent possible in the prevaling conditions and craft spaced without undue physical effort at all speeds and in all conditions for which the craft is to be certificated. The performance should be verified in accordance with Chapter 15, Annexure 6.

5.2.2 Attention is drawn to the possibility of interaction between directional control system and stabilisation systems. Where such interaction occurs or where dual purpose components are fitted requirement of the independent circuits of stabilisation system and of controllability to be complied with.

5.3 Definitions

5.3.1 **Steering gear control systems** means the equipment by which orders are transmitted from the navigating bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

5.3.2 **Main steering gear** means the machinery, rudder actuator(s), the steering gear power units, if any and ancillary equipment and the means of applying torque to the rudder stock (e.g tiller or quadrant) necessary for effecting movement and the rudder for the purpose of steering the ship under normal service conditions.

5.3.3 **Steering gear power unit** means:

a) In the case of electric steering gear, an electric motor and its associated electrical equipment;
b) In the case of electro-hydraulic steering gear, an electric motor and its associated electrical equipment and connected pump;
c) In the case of other hydraulic steering gear, a driving engine and connected pump.

5.3.4 **Auxiliary steering gear** means the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

5.3.5 **Power actuating system** means the hydraulic equipment provided for supplying power to turn the rudder stock comprising a steering gear power and or units together with associated pipes and fittings and a rudder actuator. The power actuating systems may share common mechanical components i.e. tiller, quadrant and rudder stock or components serving the same purpose.

5.3.6 **Maximum ahead service speed** means the greatest speed which the ship is designed to maintain in service at sea at her deepest seagoing draught.

5.3.7 **Rudder actuator** means the component(s) which converts directly hydraulic pressure into mechanical action to move the rudder.

5.3.8 **Maximum working pressure** means the expected pressure in the system when steering gear is operated to comply with 5.10.9.

5.4 Installation

5.4.1 The steering gear is to be secured to the seating by fitted bolts, and suitable chocking arrangements are to be provided. The seating is to be of substantial construction.

5.5 Steering gear compartment

5.5.1 The steering gear compartment is to be :

a) Readily accessible and, as far as practicable separated from machinery spaces;

b) Provided with suitable arrangements to ensure working access to steering gear machinery and controls. These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

5.6 Plans and documents

5.6.1 Plans and documents of the steering gear system to be submitted are as follows:

Plans

a) General arrangements of the main and auxiliary steering gears, and of the steering gear compartment.

b) Assembly of upper rudder stock, tiller, tie rod, rudder actuators, etc. as applicable.

c) Construction details of all torque transmitting components of steering gear such as tiller, tiller pin, tiller/rudder stock interference fit mechanism, tie rod, rudder actuator, etc. including bill of materials, welding procedures, non-destructive testing, as applicable.

d) Schematic hydraulic piping diagram, incorporating hydraulic logic diagram and including bill of materials, typical pipe to pipe joint details, pipe to valve joint details, pipe to equipment joint details, pressure rating of valves and pipe fittings and pressure relief valve settings.

e) Steering gear control system, incorporating schematic electrical control logic diagram, instrumentation, alarm devices, etc. including bill of materials.

f) Electrical power supply to power units to steering gear control, including schematic diagram of motor controlled feeder cables, feeder cable electrical protection.

Documents

- Rated torque of main steering gear.
- Calculations of torque-transmitting components
- such as tiller, tie rod, rudder actuator, etc.

5.7 Materials

5.7.1 All the steering gear components and the rudder stock are to be of sound and reliable construction to the Surveyor's satisfaction.

5.7.2 All components transmitting mechanical forces to the rudder stock are to be tested according to the requirements of Part 2 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

5.7.3 Ram; cylinders; pressure housing of rotary vane type actuators; hydraulic power piping; valves; flanges and fittings; and all steering gear components transmitting mechanical forces to the rudder stock (such as tillers, quadrants, or similar components) are to be of steel or other approved ductile material, duly tested in accordance with the requirements of Part 2 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’. In general, such material is not to have an elongation of less than 12 per cent nor a tensile strength in excess of 650 [N/mm^2]. The use of ductile (nodular) iron castings will be acceptable provided the material has an elongation of not less than 12 per cent.

5.8 Rudder, rudder stock, vanes, tiller and quadrant

5.8.1 Details and scantlings of rudder and rudder stock are to be as per Section 4 above.

5.8.2 Details and scantlings of vanes, tiller and quadrants are to be as per Part 4, Chapter 6 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

5.9 Mechanical steering gear

5.9.1 Steel-wire rope, chain and other mechanical systems, when these are used for rudder stock diameters of 120 [mm] and less but excluding allowance for strengthening in ice, will be specially considered. In general the breaking strength of rods/chains etc. is not to be less than :

$$\text{Breaking strength} = 6\,\frac{Q_r}{R}\ [N]$$

Where,

R = the distance [m] from the point of application of the effort on the tiller to the centre of rudder stock.

Q_r = rudder torque [N-m], calculated as per Part 3, chapter 14, Section 3.2 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

5.9.2 Sheaves : Sheaves are to be of ample size and so placed as to provide a fair lead to the quadrant and avoid acute angles. Parts subjected to shock are not to be of cast iron. Guards are to be placed around the sheaves to protect against injury. For sheaves intended to use with ropes, the radius of the grooves is to be equal to that of the rope plus 0.8 mm (1/32in) and the sheave diameter is to be determined on the basis of wire rope flexibility. For 5 x 37 wire rope, the sheave diameter are to be not less than 18 times that of the rope. For wire ropes of lesser flexibility, the sheave diameter is to be increased accordingly. Sheave diameters for chain are to be not less than 30 times the chain diameter.

5.9.3 Buffers : Steering gears other than hydraulic type are to be designed with suitable buffer arrangement to relieve the gear from shocks to the rudder.

5.10 Performance

5.10.1 The probability of total failure of all directional control systems should be extremely remote when the craft is cruising normally, i.e. excluding emergency situations such as grounding, collision or a major fire.

Note : Guidance to probability levels is given in Annexure 6.

5.10.2 A design incorporating a power drive or an actuation system employing powered components for normal directional controls should provide a secondary means of actuating the device unless an alternative system is provided.

5.10.3 Unless the main steering gear comprises two or more identical power units as in 5.10.11, every ship is to be provided with a main steering gear and an auxiliary steering gear in accordance with the requirements of the Rules. The main steering gear and the auxiliary steering gear are to be so arranged that the failure of one of them will not render the other one inoperative.

5.10.4 A secondary means of actuating the device is to be power-operated if the effective torque to be applied to the directional control device by the secondary means exceeds 40 kNm.

5.10.5 The directional control systems should be constructed so that a single failure in one drive or system, as appropriate, will not render any other one inoperable or unable to bring the craft to a safe situation. The Administration may allow a short period of time to permit the connection of a secondary control device when the design of the craft is such that such delay will not, in their opinion, hazard the craft.

5.10.6 A failure mode and effect analysis should include the directional control system.

5.10.7 If necessary to bring the craft to a safe condition, power drives for directional control devices, including those required to direct thrust forward or astern, should become operative automatically and respond correctly within 5s of power or other failure. Back-up electrical systems may be required for the starting-up time of an auxiliary diesel or an emergency diesel generator.

5.10.8 Directional control devices involving variable geometry of the craft or its lift system components should, so far as is practicable, be so constructed that any failure of the drive linkage or actuating system will not significantly hazard the craft.

5.10.9 The main steering gear and rudder stock are to be :

a) Capable of putting the rudder over from 35^o on one side to 35^o on the other side with the ship at its deepest seagoing draught and running ahead at maximum ahead service speed and under the same conditions, from 35^o on either side to 30^o on the other side in not more than 28 seconds;

b) So designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

5.10.10 The auxiliary steering gear is to be :

a) Of adequate strength and capable of steering the ship at navigable speed and of being brought speedily into action in an emergency:

b) Capable of putting the rudder over from 15 on one side to 15 on the other side in not more than 60 seconds with the ship at its deepest seagoing ahead service speed or 7 knots, whichever is the greater.

5.10.11 Where the main steering gear comprises two or more identical power units, an auxiliary steering gear need not be fitted, provided that :

a) The main steering gear is capable of operating the rudder as required by 5.10.9 while any one of the power units is out of operation;

b) The main steering gear is arranged so that after a single failure in its piping system or in one of the power units the defect can be isolated so that steering capability is regained.

5.10.12 Main and auxiliary steering gear power units are to be:

a) Arranged to re-start automatically when power is restored after a power failure;

b) Capable of being brought into operation from a position on the navigating bridge. In the event of a power failure to any one of the steering gear power units, an audible and visual alarm is to be given on the navigating bridge;

c) Arranged so that transfer between units can be readily effected.

5.10.13 Where the steering gear is so arranged that more than one power system can be simultaneously operated, the risk of hydraulic locking caused by a single failure is to be considered.

5.10.14 A means of two way communication is to be provided between the navigating bridge and the steering gear compartment and all other location where steering can be effected.

5.10.15 Steering gear, other than of the hydraulic type, will be accepted provided the standards are considered equivalent to the requirements of this Section.

5.10.16 Manually operated gears are only acceptable when the operation does not require an effort exceeding 16 [kgf] under normal conditions and at least 3 degrees of rudder rotation is obtained per turn of the hand wheel.

5.10.17 Steering devices are to be able to be locked in any required position for maintenance purposes.

5.10.18 The pipes of hydraulically operated control systems are to be installed in such a way as to ensure maximum protection and readily accessible. They are to be installed at a sufficient distance from the craft shell.

5.11 Rudder angle limiters

5.11.1 Power-operated steering gears are to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronized with the gear itself and not with the steering gear control.

5.12 Rudder actuators

5.12.1 Construction and design

Details of construction and design of rudder actuators are to be as per Part 4, Chapter 6, Section 3 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

5.13 Demonstrations

5.13.1 The limits of safe use of any of the control system devices should be based on demonstrations and verification process in accordance with Chapter 15, Annexure 6.

5.13.2 Demonstration in accordance with Annexure 6 is to determine any adverse effects upon safe operation of the craft in the event of an uncontrollable total deflection of any one control device. Any limitation on the operation of the craft as may be necessary to ensure that the redundancy or safeguards in the systems provide equivalent safety should be included in the craft operating manual.

5.14 Control position

5.14.1 All directional control systems are normally to be operated from the craft’s operating station.

5.14.2 If directional control systems can also be operated from other positions, then two way communication should be arranged between the operating station and those other positions.

5.14.3 Adequate indications are to be provided at the operating station and these other positions to provide the person controlling the craft with verification of the correct response of the directional control device to this demand, and also to indicate any abnormal responses or malfunction. The indications of steering response or rudder angle indicator are to be independent of the system for directional control. The logic of such feedback and indications should be consistent with the other alarms and indications so that in an emergency operators are unlikely to be confused.

5.15 Steering gear control system

5.15.1 Locations of control

a) The main steering gear is to be provided with control both from the navigating bridge and from within the steering compartment. However, if the power unit is located in a space other than the steering compartment, the control is to be provided in that space instead of the steering compartment. For purpose of controlling from the steering gear compartment (or the space containing the power unit), a means is to be provided in the steering compartment (or the space containing the power unit) to disconnect any control system from the navigating bridge.

b) The auxiliary steering gear is to be operable from a space in which the operation of the auxiliary steering gear can be effectively carried out, or from within the steering compartment. However, if power operated, it is to be provided with control from the navigation bridge also.

c) Where duplicate (or more) power units are provided and an auxiliary steering gear is not fitted, two independent systems of control are to be provided. Each of these systems is to meet the requirements of the control system of the main steering gear. Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted.

d) If steering gear is operated by manual means only, such as by means of a steering wheel through a mechanical or a non-power operated hydraulic system, only the requirements of 5.10.14 and 5.15.4a) are applicable.

5.15.2 Control system segregation

a) Control systems of the main and the auxiliary steering gears are to be independent of each other in all respects. The control wires are to be separated as far as practicable throughout their length. Where found necessary, the wiring of the two systems may share the same terminal box, provided a safety barrier is fitted in the box to segregate the wiring.

b) If the main steering gear consists of duplicated (or more) power units and an auxiliary steering is not fitted, the two independent means of control are to comply with the segregation requirement of 5.15.2a). However, this does not require duplication of steering lever or other steering apparatus on the navigating bridge.

c) If the main steering gear consists of a single power unit and the auxiliary steering gear is not power operated, only one control system for the main steering gear need be provided.

5.15.3 Control system power supply

Electrical power for steering gear control system is to be derived from the motor controller of the power unit it is controlling, or from the main switchboard at a point adjacent to the supply to the power unit.

5.15.4 Instrumentation and alarms

The following instruments and alarms are to be provided. The audible and visual alarms are to have provisions for testing.

a) Rudder position indicator : The angular position of the rudder is to be indicated on the navigating bridge and all other locations where steering can be effected, such as the steering gear compartment, the space where the power units are located and the space where auxiliary steering gear is to be operated, as applicable. The rudder angle indication is to be independent of the steering gear control system.

b) Autopilot : Where autopilot is fitted, a visual and audible alarm is to be provided on the navigating bridge to indicate its failure.

c) Motor alarm : A visual and audible alarm is to be given on the navigating bridge and the engine room control station to indicate an overload condition of the steering gear power unit motor. Where three phase electrical power is used a visual audible alarm is to be installed which indicates failure of any one of the supply phases. The operation of these alarms is not to interrupt the circuit.

d) Motor running indicators : Indicators for running indication of motors are to be installed on the navigating bridge and the engine room control station.

e) Power failure : A visual and audible alarm is to be given on the navigating bridge and engine room control station to indicate a power failure to any one of the steering gear power units.

f) Control power failure : A visual and audible alarm is to be given on the navigating bridge and engine room control station to indicate an electrical power failure in any steering gear control circuit or remote control circuit.

In addition, hydraulic power operated steering gear is to be provided with the following:

g) Low oil-level alarm : A visual and audible alarm is to be given on the navigating bridge and engine room control station to indicate a low oil level in any power unit reservoir.

h) Hydraulic lock : Where the arrangement is such that a single failure may cause hydraulic lock and loss of steering, an audible and visual alarm which identifies the failed system or component is to be provided on the navigating bridge. The alarm is to be activated upon steering gear failure if:

- Position of the variable displacement pump control system does not correspond to the given order, or
- Incorrect position of 3-way full flow valve or similar in constant delivery pump system is detected.

5.16 Electrical power supply

Electrical power circuits are to meet the requirements of Chapter 13.

5.17 Testing and trials

5.17.1 Testing of piping system

The following tests are to be performed in the presence of the Surveyor.

a) Shop tests : After fabrication, each component of the steering gear piping system, including the power units, hydraulic cylinders and piping is to be hydro-statically tested at the plant of manufacture to 1.5 times the relief valve setting, except that for steering gear cylinders of nodular iron, the test pressure is to be at least 2 times the relief valve setting.

b) Installation Tests : After installation in the craft, the complete piping system, including power units, hydraulic cylinders and piping is to be subjected to a hydrostatic test equal to 1.1 times the relief valve setting, including a check of the relief valve operation.

5.17.2 Trials

The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of the Rules have been met. The trial is to include the operation of the following:

a) The main steering gear, including demonstration of the performance requirements of 5.10.9 or with the rudder fully submerged. Where full rudder submergence cannot be obtained in ballast conditions, special consideration may be given to specified trials with less than full rudder submergence.

Trials are to be carried out with the craft running ahead at maximum continuous rated shaft RPM. For controllable pitch propeller, the propeller pitch is to be at the maximum design pitch approved for the maximum continuous ahead RPM.

b) The auxiliary steering gear, if required, including demonstration to the performance requirements of 5.10.10b) and transfer between main and auxiliary steering gear.

c) The power units, including transfer between power units.

d) The emergency power supply required by steering gear for rudder stock over 230 [mm] in way of tiller.

e) The steering gear controls, including transfer of control and local control.

f) The means of communications as required by 5.10.14.

g) The alarms and indicators required by 5.15.4 (test may be done at dockside).

h) The storage and recharging system (test may be done at dockside).

i) The isolating of one power actuating system and checking for regaining steering capability if applicable (test may be done at dockside).

j) Where steering gear is designed to avoid hydraulic locking, this feature is to be demonstrated.

5.18 Requirements for non-passenger crafts with ‘LC’ or ‘HSLC’ notation

5.18.1 Introduction

5.18.1.1 In craft with Rule rudder stock dia of 120 mm and above the main steering gear is to be power operated.

5.18.1.2 Where manual power wheel steering is fitted an alternative means of steering which may be a hand tiller is to be readily available and the performance of both systems are to be in accordance with 5.10.

5.18.2 Design and performance

5.18.2.1 For design and performance requirements refer to Part 4, Chapter 6 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’. For mechanical steering gear, the requirements given in 5.9 would apply.

5.18.3 Control and monitoring

5.18.3.1 The alarms and safeguards craft of less than 150 GT are to be adequate for the type of steering system employed. See Table 5.18.3.

5.18.3.2 Crafts of less than 150 GT need not be provided with two exclusive electrical circuits for steering gear as required in Chapter 13, 14.1.2.

5.18.4 Electrical equipment

5.18.4.1 Consideration will be given to the electrical control equipment of simple steering systems, craft of less than 150 GT.

Table 5.18.3

Item	Alarm	Note
Angular position of the steering mechanism	-	Indication
Steering power units, power	Failure	-
Steering motors	Overload single phase	Also running indication on bridge
Control system power	Failure	-
Steering gear hydraulic oil tank level	Low	
Auto pilot	Failure	Running indication
Hydraulic oil temperature	High	Where oil cooler is fitted

Section 6

Waterjet Installations

6.1 Waterjet propulsion systems – Construction

6.1.1 Scantlings of various structural items satisfying the local strength requirements of water jet propulsion units are to be determined in accordance with the general principles given in the section, irrespective of rated power.

6.1.2 Water jet ducts may be an integral part of the hull, or as a bolted on unit. In either case, detailed plans indicting dimensions, scantlings and materials of construction of the water jet unit are to be submitted for approval, including the following details:

a) method of attachment of unit to hull including welding and weld metal details if applicable
b) Sealing arrangement of shaft
c) Details of shafting support or guide vanes used in the system.
d) Details of all ports/openings including its sealing and reinforcements
e) Details of protection gratings and their attachments

6.1.3 Details of all loads and their positions of application in the hull due to jet system are to be forwarded. These are to include maximum applied thrust, moments and tunnel pressures.

6.1.4 Detailed calculations for the strength of the supporting structure is to be submitted for approval. In no case are the scantlings to be taken as less than the rule requirements for the surrounding hull structure. The structure is to be adequately reinforced and compensated as necessary. All opening are to be suitably reinforced and have radiused corners.

6.1.5 Inlet to the tunnel is to be provided with efficiently designed grating to prevent the ingress of large objects into the machinery. System is to have provision for clearing any clog/flow restricting matter, inside the tunnel.

6.1.6 Water jet unit(s) having a total rated power more than 500 [kW] are to be contained within their own watertight compartment. Other arrangements for maintaining watertight integrity would be specially considered depending on the size and installation layout.

6.1.7 For details of machinery requirements, see Chapter 12.

6.2 Waterjet systems – Installation

6.2.1 All units are to be installed in accordance with the manufacturer's instructions. Integral jet ducts to be constructed in accordance with the manufacturer's requirements and as per relevant approved plans required by Section 6.1.2.

6.2.2 Where the load is transmitted to the transom and/or bottom shell, the thickness of plating in way is to be increased by 50 percent over calculated rule thickness; however, increase in thickness is not to be less than 8 [mm]. Such reinforcement is to extend beyond the adjacent main supporting stiffeners.

6.2.3 For "bolted in" units, hull receiving rings are to be of a material compatible with the hull. All welding details are to be to the satisfaction of the attending Surveyors.

6.2.4 Bolt sizes and spacings are to be finalized in consultation with the system manufacturer and are to be of suitable marine grade, insulated as appropriate and locked by suitable means.

6.2.5 Where studs are proposed, the remaining thickness of plating below the depth of blind tap is to be not less than the rule plating thickness in way plus 2 [mm]. Bottom of all blind taps are to be free of sharp corners.

6.2.6 Use of approved alignment resins may be considered, where accurate seating and laying surfaces are required. Details are to be submitted for consideration alongwith tightening torque and bearing loads.

6.2.7 Where complex installations are proposed, an approved FE model analysis results are to be submitted in lieu of calculations from the first principle.

6.3 Design loads

6.3.1 Maximum load due to the installation(s) including the following loads are normally to be considered:

- Crash stop
- Maximum reversing load, from 10 kn
- Forward speed
- Maximum steering load
- Waterjet unit weight with dynamic load factors as per the rules i.e. unit acting as a cantilever during vessel pitching
- High cycle loads from impeller pulses, if available from the system manufacturer.

Design forces/moments and information regarding weights are to be specified by the manufacturer of the waterjet.

6.4 Allowable stresses

6.4.1 The maximum allowable stresses for the duct and hull supporting structures are as follows:

- Normal stress : $\sigma = 110/k$ [N/mm^2]
- Shear stress : $\tau = 50/k$ [N/mm^2]

Where,

k for steel is to be as per Chapter 3, Section 2

k for aluminium is to be as per Chapter 3, Section 3, and

For FRP structure, maximum allowable stresses for the duct and hull supporting structures are as follows:

Normal stress : $\sigma = 0.2\ \sigma_u$ [N/mm^2]

Shear stress : $\tau = 0.2\ \tau_u$ [N/mm^2]

where,

σ_u = ultimate tensile strength of the plate laminate [N/mm^2]

τ_u = ultimate shear strength of the plate laminate [N/mm^2].

6.4.2 For the steering, reversing and cantilever bending, the maximum allowable stresses are to be based on fatigue life considerations.

The number cycles for each load case is to be based on the expected operational time during 20 years lifetime of the craft and normally not to be taken less than:

- 10^5 cycles for reversing loads
- 10^6 cycles for steering loads, and
- 10^7 cycles for pitching loads.

End Of Chapter

Chapter 9

Anchoring and Mooring Equipment

Contents	
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1	General
2	Structural Arrangements for Anchoring Equipment
3	Equipment Specification
4	Anchors
5	Anchor Chain Cables
6	Towlines and Mooring Lines
7	Windlass and Chain Stoppers

Section 1

General

1.1 Introduction

1.1.1 To entitle a craft to the letter 'L' in its character of classification, anchoring, mooring and towing equipment is to be provided in accordance with the requirements of this Chapter.

1.1.2 Except in case of crafts assigned class notation **HSC**, towing arrangements are not subject of classification. Also see 6.4, Towing Arrangements.

1.1.3 The anchoring equipment specified in this Chapter is intended for temporary occasional anchoring of a craft within a harbour or a sheltered area when the craft is awaiting berth, tide etc. and it is not intended to hold the craft off fully exposed coasts in rough weather or to stop a craft which is moving or drifting. Where it is intended to be used for frequent anchoring in open seas or in service areas subjected to particularly rough weather, equipment in excess of that specified in Table 3.2.1, generally atleast two anchors and the associated chain cables, would be required.

1.1.4 Attention is drawn to any relevant requirements of the National Authorities of the country in which the ship is to be registered.

1.2 Documentation

1.2.1 The arrangement of anchoring, mooring and towing equipment and the Equipment Number calculations are to be submitted for information.

1.2.2 Following details of the proposed equipment are to be submitted for approval :

a) Number, weight, type and design of anchors.

b) Length, diameter, grade and type of chain cables or ropes used in lieu of the chain cables.

c) Type and breaking load of steel and fibre ropes used as mooring line or towline.

d) Towing arrangements, when applicable.

Section 2

Structural Arrangements for Anchoring Equipment

2.1 General

2.1.1 The anchors are normally to be housed in hawse pipes and anchor pockets of adequate size, scantlings and suitable form to prevent movement of anchor and chain due to wave action. Other suitable arrangements for housing of anchors may be considered.

The arrangements are to provide an easy lead of chain cable from windlass to the anchors. Upon release of the brake, the anchors are to immediately start falling by their own weight. Substantial chafing lips are to be provided at shell and deck. These are to have sufficiently large and radiused faces to minimise the probability of cable links being subjected to large bending stresses. Alternatively, roller farileads of suitable design may be fitted.

2.1.2 The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

2.1.3 On ships provided with a bulbous bow or a wave piercing bow and where it is not possible to obtain ample clearance between shell plating and anchors during anchor handling, adequate local reinforcements are to be provided in areas likely to be damaged by anchors or chain cables.

2.1.4 The chain locker is to have adequate capacity and depth to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. The chain pipes are to be of suitable size and provided with chafing lips. The port and starboard cables are to have separate spaces. Provisions are to be made to minimize the ingress of water to the chain locker in bad weather. The chain lockers fitted abaft of the collision bulkhead are to be watertight and the space is to be efficiently drained.

Provisions are to be made for securing the inboard ends of the chains to the structure. The strength of this attachment should be between 15 per cent to 30 per cent of the breaking strength of the chain cable. It is recommended that suitable arrangements be provided so that in an emergency the chain can be readily made to slip from an accessible position outside the chain locker.

2.1.5 The windlass and chain stoppers are to be efficiently bedded and secured to deck. The thickness of deck plating is to be increased in way of the windlass and chain stoppers and adequate stiffening underneath is to be provided.

Section 3

Equipment Specification

3.1 The equipment number, EN, on which the requirements of equipment are based is to be calculated as follows : -

$EN = K.EN_c$

Where,

$$EN_c = \Sigma(\Delta_i)^{2/3} + 2\left[(B.a - A_t) + \Sigma b_i\, h_i\right] + 0.1A$$

Δ_i = moulded displacement [t] of the ith hull, corresponding to the design water line. For monohull crafts i = 1 and $\Delta_i = \Delta$.

a = distance [m] from design waterline amidships to the upper deck at side

A_t = The cross sectional area, in m^2 of the tunnels in case of multihull crafts, above the design waterline.

h_i = height [m] on the centreline of each tier of houses having a breadth greater than B/4.

For lowest tier, h_i is to be measured at centre line from upper deck, or from a notional deck line where there is a local discontinuity in the upper deck.

b_i = the breadth, [m] of the widest superstructure or deckhouse of each tier having breadth greater than B/4.

A = area [m^2] in profile view of the hull, superstructures and houses above the design waterline, which is within the Rule length of the craft. Houses of breadth less than B/4 are to be disregarded.

In the calculation of h_i and A, sheer and trim are to be ignored.

Parts of windscreens or bulwarks which are more than 1.5 [m] in height are to be regarded as parts of houses when determining h_i and A.

'K' is a factor depending upon the service restriction notation as given below :

Service Restriction Notation	K
RS 0	1.0
RS 1	0.9
RS 2	0.8
RS 3	0.65

3.2 Equipment

3.2.1 The anchoring and mooring equipment is to be in accordance with the requirements given in Table 3.2.1 using EN as calculated in 3.1. However, the towline particulars given for guidance are to be obtained using EN_c; i.e. without application of the factor 'K'.

Table 3.2.1 : Anchoring, mooring and towing equipment

EN	HHP anchor	Stud-link chain cable				Towline (Recommendation)		Mooring lines		
	Mass [kg]	Length [m]	Diameter and Grade			Steel or fibre ropes				
			CC1 [mm]	CC2 [mm]	CC3 [mm]	Min. length [m]	Min. breaking strength [kN]	No	Length of each [m]	Min. breaking strength [kN]
< 5	10	55	See 5.1.1 for the required size			90	20		50	14
5 - 10	14	55				90	24		50	17
10 – 15	23	60				90	27		50	20
15 – 20	32	65				90	34		50	24
20 – 25	40	70				110	39		50	27
25 – 30	48	75				110	44		50	27
30 – 35	56	80				110	49		50	27
35 – 40	64	85				135	54		50	29
40 – 45	71	90				135	59		60	29
45 – 50	79	95				135	64		60	29
50 – 60	90	100	11	-	-	180	71		60	34
60 – 70	105	105	12.5	11	-	180	71	2	80	34
70 – 80	120	110	14	12.5	-	180	82		100	37
80 – 90	135	110	14	12.5	-	180	82		100	37
90 – 100	157	110	16	14	-	180	93		110	39
100 – 110	180	110	16	14	-	180	93		110	44
110 – 120	202	110	17.5	16	-	180	104		110	44
120 – 130	225	137.5	17.5	16	-	180	104		110	49
130 – 140	255	137.5	19	17.5	-	180	115		120	49
140 – 150	292	137.5	20.5	17.5	-	180	115		120	49
150 – 175	360	137.5	22	19	-	180	128		120	54
175 – 205	427	137.5	24	20.5	-	180	143		120	59
205 – 240	495	165	26	22	20.5	180	161		120	64
240 – 280	585	165	28	24	22	180	182		120	69
280 – 320	675	165	30	26	24	180	201		140	74
320 – 360	765	192.5	32	28	24	180	226		140	78
360 – 400	855	192.5	34	30	26	180	248	3	140	88
400 – 450	1080	192.5	36	32	28	180	273		140	98
450 – 500	967	192.5	38	34	30	180	301		140	108
500 – 550	1192	220	40	34	30	180	329		160	123
550 – 600	1305	220	42	36	32	180	356		160	132
600 - 660	1440	220	44	38	34	180	387	4	160	147
660 - 720	1575	220	46	40	36	180	420		160	157

Section 4

Anchors

4.1 General

4.1.1 Anchors are to be of an approved design.

4.1.2 The anchor mass given in Table 3.2.1 is based on the use of H.H.P (high holding power) type anchors.

4.1.3 When ordinary holding power anchors are used as bower anchors, the tabular mass is to be increased by 33%.

4.1.4 When anchors of a design approved for the designation SHHP (Super High Hold Power) are used as bower anchors the tabular mass may be reduced by 33%.

4.1.5 The actual mass of each anchor may vary by +7% to –3% per cent of the tabular mass.

4.1.6 Anchor shackles are to be of a design and material suitable to the service for which the anchor is intended.

4.2 HHP (SHHP) anchors

4.2.1 Designs of HHP and SHHP anchors are to be approved for the designation in accordance with Part 3, Chapter 15 of the 'Rules for the Construction and Classification of Steel Ships'.

4.3 Manufacture and testing

4.3.1 Anchors and anchor shackles are to be manufactured and tested in accordance with the requirements of Part 2, Chapter 10 of the 'Rules for the Construction and Classification of Steel Ships'.

Section 5

Anchor Chain Cables

5.1 General

5.1.1 Anchor chain cables are to be as required by Table 3.2.1. For EN < 50, the required size of the chain cables and ropes used in lieu of the chain cable are to be such that the breaking strength [kN] is not less than 0.565 times the HHP anchor weight [kg].

5.1.2 Short link chain cable may be accepted provided that the breaking load is not less than that of the required stud link chain cable.

5.1.3 Grade CC1 chain cable having material tensile strength of less than 400 [N/mm^2] is not to be used in association with HHP or SHHP anchors. Grade CC3 chain cable is to be used only when diameter is 20.5 [mm] or more.

5.1.4 In case of crafts assigned class notations RS1, RS2 or RS3, the chain cable may be replaced by ropes of equal breaking strength as follows:

- by steel wire ropes when EN ≤ 500
- by polyamide or other synthetic fibre ropes excluding polypropylene, when EN ≤ 100.

In both cases, a length of chain not less than the distance between the anchor in stowed position and the windlass, is to be fitted between the anchor and the wire rope.

5.2 Manufacture and testing

5.2.1 Chain cables, steel wire ropes and shackles are to be manufactured and tested in accordance with the requirements of Part 2, Chapter 10 of the 'Rules for the Construction and Classification of Steel Ships'.

Section 6

Towlines and Mooring Lines

6.1 General

6.1.1 Towlines and mooring lines may be of steel wire, natural fibre or synthetic fibre and are to be made by an approved manufacturer.

6.1.2 The number, length and breaking strength of towlines and mooring lines are to be as required by Table 3.2.1.

6.1.3 The lengths of individual mooring lines may be reduced by upto 7 percent of the tabular length, provided that the total length of mooring lines is not less than would have resulted had all lines been of equal tabular length.

6.2 Manufacture and testing

6.2.1 Steel wire ropes are to be manufactured and tested in accordance with the requirements of Part 2.

6.2.2 Fibre ropes will be specially considered in each case.

6.3 Mooring arrangement

6.3.1 Means are to be provided to enable mooring lines to be adequately secured on board a ship. bollards, cleats, etc. are to be so designed and installed as to protect ropes against excessive wear. Attention is drawn to relevant national standards and adequate stiffening in way of these fittings.

6.3.2 Mooring winches should be fitted with drum brakes, the strength of which is sufficient to prevent unreeling of the mooring line when the rope tension is equal to 80 percent of the braking strength of the rope as fitted on the first layer on the winch drum.

6.3.3 The strength of the mooring fittings, their attachment to the hull structure and under-deck supporting structure are to comply with the requirements of Pt.3, Ch.15, Sec.6 of “Rules and Regulations for the Construction and Classification of Steel Ships”. The breaking strength of the mooring ropes are to be based on Table 3.2.1 of this chapter.

6.4 Towing arrangements

6.4.1 Crafts for which HSC code is applicable i.e. which are to be assigned the class notation **HSC**, are to be provided with adequate towing arrangements to enable them to be towed in the worst intended environmental condition. It is recommended that other crafts are also provided with arrangements for towing, as far as practicable.

6.4.2 Where towage arrangement envisages attachments to the craft at more than one point, a suitable bridle is to be provided.

6.4.3 Towlines specified in Table 3.2.1 are for guidance only. For crafts which are assigned class notation **HSC,** calculations for the required tow rope pull are to be submitted alongwith the design assumptions. The maximum permissible speed at which the craft may be towed is to be included in the operating manual.

6.4.4 The towing arrangements should be such that damage to the towline or the bridle from abrasion is minimised.

Section 7

Windlass and Chain Stoppers

7.1 General

7.1.1 Windlass of sufficient power and suitable for the size of chain cable is to be fitted. Where ropes are proposed and approved in lieu of chain cables, suitable winches capable of controlling the rope at all times are to be fitted.

7.1.2 Windlass is to have one cable lifter for each anchor required to be kept ready for use. The cable lifter is normally to be connected to the driving shaft by release coupling and provided with brake.

7.1.3 For each chain cable, a chain stopper is normally to be arranged between the windlass and hawse pipe. The chain cables are to reach the hawse pipe through the cable lifter only.

7.1.4 Electrically driven windlasses are to have a torque limiting device. Electric motors are to comply with the requirements of Part 4, Chapter 8 of the 'Rules for the Construction and Classification of Steel Ships'.

7.1.5 The windlass is to be capable of exerting, for a period of 30 minutes, a continuous duty pull corresponding to the grade of chain cable, as follows:

36.8 d_c^2 [N]	For Grade CC1
41.7 d_c^2 [N]	For Grade CC2
46.6 d_c^2 [N]	For Grade CC3

Where d_c is the chain diameter [mm]. The mean hoisting speed is not to be less than 9 [m]/min. Also See Section 7.2.1.

The windlass is to be also capable of exerting, for a period of not less than 2 minutes, a pull of not less than 1.5 times the continuous duty pull. The speed in this period can be lower.

The above criteria do not require both anchors (where provided) to be raised or lowered simultaneously on windlass fitted with two cable lifters.

7.1.6 The capacity of the windlass brake is to be sufficient for safe stopping of anchor and chain cable when paying out.

The windlass with brakes engaged and release coupling disengaged is to be able to withstand static pull of 45 percent of the tabular breaking strength of the chain without any permanent deformation of the stressed parts and without brake slip.

If a chain stopper is not fitted, the windlass is to be able to withstand a static pull of 80 percent of the tabular breaking strength of the chain without any permanent deformation of the stressed parts and without brake slip.

The chain stoppers and their attachments are to withstand a pull of 80 percent of the tabular breaking strength of the chain without any permanent deformation of the stressed parts. The chain stoppers are to be so designed that additional bending of the individual link does not occur and the links are evenly supported.

7.1.7 Attention is to be paid to stress concentrations in keyways and other stress raisers and also to dynamic effects due to sudden starting or stopping of the prime mover or anchor chain.

7.2 Testing

7.2.1 After installation on board, anchoring tests are to be carried out to demonstrate satisfactory working.

The mean speed of the chain cable measured during trials, when hoisting the anchor and cable from a depth of 82.5 [m] to a depth of 27.5 [m] is not to be less than 9 [m/min]. Where the depth of water in trial areas is inadequate or the anchor cable is less than 82.5 m in length, consideration will be given to acceptance of equivalent simulated conditions.

End Of Chapter

Chapter 10

Fire Safety

Section 1

General

1.1 Application

1.1.1 The requirements of Sections 2, 3, 4 and 5 applies to crafts having ‘HSC’ notation.

1.1.2 All non-HSC, non-passenger crafts of less than 500 GT having ‘LC’ or ‘HSLC’ notation are to meet the requirements of Section 6.

1.1.3 All other crafts with ‘LC’ or ‘HSLC’ notation i.e. non-HSC, non-passenger craft of 500 tons GT and above and non-HSC passenger craft are to meet the requirements given in Part 6 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’, in general. It may be noted that as these crafts, having ‘LC’ or ‘HSLC’ notation, do not follow the design philosophy of the HSC code in totality, requirements of HSC code are not applied.

Section 2

General Requirements for Vessels with Class Notation ‘HSC’

2.1 Application

2.1.1 This section applies to crafts with notation ‘HSC’

2.2 Documentation

2.2.1 The plans and particulars detailed in 2.2.2 to 2.2.4 where applicable are to be submitted for approval, together with all additional relevant information such as gross tonnage and number of passengers.

2.2.2 For fire protection, the following plans and information are to be submitted:

a) Plans showing the arrangements of the fire subdivision, including doors and other means of closing the openings in fire resisting divisions.

b) Ventilation plan showing the ducts and any dampers in them and the position of the controls for stopping the system.

c) A plan showing automatic fire detection systems and manually operated call points, including fire alarm systems.

d) A plan showing the details of construction of the fire protection bulkheads and decks and the particulars of any surface laminates employed.

e) Copies of the certificates of approval by National Authorities in respect of all fire divisions, non-combustible materials and materials having low flame-spread characteristics, etc., which are to be used but have not been approved by IRS.

f) A plan showing the remote control for the fire doors, if applicable.

g) A plan showing the location and arrangement of the emergency stop for the oil fuel unit pumps and for closing the valves on the pipes from oil fuel tanks.

2.2.3 For fire extinguishing, the following plans are to be submitted:

a) A general arrangement plan showing the disposition of all the fire fighting equipment including the fire main, the fixed fire extinguishing systems in the cargo holds, on deck and in the machinery spaces; the disposition of the portable and non-portable extinguishers and the types used; and the position and details of the firemen’s outfits;

b) A plan showing the layout and construction of the fire main, including the main and emergency fire pumps, isolating valves, pipe sizes and materials; and the cross connections to any other system;

c) A plan showing details of each fixed fire fighting system, including calculations for the quantities of the media used and the proposed rates of application.

d) Constructional plans relevant to pressure vessels or bottles serving fixed fire extinguishing systems mentioned under (c).

e) Plans of pumping and drainage means for the water delivered by fixed water-spraying fire extinguishing systems.

Further documentation may be required, if deemed necessary by IRS.

2.2.4 Fire control plan as required by 2.11.1 of this chapter is to be submitted.

2.3 General requirements

2.3.1 The following basic principles underlay the requirements in this chapter and are embodied therein as appropriate, having regard to the category of craft and the potential fire hazard involved:

a) maintenance of the main functions and safety systems of the craft, including propulsion and control, fire detection, alarms and extinguishing capability of unaffected spaces, after fire in any one compartment on board;

b) division of the public spaces for category B craft, in such a way that the occupants of any compartment can escape to an alternative safe area or compartment in case of fire;

c) subdivision of the craft by fire resisting boundaries;

d) restricted use of combustible materials and materials generating smoke and toxic gases in a fire;

e) detection, containment and extinction of any fire in the space of origin;

f) protection of means of escape and access for fire fighting; and

g) immediate availability of fire-extinguishing appliances.

2.3.2 The requirements in this chapter are based on the following conditions:

a) Where a fire is detected, the crew immediately puts into action the fire fighting procedures, informs the base port of the accident and prepares for the escape of passengers to alternative safe area or compartment, or, if necessary, for the evacuation of passengers;

b) The use of fuel with a flashpoint below 43^{o}C is not recommended. However, fuel with a lower flashpoint, but not lower than 35^{o}C, may be used in gas turbines only subject to compliance with the provisions specified in 2.7.7.

c) The repair and maintenance of the craft is carried out in accordance with the requirements of these Rules and chapter 18 and 19 of HSC code.

d) Enclosed spaces having reduced lighting such as cinemas, discotheques and similar spaces are not permitted.

e) Passenger access to vehicle spaces and open ro-ro spaces is prohibited during the voyage except when accompanied by a crew member responsible for fire safety. Only authorized crew members are to be permitted to enter cargo spaces at sea.

2.4 Definitions

2.4.1 "Fire-resisting divisions" are those divisions formed by bulkheads and decks which comply with the following:

a) They are to be constructed of non-combustible or fire-restricting materials which by insulation or inherent-fire-resisting properties satisfy the requirements of b) to f) below.

b) They are to be suitably stiffened.

c) They are to be so constructed as to be capable of preventing the passage of smoke and flame upto the end of the appropriate fire protection time.

d) Where required they are to maintain load-carrying capabilities upto the end of the appropriate fire protection time.

e) They are to have thermal properties such that the average temperature on the unexposed side will not rise more than 140^{o}C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature during the appropriate fire protection time.

f) A test in accordance with the test procedures for a prototype bulkhead and deck should be required to ensure that it meets the above requirements.

2.4.2 "Fire-restricting materials" are those materials which have properties complying with FTP Code.

2.4.3 "Non-combustible material" is material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the FTP Code.

2.4.4 "A standard fire test" is one in which specimens of the relevant bulkheads, decks or other constructions are exposed in a test furnace by specified test method in accordance with the FTP Code.

2.4.5 Where the words "steel or other equivalent material" occur, "equivalent material" means any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (e.g. aluminium alloy with appropriate insulation).

2.4.6 "Low flame-spread" means that the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the FTP Code.

2.4.7 "Smoke-tight" or "capable of preventing the passage of smoke" means that a division made of non-combustible or fire-restricting materials is capable of preventing the passage of smoke.

2.4.8 "FTP Code" is 'International Code for Application of Fire Test Procedures' published by IMO.

2.5 Classification of space use

2.5.1 For the purposes of classification of space use in accordance with fire hazard risks, the following grouping is applicable:

a) "Areas of major fire hazard" referred to in Tables 2.5.1 and 2.5.2 by A, include the following spaces:

– Machinery spaces
– Ro-ro spaces
– Spaces containing dangerous goods
– Special category spaces
– Store-rooms containing flammable liquids
– Galleys
– Sales shops having a deck area of 50 m^2 or greater and containing flammable liquids for sale
– Trunks in direct communication with the above spaces.

b) "Areas of moderate fire hazard" referred to in Table 2.5.1 and 2.5.2 by B, include the following spaces:

– Auxiliary machinery spaces as defined in Chapter 1, 2.2.5
– Bond stores containing packaged beverages with alcohol content not exceeding 24% by volume
– Crew accommodations containing sleeping berths
– Service spaces
– Sales shops having a deck area of less than 50 m^2 containing a limited amount of flammable liquids for sale and where no dedicated store is provided separately
– Sales shops having a deck area of 50 m^2 or greater not containing flammable liquids
– Trunks in direct communication with the above spaces.

c) "Areas of minor fire hazards" referred to in Tables 2.5.1 and 2.5.2 by C, include the following spaces:

– Auxiliary machinery spaces a defined in Chapter 1, 2.2.4
– Cargo spaces
– Fuel tank compartments
– Public spaces
– Tanks, voids and areas of little or no fire risk
– Refreshment kiosks
– Sales shops other than those specified in a) and b)
– Corridors in passenger areas and stairway enclosures
– Crew accommodation other than that mentioned in b)
– Trunks in direct communication with the above spaces.

d) "Control stations" referred to in Table 2.5.1 and 2.5.2 by D, as defined in Chapter 1, 2.2.14 and as explained below:

Explanations to control stations

1. Main navigating equipment includes, in particular, the steering control and the compass, radar and direction finding equipment.
2. Where in the paras relevant to fixed fire-extinguishing systems, there are no specific requirements for the centralization within a control station of major components of a system, such major components may be placed in spaces which are not considered to be a control station.
3. Spaces containing, for instance, the following battery sources are to be regarded as control stations regardless of battery capacity:

   .1 emergency batteries in separate battery room for power supply from black-out till start of emergency generator;

   .2 emergency batteries in separate battery room as reserve source of energy to radiotelegraph installation;

   .3 batteries for start of emergency generator; and

   .4 in general, all emergency batteries required in pursuance of Chapter 13, Section 3 of these Rules.

e) "Evacuation stations and external escape routes" referred to in Tables 2.5.1 and 2.5.2 include following areas:

– External stairs and open decks used for escape routes
– Assembly stations, internal and external
– Open deck spaces and enclosed promenades forming lifeboat and liferaft embarkation and lowering stations
– The craft's side to the waterline in the lightest seagoing condition, superstructure and deckhouse sides situated below and adjacent to the liferaft's and evacuation slide's embarkation areas.

f) "Open spaces" referred to in Table 2.5.1 and 2.5.2 by F, include the following areas:

– Open spaces locations other than evacuation stations and external escape routes and control stations.

2.5.2 Insulation values of spaces with special characteristic of two or more groupings

Where a space has the special characteristic of two or more space groupings, the structural fire protection time of the divisions is to be the highest for the space groupings concerned. For example, the structural fire protection time of the divisions of emergency generator rooms is to be the higher value for the space when the space is considered as being a control station (D) and a machinery space (A).

2.5.3 Galleys are to be in compliance with chapter II/2 of the Convention, See 1.3.2 d).

2.5.4 Separating partial bulkheads of spaces

If a space is divided by partial bulkheads into two (or more) smaller areas such that they form enclosed spaces, then the enclosed spaces are to be surrounded by bulkheads and decks in accordance with Tables 2.5.1 and 2.5.2, as applicable. However, if the separating bulkheads of such spaces are atleast 30% open, then the spaces may be considered as the same space.

2.5.5 Acceptance of cabinets

Cabinets having a deck area of less than 2 m^2 may be accepted as part of the space they serve provided they have open ventilation to the space and do not contain any material or equipment which could be a fire risk

2.5.6 The risk of heat transmission of intersections and terminal points of required thermal barriers is to be considered while designing the structural fire protection details.

Table 2.5.1 : Structural fire protection times for separating bulkheads and decks of passenger craft

	A	**B**	**C**	**D**	**E**	**F**
A Areas of major fire hazard	60(1,2) 60(1,2)	30 60(1)	(3) 60(1,8)	(3,4) 60(1)	(3) 60(1)	- 60(1,7,9)
B Areas of moderate fire hazard		30(2) 30(2)	(3) 30(8)	(3,4) 60	(3) 30	- (3)
C Areas of minor fire hazard			(3) (3)	(3,4) 30(8,10)	(3) (3)	- (3)
D Control stations				(3,4) (3,4)	(3) (3,4)	- (3)
E Evacuation stations and escape routes					(3) (3)	- (3)
F Open spaces						- -

Table 2.5.2 : Structural fire protection times for separating bulkheads and decks of cargo craft

	A	**B**	**C**	**D**	**E**	**F**
A Areas of major fire hazard	60(1,2) 60(1,2)	30 60(1)	(3) 60(1,8)	(3,4) 60(1)	(3) 60(1)	- 60(1,7,9)
B Areas of moderate fire hazard		(6,2) (6,2)	(3) (6)	(3,4) 60	(3) (6)	- (3)
C Areas of minor fire hazard			(3) (3)	(3,4) 30(8)	(3) (3)	- (3)
D Control stations				(3,4) (3,4)	(3) (3,4)	- (3)
E Evacuation stations and escape routes					(3) (3)	- (3)
F Open spaces						- -

Notes : the figures on either side of the diagonal line represent the required structural fire protection time for the protection system on the relevant side of the division. When steel construction is used only the greater of the required protection times need be applied on the relevant side.

1. The upper side of the decks within spaces protected by fixed fire extinguishing systems need not be insulated.
2. Where adjacent spaces are in the same alphabetical category and a note 2 appears, a bulkhead or deck between such spaces need not be fitted if deemed unnecessary by the Administration. For example, a bulkhead need not be required between two storerooms. A bulkhead is, however, required between a machinery space and a special category space even though both spaces are in the same category.
3. No structural fire protection requirements, however a smoke-tight division of non-combustible or fire-restricting material is required.
4. Control stations which are also auxiliary machinery spaces are to be provided with 30 min structural fire protection.
5. There are no special requirements for material or integrity of boundaries where only a dash appears in the tables.
6. The fire protection time is 0 min and the time for prevention of passage of smoke and flame is 30 min as determined by the first 30 min of the standard fire test.
7. Fire-resisting divisions need not comply with 2.4.1 e).
8. When steel construction is used, fire-resisting divisions adjacent to void spaces need not comply with 2.4.1 e).
9. The fire protection time may be reduced to 0 min for those parts of open ro-ro spaces which are not essential parts of the craft's main load bearing structure, where passengers have no access to them and the crew need not have access to them during any emergency.
10. On Category A craft, this value may be reduced to 0 min where the craft is provided with only a single public space (excluding lavatories) protected by a sprinkler system and adjacent to the operating compartment.
11. Ventilation openings may be accepted in entrance doors to public toilets provided they are positioned in the lower portion of the door and fitted with closable grilles operable from outside the space and made of non-combustible or fire-restricting material.

2.6 Structural fire protection

2.6.1 Main structure

2.6.1.1 The requirements below apply to all craft irrespective of construction material. The structural fire protection times for separating bulkheads and decks should be in accordance with Tables 2.5.1 and 2.5.2, and the structural fire protection times are all based on providing protection for a period of 60 min as referred to in Chapter 4 ‘Accommodation and Escape Measures’, Section 4.8 ‘Evacuation Time’, para 4.8.1 of HSC Code. If any other lesser structural fire protection time is determined for category A craft and cargo craft by para 4.8.1 of HSC Code then the times given below in 2.6.2.2 and 2.6.2.3 may be amended pro-rata. In no case should the structural fire protection time be less than 30 min.

2.6.1.2 In using Tables 2.5.1 and 2.5.2, it is to be noted that the title of each category is intended to be typical rather than restricted. For determining the appropriate fire integrity standards to be applied to boundaries between adjacent spaces, where there is doubt as to their classification for the purpose of this section, they are to be treated as spaces within the relevant category having the most stringent boundary requirement.

2.6.1.3 The hull, superstructure, structural bulkheads, decks, deckhouses and pillars are to be constructed of approved non-combustible materials having adequate structural properties. The use of other fire-restricting materials may be permitted provided the requirements of this chapter are complied with and the materials are in compliance with the FTP Code.

Appendages such as air propellers, air ducts to propellers, transmission shafts, rudders and other control surfaces, struts, spars, flexible skirts, etc., are not intended to be of fire restricting or non-combustible material, therefore, the above paragraph is not to apply to them.

2.6.1.4 Prevention of heat transmission, details of insulation

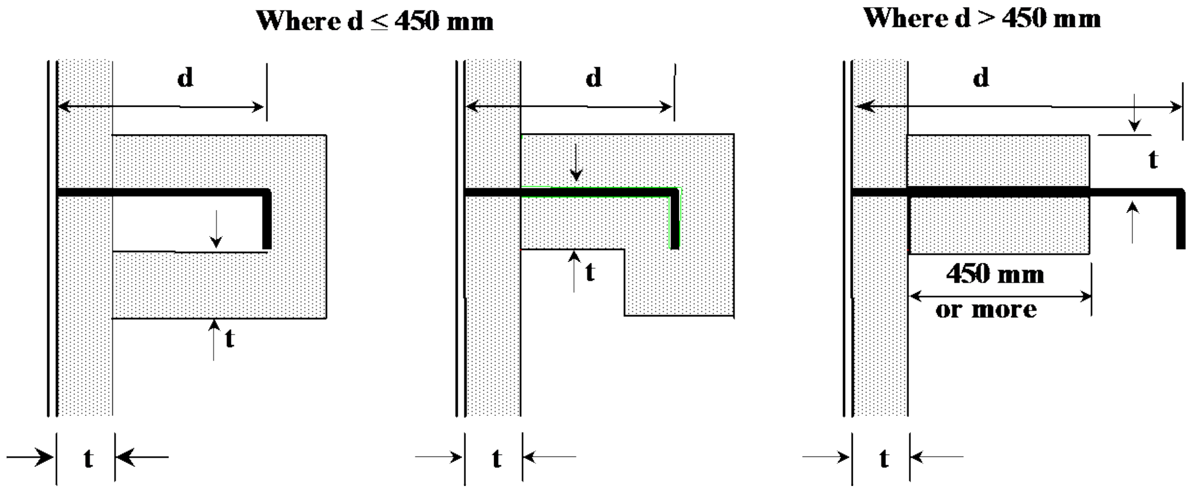

Fig.2.6.1 a)

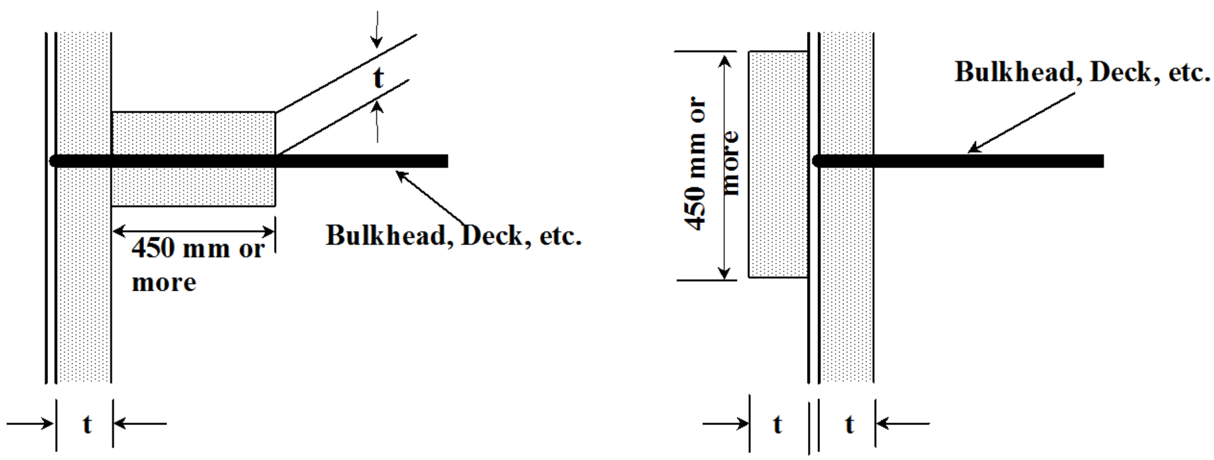

Fig.2.6.1 b)

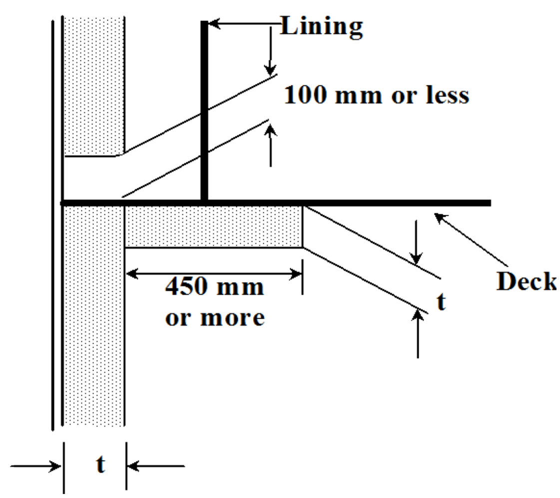

Fig.2.6.1 c)

a) To prevent heat transmission at intersections and terminal points, the insulation of the deck or bulkhead is to be carried past the intersection or terminal point for a distance of at least 450 mm in the case of steel and aluminium structures. (Refer to Fig. 2.6.1 a), b)).

b) If a space is divided by a deck or bulkhead and the fire insulation required for each space is different, the insulation with the higher structural fire protection time is to continue on the deck or bulkhead with the insulation of the lesser structural fire protection time for a distance of at least 450 mm.

c) In the event the lower part of the fire insulation has to be cut for drainage, the construction is to be in accordance with the structural details shown in Fig. 2.6.1 c).

2.6.2 Fire-resisting divisions

2.6.2.1 Areas of major and moderate fire hazard are to be enclosed by fire-resisting division complying with the requirements of 2.4.1 except where the omission of any such division would not affect the safety of the craft. These requirements need not apply to those parts of the structure in contact with water at least 300 mm below the craft's waterline in the lightweight condition in displacement mode, but due regard is to be given to the effect of temperature of hull in contact with water and heat transfer from any uninsulated structure in contact with water to insulated structure above the water.

2.6.2.2 Fire-resisting bulkheads and decks are to be constructed to resist exposure to the standard fire test for a period of 30 min for areas of moderate fire hazard and 60 min for areas of major fire hazard except as provided in 2.6.1.1.

2.6.2.3 Main load carrying structures located within major fire hazard areas (classified as A) and moderate fire hazard areas (classified as B), and load bearing structures which support the control stations, as a minimum, are to be arranged to distribute load such that there will be no collapse of the construction of the hull and superstructure when it is exposed to fire for the appropriate fire protection time as per Table 2.5.1 and 2.5.2(as applicable). In accordance with 2.6.1.1, in no case the structural fire protection is to be less than 30mins. Load bearing structures made of steel, other than those constituting the divisions dealt with in Tables 2.5.1 and 2.5.2(as applicable), need not be insulated.

All load carrying structures within areas of major and moderate fire hazard (classified as A or B) as well as all structures which are necessary to support the control stations irrespective of location are to be considered for this requirement. The vertical extent of structure supporting control stations shall be considered all the way down to and including the spaces within the hull(s). However structures within the voids in the hull can be exempted from this consideration based on 2.6.2.1.

Approvals from the standard fire test *according to the IMO FTP Code, Annex 1, Part 11* for a bulkhead or deck of a given material can be applied for protection of pillars of the same material. The structural fire protection time shall be considered to be the same as that achieved in the fire test.

When load carrying capability calculations are performed for an assumed fire within a space, all insulated or un-insulated steel structures, including pillars, as well as fire insulated aluminium and FRP structures in the space may be included; un-insulated aluminium and FRP structures shall not be included. A single fire concept can be applied where a fire is only presumed to originate in one enclosed space and not propagate to another enclosed space. The load-carrying structure should also comply with the requirements of 2.6.2.4 and 2.6.2.5.

2.6.2.4 If the structures specified in 2.6.2.3 are made of aluminium alloy, their installation is to be such that the temperature of the core does not rise more than 200°C above the ambient temperature in accordance with the times in 2.6.1.1 and 2.6.2.2.

2.6.2.5 If the structures specified in 2.6.2.3 are made of combustible material, their insulation is to be such that their temperatures will not rise to a level where deterioration of the construction will occur during the exposure to the standard fire test in accordance with the FTP Code to such an extent that the load carrying capability, in accordance with the times in 2.6.1.1 and 2.6.2.3, will be impaired.

2.6.2.6 The construction of all doors and door frames in fire-resisting divisions, with the means of securing them when closed, is to provide resistance to fire as well as to the passage of smoke and flame equivalent to that of the bulkheads in which they are situated. Watertight doors of steel need not be insulated. Also, where a fire-resisting division is penetrated by pipes, ducts, controls, electrical cables or for other purposes, arrangements are to be made to ensure that the fire-resisting integrity of the division is not impaired and necessary testing is to be carried out in accordance with FTP Code.

Where machinery shafts penetrate fire-resisting watertight divisions, arrangements are to be made to ensure that the required watertight and fire-resisting integrity of the division is not impaired.

2.6.2.7 Ventilation openings may be accepted in entrance doors to public toilets, provided they are positioned in the lower portion of the door and fitted with closable grilles made of non-combustible or fire-restricting material and operable from outside the space.

2.6.3 Restricted use of combustible materials

2.6.3.1 All separating divisions, ceilings or linings if not a fire resisting division, are to be of non-combustible or fire-restricting materials. Draught stops are to be of non-combustible or fire-restricting material.

2.6.3.2 Where insulation is installed in areas in which it could come into contact with any flammable fluids or their vapours, its surface is to be impermeable to such flammable fluids or vapours. The insulation may be covered by metal sheets (not perforated) or by vapour proof glass cloth accurately sealed at the joint.

2.6.3.3 Furniture and furnishings in public spaces and crew accommodation are to comply with the following standards:

a) all case furniture such as desks, wardrobes, dressing tables, bureaux and dressers is constructed entirely of approved non-combustible or fire-restricting materials, except that a combustible veneer with a calorific value not exceeding 45 MJ/m^2 may be used on the exposed surface of such articles;

b) all other furniture such as chairs, sofas, tables, is constructed with frames of non-combustible or fire-restricting materials;

c) all draperies, curtains and other suspended textile materials have qualities of resistance to the propagation of flame this being determined in accordance with the FTP Code;

d) all upholstered furniture has qualities of resistance to the ignition and propagation of flame this being determined in accordance with the FTP Code;

e) all bedding components have qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the FTP Code; and

f) all deck finish materials comply with the FTP Code.

2.6.3.4 The following surfaces as a minimum standard are to be constructed of materials having low flame-spread characteristics:

a) exposed surfaces in corridors and stairway enclosures and of bulkheads (including windows), wall and ceiling linings in all public spaces, crew accommodation, service spaces, control stations and internal assembly and evacuation stations;

b) surfaces in concealed or inaccessible spaces in corridors and stairway enclosures, public spaces, crew accommodation, service spaces, control stations and internal assembly and evacuation stations.

However, the above does not apply to partitions, windows and side scuttles made of glass which are deemed to be non-combustible and complying with the requirements for low-flame spread surfaces or to items and materials referred to in 2.6.3.3.

2.6.3.5 Any thermal and acoustic insulation is to be of non-combustible or of fire-restricting material. Vapour barriers and adhesives used in conjunction with insulation, as well as insulation of pipe fittings for cold service systems need not be non-combustible or fire-restricting, but they may be kept to the minimum quantity practicable and their exposed surfaces may have low flame spread characteristics.

2.6.3.6 Exposed surfaces in corridors and stairway enclosures and of bulkheads (including windows), wall and ceiling linings, in all public spaces, crew accommodation, service spaces, control stations and internal assembly and evacuation stations are to be constructed of materials which, when exposed to fire, are not capable of producing excessive quantities of smoke or toxic products, this being determined in accordance with the FTP Code.

2.6.3.7 Void compartments, where low density combustible materials are used to provide buoyancy, are to be protected from adjacent fire hazard areas by fire-resisting divisions, in accordance with Tables 2.5.1 and 2.5.2. Also, the space and closures to it are to be gastight but it is to be ventilated to atmosphere.

2.6.3.8 In compartments where smoking is allowed, suitable non-combustible ash containers are to be provided. In compartments where smoking is not allowed, adequate notices are to be displayed.

2.6.3.9 The exhaust gas pipes are to be arranged so that the risk of fire is kept to a minimum. To this effect, the exhaust system is to be insulated and all the compartments and structures which are contiguous with the exhaust system, or those which may be affected by increased temperatures caused by waste gases in normal operation or in an emergency, are to be constructed of non-combustible material or be shielded and insulated with non-combustible material to protect from high temperatures.

2.6.3.10 The design and arrangement of the exhausts manifolds or pipes are to be such as to ensure the safe discharge of exhaust gases.

2.6.4 Arrangement

2.6.4.1 Internal stairways connecting only two decks need only be enclosed at one deck by means of divisions and self-closing doors having the structural fire protection time as required by Table 2.5.1 and 2.5.2 for divisions separating those areas which each stairway serves. Stairways may be fitted in the open in a public space, provided they lie wholly within such public space.

Where stairways are fitted in a public space consisting of only two decks, the following conditions are to be met:

a) all levels are used for the same purpose;

b) the area of the opening between the lower and upper part of the space is to be at least 10% of the deck area between the upper and lower part of the space;

c) the design is to be such that persons within the space are generally aware or could easily be made aware of a developing fire or other hazardous situation located within that space;

d) sufficient means of escape are provided from both levels of the space directly leading to an adjacent safe area or compartment; and

e) the whole space is served by one section of the sprinkler system. (See 3.3).

2.6.4.2 Lift trunks are to be so fitted as to prevent the passage of smoke and flame from one deck to another and provided with means of closing so as to permit the control of draught and smoke.

2.6.4.3 In public spaces, crew accommodation, service spaces, control stations, corridors and stairways, air spaces enclosed behind ceilings, panelling or linings are to be suitably divided by close fitting draught stops not more than 14 m apart. On Category A craft provided with only a single public space, draught stops need not be provided in such public space.

Draught stops are not required in public spaces with open ceilings (perforated ceilings) where the opening is 40% or more and the ceiling is arranged in such a way that a fire behind the ceiling can be easily seen and extinguished.

2.7 Fuel and other flammable fluid tanks and systems

2.7.1 Tanks containing fuel and other flammable fluids are to be separated from passenger, crew and baggage compartments by vapour-proof enclosures or cofferdams which are suitably ventilated and drained.

2.7.2 Fuel oil tanks are not to be located in or contiguous to major fire hazard areas. However, flammable fluids of a flashpoint not less than 60^oC may be located within such areas provided the tanks are made of steel or other equivalent material. The use of aluminium in lubricating oil sump tanks for engines, or in lubricating oil filter housings fitted integral with the engines, is accepted.

2.7.3 Integral or independent fuel tanks made of aluminium alloys, GRP or equivalent may be located within major fire hazard areas when they are insulated for 60 minutes fire integrity. The same insulation standard is required for bulkheads or decks separating oil fuel tanks from major fire hazard areas.

2.7.4 Every oil fuel pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank is to be fitted with a cock or valve directly on the tank capable of being closed from a position outside the space concerned in the event of fire occurring in the space in which such tanks are situated.

Note : Refer to guidelines for materials other than steel for pipes adopted by IMO by Resolution A.753(18) or FTP Code.

2.7.5 Pipes, valves and couplings conveying flammable fluids are to be of steel or such alternative material satisfactory to a standard, in respect of strength and fire integrity having regard to the service pressure and the spaces in which they are installed. Wherever practicable, the use of flexible pipes is to be avoided.

2.7.6 Pipes, valves and couplings conveying flammable fluids are to be arranged as far from hot surfaces or air intakes of engine installations, electrical appliances and other potential sources of ignition as is practicable and be located or shielded so that the likelihood of fluid leakage coming into contact with such sources of ignition is kept to a minimum.

2.7.7 Fuel with a flash point below 35^{o}C is not to be used. In every craft in which fuel with a flashpoint below 43^{o}C is used, the arrangements for the storage, distribution and utilization of the fuel are to be such that, having regard to the hazard of fire and explosion which the use of such fuel may entail, the safety of the craft and of persons onboard is preserved. The arrangements are to comply, in addition to the requirements of 2.7.1 to 2.7.6, with the following provisions:

a) tanks for the storage of such fuel are to be located outside any machinery space and at a distance of not less than 760 mm inboard from the shell side and bottom plating, and from decks and bulkheads;

b) arrangements are to be made to prevent overpressure in any fuel tank or in any part of the oil fuel system, including the filling pipes. Any relief valves and air or overflow pipes are to discharge to a position which is safe;

c) the spaces in which fuel tanks are located are to be mechanically ventilated using exhaust fans providing not less than six air changes per hour. The fans are to be such as to avoid the possibility of ignition of flammable gas air mixtures. Suitable wire mesh guards are to be fitted to inlet and outlet ventilation openings. The outlets for such exhausts are to be discharged to a position which is safe. ‘No smoking’ signs are to be posted at the entrances to such spaces;

d) earthed electrical distribution systems are not be used, with the exception of earthed intrinsically safe circuits;

e) suitable certified safe type electrical equipment is to be used in all spaces where fuel leakage could occur, including ventilation system. Only electrical equipment and fittings essential for operational purposes are to be fitted in such spaces;

Note : Refer to the recommendations published by the International Electro-technical Commission, and in particular, publication 92 – Electrical installations in ships.

f) a fixed vapour detection system is to be installed in each space through which fuel lines pass, with alarms provided at the continuously manned control station;

g) every fuel tank where necessary, is to be provided with ‘‘savealls’’or gutters which would catch any fuel which may leak from such tank;

h) safe and efficient means of ascertaining the amount of fuel contained in any tank are to be provided. Sounding pipes are not terminate in any space where the risk of ignition of spillage from the sounding pipe might arise. In particular, they are not to terminate in passenger or crew spaces. The use of gauge glasses is not allowed. Other means of ascertaining the amount of fuel contained in any tank may be allowed if such means do not require penetration below the top of the tank and provided their failure or overfilling of the tank will not permit the release of fuel;

i) during bunkering operations no passenger is to be on board the craft or in the vicinity of the bunkering station and adequate ‘No smoking’ and 'No naked lights' signs are to be posted. Vessel-to-shore fuel connections are to be of closed type and suitably grounded during bunkering operations;

j) the provision of fire detection and extinguishing systems in spaces where non-integral fuel tanks are located are to be in accordance with paragraphs 2.9.1 to 2.9.3; and

k) In addition to above, it may be noted that the Administration would require following:

– refueling of the craft is to be done at the approved refueling facilities, detailed in the route operational manual, at which the following fire appliances are provided;

  - a suitable foam applicator system consisting of monitors and foam making branch pipes capable of delivering foam solution at a rate of not less than 500 l/min for not less than 10 min;
  - dry powder extinguishers of total capacity not less than 50 kg; and
  - carbon dioxide extinguishers of total capacity not less than 16 kg.

2.8 Ventilation

2.8.1 The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the spaces being ventilated. In addition such openings to areas of major fire hazard are to be capable of being closed from a continuously manned control station. The controls are to be easily accessible as well as prominently and permanently marked and are to indicate whether the shut-off is open or closed.

2.8.2 All ventilation fans are to be capable of being stopped from outside the spaces which they serve, and from outside the spaces in which they are installed. Ventilation fans serving major fire hazard areas are to be capable of being operated from a continuously manned control station. The means provided for stopping the power ventilation to the machinery space are to be separated from the means provided for stopping ventilation of other spaces.

2.8.3 Areas of major fire hazard and spaces serving as assembly stations are to have independent ventilation systems and ventilation ducts. Ventilation ducts for areas of major fire hazard are not to pass through other spaces, unless they are contained within a trunk or in an extended machinery space or casing insulated in accordance with Tables 2.5.1 and 2.5.2; ventilation ducts of other spaces are not to pass through areas of major fire hazard. Ventilation outlets from areas of major fire hazard are not to terminate within a distance of 1 m from any control station, evacuation station or external escape route. In addition, exhaust ducts from galley ranges are to be fitted with:

a) a grease trap readily removable for cleaning, unless an alternative approved grease removal system is fitted;

b) a fire damper located in the lower end of the duct (the junction between the duct and the galley range hood) which is automatically and remotely operated and in addition a remotely operated fire damper located in the upper end of the duct;

c) a fixed means for extinguishing a fire within the duct;

d) remote control arrangements for shutting off the exhaust fans and supply fans, for operating the fire dampers mentioned in b) and for operating the fire-extinguishing system, which is to be placed in a position close to the entrance to the galley. Where a multi-branch system is installed, remote means with above controls are to be provided to close all branches exhausting through the same main duct before an extinguishing medium is released into the system; and

e) suitably located hatches for inspection and cleaning.

   As a minimum, one hatch is to be provided close to the exhaust fan and others located in areas of high grease accumulation such as the lower end of the duct as referred to in b).

2.8.4 Where, a ventilation duct passes through a fire-resting division, a fail safe automatic closing fire damper is to be fitted adjacent to the division. The duct between the division and the damper is to be of steel or other equivalent material and insulated to the same standard as required for the fire-resisting division. The fire damper may be omitted where ducts pass through spaces surrounded by fire-resisting divisions without serving those spaces providing that the duct has the same structural fire protection time as the divisions it penetrates. Where a ventilation duct passes through a smoke-tight division, a smoke damper is to be fitted at the penetration unless the duct which passes through the space does not serve that space.

The fire and smoke dampers are to be easily accessible. Where they are placed behind ceilings or linings, they are to be provided with an inspection door on which a plate is fitted providing the identification number of the damper. Such plates with identification numbers are also to be placed on any required remote controls.

2.8.5 Where ventilation systems penetrate decks, the arrangements are to be such that the effectiveness of the deck in resisting fire is not thereby impaired and precautions are to be taken to reduce the likelihood of smoke and hot gases passing from one between deck space to another through the system.

2.8.6 All dampers fitted on fire-resisting or smoke-tight divisions are also be capable of being manually closed from each side of the division in which they are fitted, except for those dampers fitted on ducts serving spaces not normally manned such as stores and toilets that may be manually operated only from outside the served spaces. All dampers are also be capable of being remotely closed from the continuously manned control station.

Manual closing may be achieved by mechanical means of release or by remote operation of the fire or smoke damper by a fail-safe electrical switch or pneumatic release (i.e. spring-loaded, etc.)

2.8.7 Ducts are to be made of non-combustible or fire restricting material. Short ducts, however, may be of combustible materials subject to the following conditions:

a) their cross-section does not exceed 0.02 m^2;

b) their length does not exceed 2 m;

c) they may only be used at the terminal end of the ventilation system;

d) they are not to be situated less than 600 mm from an opening in a fire-resisting or fire-restricting division; and

e) their surface have low flame spread characteristics.

2.9 Fire detection and extinguishing systems

2.9.1 Fire detection systems

Areas of major and moderate fire hazard and other enclosed spaces not regularly occupied within public spaces and crew accommodation such as toilets, stairway enclosures, corridors and escape routes are to be provided with an approved automatic smoke detection system and manually operated call points complying with the requirements of 2.9.1.1 and 2.9.1.3 to indicate at the control station the location of outbreak of a fire in all normal operating conditions of the installations. Detectors operated by heat instead of smoke may be installed in galleys. Main propulsion machinery room(s) are to have, in addition, detectors sensing other than smoke and be supervised by TV cameras monitored from the operating compartment. Manually operated call points are to be installed throughout the public spaces, crew accommodation corridor and stairway enclosures, service spaces and where necessary control stations. One manually operated call point is to be located at each exit from these spaces and from areas of major fire hazard. Control stations not normally occupied (e.g. emergency generator rooms) need not be provided with manually operated call points.

2.9.1.1 General requirements

a) Any required fixed fire detection and fire alarm system with manually operated call points is to be capable of immediate operation at all times;

b) Power supplies and electric circuits necessary for the operation of the system are to be monitored for loss of power or fault conditions as appropriate. Occurrence of fault condition is to initiate a visual and audible fault signal at the control panel which is to be distinct from a fire signal;

c) There is to be not less than two sources of power supply for the electrical equipment used in the operation of the fire detection and fire alarm systems one of which is to be emergency source. The supply is to be provided by separate feeders reserved solely for this purpose. Such feeders are to run to an automatic change over switch situated in or adjacent to the control panel for the fire detection system;

d) Detectors and manually operated call points are to be grouped into sections each of which shall comprise a group of fire detectors and manually operated call points as displayed at the indicating unit(s) required by this paragraph. The activation of any detector or manually operated call point is to initiate a visual and audible fire signal at the control panel and indicating units. If the signals have not received attention within two minutes an audible alarm is to be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces. There shall be no time delay for the audible alarms in crew accommodation areas when all the control stations are unattended. The alarm sounder system need not be an integral part of the detection system;

e) The control panel is to be located in the operating compartment or in the main fire control station;

f) Indicating units are to, as a minimum, denote the section in which a detector or manually operated call point has operated. At least one unit is to be so located that it is easily accessible to responsible members of the crew at all times, when at sea or in port, except when the craft is out of service. One indicating unit is to be located in the operating compartment if the control panel is located in the space other than the operating compartment;

g) Clear information is to be displayed on or adjacent to each indicting unit about the spaces covered and the location of the sections;

h) Where the fire detection system does not include means of remotely identifying each detector individually, no section covering more than one deck within public spaces, crew accommodation, corridors, service spaces and controls stations are to be permitted normally except a section which covers an enclosed stairway. In order to avoid delay in identifying the source of fire, the number of enclosed spaces included in each section are to be limited. In no case more than 50 enclosed spaces would be permitted in any section. If the detection system is fitted with remotely and individually identifiable fire detectors, the sections may cover several decks and serve any number of enclosed spaces.

i) In passenger craft, if there is no fire detection system capable of remotely and individually identifying each detector, a section of detectors are not to serve spaces on both sides of the craft nor on more than one deck and neither it is to be situated in more than one zone according to 1.13.1. In passenger craft fitted with individually identifiable fire detectors, a section may serve spaces on both sides of the craft and on several decks. Further, the same section of detectors may serve spaces on more than one deck if such spaces are located in the fore or aft end of the craft or they are so arranged that they constitute common spaces on different decks (e.g. fan rooms, galleys, public spaces, etc.);

j) A section of fire detectors which covers a control station, a service space a public space, crew accommodation, corridor or stairway enclosure are not to include a machinery space of major fire hazard. For fire detection systems with remotely and individually identifiable fire detectors, the requirement set out in this para is considered met when a loop covering accommodation spaces, service spaces and control stations, does not include machinery spaces of a major fire hazard;

k) Detectors are to be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered provided that they are no less sensitive than such detectors. Flame detectors are only to be used in addition to smoke or heat detectors;

l) Suitable instructions and component spares for testing and maintenance are to be provided;

m) The function of the detection system is to be periodically tested by means of equipment producing hot air at the appropriate temperature, or smoke or aerosol particles having the appropriate range of density or particle size, or other phenomena associated with incipient fires to which the detector is designed to respond. All detectors are to be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component;

n) The fire detection system is not be used for any other purpose, except that following functions may be permitted at the control panel:

- To activate a paging system;
- To activate the fan stops;
- To activate the closure of fire doors;
- To activate the closure of fire and smoke dampers;
- To activate the sprinkler system.

o) Fire detection systems in which all fire detectors are individually identifiable (i.e. with a zone address identification capability) are to be so arranged that;

- a loop cannot be damaged at more than one point by a fire. For this purpose loop is not to pass through a space twice. Where this is not practical (e.g. for large public spaces) the part of the loop which by necessity passes through the space for a second time is to be installed at the maximum possible distance from the other parts of the loop;

- means are provided to ensure that any fault (e.g. power break; short circuit; earth) occurring in the loop will not render the whole loop ineffective;

- all arrangements are made to enable the initial configuration of the system to be restored in the event of failure (electrical, electronic, informatic); and

- the first initiated fire alarm is not to prevent any other detector to initiate further fire alarms.

p) the fire detection system in vehicle deck spaces, excluding manual call points, may be switched off with a timer during loading/unloading of vehicles.

2.9.1.2 Installation requirements

a) In addition to 2.9.1, manually operated call points are to be readily accessible in the corridors of each deck such that no part of the corridor is more than 20 m from a manually operated call point;

b) Where a fixed fire detection and fire alarm system is required for the protection of spaces other than stairways, corridors and escape routes, at least one detector complying with 2.9.1.1k) is to be installed in each such space;

c) Detectors are to be located for optimum performance. Positions near beams and ventilation ducts or other positions where patterns of air flow could adversely affect performance and positions where impact or physical damage is likely should be avoided. In general, detectors which are located on the overhead are to be a minimum distance of 0.5 m away from bulkheads. Distances smaller than 0.5 m from bulkheads may be accepted in corridors, lockers and stairways.

d) The maximum spacing of detectors are to be in accordance with the table below:

Type of detector	Max. floor area per detector	Max. distance apart between centres	Max. distance away from bulkheads
Heat	37 m^2	9 m	4.5 m
Smoke	74 m^2	11 m	5.5 m

Other spacings may be required or permitted based upon test data, which demonstrate the characteristics of the detectors.

e) Electrical wiring which forms part of the system is to be so arranged as to avoid machinery spaces of major fire hazard, and other enclosed spaces of major fire hazard except, where it is necessary, to provide for fire detection or fire alarm in such spaces or to connect to the appropriate power supply.

2.9.1.3 Design requirements

a) The system and equipment are to be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships;

b) Smoke detectors are to be certified to operate before the smoke density exceeds 12.5% obscuration per metre, but not until the smoke density exceeds 2% obscuration per metre. Smoke detectors to be installed in other spaces are to operate within sensitivity limits having regard to the avoidance of detector insensitivity or over-sensitivity;

c) Heat detectors are to be certified to operate before the temperature exceeds 78°C but not until the temperature exceeds 54°C, when the temperature is raised to those limits at a rate less than 1°C per minute. At higher rates of temperature rise, the heat detector is to operate within temperature limits having regard to the avoidance of detector insensitivity or over-sensitivity;

d) The permissible temperature of operation of heat detectors may be increased to 30°C above the maximum deckhead temperature in drying rooms and similar space of a normal high ambient temperature;

e) Flame detectors referred in 2.9.1.1k) are to have a sensitivity sufficient to determine flame against an illuminated space background and a false signal identification system.

2.9.2 A fixed fire detection and fire alarm system for periodically unattended machinery spaces are to comply with the following requirements:

a) The fire detection system is to be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces and under any normal conditions of operation of the machinery and variations of ventilation as required by the possible range of ambient temperatures. Except in spaces of restricted height and where their use is specially appropriate, detection system using only thermal detectors is not permitted. The detection system is to initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in sufficient places to ensure that the alarms are heard and observed on the navigating bridge and by a responsible engineer officer. When the operating compartment is unmanned the alarm is to sound in a place where a responsible member of the crew is on duty;

b) After installation, the system is to be tested under varying conditions of engine operation and ventilation;

2.9.3 Fixed fire extinguishing system

2.9.3.1 Areas of major fire hazard are to be protected by an approved fixed extinguishing system operable from the operating compartment and where provided, from a control position which is adequate for the fire hazard that may exist. The system is to comply with 2.9.3.2 and 2.9.3.3 or with alternative arrangements approved by IRS and be capable of local manual control and remote control from the continuously manned control stations. The system is to be remotely controlled in such a way that it is fully serviceable from the operating compartment without any intervention of personnel outside that space in normal conditions.

2.9.3.2 General requirements

a) In all craft where gas is used as the extinguishing medium, the quantity of gas is to be sufficient to provide two independent discharges. The second discharge into the space is to be only activated (released) manually from a position outside the space being protected. Where the space has a local fire-suppression system installed, based on the guidelines of the Administration, to protect fuel oil, lubricating coil and hydraulic oil, located near exhaust manifolds, turbo chargers or similar heated surfaces on main and auxiliary internal combustion engines, a second discharge need not be provided.

b) The use of a fire extinguishing medium which, either by itself or under expected conditions of use will adversely affect the earth’s ozone layer and/or gives off toxic gases in such quantities as to endanger persons is not allowed.

c) The necessary pipes for conveying fire extinguishing medium into protected spaces are to be provided with control valves so marked as to indicate clearly the spaces to which the pipes are led. Non-return valves are to be installed in discharge lines between cylinders and manifolds. Suitable provision is to be made to prevent inadvertent admission of the medium to any space.

d) Pipelines may pass through accommodation spaces provided they are of substantial thickness and that their tightness is verified with a pressure test, after their installation, at a pressure head not less than 5 N/mm^2. In addition, pipelines passing through accommodation areas are only to be joined by welding and are not to be fitted with drains or other openings within such spaces. Pipelines are not to pass through refrigerated spaces.

e) The piping for the distribution of fire extinguishing medium are to be arranged and discharge nozzles so positioned that a uniform distribution of medium is obtained.

f) Means are to be provided to close all openings which may admit air to, or allow gas to escape from, a protected space from a position outside the protected space.

g) Means are to be provided for automatically giving audible warning of the release of fire-extinguishing medium into any space in which personnel normally work or which personnel can be expected to enter (e.g. ro-ro spaces) and where their access is facilitated by doors or hatches or to which they have access. The alarm is to automatically operate for a suitable period before the medium is released, but not less than 20 s. Visible alarm are to be arranged in addition to the audible alarm.

h) The volume of starting air receivers, converted to free air volume are to be added to the gross volume of the machinery space when calculating the necessary quantity of extinguishing medium. Alternatively, a discharge pipe connected to a safety valve may be fitted provided it leads directly to the open air.

i) The means of control of any fixed gas fire extinguishing system is to be readily accessible and simple to operate and be grouped together in as few locations as possible at positions not likely to be cut off by a fire in a protected space. At each location there are to be clear instructions relating to the operation of the system having regard to the safety of personnel.

j) Automatic release of fire extinguishing medium is not allowed.

k) Where the quantity of extinguishing medium is required to protect more than one space, the quantity of medium available need not be more than the largest quantity required for any one space so protected. Two spaces can be considered as separated spaces where divisions comply with Table 2.5.1 and 2.5.2 as appropriate, or the divisions are gastight and of steel or equivalent materials. See also 2.9.3.2a)

l) Pressure containers required for the storage of fire extinguishing medium are to be located outside protected spaces in accordance with o) below. Pressure containers may be located inside the space to be protected if in the event of accidental release persons will not be endangered.

m) Means are to be provided for the crew to safely check the quantity of medium in the containers.

Means for checking the quantity of medium in containers are to be so arranged that it is not necessary to move the containers completely from their fixing position. This may be achieved for instance by providing hanging bars above each bottle row for a weighting device or by using suitable surface indicators.

n) Containers for the storage of fire extinguishing medium and associated pressure components are to be designed to accepted pressure codes of practice to the satisfaction of IRS having regard to their locations and maximum ambient temperatures expected in service.

o) When the fire extinguishing medium is stored outside a protected space, it is to be stored in a room which is situated in a safe and readily accessible position and effectively ventilated. Any entrance to such a storage room is to be preferably from the open deck and in any case is to be independent of the protected space. Access doors are to open outwards and bulkheads and decks including doors and other means of closing any opening therein, which form the boundaries between such rooms and adjoining enclosed spaces are to be gas tight. For the purpose of application of Tables 2.5.1 and 2.5.2, such storage rooms are to be treated as control stations.

Spaces for storage of the cylinders or tanks for extinguishing gas are not to be used for other purposes. Access to these spaces are to be possible from the open deck; spaces situated below the deck are to be directly accessible by a stairway or ladder from the open deck. The space is to be located no more than one deck below the open deck.

Storage spaces are to be effectively ventilated. Spaces which are located below deck or spaces where access from the open deck is not provided, are to be fitted with a mechanical ventilation system designed to take exhaust air from the bottom of the space and sized to provide at least 6 air changes per hour.

p) If the release of a fire-extinguishing medium produces significant over or under pressurisation in the protected space, means are to be provided to limit the induced pressures to acceptable limits to avoid structural damage.

q) Spare parts for the system are to be stored on board or at a base port.

2.9.3.3 Carbon dioxide systems

a) For cargo spaces, unless otherwise provided the quantity of carbon dioxide available is to be sufficient to give a minimum volume of free gas equal to 30% of the gross volume of the largest cargo space so protected in the craft.

b) For machinery spaces the quantity of carbon dioxide is to be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

  - 40% of the gross volume of the largest machinery space so protected, the volume to exclude that part of the casing above the level at which the horizontal area of the casing is 40% or less of the horizontal area of the space concerned taken midway between the tank top and the lowest part of the casing; or

  - 35% of the gross volume of the largest machinery space protected, including the casing;
    provided that the above mentioned percentages may be reduced to 35% and 30% respectively for cargo craft of less than 2000 tons gross tonnage; provided also that if two or more machinery spaces are not entirely separate they are to be considered as forming one space.

c) For the purpose of this paragraph the volume of free carbon dioxide is to be calculated at 0.56 m^3/kg.

d) For machinery spaces the fixed piping system is to be such that 85% of the gas can be discharged into the space within 2 min.

e) Two separate controls are to be provided for releasing carbon dioxide into a protected space and to ensure the activation of the alarm. One control is to be used to discharge the gas from its storage containers. A second control is to be used for opening the valve of the piping which conveys the gas into the protected spaces.

f) The two controls are to be located inside a release box clearly identified for the particular space. If the box containing the controls is to be locked, a key to the box is to be in a break-glass type enclosure conspicuously located adjacent to the box.

2.9.3.4 Where a fixed fire-extinguishing system not required by paragraph 2.9.3.1 above is installed, it is to meet the requirements of this section, except for the second discharge required for the fixed gas fire extinguishing systems.

2.9.4 Portable fire extinguishers

Control stations, public spaces, crew accommodation, corridors and service spaces are to be provided with portable fire extinguishers of approved types and design. At least five portable extinguishers are to be provided and so positioned as to be readily available for immediate use. In addition, at least one extinguisher suitable for machinery space fires are to be positioned outside each machinery space entrance. For details of extinguishers reference is made to IMO Resolution A.602(15) titled “Revised Guidelines for Marine Portable Fire Extinguishers”;.

Each portable fire extinguisher is to be:

a) not exceeding 23 kg in total mass;
b) having a capacity of at least 5 kg if of powder or carbon dioxide type;
c) having a capacity of at least 9 *l* if of foam type;
d) examined annually;
e) provided with a sign indicating the date when was last examined;
f) hydraulic-pressure tested (cylinders and propellant bottles) every 10 years;
g) not placed in accommodation spaces if of carbon dioxide type;
h) if located in control stations and other spaces containing electrical or electronic equipment or appliances necessary for the safety of the craft, provided with extinguishing media which are neither electrically conductive nor harmful to the equipment and appliances;
i) ready for use and located in easily visible places such that it can be reached quickly and easily at any time in the event of a fire;
j) located such that its serviceability is not impaired by the weather, vibration or other external factors; and
k) provided with a device to identify whether it has been used.

2.9.4.1 Mass and capacity of portable fire extinguishers

a) The mass of portable fire extinguishers is not to exceed 23 kg.

b) Each powder or carbon dioxide extinguisher is to have a capacity of at least 5 kg and each foam extinguisher a capacity of at least 9l.

2.9.4.2 Equivalents of portable fire extinguishers

Reference is made to ISO/DIS 7156 – Fire protection equipment – Portable fire extinguishers – Performance and construction.

Examination and testing of portable fire extinguishers

a) Fire extinguishers are to be examined annually by a competent person.

b) Each fire extinguisher are to be provided with a sign indicating that it has been examined.

c) Fire extinguisher cylinders and propellant bottles are to be hydraulic pressure tested every 10 years.

2.9.4.3 Type and location of portable fire extinguishers

a) Carbon dioxide fire extinguishers are not to be placed in accommodation spaces. In control stations and other spaces containing electrical or electronic equipment or appliances necessary for the safety of the craft, fire extinguishers are to be provided with extinguishing media which are neither electrically conductive nor harmful to the equipment and appliances.

b) Fire extinguishers are to be ready for use and located in easily visible places such that they can be reached quickly and easily at any time in the event of a fire. In addition, the fire extinguisher is to be located such that their serviceability is not impaired by the weather, vibration or other external factors. Portable fire extinguishers are to be provided with devices to identify whether they have been used.

2.9.5 Fire pumps, fire mains, hydrants and hoses

Fire pumps and appropriate associated equipment, or alternative effective fire-extinguishing systems are to be fitted as follows:

a) At least two pumps ~~(~~powered by independent sources of power~~)~~ are to be arranged. Each pump is to have at least two-thirds the capacity of a bilge pump as determined by Chapter 11, 2.7.3.1 and 2.7.3.2 but not less than 25 m^3/h. Each fire pump is to be able to deliver sufficient quantity and pressure of water to simultaneously operate the hydrants as required by d).

b) The arrangement of the pumps are to be such that in the event of a fire in any one compartment all the fire pumps will not be put out of action;

c) Isolating valves to separate the section of the fire main within the machinery space containing the main fire pump or pumps from the rest of the fire main are to be fitted in an easily accessible and tenable position outside the machinery spaces. The fire main is also to be so arranged that when the isolating valves are shut all the hydrants on the craft, except those in the machinery space referred to above, can be supplied with water by a fire pump not located in this machinery space through pipes which do not enter this space. Fire mains are to be capable of being drained. Valves are to be installed in the main so that fire main branches can be isolated when the main is used for purposes other than fire fighting.

d) Hydrants are to be arranged so that any location on the craft can be reached by the water jets from two fire hoses from two different hydrants, one of the jets being from a single length of hose. Ro-ro spaces hydrants are to be located so that any location within the space can be reached by two water jets from two different hydrants, each jet being supplied from a single length of hose. One hydrant is to be located in the vicinity and outside of each entrance to a machinery space.

e) Each fire hose is to be of non-perishable material. Fire hoses, together with any necessary fittings and tools, are to be kept ready for use in conspicuous positions near the hydrants. All fire hoses in interior locations are to be connected to the hydrants at all times. One fire hose is to be provided for each hydrant as required by d) above. Fire hoses are to have a length of:

- At least 10 m,
- Not more than 15 m in machinery spaces,
- Not more than 20 m for other spaces and open decks.

f) Each fire hose is to be provided with a nozzle of an approved dual purpose type (i.e. spray / jet type) incorporating a shutoff.

2.9.6 Protection of deep-fat cooking equipment

Where deep-fat cooking equipment is installed, all such installations are to be fitted with:

a) An automatic or manual fixed extinguishing system tested to an appropriate standard acceptable to the Administration;

b) A primary and back up thermostat with an alarm to alert the operator in the event of failure of either thermostat;

c) Arrangements for automatically shutting off the electrical power to the deep-fat cooking equipment upon activation of the extinguishing system;

d) An alarm indicating operation of the extinguishing system in the galley where the equipment is installed; and

e) Controls for manual operation of the extinguishing system which are clearly labelled for ready use by the crew.

2.10 Protection of special category and ro-ro spaces

2.10.1 Structural protection

a) Subject to c) below boundaries of special category spaces are to be insulated in accordance with Tables 2.5.1 and 2.5.2.

b) The deck of a special category space vehicle need only be insulated on the underside if required or a ro-ro space, including an open ro-ro space. Vehicle decks located totally within ro-ro spaces may be accepted without structural fire protection provided these decks are not part of or do not provide support to the craft's main load carrying structure and provided satisfactory measures are taken to ensure that the safety of the craft, including fire fighting abilities and integrity of fire resisting divisions, is not affected by a partial or total collapse of these internal decks.

c) Indicators are to be provided on the navigating bridge which should indicate when any door leading to or from the special category or ro-ro space is closed.

d) Fire doors in boundaries of special category spaces leading to spaces below the vehicle deck are to be arranged with coamings of a height of at least 100 mm.

2.10.2 Fixed fire-extinguishing system

Each special category space is to be fitted with an approved fixed pressure waterspraying system for manual operation which is to protect all parts of any deck and vehicle platform in such space, provided that the IRS may permit the use of any other fixed fire-extinguishing system that has been shown by full-scale test, in conditions simulating a flowing petrol fire in a special category space, to be not less effective in controlling fires likely to occur in such a space.

2.10.2.1 The pumps are to be capable of maintaining:

a) Half the total required application rate with any one pump unit out of function, for Category A craft; and

b) The total required application rate with any one pump unit room out of function for Category B craft.

2.10.2.2 Such systems are to fulfill the following requirements:

a) The valve manifold is to be provided with a pressure gauge and each of the valves is to be marked;

b) Instructions for maintenance and operation of the installation is to be set up in the room where the valves are located; and

c) The piping system is to be provided with sufficient number of drainage valves.

Note : For details of water spraying system refer Part 6, Chapter 8, Section 7.2 of Rules and Regulations for the Construction and Classification of Steel Ships.

2.10.3 Patrols and detection

a) A continuous fire patrol is to be maintained in special category spaces and ro-ro spaces unless a fixed fire detection and fire alarm system, complying with the requirements of 2.9.1 and a television surveillance system are provided. The fixed fire detection system is to be capable of rapidly detecting the onset of fire. The spacing and location of detectors are to be tested taking into account the effects of ventilation and other relevant factors.

b) Manually operated call points are to be provided as necessary throughout the special category spaces and one to be placed close to each exit from such spaces. Manually operated call points are to be spaced so that no part of the space will be more than 20 m from a manually operated call point.

c) The fire detection system, excluding manual call points, may be switched off with a timer during loading / unloading of vehicles to avoid "false" alarms.

2.10.4 Fire-extinguishing equipment

In each special category spaces and ro-ro spaces the following are to be provided:

a) At least three water fog applicators (Note : A water fog applicator may consist of a metal L-shaped pipe, the long limb being approximately 2 m in length and capable of being fitted to a fire hose and the short limb being approximately 250 mm in length and fitted with a fixed water fog nozzle or capable of being fitted with a water spray nozzle);

b) One portable foam applicator unit consisting of an air foam nozzle of an inductor type capable of being connected to the fire main by a fire hose, together with a portable tank containing 20 1 of foam making liquid and one spare tank. The nozzle is to be capable of producing effective foam suitable for extinguishing an oil fire of at least 1.5 m^3/min. At least two portable foam applicator units are to be available in the craft for use in such space; and

c) Portable fire extinguishers so located that no point in the space is more than approximately 15 m walking distance from an extinguisher, provided that at least one portable extinguisher is located at each access to such space. Fire extinguishers are to be suitable for A and B class fires as given in IMO Resolution A.602(15). The extinguishers are to have a capacity of 12 kg dry powder or equivalent.

   The mass and capacity of fire extinguishers are to meet the requirements of 2.9.4.1.

2.10.5 Ventilation system

2.10.5.1 An effective power ventilation system is to be provided for the special category spaces and ro-ro spaces sufficient to give at least 10 air changes per hour while navigating and 20 air changes per hour at the quayside during vehicle loading and unloading operations. The system for such spaces is to be entirely separated from other ventilation systems and is to be operating at all times when vehicles are in such spaces. Ventilation ducts serving special category spaces capable of being effectively sealed are to be separated for each such space. The system is to be capable of being controlled from a position outside such spaces. Reference is made to MSC/Circ.729 – Design guidelines and operational recommendations for ventilation systems in ro-ro cargo spaces.

2.10.5.2 The ventilation is to be such as to prevent air stratification and the formation of air pockets.

2.10.5.3 Means are to be provided to indicate on the operating compartment any loss or reduction of the required ventilating capacity.

2.10.5.4 Arrangements are to be provided to permit a rapid shutdown and effective closure of the ventilation system in case of fire, taking into account the weather and sea conditions.

2.10.5.5 Ventilation ducts, including dampers are to be made of steel or other equivalent material. Ducts lying inside the served space may be made of non-combustible or fire-restricting material.

2.10.6 Scuppers, bilge pumping and drainage

2.10.6.1 In view of the serious loss of stability which could arise due to large quantities of water accumulating on the deck or decks consequent to the operation of the fixed pressure water spraying system, pumping and drainage arrangements are to be such as to prevent such accumulation. Scuppers fitted for this purpose are to be so arranged as to ensure that such water is rapidly discharged directly overboard. Alternatively, pumping and drainage facilities are to be provided additional to the requirements of chapter 11.

2.10.6.2 In respect of scuppers and drainage pumps fitted in accordance with 2.10.6.1:

a) the amount of water for which drainage is provided is to take into account the capacity of both the water spraying system pumps and required number of fire hose nozzles;

b) the drainage system is to have a capacity of not less than 125% of the capacity specified in a) above; and

c) bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40 m in each watertight compartment.

2.10.6.3 When it is required to maintain watertight or weathertight integrity, as appropriate, the scuppers shall be arranged so that they can be operated from outside the space protected.

2.10.7 Precautions against ignition of flammable vapours

2.10.7.1 On any deck or platform, if fitted, on which vehicles are carried and on which explosive vapours might be expected to accumulate, except platforms with openings of sufficient size permitting penetration of petrol gases downwards, equipment which may constitute a source of ignition of flammable vapours and, in particular, electrical equipment and wiring, are to be installed at least 450 mm above the deck or platform.

2.10.7.2 For equipment above a height of 450 mm above the deck:

– The degree of protection for electrical equipment required by this section is to be by an enclosure having an ingress protection of at least IP 55 as defined in IEC Publication 60529 – Classification of Degree of Protection provided by Enclosures or by apparatus for use in zone 2 areas as defined in IEC Publication 60079 – Electrical apparatus for explosive gas atmospheres (Temperature Class T3).

2.10.7.3 For equipment at or below a height of 450 mm above deck:

– The electrical equipment referred to in this section is to be certified “safe type” and wiring, if fitted, is to be suitable for use in zone 1 areas as defined in IEC Publication 60079 – Electrical Apparatus for Explosive Gas Atmospheres – (Gas Group II A and Temperature Class T3).

2.10.7.4 Electrical equipment and wiring, if installed in an exhaust ventilation duct, are to be similar to those required for less than 450 [mm] above deck given in 2.10.7.3.

The outlet from any exhaust duct is to be sited in a safe position, having regard to other possible sources of ignition.

Exhaust fans are to be of a non-sparking type in accordance with Part 5, Chapter 2 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

2.10.7.5 If pumping and drainage arrangements are provided, it is to be ensured that:

a) Water contaminated with petrol or other flammable substances is not drained to machinery spaces or other spaces where sources of ignition may be present; and

b) Electrical equipment fitted in tanks or other components of the drainage system are to be of a type suitable for use in explosive petrol/air mixtures.

2.10.8 Open ro-ro spaces

2.10.8.1 Open ro-ro spaces are to comply with the requirements set out in 2.10.1a), 2.10.2, 2.10.3, 2.10.4 and 2.10.6.

2.10.8.2 For those parts of a ro-ro space which are completely open from above, the requirements set out in 2.10.2, 2.10.3a) and 2.10.6 need not be complied with. However, a continuous fire patrol or a television surveillance system is to be maintained.

2.11 Miscellaneous

2.11.1 Fire control plans are to be permanently exhibited, for the guidance of the master and officers of the craft showing clearly for each deck the following positions: the control stations, the sections of the craft which are enclosed by fire-resisting divisions together with particulars of the fire alarms, fire detection systems, the sprinkler installations, the fixed and portable fire-extinguishing appliances, the means of access to the various compartments and decks in the craft, the ventilating system including particulars of the master fan controls, the positions of dampers and identification numbers of the ventilating fans serving each section of the craft, the location of the international shore connection, if fitted and the position of all means of control referred to in 2.7.4, 2.8.2, 2.9.1 and 2.9.4.

The text of such plans is to be in the official language of the flag State. However, if the language is neither English, French or Spanish a translation into one of those languages is to be included.

Note : Refer to Graphical symbols to fire control plans adopted by IMO by Resolution A654(16).

2.11.2 A duplicate set of fire control plans or a booklet containing such plans is to be permanently stored in a permanently marked weathertight enclosure outside the deckhouse for the assistance of shore side fire-fighting personnel.

2.11.3 Openings in fire-resisting divisions

2.11.3.1 Except for the hatches between cargo, special category, store and baggage spaces and between such spaces and the weather decks, all openings are to be provided with permanently attached means of closing which are to be at least as effective for resisting fires as the divisions in which they are fitted.

2.11.3.2 Each door is to be capable of being opened and closed from each side of the bulkhead by one person only.

2.11.3.3 Fire doors bounding areas of major fire hazard and stairway enclosures are to satisfy the following requirements:

a) The doors are to be self-closing and be capable of closing with an angle of inclination of upto 3.5^{o} opposing closure and are to have an approximately uniform rate of closure of no more than 40s and no less than 10s with the craft in the upright position. The approximate uniform rate of closure for sliding fire doors shall be of no more than 0.2 m/s and no less than 0.1 m/s with the craft in the upright position.

b) Remote-controlled sliding or power-operated doors are to be equipped with an alarm that sounds at least 5s but no more than 10s before the door begins to move and continue sounding until the door is completely closed. Doors designed to re-open upon contacting an object in their paths are to re-open not more than 1 m from point of contact.

c) All doors are to be capable of remote and automatic release from a continuously manned central control station, either simultaneously or in groups and also individually from a position at both sides of the door. Indication is to be provided at the fire control panel in the continuously manned control station whether each of the remote controlled doors is closed. The release mechanism is to be so designed that the door will automatically close in the event of disruption of the control system or central power supply. Release switches are to have an on-off function to prevent automatic resetting of the system. Hold-back hooks not subject to control station release are not allowed.

d) A door closed remotely from the continuously manned control station is to be capable of being re-opened at both sides of the door by local control. After such local opening, the door is to close automatically again.

e) Local power accumulators for power-operated doors are to be provided in the immediate vicinity of the doors to enable the doors to be operated at least ten times (fully opened and closed) using the local controls.

f) Disruption of the control system or main source of electric power at one door is not to impair the safe functioning of the other doors.

g) Double-leaf doors equipped with a latch necessary to their fire integrity are to have a latch that is automatically activated by the operation of the doors when released by the system.

h) Doors giving direct access to special category spaces which are power-operated and automatically closed need not be equipped with alarms and remote-release mechanisms required in second and third paragraphs above.

i) The components of the local control system are to be accessible for maintenance and adjusting.

j) Power operated doors are to be provided with a control system of an approved type which are be able to operate in case of fire, this being determined in accordance with the FTP Code. This system is to satisfy the following requirements:

- The control system is to be able to operate at a temperature of at least 200°C for at least 60 min, served by the power supply;
- The power supply for all other doors not subject to fire will not be impaired; and
- At temperatures exceeding 200°C the control system is to be automatically isolated from the power supply and is to be capable of keeping the door closed up to at least 945°C.

2.11.3.4 The requirements for integrity of fire-resisting divisions of the outer boundaries facing open spaces of a craft are not to apply to glass partitions, windows and side scuttles. Similarly, the requirements for integrity of fire-resisting divisions facing open spaces are not to apply to exterior doors in superstructures and deckhouses.

“Open spaces” as referred to in this para is interpreted as excluding grouping E in Tables 2.5.1 and 2.5.2.

2.11.3.5 Doors in smoke-tight divisions are to be self-closing. Doors which are normally kept open are to be closed automatically or by remote control from a continuously manned control station.

2.12 Firefighter’s outfits

2.12.1 All craft other than category A passenger craft are to carry at least two firefighter’s outfits complying with the requirements of 2.12.6.

2.12.2 In addition, category B passenger craft is to be provided with, for every 80 m, or part thereof of the aggregate of the length of all passenger spaces and service spaces on the deck which carries such spaces or, if there is more than one such deck, on the deck which has the largest aggregate of such length, two firefighter’s outfits and two sets of personal equipment, each set comprising the items stipulated in 2.12.6a)i) to 2.12.6a)iii).

2.12.3 In category B passenger craft, for each pair of breathing apparatus there is to be provided one water fog applicator which is stored adjacent to such apparatus.

The water fog applicator is to be of a type as indicated in 2.10.4.

2.12.4 Additional sets of personal equipment and breathing apparatus may be required having due regard to the size and type of the craft.

2.12.5 The firefighter’s outfits and sets of personal equipment are to be so stored as to be easily accessible and ready for use and, where more than one fireman’s outfit or more than one set of personal equipment is carried, they are to be stored in widely separated positions. In passenger craft, at least two firefighter’s outfits and one set of personal equipment are to be available at any one control station. The storage of firefighter’s outfits and personal equipment are to be permanently and clearly marked.

2.12.6 A firefighter’s outfit is to consist of:

a) Personal equipment comprising:

i) Protective clothing of material to protect the skin from the heat radiating from the fire and from burns and scalding by steam or gases. The outer surface is to be water-resistant. Reference is made to ISO 6942–1983 : Clothing for protection against heat and fire; evaluation of thermal behaviour of materials and material assemblies when exposed to source of radiant heat.

ii) Boots of rubber or other electrically non-conductive material.

iii) A rigid helmet providing effective protection against impact;

iv) An electric safety lamp (hand lantern) of an approved type with a minimum burning period of 3h. Electric safety lamps intended to be used in hazardous areas are to be of an explosion proof type. Reference is made to IEC Publication 79; and

v) An axe. The handle of the axe is be provided with high-voltage insulation.

b) A self-contained compressed-air-operated breathing apparatus of an approved type, the volume of air contained in the cylinders of which is at least 1200 *1*, or other self-contained breathing apparatus which is capable of functioning for at least 30 mins. Two spare charges suitable for use with the apparatus are to be provided for each required apparatus.

c) For each breathing apparatus a flexible fireproof lifeline of approx. 30 m length and sufficient strength is to be provided capable of being attached by means of a snaphook to the harness of the apparatus or to a separate belt in order to prevent the breathing apparatus becoming detached when the lifeline is operated. The lifeline is to be subjected to a test by static load of 3.5 kN for 5 min.

Section 3

Special Requirements for Passenger Craft

3.1 Arrangement

3.1.1 For category B craft the public spaces are to be divided into zones according to the following:

a) The craft is to be divided into at least two zones. The mean length of each zone is not to exceed 40 m;

b) For the occupants of each zone there is to be an alternative safe area to which it is possible to escape in case of fire. The alternative safe area is to be separated from other passenger zones by smoke-tight divisions of non-combustible materials or fire restricting materials extending from deck to deck. The alternative safe area can be another passenger zone. Alternative safe areas are to be dimensioned on the basis of one person per seat and 0.35 m^2 per person of the net remaining area, based on the maximum number of persons they are called to accommodate in an emergency.

c) The alternative safe area is to be as far as practicable, be located adjacent to the passenger zone it is intended to serve. There is to be at least two exits from each passenger zone, located as far away from each other as possible, leading to the alternative safe area. Escape routes are to be provided to enable all passengers and crew to be safely evacuated from the alternative safe area. Safe evacuation from the alternative safe area is to be completed within the structural fire protection time for areas of major fire hazard.

3.1.2 Category A craft need not be divided into zones.

3.1.3 Control stations, life-saving appliance stowage positions, escape routes and places of embarkation into survival craft are not to be as far as practicable, located adjacent to any major or moderate fire hazard areas.

3.2 Ventilation

3.2.1 Each safe zone in the public spaces is to be served by a ventilation system independent of the ventilation system of any other zone. The ventilation fans of each zone in the public spaces are also to be capable of being independently controlled from a continuously manned control station.

3.3 Fixed sprinkler system

3.3.1 Public spaces and service spaces, storage rooms other than those containing flammable liquids and similar spaces are to be protected by a fixed sprinkler system meeting a standard developed by the IMO. (Refer IMO Resolution MSC.44(65) or FTP code and interpretations given in MSC Circ.912). Manually operated sprinkler systems are to be divided into sections of appropriate size and the valves for each section, start of sprinkler pump(s) and alarms are to be operable from two spaces separated as widely as possible, one of which is to be a continuously manned control station. In category B craft, no section of the system is to serve more than one of the zones required in 3.1. A stairway open at one deck is to be considered part of the space to which it is open and consequently to be protected by a sprinkler system, if provided.

3.3.2 Plans of the system are to be displayed at each operating station. Suitable arrangements are to be made for the drainage of water discharged when the system is activated.

3.3.3 Category A craft need not comply with the requirements of 3.3.1 and 3.3.2 provided that:

- Smoking is not permitted;
- Sales shops, galleys, service spaces, ro-ro spaces and cargo spaces are not fitted;
- The maximum number of passengers carried does not exceed 200; and
- The voyage duration at 90% of maximum speed from departure port to destination when fully laden does not exceed 2 hours.

Section 4

Special Requirements for Cargo Craft

4.1 Control station

4.1.1 Control stations, life-saving appliances stowage positions, escape routes and places of embarkation into survival craft are to be located adjacent to crew accommodation areas.

4.2 Cargo spaces

4.2.1 Cargo spaces, except open deck areas or refrigerated holds, are to be provided with an approved automatic smoke detection system complying with 2.9.2 to indicate at the control station the location of outbreak of a fire in all normal operating conditions of the installations and is to be protected by an approved fixed quick acting fire extinguishing system complying with 2.9.6 operable from the control station.

4.3 Fixed sprinkler system

4.3.1 Crew accommodation where sleeping berths are provided, having a total deck area greater than 50 m^2 (including corridors serving such accommodation) are to be protected by a fixed sprinkler system based on the standards acceptable to the Administration.*

(* Refer to the standards for fixed sprinkler systems for high speed craft, adopted by IMO by Resolution MSC.44(65), as may be amended).

4.3.2 Plans of the system are to be displayed at each operating station. Suitable arrangements are to be made for the drainage of water discharged when the system is activated.

Section 5

Requirements for Craft and Cargo Spaces Intended for the Carriage of Dangerous Goods*

(* Refer to the International Maritime Dangerous Goods Code (IMDG Code), adopted by the Organization by Resolution A.716(17), as amended and the Code of Safe Practice for Solid Bulk Cargoes, adopted by Resolution A.434(XI), as amended.)

5.1 General

In addition to complying with the requirements of 4.2 for cargo craft and with the requirements of 2.10 for both passenger and cargo craft as appropriate, craft types and cargo spaces referred to in 5.2 intended for the carriage of dangerous goods are to comply with the requirements of this section, as appropriate, except when carrying dangerous goods in limited quantities,** and excepted quantities,* unless such requirements have already been met by compliance with the requirements elsewhere in this chapter. The types of craft and modes of carriage of dangerous goods are referred to in 5.2 and in Table 5.1, where the numbers appearing in 5.2 are referred to in the top line. Cargo craft of less than 500 gross tonnage constructed on or after 1 July 2002 are to comply with this section, but the Administration may reduce the requirements and such reduced requirements are to be recorded in the document of compliance referred in 5.4.

Craft constructed on or after 1 July 2002 but before 1 January 2011, with cargo spaces intended for the carriage of packaged dangerous goods are to comply with 5.3, except when carrying dangerous goods specified as classes 6.2 and 7 and dangerous goods in limited quantities** and excepted quantities* in accordance with Tables 5.1 and 5.3, not later than the date of the first renewal survey on or after 1 January 2011.

(* Refer to Chapter 3.5 of the IMDG Code)

(** Refer to Chapter 3.4 of the International Maritime Dangerous Goods Code (IMDG Code) for the provisions on the carriage of "limited quantities".)

5.2 Application of Tables 5.1 and 5.2

Tables 5.1 and 5.2 are intended to apply to the following types of craft:

.1 craft and cargo spaces not specifically designed for the carriage and freight containers but intended for the carriage of dangerous goods in packaged form including goods in freight containers and portable tanks;

.2 purpose-built container craft and cargo spaces intended for the carriage of dangerous goods in freight containers and portable tanks. In this regard, a purpose-built container space is a cargo space fitted with cell guides for stowage and securing containers;

.3 craft and ro-ro spaces intended for the carriage of dangerous goods including special category spaces; and

.4 craft and cargo spaces intended for the carriage of solid dangerous goods in bulk.

5.3 Requirements

Unless otherwise specified the following requirements are to govern the application of Tables 5.1, 5.2 and 5.3 to both "on deck" and "under deck" stowage of dangerous goods. The numbers of the following sub-sections are indicated in the first column of the above-mentioned tables. For the purpose of this section ‘on deck’ means spaces on the weather deck.

5.3.1 Water supplies

.1 Arrangements are to be made to ensure immediate availability of a supply of water from the fire main at the required pressure either by permanent pressurization or by suitably placed remote starting arrangements for the fire pumps.

.2 The quantity of water delivered are to be capable of simultaneously supplying the arrangements required by 5.3.1.3 for the largest designated cargo space and the four nozzles of a size and at a pressure as specified in 2.9.5, capable of being trained on any part of the cargo space when empty. This amount of water may be applied by equivalent means to the satisfaction of IRS.

This requirement is to be met by the total capacity of the main fire pump(s) not including the capacity of the emergency fire pump, if fitted.

.3 Means are to be provided for effectively cooling the designated under deck cargo-space with water at not less than 5 l / min / m^2 of the horizontal area of the cargo space either by a fixed arrangement of spraying nozzles, or flooding the space with water. Hoses may be used for this purpose in small cargo spaces and in small areas of larger cargo-spaces at the discretion of IRS. In any event the drainage and pumping arrangements are to meet the requirements of 2.10.6 and be such as to prevent the build-up of free surfaces. If this is not possible the adverse effect upon stability of the added weight and free surface of water is to be taken into account.

.4 Provision to flood a designated under deck cargo-space with suitable specified media may be substituted for the requirements in 5.3.1c) above.

.5 The requirements of .1 to .4 may be fulfilled by a water spray system approved by IRS based on the standards acceptable to the Administration*, provided that the amount of water required for fire-fighting purposes in the largest cargo space allows simultaneous use of the water spray system plus four jets of water from hose nozzles in accordance with .2.

(*Refer to paragraphs 9.2, 9.3 and 9.4 of the Interim guidelines for open-top containerships (MSC/Circ.608/Rev.1)).

.6 Craft carrying dangerous goods are to be provided with three fire hoses and nozzles complying with 2.9.5f) in addition to those required by 2.9.5e).

5.3.2 Source of ignition

Electrical equipment and wiring are not to be fitted in enclosed cargo spaces or vehicle decks, unless it is essential for operational purposes. However, if electrical equipment is fitted in such spaces, it is to be of a certified safe type for use in the dangerous environments to which it may be exposed unless it is possible to completely isolate the electrical system (by removal of links in the system, other than fuses). Cable penetrations of the decks and bulkheads are to be sealed against the passage of gas or vapour. Through runs of cables and cables within the cargo spaces are to be protected against damage from impact. Any other equipment which may constitute a source of ignition of flammable vapour is not to be installed.

5.3.3 Detection system

Enclosed cargo spaces are to be provided with an approved automatic smoke detection system complying with 2.9.1 or with a detection system which, in the opinion of IRS gives equivalent protection.

5.3.4 Ventilation

.1 Adequate power ventilation is to be provided in enclosed spaces. The arrangements are to be such as to provide for at least six air changes per hour in the cargo space based on an empty space and for removal of vapours from the upper or lower parts of the space, as appropriate.

.2 The fans are to be such as to avoid the possibility of ignition of flammable gas/air mixtures. Exhaust fans are to be non-spark type suitable wire mesh guards having mesh size not exceeding 13 mm x 13 mm are to be fitted over inlet and outlet ventilation openings.

.3 If adjacent spaces are not separated from cargo spaces by gastight bulkheads or decks, ventilation requirements are to apply to the adjacent spaces as for the cargo space itself.

.4 Natural ventilation is to be provided in enclosed spaces intended for the carriage of solid dangerous goods in bulk, where there is no provision for mechanical ventilation.

.5 For open-top container craft, power ventilation is required only for the lower part of the cargo hold for which purpose-built ducting is required. The ventilation rate is to be at least two air changes per hour based on the empty hold volume below the weather deck.

5.3.5 Bilge pumping

Where it is intended to carry flammable or toxic liquids in enclosed spaces, the bilge pumping system is to be designed to ensure against inadvertent pumping of such liquids through machinery space piping or pumps. Where large quantities of such liquids are carried, consideration is to be given to the provision of additional means of draining those spaces as follows:

a) If the bilge drainage system for cargo spaces is additional to the system served by pumps in the machinery space, the capacity of the system is to be not less than 10 m^3/h per cargo space served. If the additional system is a common system, the capacity need not exceed 25 m^3/h. The additional bilge system need not be arranged with redundancy. Whenever flammable or toxic liquids are carried, the bilge line into the machinery space is to be isolated either by fitting a blank flange or by a closed lockable valve;

b) If bilge drainage of cargo spaces is arranged by gravity drainage, the drainage is to be either lead directly overboard or to a closed drain tank located outside the machinery spaces. The tank is to be provided with vent pipe to a safe location on the open deck;

c) Enclosed spaces outside machinery spaces containing bilge pumps serving cargo spaces intended for carriage of flammable or toxic liquids are to be fitted with separate mechanical ventilation giving at least six air changes per hour. Electrical equipment in the space is to be of certified safe type.* If the space has access from another enclosed space, the door is to be self-closing; and

(*Refer to publication IEC 60092-506 : Special features – Ships carrying dangerous goods and materials hazardous only in bulk).

d) Drainage from a cargo space into bilge wells in a lower space is only permitted if that space satisfies the same requirements as the cargo space above.

5.3.6 Personnel protection

.1 Four sets of full protective clothing resistant to chemical attack are to be provided in addition to the firefighter's outfits required by 2.12 and are to be selected taking into account the hazards associated with the chemicals being transported and the standards developed by IMO according to the class and physical state. The protective clothing is to cover all skin, so that no part of the body is unprotected.

.2 At least two self-contained breathing apparatuses additional to those required by 2.12 are to be provided.

In addition to the requirements of 2.12.6b), two spare charges suitable for use with the breathing apparatus are to be provided for each required apparatus.

5.3.7 Portable fire extinguishers

Portable fire extinguishers with a total capacity of at least 12 kg of dry powder or equivalent is to be provided for the cargo spaces. These extinguishers are to be in addition to any portable fire extinguishers required elsewhere in this chapter.

5.3.8 Fixed fire extinguishing system

.1 Cargo spaces, except for open decks are to be provided with an approved fixed fire extinguishing system complying with the provisions of 2.9.3 or with a fire extinguishing system which, in the opinion of IRS, gives equivalent protection for the cargo carried.

.2 Each open ro-ro space having a deck above it and each ro-ro space not capable of being sealed are to be fitted with an approved fixed pressure water-spraying system for manual operation which will protect all parts of any deck and vehicle platform in such space, except that IRS may permit the use of any other fixed fire-extinguishing system that has been shown by full-scale test to be no less effective. In any event the drainage and pumping arrangements are to meet the requirements of 2.10.6, have valves operable from outside the space at a position in the vicinity of the extinguishing system controls and be such as to prevent the build-up of free surfaces. If this is not possible the adverse effect upon stability of the added weight and free surface of water is to be taken into account during appraisal of the stability information.

5.3.9 Separation between ro-ro spaces and open ro-ro spaces

A separation is to be provided between a ro-ro space and an adjacent open ro-ro space. The separation is to be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such separation need not be provided if both spaces fully comply with the requirements for ro-ro spaces in this section.

5.3.10 Separation between ro-ro spaces and weather decks

A separation is to be provided between a ro-ro space and the adjacent weather deck. The separation is to be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, a separation need not be provided if the ro-ro space fully complies with the requirements for ro-ro spaces in this section. However, a separation is still required when dangerous goods carried shall be loaded on the weather deck only.

5.4 Document of compliance

If requested and authorized by Statutory Authority IRS will provide the craft with an appropriate document as evidence of compliance of construction and equipment with the requirements of this section.

Table 5.1 : Application of the requirements of 5.3 to different modes of carriage of dangerous goods in craft and cargo spaces

Section 5.2 / Section 5.3	Weather decks .1 to .4 inclusive	5.2.1	5.2.2	5.2.3		5.2.4
		Not specifically designed	**Container cargo spaces**	**Ro-ro spaces**	**Open ro-ro spaces**	**Solid dangerous goods in bulk***
5.3.1.1	X	X	X	X	X	For application of requirements of Section 5 to different classes of dangerous goods, see Table 5.2
5.3.1.2	X	X	X	X	X	
5.3.1.3	-	X	X	X	X	
5.3.1.4	-	X	X	X	X	
5.3.2	-	X	X	X	X	
5.3.3	-	X	X	X	-	
5.3.4.1	-	X	X[1]	X	-	
5.3.4.2	-	X	X[1]	X	-	
5.3.5	-	X	X	X	-	
5.3.6.1	X	X	X	X	X	
5.3.6.2	X	X	X	X	X	
5.3.7	X	X	-	-	X	
5.3.8.1	-	X	X	X	-	
5.3.8.2	-	-	-	X[2]	X	
5.3.9	-	-	-	X	X	
5.3.10	X	-	-	X	X	

Notes:

1 For classes 4 and 5.1 not applicable to closed freight containers

For classes 2, 3, 6.1 and 8 when carried in closed freight containers the ventilation rate may be reduced to not less than two air changes per hour. For classes 4 and 5.1 liquids when carried in closed freight containers, the ventilation rate may be reduced to not less than two air changes per hour. For the purpose of this requirement a portable tank is a closed freight container.

2 Applies only to ro-ro spaces, not capable of being sealed.

X Wherever "X" appears in the table it means that this requirement is applicable to all classes of dangerous goods as given in the appropriate line of Table 5.3, except as indicated by the notes.

* Includes cargoes of group B of the Code of safe Practice for Solid Bulk Cargoes, 2004, except for cargoes denoted materials hazardous in bulk.

Table 5.2 : Application of the requirements of 5.3 to different classes of dangerous goods for craft and cargo spaces carrying solid dangerous goods in bulk

Class / Section	**4.1**	**4.2**	**4.3**[1]	**5.1**	**6.1**	**8**	**9**
5.3.1.1	X	X	-	X	-	-	X
5.3.1.2	X	X	-	X	-	-	X
5.3.2	X	X[2]	X	X[3]	-	-	X[3]
5.3.4.1	-	X[2]	X	-	-	-	-
5.3.4.2	X[4]	X[2,5]	X[5]	X[2,4]	-	-	X[2,4]
5.3.4.4	X	X	X	X	X	X	X
5.3.6	X	X	X	X	X	X	X

Notes:

1 The hazards of substances in this class which may be carried in bulk are such that special consideration must be given by IRS to the construction and equipment of the craft involved in addition to meeting the requirements enumerated in this Table.

2 Only applicable to Seedcake containing residues of solvent extractions, to Ammonium nitrate and to Ammonium nitrate fertilizers.

3 Only applicable to Ammonium nitrate and to Ammonium nitrate fertilizers. However, a degree of protection in accordance with standards contained in the "International Electrotechnical Commission, publication 79 - Electrical Apparatus for Explosive Gas Atmospheres", is sufficient.

4 Only suitable wire mesh guards are required.

5 For seedcake containing residues of solvent extraction and cargoes of BC Code Class 4.3, two separate fans are to be permanently fitted unless portable type fans have been adapted for being securely fitted (e.g. fixed) prior to loading and during the voyage. The ventilation system is to comply with the provisions of 5.3.4.1 and 5.3.4.2. Ventilation is to be such that any escaping gases cannot reach public spaces or crew accommodation on or under deck.

Table 5.3 : Application of the requirements of section 5.3 to different classes of dangerous goods except solid dangerous goods in bulk

Class / Section	1.1 - 1.6[2]	1.4S	2.1	2.2	2.3 flammable[10]	2.3 non-flammable	3 FP < 23°C	3 FP ≥ 23°C to ≤ 60°C	4.1	4.2	4.3 liquids[11]	4.3 solids	5.1[3]	5.2[6]	6.1 liquids FP[5] < 23°C	6.1 liquids FP[5] ≥ 23°C to ≤ 60°C	6.1 liquids	6.1 solids	8 liquids FP[5] < 23°C	8 liquids FP[5] ≥ 23°C ≤ 60°C	8 liquids	8 solids	9
5.3.1.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.3.1.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
5.3.1.3	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.3.1.4	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.3.2	X	-	X	-	X	-	X	-	-	-	X[8]	-	-	-	X	-	-	-	X	-	-	-	X[7]
5.3.3	X	X	X	X	-	X	X	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	-
5.3.4.1	-	-	X	-	-	X	X	-	X[1]	X[1]	X	X	X[1]	-	X	X	-	X[1]	X	X	-	-	X[1]
5.3.4.2	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	X[7]
5.3.5	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	X	X	-	X	X[9]	X[9]	-	-
5.3.6	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X[4]
5.3.7	-	-	-	-	-	-	X	X	X	X	X	X	X	-	X	X	-	-	X	X	-	-	-
5.3.8	X[2]	X	X	X	X	X	X	X	X	X	X	X	X[3]	X	X	X	X	X	X	X	X	X	X
5.3.9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.3.10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Notes:

1 When "mechanically-ventilated spaces" are required by the International Maritime Dangerous Goods Code (IMDG Code), as amended.

2 Stow 3 m horizontally away from the machinery space boundaries in all cases.

3 Refer to the International Maritime Dangerous Goods Code.

4 As appropriate to the goods being carried.

5 Refer to flashpoint.

6 Under the provisions of the IMDG Code, stowage of class 5.2 dangerous goods under deck or in enclosed ro-ro spaces in prohibited.

7 Only applicable to dangerous goods evolving flammable vapour listed in the IMDG Code.

8 Only applicable to dangerous goods having a flashpoint less than 23°C listed in the IMDG Code.

9 Only applicable to dangerous goods having a subsidiary risk class 6.1.

10 Under the provisions of the IMDG Code, stowage of class 2.3 having subsidiary risk class 2.1 under deck or in enclosed ro-ro spaces is prohibited.

11 Under the provisions of the IMDG Code, stowage of class 4.3 liquids having a flashpoint less than 23°C under deck or in enclosed ro-ro spaces is prohibited.

Section 6

Small Craft with Class Notation 'LC' or 'HSLC'

6.1 General requirements/Application

6.1.1This section applies to non-passenger crafts with notation 'LC' or 'HSLC' and of less than 500 GT.

6.1.2 Consideration will be given to the acceptance of fire safety measures:

a) Which have been prescribed and approved by the Government of the flag state, provided they are deemed to provide an equivalent level of fire safety.

b) Where the arrangements are considered equivalent to those required by these Rules as a result of risk assessment studies.

c) Where the arrangements are considered equivalent to those required by these Rules due cognisance having been taken of any restricted service limits.

6.1.3 Special consideration, consistent with the fire hazard involved, will be given to construction or arrangements not covered by this chapter.

6.1.4 Where craft incorporate fire hazards not covered in this chapter such as helicopter landing facilities and the carriage of petrol and aviation fuel, appropriate fire protection, detection and extinction arrangements are to be provided.

6.2 Submission of plans and information

6.2.1 Refer 2.2 'Documentation'.

6.3 Definitions

6.3.1 Materials

6.3.1.1 **'Non-combustible material'**; Refer 2.4.4.

6.3.1.2 **'Steel or other equivalent material**'; Refer 2.4.6.

6.3.1.3 **'Alternative forms of construction'** means any combustible material may be accepted if it can be demonstrated that the material, which by itself or due to insulation provided has structural and fire integrity properties equivalent to 'A' or 'B' class divisions, or steel, as applicable, at the end of the applicable fire exposure to the standard fire test.

6.3.2 Fire test

6.3.2.1 **'A Standard Fire Test'** is one in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-temperature curve. The specimen is to have an exposed surface of not less than 4.65 m^2 and height (or length of deck) of 2.44 m resembling as closely as possible the intended construction and including where appropriate at least one joint. The standard time-temperature curve is defined by a smooth curve drawn through the following temperature points measured above the initial furnace temperature:

At the end of the first 5 minutes, 556^{o}C
At the end of the first 10 minutes, 659^{o}C
At the end of the first 15 minutes, 718^{o}C
At the end of the first 30 minutes, 821^{o}C
At the end of the first 60 minutes, 925^{o}C

For general guidance reference may be made to IMO Resolution A.754(18) or FTP Code.

6.3.3 Flame spread

6.3.3.1 **'Low flame spread'**; Refer 2.4.7.

6.3.4 Ship divisions and spaces

6.3.4.1 **'A' Class divisions** are those divisions formed by bulkheads and decks which comply with the following:

a) They are to be constructed of steel or other equivalent material.

b) They are to be suitably stiffened.

c) They are to be so constructed as to be capable of preventing the passage of smoke and flame up to the end of the one-hour standard fire test.

d) They are to be insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 139°C above the original temperature, nor will be temperature, at any one point, including any joint; rise more than 180°C above the original temperature, within the time listed below:

Class ‘A-60’	60 minutes
Class ‘A-30’	30 minutes
Class ‘A-15’	15 minutes
Class ‘A-0’	0 minutes

e) A test of a prototype bulkhead or deck may be required to ensure that it meets the above requirements for integrity and temperature rise.

6.3.4.2 **‘B’ class divisions** are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following:

a) They are to be so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test.

b) They are to have an insulation value such that the average temperature of the unexposed side will not rise more than 139°C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225°C above the original temperature, within the time listed below:

Class ‘B-15’	15 minutes
Class ‘B-0’	0 minutes.

c) They are to be constructed of approved non-combustible materials and all materials entering into the construction and erection of ‘B’-class divisions are to be non-combustible, except where permitted by other requirements of this chapter.

d) A test of a prototype division may be required to ensure that it meets the above requirements for integrity and temperature rise.

6.3.4.3 **‘Continuous ‘B’ Class** ceilings or linings’ are those ‘B’ class ceilings or linings which terminate only at an ‘A’ or ‘B’ Class division.

6.3.4.4 **‘Accommodation spaces’** are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, and pantries containing no cooking appliances and similar spaces.

6.3.4.5 **‘Service spaces’** are those used for galleys, pantries containing cooking appliances, stores, mail and specie rooms, store rooms, lockers, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

6.3.4.6 **‘Cargo spaces’** are all spaces used for cargo (including cargo oil tanks) and trunks to such spaces.

6.3.4.7 **‘Machinery spaces of Category A’** are those spaces and trunks to such spaces which contain:

a) Internal combustion machinery used for main propulsion; or

b) Internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or

c) Any oil-fired boiler or oil fuel unit.

6.3.4.8 **‘Machinery spaces’** are all machinery spaces of Category ‘A’ and all other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery and similar spaces and trunks to such spaces.

6.3.4.9 **‘Control stations’**; Refer Chapter 1, 2.2.

6.3.4.10 **‘Cargo area’** is that part of the craft that contains cargo tanks, slop tanks and cargo pump rooms including pump rooms, cofferdams, ballast and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the craft over the above mentioned spaces.

6.3.4.11 **‘Main vertical zones’** are those sections into which the hull, superstructure and deck houses are divided by ‘A’ Class divisions, the mean length and width of which on any one deck does not, in general, exceed 40 m.

6.3.5 Equipment

6.3.5.1 **‘Oil fuel unit’** is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 1.8 bar gauge.

6.4 Fire pumps and fire main system

6.4.1 Application

6.4.1.1 Every craft is to be provided with fire pumps, fire mains, hydrants and hoses complying as applicable with this section.

6.4.2 Capacity of fire pumps

6.4.2.1 The total capacity of the main fire pumps is to be not less than four-thirds of the capacity of each bilge pump as per Chapter 11, 2.13 or 2.14.

6.4.2.2 Any pump designated as a fire pump other than any emergency fire pump is to have a capacity not less than 80% of the total required capacity divided by the minimum number of required fire pumps and each such pump in any case is to be capable of delivering at least one jet of water. These fire pumps are to be capable of supplying the fire main system under the required conditions.

6.4.3 Fire pumps

6.4.3.1 In craft of 150 tons gross and upwards, not less than two power pumps are to be provided, one of which is to be an independent pump.

6.4.3.2 In craft of less than 150 tons gross, one power pump is to be available for fire-extinguishing service, if the service is restricted to harbour or river service, a suitable hand pump may be substituted for the power pump.

6.4.3.3 Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and that, if they are subject to occasional duty for the transfer or pumping of fuel oil, suitable changeover arrangements are fitted.

6.4.3.4 With one pump out of operation simultaneous availability of pumps for bilge and fire duty is to be ensured.

6.4.3.5 If a fire in a category ‘A’ machinery space could put all the fire pumps out of action, there is to be an alternative means consisting of a fixed independently driven emergency fire pump which is to be capable of supplying at least one satisfactory jet of water. The pump and its location is to comply with 6.4.4.

6.4.3.6 Relief valves are to be provided in conjunction with all fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

6.4.3.7 Where centrifugal pumps are provided in order to comply with this sub-section or 6.4.4, a non-return valve is to be fitted in the pipe connecting the pump to the fire main.

6.4.4 Emergency fire pumps

6.4.4.1 The emergency fire pump, its source of power and its sea connection are to be located in accessible positions outside the category ‘A’ machinery space referred to in 6.4.3.5. In craft of less than 150 tons gross a manually operated pump will be accepted (see 6.4.6.1) provided it and its sea connection meet the requirements of this paragraph.

6.4.4.2 The sea valve is to be capable of being operated from a position near the pump.

6.4.4.3 The room where the emergency fire pump prime mover is located is to be illuminated from the emergency source of supply and is to be well ventilated.

6.4.4.4 If the emergency fire pump is required to supply water for a fixed fire-extinguishing system in the space where the main fire pumps are situated, it is to be capable of simultaneously supplying water to this system and the fire main at the required rates.

6.4.4.5 The emergency fire pump may also be used for other suitable purposes subject to approval in each case.

6.4.5 Fire main

6.4.5.1 The diameter of the fire main is to be based on the required capacity of the fire pumps. The diameter of the water service pipes are to be sufficient to ensure an adequate supply of water for the operation of at least one fire-hose.

6.4.5.2 The wash deck line may be used as a fire main provided that the requirements of this sub-section are satisfied.

6.4.5.3 All water pipes for fire extinguishing are to be provided with drain valves for use in frosty weather. The valves are to be located where they will not be damaged by cargo.

6.4.6 Pressure in the fire main

6.4.6.1 Any power operated fire pump is to maintain a pressure at any hydrant sufficient to produce a jet throw at any nozzle of 12 m. Where a manually operated fire pump is permitted the jet throw need only be 6 m when produced through a suitable nozzle.

6.4.7 Number and position of hydrants

6.4.7.1 The number and position of the hydrants are to be such that at least one jet of water may reach any part normally accessible to the crew while the craft is being navigated and any part of any cargo space when empty. Furthermore, such hydrants are to be positioned near the accesses to the protected spaces. At least one hydrant is to be provided in each machinery space.

6.4.8 Pipes and hydrants

6.4.8.1 Materials readily rendered ineffective by heat are not to be used for fire mains. Where steel pipes are used, they are to be galvanized internally and externally. Cast iron pipes are not acceptable. The pipes and hydrants are to be so placed that the fire-hoses may be easily coupled to them. The arrangement of pipes and hydrants shall be such as to avoid the possibility of freezing. In craft where deck cargo may be carried, the positions of the hydrants are to be such that they are always readily accessible and the pipes are to be arranged, as far as practicable, to avoid risk of damage by such cargo. Unless one hose and nozzle is provided for each hydrant in the craft, there is to be complete interchangeability of hose couplings and nozzles.

6.4.8.2 A valve is to be fitted to serve each fire-hose so that any fire-hose may be removed while the fire pumps are at work.

6.4.8.3 Where an emergency fire pump is required, the fire main is to be so arranged that all the hydrants in the craft except those in the category ‘A’ machinery space containing the main fire pump or pumps can be supplied with water by the emergency fire pump through pipes which do not enter the space and whilst the main fire pumps are isolated from the fire main by a valve located in an easily accessible and tenable position outside the space. Where it is found necessary short lengths of the emergency fire pump suction and discharge piping may penetrate the machinery space if it is impracticable to route it externally provided that the integrity of the fire main is maintained by the enclosure of the piping in a substantial steel casing and the sea valve is operable from a readily accessible position not likely to be affected by a fire in the space containing the main fire pumps.

6.4.9 Fire hoses

6.4.9.1 Fire hoses are to be of approved non-perishable material. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Their length, in general, is not to exceed 18 m. Each hose is to be provided with a nozzle and the necessary couplings. Fire hoses, together with any necessary fittings and tools, are to be kept ready for use in conspicuous positions near the water service hydrants or connections.

6.4.9.2 The number of firehoses to be provided, each complete with couplings and nozzles, is to be one for each 15 m length of the craft, or part thereof, but need not exceed the number of hydrants provided. This number does not include any hoses required in any engine room. If necessary, the number of hoses is to be increased so as to ensure that hoses in sufficient numbers are available and accessible at all times.

6.4.10 Nozzles

6.4.10.1 For the purpose of this chapter, standard nozzle sizes are to be 12 mm, 16 mm or 19 mm, or as near thereto as possible, so as to make full use of the maximum discharge capacity of the fire pumps.

6.4.10.2 For accommodation and service spaces, the nozzle size need not exceed 12 mm.

6.4.10.3 The size of nozzles intended for use in conjunction with a manually operated emergency fire pump need not exceed 9.5 mm.

6.4.10.4 For machinery spaces and exterior locations the nozzle size is not to be less than 12 mm.

6.4.10.5 All nozzles are to be of an approved dual purpose type (i.e. spray/jet type) incorporating a shut-off.

6.5 Fire extinguishers

6.5.1 Approved types

6.5.1.1 All fire-extinguishers are to comply with the requirements of Part 6, Chapter 8, Section 4 of Rules and Regulations for the Construction and Classification of Steel Ships.

6.5.2 Location

6.5.2.1 The extinguishers are to be stowed in readily accessible positions.

6.5.2.2 One of the portable fire-extinguishers intended for use in any space is to be stowed near the entrance to that space.

6.5.3 Portable fire-extinguishers in accommodation spaces, service spaces and control stations

6.5.3.1 Accommodation spaces, service spaces and control stations are to be provided with a sufficient number of portable fire extinguishers to ensure that at least one extinguisher will be readily available for use in every compartment.

6.6 Fire extinguishing arrangements in machinery spaces

6.6.1 Machinery space of category 'A'

6.6.1.1 Machinery spaces of category 'A' are to be provided with:

a) An approved foam type fire extinguisher of at least 45 litre capacity or equivalent to enable foam or its equivalent to be directed on to any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards. Where the size of the machinery space makes the provision of a 45 litre fire extinguisher impracticable an additional number of portable extinguishers may be provided in lieu.

b) At least two portable foam extinguishers or equivalent. Where internal combustion machinery is installed an additional portable extinguisher is to be provided for every 375 kW of power output, but the number of such additional extinguishers need not exceed five.

6.6.1.2 Where the size of the machinery space precludes access under normal operating conditions, provisions is to be made to inject the extinguishing medium into the machinery space from an external location whilst maintaining the fire integrity of the machinery space boundaries.

6.6.2 Machinery spaces in service craft which are constructed mainly or wholly of fibre-reinforced plastic or wood

6.6.2.1 Machinery spaces containing internal combustion machinery, in addition to compliance with 6.6.1 are to be provided with any one of the fixed fire-extinguishing systems as per Part 6, Chapter 8, Section 5 of the Rules and Regulations for the Construction and Classification of Steel Ships, except that use of halon as fire extinguishing medium is not permitted.

6.6.3 Fire-extinguishing appliances in other machinery spaces

6.6.3.1 Where a fire hazard exists in any machinery space for which no specific provisions for fire extinguishing appliances are prescribed in 6.6.1 and 6.6.2 there are to be provided in or adjacent to, that space a satisfactory number of approved portable fire extinguishers or other approved means of fire extinction.

6.6.4 Fixed fire extinguishing systems not required by this section

6.6.4.1 Where a fixed fire extinguishing system not required by this section is installed, the arrangement will be specially considered.

6.6.5 Machinery spaces with electrical installations

6.6.5.1 Machinery spaces with electrical installations are to be provided with one or more extinguishers suitable for extinguishing electrical fire as deemed necessary. One or more of the fire extinguishers required by this section may be of the type required by this paragraph.

6.7 Special arrangements in machinery spaces

6.7.1 This section applies to machinery spaces of category A and where necessary to other machinery spaces

6.7.1.1 The number of openings to machinery spaces are to be reduced to a minimum consistent with the needs of ventilation and the proper and safe working of the craft.

6.7.1.2 Openings are to be provided with closing appliances constructed so as to maintain the fire integrity of the machinery space boundaries.

6.7.1.3 Windows are not to be fitted in machinery space boundaries. This does not preclude the use of glass in control rooms within machinery spaces.

6.7.1.4 Means of control are to be provided for:

a) closure of openings which normally allow exhaust ventilation and closure of ventilator dampers;
b) permitting the release of smoke;
c) closing power operated doors or actuating release mechanism on doors other than power operated water tight doors;
d) stopping ventilating fans; and
e) stopping forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pumps and other similar fuel pumps.

6.7.1.5 The controls required in 6.7.1.4 and Chapter 11, Section 3 are to be located outside the space concerned, where they will not be cut off in the event of fire in the space they serve.

6.8 Arrangement of oil fuel, lubricating oil and other flammable oils

6.8.1 Oil fuel arrangements

6.8.1.1 In craft in which oil fuel is used, the arrangements for the storage, distribution and utilization of the oil fuel are to be such as to ensure the safety of the craft and persons on board. For details see Chapter 11, Section 3.

6.8.1.2 Oil fuel tanks situated within the boundaries of machinery spaces of category A are not to contain oil fuel having a flash-point of less than $60^{o}C$.

6.8.2 Prohibition of carriage of flammable oils in forepeak tanks

6.8.2.1 Oil fuel, lubricating oil and other flammable oils are not to be carried in forepeak tanks.

6.9 Fireman’s outfit/axe

6.9.1 Application

6.9.1.1 All craft having enclosed spaces which are normally accessible are to carry at least two fireman’s outfits complying with the requirements of 2.12. Special consideration will be given where this is considered to be excessive due to the general arrangement.

6.9.1.2 Every craft is to be provided with at least one fireman’s axe in easily accessible location.

6.10 Miscellaneous items

6.10.1 Penetrations

6.10.1.1 Where ‘A’ class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for girders, beams or other structural members, arrangements are to be made to ensure that the fire resistance is not impaired.

6.10.1.2 Where ‘B’ class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements are to be made to ensure that the fire resistance is not impaired.

6.10.2 Materials

6.10.2.1 Pipes penetrating ‘A’ or ‘B’ class divisions are to be of approved materials having regard to the temperature such divisions are required to withstand.

6.10.2.2 Pipes conveying oil or combustible liquids through accommodation and service spaces are to be of approved materials having regard to the fire risk.

6.10.2.3 Materials readily rendered ineffective by heat are not to be used for overboard scuppers, sanitary discharges, and other outlets which are close to the water line and where the failure of the material in the event of fire would give rise to danger of flooding.

6.10.3 Waste receptacles

6.10.3.1 All waste receptacles are to be constructed of non-combustible materials with no openings in the sides or bottom.

6.10.4 Surface of insulation

6.10.4.1 In spaces where penetration of oil product is possible, the surface of insulation is to be impervious to oil or oil vapours. Insulation boundaries are to be arranged to avoid immersion in oil spillages so far as is practicable.

6.10.5 Foam concentrates

6.10.5.1 Foam concentrates carried for use in fixed foam fire extinguishing systems are to be of an approved type. They are to be tested at least twice during each five year period to verify that they remain fit for service. Evidence in the form of a report from the foam manufacturer or an independent laboratory will be accepted.

6.10.6 Protection of paint lockers and flammable liquid lockers

6.10.6.1 Paint lockers and flammable liquid lockers of deck area 4 m^2 or over, are to be provided with a fixed fire extinguishing system enabling the crew to extinguish a fire without entering the space. One of the following systems is to be provided:

a) A carbon dioxide system designed for 40 per cent of the gross volume of the space.
b) A dry powder system designed to discharge 0.5 kg powder per cubic metre of gross volume of the space.
c) A water spray system designed to give a coverage of five litres per square metre of deck area per minute. Water spray systems may be connected to the fire main.

Consideration will be given to the acceptance of other arrangements, which provide equivalent protection.

6.10.6.2 Lockers having a deck area less than 4 m^2 may be protected by carbon dioxide or dry powder portable extinguishers located near the entrance to the locker.

6.10.7 Fire control plan

6.10.7.1 Fire control plans are to meet the requirements of 2.11.

6.11 Fire safety measures for the craft

6.11.1 Structure

6.11.1.1 The hull, superstructure, structural bulkheads, decks and deckhouses are to be constructed of steel or other equivalent material. For the purpose of applying the definition of steel or other equivalent material as given in 2.4.6 the applicable fire exposure is to be according to the integrity and insulation standards given in 6.11.1.3 and 6.11.1.4, for example where divisions are permitted to have 'B-0' fire integrity, the 'applicable fire exposure' is to be one half-hour.

6.11.1.2 Crowns and casings of machinery spaces of Category 'A' and lockers containing paint and flammable liquid are to be 'A' class divisions and adequately insulated to take account of the fire risk in adjacent spaces. Openings therein, if any, are to be suitably arranged and protected to prevent the spread of fire.

6.11.1.3 Decks and bulkheads separating machinery spaces other than category A, from control stations, from each other and from accommodation and service spaces are to be constructed to B-15 class standard. In addition, machinery space boundaries are to prevent the passage of smoke. Doors and other openings in such bulkheads and decks are to be constructed so as to provide protection in resisting fire, equivalent to the surrounding structure.

6.11.1.4 Bulkheads of corridors serving accommodation spaces, service spaces and control stations are to extend from deck to deck unless continuous 'B' class ceilings are fitted on both sides of the bulkhead in which case the bulkhead may terminate at the continuous ceiling and, together with decks, they are to be constructed to at least 'B-0' standard. Doors and other openings in such bulkheads and decks are to be constructed so as to provide protection in resisting fire equivalent to the surrounding structure.

6.11.1.5 Interior stairways serving machinery spaces, accommodation spaces, service spaces or control stations are to be of steel or other equivalent material.

6.11.1.6 The number of openings in the bulkheads and decks referred to in 6.11.1.3 and 6.11.1.4 above are to be as few as reasonably practicable.

6.11.1.7 Primary deck coverings within accommodation spaces, service spaces and control stations are to be of a type which will not readily ignite.

6.11.1.8 Non-combustible insulation is to be fitted in machinery spaces and other compartments containing high fire risks. Elsewhere combustible insulation may be used provided it is totally enclosed by cladding, the exposed surfaces of which have low flame spread characteristics.

6.11.1.9 Paints, varnishes and other finishes used on exposed interior surfaces are to be of low flame spread type, that is, to adequately restrict the spread of flame on such surfaces.

6.11.1.10 Paints, varnishes and other finishes used on exposed interior surfaces are not to be capable of producing excessive quantities of smoke or toxic gases or vapours.

6.11.2 Ventilation systems

6.11.2.1 Ventilation fans are to be capable of being stopped and main inlets and outlets of ventilation systems closed from outside the spaces being served.

6.11.2.2 Ventilation openings may be fitted in the lower parts of the doors in corridor bulkheads. Ventilation grills are to be of non-combustible material. The total net area of any such openings is not to exceed 0.05 m^2.

6.11.2.3 Ventilation ducts for main machinery spaces are not in general to pass through accommodation spaces, service spaces or control station unless the ducts are constructed of steel and arranged to preserve the integrity of the division.

6.11.2.4 Ventilation ducts of accommodation spaces, service spaces or control stations are not in general to pass through main machinery spaces unless the ducts are constructed of steel and arranged to preserve the integrity of the division.

6.11.2.5 Store-rooms containing highly flammable products are to be provided with ventilation arrangements which are separate from other ventilation systems. Ventilation is to be arranged at high and low levels and the inlets and outlets of ventilators should be positioned in safe areas and fitted with spark arresters.

6.11.2.6 Ventilation systems serving machinery spaces are to be independent of systems serving other spaces.

6.11.3 Means of escape

6.11.3.1 Stairways, ladders and corridors serving crew spaces and other spaces to which the crew normally have access are to be arranged so as to provide ready means of escape to a deck from which disembarkation may be effected.

6.11.3.2 Where reasonable and practicable and having regard to the number of crew and size of space, at least two means of escape, one of which may be the normal means of access, as widely separated as possible are to be provided from each section of accommodation and service spaces. Normal means of access to accommodation and service spaces below the open deck is to be arranged so that it is possible to reach the open deck without passing through intervening spaces containing a possible source of fire. The second means of escape may be through portholes or hatches of adequate size and preferably leading directly to the open deck.

6.11.3.3 Except where the smallness of the machinery spaces makes it impracticable at least two means of escape, one of which may be the normal means of access are to be provided by steel ladders and should be as widely separated as possible.

6.11.4 Arrangements for gaseous fuel for domestic purposes

6.11.4.1 Where gaseous fuel is used for domestic purposes the arrangements for the storage, distribution and utilization of the fuel is to be such that, having regard to the hazards of fire and explosion which the use of such fuel may entail, the safety of the craft and the persons on board is preserved. The installation is to be in accordance with recognised National or International Standards.

End of Chapter

Chapter 11

Piping Systems

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1	Material and Design Requirements
2	Bilge, Ballast, Air Pipes and Sounding Systems
3	Machinery Piping Systems

Section 1

Material and Design Requirements

1.1 General

1.1.1 Application

This section is to be read in conjunction with the requirements of Part 4, Chapter 2 of 'Rules and Regulations for the Construction and Classification of Steel Ships'.

1.1.2 Plans and information

1.1.2.1 At least three copies of the following plans and information are to be submitted.

1.1.2.2 The following diagrammatic plans including details of the material and pipe dimensions/thickness:

- Bilge and ballast system including the capacities of the pumps on bilge service;
- Oil fuel, lubricating oil, hydraulic oil and other flammable liquid systems;
- Compressed air system for main and auxiliary services;
- Steam systems with a design pressure above 7 bar;
- Cooling water systems for main and auxiliary essential services.

1.1.2.3 Design details of the following components:

a) flexible hoses;
b) sounding devices;
c) resiliently seated valves;
d) expansion joints;
e) components of an unusual or novel nature.

1.1.2.4 The requirements for plans and information for the fire-fighting systems are given in Chapter 10.

1.2 Carbon and Low Alloy Steels

1.2.1 General

1.2.1.1 The minimum thickness of steel pipes is to be determined by the formulae given in Part 4, Chapter 2, Section 1.7 of 'Rules and Regulations for the Construction and Classification of Steel Ships' except that in no case it is to be less than that shown in Table 1.2.1.

Table 1.2.1 : Minimum thickness for steel pipes

External diameter D mm	Min. pipe thickness mm
10.2 - 12	1.6
13.5 – 19	1.8
20 – 44.5	2.0
48.3 – 63.5	2.3
70 – 82.5	2.6
88.9 – 108	2.9
114.3 – 127	3.2
133 – 139.7	3.6
152.4 – 168.3	4.0
177.8 and over	4.5
NOTES:	
1. The thickness of air, overflow and sounding pipes for structural tanks is to be not less than 4.5 mm.	
2. The thickness of bilge, ballast and general sea water pipes is to be not less than 4.0 mm.	
3. The thickness of bilge, air, overflow and sounding pipes through ballast and oil fuel tanks, ballast lines through oil fuel tanks and oil fuel lines through ballast tanks is to be not less than 6.3 mm.	

4. For air, bilge, ballast, oil fuel, overflow, sounding and venting pipes as mentioned in notes 1 to 3, where the pipes are efficiently protected against corrosion the thickness may be reduced by not more than 1 mm.
5. For air and sounding pipes the minimum thickness applies to the part of the pipe outside the tank but not exposed to weather. The section of pipe exposed to weather may be required to be suitably increased in thickness in accordance with statutory and loadline requirements as applicable.

1.2.1.2 For pipes passing through tanks, where the thickness has been calculated in accordance with Part 4, Chapter 2, Section 1.7 of 'Rules and Regulations for the Construction and Classification of Steel Ships', an additional corrosion allowance is to be added to take account of external corrosion; the addition will depend on the external medium and the value is to be in accordance with Table 1.2.2.

Table 1.2.2 : Values of corrosion allowance (c) for steel pipes

Piping Service	C [mm]
Saturated steam systems	0.8
Compressed air systems	1.0
Hydraulic oil systems	0.3
Lubricating oil systems	0.3
Fuel oil systems	1.0
Refrigerating plants	0.3
Fresh water systems	0.8
Sea water systems in general	3.0

1.2.1.3 Where the pipes are efficiently protected against corrosion, the corrosion allowance (c) may, be reduced by not more than 50 percent.

1.2.2 Steel pipe joints

1.2.2.1 Joints in steel pipelines may be made by:

- Screwed on or welded on bolted flanges;
- Butt welds between pipes or between pipes and valve chests;
- Socket welded joints (upto 60.3 mm outside diameter);
- Threaded sleeve joints (parallel thread) (see also 1.2.5);
- Special types of approved joints that have been shown to be suitable for the design conditions (see also 1.2.4).

1.2.2.2 Where pipes are joined by welding a suitable number of flanged joints are to be provided at suitable positions to facilitate installation and removal for maintenance.

1.2.2.3 Where welded pipes are protected against corrosion then the corrosion protection is to be applied after welding or the corrosion protection is to be made good in way of the weld damaged area.

1.2.2.4 Where it is not possible to make good the corrosion protection of the weld damaged area, then the pipe is to be considered to have no corrosion protection.

1.2.3 Welded on flange joints

1.2.3.1 Welded on flange joints are to be as per Part 4, Chapter 2, Section 2.3 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

1.2.4 Screwed fittings

1.2.4.1 Screwed fittings including compression fittings may be used in piping systems not exceeding 41 mm outside diameter.

1.2.5 Parallel threaded sleeve joints

1.2.5.1 Threaded sleeve joints in accordance with National or other established standards may be used within the limits given in Table below. They are not to be used in piping systems conveying flammable liquids.

Limiting design conditions for threaded sleeve joints

Nominal bore [mm]	Maximum pressure Bar	Maximum temperature ^{o}C
≤ 25	12.0	260
> 25 ≤ 40	10.0	260
> 40 ≤ 80	8.5	260
> 80 ≤ 100	7.0	260

1.2.6 Socket weld joints

1.2.6.1 Socket weld joints may be used with carbon steel pipes not exceeding 60.3 mm outside diameter. Socket weld fittings are to be of forged steel and the material is to be compatible with the associated piping. Such joints are not to be used where fatigue, severe erosion or crevice corrosion is expected to occur.

1.2.6.2 The thickness of the socket weld fittings is to meet the requirements of Part 4, Chapter 2, Section 1.7 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’, but is to be not less than 1.25 times the nominal thickness of the pipe or tube. The diametrical clearance between the outside diameter of the pipe and the bore of the fitting is not to exceed 0.8 mm and a gap of approximately 1.5 mm is to be provided between the end of the pipe and the bottom of the socket.

1.2.6.3 The leg lengths of the fillet weld connecting the pipe to the socket weld fitting are to be such that the throat dimension of the weld is not less than the nominal thickness of the pipe or tube.

1.2.7 Welded sleeve joints

1.2.7.1 Welded sleeve joints may be used in Class III systems only, subject to the restrictions and general dimensional requirements given in 1.2.6 for socket weld joints.

1.2.7.2 The pipe ends are to be located in the centre of the sleeve with a 1.5 to 2.0 mm gap.

1.3 Stainless Steel

1.3.1 General

1.3.1.1 Stainless steels may be used for a wide range of services and are particularly suitable for use at elevated temperatures. Austenitic steels may not be used in polluted stagnant sea water. Steel of specifications 316L or better may give superior results in circulating clean sea water.

1.3.1.2 The minimum thickness of stainless steel pipes is to be determined from the formula given in Part 4, Chapter 2, Section 1.7 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’, using a corrosion allowance of 0.8 mm. Values of the 0.2 percent proof stress and tensile strength of the material for use in this formula may be obtained from Part 2 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’, except that in no case it is to be less than that shown in Table 1.3.1.

Table 1.3 1 : Minimum thickness for stainless steel pipes

Standard pipe sizes (outside diameter) [mm]	Minimum nominal thickness [mm]
8.0 to 10.0	0.8
12.0 to 20.0	1.0
25.0 to 44.5	1.2
50.0 to 76.1	1.5
88.9 to 108.0	2.0
133.0 to 159.0	2.5
193.7 to 267.0	3.0
273.0 to 457/2	3.5

1.3.1.3 Joints in stainless steel pipe work may be made by any of the techniques described in 1.2.2 to 1.2.4.

1.3.1.4 Where pipe work is butt welded, this should preferably be accomplished without the use of backing rings, in order to eliminate the possibility of crevice corrosion between the backing ring and pipe.

1.4 Aluminium Alloy

1.4.1 General

1.4.1.1 The use of aluminium alloy material in Class III piping systems will be considered in relation to the fluid being conveyed and operating conditions of temperature and pressure.

1.4.1.2 In general, aluminium alloy may be used for air and sounding pipes for water tanks and dry spaces providing it can be shown that pipe failure will not cause a loss of integrity across watertight divisions. In craft of aluminium construction, aluminium alloy may also be used for air and sounding pipes for oil fuel, lubricating oil and other flammable liquid tanks provided the pipes are suitably protected against the effects of fire.

1.4.1.3 Aluminium alloy pipes are not to be used in machinery spaces or cargo holds for conveying oil fuel, lubricating oil or other flammable liquids, or for bilge suction pipe work within machinery spaces. Aluminium alloy pipes are not acceptable for fire extinguishing pipes unless they are suitably protected against the effect of heat.

1.4.1.4 The minimum thickness of aluminium alloy pipe is to be not less than that shown in Table 1.4.1.

Table 1.4.1 : Minimum thickness of aluminium pipes

Nominal pipe size [mm]	Min. wall thickness [mm]
10	1.7
15	2.1
20	2.1
25	2.8
40	2.8
50	2.8
80	3.0
100	3.0
150	3.4
200	3.8
250 and over	4.2

1.4.1.5 Design requirements for aluminium pressure pipes for design pressures greater than 7 bar will be specially considered.

1.4.1.6 Attention is drawn to the susceptibility of aluminium to corrosion in the region of welded connections.

1.5 Requirements for Valves

1.5.1 General

1.5.1.1 All valves are to be so constructed as to prevent the possibility of valve covers or glands being slackened back or loosened when the valves are operated.

1.5.1.2 All valves are to be arranged to shut with a right-hand (clockwise) motion of the wheels and are to be provided with indicators showing whether they are open or shut unless this is readily obvious.

1.5.1.3 Valves and cocks are to be fitted with legible nameplates and unless otherwise specifically mentioned in the Rules the valves and cocks are to be fitted in places where they are at all times readily accessible.

1.5.1.4 Additional requirements for ship side valves are given in Part 4, Chapter 3, Section 1.5 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

1.5.2 Valves with remote control

1.5.2.1 All valves which are provided with remote control are to be arranged for local manual operation, independent of the remote operating mechanism.

1.5.2.2 In the case of valves which are required by the Rules to be provided with remote control, opening and/or closing of the valves by local manual means is not to render the remote control system inoperable.

1.5.3 Resiliently seated valves

1.5.3.1 Resiliently seated valves are not to be used in oil fuel, lubricating oil or other flammable liquid systems where failure of the non-metallic seal would result in external leakage or allow oil to escape from a storage or daily service tank.

1.5.3.2 Where the valves are of the diaphragm type, they are not acceptable as shut off valves at the shell plating.

1.5.3.3 Resiliently seated valves are not to be used in main or auxiliary machinery spaces as branch or direct bilge suction valves or as pump suction valves from the main bilge line (except where the valve is located in the immediate vicinity of the pump). Where they are used in other locations and within auxiliary machinery spaces having little or no fire risk they should be of approved fire safe type and used in conjunction with a non-return valve.

1.5.3.4 Resiliently seated valves are not acceptable for use in fire water mains unless they have been satisfactorily fire tested.

1.6 Requirements for Flexible Hoses

1.6.1 General

1.6.1.1 Short joining lengths of flexible hoses of approved type may be used, where necessary to accommodate relative movement between various items of machinery connected to permanent piping systems.

1.6.1.2 The use of worm-drive or similar hose clips as a means of securing the ends of hoses is restricted to systems with a working pressure of less than 7 bar and for fluids other than oil fuel, lubricating oil, other flammable liquids and compressed air. The clips are to be of stainless steel and doubled at each connection. Means are to be provided to prevent the pipe from pulling out of the hose when under pressure.

1.6.1.3 Prototype pressure tests are to be carried out on each new type of hose, complete with end fittings, and in no case is the bursting pressure to be less than five times the maximum working pressure in service.

1.6.1.4 Attention is to be given to any statutory requirements of the National Authority of the country in which the craft is to be registered. Such requirements may include a fire test for hoses that are intended to be used in systems conveying flammable liquids or sea water.

1.6.2 Applications for rubber hoses

1.6.2.1 Synthetic rubber hoses, with integral cotton or similar braid reinforcement, may be used in fresh and sea water systems (except fire extinguishing salt water service).

1.6.2.2 Synthetic rubber hoses for use in bilge, ballast, compressed air, oil fuel, lubricating oil and other flammable liquid systems are to have single or double closely woven integral wire braid reinforcement or be otherwise inherently fire resistant and of approved fire tested type.

1.6.2.3 Hoses for use in the fuel supply to burners are to have external wire braid protection.

1.7 Copper and Copper Alloy

1.7.1 Copper and copper alloy pipes refer to Part 4, Chapter 2, Section 3 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

1.8 Plastic Pipes

1.8.1 Refer to Part 4, Chapter 2, Section 5 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

1.9 Requirements for Crafts with ‘LC’ or ‘HSLC’ Notation

1.9.1 General

1.9.1.1 The requirements of all previous sub-sections and Part 4, Chapter 2, ‘Rules and Regulations for the Construction and Classification of Steel Ships’ apply, except where modified by this sub-section.

1.9.2 Details to be submitted

1.9.2.1 Details of oil fuel storage tanks over 0.25 m^3, where these do not form part of the structure of the craft, are to be submitted.

1.9.2.2 Details of flexible hoses, sounding device, resiliently seated valves and expansion joints not required.

1.9.3 Materials

1.9.3.1 Materials for which no provision is made in this chapter may be accepted provided that they comply with an acceptable National or International Standard and are satisfactorily tested as may be considered necessary. Manufacturer’s materials test certificates are not required unless the material is of unusual or special specification.

1.9.3.2 Shell valves and cocks, inlet chests, distance pieces and other sea connections are to be of steel, bronze or other approved ductile material. Due attention is to be paid to the compatibility of the material with that of the shell.

1.9.4 Aluminium alloy

1.9.4.1 Paragraph 1.4.1.3 does not apply providing the material is of high strength type.

1.9.4.2 Aluminium alloy pipes may be used for fire-fighting systems outside machinery spaces in locations of low fire risk.

Section 2

Bilge, Ballast, Air Pipes and Sounding Systems

2.1 Application

2.1.1 This section applies to crafts required to comply with HSC Code.

2.1.2 Requirements for non-passenger craft of less than 150 GT not required to comply with the HSC Code are given in Section 2.13.

2.1.3 Requirements for non-passenger craft of 150 GT or more not required to comply with the HSC Code are given in Section 2.14.

2.1.4 For non-HSC passenger crafts refer to the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

2.2 Shell Valves and Fittings (other than those on scuppers and sanitary discharges)

2.2.1 Construction

2.2.1.1 All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell or to fabricated water boxes attached to the shell.

2.2.1.2 Distance pieces of short rigid construction and made of approved material may be fitted between the valve and shell. The thickness of such pipes, is to be equivalent to shell thickness.

2.2.1.3 The arrangements are to be such that the section of pipe immediately inboard of the shell valve may be removed without affecting the watertight integrity of the hull.

2.2.1.4 The valves are to be in accordance with the general requirements for valves given in sub-section 1.5.

2.2.1.5 Shell valves are to be manufactured from non-heat sensitive materials and tested in accordance with the appropriate requirements of Part 2. Where the valves are manufactured from spheroidal or nodular graphite cast iron they are to be produced at an approved work. Grey cast iron is not acceptable.

2.2.1.6 Shell valves are to be fitted in accessible positions and are to be capable of being operated from positions which are readily accessible in case of influx of water to the compartment.

2.2.1.7 Valve hand wheels and cock handles are to be suitably retained on the spindles. Means are to be provided to indicate whether the valve or cock is open or closed.

2.2.1.8 The scantlings of valves and valve stools fitted with steam or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

2.3 Bilge Pumping and Drainage Systems

2.3.1 General

2.3.1.1 Arrangements are to be made for draining all watertight compartments other than those intended for permanent storage of fluids. Where drainage is not considered necessary, drainage arrangements may be omitted provided the safety of the craft is not impaired.

2.3.1.2 Pumping arrangements are to be provided having suctions and means of drainage so arranged that any water within any watertight compartment of the craft or any watertight section of any compartment, can be pumped out through at least one suction under all possible conditions of list and trim in the maximum assumed damage condition.

2.3.1.3 The bilge pumping system is to be designed to prevent water flowing from one watertight compartment to another. The necessary valves for controlling the bilge suctions are to be capable of being operated from above the watertight deck.

2.3.1.4 Where a bilge main is not fitted and a compartment is served by a fixed submersible pump in accordance with sub-section 2.9, then an additional emergency means of pumping out the compartment is to be provided.

2.3.1.5 Small compartments may be drained by individual hand pump suctions.

2.3.1.6 The intactness of watertight bulkheads is not to be impaired by the fitting of scuppers discharging to machinery spaces or tunnels from adjacent compartments situated below the highest watertight deck.

2.3.1.7 Any unattended space for which bilge pumping arrangements are required is to be provided with a bilge level alarm.

2.4 Bilge Drainage of Machinery Spaces with a Propulsion Prime Mover

2.4.1 General

2.4.1.1 The bilge drainage arrangements are to comply with sub-section 2.3, except that the arrangements are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions under all possible conditions of list and trim in the maximum assumed damage condition.

2.4.1.2 Where a bilge main is fitted, one of the suctions referred to in 2.4.1.1 is to be a branch bilge suction i.e. a suction connected to the bilge main. The second bilge suction is to be a direct bilge suction as detailed in 2.7.6.

2.4.1.3 Where a bilge main is not fitted, the branch bilge suction referred to in 2.4.1.2 may be replaced by a suction from a submersible bilge pump. The second bilge suction is to be either a second submersible bilge pump or a direct bilge suction as detailed in 2.7.6.

2.4.1.4 The emergency bilge drainage arrangements detailed in sub-section 2.5 are to be provided where either 2.4.1.2 or 2.4.1.3 applies.

2.4.2 Additional bilge suctions

2.4.2.1 Additional bilge suctions may be required for the drainage of wells or other recesses.

2.5 Emergency Bilge Drainage

2.5.1 In machinery spaces the emergency bilge suction required by 2.3.1.4 and 2.4.1.4 is to be led to the largest available power pump other than a bilge pump, propulsion pump or oil pump, from a suitable low level in the machinery space and is to be fitted with a screw down non-return valve with an extended spindle and hand wheel situated above the floor plating.

2.5.2 As an alternative to 2.5.1, or in compartments other than machinery spaces, the emergency bilge pumping arrangements may be provided by a portable submersible self-priming pump of capacity not less than that required by sub-section 2.7.3.5.

2.5.3 The pump referred to in 2.5.2 together with its suction and delivery hoses is to be stored in a locker marked ‘For emergency use only’ and is to be available for immediate use. Arrangements to facilitate safe handling under adverse conditions are to be provided. If the pump is electrically driven it is to be supplied from the emergency switchboard.

2.6 Size of Bilge Suction Pipes

2.6.1 Bilge main

2.6.1.1 Where a bilge main is fitted, its internal diameter d_m is to be not less than that required by the following formula:

$$d_m = 1.68 \sqrt{L (B + D)} + 25 \text{ [mm]}$$

where,

B = moulded breadth of the craft [m] – for monohull
= moulded breadth of a hull at or below the design waterline [m] – for multihull
D = moulded depth to the watertight deck [m]
L = length of craft [m] as defined in Chapter 1.

2.6.1.2 The actual internal diameter of the bilge main may be rounded off to the nearest pipe size of recognised standard, but *d_m is in no case to be less than 50 [mm]*.

2.6.2 Branch bilge suctions

2.6.2.1 The diameter d_b of branch bilge suction pipes is to be not less than that required by the following formula:

$$d_b = 2.15 \sqrt{C (B + D)} + 25 \text{ [mm]}$$

Where,

B & D = are as defined in 2.6.1.1
C = length of compartment [m].

2.6.2.2 The actual internal diameter of branch bilge suction pipes may be rounded off to the nearest pipe size of a recognised standard, but *d_b is in no case to be less than 25 mm.*

2.7 Pumps on Bilge Service

2.7.1 Number of pumps

2.7.1.1 For craft fitted with a bilge main, at least two power bilge pumping units are to be provided. One of these units may be worked from the main engines and the other is to be independently driven.

2.7.1.2 Each unit may consist of one or more pumps connected to the main bilge line, provided that their combined capacity is not less than that required by 2.7.3.2.

2.7.1.3 A bilge ejector in combination with a high pressure sea-water pump may be accepted as a substitute for an independent bilge pump as required by 2.7.1.1.

2.7.1.4 For craft fitted with fixed submersible bilge pumps, one pump is to be provided for each watertight compartment.

2.7.1.5 For the bilge pumping requirements for multi-hull craft, see sub-section 2.11.

2.7.2 General service pumps

2.7.2.1 The bilge pumping units or pumps required by 2.7.1 may also be used for ballast, fire or general service duties of an intermittent nature, but they are to be immediately available for bilge duty when required. For the use of bilge pumping units for fire-extinguishing duties, see Chapter 10.

2.7.3 Capacity of pumps

2.7.3.1 Each bilge pumping unit is to be connected to the bilge main and is to be capable of giving a speed of water through the Rule size of bilge main of not less than 2 m/s.

2.7.3.2 To achieve the flow velocity required by 2.7.3.1, the capacity Q of each bilge pumping unit or bilge pump is to be not less than that required by the following formula:

$$Q = (5.75/10^3) \text{ x } d_m^2 \quad [m^3/hour]$$

where,

d_m is as defined in 2.6.1.1;

Q = Rule minimum capacity in m^3/hour.

2.7.3.3 Where one bilge pumping unit is of slightly less than Rule capacity, the deficiency may be made good by an excess capacity of the other unit. In general, the deficiency is to be limited to 30 percent.

2.7.3.4 Where fixed submersible bilge pumps are fitted, the total capacity Q_t of the pumps is to be not less than that required by the following formula:

$$Q_t = \frac{13.8}{10^3} . d_m^2 \quad [m^3/hr]$$

where,

d_m is as defined in 2.6.1.1;

Q_n = Rule minimum total capacity in m^3/hour.

2.7.3.5 The capacity Q_n of each submersible bilge pump is to be not less than that required by the following formula:

$$Q_n = \frac{Q_t}{(N-1)} \quad [m^3/hr]$$

where,

N = number of fixed submersible pumps

Q_t is as defined in 2.7.3.4.

Q_n = rule minimum submersible pump capacity in m^3/hour

Q_n is in no case to be less than 8 m^3/hour.

2.7.4 Self-priming pumps

2.7.4.1 All power pumps which are essential for bilge services are to be of the self-priming type, unless an approved central priming system is provided for these pumps.

2.7.5 Pump connections

2.7.5.1 The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

2.7.5.2 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any pumps so connected is unaffected by the other pumps being in operation at the same time.

2.7.6 Direct bilge suctions

2.7.6.1 The direct bilge suction in the machinery space required by 2.4.1.2 and referred to in 2.4.1.3 is to be led to an independent power pump and the arrangements are to be such that the direct suction can be used independently of the main bilge line suctions.

2.7.6.2 The machinery space direct bilge suction is not to be of a diameter less than required for the machinery space branch bilge suction and arranged as detailed in 2.7.6.1.

2.8 Bilge Main Arrangements and Materials

2.8.1 General

2.8.1.1 Bilge mains, branch bilge suctions and bilge overboard discharge arrangements within machinery spaces are to be of steel or other equivalent material.

2.8.1.2 Where bilge suction pipe work outside machinery spaces is manufactured from material sensitive to heat then the arrangements are to be such that pipe failure in one compartment will not render the bilge suction pipe work in another compartment inoperable.

2.8.1.3 Bilge pipe work is to be mounted inboard such that in the event of the maximum assumed damage the pipe work will remain intact.

2.8.2 Prevention of communication between compartments

2.8.2.1 The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks. For this purpose, screw-down non-return valves are to be provided in the following fittings:

a) Bilge valve distribution chests within machinery spaces;

b) Direct bilge suctions and bilge pump connections to main bilge line within machinery spaces.

2.8.3 Isolation of bilge system

2.8.3.1 Bilge suction pipes are to be entirely separate from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried.

2.8.4 Bilge suction strainers

2.8.4.1 The open ends of bilge suctions are to be enclosed in strum boxes having perforations of not more than 10 mm diameter, whose combined area is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

2.9 Submersible Bilge Pump Arrangements

2.9.1 General

2.9.1.1 Arrangements are to be such that at least two automatic non-return devices are fitted between the overboard discharge and the watertight space being served by the pump.

2.9.1.2 One of these devices is to be an automatic non-return valve situated at or near the shell and the other may be a pipe work loop taken up to the highest practicable point below the watertight deck. The arrangements are to be effective in the maximum assumed damaged condition.

2.10 Air, Overflow and Sounding Pipes

2.10..1 Air pipes

2.10.1.1 Air pipes are to be fitted to all tanks, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements.

2.10.1.2 Air pipes are to be fitted at the opposite end of the tank to that which the filling pipes are placed and at the highest part of the tank. Where the tank top is of unusual or irregular profile, special consideration will be given to the number and position of the air pipes.

2.10.1.3 Air pipes to oil fuel, lubricating oil and other tanks containing flammable liquids which are located in or pass through compartments of high fire risk or on open deck are to be of steel or other equivalent material.

2.10.2 Termination of air pipes

2.10.2.1 Air pipes to double bottom tanks, deep tanks extending to the shell plating, or tanks which can be run up from the sea are to be led to above the watertight deck. Air pipes to oil fuel tanks, cofferdams and all tanks which can be pumped up are to be led to the open.

2.10.2.2 Air pipes from storage tanks containing lubricating or hydraulic oil may terminate in the machinery space, provided that the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

2.10.2.3 The open ends of air pipes to oil fuel tanks are to be situated where no danger will be incurred from issuing oil vapour when the tank is being filled.

2.10.3 Gauze diaphragms

2.10.3.1 The open ends of air pipes to oil fuel tanks are to be fitted with a wire gauze diaphragm of non-corrodible material which can be readily removed for cleaning or renewal.

2.10.3.2 Where wire gauze diaphragms are fitted at air pipe openings, the area of the opening through the gauze is to be not less than twice the cross-sectional area required for the pipe.

2.10.4 Air pipe closing appliances

2.10.4.1 Closing appliances fitted to tank air pipes are to be of a type which will allow the free passage of air or liquid to prevent the tanks being subjected to a pressure or vacuum greater than that for which they are designed.

2.10.4.2 Wood plugs and other devices which can be secured closed are not to be fitted at the outlets.

2.10.5 Nameplates

2.10.5.1 Nameplates are to be affixed to the upper ends of all air and sounding pipes.

2.10.6 Size of air pipes

2.10.6.1 For every tank which can be filled by onboard pumps, the total cross-sectional area of the air pipes and the air pipe closing devices is to be such that when the tank is overflowing at the maximum pumping capacity available for the tank, it will not be subjected to a pressure greater than that for which it is designed.

2.10.6.2 In all cases, whether a tank is filled by onboard pumps or other means, the total cross-sectional area of the pipes is to be not less than 25 percent greater than the effective area of the respective filling pipe.

2.10.6.3 Air pipes are to be generally not less than 38 mm bore. In the case of small gravity filled tanks smaller bore pipes may be accepted but in no case is the bore to be less than 25 mm.

2.10.7 Overflow pipes

2.10.7.1 For all tanks which can be pumped up, overflow pipes are to be fitted where:

a) The total cross sectional area of the air pipes is less than that required by 2.10.6.

b) The pressure head corresponding to the height of the air pipe is greater than that for which the tank is designed.

2.10.7.2 In the case of oil fuel tanks, lubricating oil tanks and other tanks containing flammable liquids, the overflow pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes. Suitable means is to be provided to indicate when overflowing is occurring.

2.10.7.3 Overflow pipes are to be self draining under normal conditions of trim.

2.10.7.4 Where overflow sight glasses are provided, they are to be in a vertical dropping line and designed such that the oil does not impinge on the glass. The glass is to be of heat resisting quality and be adequately protected from mechanical damage.

2.10.8 Combined air and overflow systems

2.10.8.1 Where a combined air or overflow system is fitted, the arrangement is to be such that in the event of any one of the tanks being bilged, the other tanks cannot be flooded from the sea through combined air pipes or the overflow main. For this purpose, it will normally be necessary to lead the overflow pipe to a point above the waterline in the maximum assumed damage condition.

2.10.8.2 Where a common overflow main is provided, the main is to be sized to allow any two tanks connected to that main to overflow simultaneously.

2.10.9 Sounding arrangements

2.10.9.1 Provision is to be made for sounding all tanks and the bilges of those compartments which are not at all times readily accessible. The soundings are to be taken as near the suction pipes as practicable.

2.10.9.2 An approved level gauge or remote reading level device may be accepted in lieu of a sounding pipe.

2.10.9.3 Bilges of compartments which are not at all times readily accessible are to be provided with sounding pipes.

2.10.9.4 Where fitted, sounding pipes are to be as straight as practicable and if curved to suit the structure of the craft, the curvature is to be sufficiently easy to permit the ready passage of the sounding rod or chain.

2.10.9.5 Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes.

2.10.9.6 Where slotted sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.

2.10.9.7 Sounding pipes are to be not less than 32 mm bore.

2.10.10 Termination of sounding pipes

2.10.10.1 Except as permitted by 2.10.11, sounding pipes are to be led to positions above the bulkhead deck which are at all times accessible and in the case of oil fuel tanks, cargo oil tanks and lubricating oil tanks, the sounding pipes are to be led to safe positions on the open deck.

2.10.11 Short sounding pipes

2.10.11.1 In machinery spaces, where it is not practicable to extend sounding pipes as mentioned in 2.10.10 short sounding pipes extending to readily accessible positions above the platform may be fitted.

2.10.12 Sounding arrangements for oil fuel, lubricating oil and other flammable liquids

2.10.12.1 Safe and efficient means of ascertaining the amount of oil in any storage tank are to be provided.

2.10.12.2 For oil fuel, lubricating oil and other flammable liquids, closed sounding devices are preferred. Design details of such devices are to be submitted and they are to be tested after fitting on board, to the satisfaction of the Surveyors.

2.10.12.3 If closed sounding devices are fitted, failure of the device or over filling of the tank is not to result in the release of tank contents. In passenger craft such means is not to require penetration below the top of the tank.

2.10.12.4 Where sounding pipes are used they are not to terminate in any space where risk of ignition or spillage from the sounding pipe might arise. In particular they are not to terminate in public spaces or crew accommodation. Additionally for oil fuel tanks they are not to terminate in machinery spaces. Terminations are to be provided with a suitable means of closure and provision to prevent spillage during refueling/refilling operations.

2.10.12.5 Where gauge glasses are used they are to be of the flat type of heat resisting quality, adequately protected from mechanical damage and fitted with self closing valves at the lower ends and at the top ends if these are connected to the tanks below the maximum liquid level.

2.11 Requirements for Multi-Hull Craft

2.11.1 General

2.11.1.1 The requirements of sub-sections 2.3 to 2.10 apply to multi-hull craft except where modified by the requirements of this section.

2.11.2 Drainage of raft void spaces

2.11.2.1 Arrangements are to be provided for venting, sounding and draining raft void spaces generally as required by sub-sections 2.3 to 2.10.

2.11.2.2 Where the raft void space is located above the waterline in the maximum assumed damage condition then it may be drained directly overboard through scuppers fitted with non-return valves.

2.11.2.3 Raft void spaces which are not located above the water line in the worst expected damage condition are to be provided with pumping arrangements in accordance with sub-section 2.4.

2.11.3 Size of bilge suction pipes

2.11.3.1 Where a bilge main is fitted in each hull, its internal diameter d_m is to be not less than that required by the following formula:

$$d_m = 1.68 \sqrt{\{L (B + D)\}} + 25 \text{ mm}$$

where,

L = length of craft as defined in Chapter 1.
B & D are as defined in 2.6.1.1.

The actual internal diameter of bilge main suction pipes may be rounded off to the nearest pipe size of a recognised standard, but *d_m is in no case to be less than 50 mm.*

2.11.3.2 The diameter d_b of branch bilge suction pipes is to be not less than that required by the following formula:

$$d_b = 2.15 \sqrt{\{C (B + D)\}} + 25 \text{ mm}$$

where,

C = length of compartment [m];
B & D are as defined in 2.6.1.1

The actual internal diameter of branch bilge suction pipes may be rounded off to the nearest pipe size of a recognised standard, but *d_b is in no case to be less than 25 mm.*

2.11.4 Capacity and number of pumps on bilge main services

2.11.4.1 Each power bilge pump should be capable of pumping water through the required size of bilge main at a speed of not less than 2 m/s.

2.11.4.2 To achieve the flow velocity required by 2.11.4.1, the capacity Q of each bilge pumping unit or bilge pump is to be not less than that required by the following formula:

$$Q = \frac{5.75}{10^3} . d_m^2 \quad [m^3/hr]$$

where,

d_m is a defined in 2.11.3.1.

2.11.4.3 Not less than two power bilge pumping units taking suction from the bilge main in each hull are to be provided. At least one independent power pump should be located in each hull.

2.11.4.4 Where the bilge system in each hull is entirely separate then two bilge pumping units in each hull are to be provided. At least one pump in each hull should be an independent power pump.

2.11.4.5 Where fixed submersible bilge pumps are fitted, the total capacity Q_t of the pumps in each hull is to be not less than that required by the following formula:

$$Q_t = \frac{13.8}{10^3} . d_m^2 \quad [m^3/hr]$$

where,

d_m is as defined in 2.11.3.1.

2.11.4.6 The capacity Q_n of each submersible pump is to be not less than that required by the following formula:

$$Q_n = \frac{Q_t}{(N-1)} \quad [m^3/hr]$$

where,

N = number of fixed submersible pumps in each hull
Q_t is as defined in 2.11.4.5;
Q_n is in no case to be less than 8 m^3/hour.

2.12 Additional Requirements for Passenger Craft of Category-B

2.12.1 Bilge pumping arrangements

2.12.1.1 At least three power bilge pumping units are to be fitted connected to the bilge main, one of which may be driven by the propulsion machinery.

2.12.1.2 For multi-hull craft the bilge pumping units are to be capable of taking suction from the bilge main in any hull of the craft. At least one pump in each hull should be of independent power.

2.12.13 The arrangements are to be such that at least one power bilge pump is to be available for use in all flooding conditions which the craft is required to withstand as follows:

a) one of the required bilge pumps is to be an emergency pump of a reliable submersible type having a source of power located above the waterline after the craft has sustained the maximum assumed damage; or

b) the bilge pumps and their sources of power are to be so distributed throughout the length of the craft that at least one pump in an undamaged compartment will be available.

2.12.1.4 Alternatively fixed submersible bilge pumps may be provided in accordance with the requirements of 2.7.3.4 for monohull craft or 2.11.4.5 multihull craft.

2.12.1.5 Distribution boxes, cocks and valves in connection with the bilge pumping system are to be so arranged that, in the event of flooding, one of the bilge pumps may take suction from any compartment.

2.12.1.6 Damage to a pump or its pipe connecting to the bilge main is not to put the bilge system out of action.

2.12.1.7 When in addition to the main bilge pumping system an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating in any compartment under the maximum assumed flooding conditions. In that case only the valves necessary for the operation of the emergency system need be capable of remote operation.

2.12.1.8 All cocks and valves referred in 2.12.1.5 which can be remotely operated are to have their controls at their place of operation clearly marked and are to be provided with means to indicate whether they are open or closed.

2.13 Requirements for Non-passenger Craft less than 150 GT with 'LC' or 'HSLC' Notation

2.13.1 General

2.13.1.1 These requirements replace Sections 2.3 to 2.9, 2.11 and 2.12 of this chapter. In general requirements of Section 2.10 are to be complied with, however, 2.10.4 and 2.10.9.3 do not apply.

2.13.1.2 Bilge and cooling water pipe work systems are to be of steel, copper or other approved material. In wood and composite craft approved plastics material may also be used.

2.13.1.3 Oil fuel and lubricating oil systems are to be of steel, copper or aluminium. Synthetic rubber hoses with single or double closely woven integral wire braid reinforcement or convoluted metal pipes with wire braid protection may be used as short joining lengths to the engine.

2.13.2 Shell valves and fittings

2.13.2.1 All sea inlet and overboard discharges are to be provided with shut off valves or cocks arranged in positions where they are readily accessible at all times.

2.13.2.2 Where valves, cocks, inlet chests, distance pieces and other sea connections are made of steel or other approved materials of low corrosion resistance they are to be suitably protected against wastage.

2.13.3 Fittings for steel and aluminium hulls

2.13.3.1 All suction and discharge valves and cocks secured direct to the plating are to be fitted with spigots passing through the plating, but spigots on the valves and cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the plating.

2.13.4 Fittings for wood and glass reinforced plastics hulls

2.13.4.1 The openings in the shell or planking are to have suitably reinforced areas or pads into which the attached fittings are to be spigoted.

2.13.4.2 Valves or fittings are to be secured with an external ring under the bolt heads. The ring is to be of copper nickel alloy, bronze, dezincification resistant brass or other material approved for use in sea water.

2.13.4.3 Valves or cocks upto 50 mm bore may be attached to spigot pieces or hull fittings having an external collar and internal nut.

2.13.4.4 Valves or cocks over 50 mm bore are to be flanged and attached as per 2.13.3.

2.13.5 Bilge pumping arrangements

2.13.5.1 An efficient bilge pumping system is to be fitted having suctions and means of drainage so arranged that any water which may enter any compartment could be pumped overboard.

2.13.5.2 The system is to be tested on completion of the craft to ensure that all limber holes are free and that under normal conditions of trim any bilge water can drain to an appropriate suction.

2.13.5.3 The arrangement of pumps, valves, cocks, pipes and sea connections is to be such as to prevent water entering the craft accidentally or the possibility of one watertight compartment being placed in communication with another.

2.13.5.4 Readily accessible strum boxes are to be fitted at the open ends of tail pipes.

2.13.5.5 The perforations in the strum boxes are to be not greater than 10 mm diameter and the combined area is to be not less than twice that required for the bilge suction pipe.

2.13.5.6 Where a collision bulkhead is fitted, the fore peak dry space is to be drained either by a branch suction to the main bilge line or by a manual pump. Alternatively, it may be drained to the adjacent compartment by means of self closing drain cock which is to be readily accessible under all conditions.

2.13.5.7 Where a bilge main is fitted, the internal diameter d of the main and the branch suction pips is to be not less than that required by the following formula:

$$d = L/1.2 + 25 \text{ mm}$$

where,

L = length of craft in metres.

2.13.6 Pumps on bilge service and their connections

2.13.6.1 Not less than one power pump and one manual bilge pump are to be provided. Both pumps are to be arranged to take suction from the bilge main or suction valve chest as applicable.

2.13.6.2 The power driven pumps may be used for other services such as deck washing, fire extinguishing or standby cooling water duty but not for pumping oil fuel or other flammable liquids.

2.13.6.3 The total capacity Qt of the bilge pumps is to be not less than required by the following formula:

$$Q_t = 1.5\,(d - 25) - 6.7 \quad [m^3/\text{hour}]$$

where,

D is as defined in 2.13.5.7;
Q_t is in no case to be less than 3 [m^3/hour].

2.13.6.4 A reduction in capacity of one pump may be permitted provided the deficiency is made good by an excess capacity of the other pump or by an additional pump. In no case is this deficiency to be more than 40 percent of the Rule capacity

2.13.6.5 Pumps on bilge service are to be of the self-priming type.

2.13.6.6 The bilge pumps are to be connected to a common bilge line provided with a branch connection to each compartment.

2.13.6.7 A non-return valve is to be fitted between each bilge pump and the bilge main.

2.13.6.8 Non-return valves are to be fitted in each branch bilge suction from the main bilge line.

2.13.6.9 Power pumps may be driven by the main engine, an auxiliary engine or by an electric motor.

2.13.6.10 The power pump is to be provided with a suction enabling it to pump direct from the engine space in addition to the suction from the main bilge line. This direct bilge suction is to be controlled by a screw down non-return valve or equivalent.

2.13.6.11 Manual bilge pumps are to be capable of being operated from readily accessible positions above the water line.

2.13.6.12 As an alternative to fitting a bilge main, individual submersible pumps may be fitted. In this case the arrangements are to be in accordance with the requirements of Sections 2.7, 2.9 and 2.11 of this Chapter, as applicable.

2.14 Requirements for Non-passenger Craft of 150 GT or more with 'LC' or 'HSLC' Notation

2.14.1 General

2.14.1.1 The requirements of Sections, 2.1, 2.2, 2.10 and 2.11 of this chapter are generally applicable. The remaining sections concerning the requirements for bilge pumping and drainage systems are replaced by the requirements given in following sub-sections.

2.14.2 Bilge pumping and drainage systems

2.14.2.1 The following requirements replace Sections 2.3 to 2.9 of this chapter.

2.14.3 Drainage of compartments, other than machinery spaces

2.14.3.1 All craft are to be provided with efficient pumping plant having the suctions and means for drainage so arranged that any water within any compartment of the craft, or any watertight section of any compartment, can be pumped out through at least one suction when the craft is on an even keel and is either upright or has a list of not more than 5^{o}. For this purpose, wing suctions will generally be necessary, except in shot narrow compartments where one suction can provide effective drainage under the above conditions.

2.14.3.2 In the case of dry compartments, the suctions required by 2.14.3.1 are, except where otherwise stated, to be branch bilge suctions, i.e. suctions connected to a main bilge line.

2.14.4 Tanks and cofferdams

2.14.4.1 All tanks (including double bottom tanks), whether used for water ballast, oil fuel or liquid cargoes, are to be provided with suction pipes, led to suitable power pumps, from the after end of each tank.

2.14.4.2 In general, the drainage arrangements are to be in accordance with 2.14.3. However, where the tanks are divided by longitudinal watertight bulkheads or girders into two or more tanks, a single suction pipe, led to the after end of each tank, will normally be acceptable.

2.14.4.3 Similar drainage arrangements are to be provided for cofferdams, except that the suctions may be led to the main bilge line.

2.14.5 Fore and after peaks

2.14.5.1 Where the peaks are used as tanks, a power pump suction is to be led to each tank, except in the case of small tanks used for the carriage of domestic fresh water, where hand pumps may be used.

2.14.5.2 Where the peaks are not used as tanks, and main bilge line suctions are not fitted, drainage of both peaks may be effected by hand pump suctions, provided that the suction lift is well within the capacity of the pumps. Drainage of the after peak may be effected by means of a self-closing cock fitted in a well lighted and readily accessible position.

2.14.5.3 Pipes piercing the collision bulkhead are to be fitted with suitable valves secured to the bulkhead. The valves are to be operable from above the freeboard deck.

2.14.6 Spaces above fore peaks, after peaks and machinery spaces

2.14.6.1 Provision is to be made for the drainage of the chain locker and watertight compartments above the fore peak tank by hand or power pump suctions.

2.14.6.2 Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage, either by hand or power pump bilge suctions.

2.14.6.3 The compartments referred above may be drained by scuppers of not less than 38 mm bore, discharging to the tunnel or machinery space and fitted with self-closing cocks situated in well lighted and visible positions.

2.14.7 Maintenance of integrity of bulkheads

2.14.7.1 The intactness of the machinery space bulkheads and of tunnel plating required to be of watertight construction, is not to be impaired by the fitting of scuppers discharging to machinery space or tunnels from adjacent compartments which are situated below the bulkhead deck.

2.14.7.2 No drain valve or cock is to be fitted to the collision bulkhead. Drain valves or cocks are not to be fitted to other watertight bulkheads if alternative means of drainage are practicable.

2.14.8 Bilge drainage of machinery space

2.14.8.1 The bilge drainage arrangements in the machinery space are to comply with 2.14.3 except that the arrangements are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions when the craft is on an even keel, and is either upright or has a list of not more than 5 ^{o}. One of these suctions is to be a branch bilge suction, i.e. a suction connected to the main bilge line and the other is to be a direct bilge suction i.e. a suction led direct to an independent power pump.

2.14.9 Machinery space with double bottom

2.14.9.1 Where the double bottom extends the full length of the machinery space and forms bilges at the wings, it will be necessary to provide one branch and one direct bilge suction at each side.

2.14.9.2 Where the double bottom plating extends the full length and breadth of the compartment, one branch bilge suction and one direct bilge suction are to be led to each of two bilge wells, situated one at each side.

2.14.9.3 Where there is no double bottom and the rise of floor is not less than 5^{o}, one branch and one direct bilge suction are to be led to accessible positions as near the centre line as practicable.

2.14.10 Machinery space – Emergency bilge drainage

2.14.10.1 In addition to the bilge suctions detailed in 14.8 to 14.9, an emergency bilge suction is to be provided in each main machinery space. This suction is to be led to the main cooling water pump from a suitable low level in the machinery space and is to be fitted with a screw down non return valve having the spindle so extended that the hand wheel is not less than 460 mm above the bottom platform.

2.14.10.2 Where two or more cooling water pumps are provided, each capable of supplying cooling water for normal power, only one pump need be fitted with an emergency bilge suction.

2.14.10.3 Where main cooling water pumps are not suitable for bilge pumping duties, the emergency bilge suction is to be led to the largest available power pump, which is not a bilge pump.

2.14.10.4 Emergency bilge suction valve name plates are to be marked ‘For emergency use only’.

2.14.11 Sizes of bilge suction pipes

2.14.11.1 The diameter, d_m, of the main bilge line is to be not less than that required by the following formula, to the nearest pipe size of recognised standard, but in no case is the diameter to be less than that required for any branch bilge suction:

$$d_m = 1.68 \sqrt{L (B + D)} + 25 \text{ mm}$$

where,

d_m = internal diameter of main bilge line, in mm
B = greatest moulded breadth of craft, in metres
D = moulded depth to bulkhead deck, in metres
L = Rule length of craft in metres.

2.14.11.2 The diameter d_b, of branch bilge suction pipes to cargo and machinery spaces is to be not less than required by the following formula, to the nearest 5 mm, but in no case is the diameter of any suction to be less than 50 mm:

$$d_b = 2.15 \sqrt{C (B + D)} + 25 \text{ mm}$$

where.

d_b = internal diameter of branch bilge suction, in mm
C = length of compartment, in metres
B and D are as defined in 2.14.11.1.

2.14.11.3 The direct bilge suctions in the machinery space are not to be of a diameter less than that required for the main bilge line.

2.14.11.4 For sizes of emergency bilge suctions, see 2.14.10.

2.14.12 Distribution chest branch pipes

2.14.12.1 The area of each branch pipe connecting the bilge main to a distribution chest is to be not less than the sum of the areas required by the Rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

2.14.13 Pumps on bilge service and their connections

2.14.13.1 At least two power bilge pumping units are to be provided in the machinery space. One of these units may be worked from the main engines and the other is to be independently driven.

2.14.13.2 Each unit may consist of one or more pumps connected to the main bilge line, provided that their combined capacity is adequate.

2.14.13.3 A bilge ejector in combination with a high pressure sea water pump may be accepted as a substitute for an independent bilge pump as required by 2.14.3.1.

2.14.13.4 Special consideration will be given to the number of pumps for small craft and in general, if there is a class notation restricting a small craft to harbour or river service a hand pump may be accepted in lieu of one of the bilge pumping units.

2.14.14 General service pumps

2.14.14.1 The bilge pumping units, or pumps, required by 2.14.13 may also be used for ballast, fire or general service duties of an intermittent nature, but they are to be immediately available for bilge duty when required.

2.14.15 Capacity of pumps

2.14.15.1 Each bilge pumping unit is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of main bilge pipe of not less than 122 m/min.

2.14.15.2 The capacity of each bilge pumping unit or bilge pump is to be not less than required by the following formula:

$$Q = 5.75/10^3 \ d_m^2$$

where,

D_m = rule internal diameter of main bilge line, mm
Q = capacity, in m^3/hour.

2.14.15.3 Where one bilge pumping unit is of slightly less than Rule capacity, the deficiency may be made good by an excess capacity of the other unit. In general, the deficiency is to be limited to 30 percent.

2.14.16 Self-priming pumps

2.14.16.1 All power pumps, which are essential for bilge services are to be of the self-priming type, unless an approved central priming system is provided for these pumps. Details of this system are to be submitted.

2.14.16.2 Cooling water pumps having emergency bilge suctions need not to of the self-priming type.

2.14.17 Pump connections

2.14.17.1 The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

2.14.17.2 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any pumps so connected is unaffected by the other pumps being in operation at the same time.

2.14.18 Direct bilge suctions

2.14.18.1 The direct bilge suctions in the machinery space are to be led to independent power pumps, and the arrangements are to be such that these direct suctions can be used independently of the main bilge line suctions.

2.14.19 Main bilge line suctions

2.14.19.1 Suctions from the main bilge line, i.e. branch bilge suctions, are to be arranged to draw water from any hold or machinery compartment within the craft excepting small spaces such as those mentioned in 2.14.5 and 2.14.6 where manual pump suctions are accepted and are not to be of smaller diameter than that required by the formula in 2.14.11.2.

2.14.20 Prevention of communication between compartments

2.14.20.1 The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks. For this purpose, screw down non return valves are to be provided in the following fittings:

a) Bilge valve distribution chests;
b) Bilge suction hose connections, whether fitted direct to the pump or on the main bilge line;
c) Direct bilge suctions and bilge pump connections to main bilge line.

2.14.21 Isolation of bilge system

2.14.21.1 Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change over device to a bilge, ballast or oil line.

2.14.22 Machinery space suctions – Mud boxes

2.14.22.1 Suctions for bilge drainage in machinery spaces and tunnels, other than emergency suctions, are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges and having covers secured in such a manner as to permit their being expeditiously opened or closed., Strum boxes are not to be fitted to the lower ends of these tail pipes or to the emergency bilge suctions.

2.14.23 Hold suctions – Strum boxes

2.14.23.1 The open ends of bilge suctions in holds and other compartments outside machinery spaces and tunnels are to be enclosed in strum boxes having perforations of not more than 10 mm diameter, whose combined areas is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

2.14.24 Tail pipes

2.14.24.1 The distance between the foot of all bilge tail pipes and the bottom of the bilge well is to be adequate to allow a full flow of water and to facilitate cleaning.

2.14.25 Location of fittings

2.14.25.1 Bilge valves, cocks and mud boxes are to be fitted at, or above, the machinery space platforms.

2.14.25.2 Where relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform. The arrangements are to be such that any discharge from the relief valves will also be readily visible.

2.14.26 Bilge pipes in way of double bottom tanks

2.14.26.1 Bilge suction pipes are not to be led through double bottom tanks if it is possible to avoid doing so.

2.14.26.2 Bilge pipes which have to pass through these tanks are to have a minimum wall thickness of 6.3 mm. The thickness of pipes made from material other than steel will be specially considered.

2.14.26.3 Expansion bends, not glands, are to be fitted to these pipes within the tanks and the pipes are to be tested, after installation, to the same pressure as the tanks through which they pass.

2.14.27 Hold bilge non-return valves

2.14.27.1 Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

Section 3

Machinery Piping Systems

3.1 Application

3.1.1 The requirements of sub-sections 3.2 to 3.6 of this section apply to piping systems on mono-hull and multi-hull craft except where modified by Sections 3.7 to 3.9 as applicable.

3.1.2 Special requirements for multi-hull craft are given in sub-section 3.7.

3.1.3 These requirements satisfy the relevant design and construction requirements of the HSC Code. They are also applicable to craft with 'LC' or 'HSLC' notation of more than 150 GT which are not required to comply with the Code.

3.1.4 Requirements for passenger craft of Category A are given in sub-section 3.8.

3.1.5 Requirements for small craft of less than 150 GT which are not required to comply with the HSC Code are given in Section 3.9.

3.1.6 In addition to the requirements of this chapter, attention is to be given to any relevant statutory requirements of the National Authority of the country in which the craft is to be registered.

3.2 Oil Fuel Storage

3.2.1 Flash point

3.2.1.1 The flash point (closed cup test) of oil fuel for use in craft classed for unrestricted service is in general to be not less than 60^{o}C. For emergency generator engines, a flash point of not less than 43^{o}C is permissible.

3.2.1.2 Oil fuel with a flash point lower than 60^{o}C may be used in craft intended for restricted service where it can be demonstrated that the temperature of machinery spaces will always be 10^{o}C below the flash point of the oil fuel.

3.2.1.3 The use of oil fuel with a flash point below 43^{o}C is not recommended. However, oil fuel with a lower flash point, but not lower than 35^{o}C, may be used in gas turbines only subject to compliance with the provisions specified in sub-section 3.4.

3.2.2 Oil fuel storage arrangements

3.2.2.1 Tanks containing oil fuel and other flammable liquids are to be separated from passenger, crew and baggage compartments by vapour-proof enclosures or cofferdams which are suitably ventilated and drained.

3.2.2.2 Oil fuel tanks are not to be located in or adjacent to major fire hazard areas. However, other flammable liquids with a flash point not less than 60^{o}C may be located within such areas provided the tanks are made of steel or other equivalent material.

3.2.2.3 Oil fuel, lubricating oil and other flammable liquids are not to be carried forward of the area for which public spaces or crew accommodation are permitted.

3.2.2.4 No oil fuel tank is to be situated where spillage or leakage therefrom can constitute a hazard by failing on heated surfaces.

3.2.2.5 Safe and efficient means of ascertaining the amount of oil fuel contained in any oil fuel tank is to be provided.

3.2.2.6 Oil fuel tanks are to be provided with self-closing valves or cocks for draining water from the bottom of the tanks.

3.2.2.7 As far as practicable, all parts of the oil fuel system containing heated oil under pressure exceeding 2 bar are not to be placed in a concealed position such that defects and leakage cannot be readily observed. The machinery spaces in way of such parts of the oil fuel system are to be adequately illuminated.

3.2.3 Oil fuel storage arrangements for crafts with 'LC' or 'HSLC' notation of 150 GT or more

3.2.3.1 Oil fuel tanks are normally to be located outside machinery spaces and other areas of major fire hazard.

3.2.3.2 Where structural tanks are located adjacent to machinery spaces they are to be arranged such that the area of the tank common with the machinery space is kept to a minimum. In craft constructed of aluminium or other heat sensitive material the tanks are to be suitably protected against the effect of fire in the machinery space.

3.2.3.3 Where free standing tanks are fitted in machinery spaces they are to be of steel or equivalent material and positioned in an oil tight drip tray of ample size having suitable drainage arrangements to a spill oil tank.

3.2.3.4 The requirements of 3.2.2.4 to 3.2.2.7 are to be complied with.

3.2.4 Unattended machinery

3.2.4.1 Where machinery is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, the requirements of 3.2.4.2 to 3.2.4.5 apply.

3.2.4.2 Where daily service tanks are filled automatically or by remote control, means are to be provided to prevent overflow spillages.

3.2.4.3 Other equipment which treats flammable liquid automatically, such as oil fuel purifiers, are to have arrangements to prevent spillage of the liquid through overflow or malfunction of seals.

3.2.4.4 Alarms are to be provided for purifier broken water seal and high oil inlet temperature.

3.2.4.5 Where daily service oil fuel tanks of settling tanks are fitted with heating arrangements, a high temperature alarm is to be provided if the flash point of the oil can be exceeded.

3.3 Oil Fuel Systems

3.3.1 Oil fuel supply to main and auxiliary engines

3.3.1.1 Two or more filters are to be fitted in the oil fuel supply lines to the main and auxiliary engines, and the arrangements are to be such that any filter can be cleaned without interrupting the supply of filtered oil fuel to the engines.

3.3.2 Booster pumps

3.3.2.1 Where an oil fuel booster pump is fitted, which is essential to the operation of the main engine, a standby pump is to be provided.

3.3.2.2 The standby pump is to be connected ready for immediate use, but where two or more main engines are fitted, each with its own pump, a complete spare pump may be accepted provided that it is readily accessible and can easily be installed.

3.3.3 Fuel valve cooling pumps

3.3.3.1 Where pumps are provided for fuel valve cooling, the arrangements are to be in accordance with 3.3.2.1 and 3.3.2.2.

3.3.4 Transfer pumps

3.3.4.1 Where a power driven pump is necessary for transferring oil fuel, a standby pump is to be provided and connected ready for use. The standby pump may be a manual pump. Alternatively, emergency connections may be made to another suitable power driven pump.

3.3.5 Control of pumps

3.3.5.1 All independently driven oil fuel transfer and pressure pumps are to be capable of being stopped locally and from a position outside of the space in which they are located. The remote stop position is always to be accessible in the event of fire occurring in the space in which these pumps are located.

3.3.6 Relief valves on pumps

3.3.6.1 All pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves. Each relief valve is to be in close circuit, i.e. arranged to discharge back to the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system.

3.3.7 Pump connections

3.3.7.1 Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

3.3.8 Low pressure pipes

3.3.8.1 Transfer, suction and other low pressure pipes and all pipes passing through oil storage tanks are to be suitable for a working pressure of not less than 7 bar.

3.3.9 Valves on deep tanks and their control arrangements

3.3..9.1 Every oil fuel suction pipe from a storage, settling and daily service tank situated above the double bottom and every oil fuel leveling pipe within the machinery space is to be fitted with a valve or cock secured to the tank.

3.3.9.2 In machinery spaces such valves and cocks are to be capable of being closed locally and from positions outside these spaces which will always be accessible in the event of fire occurring in these spaces. Instructions for closing the valves or cocks are to be indicated at the valves and cocks and at the remote control positions.

3.3.9.3 In the case of tanks of less than 0.5 m^3, consideration will be given to the omission of remote controls.

3.3.9.4 Every oil fuel suction pipe which is led into the machinery spaces, from a deep tank outside these spaces is to be fitted in the machinery space with a valve controlled as in 3.3.9.2 except where the valve on the tank is already capable of being closed from an accessible position above the bulkhead deck.

3.3.9.5 Where the filling pipes to deep oil tanks are not connected to the tanks near the top, they are to be provided with non-return valves at the tanks or with valves or cocks fitted and controlled as in 3.3.9.2.

3.3.10 Filling arrangements

3.3.10.1 Filling stations are to be isolated from other spaces and are to be efficiently drained and ventilated.

3.3.10.2 Provision is to be made against over pressure in the filling pipelines. Any relief valve fitted for this purpose is to discharge to an overflow tank or other safe position.

3.4 Low Flash Point Fuels

3.4.1 General

3.4.1.1 For craft having oil fuel with a flash point below 43^{o}C the arrangements for the storage, distribution and utilisation of the oil fuel are to be such that the safety of the craft and persons on board is preserved, having regard to fire and explosion hazards. The arrangements are to comply with Sections 3.2 and 3.3 and 3.4.1.3 to 3.4.1.6

3.4.1.2 Tanks for the storage of such oil fuel are to be located outside any machinery space and at a distance of not less than 760 mm inboard from the shell and bottom plating, and from decks and bulkheads.

3.4.1.3 The spaces in which oil fuel tanks are located are to be mechanically ventilated using exhaust fans providing not less than six air changes per hour. The fans are to be such as to avoid the possibility of ignition of flammable gas air mixtures. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings. The outlets for such exhausts are to discharge to a safe position.

3.4.1.4 A fixed vapour detection system is to be installed in each space through which oil fuel lines pass, with alarms provided at a continuously manned control station.

3.4.1.5 Safe and efficient means of ascertaining the amount of oil fuel contained in any tank is to be provided. Gauge glasses are not to be used. Other means of ascertaining the amount of oil fuel contained in any tank may be permitted if such means do not require penetration below the top of the tank, and providing their failure or overfilling of the tanks will not permit the release of oil fuel.

3.4.1.6 Vessel to shore oil fuel connections are to be of closed type and suitably grounded during bunkering operations.

3.4.1.7 Provision to be made to prevent overpressure in oil tank or oil fuel system, including filling pipes. Relief valves and air or overflow pipes to terminate with flame arrestors.

3.5 Lubricating / Hydraulic Oil Systems

3.5.1 Lubricating oil arrangements

3.5.1.1 The arrangements for the storage, distribution and utilisation of oil used in pressure lubrication systems in machinery spaces and whenever practicable in auxiliary machinery spaces are to comply with the provisions of same as fuel storage.

3.5.1.2 The use of aluminium in lubricating oil sump tanks for engines or in lubricating oil filter housing fitted integral with the engines is accepted.

3.5.2 Arrangements for other flammable oils

3.5.2.1 The arrangements for storage, distribution and utilisation of other flammable oils employed under pressure in power transmission systems, control and activating systems and heating systems in locations where means of ignition are present are to comply with the provisions of fuel oil storage.

3.5.3 Lubricating/hydraulic oil standby arrangements

3.5.3.1 Where lubricating oil for the main engine(s) is circulated under pressure, a standby lubricating oil pump is to be provided where the following conditions apply:

a) The lubricating oil pump is independently driven and the total output of the main engine(s) exceeds 370 kW.
b) One main engine with its own pump is fitted and the output of the engine exceeds 370 kW.
c) More than one engine each with its own lubricating oil pump is fitted and the output of each engine exceeds 370 kW.

3.5.3.2 The standby pump is to be of sufficient capacity to maintain the supply of oil for normal conditions with any one pump out of action. The pump is to be fitted and connected ready for immediate use, except that where the conditions referred to in 3.5.3.1(c) apply, a complete spare pump may be accepted. In all cases, satisfactory lubrication of the engines is to be ensured while starting and manoeuvring.

3.5.3.3 Similar provisions to those of 3.5.3.1 and 3.5.3.2 are to be made where separate lubricating/hydraulic oil systems are employed for piston cooling, reduction gears, oil operated couplings controllable pitch propellers and steering systems etc. unless approved alternative arrangements are provided.

3.5.3.4 Independently driven pumps of rotary type are to be fitted with a non-return valve on the discharge side of the pump.

3.6 Engine Cooling Water Systems

3.6.1 General

3.6.1.1 The cooling arrangements provided are to be adequate to maintain all lubricating and hydraulic fluid temperatures within the manufacturer’s recommended limits.

3.6.2 Main supply

3.6.2.1 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to the lubricating oil and fresh water coolers and air coolers for electric propelling machinery, where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

3.6.3 Standby supply

3.6.3.1 Provisions is also to be made for a separate supply of cooling water from a suitable independent pump of adequate capacity.

3.6.3.2 The following arrangements are acceptable depending on the purpose for which the cooling water is intended:

a) Where only one main engine is fitted, the standby pump is to be connected ready for immediate use.
b) Where more than one main engine is fitted, each with its own pump, a complete spare pump of each type may be accepted.
c) Where fresh water cooling is employed for main and/or auxiliary engines, a standby fresh water pump need not be fitted if there are suitable emergency connections from a salt water system.
d) Where each auxiliary engine is fitted with a cooling water pump, standby means of cooling need not be provided. Where, however, a group of auxiliary engine is supplied with cooling water from a common system, a standby cooling water pump is to be provided for this system. This pump is to be connected ready for immediate use and may be a suitable general service pump.

3.6.4 Selection of standby pumps

3.6.4.1 When selecting a pump for standby purposes, consideration is to be given to the maximum pressure which it can develop if the overboard discharge valve is partly or fully closed. Where necessary, water boxes etc. are to be protected against inadvertent over pressure by an approved device.

3.6.5 Relief valves on main cooling water pumps

3.6.5.1 Where cooling water pumps can develop a pressure head greater than the design pressure of the system, they are to be provided with relief valves on the pump discharge to effectively limit the pump discharge pressure to the design pressure of the system.

3.6.6 Sea inlets

3.6.6.1 Not less than two sea inlets are to be provided for the pumps supplying the sea water cooling system, one for the main pump and one for the standby pump. Alternatively, the sea inlets may be connected to a suction line available to main and standby pumps.

3.6.6.2 Where standby pumps are not connected ready for immediate use the main pump is to be connected to both sea inlets.

3.6.6.3 The auxiliary cooling water sea inlets are to be located one on each side of the craft.

3.6.7 Strainers

3.6.7.1 Where sea water is used for the direct cooling of the main engines and essential auxiliary engines, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply.

3.7 Special Requirements for Multi-hull Craft

3.7.1 General

3.7.1.1 The requirements of sections 3.2 to 3.6 are generally applicable to multi-hull craft except where these are modified by the requirements of this section.

3.7.1.2 Where the machinery piping arrangements in each hull of a multi-hull craft are separate, the machinery piping and standby requirements for each hull are to be as detailed in 3.5.3.1(c) and 3.6.3.2(b), i.e. the requirements for a twin engined mono-hull and craft apply.

3.7.1.3 Where a multi-hull craft cannot navigate safely with the main propulsion machinery in one hull out of action, the machinery piping and standby requirements are to be as detailed in 3.5.3.1(a) or (b), and 3.6.3(a), i.e. the requirements for a single engined mono-hull craft apply to the machinery in each hull.

3.8 Requirements for Passenger craft of Category-A

3.8.1 General

3.8.1.1 The requirements of sub-sections 3.2 to 3.7 except that the standby machinery arrangements detailed in sub-sections 3.5 and 3.6 are not required.

3.9 Requirements for Craft with ‘LC’ or ‘HSLC’ Notation of less than 150 GT

3.9.1 General

3.9.1.1 The requirements for this sub-sections replace sub-section 3.2 to 3.6 of this section.

3.9.2 Oil fuel system

3.9.2.1 Where a power driven oil fuel transfer pump is fitted, it is to be capable of being stopped from a position outside the space which will always be accessible in the event of fire occurring in the compartment in which the pump is situated, as well as from the compartment itself.

3.9.2.2 Where a power driven pump is necessary for transferring oil fuel, a standby pump is to be provided and connected ready for use.

3.9.3 Separate oil fuel tanks

3.9.3.1 Except for very small tanks separate oil fuel tanks are to be not less than 3 mm in thickness. The seams are to be welded or brazed. Steel tanks are to be protected from corrosion.

3.9.3.2 Before installation, all tanks are to be tested by a head of water equal to the maximum to which the tanks may be subjected, but not less than 3.5 m above the crown of the tank.

3.9.3.3 Separate oil fuel tanks are to be securely fixed in position and located as remote as practicable from exhaust manifolds and exhaust pipes or other hot surfaces and not above any electrical apparatus. Where this cannot be avoided, a drip tray is to be fitted under the tank and extended sufficiently to catch any drips from fittings attached to the tank.

3.9.3.4 Oil fuel tanks are not to be fitted above or adjacent to oil fired heaters, cooking stoves, equipment using naked flames or electrical equipment unless this is suitably constructed or enclosed.

3.9.4 Oil fuel filling, air and sounding arrangements

3.9.4.1 The filling pipe is to be of metallic construction and is to be a permanent fixture led from the deck and secured to the tank by an approved connection. A screwed cap and name plate inscribed “Oil Fuel” is to be provided at the filling point.

3.9.4.2 Flexible hoses are not permitted as filling pipes. In wood or composite craft short lengths may be employed at the deck connection to accommodate any movement between the tank and the deck fitting.

3.9.5 Oil fuel supply

3.9.5.1 Provision is to be made for efficient filtration of the oil fuel supply to the engine.

3.9.6 Oil fuel valves and cocks

3.9.6.1 Outlet valves or cocks are to be fitted to all deep tanks. The valves are to be fitted directly to the tank plating and are to be capable of being closed locally and from positions which will always be readily accessible in the event of fire.

3.9.6.2 Valve covers are to be so constructed that they will not become slack when the valves are operated.

3.9.6.3 Heat sensitive materials are not to be used in the construction of valves and cocks.

3.9.6.4 Where drain cocks or valves are fitted to oil fuel tanks they are to be of the self-closing type and suitable provision is to be made for collecting the oil discharge.

3.9.7 Flexible hoses for oil fuel systems

3.9.7.1 Where necessary, flexible pipes of approved type may be used as short joining lengths to the engine.

3.9.8 Pipe joints for oil fuel systems

3.9.8.1 Where flanged joints are used the jointing material is to be impervious to oil. Cone type joints and approved types of compression fittings may be permitted for pipes having a bore not exceeding 40 mm.

3.9.8.2 Soft solder is not to be used for attaching pipe fittings.

3.9.9 Engine cooling system

3.9.9.1 Where sea water is used for the direct cooling of the engine, an efficient strainer which can be cleared from inside the craft is to be fitted between the sea inlet valve and the pump.

3.9.9.2 Means are to be provided for cleaning the strainer without interruption to the cooling water supply, where necessary.

3.9.9.3 Means are to be provided for indicating the temperature of the engine cooling media.

3.9.9.4 Alarms for the engine cooling water system are to be provided in accordance with Chapter 14.

3.9.10 Lubricating oil system

3.9.10.1 Where the lubricating oil for main propelling engines is circulated under pressure, provision is to be made for the efficient filtration of the oil.

3.9.10.2 Where necessary, flexible pipes of approved type may be used as short joining lengths to the engine.

3.9.10.3 In general, joints are to be of the flanged type with jointing materials which are impervious to oil. Cone type joints and approved types of compression fittings may be permitted for pipes having a bore not exceeding 40 mm.

3.9.10.4 Soft solder is not to be used for attaching pipe fittings.

3.9.10.5 Means are to be provided for indicating the lubricating oil pressure.

3.9.10.6 Alarms for the lubricating oil systems are to be provided in accordance with Chapter 14.

End Of Chapter

Chapter 12

Main and Auxiliary Machinery

Contents	
Section	
1	General Requirements for Machinery
2	Propulsion Shafting Systems
3	Prime Mover and Gearing
4	Propeller, Thruster, Water Jet System
5	Pressure Vessels

Section 1

General Requirements for Machinery

1.1 Application

1.1.1 Sections 2 to 5 apply to the design, construction, installation and testing of:

Main propulsion machinery systems;
Essential auxiliary machinery systems having powers in excess of 100 kW;

together with their associated equipment, pressure plant, piping systems, control engineering and electrical engineering systems for the craft types stated in Chapter 1.

1.1.2 The rules incorporate those requirements of the international convention for the Safety of Life at Sea, 1974 as amended (SOLAS 1994) Chapter X – Safety Measures for High Speed Craft (International Code of Safety for High Speed Craft) hereinafter referred to as the HSC Code, as applicable to the classification of craft with HSC notation.

1.1.3 Requirements for crafts to be assigned ‘LC’ or ‘HSLC’ notation are given at the end of each section. Crafts with 150 GT or greater and with less than 150 GT are considered separately.

1.1.4 These Rules are applicable for machinery systems burning distillate fuels which do not require to be heated.

1.2 General

1.2.1 The units and formulae used in the rules are in SI units.

1.2.2 It is the responsibility of the Shipbuilder as main contractor to ensure that the information required is prepared and submitted.

1.2.3 Where the craft is defined as a Passenger Craft of Category (B) (see Chapter 1, Section 2), sufficient redundancy is to be provided such that in the event of damage to any part of a main propulsion drive system, the craft is able to maintain sufficient seaway. The craft should be capable of maintaining the essential machinery and control so that in the event of a fire or other casualties in one compartment on board, the craft can return to a port of refuge under its own power.

1.2.4 Sufficient astern power is to be provided to maintain control of the craft in all normal circumstances.

1.2.5 The main propulsion machinery will be approved for the maximum continuous power and associated shaft speed, required to achieve the maximum craft velocity at the certified maximum operational weight in smooth water.

1.2.6 Main propulsion machinery will be considered for operation at a higher power rating than the classification rating for short time intervals (referred to as short term high power operation) in conjunction with the intended operation service profile.

1.3 Fuel flash point

1.3.1 The flash point (closed cup test) of oil fuel is in general to be not less than 60°C. For emergency generator engines a flash point of not less than 43°C is permissible.

1.3.2 Oil fuel with a flash point lower than 60°C may be used where it can be shown that the temperature of the oil fuel will always be not more than 10°C below its flash point.

1.3.3 The use of fuel with a flash point below 43°C is not recommended. However, fuel with a lower flash point, but not lower than 35°C, may be used in gas turbines only, subject to compliance with the provisions in Chapter 10, Section 2.7.7.

1.4 Exhaust

1.4.1 All engines exhaust systems to be adequate to ensure the correct functioning of the machinery and the safe operation of the craft is not put at risk.

1.4.2 Where the surface temperature of the exhaust pipes and silencer may exceed 220°C, they are to be water cooled or efficiently lagged to minimise the risk of fire and to prevent damage by heat. Where lagging covering the exhaust piping system including flanges is oil-absorbing or may permit penetration of oil, the lagging is to be encased in sheet metal or equivalent. In locations where the Surveyor is satisfied that oil impingement could not occur, the lagging need not be encased.

1.5 Bearings

1.5.1 Roller element bearings are to have an L_{10h} design life of at least 30,000 hours, based upon the design operating conditions, including short term high power operation. An L_{10h} design life of less than 30,000 hours would be accepted, provided it is proposed in conjunction with the manufacturer's design/maintenance manual.

Note : L_{10h} is the basic rating life in hours which 90% of a sufficiently large group of apparently identical bearings is expected to attain.

1.6 Vibration of shaft systems

1.6.1 The shipbuilders are to ensure that the systems are free from excessive vibrations, excessive bearing reactions and excessive bending moments under all design operating conditions.

1.6.2 Where changes are subsequently made to a dynamic system which has been approved by IRS e.g. machining a shaft, fitting a propeller of a different design to the working propeller or fitting a different flexible coupling, full details of the changes are to be advised. Revised calculations may be required to be submitted.

1.6.3 Where there is experience of previous similar systems which have been approved, full details of these installations may be submitted for consideration in lieu of calculations.

1.7 Alternative system of survey

1.7.1 Where items of machinery are manufactured as individual or series produced units, IRS will give consideration to the adoption of a survey procedure based upon an approved quality assurance system to ISO 9001 (or equivalent) utilizing regular and systematic audits of the approved manufacturing and quality control processes and procedures as an alternative to the direct survey of individual components.

1.8 Submission of information

1.8.1 At least three copies of plans, information and specifications as listed are to be submitted.

1.9 Plans

1.9.1 Plans are to indicate clearly the scantlings and materials of construction. Any design alteration to the plan is to be resubmitted for approval, indicating clearly the alteration.

1.9.2 Individual chapters also list plans to be submitted for specific machinery systems or components.

1.9.3 Where machinery system components have been approved under IRS's Type Approval System or Machinery General Design Appraisal for the proposed design conditions or service, plans of the component will not be required to be submitted for individual new buildings. Full details of the components are to be advised.

1.9.4 Plans showing the arrangement of resiliently mounted machinery are to indicate the number, position, type and design of mounts.

1.9.5 The plans of arrangement of resin chocks for machinery requiring accurate alignment are to be submitted.

1.10 Calculations and specifications

1.10.1 Relevant data covering the following topics is to be submitted.

1.10.2 **Service Profile** : The machinery power / speed operational envelope indicating all the intended operational points applicable to the class notation and any short term high power operation.

1.10.3 **Classification Rating** : The following operational parameters, using the design conditions for the intended Class Notation:

- Total barometric pressure, bar.
- Temperature of engine room or suction air, ^{o}C.
- The relative humidity, percent.
- Temperature of sea water, or charge air coolant inlet, ^{o}C.

For unrestricted service the operational parameters ambient reference conditions are to be taken as:

- Total barometric pressure, 1000 mb.
- Temperature of engine room or suction air, 45^{o}C.
- Relative humidity, 60 percent.
- Temperature of sea water or charge air coolant inlet, 32^{o}C.

1.10.4 **Short term high power operation**. Where the propulsion machinery is being considered for short term high power operation full details of the power, speed and time intervals together with fatigue endurance calculations, and documentary evidence indicating the suitability of the component design under these conditions and for the intended class notation are required. The following are to be considered prime mover, gearbox, flexible coupling, vibration dampers, shafting and propeller.

a) The accrued number of load cycles and the percentage overload are to be those recommended by the designers.

b) Excessive overload may require the interval between surveys to be reduced.

c) Machinery is to be maintained in accordance with manufacturer's requirements.

1.10.5 **Damper and flexible coupling characteristics**. Documentary evidence that the characteristics have been verified.

1.10.6 **Machinery fastening**

a) Documentary evidence and calculations indicating that machinery is securely mounted for the accelerations to be expected during service.

b) Calculations that mountings of large masses such as main engines, auxiliary engines, lift fans and electrical equipment can withstand the design collision acceleration according to 1.15.1 without fracturing.

c) Natural frequency calculation of resilient mounted machinery.

d) For non-metallic machinery chocks.

   i) Resin type.
   ii) The effective area and minimum thickness of the chocks.
   iii) The total deadweight loading of machinery.
   iv) The thrust load, where applicable, that will be applied to the chocked item.
   v) The loading to be applied to the holding-down bolts.
   vi) The material of the holding-down bolts.
   vii) The number, thread size and waisted shank diameter (where applicable) of the holding-down bolts.

1.10.7 **Manuals**. The operation and maintenance manuals.

1.10.8 **Failure mode and effect analysis**. Where required for high speed craft, a FMEA is to be carried out as per Annexure 3 covering the following systems:

a) Main and auxiliary machinery systems and their controls.
b) Steering systems.

c) Electrical systems.

1.10.9 **Fatigue strength analysis**. Where undertaken as an alternative to the requirements of the individual chapters, fatigue strength analysis of components indicating a factor of safety of 1.5 at the design loads based on a suitable fatigue failure criteria. The effects of stress concentrations, material properties and operating environment are to be taken into account.

1.11 Certification of materials

Materials of construction

1.11.1 Materials used in the construction are to be in accordance with or shown to be equivalent, to Part 2 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'. Details of all materials included and not included in Part 2 are to be forwarded as soon as possible (preferably at the design concept stage) and before commencement of manufacture.

1.12 Operating control

Machinery control

1.12.1 The design and arrangement is to be such that the machinery can be started and controlled on board, without external aid, so that the operating conditions for which the craft is classed, can be maintained.

1.13 Inclination of the craft

1.13.1 The main and auxiliary machinery is to be designed and installed such that it operates satisfactorily under the conditions as shown in Table 1.13.1.

1.13.2 The arrangements for lubricating bearings and for draining crankcase and other oil sumps of main and auxiliary engines, gearcases, electric generators, motors and other running machinery are to be so designed that lubrication will remain efficient with the craft inclined under the conditions as shown in Table 1.13.1.

1.13.3 Deviations from these conditions may be accepted taking into consideration type and size of the craft and the class notation. The shipbuilder is to ensure that the main and auxiliary machinery is capable of operating at the proposed angles of inclination.

1.14 Securing of machinery

Fastenings

1.14.1 Bedplates, thrust seatings and other fastenings are to be of robust construction. The machinery is to be securely fixed to the craft's structure, such that the arrangement is sufficient to restrain the dynamic forces arising from vertical and horizontal acceleration appropriate to the intended service.

Table 1.13.1 : Inclinations

Installations, components	Angle of inclination, degrees (see Note 1)			
	Athwartship		Fore-and-aft	
	Static	Dyna-mic	Static	Dyna-mic
Main and auxiliary machinery essential to the propulsion and safety of the craft	15	22.5	5 (see Note 2)	7.5
Emergency machinery and equipment fitted in accordance with statutory requirements	22.5	22.5	10	10

Notes:
1. Athwartships and fore-and-aft inclination may occur simultaneously.
2. Where the length of the craft exceeds 100 m, the fore-and-aft static angle of inclination may be taken as:
   500/L degrees

where,
L = Length of craft, in metres

1.15 Collision load

1.15.1 Unless an accurate analysis of the collision load is submitted and found acceptable by IRS, the collision load is to be determined from:

g (collision) = $1.2\ P/(\Delta g)$

where the load P is taken as the lesser of:

$P = 460\ (M \cdot C_L)^{2/3}\ (E.C_H)^{1/3}\ [kN]$

$P = 9000\ M.C_L\ [C_H\ (T+2)]^{1/2}\ [kN]$

where,

C_H = a factor given in Table 1.15.1

$$C_L = \frac{(165 + L)}{245} \cdot \left(\frac{L}{80}\right)^{0.4}$$

D = craft depth, in metres, from the underside of keel amidships to the top of effective hull girder for catamarans and surface effect ships.

$E = 0.5\ \Delta\ V^2\ [kNm]$

H_T = minimum height, in metres, from tunnel or wet-deck bottom to the top of effective hull girder for catamarans and surface effect ships

= D for air cushion vehicles

L = craft length, in metres.
M = 1.3 for high tensile steel
M = 1.0 for aluminium alloy
M = 0.95 for mild steel
M = 0.8 for fibre reinforced plastics
T = buoyancy tank clearance to skirt tip, in metres, (negative) for ACVs.
= lifted clearance from keel to water surface, in metres, (negative) for hydrofoils
= craft draught to the underside of keel amidships, in metres, for all other craft.
V = operational speed of craft [m/s]
g = gravitational acceleration = 9.806 [m/s^2]
Δ = craft displacement, to be taken as the mean of the lightweight and maximum operational weight, in tonnes.

Table 1.15.1 : Factor C_H

Factor C_H	**Catama-rans/SES**	**Mono-hulls, H.Foils**	**ACVs**
C_H	$\frac{T + 2 + f(D/2)}{2D}$	$\frac{T + 2 + f(D/2)}{2D}$	$\frac{f}{4}$
Where f = 0 for f = 1 for f = 2 for	 $T+2<D-H_T$ $D>T+2\geq D-H_T$ $T+2\geq D$	 $T+2<D$ $T+2\geq D$	 - $H_T>2$ $H_T\leq 2$

1.16 Resilient mounts

1.16.1 Creep of rubber mounts and the effects on the alignments are also to be considered.

1.16.2 Shafting, piping connections and electrical cable connections are to be provided with sufficient flexibility to accommodate such movements. Particular attention should be paid to exhaust bellows and the effectiveness of flexible couplings.

1.16.3 Limit stops are to be fitted as necessary to ensure that manufacturers' limits are not exceeded. Suitable means are to be provided to accommodate propeller thrust.

1.16.4 Mounts are to be shielded from the possible detrimental effects of oil.

1.17 Machinery mounted on resin chocks

1.17.1 These Rules relate to the application of synthetic resin compounds as materials for chocks under machinery components where accurate alignments is important, e.g. main engine, gearbox and auxiliary installations where the engine and generator do not share a common baseplate.

1.17.2 Resin compounds used in these applications are to be of a type accepted by IRS.

1.17.3 The use of resin for chocking gas turbine casings or similar high temperature applications will not be considered.

1.18 Ventilation system

1.18.1 Machinery spaces to be adequately ventilated so as to ensure that when machinery therein is operating at full power in all weather conditions including heavy weather, an adequate supply of air is maintained. Ventilation system to be adequate to ensure that safe operation of the craft is not put at risk.

1.18.2 Ventilation to be sufficient under all normal conditions to prevent accumulation of oil vapour.

1.19 Recovery from dead craft condition

1.19.1 Means shall be provided to ensure that machinery can be brought into operation from the dead craft condition without external aid.

1.19.2 Dead craft condition for the purpose of 1.19.1 is to be understood to mean a condition under which the main propulsion plant and auxiliaries are not in operation and, in restoring the propulsion, no stored energy is assumed to be available for starting and operating the propulsion plant, the main source of electrical power and other essential auxiliaries. It is assumed that means are available at all times to start the emergency generator or one of the main generators when the main source is arranged according to Ch.13, 3.1.2.

1.19.3 Where the emergency source of power is an emergency generator which complies with Ch.13, Sec.3.4 or a main generator meeting the requirements of Ch.13, 3.1.2, it is assumed that means are available to start this generator and consequently this generator may be used for restoring operation of the main propulsion plant and auxiliaries where any power supplies necessary for engine operation are also protected to a similar level as the starting arrangements.

1.19.4 Where there is no emergency generator installed or an emergency generator does not comply with Ch.13, Sec.3.4, the arrangements for bringing main and auxiliary machinery into operation are to be such that initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed on board the craft without external aid. If for this purpose an emergency air compressor or electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor.

1.19.5 The arrangements for bringing main and auxiliary machinery into operation are to have a capacity such that the starting energy and any power supplies for engine operation are available within 30 minutes of dead craft condition.

1.20 Requirements for craft with ‘LC’ or ‘HSLC’ notation

1.20.1 Plans and particulars

1.20.1.1 At least three copies of the following plans are to be submitted for approval at the earliest opportunity:

- Crankshaft including details of the material specification.
- Gearing including details of the material specification.
- Arrangement and details of the propulsion shafting, couplings and bearing disposition etc.
- Propeller where the diameter exceeds 1 m.
- Diagrammatic arrangements of the exhaust systems indicating the materials, methods of cooling and if water spray injected, the method of draining.
- Starting air system and receivers.
- Diagrammatic arrangements of pumping and piping systems including the air and sounding pipes for the tanks.
- Diagrammatic arrangements of bilge and fire pumps and piping for craft having a rules length of 12 m and over and subdivided into watertight compartments.
- Diagrammatic arrangement of oil fuel piping.
- Construction arrangements of separate oil fuel tanks having a capacity exceeding 250 litres.
- Electrical equipment as detailed in Chapter 13.
- Steering gear machinery and hydraulic circuit diagram if applicable.
- Fire extinction equipment as detailed in Chapter 10.
- Safety plan showing the position of all fire prevention controls, fixed and loose equipment, portable extinguishers.
- Control circuits and alarm points as detailed in Chapter 14.

1.20.1.2 The following particulars are to be submitted with the plans of crankshaft, gearbox or shafting as applicable:

- Name of manufacturer
- Type designation
- Particulars of engine cycle
- Number of cylinders and vee angle where applicable.
- Maximum combustion pressure and mean indicated pressure.
- Span of bearings adjacent to a crank measured from centerline of the bearing to the centerline of the adjacent bearing.
- Proposed shaft power (kW) and revolutions per minute of the engine at each operating condition.
- Gear box reduction ratio.
- For engines over 500 kW, see Section 3.

1.20.1.3 Where machinery system components or equipment have been approved under IRS’s Type Approval System or Machinery Design Appraisal for the proposed design conditions or intended service, full details of the components should be advised to enable the validity of the approval to be checked. In cases where valid approvals are confirmed, plans are not required to be submitted for approval for individual craft.

1.20.2 Calculations

1.20.2.1 Design calculations are to be submitted for the following systems and conditions:

a) Direct calculation for design strength of machinery supports, such as engine mountings, on craft subjected to high accelerations, see Section 1.14.

b) Calculations of torsional, axial or lateral vibrations where the engine power exceeds 200 kW.

c) Calculations for any fixed gas or water fire smothering systems for machinery space, See Chapter 10.

1.20.3 Certification of materials

1.20.3.1 The requirements of Part 2 of the 'Rules and Regulations for the Construction and Classification of Steel Ships', apply to all types of craft.

1.20.3.2 Where no provision is made in these Rules, materials may be accepted provided that they comply with an approved specification and such tests as may be considered necessary by the Surveyor.

1.20.3.3 The requirements for materials for machinery components are indicated in the relevant Part or Chapter of the Rules.

1.20.4 Operating conditions

1.20.4.1 The requirements of 1.13 do not apply to crafts with 'LC' or 'HSLC' notation of less than 150 GT.

1.20.4.2 For 'LC' or 'HSLC' craft of 150 GT or greater, the main and auxiliary machinery is to be designed to operate under the conditions defined in Sections 1.12, 1.13, 1.14, 1.15, 1.16 and 1.17.

1.20.4.3 If operation under the required accelerations cannot be demonstrated on trials, alternative documentary evidence is to be presented to confirm that the machinery is capable of operating under such conditions.

1.20.4.4 Additional trials or conditions may be imposed to prove the machinery as considered necessary.

1.20.5 Securing of machinery

1.20.5.1 Crafts with 'LC' or 'HSLC' notation of less than 150 GT do not have to comply with 1.15. These craft are, in general, to have rigid engine seatings constructed integral with the craft. The arrangements are to permit easy access to any fittings such as lubricating oil connections, bilge suctions and sea cocks.

1.20.5.2 Where the hull is constructed of FRP, wood or composites and the hull surfaces are not adequately protected against oil contamination, drip trays are to be fitted under those parts of the engine and gearbox where leakage of oil fuel or lubricating oil might occur. Means are to provided for removing any leakage easily.

1.20.5.3 Where resilient mounts are fitted, the name of the manufacturer and details of the type of mounting are to be indicated on the plan of the shafting.

1.20.5.4 Satisfactory arrangements are to be made to transmit the propulsion thrust into the craft structure.

1.20.6 Ventilation of machinery spaces

1.20.6.1 For crafts with 'LC' or 'HSLC' notation of less than 150 GT the ventilation of the machinery space is to be adequate for all conditions of the operation of the machinery and in no case is to be less than that required by the engine manufacturer.

1.20.6.2 The engine compartment is to be provided with inlet and outlet ventilating ducts. One or more inlet ducts are to extend down to a suitable low level.

1.20.6.3 Outlet ducts are to be connected near or at the top of the compartment and are to be arranged for natural or mechanical extraction as necessary.

1.20.6.4 Consideration will be given to equivalent alternative arrangements provided full details are submitted before construction is commenced.

1.21 Surveys during construction

1.21.1 Machinery is to be surveyed at the manufacturer's works from the commencement of work until the final test under working conditions. The Surveyors are to be satisfied that the materials, workmanship and arrangements are satisfactory and in accordance with the Rules.

1.21.2 IRS requirements for the conditions of manufacture, survey and certification of materials used for the production of forged steel and castings used in the production of components are given in Part 2.

1.21.3 Resilient mounts are to be installed under survey and the machinery tested under full working conditions.

1.21.4 Alignment of machinery is to be checked after the first six months of operation.

1.22 Sea trials

1.22.1 Sea trials are to be of sufficient duration and carried out under normal operating conditions applicable to the intended class notation. Individual chapters give specific requirements.

1.22.2 Sea trials are to include the demonstration of:

a) The adequacy of the starting arrangements of the main engines, auxiliary systems and emergency generators.

b) The effectiveness of the steering gear control systems.

c) Manoeuvring, to include:

- Starting;
- Normal and emergency stopping;
- Reversing;
- governor testing;
- Safety devices and associated indicators and alarms.

d) The redundancy arrangements for Category B craft.

e) Tooth contact markings in geared installations using a recognised technique. The marking is to be as detailed in 3.3.2.10.

f) For controllable pitch propellers, the pitch setting under failure conditions.

1.22.3 It is to be verified that the propeller performs satisfactorily under ahead and astern conditions. Where controllable pitch propellers are fitted, the free route astern trial is to be carried out with the propeller blades set in the full pitch astern condition.

1.22.4 It is to be verified that large movements of resiliently mounted machinery do not occur during start up and stop, or during normal operating conditions.

1.22.5 The installation should be tested to ensure that gas turbines can not be continuously operated within any speed range where excessive vibration, stalling or surging may be encountered.

1.22.6 Overloading of machinery is not to occur under continuous astern power.

Section 2

Propulsion Shafting Systems

2.1 General requirements

Application

2.1.1 This chapter is to be read in conjunction with the general requirements for Machinery in Section 1.

2.1.2 This chapter gives the requirements for the dimensions of transmission shafts, other than gearing, crankshaft and turbine shafts, couplings, coupling bolts, keys, key ways, stern bushes and other associated components of main propulsion shafting.

2.1.3 The diameters may require to be modified as a result of alignment considerations and vibration characteristics or the inclusion of stress raisers, other than those contained in this Chapter.

2.2 Power ratings

2.2.1 For determining the dimensions of main propulsion components power P is in kW and R in revolutions per minute of the component.

2.3 Clutches

2.3.1 Clutches for single engine propulsion plants are to be provided with a suitable means for emergency operation in the event of loss of operating fluid systems. Their suitability for short term high power operation is to be demonstrated.

2.4 Safety

2.4.1 Means are to be provided such that in the event of a failure to a shaft or coupling the occupants of the craft are not endangered, either directly or by damaging the craft or its systems. Where necessary, guards may be fitted to achieve compliance with these requirements.

2.5 Plans

2.5.1 At least three copies of the following plans are to be submitted:

- Shafting arrangement
- Thrust shaft
- Intermediate shafting
- Tube shaft, where applicable
- Screw shaft
- Screw shaft oil gland
- Screw shaft protection
- Sternbush and arrangement in housing
- Couplings
- Coupling bolts
- Flexible coupling
- Cardan shafts.

2.5.2 The shafting arrangement plan is to indicate the relative position of the main engine(s), flywheel, flexible coupling(s), gearing, thrust block, line shafting and bearing(s), stern tube, 'A' bracket and propulsion device, as applicable.

2.6 Calculations and specifications

2.6.1 The following calculations and specifications are to be submitted:

- Calculations or relevant documentation indicating the suitability of all components for short term high power operation, where applicable.

- Where undertaken as an alternative to the requirements to this chapter, fatigue endurance calculations of all components according to Section 1.

- Vibration analysis and alignment analysis as per Part 4, Chapter 4, Section 8 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

- The material specifications, including the minimum specified tensile strength of each shaft and coupling component is to be stated. Where corrosion resistant material not included in Table 2.8.1 is used for unprotected screw shafts the corrosion fatigue strength in sea water is to be stated together with the chemical composition and mechanical properties.

- Where it is proposed to use composite (non-metallic) shafts, details of materials, resin, lay-up procedure and documentary evidence of fatigue endurance strength.

2.7 Materials for shafts

2.7.1 Components are to be manufactured and tested in accordance with the requirements of Part 2 of 'Rules and Regulations for the Construction and Classification of Steel Ships'.

2.7.2 Where it is proposed to use alloy steel forgings, particulars of the chemical composition, mechanical properties and heat treatment are to be submitted for approval. For main propulsion shafting, not exposed to sea water, in alloy steels, the specified minimum tensile strength is not to exceed 800 [N/mm^2] and for other forgings is not to exceed 1100 [N/mm^2].

2.7.3 Unprotected screw shafts and tube shafts exposed to seawater are in general to be manufactured, from corrosion resistant ferrous or non-ferrous material, such as those indicated in Table 2.8.1.

2.7.4 In the selection of materials for shafts, keys, locking nuts etc., consideration is to be given to their compatibility with the proposed propeller material.

2.7.5 Where shafts are manufactured from composite material the process is to be approved.

2.8 Design and Construction

2.8.1 Fatigue strength analysis

2.8.1.1 As an alternative to the following requirements, a fatigue strength analysis of components can be submitted indicating a factor of safety of 1.5 at the design loads, based on a suitable fatigue criteria. The effects of stress concentrations, material properties and operating environment are to be taken into account.

2.8.2 Intermediate shafts

2.8.2.1 The diameter, d, of the intermediate shaft is to be not less than:

$$d = F\,k\,\sqrt[3]{\frac{P}{R}\left(\frac{560}{\sigma_u + 160}\right)} \text{ [mm]}$$

where,

k = 1.0 for shafts with integral coupling flanges complying with 2.8.8 or shrink fit couplings

= 1.10 for shafts with key ways, where the fillet radii in the transverse section of the bottom of the key way are not less than 0.0125d.

= 1.10 for shafts with transverse or radial holes where the diameter of the hole does not exceed 0.3d.

= 1.20 for shafts with longitudinal slots having a length of not more than 1.4d and a width of not more than 0.2d where d, is determined with k = 1.0.

F = 95 for turbine installations, electric propulsion installations and diesel engine installations with slip type couplings.

= 100 for other diesel engine installations.

P and R are defined in Section 2.2.1.

σ_u = specified minimum tensile strength of the shaft material [N/mm^2].

2.8.2.2 Beyond a length of 0.2d from the end of a key way, transverse hole or radial hole and 0.3d from the end of a longitudinal slot, the diameter of the shaft may be gradually reduced to that determined with k = 1.0.

2.8.2.3 For shafts with design features other than stated as above, the value of k will be specially considered.

2.8.3 Thrust shafts

2.8.3.1 The diameter at the collars of the thrust shaft transmitting torque or in way of the axial bearing where a roller bearing is used as a thrust bearing is to be not less than that required for the intermediate shaft in accordance with 2.8.2 with a k value of 1.10. Beyond a length equal to the thrust shaft diameter from the collars, the diameter may be tapered down to that required for the intermediate shaft with a k value of 1.0. For the purpose of the foregoing calculations, σ_u is to be taken as the minimum tensile strength of the thrust shaft material [N/mm^2].

2.8.4 Screw shafts and tube shafts

2.8.4.1 Screw shafts and tube shafts (i.e. the shaft which passes through the stern tube, but does not carry the propeller), made from carbon manganese steel are to be protected by a continuous bronze liner, where exposed to sea water. Alternatively, the liner may be omitted provided the shaft is arranged to run in an oil lubricated bush with an approved oil sealing gland at the after end. Lengths of shafting between stern tubes and brackets, which are readily visible may be protected by coatings of an approved type.

2.8.4.2 Means for the protection of screw shafts and tube shafts are not required when the shafts are made of corrosion resistant material.

2.8.4.3 The diameter, d_p of the protected forged steel screw shaft immediately forward of the forward face of the propeller boss or, if applicable, the forward face of the screw shaft flange, is to be not less than:

where,

$$d_p = 100\,k\,\sqrt[3]{\frac{P}{R}\left(\frac{560}{\sigma_u + 160}\right)} \text{ [mm]}$$

k = 1.22 for a shaft carrying a keyless propeller, or where the propeller is attached to an integral flange and where the shaft is fitted with a continuous liner, a coating of an approved type, or is oil lubricated and provided with an approved type of oil sealing gland.

= 1.26 for a shaft carrying a keyed propeller and where the shaft is fitted with a continuous liner, a coating of an approved type, or is oil lubricated and provided with an approved type of oil sealing gland.

P and R are defined in Section 2.2.1.

σ_u = specified minimum tensile strength of the shaft material [N/mm^2] but is not to be taken as greater than 600 [N/mm^2].

2.8.4.4 The diameter, d_p of the screw shaft determined in accordance with 2.8.4.3 is to extend over a length not less than that to the forward edge of the bearing immediately forward of the propeller or 2.5 d_p whichever is the greater.

2.8.4.5 The diameter of the portion of the screw shaft and tube shaft forward of the length required by 2.8.4.3 to the forward end of the stern tube seal is to be determined in accordance with 2.8.4.3 with a k value of 1.15. The change of diameter from that determined with k = 1.22 or 1.26 to that determined with k = 1.15 should be gradual.

2.8.4.6 Screw shafts which run in stern tubes and tube shafts may have the diameter forward of the forward stern tube seal gradually reduced to the diameter of the intermediate shaft. Abrupt changes in shaft section at the screw shaft/tube shaft to intermediate shaft couplings are to be avoided.

2.8.4.7 The diameter of corrosion resistant screw shafts and tube shafts of materials having properties as shown in Table 2.8.1 is to be not less than:

$$d_{up} = 128\,A\,\sqrt[3]{\frac{P}{R}}$$

where,

'A' is taken from Table 2.8.1.

P and R are as defined in Section 2.2.1.

The diameter of the unprotected screw shaft forward of the stern seal need not be greater than the diameter as required by 2.8.4.6.

Table 2.8.1 : Provisional 'A' value for use in unprotected screw shaft formula

Material	'A' Value
Stainless steel type 316 (austenitic)	0.71
Stainless steel type 431 (martensitic)	0.69
Manganese bronze	0.8
Aluminium bronze	0.65
Nickel copper alloy – monel 400	0.65
Nickel copper alloy – monel K 500	0.55
Duplex steels	0.49

2.8.5 Hollow shafts

2.8.5.1 Where the thrust, intermediate, tube shafts and screw shafts have central holes having a diameter greater than 0.4 times the outside diameter, the equivalent diameter, d_e, of a solid shaft is not to be less than the Rule size, d, (of a solid shaft), where d_e is given by:

$$d_e = d_o\,\sqrt[3]{1-\left(\frac{d_i}{d_o}\right)^4}$$

where,

d_o = proposed outside diameter [mm]
d_i = diameter of central hole [mm].

Where the diameter of the central hole does not exceed 0.4 times the outside diameter, the diameter is to be calculated in accordance with the appropriate requirements for a solid shaft.

2.8.6 Cardan shafts

2.8.6.1 Cardan shafts, used in installations having more than one propulsion shaftline, are to be of an approved design, suitable for the designed operating conditions including short term high power operation. Consideration will be given to accepting the use of approved cardan shafts in single propulsion unit applications if a complete spare coupling is to be provided on board.

2.8.6.2 Cardan shaft ends are to be contained within substantial tubular guards that also permit ready access for inspection and maintenance.

2.8.7 Coupling bolts

2.8.7.1 Close tolerance fitted bolts transmitting shear are to have a diameter, d_b, at the flange joining faces of the couplings not less than:

$$d_b = \sqrt{\frac{240 \cdot 10^6 P}{nD\,\sigma_u\,R}} \text{ [mm]}$$

where,

n = number of bolts in the coupling
D = pitch circle diameter of bolts [mm]
σ_u = specified minimum tensile strength of bolts [N/mm^2].

P and R are as defined in Section 2.2.1.

2.8.7.2 At the joining faces of couplings, other than within the crankshaft and at the thrust shaft/crankshaft coupling, the Rule diameter of the coupling bolts may be reduced by 5.2 percent for craft with notation RS3.

2.8.7.3 The minimum diameter of tap bolts or of bolts in clearance holes at the joining faces of coupling flanges, pretensioned to 70 percent of the bolt material yield strength value, is not to be less than:

$$d_R = 1.348\ X \sqrt{\left(\frac{120(10^6)FP(1+C)}{RD} + Q\right)\frac{1}{n\sigma_y}}$$

where,

d_R is taken as the lesser of:

a) Mean of effective (pitch) and minor diameters of the threads.
b) Bolt shank diameter away from threads. (Not for waisted bolts which will be specially considered).

P and R are defined in Section 2.2.1.

F = 2.5 where the flange connection is not accessible from within the craft
  = 2.0 where the flange connection is accessible from within the craft

C = ratio of vibratory/mean torque values at the rotational speed being considered

D = pitch circle diameter of bolt holes [mm]

Q = external load on in N

n = number of tap or clearance bolts

σ_y = bolt material yield stresses [N/mm^2].

2.8.7.4 Consideration will be given to those arrangements where the bolts are pretensioned to loads other than 70 percent of the material yield strength.

2.8.8 Flange connections of couplings

2.8.8.1 The minimum thicknesses of the coupling flanges are to be equal to the diameters of the coupling bolts at the face of the couplings as required by 2.8.7.1, and for this purpose the minimum tensile strength of the bolts is to be taken as equivalent to that of the shafts. For intermediate, thrust shafts and the inboard end of the screw shaft, the thickness of the coupling flange is in no case to be less than 0.20 of the diameter of the intermediate shaft as required by 2.8.2.1.

2.8.8.2 The fillet radius at the base of the coupling flange, integral with the shaft, is to be not less than 0.08 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and are not to be recessed in way of nut and bolt heads.

2.8.8.3 Where the propeller is attached by means of a flange, the thickness of the flange is to be not less than 0.25 of the actual diameter of the adjacent part of the screw shaft. The fillet radius at the base of the coupling flange is to be not less than 0.125 of the diameter of the shaft at the coupling.

2.8.8.4 All couplings which transmit torque are to be of approved dimensions.

2.8.8.5 Where couplings are separate from the shafts, provision is to be made to resist the astern pull.

2.8.8.6 Where a coupling is shrunk on to the parallel portion of a shaft or is mounted on a slight taper, e.g. by means of the oil pressure injection method, the assembly is to meet the requirements of 2.8.11.

2.8.9 Tooth couplings

2.8.9.1 The contact stress, σ_c, at the flanks of mating teeth of a gear coupling is not to exceed that given in Table below, where:

$$\sigma_c = \frac{24 \times 10^6 \, P}{R d_p \, bhz} \quad [\mathrm{N/mm}^2]$$

P and R are defined in 2.2.1.

d_p = pitch circle diameter of coupling teeth [mm]
b = tooth facewidth [mm]
h = tooth height [mm]
z = number of teeth (per coupling half).

Allowable σ_c values	
Tooth material surface treatment	**Allowable σ_c value [N/mm^2]**
Surface hardened teeth	19
Through hardened teeth	11

2.8.9.2 Where experience has shown that under similar operating and alignment conditions, a higher tooth loading can be accommodated full details are to be submitted for consideration.

2.8.10 Flexible couplings

2.8.10.1 Details of flexible couplings are to be submitted together with the manufacturer's rating capacity, for the designed operating conditions including short term high power operation. Verification of coupling characteristics will be required.

2.8.10.2 In determining the allowable mean, maximum and vibratory torque ratings consideration of the mechanical properties of the selected elastic element type in compression, shear and fatigue loading together with heat absorption/generation is to be given.

2.8.10.3 In determining the allowable torque ratings of the steel spring couplings, consideration of the material mechanical properties to withstand fatigue loading and overheating is to be given.

2.8.11 Interference fit assemblies

2.8.11.1 The interference fit assembly is to have a capacity to transmit a torque of S (T_{max}) without slippage.

Note: For guidance purposes only
$T_{max} = T_{mean}$ (1+C).

Where, C is to be taken from Table 2.8.2.

S = 2.0 for assemblies accessible from within the vessel
= 2.5 for assemblies not accessible from within the vessel.

Table 2.8.2 : 'C' values for guidance purposes

Coupling Location	**C**
High Speed Shafting - IC engine driven	0.3
High Speed Shafting - Electric Motor or Turbine driven	0.1
Low Speed Shafting - main or PTO stage gearing	0.1

2.8.11.2 The effect of any axial load acting on the assembly is to be considered.

2.8.11.3 The resulting equivalent von Mises stress in the assembly is not to be greater than the yield strength of the component material.

2.8.11.4 Reference marks are to be provided on the adjacent surfaces of parts secured by shrinkage alone.

2.8.12 Keys and keyways for propeller connections

2.8.12.1 Round ended or sled-runner ended keys are to be used and the keyways in the propeller boss and cone of the screw shaft are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0.0125 of the diameter of the screw shaft at the top of the cone. The sharp edges at the top of the keyways are to be removed.

2.8.12.2 Two screwed pins are to be provided for securing the key in the keyway and the forward pin is to be placed at least one-third of the length of the key from the end. The depth of the tapped holes for the screwed pins is not to exceed the pin diameter and the edges of the holes are to be slightly bevelled. The omission of pins for keys for small diameter shafts will be specially considered.

2.8.12.3 The distance between the top of the cone and the forward end of the keyway is to be not less than 0.2 of the diameter of the screw shaft at the top of the cone.

2.8.12.4 The effective sectional area of the key in shear, is to be not less than:

$$\frac{155\,d^3}{\sigma_u\,d_1}\ [mm^2]$$

where,

d = diameter [mm] required for the intermediate shaft determined in accordance with 2.8.2, based on material having a specified minimum tensile strength of 400 [N/mm2] and k = 1.

d_1 = diameter of shaft at mid length of the key [mm].

σ_u = specified minimum tensile strength (UTS) of the key material [N/mm^2].

The effective area in crushing of key, shaft or boss is to be not less than:

$$\frac{24\,d^3}{\sigma_y\,d_1}\ [mm^2]$$

where,

σ_y = yield strength of key, shaft or boss material as appropriate [N/mm^2].

2.8.13 Keys and keyways for inboard shaft connections

2.8.13.1 Round ended keys are to be used and the keyways are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0.0125 of the diameter of the shaft at the coupling. The sharp edges at the top of the keyways are to be removed.

2.8.13.2 The effective area of the key in shear, A, is to be not less than:

$$A = \frac{126\,d^3}{\sigma_u\,d_1}\ [mm^2]$$

where,

d = diameter [mm], required for the intermediate shaft determined in accordance with 2.8.2, based on material having a specified minimum tensile strength of 400 [N/mm^2] and k=1

d_1 = diameter of shaft at mid-length of the key [mm]

σ_u = specified minimum tensile strength (UTS) of the key material [N/mm^2].

2.8.14 Corrosion resistant liners on shafts

2.8.14.1 Liners may be bronze, gunmetal, stainless steel or other approved alloy.

2.8.14.2 The thickness, t of liners fitted on screw shafts or on tube shafts, in way of the bushes, is to be not less, when new, than given by the following formula:

$$t = \frac{D + 230}{32}\ [mm]$$

where,

t = thickness of the liner [mm]

D = diameter of the screw shaft or tube shaft under the liner [mm].

The thickness of a continuous liner between the bushes is to be not less than 0.75t.

2.8.14.3 Continuous liners are to be fabricated or cast in one piece.

2.8.14.4 Where liners consist of two or more lengths, these are to be butt welded together. In general, the lead content of the gunmetal of each length forming a butt welded liner is not to exceed 0.5 percent. The composition of the electrodes or filler rods is to be substantially lead-free.

2.8.14.5 The circumferential butt welds are to be of multi-run, full penetration type. Provision is to be made for contraction of the weld by arranging for a suitable length of the liner containing the weld, if possible about three times the shaft diameter, to be free of the shaft. To prevent damage to the surface of the shaft during welding, a strip of heat resisting material covered by a copper strip should be inserted between the shaft and the liner in way of the joint. Other methods for welding this joint may be accepted if approved. The welding is to be carried out by an approved method and to the Surveyor's satisfaction.

2.8.14.6 Each continuous liner or length of liner is to be tested by hydraulic pressure to 2.0 bar after rough machining.

2.8.14.7 Liners are to be carefully shrunk on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

2.8.14.8 Effective means are to be provided for preventing water from reaching the shaft at the part between the after end of the liner and the propeller boss.

2.8.14.9 If the liner does not fit the shaft tightly between the bearing portions in the stern tube, the space between the shaft and the liner is to be fitted with a plastic insoluble non-corrosive compound.

2.8.15 Sternbushes and sterntube arrangement

2.8.15.1 Where the sterntube or sternbushes are to be installed using a resin, of an approved type, the following requirements are to be met:

a) Pouring and venting holes are to be provided at opposite ends with the vent hole at the highest point.
b) The minimum radial gap occupied by the resin is to be not less than 6 mm at any one point with a nominal resin thickness of 12 mm.
c) In the case of oil lubricated sterntube bearings, the arrangement of the oil grooves is to be such as to promote a positive circulation of oil in the bearing.
d) Provision is to be made for the remote measurement of the temperature at the aft end of the aft bearing, with indication and alarms at the control stations.

2.8.15.2 The length of the bearing in the sternbush next to and supporting the propeller is to be as follows:

a) For water lubricated bearings which are lined with rubber composition or staves of approved plastics material, the length is to be not less than four times the diameter required for the screw shaft under the liner.

b) For water lubricated bearings lined with two or more circumferentially spaced sectors, of an approved plastics material, without axial grooves in the lower half, the length of the bearing is to be such that the nominal bearing pressure will not exceed 0.55 [N/mm2]. The length of the bearing is to be not less than twice its diameter.

c) For bearings which are white-metal lined, oil lubricated and provided with an approved type of oil sealing gland, the length of the bearing is to be approximately twice the diameter required for the screw shaft and is to be such that the nominal bearing pressure will not exceed 0.8 [N/mm2]. The length of the bearing is to be not less than 1.5 times its diameter.

d) For bearings of cast iron and bronze which are oil lubricated and fitted with an approved oil sealing gland, the length of the bearing is, in general, to be not less than four times the diameter required for the screw shaft.

e) Non metallic bearings are to be manufactured from approved material.

2.8.15.3 Sternbushes are to be adequately secured in housings.

2.8.15.4 Forced water lubrication is to be provided for all bearings lined with rubber or plastics. The supply of water may come from a circulating pump or other pressure source. Flow indicators are to be provided for the water service to plastics and rubber bearings. The water grooves in the bearings are to be of ample section and of a shape which will be little affected by weardown, particularly for bearings of the plastics type.

2.8.15.5 The shut-off valve or cock controlling the supply of water is to be fitted direct to the after peak bulkhead, or to the sterntube where the water supply enters the sterntube forward of the bulkhead.

2.8.15.6 Oil sealing glands must be capable of accommodating the effects of differential expansion between hull and line of shafting for all sea temperatures in the proposed area of operation. This requirement applies particularly to those glands which span the gap and maintain oiltightness between the sterntube and the propeller boss.

2.8.15.7 Where a tank supplying lubricating oil to the sternbush is fitted, it is to be located above the load waterline and is to be provided with a low level alarm device in the machinery space. See also 2.11.1.

2.8.15.8 Where sternbush bearings are oil lubricated, provision is to be made for cooling the oil by maintaining water in the after peak tank above the level of the sterntube or by other approved means. Means for ascertaining the temperature of the oil in the sterntube are also to be provided.

2.8.15.9 Where In-Water-Survey is proposed to be carried out means are to be provided for ascertaining the clearance in the sternbush with the vessel afloat.

2.9 Vibration and alignment

2.9.1 For the requirements for torsional, axial and lateral vibration and for alignment of the shafting, see Part 4, Chapter 4, Section 8 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

2.10 Protection of propeller shafts

2.10.1 In monohulls, propeller shaft and bearings of at least one main engine, when passing through the aft machinery space, are to be protected as follows:

a) steel shaft bearings by water spray,

b) shafts made of composite material (FRP), either by

i) passive fire protection for 60 minutes duration, or

ii) a water spray system and able to transmit the full torque of the propulsion engine after a standard fire test of 7 minutes.

2.11 Control and Monitoring

2.11.1 Unattended machinery

2.11.1.1 Where sterntube lubrication oil systems are fitted with automatic or remote controls so that under normal operating conditions they do not require any manual intervention by the operators, they are to be provided with the alarms indicated in Table 2.11.1.

Table 2.11.1 : Alarms

Item	Alarm
Sterntube lubricating oil tank level	Low
Sterntube bearing temperature (oil lubricated)	High

2.12 Requirements for Craft with 'LC' or 'HSLC' notation

2.12.1 General

2.12.1.1 Crafts with 'LC' or 'HSLC' notation do not have to comply with 2.3.1 in respect of emergency operation of clutches on single screw installations.

2.12.2 Details to be submitted

2.12.2.1 The corrosion fatigue strength of corrosion resistant shaft material need not be submitted if the material is as shown in Table 2.8.1. See also 2.6.

2.12.3 Materials

2.12.3.1 The proposals to use extruded non-ferrous or composite materials will receive special consideration.

2.12.3.2 Otherwise requirements of Part 2 of 'Rules and Regulations for the Construction and Classification of Steel Ships' will apply.

2.12.4 Sternbushes and sterntube arrangement

2.12.4.1 For craft of less than 150 GT, the requirements of 2.8.15.6 do not apply. Sterntube bearings of approved plastics materials are to be so designed as to ensure an adequate supply of water for lubrication.

2.12.4.2 The aftermost propeller shaft bearing in the sterntube is to be secured to prevent rotational and axial movement.

2.12.4.3 For craft of less than 150 GT, the requirements of 2.8.15.8 do not apply.

2.12.5 Alarms

2.12.5.1 The requirements of 2.11.1 do not apply to craft of less than 150 GT.

2.13 Construction

2.13.1 Boring of the sternframe, fitting of the sterntube and bearings and aligning the shafting are to be carried out to a formal traceable procedure.

2.13.2 Before boring the sternframe the structural steel work should be generally complete to the upper deck and to the engine room forward bulkhead.

Section 3

Prime Mover and Gearing

3.1 Diesel Engines

3.1.1 General Requirements

3.1.1.1 Application

3.1.1.1.1 This section is to be read in conjunction with the General Requirements for Machinery in Section 1.

3.1.1.1.2 The requirements of crankshaft design do not apply to diesel engines intended for essential services where power does not exceed 100 kW.

3.1.1.2 Power ratings

3.1.1.2.1 For determining the dimensions of main propulsion components power P is in kW and R in revolutions per minute of the component.

3.1.1.3 Power conditions for generator sets

3.1.1.3.1 Auxiliary engines coupled to electrical generators are to be capable under service conditions of developing continuously the power to drive the generators at full rated output (kW) and of developing for a short period (15 minutes) an overload power of not less than 10 percent (See Chapter 13).

3.1.1.4 Inclination of craft

3.1.1.4.1 Main and essential auxiliary diesel engines are to operate satisfactorily under the conditions as shown in Table 1.13.1 in Section 1.

3.1.1.5 Engine type testing

3.1.1.5.1 New engine types or developments of existing types are to be subjected to an agreed programme of type testing to complement the design appraisal and review of documentation. The programme will need to include short term high power operation where applicable.

3.1.1.6 Plans and information

3.1.1.6.1 At least three copies of the following plans are to be submitted:

- Crankshaft assembly plan.
- Crankshaft details plan
- Thrust shaft.
- Thrust bearing assembly.
- Coupling bolts.
- Counterweights, where attached to crankthrow.
- Main engine holding down arrangement.
- Type and arrangement of crankcase explosion relief valves.
- Details of the securing and collision arrangements.
- Schematic oil fuel system, including controls and safety devices.
- Lubricating oil system.
- Starting air system.
- Cooling water system.
- Control engineering aspects in accordance with Chapter 14.
- Shielding of high pressure fuel pipes.
- Longitudinal and transverse cross-section.
- Cast bedplate, crankcase and frames.

- Cylinder cover, liner and jacket (or engine block).
- Piston assembly.
- Tie rod.
- Connecting rod, piston rod and crosshead assemblies.
- Camshaft drive and camshaft general arrangement.
- Shielding and insulation of exhaust pipes.
- Details of turbochargers.
- Vibration dampers/detuners and moment compensators.
- Cross-sectional plans of the assembled turbo-charger with main dimensions.
- Fully dimensioned plans of the rotor.
- Material particulars with details of welding and surface treatments.
- Turbo-charger operating and test data.

3.1.1.6.2 The following information and calculations are to be submitted:

- Crankshaft design data as outlined in Part 4, Chapter 4, Section 4 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.
- Combustion pressure displacement relationship
- Power/speed operational envelope.
- Calculations and information for short term high power operation where applicable.
- Arrangement and welding specifications with details of the procedures for fabricated bed plate, crankcases, frames and entablatures. Details of welding consumables, fabrication sequence and heat treatments are to be included.
- Operation and maintenance manuals.
- Material specifications covering the listed components together with details of any surface treatments, non-destructive testing and hydraulic tests.
- Arrangement of interior lighting, where provided.
- Engine type test programme, where required including proposals for short term high power operation.
- Alternative proposals for hydraulic tests where design features are such that modifications to the test requirements are necessary.

3.1.1.6.3 Where it is proposed to use alloy castings, micro alloyed or alloy steel forgings or iron castings, details of the chemical composition, heat treatment and mechanical properties are to be submitted.

3.1.1.6.4 For engine types built under licence it is intended that the above documentation be submitted by the Licensor. Each Licensee is then to submit the following:

- A list, based on the above, of all documents required with the relevant drawing numbers and revision status from both Licensor and Licensee.
- The associated documents where the Licensee proposes design modifications to components. In such cases a statement is to be made confirming the Licensor’s acceptance of the proposed changes.

3.1.1.6.5 In all cases a complete set of endorsed documents will be required by the Surveyor attending the Licensee’s works.

3.1.1.6.6 A Failure Modes and Effects Analysis (FMEA) as detailed in Section 1 is to be submitted.

3.1.1.6.7 Where considered necessary additional documentation may be required.

3.1.2 Material, design and construction

3.1.2.1 For material test and inspection refer to Part 2 and Part 4 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

3.1.2.2 For crankshaft design refer to Part 4, Chapter 4, Section 8 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

3.1.2.3 Requirements of construction of welded structure to meet Part 4, Chapter 4, Section 4 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

3.1.2.4 For crankcase, relief valve, vent pipes, crankcase covers, starting arrangement, air compressor, receiver, starting air pipe and electrical starting refer Part 4, Chapter 4, Section 4 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

3.1.2.5 The requirements for battery installations are given in Chapter 13.

3.1.3 Safety Arrangements on Engines

3.1.3.1 Cylinder relief valves

3.1.3.1.1 Cylinder relief valves are to be fitted to engines having cylinders over 230 mm bore. The valves are to be loaded to not more than 40 percent above the designed maximum pressure and are to discharge where no damage can occur. Consideration will be given to any other alternative relief arrangement.

3.1.3.1.2 In the case of auxiliary engines, consideration will be given to the replacement of the relief valve by an efficient warning device of overpressure in the cylinder.

3.1.3.2 Scavenge relief valve

3.1.3.2.1 Scavenge spaces in open connection with cylinders are to be provided with explosion relief valves.

3.1.4 Piping Systems

3.1.4.1 General

3.1.4.1.1 Diesel engine piping systems are, in general, to comply with the requirements of Chapter 11, due regard being paid to the particular type of installation.

3.1.4.1.2 Synthetic rubber hoses, with single or double closely woven integral wire braid reinforcement, or convoluted metal pipes with wire braid protection, may be used in compressed air, fresh water, sea-water, oil fuel and lubricating oil systems. Where synthetic rubber hoses are used for fuel the hoses are to have external wire braid protection in addition to the integral wire braid.

3.1.4.2 **Oil fuel systems**

3.1.4.2.1 Oil fuel arrangements are to comply with the requirements of Chapter 11, as applicable.

3.1.4.2.2 On main and auxiliary engines all external high pressure fuel delivering lines between the high pressure fuel pumps and fuel injectors to be protected with a jacketed piping system capable of containing fuel from a high pressure line failure. The jacketed piping system shall include a means of collection of leakages and arrangements to be provided for an alarm to be given of a fuel line failure.

3.1.4.2.3 The protection is to prevent oil fuel or oil fuel mist from reaching a source of ignition on the engine or its surroundings. Suitable drainage arrangements are to be made for draining any oil fuel leakage and for preventing contamination of the lubricating oil by oil fuel.

3.1.4.3 Oil fuel filters and fittings

3.1.4.3.1 Two or more filters are to be fitted in the oil fuel supply lines to the main and auxiliary engines and the arrangements are to be such that any filter can be cleaned without interrupting the supply of filtered oil fuel to the engines.

3.1.4.3.2 Drip trays are to be fitted under oil fuel filters and other fittings which are required to be opened up frequently for cleaning or adjustment or where there is the possibility of leakage. Alternative arrangements may be acceptable and full details should be submitted for consideration.

3.1.4.4 Lubricating oil systems

3.1.4.4.1 Lubricating oil arrangements are to comply with the requirements of Chapter 11 as applicable.

3.1.4.4.2 Where the lubricating oil for main propelling engines is circulated under pressure, provision is to be made for the efficient filtration of the oil. The filters are to be capable of being cleaned without stopping the engine or reducing the supply of filtered oil to the engine. Proposals for an automatic by-pass for emergency purposes in high speed engines are to be submitted for special consideration.

3.1.4.5 Engine cooling water systems

3.1.4.5.1 Cooling water arrangements are to comply with the requirements of Chapter 11, as applicable.

3.1.4.6 Exhaust systems

3.1.4.6.1 Where the exhaust is led overboard near the waterline, means are to be provided to prevent water from being siphoned back to the engine. Where the exhaust is cooled by water spray, the exhaust pipes are to be self draining overboard. Erosion/corrosion resistant shut-off flaps or other devices are to be fitted on the hull side shell or pipe end and acceptable arrangements made to prevent water flooding the space or entering the engine exhaust manifold.

3.1.4.6.2 Where the exhausts of two or more engines are led to a common silencer or exhaust gas heated boiler or economizer, an isolating device is to be provided in each exhaust pipe.

3.1.4.6.3 The arrangement of the exhaust system is to be such as to prevent exhaust gases being drawn into the manned spaces, air conditioning systems and air intakes. They should not discharge into air cushion intakes.

3.1.5 Control and monitoring

3.1.5.1 General

3.1.5.1.1 The control and monitoring systems are to comply with the requirements of Chapter 14.

3.1.5.1.2 While it is recommended that oil mist monitoring or engine bearing temperature monitors for crankcase protection be fitted, they are in any case to be provided:

a) When arrangements are fitted to override the automatic stop for excessive reduction of the lubricating oil supply pressure.
b) For engines of 2,250 kW and above or having cylinders of more than 300 mm bore.

3.1.5.1.3 All main and auxiliary engines intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Where such engines are of more than 220 kW, audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

3.1.5.2 Main engine governors

3.1.5.2.1 An efficient governor is to be fitted to each main engine so adjusted that the speed does not exceed that for which the engine is to be classed by more than 15 percent.

3.1.5.3 Auxiliary engine governors

3.1.5.3.1 Auxiliary engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within 10 percent momentary variation and 5 percent permanent variation under the following conditions:

a) Full load is suddenly taken off.

b) Full load is suddenly applied following a minimum of 15 minutes no load. If the BMEP is greater than 8 bar the load may be applied as follows:

$$\frac{800}{\text{BMEP}}\%$$

(but not less than 1/3 full load), then full load being attained in not more than two equal stages as rapidly as possible.

3.1.5.3.2 Emergency engines are to comply with above except that the initial load required by above is to be not less than the total connected emergency statutory load.

3.1.5.3.3 For alternating current installations, the permanent speed variation of the machines intended for parallel operation are to be equal within a tolerance of ± 0.5 percent. Momentary speed variations with load changes in accordance with above are to return to and remain within one percent of the final steady state speed in not more than eight seconds.

3.1.5.4 Overspeed protective devices

3.1.5.4.1 Each main engine developing 200 kW or over which can be declutched or which drives a controllable (reversible) pitch propeller, also each auxiliary engine developing 200 kW and over for driving an electric generator, is to be fitted with an approved overspeed protective device.

3.1.5.4.2 The overspeed protective device, including its driving mechanism, is to be independent of the governor required by 3.1.5.2 or 3.1.5.3 and is to be so adjusted that the speed does not exceed that for which the engine and its driven machinery are to be classed by more than 20 percent for main engines and 15 percent for auxiliary engines.

3.1.5.5 Engine stopping

3.1.5.5.1 At least two independent means of stopping the engines quickly from the control station under any conditions is to be available.

3.1.5.6 Unattended machinery

3.1.5.6.1 Where machinery, is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, it is to be provided with the alarms and safety arrangements required by 3.1.5 to 3.1.6 as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

3.1.5.6.2 Where a first stage alarm together with a second stage alarm and automatic shutdown of machinery are required by Tables 3.1.5.1 and 3.1.5.2, the sensors and circuits utilised for the second stage alarm and automatic shutdown are to be independent of those required for the first stage alarm.

Table 3.1.5.1

Item	Alarm	Note
Lubricating oil sump level	Low	-
Lubricating oil inlet pressure++	1st stage Low++ 2nd stage Low	Engines (and gearing if fitted) Automatic shutdown engines (and gearing if fitted) 3.1.5.6.2
Lubricating oil inlet temperature*	High	Engines (and gearing if fitted)
Lubricating oil filters differential pressure	High	-
Cylinder lubricator flow	Low unit	One sensor per lubricator
Piston coolant inlet pressure	Low	If a separate system
Piston coolant outlet temperature*	High	Per cylinder (if a separate system)
Piston coolant outlet flow	Low	Per cylinder (if a separate system)
Cylinder coolant inlet pressure or flow*++	Low	-
Cylinder coolant outlet temperature*++	1st stage High++ 2nd stage High	Per cylinder (if a separate system) or manifold++ Automatic shutdown medium and high speed engines, 3.1.5.6.2
Sea water cooling pressure	Low	-
Thrust bearing temperature*	High	-
Fuel valve coolant pressure	Low	If a separate system
Fuel valve coolant, temperature	High	If a separate system
Oil fuel pressure from booster pump	Low	-
Oil fuel temperature or viscosity	High and Low	Heavy oil only
Charge air cooler outlet temperature	High and Low	4 stroke medium and high speed engines
Scavenge air temperature	High	Per cylinder (fire detection, 2 stroke engines)
Exhaust gas temperature	High	Per cylinder (or deviation from average temperature)
Turbo-charger exhaust gas outlet temperature*	High	-
Turbo-charger lubricating oil inlet pressure	Low	If system not integral with turbo-charger
Turbo-charger lubricating oil inlet temperature	High	If system not integral with turbo-charger
Starting air pressure*	Low	Before engine manoeuvring valve
Overspeed	High	See 3.1.5.4
Automatic start of engine	Failure	See 3.1.6.6

Notes:
1. Where 'per cylinder' appears in this table, suitable alarms maybe situated on manifold outlets for medium and high speed engines
2. For engines of 1500 kW or less only the items marked * are required.
3. For craft of 'LC' or 'HSLC' notation with engines of 500 kW or less, only the items marked ++ are required.

3.1.5.6.3 Means are to be provided to prevent leaks from high pressure oil fuel injection piping for main and auxiliary engines dripping or spraying onto hot surfaces or into machinery air inlets. Such leakage should be led to a collector tank(s) fitted in a safe position with an alarm to indicate that leakage is taking place. These requirements may also be applicable to high pressure hydraulic oil piping depending upon the location.

3.1.6 Diesel engines for propulsion purposes

3.1.6.1 Alarms and safeguards are indicated in below and Table 3.1.5.1. See also 3.1.5.1.2 and 3.1.5.1.3.

3.1.6.2 Alarms are to operate and indication is to be given at the relevant control stations that the speed or power of the main propulsion engine(s) is to be reduced for the following fault conditions:

a) Oil mist in crankcase or high bearing temperature (if detection is fitted 3.1.5.1.2).
b) Low piston coolant pressure or flow.
c) High piston coolant outlet temperature.
d) Low cylinder coolant pressure or flow.
e) High cylinder coolant temperature.
f) High exhaust gas temperature per cylinder or deviation from average temperature (high).

3.1.6.3 Reduction of speed or power may be effected by either manual or automatic control.

3.1.6.4 The following engine services are to be fitted with automatic temperature controls so as to maintain steady state conditions throughout the normal operating range of the propulsion engine(s):

a) Lubricating oil supply.
b) Piston coolant supply, where applicable.
c) Cylinder coolant supply, where applicable.
d) Fuel valve coolant supply, where applicable.

3.1.6.5 Indication of the starting air pressure is to be provided at each control station from which it is possible to start the main propulsion engine(s).

3.1.6.6 The number of automatic consecutive attempts which fail to produce a start is to be limited to three attempts. For reversible engines which are started and stopped for manoeuvring purposes, means are to be provided to maintain sufficient starting air in the air receivers. For electric starting, see Part 4, Chapter 4, Section 4, Clause 4.11 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3.1.6.7 Prolonged running in a restricted speed range is to be prevented automatically or, alternatively, an indication of restricted speed ranges is to be provided at each control station.

3.1.7 Auxiliary and other engines

3.1.7.1 Alarms and safeguards are indicated in Table 3.1.5.2. See also 3.1.5.1.2 and 3.1.5.6.3.

Table 3.1.5.2

Item	Alarm	Note
Lubricating oil inlet temperature	High	-
Lubricating oil inlet pressure	1st stage Low 2nd stage Low	- Automatic shutdown of engine*, see 3.1.5.6.2
Coolant outlet temperature	1st stage High 2nd stage High	For engines over 200 kW For engines over 200 kW Automatic shutdown of engine*, see 3.1.5.6.2
Coolant pressure or flow	Low	-
Overspeed	High	See 3.1.5.4
Starting air pressure	Low	-

Notes:
1. There are no classification requirements for the items marked* in the case of engines being used for the emergency source of electrical power required by SOLAS.
2. The arrangements are to comply with the requirements of the National Authority concerned.

3.1.8 Requirements for craft with 'LC' or 'HSLC' notation

3.1.8.1 General

3.1.8.1.1 The requirements for inclination of craft do not apply to craft with 'LC' or 'HSLC' notation less than 150 GT.

3.1.8.2 Details to be submitted

3.1.8.2.1 The requirements of 3.1.1.6.6 (FMEA) as detailed in Section 1 do not apply to crafts with 'LC' or 'HSLC' notation.

3.1.8.3 Materials

3.1.8.3.1 Materials for which no provision is made in this part of the Rules may be accepted provided that they comply with an approved specification and such tests as may be considered necessary.

3.1.8.4 Crankshaft design

3.1.8.4.1 The requirements of 3.1.1.5 and 3.1.2.2 do not apply to crafts with 'LC' or 'HSLC' notation having main or auxiliary diesel engines with a power output not exceeding 100 kW:

3.1.9 Turbochargers

3.1.9.1 A type test is to consist of hot gas running test of at least one hour duration at the maximum permissible speed and maximum permissible temperature. Following the test the turbo-charger is to be completely dismantled for examination of all parts. Alternative arrangements will be considered.

3.1.9.2 All rotors are to be dynamically balanced on final assembly to the Surveyor's satisfaction.

3.1.9.3 All fully bladed rotor sections and impeller/inducer wheels are to be over-speed tested for three minutes at either 20 percent above the maximum permissible speed at room temperature or 10 percent above the maximum permissible speed at the normal working temperature.

3.1.9.4 Turbo-chargers are to be given a mechanical running test of 20 minutes duration at the maximum permissible speed.

3.1.9.5 Upon application, with details of an historical audit covering previous testing of turbo-chargers manufactured under an approved quality assurance scheme, consideration will be given to confining the test to a representative sample of turbo-chargers.

3.2 Gas Turbine

3.2.1 General Requirements

The requirements of this chapters are applicable to gas turbine for main propulsion and essential machinery.

3.2.1.1 Power ratings

3.2.1.1.1 For determining the dimensions of main propulsion components power P is in kW and R in revolutions per minute of the component.

3.2.1.2 Power conditions for generator sets

3.2.1.2.1 Auxiliary gas turbines coupled to electrical generators are to be capable under service conditions of developing continuously the power to drive the generators at full rated output and of developing for a short period (15 minutes) an overload power of not less than 10 per cent.

3.2.1.3 Inclination of craft

Main and essential auxiliary gas turbines are to operate satisfactorily under the conditions as shown in Section 1, Table 1.13.1

3.2.2 Particulars to be submitted

3.2.2.1 Plans and information

At least three copies of the following plans are to be submitted:

- All plans as in 'Rules and Regulation for the Construction and Classification of Steel Ships'.
- Securing arrangement (including details of resilient mounts where applicable).
- Control engineering aspects in accordance with Part 16, Chapter 1.
- Lubricating oil system schematic.
- Starting system schematic.
- Cooling water system schematic, where applicable.

3.2.2.2 The following information and calculations are to be submitted:

a) Details of the acoustic enclosure fire detection and extinguishing system, where applicable;
b) Power/speed operational envelope. Calculations and information for short term high power operation were applicable. Operation and maintenance manuals.
c) Calculations of the critical speeds of blade and rotor vibration giving full details of the basic assumptions. An analysis of the effect of a rotor blade failure and any details of service experience.
d) High temperature characteristics of the materials, where applicable, including (at the working temperatures) the associated creep rate and rupture strength for the designed service life, fatigue strength, corrosion resistance and scaling properties. Particulars of heat treatment, including stress relief, where applicable. Material specifications covering the listed components together with details of any surface treatments, non-destructive testing and hydraulic tests.

3.2.2.3 The most onerous pressures and temperatures to which each component may be subjected are to be indicated on plans or provided as part of the design specification.

3.2.2.4 Calculations of the steady state stresses, including the effect of stress raisers, etc., in the turbine and compressor rotors and blading at the maximum speed and temperature in service are to be submitted. Such calculations should indicate the designed service life and be accompanied, where possible, by test results substantiating the limiting criteria.

3.2.2.5 Details of calculations and tests to establish the service life of other stressed parts, including gearing (where applicable), bearings, seals, etc., are also to be submitted. All calculations and tests should take account of all relevant environmental factors including particular type of service and fuel intended to be used.

3.2.2.6 Components fabricated by means of welding will be considered for acceptance if constructed by firms whose works are properly equipped to undertake welding of the standards appropriate to the components. Details are to be submitted for consideration.

3.2.2.7 Before work is commenced, manufacturers are to submit for consideration details of proposed welding procedures and their proposals for routine examination of joints by non-destructive means.

3.2.2.8 The manufacturer's proposals for testing the gas turbine are to be submitted for consideration.

3.2.2.9 A Failure Mode and Effects Analysis (FMEA) is to be submitted as detailed in Section 1.

3.2.3 Materials

3.2.3.1 Materials for forgings

3.2.3.1.1 Refer Part 2, Chapter 5, Section 3 and Part 4, Chapter 4, Section 3.3 of 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3.2.3.1.2 For alloy steels, specifications giving the proposed chemical composition and heat treatment are to be submitted for approval.

3.2.3.1.3 When it is proposed to use a material of higher tensile strength, full details are to be submitted for approval.

3.2.3.1.4 Components of non-ferrous construction should be submitted for consideration, together with full details of materials to be used and method of fabrication.

3.2.3.2 Material tests and inspection

3.2.3.2.1 Components are to be rested in accordance with the relevant requirements of Part 2.

3.2.3.2.2 For components of novel design special consideration will be given to the material test and non-destructive testing requirements.

3.2.4 Design

3.2.4.1 General

3.2.4.1.1 All parts of turbines, compressors, etc., are to have clearances and fits consistent with adequate provision for the relative thermal expansion of the various components. Special attention is to be given to minimizing casing and rotor distortion under all operating conditions.

3.2.4.1.2 Turbine bearings are to be so disposed and supported that lubrication is not adversely affected by heat flow from adjacent hot parts. Effective means are to be provided for intercepting oil leakage and preventing oil from reaching high temperature glands and casings.

3.2.4.2 Vibration

3.2.4.2.1 Care is to be taken in the design and manufacture of turbine and compressor rotors, rotor discs and rotor blades to ensure freedom from undue vibration within the operating speed range. Where critical speeds are found by calculation to occur within the operating speed range, vibration measurements may be required in order to verify the calculations.

3.2.4.3 Containment

3.2.4.3.1 The gas turbine is to be located such that any flying debris resulting from a failure will not endanger the craft, other machinery, occupants of the craft or any other persons.

3.2.4.3.2 Where an acoustic enclosure is fitted which completely surrounds the gas generator and the high pressure oil pipes, a fire detection and extinguishing system is to be provided for the acoustic enclosure.

3.2.4.4 External influences

3.2.4.4.1 Pipes and ducting connected to casings are to be so designed that no excessive thrust loads or moments are applied by them to the compressors and turbines.

3.2.4.4.2 Platform gratings and fittings in way of the supports are to be so arranged that casing expansion is not restricted.

3.2.4.4.3 Where main turbine seatings incorporating a tank structure we proposed, consideration is to be given to the temperature variation of the tank in service to ensure that turbine alignment will not be adversely affected.

3.2.5 Construction

3.2.5.1 Welded components

3.2.5.1.1 Major joints are to be designed as full strength welds and for complete fusion of the joint.

3.2.5.1.2 Stress relief heat treatment is to be applied to all cylinders, rotors and associated components on completion of the welding of all joints and attached structures.

3.2.6 Starting arrangement and piping system

3.2.6.1 For Details refer Part 4, of 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3.2.7 Control and Monitoring

3.2.7.1 Lubricating oil failure

3.2.7.1.1 Refer Part 4, of 'Rules and Regulations for the Construction and Classification of Steel Ships' for overspeed device and speed governor.

3.2.7.1.2 Main turbines are to have an arrangement whereby fuel is automatically shut off, near the burners, in the event of failure of the lubrication system.

3.2.7.2 Indication of temperature

3.2.7.2.1 Means are to be provided for indicating the temperature of power turbine exhaust gases.

3.2.7.3 Automatic and remote controls

3.2.7.3.1 Where gas turbines are fitted with automatic or remote controls so that under normal operating conditions they do not require any manual intervention by the operators, they are to be provided with the alarm and safety arrangements required by Table 3.2.7.1 as appropriate. Alternative arrangements, which provide equivalent safeguards will be considered.

3.2.7.3.2 The following turbine services are to be fitted with automatic temperature controls so as to maintain steady state conditions throughout the normal operating range of the turbine:

a) lubricating oil supply,
b) exhaust gas.

Table 3.2.7.1

Item	Alarm	Note
Overspeed	High	Automatic Shutdown
Lubricating oil pressure	Low	
Exhaust gas temperature	High	
Turbine vibration	High	
Flame and ignition	Failure	

3.2.8 For surveys during construction installation and trials refer to Part 4, Chapter 4, Section 3.15 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3.2.9 Requirements for craft with 'LC' or 'HSLC' notation

3.2.9.1 General

3.2.9.1.1 The requirements of Table 1.13.1 do not apply to craft with 'LC' or 'HSLC' notation less than 150 GT.

3.2.9.2 Information and calculations

3.2.9.2.1 Gas turbines for craft with a power output not exceeding 100 kW do not have to comply with 3.2.2.2(c), (d) and 3.2.2.4 to 3.2.2.7 inclusive and 3.2.2.9.

3.2.9.3 Piping systems

3.2.9.3.1 Soft solder is not to be used for attaching pipe fittings forming part of oil fuel systems.

3.2.10 Tests

3.2.10.1 For tests during construction and installation and trials refer to Part 4, Chapter 4, Section 3.15 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3.3 Gearing

3.3.1 General requirements

3.3.1.1 Application

3.3.1.1.1 This chapter is to be read in conjunction with the general requirements for machinery in Section 1.

3.3.1.1.2 The requirements of this chapter, except where otherwise stated are applicable to electric motor, gas turbine and diesel engine gearing for driving:

a) Conventional, totally submerged propeller(s) / impeller(s) for main propulsion purposes, for transmitted powers.

b) Auxiliary machinery which is essential for the safety of the craft or for safety of persons on board.

3.3.1.1.3 Gear designs for applications other than those specified in 3.3.1.1.2 will be specially considered.

3.3.1.1.4 In any mesh, the terms pinion and wheel refer to the smaller and larger gear respectively.

3.3.1.1.5 Bevel gears will be specially considered on the basis of a conversion to equivalent cylindrical gears.

3.3.1.1.6 For vibration and alignment requirements, see Part 4, Chapter 4, Section 8 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3.3.1.2 Power ratings

3.3.1.2.1 In this chapter where the dimensions of any particular components are determined from shaft power, P, in kW and revolutions per minute, R, the values to be used are those defined in Section 1.

3.3.1.3 Inclination of craft

3.3.1.3.1 Main and auxiliary gear units are to operate satisfactorily under the conditions as shown in Table 1.13.1 in Section 1.

3.3.2 Particulars to be submitted

3.3.2.1 Submission of information

3.3.2.1.1 At least three copies of the following plans and information as detailed in 3.3.2.2 to 3.3.2.3 are to be submitted.

3.3.2.2 Plans

3.3.2.2.1 Gearing

- Cross sectional views indicating general arrangement.

- Plans of elements as detailed in Part 4, Chapter 4, Section 5 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3.3.2.2.2 Shafting and auxiliary systems

- Mass elastic schematic showing gear unit torsional data.
- Arrangements plan indicating bearing positions.
- Detail plans indicating scantlings of shafts, couplings and bolting.
- Schematic plans of the lubricating oil system, together with pipe material, relief valve and working pressures.
- Schematic of the control and electrical system.
- Calculations for short term high power operation, where applicable.
- Failure mode effects analysis as required by Section 1.
- Details of clutch units, where fitted.
- Details of alarms and control systems where fitted.
- Schematic plans of the lubricating oil system, together with pipe material, relief valve and working pressures.

3.3.2.3 Design of gearing

3.3.2.3.1 Refer Part 4, of 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3.3.2.4 Design of enclosed gear shafting

3.3.2.4.1 The following symbols apply:

P in kW and R in rpm.

L = span between shaft bearing centres, in mm

α_n = normal pressure angle at the gear reference diameter, in degrees

β = helix angle at the gear reference diameter, in degrees

d_w = pitch circle diameter of the gear teeth, [mm]

σ_u = specified minimum tensile strength of the shaft material, [N/mm^2]

Note : Numerical value used for σ_u is not to exceed 800 N/mm^2 for gear and thrust shafts and 1100 N/mm^2 for quill shafts.

3.3.2.4.2 This sub-section is applicable to the main and ancillary transmission shafting, enclosed within the gear case.

3.3.2.4.3 The diameter of the enclosed gear shafting adjacent to the pinion or wheel is to be not less than the greater of d_b or d_t, where:

$$d_b = 365\left(\frac{P_L}{R\, d_w\, S_b}\right)^{1/3}\left(1+\left(\frac{\tan\alpha_n}{\cos\beta}+\frac{\tan\beta\, d_w}{L}\right)^2\right)^{\frac{1}{6}}$$

$$d_t = 365\left(\frac{P}{R\, S_s}\right)^{\frac{1}{3}}$$

where,

$S_b = 45 + 0.24\ (\sigma_u - 400)$ and

$S_s = 42 + 0.09\ (\sigma_u - 400)$.

3.3.2.4.4 For the purposes of the above it is assumed that the pinion or wheel is mounted symmetrically spaced between bearings.

3.3.2.4.5 Outside a length equal to the required diameter at the pinion or wheel, the diameter may be reduced, if applicable, to that required for d_t.

3.3.2.4.6 For bevel gear shafts, where a bearing is located adjacent to the gear section, the diameter of the shaft is to be not less than d_t. Where a bearing is not located adjacent to the gear the diameter of the shaft will be specially considered.

3.3.2.4.7 The diameter of quill shaft (not axially constrained and subject only to external torsional loading) is to be not less than given by the following formula:

$$\text{Diameter of quill shaft} = 101 \text{ x } \sqrt[3]{\frac{400\text{P}}{\text{R}\,\sigma_\text{u}}} \quad [\text{mm}]$$

3.3.2.4.8 Where a shaft, located within the gear case, is subject to the main propulsion thrust the diameter at the collars of the shaft transmitting torque, or in way of the axial bearing where a roller bearing is used as a thrust bearing, is to be not less than 1.1 d_t. For thrust bearings located outside the gear case see Section 2.

3.3.2.5 Gear wheels

3.3.2.5.1 In general, arrangements are to be made so that the interior structure of the wheel may be examined. Alternative proposals will be specially considered.

3.3.2.6 Gear cases

3.3.2.6.1 Gear cases and their supports are to be designed sufficiently stiff such that misalignment at the mesh due to movements of the external foundations and the thermal effects under all conditions of service do not disturb the overall tooth contact.

3.3.2.6.2 Inspection openings are to be provided at the peripheries of gear cases to enable the teeth of pinions and wheels to be readily examined. Where the construction of gear cases is such that sections of the structure cannot be readily be removed for inspection purposes, access openings of adequate size are also to be provided at the ends of the gear cases to permit examination of the structure of the wheels. Their attachment to the shafts is to be capable of being examined by removal of bearing caps or by equivalent means.

3.3.2.6.3 For gear cases fabricated by fusion welding the carbon content of the steels should generally not exceed 0.23 percent. Steels with higher carbon content may be approved subject to satisfactory results from weld procedure tests.

3.3.2.6.4 Gear cases are to be stress relieved upon completion of all welding.

3.3.2.6.5 Gear cases manufactured from material other than steel will be considered upon full details being submitted.

3.3.2.7 Alignment

3.3.2.7.1 Reduction gears with sleeve bearings, for main and auxiliary purposes are to be provided with means for checking the internal alignment of the various elements in the gear cases.

3.3.2.7.2 In the case of separately mounted reduction gearing for main propulsion, means are to be provided by the gear manufacturer to enable the Surveyors to verify that no distortion of the gear case has taken place, when chocked and secured to its seating on board the craft.

3.3.2.8 Control and Monitoring

3.3.2.8.1 General

3.3.2.8.1.1 Control engineering systems are to be in accordance with Chapter 14.

3.3.2.8.1.2 All main and auxiliary gear units, intended for essential services, are to be provided with means of indicating the lubricating oil supply pressure. Audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. These alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

3.3.2.8.2 Unattended machinery

3.3.2.8.2.1 Where the machinery is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, gear units are to be provided with the alarms and safety arrangements required by 3.3.2.8.2.2 and Table 3.3.2.8.1. The sensors and circuits utilised for the second stage alarm and automatic shut down in Table 3.3.2.8.1 are to be independent of those required for the first stage alarm.

3.3.2.8.2.2 Where the gear unit is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pump falls below a predetermined value.

Table 3.3.2.8.1 : Alarms and safeguards

Item	Alarm	Note
Lubricating oil sump level	Low	
Lubricating oil inlet pressure	1st Stage Low	
Lubricating oil inlet pressure	2nd Stage Low	Automatic shutdown of engine
Lubricating oil inlet temperature	High	
Thrust bearing temperature	High	

3.3.2.9 Requirements for Craft with 'LC' or 'HSLC' notation

3.3.2.9.1 Details to be submitted

3.3.2.9.1.1 Failure mode and effect analysis is not required for craft with 'LC' or 'HSLC' notation.

3.3.2.9.1.2 Mass elastic schematic showing gear unit torsional data is only required for gears with an input power greater than 200 kW.

3.3.2.9.2 Design of gearing

3.3.2.9.2.1 Where they are not intended for passenger carrying duties, the gearing factors of safety for crafts with 'LC' or 'HSLC' notation less than 150 GT are to satisfy Table 3.3.2.9.1.

Table 3.3.2.9.1 : Factors of safety

	SH min	SF min
Main propulsion gears single screw	1.25	1.50
Main propulsion gears multiple screw	1.20	1.45

3.3.2.9.3 Piping systems

3.3.2.9.3.1 These craft are to have gearing provided with an efficient lubricating oil pump, a cooler where necessary and a filter arrangement which can be cleaned.

3.3.2.9.4 Control and monitoring

3.3.2.9.4.1 For craft with 'LC' or 'HSLC' notation less than 150 GT the alarms required by 3.3.2.8.2.1 are not applicable.

3.3.2.10 Tests

3.3.2.10.1 Where castings are used for wheel centres, any radial slots in the periphery are to be fitted with permanent chocks before shrinking-on-the rim.

3.3.2.10.2 Where welding is employed in the construction of wheels and gear cases, the welding procedure is to be approved before work is commenced. For this purpose, welding procedure approval test are to be carried out with satisfactory results. Such tests are to be representative of the joint configuration and materials. All welds are to have a satisfactory surface finish and contour. Magnetic particle or liquid penetrant examination of all important welded joints is to be carried out.

3.3.2.10.3 Welded constructions are to be stress relief heat treated on completion of welding.

3.3.2.10.4 Bolted attachments within the gear case are to be secured by locking wire or equivalent means.

3.3.2.10.5 The machining accuracy (Q grade) of pinions and wheels is to be demonstrated. For this purpose records of measurements are to be available for review.

3.3.2.10.6 Magnetic particle or liquid penetrant testing is to be carried out on the teeth of all surface hardened forgings. This examination may also be requested on the finished machined teeth of through hardened gear forgings.

3.3.2.10.7 The manufacturer is to carry out an ultrasonic examination of all forgings where the finished diameter of the surfaces, where teeth will be cut, is in excess of 200 mm and is to provide IRS with a signed statement that such inspection has not revealed any significant internal defects.

3.3.2.10.8 On gear forgings where the teeth have been surface hardened, additional test pieces may be required to be processed with the forgings and subsequently sectioned to determine the depth of the hardened zone. These tests are to be carried out at the discretion of the Surveyor and for induction or carburised gearing the depth of the hardened zone is to be in accordance with the approved specification. For nitrided gearing, the full depth of the hardened zone, i.e. depth to core hardness, is to be not less than 0.5 mm and the hardness at a depth of 0.25 mm is to be not less than 500 Hv.

3.3.2.10.9 All rotating elements such as pinion and wheel shaft assemblies and coupling parts, are to be appropriately balanced.

3.3.2.10.10 The permissible residual unbalance, U, is defined as follows:

$$U = \frac{60\text{m}}{R}.10^3 \text{ g mm for } R \leq 3000$$

$$U = \frac{24\text{m}}{R}.10^3 \text{ g mm for } R > 3000$$

where,

m = mass of rotating element [kg]

R = maximum service rev/min of the rotating element.

3.3.2.10.11 Where the size or geometry of a rotating element precludes measurement of the residual unbalance a full speed running test of the assembled gear unit at the manufacturer's works will normally be required to demonstrate satisfactory operation.

3.3.2.10.12 Initially, meshing gears are to be carefully matched on the basis of the accuracy measurements taken. The alignment is to be demonstrated in the workshop by meshing in the gearbox without oil clearance in the bearings. Meshing is to be carried out with the gears locating in their light load positions and a load sufficient to overcome pinion weight and axial movement is to be imposed.

3.3.2.10.13 The gears are to be suitably coated to demonstrate the contact marking. The thickness of the coating to determine the contact marking is not to exceed 0.005 mm. The marking is to reflect the accuracy grade specified and end relief, crowning or helix correction, where these have been applied.

3.3.2.10.14 For gears without crowning or helix correction the marking is to be not less than shown in the following Table:

No load tooth contact marking	
ISO accuracy grade	**Contact marking area**
$Q \leq 5$	50% b x 40% h_w + 40% b x 20% h_w
$Q \geq 6$	35% b x 40% h_w + 35% b x 20% h_w
Notes: 1. Where b is face width and h_w is the working tooth depth. 2. For spur gears the values of h_w should be increased by a further 10%.	

3.3.2.10.15 Where allowance has been given for end relief, crowning or helix correction, the normal shop meshing tests are to be supplemented by tooth alignment traces or other approved means to demonstrate the effectiveness of such modifications.

3.3.2.10.16 For gears with crowning or helix correction the marking is to correspond to the designed no load contact pattern.

3.3.2.10.17 A permanent record is to be made of the meshing contact for purpose of checking the alignment when installed on board the craft.

3.3.2.10.18 The full load tooth contact marking is to be not less than shown in the following Table:

No load tooth contact marking	
ISO accuracy grade	**Contact marking area**
$Q \leq 5$	60% b x 70% h_w + 30% b x 50% h_w
$Q \geq 6$	45% b x 60% h_w + 35% b x 40% h_w
Notes: 3. Where b is face width and h_w is the working tooth depth. 4. For spur gears the values of h_w should be increased by a further 10%.	

3.3.2.10.19 Where, due to the compactness of the gear unit, meshing tests of individual units cannot be verified visually, consideration may be given to the gear manufacturer providing suitable evidence that the design meshing condition has been attained on units of the same design.

3.3.2.10.20 The normal backlash between any pair of gears should not be less than:

$$\frac{a \cdot \alpha_n}{90000} + 0.1 \; [mm]$$

where,

α_n = normal pressure angle, in degrees
a = centre distance [mm].

Section 4

Propeller, Thruster, Water Jet System

4.1 Propeller

4.1.1 General Requirements

4.1.1.1 For design requirements refer to Part 4, Chapter 4, Section 7 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

4.1.1.2 For propellers having a skew angle equal or greater than 50^o in addition to the particulars detailed in 4.1.1.1 the following details are to be submitted:

a) Full blade section details at each radial station defined for manufacture.

b) A detailed blade stress computation supported by the following hydrodynamic data for the ahead mean wake condition and when absorbing full power:

   i) Radial distribution of lift and drag coefficients, section inflow velocities and hydrodynamic pitch angles.
   ii) Section pressure distributions.

4.1.2 Calculations and information

4.1.2.1 In cases where the craft has been the subject of model wake field tests a copy of the results is to be submitted.

4.1.2.2 The following information is to be submitted as applicable:

– For controllable pitch propellers plans (in diagrammatic form) of the hydraulic systems together with pipe material and working pressures.

– Details of control engineering aspects in accordance with Chapter 14.

– Calculations, or relevant documentation indicating the suitability of all components for short term high power operation.

– Where undertaken, fatigue strength analysis of components indicating a factor of safety of 1.5 at the design loads.

4.1.2.3 For cases where the propeller material is not specified in Table 7.4.1 of Part 4, Chapter 4, Section 7 of the 'Rules and Regulations for the Construction and Classification of Steel Ships', details of the chemical composition, mechanical properties and density are to be provided, together with results of fatigue tests in sea water in order to assign a value for U.

4.1.3 Interference fit of keyless propellers

4.1.3.1 The symbols used in 4.1.3.2 are defined as follows:

d_1 = diameter of the screwshaft cone at the mid-length of the boss or sleeve [mm]

d_3 = outside diameter of the boss at its mid lent [mm]

d_i = bore diameter of screwshaft [mm]

$$k_3 = \frac{d_3}{d_1}$$

$$l = \frac{d_i}{d_1}$$

$$P_1 = \frac{2M}{A_1 \theta_1 V_1}\left(-1 + \sqrt{1 + V_1\left(\frac{F_1^2}{M^2} + 1\right)}\right)$$

A_1 = contact area fitting at screwshaft [mm^2]

$$B_3 = \frac{1}{E_3}\left(\frac{k_3^2 + 1}{k_3^2 - 1} + v_3\right) + \frac{1}{E_1}\left(\frac{1 + l^2}{1 - l^2} - v_1\right)$$

C = 0 for turbine installations or electric propulsion

$$= \frac{\text{vibratory torque at the service speed}}{\text{mean torque at the service speed}} \quad \text{for oil engine installations}$$

E_1 = modulus of elasticity of screwshaft material [N/mm^2]

E_3 = modulus of elasticity of propeller material [N/mm^2]

$$F_t = \frac{2000Q}{d_f}(1 + C)$$

M = propeller thrust [N]

Q = mean torque corresponding to P and R [Nm]

T_1 = temperature at time of fitting propeller on shaft ^{o}C

$$V_1 = 0.51\left(\frac{\mu_1}{\theta_1}\right)^2 - 1$$

α_1 = coefficient of linear expansion of screwshaft material mm/mm/^{o}C

α_3 = coefficient of linear expansion of propeller material mm/mm/^{o}C

θ_1 = taper of the screwshaft cone but is not to exceed 1/15 on the diameter, i.e. $\theta_1 \leq 1/15$

μ_1 = coefficient of friction for fitting of boss assembly on shaft

= 0.13 for oil injection method of fitting

v_1 = Poisson's ratio for screwshaft material
v_3 = Poisson's ratio for propeller material.

4.1.3.2 Where it is proposed to fit a keyless propeller by the oil shrink method, the pull up, δ on the screwshaft is to be not less than:

$$\delta = \frac{d_1}{\theta_1}\left(p_1 B_3 + \left(\alpha_3 - \alpha_1\right)\left(35 - T_1\right)\right) \text{ [mm]}$$

The yield stress or 0.2 per cent proof stress, σ_0 of the propeller material is to be not less than:

$$\sigma_0 = \frac{1.4}{B_3}\left(\frac{\theta_1 \delta_p}{d_1} + T_1(\alpha_3 - \alpha_1)\right)\sqrt{\frac{3k_3^4 + 1}{k_3^2 - 1}} \text{ [N/mm}^2\text{]}$$

where,

δ_p = proposed pull-up at the fitting temperature. The start point load, W, to determine the actual pull up is to be not less than:

$$W = A_1 \left(0.002 + \frac{\theta_1}{20} \right) \left(p_1 + \frac{18}{B_3} (\alpha_3 - \alpha_1) \right) [N]$$

4.1.4 Automatic and remote controls

4.1.4.1 Where controllable pitch propellers are fitted with automatic or remote controls so that under normal operating conditions they do not require any manual intervention by the operators, they are to be provided with the alarms and safety arrangements required by 4.1.4.2, 4.1.4.3 and Table 4.1.1.

4.1.4.2 For controllable pitch propellers for main propulsion, a standby or alternative power source of actuating medium for controlling the pitch of the propeller blades is to be provided. Automatic start of the standby pump supplying hydraulic power for pitch control is to be provided.

Table 4.1.1

Item	Alarm	Note
Hydraulic system pressure	Low	-
Hydraulic oil supply tank level	Low	-
Hydraulic oil temperature	High	Where an oil cooler is fitted
Power supply to the control system between the remote control station and hydraulic actuator	Failure	Failure of any power supply to a control system is to operate an audible and visual alarm
Propulsion motor	Overload	See Chapter 14

4.1.4.3 For controllable pitch propellers, a shaft speed indicator and a pitch indicator which shows the degree of pitch as a measure of the propeller blade or actuator movement are to be provided at each station from which it is possible to control shaft speed or propeller pitch.

4.1.5 Requirements for craft with ‘LC’ or ‘HSLC’ notation

Propellers not exceeding one metre in diameter

4.1.5.1 The materials and the scantlings need not comply with sections 4.1.1 to 4.14

4.1.5.2 Propellers for craft less than 150 GT and main engine power output not exceeding 500 kW are to be manufactured from materials in accordance with Part 2 at a works recognised for the quality of its casting and machining, and be free from defects.

4.1.5.3 Specific requirements for the piping systems are given in Chapter 11.

4.1.5.4 The alarm and monitoring arrangements and for controllable pitch propellers the safety arrangements and standby power sources, will be specially considered.

4.1.6 Alternative materials and design

4.1.6.1 Propellers made from materials not listed in Part 2 or of unusual form or design will be specially considered.

4.1.7 Tests

4.1.7.1 Castings are to be examined at the manufacturer’s works.

4.1.7.2 All finished propellers are to be examined for material defects and finish and measured for dimensional accuracy of diameter and pitch., Propeller repairs by welding, where proposed, are to be in accordance with the requirements of Part 2, Chapter 8, Section 3.

4.1.7.3 The bedding of the propeller with the shaft is to be demonstrated. Sufficient time is to be allowed for the temperature of the components to equalize before bedding. Alternative means for demonstrating the bedding of the propeller will be considered.

4.1.7.4 Means are to be provided to indicate the relative axial position of the propeller boss on the shaft taper.

4.1.7.5 The components of controllable pitch propellers are also subject to material tests, as in the case of solid propellers.

4.1.7.6 Examination of all the major components including dimensional checks, hydraulic pressure testing of the hub and cone assembly and the oil distribution box, where fitted, together with a full shop trial of the completed controllable pitch propeller assembly, is to be carried out.

4.1.7.7 After verifying that the propeller and shaft are at the same temperature and the mating surfaces are clean and free from oil or grease, the propeller is to be fitted on the shaft under survey. The propeller nut is to be securely locked to the shaft.

4.1.7.8 Permanent reference marks are to be made on the propeller boss nut and shaft to indicate angular and axial positioning of the propeller. Care is to be taken in marking the inboard end of the shaft taper to minimize stress-raising effects.
4.1.7.9 The outside of the propeller boss is to be hard stamped with the following details:

– For oil injection method of fitting, the start point load, in Newtons, and the axial pull-up to 0^{o}C and 35^{o}C in mm.

– For the dry fitting method, the push-up load at 0^{o}C and 35^{o}C in Newtons.

4.1.7.10 A copy of the fitting curve relative to temperature and means for determining any subsequent movement of the propeller are to be placed on board.

4.1.7.11 The fit of the screwshaft cone to both the working and any spare propeller is to be carried out under survey. Generally, a satisfactory fit for keyed type propellers should show a light, overall marking of the cone surface with a tendency towards heavier marking in way of the larger diameter of the cone face. The final fit to cone should be made with the key in places.

4.2 Thruster

4.2.1 General Requirements

4.2.1.1 Application

4.2.1.1.1 This chapter is to be read in conjunction with the General Requirements for machinery.

4.2.1.1.2 This chapter gives requirements for fixed or steerable thruster units (azimuth thrusters) which are used for propulsion and steering and also applies to transverse propulsion (tunnel) thrusters which are an aid to manoeuvring.

4.2.1.1.3 For determining the dimensions of main propulsion components power P is in kW and R in revolutions per minute of the component.

4.2.1.2 Redundancy

4.2.1.2.1 A minimum of two azimuth thruster units are to be provided where these form the sole means of propulsion. Where a single azimuth thruster installation is proposed, it will be subject to consideration, taking into account the proposed restricted area notation.

4.2.1.2.2 The failure of one azimuth thruster unit or its control system is not to render any other thruster inoperative.

4.2.1.3 Inclination of craft

4.2.1.3.1 Thruster units are to operate satisfactorily under the conditions as shown in Section 1.

4.2.2 Particulars to be submitted

4.2.2.1 Submission of information

4.2.2.1.1 At least three copies of the following plans are to be submitted.

4.2.2.1.2 Fixed/Azimuth propulsion thrusters

a) A general arrangement sectional assembly plan showing all the connections of the torque transmitting components from the prime mover to the propeller, together with the azimuthing mechanism and if a nozzle is provided, the nozzle ring structure and nozzle support struts.
b) Detailed and dimensional plans of the individual torque transmitting components.
c) Schematic plans of lubricating and hydraulic systems, together with pipe material, relief valves and working pressures.

4.2.2.1.3 Tunnel thrusters

Structural assembly plan including connections to tunnel.

4.2.2.2 Calculations and specifications

4.2.2.2.1 At least three copies of the following information are to be submitted:

a) Thruster prime mover type and operational power/speed envelop.
b) Rating and type of motor for the azimuthing mechanism (e.g. type hydraulic or electric).
c) Gearing calculations for the azimuthing mechanism which is to be designed to a recognised National/International Standard.
d) Bearing specifications.
e) Details of control engineering aspects in accordance with Chapter 14.
f) Calculations indicating suitability of components for short term high power operation, where applicable.
g) Where carried out in accordance with Section 1, a fatigue strength analysis of components indicating a factor of safety of 1.5 at the design loads, based on a suitable fatigue failure criteria.

4.2.2.2.2 Tunnel thrusters

Specification for materials of gears, shafts, couplings and propeller, stock and struts.

4.2.3 Materials

4.2.3.1 Azimuth thrusters

4.2.3.1.1 The materials used in the construction are to be manufactured and tested in accordance with Part 2.

4.2.4 Design and Construction

4.2.4.1 General

4.2.4.1.1 The arrangement of all types of thrusters is to be such that the craft can be manoeuvred in accordance with the design specifications.

4.2.4.1.2 The requirements associated with the structural and watertight integrity and the installation arrangement are to be in accordance with Chapter 7.

4.2.4.1.3 In addition to the requirements of this section reference is to be made to:

a) Main transmission gearing (Section 3.3).
b) Main transmission shafting (Section 2).
c) Propeller (Section 4.1).
d) Torsional vibration (Part 4, Chapter 4, Section 8 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’).
e) Lateral vibration for shafting systems which include cardan shafts (Part 4, Chapter 4, Section 8 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’).

4.2.4.2 Azimuth thrusters

4.2.4.2.1 The following requirements are to be complied with:

a) The azimuthing mechanism is to be capable of a maximum rotational speed of not less than 1.5 rev/min.

b) Gearing for the azimuthing mechanism is to be designed to a recognised National Standard.

c) Under dynamic operating conditions, the gear is to be considered for:

   – Design maximum dynamic duty steering torque,
   – Variable loading, where applicable. A spectrum (duty) factor may be used. The load spectrum value is to be derived using load measurements of similar units, where possible.

d) Under a static duty (< 10^3 load cycles) steering torque, which should be not less than Q_R, as defined in Part 3 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

e) The following minimum factor of safety values are to be achieved:

   - Surface Stress $S_{Hmin} = 1.0$
   - Bending Stress $S_{Fmin} = 1.5$

f) For hydraulic pressure retaining parts and load bearing (See Chapter 8).

4.2.4.3 Azimuth thrusters with a nozzle

4.2.4.3.1 Where the propeller is contained within a nozzle, the equivalent rudder stock diameter in way of tiller, used in Chapter 8 is to be determined as follows:

$$d_u = 26.03 \times \sqrt[3]{(V+3)^2 A_N \; r} \quad [\text{mm}]$$

where,

V = maximum service speed, in knots, which the craft is designed to maintain under thruster operation.

A_N = projected nozzle area, in m^2, and is equal to the length of the nozzle multiplied by the mean external vertical height of the nozzle

r = horizontal distance from the centreline of the steering tube to the centre of pressure, in metres.

The corresponding maximum turning moment, Q_R, is to be determined as follows:

$$Q_R = 11.1 \text{ x } d_u^3 \text{ [Nmm]}$$

4.2.4.3.2 In addition to the requirements in Chapter 8 the scantlings of the nozzle stock or steering tube are to be such that the section modulus Z against transverse bending at any section x-x is not less than:

$$Z = 1.73 \text{ x } \sqrt{(V+3)^4 \, A_N^2 \quad r^2 + \frac{a^2}{4} T^2 \text{ x} 10^4} \text{ [cm}^3\text{]}$$

where,

a = dimension, in metres, as shown in Fig.4.2.4.3.2.

T = maximum thrust of the thruster unit, in tonnes.

4.2.4.3.3 The scantlings of nozzle connections or struts will be specially considered. In the case of certain high powered craft, direct calculation may be required.

4.2.4.3.4 Where the propeller is not contained in a nozzle, the scantlings in way of the tiller will be subject to special consideration.

4.2.5 Piping Systems

4.2.5.1 General

4.2.5.1.1 The piping system for azimuth thrusters is to comply with the general design requirements given in Chapter 11.

4.2.5.1.2 The specific requirements for lubricating / hydraulic oil systems and standby arrangements are given in Chapter 11.

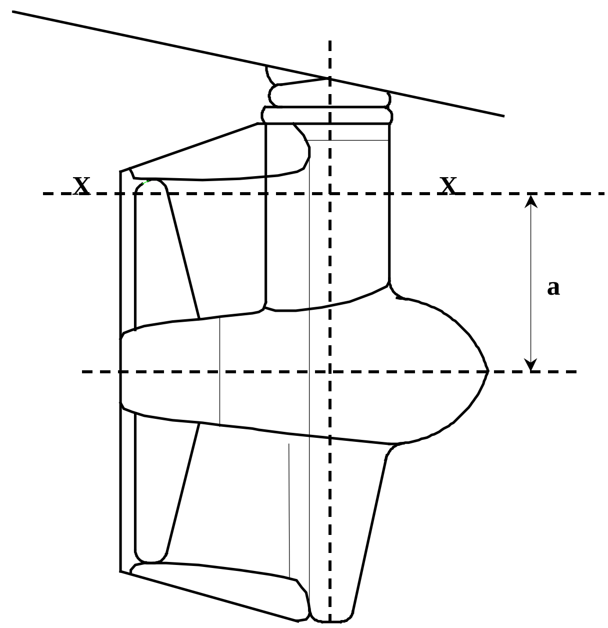

Fig. 4.2.4.3.2 : Azimuth thruster

4.2.5.2 Azimuth thruster

4.2.5.2.1 The hydraulic power operating systems for each azimuth thruster are to be provided with the following:

a) Arrangements to maintain the cleanliness of the hydraulic fluid, taking into consideration the type and design of the hydraulic system.

b) A fixed storage tank having sufficient capacity to recharge at least one azimuth power actuating system including the reservoir. The piping from the storage tank is to be permanent and arranged in such a manner as to allow recharging from within the thruster space.

4.2.5.2.2 Where the lubricating oil for the azimuth thrusters is circulated under pressure, provision is to be made for the efficient filtration of the oil. The filters are to be capable of being cleaned without stopping the thruster or reducing the supply of filtered oil.

4.2.6 Control and Monitoring

4.2.6.1 General

4.2.6.1.1 Except where indicated in this section the control engineering systems are to be in accordance with Chapter 14.

4.2.6.1.2 Azimuthing control for azimuth thruster(s) and propeller pitch control for azimuth and/or tunnel thruster(s) are to be provided from the navigating bridge, the main machinery control station and locally.

4.2.6.1.3 Means are to be provided at the remote control station(s) to stop each azimuth or tunnel thruster unit.

4.2.6.2 Monitoring and alarms

4.2.6.2.1 Alarms and monitoring requirements are indicated in 4.2.6.2.2, 4.2.6.2.3 and Table 4.2.6.1.

4.2.6.2.2 An indication of the angular position of the azimuth thruster(s) and the propeller pitch position for azimuth and/or tunnel thruster(s) are to be provided at each station from which it is possible to control the direction of thrust or the pitch.

4.2.6.2.3 All alarms associated with thruster unit faults are to be indicated individually on the navigating bridge and in accordance with the alarm system specified by Chapter 14.

Table 4.2.6.1

Item	Alarm	Note
Thruster, azimuth or tunnel		Indicators, see 4.2.6.2.2
Azimuthing motor	Power failure, single phase	Also running indication on bridge and at machinery control station
Propeller pitch motor	Power failure	Also running indication on bridge and at machinery control station
Propulsion motor	Overload, power failure	Also running indication on bridge and at machinery control station
Control system	Failure	
Hydraulic oil supply tank level	Low	
Hydraulic oil system pressure	Low	
Hydraulic oil system temperature	High	Where oil cooler is fitted
Hydraulic oil filters differential pressure	High	Where oil filters are fitted
Lubricating oil supply pressure	Low	If separate forced lubrication

4.2.7 Electrical Systems

4.2.7.1 General

4.2.7.1.1 The electrical installation is to be designed, constructed and installed in accordance with the requirements of Chapter 13.

4.2.7.2 Emergency power for steering systems and drives

4.2.7.2.1 For high speed craft, in the event of total power failure, either:

a) emergency power for steering systems / drives is to be restored automatically within five seconds. To achieve this an interim fast acting system may be required to come into operation until such time as the auxiliary / emergency power source comes on line. (Note : starting arrangements are to comply with the requirements relating to starting arrangements of emergency generators),

OR

b) means are to be provided to bring the craft to a safe condition.

4.2.7.3 Circuits

4.2.7.3.1 Azimuth thruster auxiliaries and controls are to be served by individual circuits. Services that are duplicated are to be separated throughout their length as widely as is practicable and without the use of common feeders, transformers, converters, protective devices or control circuits.

4.2.8 Requirements for Craft with 'LC' or 'HSLC' notation

4.2.8.1 Design and installation

4.2.8.1.1 Tunnel thrusters on craft less than 150 GT which are not essential for steering and manoeurving do not have to comply with the design requirements of this chapter.

4.2.8.1.2 The installation of such thrusters is to be such as to maintain the structural and watertight integrity of the craft.

4.2.8.2 Control and monitoring

4.2.8.2.1 Alarms and monitoring requirements of Table 4.2.6.1 are not required for craft of less than 150 GT.

4.2.9 Tests

4.2.9.1 Azimuth thrusters

4.2.9.1.1 The performance specified for the craft is to be demonstrated.

4.2.9.1.2 The actual values of steering torque are to be verified during sea trials to confirm that the design maximum dynamic duty torque has not been exceeded.

4.2.9.2 Tunnel thrusters

4.2.9.2.1 It is to be demonstrated that the thruster unit meets the specified performance.

4.3 Water Jet System

4.3.1 General Requirements

4.3.1.1 Application

4.3.1.1.1 This chapter is to be read in conjunction with the General Requirements for Machinery in Section 1.

4.3.1.1.2 This chapter gives requirements for fixed or steerable water jet propulsion systems which are integral with the craft's hull structure and form the main means of propulsion. The arrangements of water jet units for other purposes will be considered in relation to their intended duty.

4.3.1.1.3 A water jet propulsion unit is defined as a machine which takes in water, by means of a suitable inlet and ducting system and accelerates the mass of water using an impeller and nozzle to form a jet propulsion system.

4.3.1.2 Redundancy

4.3.1.2.1 In general a minimum of two water jet units are to be provided where these form the sole means of propulsion.

4.3.1.2.2 The failure of one water jet unit or its control system is not to render any other water to unit inoperative.

4.3.1.2.3 Where a single water jet installation is proposed, it will be subject to special consideration, taking into account the proposed restricted area notation. A formal risk assessment will be required in these cases.

4.3.2 Particulars to be submitted

4.3.2.1 Plans

4.3.2.1.1 General arrangement plans showing details of the following:

a) Shafting assembly indicating bearing positions;
b) Steering assembly;
c) Reversing assembly;
d) Longitudinal section of the complete water jet unit.

4.3.2.1.2 Details dimension plans indicating scantlings and materials of construction of the following:

a) Arrangement of the system, including intended method of attachment to the hull and building in, geometry of tunnel, shell openings, method of stiffening, reinforcement, etc.

b) All torque transmitting components, including impeller and also stator if fitted.

c) Steering components, together with a description and line diagram of the control circuit. This includes steerable exit water jet nozzles where fitted.

d) Components of retractable buckets where these are used for providing astern thrust.

e) The bearing or bearings absorbing the thrust and supporting the impeller, together with the method of lubrication.

f) Shaft sealing arrangements.

g) Details of any shafting support or guide vanes used in the water jet system.

4.3.2.1.3 Schematic plans of the lubricating and hydraulic systems, together with pipe material, relief valves and working pressures.

4.3.2.2 Calculations and information

4.3.2.2.1 Details of the power/speed range of operation indicating the maximum continuous torque together with flow rate and thrust.

4.3.2.2.2 Strength calculations, using the maximum continuous torque rating and the most 'onerous' operating condition, including short term high power operation, as a design case including the effects of mean and fluctuating loads, residual stresses and stress raisers, for:

a) Impeller and, if fitted, the stator and any bolting arrangements.

b) Shaft supports and guide vanes if fitted.

   In the absence of precise information, the fluctuating stress may be assumed to be 15 percent of the maximum stress. As an alternative to fatigue strength calculation results of an approved measurement programme may be submitted. In all cases, a factor of safety of at least 1.5 is to be demonstrated for the maximum continuous rating condition.

c) Detailed weld specification where an impeller has welded blades. Welds are to be full penetration type or of equivalent strength.

d) Steering components, including lugs of steerable nozzles where fitted.

e) Retractable buckets and associated mechanism, which are used to provide astern thrust. A calculation of the hydrodynamic transient loads is to be made for each design and is to include the full ahead to full astern condition. The calculation procedure used is to be supported, where possible, with appropriate full scale or model test data or satisfactory service experience to validate the design method.

4.3.2.2.3 Details of the Designer's loadings and positions of application in the hull are to be submitted and should include maximum applied thrust, moments and tunnel pressures. The tunnel strength and supporting structure are to be examined by direct calculation procedures and submitted for consideration.

4.3.2.2.4 Calculations, or relevant documentation indicating the suitability of all components for short term high power operation, where applicable.

4.3.2.2.5 Where it is proposed to use composite (non-metallic) shafts, details of materials, resin, lay-up procedure and documentary evidence of fatigue endurance strength.

4.3.2.2.6 Torsional vibration calculations of the complete dynamic system in accordance with Part 4, Chapter 4, Section 8 of the 'Rules and Regulations for the Construction and Classification of Steel Ships', together with a torsional schematic of the water jet unit.

4.3.2.2.7 Shaft whirling calculations where required by Part 4, Chapter 4, Section 8 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

4.3.2.2.8 Details of control engineering aspects are to be in accordance with Chapter 14.

4.3.3 Materials

4.3.3.1 General

4.3.3.1.1 The materials used in the construction are to be manufactured and tested in accordance with Part 2.

4.3.3.1.2 Machinery components are to be of steel or other approved non-ferrous metals suitable for the intended environment.

4.3.3.2 Fibre reinforced plastic

4.3.3.2.1 Fibre Reinforced Plastic materials (FRP) may be used for certain components, provided that they are of adequate strength and comply with the requirements of Chapter 7.

4.3.4 Design and Construction

4.3.4.1 Shaftline

4.3.4.1.1 The diameter of the shafting is to comply with Section 2. For calculation purposes the shaft carrying the impeller is to be taken as equivalent to a screwshaft.

4.3.4.1.2 Where it is proposed to use carbon or carbon manganese steel shafts which may be in contact with seawater, these are to be protected. Full details of the means of protection are to be submitted.

4.3.4.1.3 Where lengths of shafts are joined using couplings of the shrunk element type, full particulars of the method of achieving the grip force are to be forwarded for consideration. A factor of safety against slippage of 2.0, based upon mean plus vibratory torque, is to be achieved for couplings located inboard, and likewise 2.5 for couplings which are located outboard.

4.3.4.1.4 For the interference fit of keyless impellers the requirements of Section 4 are to be applied.

4.3.4.2 Shaft support system and guide vanes

4.3.4.2.1 In cases where the shaft requires support from the tunnel walls ahead of the impeller, or, alternatively, where guide vanes are required to assist the flow around a bend in the ducting system, the supports or guide vanes are to be aligned to the flow and have suitably rounded leading and trailing edges or be of an aero-foil section.

4.3.4.2.2 Fatigue strength calculations of supports or guide vanes are to be submitted and are to include the effects of mean and fluctuating loads, residual stresses and stress raisers, in general, the fillet radius should not be less than the maximum thickness at that location. Smaller radii may be considered for which the results of an approved measurement programme are to be submitted. In all cases, a factor of safety of at least 1.5 is to be demonstrated for the designed operating conditions.

4.3.4.2.3 A facility for the inspection of the supports or guide vanes is to be provided which will allow either direct visual or boroscope inspection of these components.

4.3.4.3 Impeller

4.3.4.3.1 In general, the fillet radius should not be less than the maximum thickness at that location. Composite radiused fillets or elliptical fillets which provide an improved stress concentration factor are acceptable and are to be preferred.

4.3.4.3.2 Where an impeller has bolted on blades, consideration is also to be given to the distribution of stress in the palms of the blade and in the hub and bolting arrangements.

4.3.4.3.3 The blades are to be provided with hydro-dynamically faired leading and trailing edges which may be either of simple radius or of a more complex aerofoil edge form. The tip clearance, whilst being kept to a minimum for hydrodynamic purposes must be sufficient to allow for any transient vibrational behaviour, axial shaft movement or differential thermal expansion.

4.3.4.3.4 A calculation of the blade natural frequency for the impeller blades is to be undertaken. As such the natural frequency should be shown to lie outside any expected excitation frequencies within a speed range of 30 percent below to 10 percent above the maximum impeller speed. Deviations from these limits will be considered.

4.3.4.3.5 A facility for the in service inspection of the impeller and sector (if fitted) blades is to be provided which will allow for either a direct visual or boroscope inspection of the complete blade surfaces.

4.3.4.4 Stator

4.3.4.4.1 The stator blades, where fitted, are to be designed to be capable of withstanding the combined hydrodynamic and mechanical loads (including any loads transmitted via shaft bearings) developed by the unit and reacted through the blades when the impeller is absorbing full power and the vessel is either free running or undergoing a crash stop manoeuvre, whichever imposes the greater loading on the blades.

4.3.4.4.2 In general, the fillet radius should not be less than the maximum thickness at that location. Composite radiused fillets or elliptical fillets which provide improved stress concentration factors are acceptable and are to be preferred.

4.3.4.4.3 If the stator ring is a composite assembly then consideration is also to be given to the distribution of stress in the various adjacent members.

4.3.4.4.4 A calculation of the relative blade passing frequency between the rotor and stator blades is to be carried out and it is to be demonstrated that this does not coincide with the natural frequency of the stator blades over a speed range of 30 percent below to 10 percent above maximum impeller speed. Similarly this condition is to be demonstrated for the manoeuvring speeds.

4.3.4.4.5 The stator blades are to be provided with hydro-dynamically faired leading edges which may have either a simple radius or a more complex aerofoil edge form.

4.3.4.4.6 Where the stator blading assembly forms part of the nozzle, the requirements of 4.3.4.6 must be considered in association with those for the stator assembly.

4.3.4.5 Tunnel and securing arrangements

4.3.4.5.1 The tunnel is to be adequately supported, framed and fully integrated into the hull structure.

4.3.4.5.2 The tunnel and supporting structure scantlings are to be not less than the Rule requirements for the surrounding structure. The strength of the hull structure in way of tunnels is to be maintained. The structure is to be adequately reinforced and compensated as necessary. All openings are to be suitably reinforced and have radiused corners.

4.3.4.5.3 Consideration should be given to providing the inlet to the tunnel with a suitable guard to prevent the ingress of large objects into the roto-dynamic machinery. The dimensions of this guard must strike a balance between undue efficiency loss due to flow restriction and viscous losses, the size of object allowed to pass and susceptibility to clog with weed and other flow restricting matter.

4.3.4.5.4 The inlet profile of the tunnel is to be designed so as to provide a smooth uptake of the water over the range of vessel operating trims and avoid significant separating of the flow into the rotating machinery.

4.3.4.5.5 Design consideration is to take account of pressures which could develop as a result of a duct blockage, and to the axial location of rotating parts.

4.3.4.6 Nozzle and reversing bucket

4.3.4.6.1 Nozzles can be either of a fixed or steerable form. The design of the nozzle must fully take into account the change in pressure distribution along its inner surface together with the other mechanical loads (e.g. stator assembly loads) and transient loads caused by the flow directing attachments and bucket loads which may be reacted through the body of the nozzle. In this analysis the changes to the pressure distribution caused by transient manoeuvres are to be considered.

4.3.4.6.2 Consideration is to be given to all transient loads the bucket is likely to experience from manoeuvring and the sea conditions.

4.3.4.6.3 The bucket is to be given reasonable mechanical protection from other impact damage such as collision with harbour walls, other vessels, buoys, etc.

4.3.4.7 Steering system

4.3.4.7.1 In general the steering systems are to comply with the requirements of Chapter 8.

4.3.4.7.2 In addition to the requirements of Chapter 8 the steering mechanism is to be capable of turning the nozzle unit at not less than 1.5 rev/min.

4.3.5 Piping Systems

4.3.5.1 General

4.3.5.1.1 The piping systems for a water jet unit are to comply with the general requirements of Chapter 11, Section 1.

4.3.5.1.2 The specific requirements for lubricating hydraulic oil systems and standby arrangements are given in Chapter 11. Requirements for steering hydraulic systems are given in Chapter 8.

4.3.5.2 Hydraulic power systems

4.3.5.2.1 The hydraulic power operating systems for each water jet unit are to be provided with the following:

a) Arrangements to maintain the cleanliness of the hydraulic fluid, taking into consideration the type and design of the hydraulic system.

b) A fixed storage tank having sufficient capacity to recharge at least one water jet power actuating system including the reservoir.

4.3.6 Control and monitoring

4.3.6.1 General

4.3.6.1.1 For water jets used as the only means of propulsion, a standby or alternative power source of actuating medium for controlling the angular position and/or the reversing angle is to be provided. Automatic start of the standby pump supplying hydraulic power for steering and reserving is to be provided.

4.3.6.1.2 Means are to be provided at each station to stop each water jet.

4.3.6.2 Monitoring and alarms

4.3.6.2.1 Alarms and monitoring requirements are indicated in 4.3.6.2.2 to 4.3.6.2.4 and Table 4.3.6.2.

Table 4.3.6.2

Item	Alarm	Note
Hydraulic system pressure	Low	-
Hydraulic oil supply tank level	Low	-
Hydraulic oil temperature	High	Where an oil cooler is fitted
Hydraulic system flow	Low	-
Lubricating oil pressure	Low	-
Control system	Fault	-
Control system power supply	Failure	-

4.3.6.2.2 An indication of the angular position of the nozzle is to be provided at each station from which it is possible to control the direction of thrust.

4.3.6.2.3 An indication of both the required and actual reversing bucket position is to be provided at each station from which it is possible to control the reversal of thrust.

4.3.6.2.4 All alarms associated with water jet unit faults are to be indicated individually at the controls stations and in accordance with the alarm system specified by Chapter 14.

4.3.7 Electrical Systems

4.3.7.1 Distribution arrangements

4.3.7.1.1 Water jet auxiliaries and controls are to be served by individual circuits. Services that are duplicated are to be separated throughout their length as widely as is practicable and without the use of common feeders, transformers, convertors, protective devices or control circuits.

4.3.8 Tests

4.3.8.1 The following components are to be inspected at the manufacturer's works:

– steering nozzle,
– reverse bucket,
– stator impeller
– integral bearing.

4.3.8.2 Welded components are to comply with the requirement of Chapter 12 and be subject to stress relief heat treatment upon completion. Where an impeller has welded blades, non-destructive testing is to be carried out to an approved procedure.

4.3.8.3 Testing of the first installation of a new type of water jet unit is required and is to demonstrate the adequacy of the steering and reversing mechanisms during the most arduous manoeuvres.

4.3.8.4 Upon completion, the impeller assembly is to be suitably balanced in accordance with ISO 940 Grade G6.3 or an equivalent standard.

Section 5

Pressure Vessels

5.1 Application

5.1.1 The requirements of this chapter are applicable to fusion welded pressure vessels and their mountings and fittings, where plans have to be submitted in accordance with 5.2.

5.1.2 Seamless pressure vessels are to be manufactured in accordance with the requirements of Part 2 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

5.1.3 Steam raising plant and associated pressure vessels should be designed and constructed in accordance with Part 4, Chapter 5 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

5.2 Details to be submitted

5.2.1 Plans of pressure vessels are to be submitted in triplicate for consideration where all the conditions in (a) or (b) are satisfied:

a) The vessel contains vapours or gases, e.g. air receivers, hydrophore or similar vessels and gaseous CO_2 vessels for fire fighting and

$pV > 600$
$p > 1$
$V > 100$

Where,

V = volume (litres) of gas or vapour space.
p = design pressure (bar)

b) The vessel contains liquefied gases for fire fighting, or flammable liquids, and

$p > 7$
$V > 100$

Where,

V = volume (litres)
p = design pressure (bar)

5.3 Materials

5.3.1 Materials used in the construction are to be manufactured and tested in accordance with the requirements of Part 2.

5.3.2 Where it is proposed to use materials other than those specified in Part 2, details of the chemical compositions, heat treatment and mechanical properties are to be submitted for approval. In such cases, the values of the mechanical properties used for deriving the allowable stress are to be subject to agreement by IRS.

5.4 Design pressure

5.4.1 The design pressure is the maximum permissible working pressure and is to be not less than the highest set pressure of any safety valve.

5.5 Metal temperature

5.5.1 The metal temperature, T, used to evaluate the allowable stress, σ, is to be taken as the actual metal temperature expected under operating conditions for the pressure part concerned, and is to be stated by the manufacturer when plans of the pressure parts are submitted for consideration.

5.5.2 For fusion welded pressure vessels the minimum design temperature, T, is not to be less than $50^{o}C$.

5.6 Design and construction

5.6.1 Refer Part 4, Chapter 5 of ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

5.7 Mountings and Fittings for Pressure Vessels

5.7.1 General

5.7.1.1 Each pressure vessel or system is to be fitted with a stop valve situated as close as possible to the shell.

5.7.1.2 Adequate arrangements are to be provided to prevent over-pressure of any part of a pressure vessel which can be isolated. Pressure gauges are to be fitted in positions where they can be easily read.

5.7.1.3 Adequate arrangements are to be provided for draining and venting the separate parts of each pressure vessel.

5.7.2 Receivers containing pressurized gases

5.7.2.1 Each air receiver is to be fitted with a drain arrangement at its lowest part, permitting oil and water to be blown out.

5.7.2.2 Each receiver which can be isolated from a relief valve is to be provided with a suitable fusible plug to discharge the contents in case of fire. The melting point of the fusible plug is to be approximately 150^{o}C. See also below.

5.7.2.3.Where a fixed system utilizing fire extinguishing gas is fitted, to protect a machinery space containing an air receiver(s), fitted with a fusible plug, it is recommended that the discharge from the fusible plug be piped to the open deck.

5.7.2.4 Receivers used for the storage of air for the control of remotely operated valves are to be fitted with relief valves and not fusible plugs.

5.8 Hydraulic tests

5.8.1 Fusion welded pressure vessels

5.8.1.1.Fusion welded pressure vessels are to be tested on completion to a pressure, p_T, determined by the following formula, without showing signs of weakness or defect:

$$p_T = 1.3 \frac{\sigma_{50}}{\sigma_T} \frac{t}{(t - 0.75)} p$$

but in no case is to exceed

$$1.5 \frac{t}{(t - 0.75)} p$$

where,

p = design pressure in bar

p_T = test pressure, in bar

t = nominal thickness of shell as indicated on the plan [mm]

σ_T = allowable stress at design temperature [N/mm^2]

σ_{50} = allowable stress at 50^{o}C [N/mm^2].

5.8.2 Mountings

5.8.2.1 Mountings are to be subjected to a hydraulic test of twice the approved design pressure.

5.9 Fibre Reinforced Plastics Pressure Vessels

5.9.1 General

5.9.1.1 Pressure vessels may be constructed in fibre reinforced plastics provided the manufacturer is competent and suitably equipped for this purpose.

5.9.1.2 Pressure vessels are to be of standard design whose suitability has been established by fatigue and burst tests on a prototype.

5.9.2 Prototype testing

5.9.2.1 For the fatigue test the pressure shall be cycled from atmospheric to design pressure 100 000 times at the design temperature.

5.9.2.2 For the burst test the minimum bursting pressure shall be six times the design pressure.

5.9.3 Production hydraulic test

5.9.3.1 Vessels subject to internal pressure shall be hydraulically tested to not less than 1.5 times the design pressure.

5.10 Requirements for Craft with ‘LC’ or ‘HSLC’ notation

5.10.1 Fibre reinforced plastics pressure vessels

5.10.1.1 Fibre reinforced plastics pressure vessels, where the product of the design pressure in bar and volume in litres exceeds 600, are not to be situated in machinery spaces or high risk areas on craft less than 150 GT.

5.10.1.2 Small fibre reinforced plastics pressure vessels will receive special consideration in relation to their intended duty and service conditions.

End Of Chapter

Chapter 13

Electrical Installations

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Section 1

General Requirements

1.1 General

1.1.1 The requirements of Section 1 to 17 and 19 are applicable to all crafts having ‘HSC’ notation.

All non-HSC non-passenger crafts of less than 500 tons GT having ‘LC’ or ‘HSLC’ notation are to meet the requirements of Section 18.

For all non-HSC craft of more than 500 tons GT and non-HSC passenger craft of less than 500 tons GT (having ‘LC’ or ‘HSLC’ notation), the requirements given in Part 4, Chapter 8 of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’ are to be applied, in general. It may be noted that as these crafts, do not follow the design philosophy of the HSC Code in totality the requirements of HSC code are not applied.

1.1.2 Whilst this chapter applies to the electrical engineering equipment and systems on High Speed Craft and Light Crafts intended to be classed, attention should also be given to any relevant statutory regulations of the National Authority of the country in which the craft is to be registered.

1.1.3 Electrical services required to maintain the craft in a normal seagoing, operational and habitable condition are to be capable of being maintained without recourse to the emergency source of electrical power.

1.1.4 Electrical services essential for safety are to be maintained under various emergency conditions. The safety of passengers, crew and craft from electrical hazards is to be ensured.

1.1.5 Failure mode and effects analysis of the craft is to include the electrical system, taking into account the effects of electrical failure on the systems being supplied. In cases where faults can occur without being detected during routine checks on the installation the analysis is to take into account the possibility of faults occurring simultaneously or consecutively.

1.2 Definitions

1.2.1 ***Normal operational and habitable condition*** is condition under which the craft as a whole, the machinery, services, means and aids ensuring propulsion, ability to steer, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape, and emergency boat winches, as well as designed comfortable conditions of habitability are in working order and functioning normally.

1.2.2 ***Emergency condition*** is a condition under which any services needed for normal operational and habitable conditions are not in a working order due to the failure of the main source of electrical power.

1.2.3 ***Main source of electrical power*** is a source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship in normal operational and habitable conditions.

1.2.4 ***Dead craft condition and blackout*** are both understood to mean a condition under which the main propulsion plant, boilers and auxiliaries are not in operation and in restoring the propulsion, no stored energy for starting the propulsion plant, the main source of electrical power and other essential auxiliaries is to be assumed available. It is assumed that means are available at all times to start the emergency generator or one of the main generators when the main source is arranged according to 3.1.2.

1.2.5 ***Main generating station*** is the space in which the main source of electrical power is situated.

1.2.6 ***Main switchboard*** is a switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to craft's services.

1.2.7 ***Emergency switchboard*** is a switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power or transitional source of emergency power and is intended to distribute electrical energy to the emergency services.

1.2.8 ***Emergency source of electrical power*** is a source of electrical power, intended to supply the emergency switchboard in the event of failure of the supply from the main source of electrical power.

1.2.9 ***Special category spaces*** are those enclosed spaces above or below the bulkhead deck intended for the carriage of motor vehicles with fuel, for their own propulsion, in their tanks, into and from which such vehicles can be driven and to which passengers have access.

1.3 Plans

1.3.1 The following plans and details for electrical installation are to be submitted in triplicate for approval.

1.3.2 Single line diagram of main and emergency power and lighting systems which is to include:

a) ratings of machines, transformers, batteries and semi-conductor converters;
b) all feeders connected to the main and emergency switchboards;
c) section boards and distribution boards;
d) insulation type, size and current loadings of cables;
e) make, type and rating of circuit breakers and fuses.

1.3.3 Simplified diagrams of generator circuits, inter-connector circuits and feeder circuits showing:

a) protective devices e.g. short circuit, overload, reverse power protection;
b) instrumentation and synchronizing devices;
c) preference tripping;
d) remote stops;
e) earth fault indication/protection.

1.3.4 Calculations of prospective short circuit currents of main busbar and secondary side of transformers (Additionally load schedule of normal and emergency operating loads on the system estimated for the different operating conditions expected is to be submitted for information).

1.3.5 For battery installations, arrangement plans and calculation to show compliance with Section 11.

1.3.6 Details of electrically operated passenger and crew safety systems which are to include single line diagrams and a general arrangement plan of the craft showing the vertical fire zones and location of equipment and cable routes of:

a) emergency lighting;
b) accommodation fire detection, alarm and extinction systems;
c) public address system;
d) general alarm;
e) watertight doors, shell doors and other electrically operated closing appliances.

1.3.7 In order to establish compliance with 5.1.3 to 5.1.5. General Arrangement plan of the craft showing location of major items of electrical equipment, i.e. main and emergency generators, main and emergency switchboards, emergency batteries, motors for emergency services.

1.3.8 Arrangement plans of main and emergency switch board and section boarding.

1.4 Surveys

1.4.1 Electrical machinery and auxiliary services essential for the safety of the craft are to be installed in accordance with the relevant requirements of this chapter, surveyed and have tests witnessed by the Surveyors.

1.4.2 Generators, motors and transformers of 100 kW or over intended for essential services are to be surveyed during manufacture and testing.

1.5 Essential and other services

1.5.1 Essential services wheresoever mentioned in the Rules are those which need to be in continuous operation for maintaining the craft's maneuverability with regard to propulsion and steering and for the safety of the craft. Examples of essential services are:

- steering gear,
- pumps for variable pitch propellers,
- fuel oil supply pumps,
- fuel valve cooling pumps,
- lubricating oil pumps,
- circulating and cooling water pumps,
- automatic sprinkler systems,
- main engine remote control devices,
- fire detection and alarm system,
- communication systems,
- windlasses,
- ventilating fans for engine room,
- air compressors for starting and maneuvering essential mains and auxiliary machinery,
- air pumps,
- ballast and bilge pumps,
- fire pumps,
- main lighting system for those parts of craft normally accessible to and used by personnel and passengers,
- navigational aids where required by statutory regulations,
- navigational lights and special purpose lights where required by statutory regulations,
- watertight doors and other electrically operated closing appliances,
- scavenge blowers,
- valves which are required to be remotely operated,
- power sources and supply system for supplying the above services.

1.5.2 Services such as following are considered necessary for minimum comfortable conditions of habitability :

- cooking;
- heating;
- domestic refrigeration;
- mechanical ventilation;
- sanitary and fresh water.

1.5.3 Services such as following, which are in addition to 1.5.1 and 1.5.2, are considered necessary to maintain the craft in a normal seagoing operational and habitable condition :

- cargo handling and cargo gear equipment;
- hotel services, other than those required for habitable conditions;
- thrusters systems for manoeuvring.

1.6 Design and construction

1.6.1 Equipment for services essential for the safety of the craft are to be constructed in accordance with the relevant requirements of this chapter.

1.6.2 The design and installation of other equipment is to be such that risk of fire due to its failure is minimized. It is to, as a minimum, comply with a National or International Standard revised where necessary for ambient conditions.

1.7 Voltage and frequency variation

1.7.1 All electrical appliances supplied from the main or emergency systems are to be so designed and manufactured that they are capable of operating satisfactorily under the normally occurring variations in voltage and frequency. Unless otherwise stated, all equipments are to operate satisfactorily with the variations from its rated value shown in the following table:

Item	Variations	
	Permanent	Transient
Frequency	± 5%	± 10% (recovery time 5 seconds)
Voltage	+ 6% - 10%	± 20% (recovery time 1.5 seconds)
Note : The above values do not apply to battery systems		

1.8 Ambient reference conditions

1.8.1 For details regarding ambient reference condition see Part 4, Chapter 1, Section 1.7 of Rules and Regulations for the Construction and Classification of Steel Ships.

1.9 Inclination of craft

1.9.1 Emergency and essential electrical equipment is to operate satisfactorily under the conditions as shown in Table 1.9.1.

Table 1.9.1 : Machinery inclination

Installations/Components	Angle of inclination [1)]			
	Athwartships		Fore-and-aft	
	Static	Dynamic	Static	Dynamic
Main and auxiliary machinery	15°	22.5°	5°	7.5°
Safety equipment e.g. emergency power installations, emergency fire pumps and their devices switchgear, electrical and electronic appliances[2)] and remote control systems	22.5°	22.5°	10°	10°

Notes:
1) Athwartships and core-and-aft inclinations occur simultaneously.
2) Switches and controls are to remain in their last set position.

1.10 Location and construction

1.10.1 Electrical equipment is, as far as is practicable, to be accessibly placed, clear of flammable material in well ventilated, adequately lighted spaces, in which flammable gases cannot accumulate and where it is not exposed to risk of mechanical injury or damage from water, steam or oil. Where necessarily exposed to such risks, the equipment is to be suitably constructed or enclosed. Live parts are to be guarded where necessary.

1.10.2 All electrical apparatus is to be so constructed and so installed that it does not cause injury when handled or touched in the normal manner.

1.10.3 Insulating materials and insulated windings are to be flame retardant and resistant to tracking, moisture, sea air and oil vapour unless special precautions are taken to protect them.

1.10.4 Equipment is not to remain alive through the control circuits and/or pilot lamps when switched off by the control switch. This does not apply to synchronizing switches and/or plugs.

1.10.5 The operation of all electrical equipment and the lubrication arrangements are to be efficient under such conditions of vibration and shock as arise in normal practice.

1.10.6 All nuts and screws used in connection with current-carrying and working parts are to be effectively locked.

1.10.7 Conductors and equipment are to be placed at such a distance from the magnetic compasses, or are to be so disposed, that the interfering magnetic field is negligible when circuits are switched on and off.

1.11 Earthing

1.11.1 Unless specifically exempted in 1.11.2 all accessible metal of the electric installation, other than current carrying accessible parts should be earthed.

1.11.2 The following parts may be exempted from the requirements of 1.11.1:

a) lamp-caps, where suitably shrouded;
b) shades, reflectors and guards supported on lamp-holders or light fittings constructed of, or shrouded in, non-conducting material;
c) metal parts on, or screws in or through, non-conducting materials, which are separated by such material from current-carrying parts and from earthed non-current carrying parts in such a way that in normal use they cannot become live or come into contact with earthed parts;
d) apparatus which is constructed in accordance with the principle of double insulation;
e) bearing housings which are insulated in order to prevent circulation of current in the bearings;
f) clips for fluorescent lamps;
g) cable clips and short lengths of pipes for cable protection;
h) apparatus supplied at a voltage not exceeding 55 V direct current or 55 V, root mean square, between conductors, or between any conductor and earth in a circuit isolated from the supply. Autotransformers are not to be used for the purpose of achieving the alternating current voltage;
i) apparatus or parts of apparatus which although not shrouded in insulating material is nevertheless otherwise so guarded that it cannot be touched and cannot come in contact with exposed metal.

1.11.3 Metal coverings of cables are to be effectively earthed at both ends of the cable. In final sub-circuits, other than those installed in hazardous zones or spaces, earthing at the supply end only will be considered adequate. Single point earthing may be accepted for instrumentation cables if desirable for technical reasons.

1.11.4 The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and tappings, is to be ensured.

1.11.5 Metal parts of portable appliances, other than current-carrying parts and parts exempted by 1.11.2 are to be earthed by means of an earth-continuity conductor in the flexible cable or cord through the associated plug and socket-outlet.

1.11.6 Earthing conductors are to be of copper or other corrosion-resistant material and be securely installed and protected where necessary against damage and also, where necessary, against electrolytic corrosion. Connections are to be so secured that they cannot work loose under vibration.

1.11.7 The nominal cross-section areas of copper earthing conductors are, in general to be equal to the cross section of the current carrying conductor upto 16 mm^2. Above this figure they are to be equal to at least half the cross-section of the current-carrying conductor with a minimum of 16 mm^2. Every other earthing conductor is to have a conductance not less than that specified for an equivalent copper earthing conductor.

1.11.8 The connection of the earthing conductor to the hull of the craft is to be made in an accessible position and is to be secured by a screw or stud of diameter not less than 6 mm which is to be used for this purpose only. Bright metallic surfaces at the contact areas are to be ensured immediately before the nut or screw is tightened and, where necessary, the joint is to be protected against electrolytic corrosion. The connection is to remain unpainted.

1.12 Electrical bonding for the control of static electricity

1.12.1 In non-metallic craft, all metallic parts of the craft are to be electrically bonded together, as far as possible, in consideration of galvanic corrosion between dissimilar metals, to ensure an earth return path and to connect the craft to the water when water-borne. This does not apply to isolated components, which cannot become live, nor require control of static electricity.

1.12.2 Bonding straps for the control of static electricity are required for piping systems, including pressure refuelling points, which are not electrically continuous throughout their length and for flammable products, which are not permanently connected to the hull of the craft either directly or via their bolted or welded supports and where the resistance between them and the hull exceeds 1MΩ.

1.12.3 Where bonding straps are required for the control of static electricity, they are to be robust, that is, having a cross sectional area of about 10 mm^2, and are to comply with 1.11.6 and 1.11.8.

1.12.4 Where bonding conductors are provided for lightning discharge currents, they are to have a minimum cross section of 50 mm^2 in copper.

1.13 Enclosures

1.13.1 The enclosure types given in Table 1.13.1 are required as a minimum.

Table 1.13.1 : Enclosure types in relation to location
(N : Normally not accepted for installation in this location).

Location	**Switch-boards**	**Control gear and motor starters**	**Rotating machines**	**Trans-formers and rectifiers**	**Lighting fittings**	**Heating applian-ces**	**Socket outlets**	**Accesso-ries such as switches, connecti-on boxes**
Engine rooms								
Above the floor	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
Dry control rooms	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22
Below the floor	N	N	IP 44	N	IP 44	IP 44	N	IP 44
Closed compartments for fuel oil and lub.oil separators	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	N	IP 44
Fuel oil tanks	N	N	N	N	N	N	N	N
Ballast and other water tanks, bilge wells	N	N	IP 68	N	N	IP 68	N	N
Ventilation ducts	N	N	IP 44	N	N	N	N	N
Deckhouses, forecastle spaces, steering gear compartments and similar spaces	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
Ballast pump rooms and similar rooms below the loadline	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	IP 56	IP 56
Cargo holds	N	N	IP 44	N	IP 55	N	IP 56	IP 56
Open deck, keel ducts	IP 56	IP 56	IP 56	IP 56	IP 55	IP 56	IP 56	IP 56
Battery rooms, lamp rooms, paint stores, stores for welding gas bottles	N	N	EX	N	EX	EX	N	EX
Dry accommodation spaces	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20
Bath rooms and showers	N	N	N	N	IP 44	IP 44	N	IP 56
Galleys, laundries and similar rooms	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44

1.14 Creepage and clearance distances

1.14.1 Distance between live parts and between live parts and earthed metal, whether across surfaces or in air, are to be adequate for the working voltages considering the nature of the insulating material and the transient over voltages developed by switch and fault conditions.

1.14.2 For bare busbars the minimum clearance distances in Table 1.14.1 are to be observed. Where necessary these distances are to be increased to allow for the electromagnetic forces involved and also depend upon insulating material, dust, deposits, humidity etc.

1.15 Additions or alterations

1.15.1 No addition, temporary or permanent, is to be made to the approved load of an existing installation until it has been ascertained that the current carrying capacity and the condition of the existing equipment including cables and switchgear are adequate for the increased load.

1.15.2 Plans are to be submitted for consideration and the alterations or additions are to be carried out under the survey and to the satisfaction of the Surveyors.

Table 1.14.1 : Minimum clearances distances

Voltage between phases or poles	Minimum clearance to earth		Minimum clearance between phases or poles	
	In air [mm]	In oil [mm]	In air [mm]	In oil [mm]
660 or less	16	-	19	-
2200	38	-	38	-
3300	51	13	51	19
6600	63	19	89	25

Section 2

Main Source of Electrical Power

2.1 General

2.1.1 The main source of electrical power is to comply with the requirements of this section without recourse to the emergency source of electrical power.

2.2 Number and rating of generating sets

2.2.1 Under seagoing conditions, the number and rating of service generating sets and converting sets, when any one generating set or converting set is out of action, are:

a) to be sufficient to ensure the operation of electrical services for essential equipment and habitable conditions;

b) to have sufficient reserve capacity to permit the starting of the largest motor without causing any motor to stall or any device to fail due to excessive voltage drop on the system;

c) to be capable of providing the electrical services necessary to start the main propulsion machinery from a “dead ship condition”. The emergency source of electrical power may be used to assist if it can provide power at the same time to those services required to be supplied by Section 3. (See also 2.4.2).

2.2.2 The arrangement of the craft’s main source of power is to be such that the operation of electrical services for essential equipment and habitable conditions can be maintained regardless of the speed and direction of the propulsion machinery shafting.

2.2.3 Where the electrical power requirement to maintain the craft in a normal operational and habitable condition is usually supplied by one generating set, arrangements are to be provided to prevent overloading of the running generator. On loss of power there is to be provision for automatic starting and connecting to the main switchboard of the standby set and automatic sequential restarting of essential services in as short a time as practicable.

2.3 Number and rating of converting equipment

2.3.1 Where the electrical services for essential equipment and habitable conditions is supplied via converting equipment, such as transformers and semi conducting converters, the number of sets and the rating of the converting equipment are to be sufficient to ensure the operation of these electrical services even when one set of converting equipment is out of source.

2.3.2 Each transformer or semi conducting converter is to be fitted as separate unit, with a separate enclosure.

2.4 Starting arrangements

2.4.1 The starting arrangements of the generating sets prime movers are to comply with the requirements of Part 4, Chapter 4 as applicable in Rules & Regulations for the Construction and Classification of Steel Ships.

2.4.2 Where the emergency source of electrical power is required to be used to restore propulsion from a “dead craft condition”, the emergency generator is to be capable of providing initial starting energy for the propulsion machinery within 30 minutes of the “dead craft condition”. The emergency generator capacity is to be sufficient for restoring propulsion in addition to supplying those services in Section 3. See Part 4, Chapter 4, Section 4 for initial starting arrangements in ‘Rules and Regulations for the Construction and Classification of Steel Ships’.

2.5 Prime mover governors

2.5.1 The governing accuracy of the generating sets’ prime movers is to meet the requirements of Part 4, Chapter 4 in Rules & Regulations for the Construction and Classification of Steel Ships.

2.5.2 The maximum load step applied to the electrical installation is not to cause the frequency variation of the electrical supply to exceed the parameters given in 1.7.1. See also Part 4, Chapter 4 in Rules and Regulations for the Construction and Classification of Steel Ships.

Section 3

Emergency Source of Electrical Power

3.1 General

3.1.1 The requirements of this section apply to passenger craft and to cargo craft of 500 tonnes gross tonnage and above, in general.

3.1.2 Where the main source of electrical power is located in two or more compartments which are not contiguous, each of which has its own self-contained systems, including power distribution and control systems, completely independent of each other and such that a fire or other casualty in any one of the spaces will not affect the power distribution from the others, or to the services required by 3.2 and 3.3, the requirement of this section may be considered satisfied without an additional emergency source of electrical power, provided that:

a) there is at least one generating set of sufficient capacity to meet the requirement of 3.2 or 3.3 and 3.4 in at least two non-contiguous spaces;

b) the generator sets referred to in 3.1.2(a) and their self-contained systems are installed such that one of them remains operable after damage or flooding in any one compartment.

3.1.3 Cargo craft of 300 tons gross tonnage and above are to comply with 3.6.

3.2 Emergency source of electrical power in passenger craft

3.2.1 A self-contained emergency source of electrical power is to be provided.

3.2.2 The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the waterline in the final condition of damage, be operable in that condition and be readily accessible from the open deck. They are not to be located forward of the collision bulkhead.

3.2.3 The location of the emergency source of electrical power and associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard is to be such as to ensure that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space will not interfere with the supply, control and distribution of emergency electrical power. The space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard is not to be contiguous to the boundaries of machinery spaces and those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard.

3.2.4 Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used exceptionally, and for short periods, to supply non-emergency circuits. Failure of the emergency switchboard when being used in other than an emergency is not to put at risk the operation of the craft.

3.2.5 For Category (B) craft, the electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

a) for a period of 12 hours, emergency lighting:

- i) at the stowage positions of life saving appliances;
- ii) at all escape routes, such as alleyways, stairways, exits from accommodation and service spaces, embarkation points, etc.;
- iii) in the passenger compartments;
- iv) in the machinery spaces and main emergency generating spaces including their control positions;
- v) in control stations;
- vi) at the stowage positions for firemen's outfits; and
- vii) at the steering gear.

b) for a period of 12 hours:

- i) the navigation lights and other lights required by International Regulations for Preventing Collisions at Sea in force;
- ii) electrical internal communication equipment for announcements for passengers and crew required during evacuation;
- iii) fire detection and general alarm system and manual alarms; and
- iv) remote control devices of fire-extinguishing system, if electrical.

c) for a period of 4 hours on intermittent operation:

- i) daylight signalling lamps if they have no independent supply from their own accumulator battery; and
- ii) the craft's whistle, if electrically driven.

d) for a period of 12 hours:

- i) the navigational equipment as required by HSC Code Chapter 13; where such provision is unreasonable or impractical this requirement may be waived for craft of less than 5000 tons gross tonnage;
- ii) essential electrically powered instruments and control for propulsion machinery, if alternate sources of power not available for such devices;
- iii) emergency fire pump;
- iv) the automatic sprinkler pump and drencher pump, if fitted;
- v) the emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves;
- vi) the VHF radio installation required by SOALS 1974, as amended, Chapter IV, Regulation 7.1.1 and 7.1.2; and, if applicable;

  .1 the MF radio installation required by SOLAS 74, as amended, chapter IV regulations 9.1.1, 9.1.2, 10.1.2 and 10.1.3;

  .2 the ship earth station required by SOLAS 74, as amended, chapter IV, regulations 10.1.2, 10.2.2 and 11.1;

e) for a period of 10 min:

- i) power drives for directional control devices including those required to direct thrust forward and astern, unless there is a manual alternative complying with Part 4, Chapter 6 of 'Rules and Regulations for the Construction and Classification of Steel Ships'; and

f) for a period of half an hour;

- i) any watertight doors which are required to be power operated together with their indicators and warning signals.

g) Where applicable, the services required by 2.4.2.

3.2.6 The emergency source of electrical power may be either a generator or an accumulator battery, which is to comply with the following:

a) Where the emergency source of electrical power is a generator it is to be:

   i) Driven by a suitable prime mover with an independent supply of fuel having a flashpoint (closed cut test) of not less than 43^{o}C;
   ii) Started automatically upon failure of the electrical supply from the main source of electrical power and is to be automatically connected to the emergency switchboard; those services referred to in 3.2.5 are then to be transferred automatically to the emergency generating set. The automatic starting system and the characteristics of the prime mover are to be such as to permit the emergency generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum of 45 seconds; and
   iii) Provided with a transitional source of emergency electrical power according to 3.2.7.

b) Where the emergency source of electrical power is an accumulator battery, it is to be capable of:

   i) Carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage;
   ii) Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and
   iii) Immediately supplying at least those services specified in 3.2.7.

3.2.7 The transitional source of emergency electrical power required by 3.2.6 may consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 percent above or below its nominal voltage and be of sufficient capacity and so arranged as to supply automatically in the event of failure of either the main or emergency source of electrical power at least the following services, if they depend upon an electrical source for their operation:

a) For half an hour;

   i) The lighting required by 3.2.5(a), (b) and (c);
   ii) All services required by 3.2.5(d) unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency;

b) With respect to watertight doors;

   i) Power to operate the watertight doors but not necessarily simultaneously, unless an independent temporary source of stored energy is provided. The power source should have sufficient capacity to operate each door at least three times i.e. closed-open-closed, against an adverse list of 15^o;
   ii) Power to the control, indication and alarm circuits for the watertight doors for half an hour.

Alternatively the above services may have individual supplies for the period specified from accumulator batteries suitably located for use in an emergency.

3.2.8 The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

3.2.9 Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

3.2.10 No accumulator battery except for engine starting, fitted in accordance with this section is to be installed in the same space as the emergency switchboard. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power are being discharged and provision is to be made to charge them in situ from a reliable onboard supply.

3.2.11 The emergency switchboard is to be supplied during normal operation from the main switchboard by an inter-connector feeder which is to be adequately protected at the main switchboard against overload and short circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the inter-connector feeder is also to be protected at the emergency switchboard at least against short circuit.

3.2.12 In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power will be available to the emergency circuits.

3.2.13 Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

3.2.14 In addition to the emergency lighting required by 3.2.5(a) passenger craft with roll on-roll off cargo spaces or special category spaces, are to be provided with the following:

a) In all passenger public spaces and alleyways supplementary electric lighting that can operate for at least three hours when all other sources of electric power have failed and under any condition of heel. The illumination provided is to be such that the approach to the means of escape can be readily seen. The source of power for the supplementary lighting is to consist of accumulator batteries within the lighting units that are continuously charged where practicable, from the emergency switchboard. Consideration would be given to other means of lighting which is at least as effective. The supplementary lighting is to be such that any failure of the lamp will be immediately apparent. Any accumulator battery provided is to be replaced at intervals having regard to the specified service life in the ambient conditions that they are subject to in service.

b) A portable rechargeable battery operated lamp is to be provided in every crew space alleyway, recreational space and every working space which is normally occupied unless supplementary emergency lighting, as required by (a) is provided.

3.3 Emergency source of electrical power in cargo craft

3.3.1 A self-contained emergency source of electrical power is to be provided.

3.3.2 The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the waterline in the final condition of damage, be operable in that condition and be readily accessible from the open deck. They are not to be located forward of the collision bulkhead, if fitted.

3.3.3 The location of the emergency source of electrical power and associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard is to be such as to ensure that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space will not interfere with the supply, control and distribution of emergency electrical power. The space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard is not to be contiguous to the boundaries of machinery spaces and those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard.

3.3.4 Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used exceptionally, and for short periods, to supply non-emergency circuits. Failure of the emergency switchboard when being used in other than an emergency is not to put at risk the operation of the craft.

3.3.5 The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

a) for a period of 12 hours, emergency lighting:

i) at the stowage positions of life saving appliances,
ii) at all escape routes, such as alleyways, stairways, exits from accommodation and service spaces, embarkation points, etc.;
iii) in the public spaces, if any;
iv) in the machinery spaces, and main emergency generating spaces including their control positions;
v) in control stations;
vi) at the stowage positions for firemen's outfits; and
vii) at the steering gear.

b) for a period of 12 hours:

i) the navigation lights and other lights required by International Regulations for Preventing Collisions at Sea in force;
ii) electrical internal communication equipment for announcements for passengers and crew required during evacuation;
iii) fire detection and general alarm system and manual alarms; and
iv) remote control deices of fire-extinguishing system, if electrical;

c) for a period of 4 hours on intermittent operation:

i) the daylight signaling lamps, if they have no independent supply from their own accumulator battery and
ii) the craft's whistle or siren, if electrically driven;

d) for a period of 12 hours:

i) the navigational equipment as required by statutory regulations; where such provision is unreasonable or impractical this requirement may be waived for craft of less than 5000 tons gross tonnage;
ii) essential electrically powered instruments and control for propulsion machinery, if alternate sources of power not available for such devices;
iii) emergency fire pump;
iv) the automatic sprinkler pump and drencher pump, if fitted;
v) the emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves;
vi) the VHF radio installation required by SOLAS 1974, as amended, chapter IV, regulation 7.1.1 and 7.1.2; and, if applicable;

.1 the MF radio installation required by SOLAS 74, as amended, chapter IV regulations 9.1.1, 9.1.2, 10.1.2 and 10.1.3;

.2 the ship earth station required by SOLAS 74, as amended, chapter IV, regulations 10.1.1 and;

.3 the MF/HF radio installation required by SOLAS 1974, as amended, Chapter IV, regulations 10.2.1, 10.2.2 and 11.1.

e) for a period of 10 min:

- power drives for directional control devices including those required to direct thrust forward and astern, unless there is a manual alternative complying with Part 4, Chapter 6 of 'Rules and Regulations for the Construction and Classification of Steel Ships'; and

f) Where applicable, the services required by 2.4.2.

3.3.6 The emergency source of electrical power may be either a generator or an accumulator battery, which is to comply with the following:

a) Where the emergency source of electrical power is a generator it is to be:

i) Driven by a suitable prime mover with an independent supply of fuel having a flashpoint (closed cut test) of not less than 43^{o}C;
ii) Started automatically upon failure of the main source of electrical power supply unless transitional source of emergency electrical power in accordance with 3.3.7 is provided; where the emergency generator is automatically started, it is to be automatically connected to the emergency switchboard; those services referred to in

3.3.7 are to be connected automatically to the emergency generator; and

iii) Provided with a transitional source of emergency electrical power as specified in 3.3.7 unless an emergency generator is provided capable both of supplying the services mentioned in that paragraph and of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 seconds.

b) Where the emergency source of electrical power is an accumulator battery, it is to be capable of:

i) Carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage;
ii) Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and
iii) Immediately supplying at least those services specified in 3.3.7.

3.3.7 The transitional source of emergency electrical power required by 3.3.6 may consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 percent above or below its nominal voltage and be of sufficient capacity and so arranged as to supply automatically in the event of failure of either the main or emergency source of electrical power at least the following services, if they depend upon an electrical source for their operation:

a) The lighting required by 3.3.5 (a) and (b) (i). For this transitional phase, the required emergency electric lighting in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps, and

b) All services required by 3.3.5(b)(ii), (iii) and (iv) and (c) unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency;

c) With respect to watertight doors;

i) Power to operate the watertight doors but not necessarily simultaneously, unless an independent temporary source of stored energy is provided. The power source should have sufficient capacity to operate each door at lest three times i.e. closed-open-closed, against an adverse list of 15^{o};
ii) Power to the control, indication and alarm circuits for the watertight doors for half an hour.

3.3.8 The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

3.3.9 Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

3.3.10 No accumulator battery except for engine starting, fitted in accordance with this section is to be installed in the same space as the emergency switchboard. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power are being discharged and provision is to be made to charge them in situ from a reliable onboard supply.

3.3.11 The emergency switchboard is to be supplied during normal operation from the main switchboard by an inter-connector feeder which is to be adequately protected at the main switchboard against overload and short circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the inter-connector feeder is also to be protected at the emergency switchboard at least against short circuit.

3.3.12 In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power will be available to the emergency circuits.

3.3.13 Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

3.4 Starting arrangements for emergency generating sets

3.4.1 Emergency generating sets should be capable of being readily started in their cold condition at a temperature of 0^oC. If this is impracticable, or if lower temperatures are likely to be encountered, provisions should be made for heating arrangements to ensure ready starting of the generating sets.

3.4.2 Each emergency generating set should be equipped with starting devices with a stored energy capability of at least three consecutive starts. The source of stored energy should be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. A second source of energy should be provided for an additional three starts within 30 min, unless manual starting can be demonstrated to be effective.

3.4.3 The stored energy should be maintained at all times, as follows:

a) electrical and hydraulic starting systems should be maintained from the emergency switchboard;

b) compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;

c) all of these starting, charging and energy-storing devices should be located in the emergency generator space. These devices should not be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

3.4.4 Where automatic starting is not required, manual starting is permissible, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or powder charge cartridges, where they can be demonstrated as being effective.

3.4.5 When manual starting is not practicable, the requirements of 3.4.2 and 3.4.3 are to be complied with except that starting may be manually initiated.

3.5 Prime mover governor

3.5.1 Where the emergency source of power is a generator, the governor is to comply with Section 2.5.

3.6 Radio installation

3.6.1 Every radio installation as required by SOLAS 1974 as amended Ch.IV Part C is to be provided with reliable, permanently arranged electrical lighting, independent of the main and emergency sources of electrical power, for the adequate illumination of the radio controls for operating the radio installation.

3.6.2 A reserve source or sources of energy is to be provided on every craft for the purpose of conducting distress and safety radio-communications, in the event of failure of the crafts main and emergency sources of electrical power. The reserve source or sources of energy is to be capable of simultaneously operating the VHF radio installation and, as appropriate for the sea or sea area for which the craft is equipped, either the MF radio installation, the MF/HF radio installation, or the INMARSAT ‘ship to earth’ station and any of the additional loads mentioned in 3.6.4, 3.6.5 and 3.6.7 for a period of at least one hour.

The reserve source of energy need not supply independent HF and MF radio installation at the same time.

3.6.3 The reserve source or sources of energy is to be independent of the propelling power of the craft and the craft’s electrical system.

3.6.4 Where, in addition to the VHF radio installation, two or more of the other radio installations, referred to in 3.6.2, can be connected to the reserve source or sources of energy, they are to be capable of simultaneously supplying, for the period specified by 3.6.2, the VHF radio installation and:

a) All other radio installations which can be connected to the reserve source or sources of energy at the same time; or
b) Whichever of the other radio installations will consume the most power, if only one of the other radio installations can be connected to the reserve source or sources of energy at the same time as the VHF radio installation.

3.6.5 The reserve source or sources of energy may be used to supply the electrical lighting required by 3.6.1.

3.6.6 Where a reserve source of energy consists of a rechargeable accumulator battery or batteries a means of automatically charging the batteries is to be provided which is to be capable of recharging them to minimum capacity requirements within 10 hours.

3.6.7 If an uninterrupted input of information from the craft's navigational or other equipment to a radio installation is needed to ensure its proper performance, means are to be provided to ensure the continuous supply of such information in the event of failure of the craft's main or emergency source of electrical power.

Section 4

External Source of Electrical Power

4.1 Temporary external supply (shore supply)

4.1.1 Where arrangements are provided for the supply of electric power from a source on shore or elsewhere, a connection box is to be installed in an easily accessible location in a manner suitable for the convenient reception of flexible cables from the external source. This box should contain a circuit-breaker or isolating switch and fuses and terminals of ample size and suitable shape to facilitate a satisfactory connection. The mechanical stress of the portable cable is to be conveyed directly to the metallic framework and not to electrical connectors. Suitable cables, permanently fixed, are to be provided, connecting the circuit breaker/isolating switch in the connection box to a linked switch and/or circuit breaker at the main switchboard.

4.1.2 For alternating current systems an earthed terminal is to be provided for the reception of three-phase external supplies with earthed neutrals.

4.1.3 The external connection is to be provided with an indicator at the main switchboard in order to show when the cable is energized.

4.1.4 Means are to be provided for checking the polarity (for direct current) or the phase sequence (for three-phase alternating current) of the incoming supply. This device should be connected between the incoming connectors and the interrupting device in the connection box.

4.1.5 A notice is to be provided at the connection box giving complete information on the system of supply and the normal voltage (and frequency for alternating current) of the ship's installed system. Full details of the procedure for effecting the connection are to be given on this notice.

4.1.6 Alternate arrangements for providing a temporary external supply will be specially considered.

Section 5

Supply and Distribution

5.1 Systems of supply and distribution

5.1.1 The following systems of generation and distribution are acceptable:

a) d.c., two-wire;
b) a.c., single-phase, two-wire;
c) a.c., three-phase, three-wire neutral insulated
d) three-phase, four-wire with neutral solidly earthed but without hull return.

5.1.2 System voltages for both alternating current and direct current in general are not to exceed:

500 V for power, cooking and heating equipment permanently connected to fixed wiring;
250 V for lighting, heaters in cabins and public rooms, and other applications not mentioned above;
Voltage exceeding these will be the subject to special consideration.

5.1.3 The arrangement of the main system of supply is to be such that a fire or other casualty in any space containing the main source of electrical power, associated converting equipment, if any, the main switchboard or the main lighting switchboard will not render inoperable any emergency service, other than those located within the space where fire or casualty has occurred.

5.1.4 The main switch board is to be so placed relative to the main source of power that, as far as is practicable, the integrity of the main system of supply will be affected only by a fire or other casualty in one space.

5.1.5 The arrangement of the emergency system of supply is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated converting equipment, if any, the emergency switchboard and the emergency lighting switchboard, will not cause loss of services required to maintain the propulsion and safety of crafts.

5.1.6 Distribution systems required in an emergency are to be so arranged that a fire in any main vertical zone will not interfere with the emergency distribution in any other such zone.

5.1.7 Feeders from the main and the emergency sources of electrical power are to be separated both vertically and horizontally as widely as is practicable.

5.1.8 For Category (A) or Category (B) craft or cargo craft of 500 tons gross tonnage and over, and in any case where the total installed electrical power of the main generating sets is in excess of 3 MW or is supplied at high voltage, arrangements are to be made so that it is possible to split the switchboard, by removable links or other means, into at least two independent sections, each supplied by at least one generator.

5.1.9 Where 5.1.8 is applicable and the essential services which are duplicated are supplied from a section-board, arrangements are to be made so that it is possible to split the section-board into at least two independent sections each supplied by an independent section of the main switchboard either directly or through a transformer.

5.2 Essential services

5.2.1 Essential services that are required to be duplicated are to be served by individual circuits, separated in their switchboard or section board and throughout their length as widely as is practicable without the use of common feeders, protective devices, control circuits or control gear assemblies so that any single fault will not cause the loss of both services.

5.2.2 Where 5.2.1 is applicable the main busbars of switchboard or section board, are to be capable of being split, by removable links or other means, into at least two independent sections, each supplied by at least one generator, either directly or through a converter the essential services are to be equally divided, as far as practicable between the independent sections.

5.2.3 Where the loss of the electrical supply to a particular essential service, which is not duplicated, would cause serious risk to the craft, it is to be fed by two independent supplies complying with 5.2.1. Such circuits are to be provided with short circuit protection and an overload and phase-failure alarm.

Failure of either supply is not to cause risk to the craft during switching to the alternative supply.

5.3 Isolation and switching

5.3.1 The incoming and outgoing circuits from every switchboard or section board are to be provided with a means of isolation and switching to permit each circuit to be switched off:

a) on load;
b) for mechanical maintenance;
c) in an emergency to prevent or remove danger.

Precautions are to be taken to minimise the risk of inadvertent or accidental switching.

5.3.2 Isolation and switching is to be by means of a circuit breaker or switch arranged to open simultaneously all insulated poles. Where a switch is used as the means of isolation and switching, it is to be capable of:

a) switching off the circuit on load;
b) withstanding, without damage, the over-currents which may arise during overloads and short circuit.

5.3.3 Provision is to be made, in accordance with one of the following, to prevent any circuit being inadvertently energized:

a) the circuit breaker or switch can be withdrawn, or locked in the open position;
b) the operating handle of the circuit breaker or switch can be removed;
c) the circuit fuses, where fitted, can be readily removed and retained by authorized personnel.

5.3.4 Where a section board, distribution board or item of equipment can be supplied by more than one circuit, a switching device is to be provided to permit each incoming circuit to be isolated and the supply transferred to the alternative circuit.

5.3.5 The switching device required by 5.3.4 is to be situated within or adjacent to the section board, distribution board or item of equipment and capable of opening and closing all insulated poles. Where necessary, interlocking arrangements are to be provided to prevent circuits being inadvertently energized.

5.3.6 A notice is to be fixed to any section board, distribution board or item of equipment to which 5.3.4 applies warning personnel before gaining access to live parts of the need to open the appropriate circuit breakers or switches, unless an interlocking arrangement is provided so that all circuits concerned are isolated before access is gained.

5.4 Insulated distribution systems

5.4.1 A device(s) is to be installed for every insulated distribution system, whether primary or secondary, for power, heating and lighting circuits, to continuously monitor the insulation level to earth and to operate an alarm in the event of an abnormally low level of insulation.

5.5 Earthed distribution systems

5.5.1 No fuse, non-linked switch or non-linked circuit-breaker is to be inserted in an earthed conductor. Any switch or circuit-breaker fitted is to operate simultaneously in the earthed conductor and the insulated conductors. These requirements do not preclude the provision (for test purposes) of an isolating link to be used only when the other conductors are isolated.

5.5.2 Generator neutrals may be connected in common, provided that the third harmonic content of the voltage waveform of each generator does not exceed five percent.

5.5.3 Where a switchboard is split into sections operated independently or where there are separate switchboards, neutral earthing is to be provided for each section or for each switchboard. Means are to be provided to ensure that the earth connection is not removed when generators are isolated.

5.5.4 A means of isolation is to be fitted in the earthing connection of each generator so those generators can be completely isolated for maintenance.

5.5.5 All earthing impedances are to be connected to a common earth connection/bar, in order to eliminate possible interference with radio, radar and communication circuits, earthing impedances are to be connected together on the earth side of the impedances and with single connection to earth. On craft with metallic hulls, the common earth connection is to be the hull.

5.6 Diversity factor

5.6.1 Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justified, to the application of a diversity factor. Where spare ways are provided on a section or distribution board, an allowance for future increase of load is to be added to the total connection load before application of any diversity factor.

5.6.2 A diversity factor may be applied to the calculation for size of cable and rating of switchgear and fusegear, taking into account the duty cycle of the connected loads and the frequency and duration of any motor starting loads.

5.6.3 The calculations of diversity factor is to be submitted along with all relevant data.

5.7 Lighting circuits

5.7.1 Lighting circuits are to be supplied by final sub-circuits, which are separate from those for heating and power. This provision need not be applied to cabin fans and small wardrobe heaters.

5.7.2 A final sub-circuit of rating exceeding 15 amperes is not to supply more than one point.

5.7.3 A final sub-circuit of rating 15 amperes or less is not to supply more than the following number of lighting points:-

10 for	24 - 55 V circuits
14 for	110 - 127 V circuits
18 for	220 - 250 V circuits

5.7.4 This provision is not applicable to final sub-circuits for cornice lighting, panel lighting and electric signs where lamp-holders are closely grouped; in such cases, the number of points is unrestricted provided the maximum operating current in the sub-circuit does not exceed 10 amperes.

5.7.5 Lighting for machinery spaces, control stations, work spaces, public spaces, corridors and stairways leading to boat decks should be supplied from at least two final sub-circuits in such a way that failure of any one of the circuits does not leave the spaces in darkness.

5.7.6 Lighting of unattended spaces, is to be controlled by multi-pole linked switches located outside such spaces. Provision is to be made for the complete isolation of these circuits and locking in the "OFF" position of the means of control.

5.7.7 Lighting for enclosed hazardous spaces is to be supplied from at least two final sub-circuits to permit light from one circuit to be retained while maintenance is carried out on the other.

5.7.8 Emergency lighting is to be fitted in accordance with Section 3. (See also Section 16).

5.8 Motor circuits

5.8.1 A separate final sub-circuit is to be provided for every motor for essential services (See 1.5.1).

5.9 Motor control

5.9.1 Every electric motor is to be provided with efficient means for starting and stopping so placed as to be easily operated by the person controlling the motor. Every motor above 0.5 kW is to be provided with control apparatus as given in 5.9.2 to 5.9.4.

5.9.2 Means to prevent undesired restarting, after a stoppage due to low volts or complete loss of volts, are to be provided. This does not apply to motors where a dangerous condition might result from the failure to restart automatically, e.g. steering gear motor.

5.9.3 Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor are to be provided. See also 6.8.

5.9.4 Motor control gear is to be suitable for the starting current and for the full load rated current of the motor.

Section 6

System Design - Protection

6.1 General

6.1.1 All installations are to be protected against accidental over-currents including short circuits. The choice, location and characteristics of the protective device are to provide complete and coordinated protection to ensure:

a) Elimination of the fault to reduce damage to the system and hazard of fire.

b) Continuity of service so as to maintain, through the discriminative action of the protective devices, the supply to circuits not directly affected by the fault.

6.2 Protection against overload

6.2.1 Protection against overloads may be provided by circuit-breakers, automatic switches or fuses. The tripping characteristics of these devices are to be appropriate to the system, ensuring the protection of cablings and electrical machinery against overheating resulting from mechanical or electrical overload.

6.2.2 Fuse of a type intended for short circuit protection only (e.g. fuse links complying with IEC 269-1 of type ‘a’) are not to be used for overload protection.

6.3 Protection against short-circuit

6.3.1 Protection against short-circuit currents is to be provided by circuit-breakers or fuses.

6.3.2 The breaking capacity of every protective device is to be not less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.

6.3.3 The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short circuit, is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

6.3.4 Every protective device or contactor not intended for short circuit interruption is to be adequate for the maximum short-circuit current which can occur at the point of installation having regard to the time required for the short circuit to be removed.

6.3.5 In the absence of precise data of rotating machines the following short-circuit currents at the machine terminals are to be assumed. The short circuit current is to be the sum of short circuit currents of generators and that of motors;

a) Direct current systems

   i) Ten times full load current for generators normally connected (including spare);

   ii) Six times full load current for motors simultaneously in service;

b) Alternating current systems.

   i) Ten times full load current for generators normally connected (including spare) - symmetrical RMS,

   ii) Three times full load current for motors simultaneously in service.

6.4 Combined circuit-breakers and fuses

6.4.1 The use of a circuit-breaker of breaking capacity less than the prospective short-circuit current at the point of installation is permitted, provided that it is preceded on the generator side by fuses, or by a circuit-breaker having at least the necessary breaking capacity. The generator breakers are not to be used for this purpose.

6.4.2 Fused circuit-breakers with fuses connected to the load side may be used where operation of the circuit-breaker and fuses is co-ordinated.

6.4.3 The characteristics of the arrangement are to be such that:

a) When the short-circuit current is broken, the circuit-breaker on the load side is not to be damaged and is to be capable of further service,

b) When the circuit-breaker is closed on the short-circuit current, the remainder of the installation is not to be damaged. However, it is admissible that the circuit-breaker on the load side may require servicing after the fault has been cleared.

6.5 Protection of circuits

6.5.1 Short circuit protection is to be provided in each live pole of a direct current system and in each phase of an alternating current system.

6.5.2 Protection against overloads is to be provided as follows:

a) Two-wire direct current or single-phase alternating current system - at least one line or phase,

b) Insulated three-phase alternating current system - at least two phases,

c) Earthed three-phase alternating current system - all three phases.

6.6 Protection of generators

6.6.1 The protective gear required by 6.6.2 and 6.6.3 is to be provided as a minimum.

6.6.2 Generators not arranged to run in parallel are to be provided with a circuit breaker arranged to open simultaneously, in the event of short circuit, overload or under voltage, all insulated poles. In the case of generators rated at less than 50 kW, a multiple linked switch with a fuse, complying with 5.3.2, in each insulated pole will be acceptable.

6.6.3 Generators arranged to operate in parallel are to be provided with a circuit breaker arranged to open simultaneously all insulated poles in the event of short circuit, overload or under voltage. This circuit breaker is to be provided with reverse power protection with time delay, selected or set within the limits of two per cent to 15 per cent of full load to a value fixed in accordance with the characteristics of the prime mover. A fall of 50 per cent in the applied voltage is not to render the reverse power mechanism inoperative, although it may alter the amount of reverse power required to open the breakers.

6.6.4 The generator circuit breaker short circuit and overload tripping arrangements, or fuse characteristics, are to be such that the machine's thermal withstand capability is not exceeded.

6.6.5 Generator circuit breakers are normally to be provided with under voltage release.

6.7 Protection of essential services

6.7.1 Where generators are operated in parallel and essential services are electrically operated, arrangements are to be made to disconnect automatically the excess non-essential load when the generators are overloaded.

6.7.2 If required, this load shedding may be carried out in one or more stages according to the overload ability of the generating sets, taking into consideration the relative importance of the loads being thus disconnected.

6.7.3 In cargo crafts, circuits for cargo refrigeration machinery are to be included in the last group of services to be disconnected.

6.8 Load management

6.8.1 Arrangements are to be made to disconnect automatically, after an appropriate time delay, circuits of the categories noted below, when the generator(s) is/are overloaded; sufficient to ensure the connected generating set(s) is/are not overloaded:

a) non-essential circuits;
b) circuits feeding services for habitability see 1.5.2;
c) in cargo ships, circuits for cargo refrigeration.

6.8.2 If required, this load switching may be carried out in one or more stages, in which case the non-essential circuits are to be included in the first group to be disconnected.

6.8.3 An alarm is to be provided to indicate when such switching has taken place.

6.8.4 Consideration is to be given to providing means to inhibit automatically the starting of large motors, or the connection of other large loads, until sufficient generating capacity is available to supply them.

6.8.5 When the electric generating plant is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, it is to be provided with audible and visual alarms for:

Busbar voltage high or low;
Busbar frequency low;
Operating of load switching;
Generator cooling air temperature high (closed air circuit machines only).

6.9 Protection of feeder circuits

6.9.1 Isolation and protection of each main distribution circuit is to be ensured by a multi-pole circuit-breaker, multi-pole fused circuit-breakers or multi-pole switch and fuses. The provisions of 6.2, 6.3 and 6.5 are to be complied with. The protective devices are to allow excess current to pass during the normal accelerating period of motors. Where multi-pole switch and fuses are used, the fuses are generally to be installed between the busbars and the switch.

6.9.2 Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

6.9.3 Motors of rating exceeding 0.5 [kW] and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection can be provided by the same protective device for the motor and its supply cable. For essential motors which are duplicated, the overload protection may be replaced by an overload alarm, if desired.

6.9.4 For motors for intermittent service the current setting and the delay are to be chosen in relation to the load factor of the motor.

6.9.5 Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overloads in the case of single phasing.

6.10 Protection of power transformers

6.10.1 The primary circuits of power transformers are to be protected against short-circuit by circuit-breakers or fuses. The rating of fuses or the setting for overcurrent releases of circuit breakers is not to exceed 125 per cent of rated primary current.

6.10.2 Where a transformer may be energized from its secondary side, there is to be a means of automatic isolation so that primary windings cannot inadvertently be energized when disconnected from their source of supply.

6.11 Protection of lighting circuits

6.11.1 Lighting circuits are to be provided with overload and short-circuit protection.

6.12 Protection of meters, pilot lamps, capacitors and control circuits

6.12.1 Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps, together with their connecting leads by means of protective devices fitted to each insulated pole or phase.

6.12.2 A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided it is fitted in the same enclosure. Where a fault in a pilot lamp would jeopardise the supply to essential equipment such lamps are to be individually protected.

6.12.3 Where capacitors for suppression of radio interference are fitted to busbars, generators or steering gear, fuses of appropriate size are to be connected in the capacitor circuit.

6.13 Protection of batteries

6.13.1 Accumulator batteries other than engine starting batteries are to be protected against short circuit by devices, in each insulated pole, placed at a position adjacent to the battery compartment.

6.14 Protection of communication circuits

6.14.1 Communication circuits other than those supplied from primary batteries are to be protected against overload and short-circuit.

6.15 Protection against earth faults

6.15.1 Every distribution system that has an intentional connection to earth, by way of an impedance, is to be provided with a means to continuously monitor and indicate the current flowing in the earth connection.

6.15.2 If the current in the earth connection exceeds 5A there is to be an alarm and the fault current is to be automatically interrupted or limited to a safe value.

6.15.3 The rated short circuit capacity of any device used for interrupting earth fault currents is to be not less than the prospective earth fault current at its point of installation.

6.15.4 Insulated neutral systems with harmonic distortion of the voltage waveform, which may result in earth fault currents exceeding the level given in 6.15.2 because of capacitive effects, are to be provided with arrangements to isolate the faulty circuit(s).

Section 7

Switch Gear and Control Gear Assemblies

7.1 Switchboards

7.1.1 Location and installation

7.1.1.1 Switchboards are to be installed in accessible and well ventilated dry spaces free from flammable gases and acid fumes.

7.1.1.2 Switchboards are to be secured to a solid foundation and protected against shocks and damage due to leaks and falling objects. They are to be self-supported, or be braced to the bulkhead or the deck above. In case the latter method is used, the means of bracing is to allow normal deflections of the deck without buckling the control cell or assembly structure.

7.1.1.3 Pipes should not be installed directly above or in front of or behind switchboards. If such piping is unavoidable, suitable protection is to be provided in these positions.

7.1.1.4 An adequate, unobstructed working space is to be left in front of switchboards. At the rear, a clearance of at least 0.6 m is to be maintained except that this may be reduced to 0.5 m in way of stiffeners or frames. If switchboards are enclosed at the rear and are fully serviceable from the front, clearance at the rear will not be required unless necessary for cooling.

7.1.1.5 The main switchboard is to be so placed relative to one main generating station that, as far as practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space. An environmental enclosure for main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating the switchboards from the generators.

7.1.2 Construction of switchboards

7.1.2.1 Switchboards are to have roof with degree of protection IP 22 and are to be of dead front type.

On systems with voltages above 500 V up to and including 1000 V, front and rear dead type switchboards are to be used.

7.1.2.2 All main and emergency switchboards are to be guarded by hand rails either made of hardwood or insulated. Where access is provided behind a main switchboard, the handrails on the rear are to be horizontal, and so placed that one cannot accidentally fall into the switchboard. Further, insulated mats or gratings are to be laid on the floor of passage-ways in front of and to the rear of switchboards. Instruments and handles or push buttons for switchgear are to be placed on the front of the switchboard (except for isolating switches, if used). All other parts which require operation, are to be accessible and so placed that the risk of accidental touching of current carrying parts, or accidental making of short-circuits and earthings, is reduced as far as practicable.

7.1.2.3 Section boards (sub-switchboards) and distribution boards are to be enclosed unless they are installed in a cupboard or compartment to which only authorised personnel have access, in which case the cupboard may serve as an enclosure.

7.1.2.4 Framework, panels and doors of switchboards are generally to be of steel or aluminium alloy, and are to be of rigid construction.

7.1.2.5 All parts of the main switchboard are to be accessible for maintenance work.

7.1.2.6 Equipment for each generator and for different distribution systems are to be placed in separate cubicles (panels) or are to be separated from each other by partitions clearly marked with the actual voltages.

7.1.2.7 Doors, behind which equipment requiring operation is placed, are to be hinged. Arrangement is also to be provided to keep the hinged doors open.

7.1.2.8 Cable entrances are generally to be from below or from the side. Cable entries from the top may be accepted provided watertight glands are used.

7.2 Marking and labels

7.2.1 The identification of individual circuits and their device is to be made on tables of durable material. The ratings of fuses and setting of protective devices are also to be indicated. Section board and distribution boards are to be marked with the rated voltage.

7.3 Busbars

7.3.1 Busbars and their connections are to be of copper, all connections being so made as to prevent deterioration of the joint by corrosion or oxidation.

7.3.2 The sizes of busbars and their connections are to be calculated to ensure that their mean temperature rise does not exceed by more than 45^{o}C from the ambient temperature, when running continuously at the normal rating.

7.3.3 Busbars, together with their connections and supports, are to be capable of withstanding, without detrimental effect, the mechanical stresses which will arise during short-circuits. Further, provision is to be made to allow the busbars to expand without causing any abnormal stress on their supports.

7.4 Instruments for alternating current generators

7.4.1 For alternating current generators not arranged to run in parallel, each generator is to be provided with at least one voltmeter, one frequency meter, and one ammeter with an ammeter switch to enable the current in each phase to be read or an ammeter in each phase. Generators above 50 kVA are to be provided with a wattmeter.

7.4.2 For alternating current generators arranged to run in parallel, each generator is to be provided with a wattmeter, and an ammeter in each phase conductor or an ammeter with a selector switch to enable measurement of current in each phase.

7.4.3 For paralleling of the generators, two voltmeters, two frequency meters and a synchronising aid comprising either a synchroscope and lamps, or an equivalent arrangement, are to be provided. One voltmeter and one frequency meter are to be connected permanently to the busbars, the other voltmeter and frequency meter are to be provided with arrangements to enable the voltage and frequency of any generator to be measured.

7.5 Instrument scales

7.5.1 Main switchboard instruments are to be of accuracy class 1.5 and other switchboard instruments are to be of accuracy class 2.5.

7.5.2 The upper limit of the scale of every voltmeter is to be approximately 120 per cent of the normal voltage of the circuit, and the normal voltage is to be clearly indicated.

7.5.3 The upper limit of the scale of every ammeter is to be approximately 130 per cent of the normal rating of the circuit in which it is installed. Normal full load is to be clearly indicated.

7.5.4 Ammeters for use with direct current generators, and wattmeters for use with alternating current generators, which may be operated in parallel, are to be capable of indicating 15 per cent reverse-current or reverse-power respectively.

7.5.5 The upper limit of the scale of every wattmeter is to be approximately 130 per cent of the rated full load of the circuit in which it is installed. Rated full load is to be clearly indicated.

7.5.6 Frequency meters are to be capable of indicating a variation in the frequency from minus 8 per cent to plus 8 per cent of the nominal frequency of the installation.

7.5.7 Instruments are to have effective screening, for example, by metal enclosures, in order to diminish faulty readings caused by induction from adjacent current-carrying parts.

7.6 Instrument transformers

7.6.1 The secondary windings of instrument transformers are to be earthed.

7.7 Circuit-breakers

7.7.1 Circuit-breakers are to comply with IEC Publication 947-1 and 947-2, "Low Voltage Distribution Switchgear" or an equivalent national standard, amended where necessary for ambient temperature.

7.7.2 Test reports, based on the requirements of IEC Publication 947-1 and 947-2 or an equivalent national standard, are to be submitted for approval when required.

7.7.3 A circuit breakers are to be of the trip free type and where applicable, be fitted with auto pumping control.

7.8 Fuses

7.8.1 Fuses are to comply with IEC Publication 269 "Low Voltage Fuse with High Breaking Capacity" or an equivalent national standard, amended where necessary for ambient temperature.

7.8.2 A report, giving details of test performance, fusing characteristics, temperature and insulation tests and details of the specification to which the fuse has been tested is to be submitted for consideration when required.

7.9 Distribution switchboards

7.9.1 Large distribution switchboards are to be constructed in accordance with 7.1.

7.9.2 All parts which require operation in normal use are to be placed on the front or easily accessible from behind front doors.

When such parts are placed behind front doors, the interior front is to comply with enclosure type IP 20, except that fuses with accessible current-carrying parts may be permitted, provided that the door is lockable.

7.9.3 Switchboards, supplied from different voltage supply circuits, are not to be placed in the same enclosure unless these are separated by partitions of flame retardant material.

7.9.4 Switchboards, which are provided with two or more supply circuits arranged for automatic standby connection, are to be provided with positive means to show the circuit feeding the switchboard. Such switchboards are to be provided with warning notice that all the supply circuits are to be disconnected before maintenance work is undertaken.

7.10 Protection

7.10.1 For details of the electrical protection required of switch gear and control gear. See Section 6.

7.11 Testing

7.11.1 Switchgear and control gear assemblies with supply voltage of 60 V and above are to be tested as follows:

- High voltage test with 1000 V plus twice the rated voltage with a minimum of 2000 V. The test voltage is to be supplied for 1 minute at any frequency between 25 and 100 Hz.

- Insulation resistance measuring.

7.11.2 Switchgear and control gear assemblies with supply voltage less than 60 V are to be tested in accordance with 7.11.1 except that the test voltage is to be 500 V.

7.11.3 Demonstration of the satisfactory operation of protection circuits, control circuits and interlocks by means of simulated functional tests.

Section 8

Rotating Machines

8.1 General requirements

8.1.1 Rotating machines are to comply with the relevant part of IEC Publication IEC 92, or an acceptable and relevant national standard, and the requirements of this Section.

8.1.2 For all the rotating machines, manufacturer's test certificate is to be provided (See also Sec.1.4).

8.1.3 Shaft materials are to comply with the applicable requirements of Part 2 of Rules and Regulations for the Construction and Classification of Steel Ships.

8.1.4 The rotating parts are to be so balanced that when running at any speed in the normal working range the vibration level does not exceed the levels specified in IEC 34.

8.1.5 The lubrication arrangement for bearings are to be effective under all operating conditions including the maximum ship inclinations specified in Section 1.9 and there are to be effective means to ensure that lubricant does not reach the machine windings or other conductors and insulators.

8.1.6 Steps are to be taken to prevent the ill effects of flow of currents circulating between the shaft and bearings.

8.1.7 Where welding is proposed to be applied to shafts of machines for securing armature arms or spiders, stress relieving is to be carried out after welding. The proposal is to be submitted for scrutiny and approval.

8.1.8 Alternating current machines are to be constructed such that, under any operating conditions, they are capable of withstanding the effects of sudden short circuit at their terminal without damage.

8.2 Rating

8.2.1 Generators including their exciters, and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air or water temperature for an unlimited period, without the limits of temperature rise in 8.3 being exceeded. Other generators and motors are to be rated in accordance with the duty which they are to perform, and when tested under rated load conditions the temperature rise is not to exceed the values in 8.3.

8.3 Temperature rise

8.3.1 The limits of temperature rise specified in Table 8.3.1 are based on a cooling air temperature of 45C and a cooling water temperature of 30^{o}C.

8.3.2 If the temperature of the cooling medium is known to exceed the value given in 8.3.1, the permissible temperature rise is to be reduced by an amount equal to the excess temperature of the cooling medium. These temperature rises are, if necessary to be reduced to satisfy the requirements of flame-proof equipment.

8.3.3 If the temperature of the cooling medium is known to be permanently less than the value given in 8.3.1, the permissible temperature rise may be increased by an amount equal to the difference between the declared temperature and that given in 8.3.1 upto a maximum of 15^{o}C.

8.4 Generator control

8.4.1 Each alternating current generator, unless of the self-regulating type, is to be provided with automatic means of voltage regulation; voltage build-up is not to require an external source of power. Provision is to be made to safeguard the distribution system should there be a failure of the voltage regulating system resulting in high voltage.

8.4.2 The voltage regulation of any alternating current generator with its regulating equipment is to be such that at all loads, from zero to full load at rated power factor, the rated voltage is maintained within 2.5 per cent under steady conditions. There is to be provision at the voltage regulator to adjust the generator no load voltage.

8.4.3 Generators, and their excitation systems, when operating at rated speed and voltage on no-load are to be capable of absorbing the suddenly switched, balanced, current demand of the largest motor or load at a power factor not greater than 0.4 with a transient voltage dip which does not exceed 15 per cent of rated voltage. The voltage is to recover to rated voltage within a time not exceeding 1.5 seconds.

8.4.4 The transient voltage rise at the terminals of a generator is not to exceed 20 per cent of rated voltage when rated KVA at a power factor not greater than 0.8 is thrown off.

8.4.5 Generators and their voltage regulation system are to be capable of maintaining without damage under steady state short circuit conditions a current of at least three times the full load rated current for a duration of at least two seconds or where precise data is available for the duration of any longer time delay which may be provided by a tripping device for discrimination purposes.

8.4.6 Generators required to run in parallel are to be stable from no load [kW] up to the total combined full load [kW] of the group, and load sharing is to be such that the load on any generator does not normally differ from its proportionate share of the total load by more than 15 per cent of the rated output [kW] of the largest machine or 25 per cent of the rated output [kW] of the individual machine, whichever is less.

8.4.7 When generators are operated in parallel, the kVA loads of the individual generating sets are not to differ from the proportionate share of the total kVA load by more than 5 per cent of the rated kVA output of the largest machines.

Table 8.3.1 : Limits of temperature rise in ^oC

Item		Part of machines	Method of measu-rement of temp.	Temperature rise in ^oC					
				Air-cooled machines Insulation Class			Water-cooled machines Insulation Class		
				A	E	B	A	E	B
1	(a)	a.c. windings of turbine-type machines having output of 5000 KVA or more	ETD or R	50	60	70	70	80	90
	(b)	a.c. windings of salient pole and of induction machines having output of 5000 KVA or more, or having a core length of one metre or more	ETD or R	50	60	70	70	80	90
2	(a)	a.c. windings of machines smaller than in Item 1	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
	(b)	Field windings of a.c. and d.c. machines having d.c. excitation other than those in Items 3 and 4	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
	(c)	Windings of armatures having commutators	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
3		Field windings of turbine-type machines having d.c. excitation	R	-	-	80	-	-	100
4	(a)	Low-resistance field windings of more than one layer and compensating windings	T,R	50	65	70	70	85	90
	(b)	Single-layer windings with exposed bare surfaces	T,R	55	70	80	75	90	100
5		Permanently short-circuited insulated windings	T	50	65	70	70	85	90
6		Permanently short-circulated windings, un-insulated	T	The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts					
7		Iron core and other parts not in contact with windings	-	The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts					
8		Iron core and other parts in contact with windings	T	50	65	70	70	85	90
9		Commutators and slip-rings, open or enclosed	T	50	60	70	70	80	90

Notes:

1 T = Thermometer method
R = Resistance method
ETD = Embedded temperature detector

2 When the commutators, sliprings or bearings of machines provided with water coolers are not in the enclosed air circuit cooled by the water cooler, but are cooled by the ambient cooling air, the permissible temperature-rise above the ambient cooling air should be the same as for ventilated machines.

3 When Class F or Class H insulation is employed, the permitted temperature rises are respectively 20°C and 40°C higher than the values given for Class B insulation.

4 Classes of insulation are to be in accordance with IEC Publication 85 (1984). "Recommendations for the Classification of Material for the Insulation of Electrical Machinery and Apparatus in relation to their thermal stability in service".

8.5 Overloads

8.5.1 Machines are generally to be capable of withstanding, on test, without injury, the following overload conditions :

a) Generators - an excess current of 50 per cent for 15 seconds for D.C. machines and 2 minutes for A.C. machines, after attaining the temperature rise corresponding to rated load, the terminal voltage being maintained as near the rated value as possible. This requirement does not apply to the overload torque capacity of the prime mover.

b) Motors - At rated speed or in the case of a range of speeds, at the highest and lowest speeds, under gradual increase of torque, the voltage and frequency being maintained as near to their rated value as possible, the appropriate excess torque given below. Synchronous motors and synchronous induction motors are required to withstand the excess torque without falling out of synchronism and without adjustment of the excitation current preset at the value corresponding to rated load.

d.c. motors	50 per cent for 15 seconds
polyphase a.c. synchronous motors	50 per cent for 15 seconds
polyphase a.c. synchronous induction motors	35 per cent for 15 seconds
polyphase a.c. induction motors	60 per cent for 15 seconds

8.6 Direct current machines

8.6.1 The final running position of brushgear is to be clearly and permanently marked.

8.6.2 Direct current machines are to work with fixed brush setting from no load to the momentary overload specified without injurious sparking.

8.7 Inspection and testing

8.7.1 On all machines intended for essential services, the following tests are to be carried out and a certificate furnished by the Manufacturer (see also Sec.1). Any other relevant tests required by applicable national/international standards are also to be carried out.

a) For generators

- Temperature rise test at full load
- Overload test
- Overspeed test
- High voltage test
- Insulation resistance test
- Measurement of winding resistance
- Measurement of air gap (for generators above 100 [kW])

Additionally for D.C. generators

- Measurement of voltage characteristics

Additionally for A.C. generators

- Open circuit voltage characteristics
- Short circuit current characteristics
- Measurement of excitation current at rated current, voltage and power factor
- Short circuit test (if required)

b) For motors

- Temperature rise test at full load
- Overload test
- Overspeed test
- High voltage test
- Insulation resistance test
- Measurement of winding resistance
- Measurement of air gap (for motors above 100 [kW])
- Measurement of speed range, if variable speed.

Additionally for D.C. motors

- Measurement of speed/load characteristics

Additionally for A.C. induction motors

- Measurement of no-load current at rated voltage and frequency
- Measurement of applied voltage by locked rotor, at rated current and frequency (locked rotor test)

Additionally for A.C. synchronous motors

- As per additional tests for a.c. generators.

8.7.2 For machines of less than 100 [kW] rating, type tests of temperature rise, overload and over speed will be acceptable. The date of the type tests and the serial number of the type tested machine are to be inserted in the manufacturer’s test certificate for each machine of the same type.

8.7.3 For machines of 100 [kW] or more, tests of temperature rise, overload and over speed will be acceptable when made on only one of several identical machines, manufactured and tested at the same time for delivery. The date of these tests and the serial number of the tested machine are to be inserted in the test certificate for the other machines.

8.7.4 The high voltage test is to be carried out at 1000 plus twice the rated voltage with a minimum of 2000 volts on new machines, preferably at the conclusion of the temperature rise test. The test is to be applied between the windings and the frame with the core connected to the frame and to any windings or sections of windings not under test. Where both ends of each phase are brought out to accessible separate terminals, each phase is to be tested separately. The test is to be made with alternating voltage at any convenient frequency between 25 and 100 Hz of approximately sine wave form. The test is to be commenced at a voltage of not more than one half of the full test voltage and is to be increased progressively to full value, the time allowed for the increase of the voltage from half to full value being not less than 10 seconds. The full test voltage is then to be maintained for one minute and then reduced to one half full value before switching off.

8.7.5 When additional high voltage tests are required on a machine which has already passed its tests or on machines after repair, the voltage of such further tests is to be 75 per cent of the value given in 8.7.4.

8.7.6 An insulation resistance test is to be carried out immediately after the high voltage test. The insulation resistance of a new, clean dry machine, immediately after the temperature rise test has been carried out is to be at least 1 MΩ.

Section 9

Converter Equipment

9.1 Transformers

9.1.1 The following requirements apply to transformers of 5 kVA and above.

9.1.2 Transformers are to comply with the requirements of IEC Publication 76 or an acceptable and relevant national standard amended where necessary for ambient temperature.

9.1.3 Transformers may be of the dry type, encapsulated or liquid filled type.

9.1.4 Transformers are to be placed in easily accessible well ventilated spaces free from any gaseous or acid fumes. They are to be clear of non-protected ignitable materials, and so arranged as to be protected against shocks and any damage resulting from water, oil, liquid fuel, steam etc.

9.1.5 The live parts of transformers are to be provided with means of protection against accidental contact.

9.1.6 Transformers are to be double wound except those for motor starting.

9.1.7 Windings of air cooled transformers are to be treated to efficiently resist moisture, sea air and oil vapours.

9.1.8 Each transformer is to be provided with a nameplate of corrosion-resistant metal giving information on make, type, serial number, insulation class and any other technical data necessary for the application of the transformer.

9.1.9 Liquid fillings for transformers are to be non-toxic and of a type which does not readily support combustion. Liquid filled transformers are to have a pressure relief-device with an alarm and there is to be a suitable means provided to contain any liquid which may escape from the transformer.

9.1.10 When forced cooling is employed, whether air or liquid, there is to be monitoring of the cooling medium and transformer winding temperature with an alarm should these exceed preset limits. There are to be arrangements so that the load may be reduced to a level commensurate with the cooling available.

9.1.11 All transformers are to be constructed to withstand, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any winding for 2 seconds with rated primary voltage and frequency without damage. This may be required to be verified by type test or random test.

9.1.12 The temperature rise of windings of transformers above the ambient temperatures given in Part 4, Chapter 1 of the 'Rules and Regulations for the Construction and Classification of Steel Ships', when measured by resistance, during continuous operation at the maximum rating, is not to exceed :

a) For dry type transformers, air cooled

- 50^{o}C for Class A;
- 60^{o}C for Class E;
- 70^{o}C for Class B;
- 90^{o}C for Class F; and
- 110^{o}C for Class H.

b) For liquid filled transformers

- 50^{o}C - where air provides cooling of the fluid;
- 65^{o}C - where water provides cooling of the fluid.

9.1.13 The tests given hereunder are to be carried out on all transformers at the manufacturer's works and a certificate of tests issued by the manufacturer.

a) **High voltage test** : The test voltage is to be applied, preferably after the temperature rise test, to each winding in turn, between the winding under test and the remaining windings, core, frame and tank or casing connected together and to earth. The test is to be made with 1 kV a.c. plus twice the highest voltage between lines with a minimum of 2.5 KV at any frequency between 25 and 100 Hz and maintained for 1 minute without failure.

b) When additional high voltage tests are carried out and for transformers that have been rewound or subject to extensive repair, the test voltage may be limited to a value which is 75 per cent of that stated in (a).

c) Induced high voltage test : To test between turns, coils and terminals, an a.c. voltage is to be applied between the above parts corresponding to twice the voltage appearing between these parts when rated voltage is applied to the terminals. The duration of the test is to be 1 minute for any test frequency up to and including twice the rated frequency.

d) **Insulation resistance** : The insulation resistance of each winding in turn to all the other windings, core, frame and tank or casing connected together and to earth is to be measured after the high voltage test and recorded together with the temperature of the transformer at the time of the test.

e) **Temperature rise** : One transformer of each size and type is to be given a temperature rise test. For transformers of rating 100 KVA and above, it will be accepted that the temperature rise test is made on one of several identical transformers manufactured and tested at the same time.

9.1.14 When a transformer is connected to a supply system with harmonic distortion, the rating of the transformer is to allow for the increased heating effect of the harmonic loading. Special attention is to be given to transformers connected for the purpose of reducing harmonic distortion.

9.1.15 The following tests are to be carried out on all transformers at the manufacturer's works and a certificate of tests issued by the manufacturer:

a) measurement of winding resistances, voltage ratio, impedance voltage, short circuit impedance, insulation resistance, load loss, no load loss and current;
b) dielectric tests;
c) temperature rise test on one transformer of each size and type.

9.2 Semiconductor equipment

9.2.1 The requirements of 9.2.2 to 9.2.16 apply to semiconductor equipment rated for 5 [kW] upwards.

9.2.2 Semiconductor equipment is to comply with the requirements of IEC 146 : Semiconductor converters, or an acceptable and relevant national standard amended where necessary for ambient temperature (see 1.8)

9.2.3 Semiconductor static power converter equipment is to be rated for the required duty having regard to peak loads, system transients and over voltage.

9.2.4 Converter equipment may be air or liquid cooled and is to be so arranged that it cannot remain loaded unless effective cooling is maintained. Alternatively the load may be automatically reduced to a level commensurate with the cooling available.

9.2.5 Liquid cooled converter equipment is to be provided with leakage alarms and there is to be a suitable means provided to contain any liquid which may leak from the system. In order to ensure that it does not cause electric failure of the equipment. Where the semiconductors and other current carrying parts are in direct contact with the cooling liquid, the liquid is to be monitored for satisfactory resistivity and alarm initiated at the relevant control station should the resistivity be outside the agreed limits.

9.2.6 Where forced cooling is used there is to be temperature monitoring of the heated cooling medium with an alarm and shutdown when the temperature exceeds a preset value.

9.2.7 Cooling fluids are to be non-toxic and of low flammability.

9.2.8 Converter equipment is to be so arranged that the semiconductor devices, fuses, control and firing circuit boards may be readily removed from the equipment for repair or replacement.

9.2.9 Test and monitoring facilities are to be provided to permit identification of control circuit faults and faulty components.

9.2.10 Devices fitted for converter equipment protection are to ensure that, under fault conditions, the protective action of circuit breakers, fuses or control systems is such that there is no further damage to the converter or the installation.

9.2.11 Converter equipment, including any associated transformers, reactors, capacitors and filters, if provided, is to be so arranged that the harmonic distortion, and voltage spikes, introduced in to the ships electrical system are restricted to a level necessary to ensure that it causes no malfunction of equipment connected to the electrical installation.

9.2.12 Over-voltage spikes or oscillations caused by commutation or other phenomena, are not to result in the supply voltage waveform deviating from the superimposed equivalent sine wave by more than 10 percent of the maximum value of the equivalent sine wave.

9.2.13 When converter equipment is operated in parallel, load sharing is to be such that under normal operating conditions overloading of any unit does not occur and the combination of parallel equipment is stable throughout the operating range.

9.2.14 When converter equipment has parallel circuits there is to be provision to ensure that the load is disturbed uniformly between the parallel paths.

9.2.15 Transformers, reactors, capacitors and other circuit devices associated with converter equipment or associated filters are to be suitable for the distorted voltage and current waveforms to which they may be subjected and filter circuits are to be provided with facilities to ensure that their capacitors are discharged before the circuits are energized.

9.2.16 Tests at the manufacturer’s works are to include:

- high voltage test for one minute applied between terminals and earthed parts at a frequency between 25 – 100 Hz. For system voltage upto 60 V the test voltage is to be 600 V; for system voltage between 60 – 90 V the test voltage is to be 900 V; for system voltage over 90 V the test voltage is to be twice the system voltage plus 1000 V;

- functional tests;

- temperature rise test; and

- such other agreed tests as are necessary to demonstrate the suitability of the equipment for its intended duty. Details of tests are to be submitted for consideration when required.

Section 10

Electrical Cables

10.1 General

10.1.1 The requirements of this Section are applicable to fixed cables on permanent installations. For flexible cables, the requirements apply only as far as applicable.

10.1.2 Electric cables for fixed wiring are to be designed, manufactured and tested in accordance with the relevant IEC Publication stated in Table 10.1.1 or an acceptable relevant standard.

Table 10.1.1 : Electric cables

Application	**IEC Publication**
General constructional and testing requirements	92-350
Fixed power and control circuits	92-353
Instrumentation	
control and communication circuits up to 60 V	92-375
Control circuits up to 250 V	92-376
Mineral insulated	702

10.1.3 The use of flexible cables on permanent installations is to be limited to applications where flexibility is necessary, and the lengths of such flexible cables are to be kept as short as practicable. Additional requirements may be specified for flexible cable, depending on the applications.

10.1.4 Electric cables complying with IEC Publication 502 is to have stranded conductors.

10.1.5 Electric cables for non-fixed wiring applications are to comply with an acceptable and relevant standard.

10.1.6 For the purpose of this section pipes, conduits, trending or any other system for the additional mechanical protection of cables are hereafter referred to under the generic name ‘protective casings’.

10.2 Testing

10.2.1 Routine tests are to include at least

- measurement of electrical resistance of conductors;

- high voltage test;

- insulation resistance measurement.

Evidence of successful completion of routine tests is to be provided by the manufacturer.

10.2.2 Particular, special and type tests are to be made, when required, in accordance with the requirements of relevant publication or national standard.

10.3 Voltage rating

10.3.1 The rated voltage of any cable is not to be lower than the nominal voltage of the circuit for which it is used. Cables exposed to voltage surges associated with highly inductive circuits, e.g. contactor operating circuits for winches etc., are to be given special consideration.

10.3.2 Electric cables used in unearthed systems are to be suitably rated to withstand the additional stresses imposed on the insulation due to an earth fault.

10.4 Operating temperature

10.4.1 The maximum rated conductor temperature of the insulating material for normal operation is to be at least 10^{o}C higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

10.4.2 The maximum rated conductor temperatures for normal and short circuit operation, for the insulating materials included within the publications referred to in 10.1.2 is not to exceed the values stated in Table 10.4.2.

10.4.3 Electric cables constructed of an insulating material not included in Table 10.4.2 are to be rated in accordance with relevant standard chosen in compliance with 10.1.2.

Table 10.4.2 : Insulating materials and maximum rated conductor temperature

Type of insulating compound	Maximum rated conductor temperature ^{o}C
Thermoplastics	
Based upon polyvinyl chloride or co-polymer of vinyl chloride and vinyl acetate	60
Based upon polyethylene	60
Elastometric or thermosettings	
Based upon ethylene propylene rubber or similar (EPM or EPDM)	85
Based upon chemically crosslinked polyethylene	85
Based upon silicon rubber	95
Mineral	95

10.5 Construction

10.5.1 Electric cables are to be at least of a flame-retardant type. Compliance with IEC Publication 332-1: Tests on a single vertical insulated wire or cable, will be acceptable.

10.5.2 Exemption from the requirements of 10.5.1 for applications such as radio frequency or digital communication systems, which require the use of particular types of cable, will be subject to special consideration.

10.5.3 Where electric cables are required to be of a 'fire resistant type', they are in addition to comply with the performance requirements of IEC Publication 331: Fire characteristics of electric cables.

10.5.4 Where electric cables are installed in locations exposed to the weather, in damp and in wet situations, in machinery compartments, refrigerated spaces or exposed to harmful vaporous including oil vapour they are to have the conductor insulating materials enclosed in an impervious sheath of material appropriate to the expected ambient conditions.

10.5.5 Electric cables where it is required that their construction includes metallic sheaths, armouring or braids are to be provided with an overall impervious sheath or other means to protect the metallic elements against corrosion.

10.5.6 Where single core electric cables are used in circuits rated in excess of 20 Amperes and are armoured the armour is to be of a non-magnetic material.

10.5.7 Electric cables are to be constructed such that they are capable of withstanding the mechanical and thermal effects of the maximum short circuit current which can flow in any part of the circuit in which they are installed, taking into consideration not only the time/current characteristics of the circuit protective device but also the peak value of the prospective short circuit current. Where electric cables are to be used in circuits with a maximum short circuit current in excess of 70 kA, evidence is to be submitted for consideration when required demonstrating that the cable construction can withstand the effects of the short circuit current.

10.6 Conductor size

10.6.1 The maximum continuous load carried by a cable is not to exceed its current rating. The diversity factor of the individual loads and the duration of the maximum demand may be allowed for in estimating the maximum continuous load and is to be shown on the plans submitted for approval.

10.6.2 The cross sectional area of the conductors is to be sufficient to ensure that, under short circuit conditions, the maximum rated conductor temperature for short circuit operation is not exceeded taking into account the time current characteristics of the circuit protective device and the peak value of the prospective short circuit current.

10.6.3 The cross sectional area of the conductor is to be sufficient to ensure that at no point in the installation will the voltage variation stated in 1.7 be exceeded when the conductors are carrying the maximum current under normal conditions of service.

10.6.4 The size of earth conductors is to comply with 1.12.7.

10.6.5 The current rating given in Table 10.6.1 are based on the maximum operating conductor temperature rise given in Table 10.4.2 where more precise evaluation of current rating has been carried out based on experimental or calculated data, details may be submitted for approval.

Table 10.6.1 : Electric cable current ratings, normal operation, based on ambient 45°C

Nominal cross section	Continuous r.m.s. current rating, in amperes								
	Thermoplastic, PVC, PE			EP rubber and cross-linked PE			Silicon rubber or mineral		
	Single core	2 core	3 or 4 core	Single core	2 core	3 or 4 core	Single core	2 core	3 or 4 core
0.75	6	5	4	13	11	9	17	14	12
1	8	7	6	16	14	11	20	17	14
1.25	10	8	7	18	15	13	23	19	16
1.5	12	10	8	20	17	14	24	20	17
2	13	11	9	25	21	17	31	26	21
2.5	17	14	12	28	24	20	32	27	22
3.5	21	18	14	35	30	24	39	33	27
4	22	19	15	38	32	27	42	36	29
5.5	27	23	19	46	39	32	52	44	36
6	29	25	20	48	41	34	55	47	39
8	35	30	24	59	50	41	66	56	46
10	40	34	28	67	57	47	75	64	53
14	49	42	34	83	71	58	94	80	66
16	54	46	38	90	77	63	100	85	70
22	66	56	46	110	93	77	124	105	87
25	71	60	50	120	102	84	135	115	95
30	80	68	56	135	115	94	151	128	106
35	87	74	61	145	123	102	165	140	116
38	92	78	64	155	132	108	175	149	122
50	105	89	74	185	153	126	200	175	140
60	123	104	86	205	174	143	233	198	163
70	135	115	95	225	191	158	255	217	179
80	147	125	103	245	208	171	278	236	195
95	165	140	116	275	234	193	310	264	217
100	169	144	118	285	242	199	320	272	224
120	190	162	133	320	272	224	360	306	252
125	194	165	134	325	280	230	368	313	258
150	220	187	154	365	310	256	410	349	287
185	250	213	175	415	353	291	470	400	329
200	260	221	182	440	375	305	494	420	346
240	290	247	203	490	417	343	570	485	400
300	335	285	235	560	476	392	660	560	460

Table 10.7.2 : Correction factors											
Insulation material	**Correction factor for ambient air temperature of °C**										
	35	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**
PVC Polyethylene	1.29	1.15	1.00	0.82	-	-	-	-	-	-	-
EPR, XLPE	1.12	1.06	1.00	0.94	0.87	0.79	0.71	0.61	0.50	-	-
Mineral, Silicon rubber	1.10	1.05	1.00	0.95	0.89	0.84	0.77	0.71	0.63	0.55	0.45

10.6.6 The cross sectional area of conductors used in circuits supplying cyclic or non-continuous loads is to be sufficient to ensure that the cables maximum rated conductor temperature for normal operation is not exceeded when the conductors are operating under their normal conditions of service.

10.7 Correction factors for current rating

10.7.1 **Bunching of cables** : Where more than six cables belonging to the same circuit are bunched together a correction factor of 0.85 is to be applied.

10.7.2 **Ambient temperature** : The current ratings in Table 10.6.1 are based on an ambient temperature of 45°C. For other values of ambient temperature the correction factors shown in Table 10.7.2 are to be applied.

10.7.3 **Intermittent service** : Where the load is intermittent, the correction factors in Table 10.7.3 may be applied for half hour and one hour ratings. In no case is a shorter rating than one half hour rating to be used, whatever the degree of intermittence.

Table 10.7.3 : Correction factors for intermittent rating				
Correc-tion factor	**Half-hour rating**		**One-hour rating**	
	With metallic sheath [mm²]	**Without metallic sheath [mm²]**	**With metallic sheath [mm²]**	**Without metallic sheath [mm²]**
1.00	Upto 20	Upto 75	Upto 67	Upto 230
1.10	21 – 40	76 – 125	68 – 170	231 – 400
1.15	41 – 65	126 – 180	171 – 290	401 - 600
1.20	66 – 95	181 – 250	291 – 430	-
1.25	96 – 130	251 – 320	431 - 600	-
1.30	131 – 170	321 – 400	-	-
1.35	171 – 220	401 – 500	-	-
1.40	221 - 270	-	-	-

10.8 Installation of electric cables

10.8.1 Cable runs are to be, as far as practicable, straight and accessible and as high as possible above bilges.

10.8.2 The installation of cables across expansion joints in any structure is to be avoided. Where such installation is unavoidable, a loop of cable of length proportional to the expansion of the joint is to be provided. The internal radius of the loop is to be at least twelve times the external diameter of the cable.

10.8.3 Where a duplicate supply is required and provided for any particular service, the two cables are to follow different routes which are separated throughout their length as widely as is practicable, to minimise the probability of simultaneous damage to the two circuits. The provision is also applicable to control circuits.

10.8.4 Electric cables are to be as far as practicable installed remote from sources of heat. Where installation of cable near source of heat cannot be avoided and where there is consequently a risk of damage to the cables by heat suitable shields, insulation or other precautions are to be installed.

10.8.5 Cables supplying essential or important consumers are generally not to be installed in rooms where there is an excessive fire hazard such as paint stores, galleys, etc. purifiers, welding-gas bottles etc.

10.8.6 Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, where this is not practicable, the cables are to be operated so that no cable reaches temperature higher than that permitted for the lowest temperature-rated cable in the group.

10.8.7 Cables having a protective covering which may damage the covering of other cables are not to be bunched with those of other cables.

10.8.8 The minimum internal radius of cable bends, which are not subjected to movements by expansion when installed, is to be generally in accordance with Table 10.8.1.

Table 10.8.1 : Minimum internal radii of bends in cables for fixed wiring

Cable construction		Overall diameter of cable	Min. internal radius of bend (times overall diameter of cable)
Insulation	**Outer covering**		
Thermoplastic and electrometric 600/1000 V and below	Metal sheathed Armoured and braided	Any	6D
	Other finishes	≤ 25 [mm] > 25 [mm]	6D 6D
Mineral	Hard metal sheathed	Any	6D
Thermoplastic and elastometric above 600/1000 V			
Single core	Any	Any	20D
Multi-core	Any	Any	15D

10.8.9 Electric cables are not to be coated or painted with materials which may adversely affect their sheath or their fire protection.

10.8.10 Where electric cables are installed in refrigerated spaces they are not to be covered with thermal insulation but may be placed directly on the face of the refrigeration chamber, provided that precautions are taken to prevent the electric cables being used as casual means of suspension. PVC insulated cables are not to be installed in refrigerated spaces.

10.8.11 Cable runs are normally not to include joints. However, if a joint is necessary it is to be carried out with prior approval and with due consideration to methods of splicing that retain the original mechanical and electrical properties of the cable and which ensure that all conductors are adequately secured, insulated and protected from atmospheric action. Terminals and busbars are to be of dimensions adequate for the cable rating.

10.8.12 Where electric cables are installed in bunches, provision is to be made to limit the propagation of fire, which may be achieved by the use of suitably located fire stops. Alternative arrangements will be considered.

10.8.13 All metal coverings of electric cables are to earthed in accordance with 1.12.

10.9 Mechanical protection of cables

10.9.1 Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit unless the protective covering (e.g. armour or sheath) is adequate to withstand the possible damage.

10.9.2 Cables, in spaces where there is exceptional risk of mechanical damage (e.g. on weather decks, in cargo hold areas and inside the cargo holds) and also below the floor in engine and boiler rooms, are to be suitably protected, even if armoured, unless the steel structure affords adequate protection.

10.9.3 Metal casings for mechanical protection of cables are to be efficiently protected against corrosion and effectively earthed in accordance with 1.12.

10.9.4 Non metallic protective casings and fixings are to be flame retardant in accordance with the requirements of IEC Publication 92-101.

10.10 Securing of cables

10.10.1 Cables, other than those attached to portable appliances and those installed in pipes, conduits or special casing are to be effectively supported and secured in a manner that prevents damage to their coverings.

10.10.2 Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection.

10.10.3 The distance between supports, for horizontal as well as vertical runs of cables, is to be chosen according to the type/size of cable, but generally in accordance with Table 10.10.3.

10.10.4 When electric cables are fixed by means of clips or straps manufactured from a material other than metal the material is to be flame retardant and the fixings are to be supplemented by suitable metal clips or straps at regular intervals, each not exceeding 2 [m].

10.10.5 Single core cables are to be firmly fixed, using supports of strength adequate to withstand forces corresponding to the values of the peak prospective short circuit current.

Table 10.10.3 : Distance between supports

External diameter of cable		Non-armoured cables	Armoured cables
Exceeding mm	Not exceeding mm	mm	mm
-	8	200	250
8	13	250	300
13	20	300	350
20	30	350	400
30	-	400	450

10.11 Penetration of bulkheads and decks by cables

10.11.1 Where electric cables pass through watertight, fire insulated or gas tight bulkheads, the arrangements are to be such as to ensure the integrity of the bulkhead or deck is not impaired. The arrangements chosen are to ensure that the cables are not adversely affected.

10.11.2 Where cables pass through non-watertight bulkheads or structural steel, the holes are to be bushed with suitable material. If the steel is at least 6 mm thick, adequately rounded edges may be accepted as the equivalent of bushing.

10.11.3 Electric cables passing through decks are to be protected by deck tubes or ducts.

10.11.4 Where cables pass through thermal insulation they are to do so at right angles, in tubes sealed at both ends.

10.12 Installation of electric cables in protective casings

10.12.1 Installation of cables in pipes and conduits is to be carried out in such a manner that there is no damage to the cable covering.

10.12.2 The internal radius of bend of protective casings are to be not less than that required for largest cable installed therein (See 10.8.8).

10.12.3 The drawing in factor (ratio of the sum of the cross-sectional areas of the cables, based on their external diameter, to the internal cross section area of the pipe) is not to exceed 0.4.

10.12.4 Expansion joints are to be provided where necessary.

10.12.5 Cable pipes and conduits are to be adequately and effectively protected against corrosion. Where necessary, openings are to be provided at the highest and lowest points to permit air circulation and to prevent accumulation of water.

10.12.6 Cables used for cold cathode luminous discharge lamps are not to be installed in metal conduit unless protected by metal sheath or screen.

10.13 Single core electric cables for alternating current

10.13.1 When installed in protective casings, electric cables belonging to the same circuit are to be installed in the same casing, unless the casing is of non-magnetic material.

10.13.2 Cable clips are to include electric cables of all phases of a circuit unless the clips are of non-magnetic material.

10.13.3 Single-core cables of the same circuit are to be in contact with one another, as far as possible. In any event the distance between adjacent electric cables is not to be greater than one cable diameter.

10.13.4 If single-core cables of current rating greater than 250 A are installed near a steel bulkhead, the clearance between the cables and the bulkhead is to be at least 50 mm unless the cables belonging to the same a.c. circuit are installed in trefoil formation.

10.13.5 Magnetic material is not to be used between single core cables of a group. Where cables pass through steel plates, all the conductors of the same circuit are to pass through a plate or gland, so made that there is no magnetic material between the cables and the clearance between the cables and the magnetic material is not to be less than 75 mm, unless the cables belonging to the same a.c. circuit are installed in trefoil formation.

10.14 Cable ends

10.14.1 The ends of all conductors of cross-sectional area greater than 4 [mm^2] are to be fitted with soldering sockets, compression type sockets or mechanical clamps. Corrosive fluxes are not to be used.

10.14.2 Cables having hygroscopic insulation (e.g. mineral insulated) are to have their ends sealed against ingress of moisture.

10.14.3 Cable socket and connecting terminals are to be of such a design and dimension that maximum current likely to flow through them will not produce heat which would damage the insulation.

Section 11

Batteries

11.1 General

11.1.1 The requirements of this section apply to permanently installed secondary batteries of the vented and valve regulated sealed type.

11.1.2 A vented battery is one in which the electrolyte can be replaced and which freely releases gas during periods of charge and overcharge.

11.1.3 A valve regulated sealed battery minimises the quantity of gas released through a pressure relief valve by recombining the products of electrolysis. The electrolyte cannot be replaced.

11.2 Construction

11.2.1 Batteries are to be constructed so as to prevent spilling of the electrolyte due to motion and to minimise the emission of elecrolyte spray.

11.3 Location

11.3.1 Vented batteries connected to a charging device with a power output of more than 2 kW are to be housed in an adequately ventilated compartment assigned to batteries only, or may be installed in a suitable box on open deck.

11.3.2 Vented batteries connected to a charging device with a power output within the range 0.2 kW to 2 kW are to be installed in accordance with 11.3.1, or may be installed in a box within a well ventilated machinery or similar space.

11.3.3 Vented batteries connected to a charging device with a power output of less than 0.2 kW may be installed in an open position or in a battery box in any suitable space.

11.3.4 Where more than one charging device is installed for any battery or group of batteries in one location, the total power output is to be used to determine the installation requirements of 11.3.1, 11.3.2 or 11.3.3.

11.3.5 Where lead-acid and nickel-cadmium batteries are installed in the same compartment precautions are to be taken, such as the provision of screens, to prevent possible contamination of electrolytes.

11.3.6 Where batteries may be exposed to the risk of mechanical damage or falling objects they are to be suitably protected.

11.3.7 Batteries installed in crew and passenger cabins together with their associated corridors, are to be of the hermetically sealed type.

11.3.8 A permanent notice prohibiting smoking and the use of naked lights or equipment, capable of creating a source of ignition, is to be prominently displayed adjacent to the entrances of all compartments containing batteries.

11.4 Installation

11.4.1 Batteries are to be arranged such that each cell or crate of cells is accessible from the top and at least one side.

11.4.2 Where cells are carried on metal stands, non-absorbent insulation appropriate to the working voltage is to be provided between the cells and stands and similar insulation fitted to prevent any movement arising from the ship’s motion. Metal stands are to be insulated from the structure where the battery has a nominal working voltage exceeding 110 volts.

11.4.3 Where acid is used as the electrolyte for vented type batteries, a tray of acid resisting material is to be provided below the cells, unless the deck below is similarly protected. Alkaline batteries are to be provided with equivalent arrangements for containing any escape or spillage of electrolyte.

11.4.4 The interiors of all compartments for vented batteries including crates, trays, boxes, shelves and other structural parts therein are to be of a corrosion resistant material and if necessary covered with a suitable paint or lining material.

11.5 Ventilation

11.5.1 Battery compartments and boxes are to be ventilated to avoid accumulation of dangerous concentrations of flammable gas. The ventilation openings are to be of a non-closeable type and a permanent notice is to be prominently displayed adjacent to them, stating:

THIS VENTILATOR OPENING IS NOT TO BE CLOSED OR BLOCKED AT ANY TIME – EXPLOSIVE GAS.

11.5.2 Natural ventilation may be employed where the number of air changes necessary are small, provided ducts can be run directly from the top of the compartment to the open air above, with no part of the duct more than 45^{o} from the vertical.

11.5.3 Where natural ventilation is impracticable or insufficient, mechanical ventilation is to be provided, with the air inlet located near the floor and the exhaust at the top of the compartment.

11.5.4 Mechanical exhaust ventilation is to be provided for vented type battery installations connected to a charging device with a total maximum power output of more than 2 kW.

11.5.5 The ventilation system for battery compartment and boxes other than boxes located on open deck or in spaces to which 11.3.2 and 11.3.3 refer, is to be separate from other ventilation systems. The exhaust ducting is to be led to a location in the open air, where any gases can be safely diluted, away from possible sources of ignition and openings into spaces where gases may accumulate.

11.5.6 Fan motors associated with exhaust ducts from battery compartments are to be placed external to the ducts and the compartments.

11.5.7 Ventilating fans for battery compartments are to be so constructed and be of material such as to minimise risk of sparking in the event of the impeller touching the casing. Non-metallic impellers are to be of an anti-static material.

11.5.8 Battery boxes are to be provided with sufficient ventilation openings located so as to avoid accumulation of flammable gas whilst preventing the entrance of rain or spray.

11.6 Charging facilities

11.6.1 Charging facilities are to be provided for all secondary batteries such that they may be completely charged from the completely discharged state in a reasonable time having regard to the service requirements.

11.6.2 Suitable means, including an ammeter and a voltmeter, are to be provided for controlling and monitoring charging of batteries and to protect them against discharge into the charging circuits.

11.6.3 For floating circuits or any other conditions where the load is connected to the battery whilst it is on charge, the maximum battery voltage is not to exceed the safe value for any connected apparatus.

11.6.4 Where valve regulated sealed batteries are installed, a device independent of the normal charging arrangements is to be provided to prevent gas evolution in excess of the manufacturer’s design quantity.

11.6.5 Boost charge facilities, where provided, are to be arranged such that they are automatically disconnected should the battery compartment ventilation system fail.

11.6.6 Means are to be provided to minimise the risk of overcharging or overheating the batteries.

11.7 Electrical equipment

11.7.1 Only electrical equipment necessary for operational reasons and for the provision of lighting is to be installed in compartments provided in compliance with 11.3.1. Such electrical equipment is to be certified for group IIC gases and temperature Class T1 in accordance with IEC Publication 79:

Electrical apparatus for explosive gas atmospheres, or an acceptable and relevant National Standard.

11.7.2 Standard marine or industrial electrical equipment may be installed in compartments containing valve-regulated sealed batteries provided that the ventilation requirements of 11.5 and the charging requirements of 11.6.4 and 11.6.5 are complied with.

11.8 Cables

11.8.1 Where it is impracticable to provide electrical protective devices for certain cables supplied from batteries, e.g. within battery compartments and in engine starting circuits, unprotected cable runs are to be kept as short as possible and special precautions should be taken to minimize risk of faults, e.g. use of single core cables with additional sleeve over the insulation of each core, with shrouded terminals.

Section 12

Equipment – Heating, Lighting and Accessories

12.1 Heating and cooking equipment

12.1.1 The construction of heaters is to give a degree of protection according to IEC Publication 529: Degrees of protection provided by enclosures (IP Code), or an acceptable and relevant National Standard, suitable for the intended location.

12.1.2 Heating elements are to be suitably guarded.

12.1.3 Heating and cooking equipment is to be installed such that adjacent bulkheads and decks are not subjected to excessive heating.

12.2 Lighting – General

12.2.1 Lampholders are to be constructed of flame retarding non-hydroscopic materials.

12.2.2 Lighting fittings are to be so arranged as to prevent temperature rises which overheat or damage surrounding materials. They must not impair the integrity of fire divisions.

12.3 Incandescent lighting

12.3.1 Tungsten filament lamps and lampholders are to be in accordance with Table 12.2.1.

12.3.2 Lampholders of type E40 are to be provided with a means of locking the lamp in the lampholder.

12.4 Fluorescent lighting

12.4.1 Fluorescent lamps and lampholders are to be in accordance with Table 12.2.1.

12.4.2 Fittings, reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are subject to high temperatures. If mounted separately they are additionally to be enclosed in an earthed conductive casing.

12.4.3 Where capacitors of 0.5 microfarads and above are installed, means are to be provided to promptly discharge the capacitors on disconnection of the supply

Table 12.2.1 : Lamps and lampholders

Designation	Maximum lamp rating		Maximum lamp-holder current, A
	Voltage, V	Power, W	
Screw cap lamps			
E40	250	3000	16
E27	250	200	4
E14	250	15	2
E10	24	-	2
Bayonet cap lamps			
B22	250	200	4
B15d	250	15	2
B15s	55	15	2
Tubular fluorescent lamps			
G13	250	80	-
G5	250	13	-

12.5 Discharge lighting

12.5.1 Discharge lamps operating in excess of 250 V are only acceptable as fixed fittings. Warning notices calling attention to the voltage are to be permanently displayed at points of access to the lamps and where otherwise necessary.

12.6 Socket outlets and plugs

12.6.1 The temperature rise on the five parts of socket outlet and plugs is not to exceed 30^{o}C. Socket outlets and plugs are to be so constructed that they cannot be readily short-circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket outlet.

12.6.2 All socket outlets of current rating 16 A or more are to be provided with a switch and be interlocked such that the plug cannot be inserted or withdrawn when the switch is in the 'on' position.

12.6.3 Where it is necessary to earth the non-current carrying parts of portable or transportable equipment, an effective means of earthing is to be provided at the socket outlet.

12.6.4 On weather decks, galleys, laundries, machinery spaces and all wet situations socket outlets and plugs are to be effectively shielded against rain and spray and are to be provided with means of maintaining this quality after removal of the plug.

12.7 Enclosures

12.7.1 Enclosures for the containing and mounting of electrical accessories are to be of metal, effectively protected against corrosion, or of flame-retardant insulating materials.

Section 13

Electrical Equipment for Use in Explosive Atmospheres

13.1 General

13.1.1 Electrical equipment is not to be installed in areas where an explosive atmosphere may be present, except where necessary for operational and/or safety purposes, when the equipment is to be of a certified safe type as listed below and details of the equipment and installation are to be submitted for approval. The construction and type testing is to be in accordance with IEC Publication 79: Electrical equipment for explosive gas atmospheres or an acceptable and relevant National Standard.

Intrinsically safe	-	Ex 'i'
Increased safety	-	Ex 'e'
Flameproof	-	Ex 'd'
Pressurized enclosure	-	Ex 'p'
Powder filled	-	Ex 'q'
Encapsulated	-	Ex 'm'

13.1.2 Where cables are installed in hazardous areas, precautions are to be taken against risks being introduced in the event of an electrical fault.

13.1.3 For craft with spaces for carrying vehicles with fuel in their tanks for their own propulsion, the following requirements are also applicable:

a) electrical equipment fitted within a height of 45 cm above the vehicle deck, or any platform on which vehicles are carried, or within the exhaust ventilation trunking for the space, is to be of a safe type;

b) electrical equipment situated elsewhere within the space is to have an enclosure of ingress protection rating of at lest IP55, if not of a safe type. (See IEC Publication 529: Classification of Degrees of Protection provided by enclosures). Smoke and gas detector heads are exempt from this requirement.

Section 14

Navigation and Manoeuvring Systems

14.1 Steering systems

14.1.1 The requirements of 14.1.2 to 14.1.7 are to be read in conjunction with those in Chapter 8.

14.1.2 Two exclusive circuits, fed from the main source of electrical power and each having adequate capacity to supply all the motors which may be connected to it simultaneously are to be provided for each electric or electro-hydraulic steering unit arrangement consisting of one or more electric motors. One of these circuits may pass through the emergency switchboard.

14.1.3 The main and auxiliary steering unit motors are to be capable of being started from a position on the navigating bridge and also arranged to restart automatically when power is restored after a power failure.

14.1.4 The motor of an associated auxiliary electric or electro-hydraulic power unit may be connected to one of the circuits supplying the main steering unit.

14.1.5 Only short circuit protection is to be provided for each main and auxiliary steering unit motor circuit.

14.1.6 In craft of less than 1600 gross tonnage, if an auxiliary steering unit is not electrically powered or is powered by an electric motor primarily intended for other services, the main steering unit may be fed by one circuit from the main switchboard. Consideration would be given to other protective arrangements other than described in 14.1.5 for such a motor primarily intended for other services.

14.1.7 Each main and auxiliary steering unit electric control system which is to be operated from the navigating bridge is to be served with electric power by a separate circuit supplied from the associated steering gear power circuit, from a point within the steering unit compartment, or directly from the same section and switchboard busbars, main or emergency, to which the associated steering unit power circuit is connected. Each separate circuit is to be provided with short circuit protection only.

14.2 Thruster systems for manoeuvring

14.2.1 Where a tunnel or athwartship thruster is fitted solely for the purpose of manoeuvring and is electrically driven, its starting and operation is not to cause the loss of any essential services.

14.2.2 In order to ensure that the thruster system is not tripped inadvertently whilst manoeuvring the craft, overload protection in the form of an alarm is to be provided for the electric motor and any associated supply converters, in lieu of tripping.

14.2.3 The thruster electric motor is not to be disconnected as part of a load management switching operation.

14.3 Navigation lights

14.3.1 Navigation lights are to be connected separately to a distribution board reserved for this purpose only, and connected directly or through transformers to the emergency switchboard. The distribution board is to be accessible to the officer of the watch.

14.3.2 Each navigation light is to be controlled and protected in each insulated pole by a switch and fuse or circuit-breaker mounted on the distribution board.

14.3.3 Each navigation light is to be provided with an automatic indicator giving audible and/or visual indication of failure of the light. If an audible device alone is fitted, it is to be connected to an independent source of supply, e.g. a battery, with means provided to test this supply. If a visual signal is used connected in series with the navigation light, means are to be provided to prevent extinction of the navigation light due to failure of the signal. The requirements of this paragraph do not apply to pilot boats, fishing boats and similar small vessels.

14.3.4 Provision is to be made on the navigating bridge for the navigation lights to be transferred to an alternative circuit led from the main source of electrical power.

14.3.5 Any statutory requirements of the country of registration are to be complied with and may be accepted as an alternative to the above.

14.4 Navigational aids

14.4.1 Navigational aids as required by statutory regulations are to be fed from the emergency source of electrical power. (See Section 3).

14.5 Stabilization

14.5.1 Where the stabilization of a craft is essentially dependent upon a single device which in turn is dependent upon a continuous supply of electrical power, the supply arrangements are to comply with 5.2.3.

14.5.2 Where such systems are not dependent upon the continuous availability of electrical power, but one or more alternative systems not dependent upon the electrical supply are installed, a single circuit may be provided, with the protection and alarms required by 5.2.3.

Section 15

Fire Safety Systems

15.1 Fire detection and alarm systems

15.1.1 This section is to be read in conjunction with the requirements given in Chapter 10.

15.1.2 A loop circuit of an addressable fire detection system, capable of interrogating from either end of the loop any detector served by the circuit, may comprise more than one section of detectors. Such sections are to be separated by devices which will ensure that if a short circuit occurs anywhere in the loop only the attached section of detectors will be isolated from the control panel. No section of detectors between these devices is in general to include more than 50 detectors.

15.1.3 A loop circuit of an addressable fire detection system is not to be situated in more than one main vertical zone, nor is a loop circuit which covers a control station, a service space or an accommodation space to include a machinery space.

15.1.4 The wiring for each section of detectors in an addressable fire detector system is to be separated as widely as practicable from that of all other sections on the same loop.

15.2 Automatic sprinkler system

15.2.1 Any electrically driven power pump, provided solely for the purpose of continuing automatically the discharge of water from the sprinklers, is to be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted.

15.2.2 For passenger crafts, electrically driven sea-water pumps for automatic sprinkler systems are to be served by not less than two circuits reserved solely for this purpose, one fed from the main source of electrical power and one from the emergency source of electrical power. Such feeders are to be connected to an automatic change-over switch situated near the sprinkler pump and the switch is to be normally closed to the feeder from the main source of electrical power. The switches on the main and emergency switchboards are to be clearly labeled and normally kept closed.

15.2.3 The automatic alarm and detection system is to be fed by exclusive feeders from two sources of electrical power, one of which is to be an emergency source, with automatic changer-over facilities located in, or adjacent to, the main alarm and detection panel.

15.3 Fire pumps

15.3.1 When the emergency fire pump is electrically driven, the power is to be supplied by a source other than that supplying the main fire pumps. This source is to be located outside the machinery spaces containing the main fire pumps and their source of power and drive units.

15.3.2 The cables to the emergency fire pumps are not to pass through the machinery spaces containing the main fire pumps and their source of power and drive units. The cables are to be of a fire resistant type where they pass through other high fire risk areas.

15.4 Refrigerated liquid carbon dioxide systems

15.4.1 Where there are electrically driven refrigeration units for carbon dioxide fire-extinguishing systems, one unit is to be supplied by the main source of electrical power and the other unit from the emergency source of electrical power. Exclusive circuits are to be used for the two units.

15.4.2 Each electrically driven carbon dioxide refrigerating unit is to be arranged for automatic operation in the event of loss of the alternative unit.

15.5 Fire safety stops

15.5.1 Means of stopping all ventilating fans are to be provided, outside the spaces being served, at positions which will not readily be cut off in the event of a fire. The provisions for machinery spaces are to be independent of those for other spaces.

15.5.2 Machines driving forced and induced draught fans, independently driven pumps delivering oil to main propulsion machinery for bearing lubrication and piston cooling, oil fuel transfer pumps, oil fuel unit pumps, cargo oil pumps and other similar fuel pumps are to be fitted with remote controls situated outside the space concerned so that they may be stopped in the event of fire arising in the space in which they are located.

15.5.3 In passenger crafts all power ventilation systems, except cargo and machinery space ventilation, which is to be in accordance with 15.5.2 are to be fitted with master controls so that all fans may be stopped, in the event of fire, from either of two separate positions which are to be situated as far apart as is practicable.

15.5.4 Means of cutting off power to the galley, in the event of a fire, are to be provided outside the galley exits, at positions, which will not readily be rendered inaccessible by such a fire.

15.5.5 Fire safety stop systems are to be designed on the fail-safe principle or alternatively the power supplies to and the circuits of, the fire safety stop systems are to be continuously monitored and an alarm initiated in the event of a fault and the cables are to be of a fire resistant type. See 10.5.3.

15.6 Fire doors

15.6.1 The electrical power required for the control, indication and alarm circuits of fire doors is to be supplied from the emergency source of electrical power as required by Section 3. In passenger craft an alternative supply fed from the main source of electrical power, with automatic change-over facilities, is to be provided at the central control station.

15.6.2 The control and indication systems for the fire doors are to be designed on the fail-safe principle with the release system having a manual reset.

15.7 Fire dampers

15.7.1 The electrical power required for the control and indication circuits of fire dampers is to be supplied from the emergency source of electrical power.

15.7.2 The control and indication systems for the fire dampers are to be designed on the fail-safe principle with the release system having a manual reset.

15.8 Fire extinguishing media release alarms

15.8.1 Where it is required that alarms be provided to warn of the release of a fire extinguishing medium and these are electrically operated, they are to be fed by exclusive circuits from two sources, one of which is to be an emergency source. Automatic change over facilities are to be provided between the two services together with indication, located in or adjacent to the operation panel, to show that the supply to the alarms is healthy.

Section 16

Crew and Passenger Emergency Safety Systems

16.1 Emergency lighting

16.1.1 For the purpose of this section emergency lighting, transitional emergency lighting and supplementary emergency lighting are hereafter referred to under the generic name 'emergency lighting'.

16.1.2 Emergency lighting is to be arranged so that a fire or other casualty in the spaces containing the emergency source of electrical power, associated transforming equipment and the emergency lighting switchboard does not render the main lighting system inoperative.

16.1.3 The level of illumination provided by the emergency lighting is to be adequate to permit safe evacuation in an emergency, having regard to the possible presence of smoke.

16.1.4 The exit(s) from every main compartment occupied by passengers or crew is to be continuously illuminated by an emergency lighting fitting.

16.1.5 Switches are not to be installed in the final sub-circuits to emergency light fittings unless the light fittings are serving normally unmanned spaces, i.e. storage-rooms, cold rooms, etc. Where switches are fitted they are to be accessible only to ships crew with provision made to ensure that the emergency lighting is energised when such spaces are manned.

16.1.6 Where emergency lighting fittings are connected to dimmers, provision is to be made, upon the loss of the main lighting, to automatically restore them to their normal level of illumination.

16.1.7 Fittings are to be specially marked to indicate that they form part of the emergency lighting system.

16.2 General emergency alarm system

16.2.1 An electrically operated bell or klaxon or other equivalent warning system installed in addition to the ship's whistle or siren, for sounding the general emergency alarm signal is to comply with the requirement of this Section.

16.2.2 The alarm system is to be fed by exclusive circuits, one from the main source of electrical power and one from an emergency source of electrical power with automatic change-over facilities located in, or adjacent to the main alarm signal distribution panel.

16.2.3 The alarm system is to be audible throughout all the accommodation and normal crew working spaces with all doors and accesses closed and is to have a sound pressure level, in the 1/3-octave band above the fundamental, of not less than 75dB(A) and at least 10 dB(A) above normal ambient noise levels, with the ship underway in moderate weather, when measured at the sleeping positions in the cabins and one metre from the source. An audible alarm level of 120 dB(A) is not to be exceeded in any space.

16.2.4 With the exception of bells, the alarm is to have a signal frequency between 200 Hz and 2.5 kHz.

16.2.5 Where the special alarm fitted to summon the crew from the navigation bridge, of fire control station, forms part of the ship's general alarm system, it is to be capable of being sounded independently of the alarm to the passenger spaces.

16.2.6 The system is to be capable of operation from at least the navigating bridge and at a position adjacent to the alarm signal distribution panel. After being bought into operation the alarm is to continue to function until it is manually turned off or is temporarily interrupted by a message on the public address system. The access points for such messages are to be restricted to the navigating bridge and other strategic positions.

16.3 Public address system

16.3.1 Public address systems are to comply with requirements of this Section.

16.3.2 Where the public address system forms part of the internal communication equipment required in an emergency it is to be fed by exclusive circuits, one from the main source of electrical power and one from an emergency source of electrical power with automatic change-over facilities located adjacent to the public address system.

16.3.3 Amplifiers are to be continuously rated for the maximum power that they are required to deliver into the system for audio and, where alarms are to be sounded through the public address system, for tone signals.

16.3.4 Loudspeakers are to be continuously rated for their proportionate share of amplifier output.

16.3.5 Amplifiers and loudspeakers are to be selected and arranged to prevent feedback and other interference.

16.3.6 Where the public address system does not form part of the internal communication equipment required in an emergency, provision is to be made, at a position adjacent to the emergency system control panel, to silence the public address system.

Section 17

Craft Safety Systems

17.1 Watertight doors

17.1.1 The electrical power required for power-operated sliding watertight doors is to be separate from any other power circuit and supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck. The associated control, indication and alarm circuits are to be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck and be capable of being automatically supplied by the transitional source of emergency electrical power, provided as per Section 3, in the event of failure of either the main or emergency source of electrical power.

17.1.2 Where the source for opening and closing the watertight doors have electric motors, unless an independent temporary source of stored energy is provided, the electric motors are to be capable of being automatically supplied from the transitional source of emergency electrical power provided as per Section 3.

17.1.3 A single electrical failure in the power operating or control system of power-operated sliding watertight doors is not to result in a closed door opening or prevent the hand operation of any door.

17.1.4 Availability of the power supply is to be continuously monitored at a point in the electrical circuit adjacent to the door operating equipment. Loss of any such power supply is to activate an audible and visual alarm at the central operating console at the navigating bridge.

17.1.5 Electrical power, control, indication and alarm circuits are to be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuit. Short circuits or other faults in the alarm or indicator circuits of a door are not to result in a loss of power operation of the door. Arrangements are to be such that leakage of water into the electrical equipment located below the bulkhead deck will not cause the door to open.

17.1.6 The enclosures of electrical components necessarily situated below the bulkhead deck are to provide suitable protection against the ingress of water with ratings as defined in IEC Publication 529 or an acceptable and relevant national standard, as follows :

a) Electrical motors, associated circuits and control components, protected to IPX7 standard.
b) Door position indicators and associated circuit components protected to IPX8 standard, where the water pressure testing of the enclosures is to be based on the pressure that may occur at the location of the component during flooding for a period of 36 hours.
c) Door movement warning signals, protected to IPX6 standard.

17.1.7 Watertight door electrical controls including their electric cables are to be kept as close as is practicable to the bulkhead in which the doors are fitted and so arranged that the likelihood of them being involved in any damage which the ship may sustain is minimized.

17.1.8 An audible alarm, distinct from any other alarm in the area, is to sound whenever the door is closed remotely by power and sound for at least five seconds but no more than ten seconds before the door begins to move and is to continue sounding until the door is completely closed. The audible alarm is to be supplemented by an intermittent visual signal at the door in passenger areas and areas where the noise level exceeds 85 dB(A).

17.1.9 A central operating console is to be fitted on the navigating bridge and is to be provided with a 'master-mode' switch having :

a) a 'local control' mode for normal use which is to allow any door to be locally opened and locally closed after use without automatic closure, and;

b) a 'doors closed' mode for emergency use which is to allow any door that is opened to be automatically closed whilst still permitting any doors to be locally opened but with automatic reclosure upon release of the local control mechanism.

17.1.10 The 'master mode' switch is to be arranged to be normally in the 'local control' mode position; be clearly marked as to its emergency function.

17.1.11 The central operating console at the navigating bridge is to be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light is to indicate a door is fully open and a green light, a door fully closed. When the door is closed remotely a red light is to indicate the intermediate position by flashing. The indicating circuit is to be independent of the control circuit for each door.

17.1.12 The arrangements are to be such that it is not possible to remotely open any door from the central operating console.

17.2 Shell doors, loading doors and other closing appliances

17.2.1 Where it is required that indicators be provided for shell doors, loading doors and other closing appliances, which are intended to ensure the watertight integrity of the craft’s structure in which they are located, the indicator system is to be designed on the fail-safe principle. The system is to indicate if any of the doors or closing appliances are open or are not fully closed or secured.

17.2.2 Where such doors and appliances are to be operated at sea, the requirements of 17.1 are to be complied with as far as is practicable.

17.2.3 The electrical power supply for the indicator system is to be independent of any electrical power supply for operating and securing the doors.

17.3 Lightning conductors

17.3.1 In wood and composite vessels fitted with wooden masts, the lightning conductors are to be composed of continuous copper tape and/or rope, having a cross sectional area not less than 100 mm^2 which are to be reveted with copper rivets or fastened with copper clamps to a suitable copper spike not less than 13 mm in diameter, projecting at least 150 mm above the top of the mast. Where tape is used the lower end of the tape is to terminate at the point at which the shrouds leave the mast, and is to be securely clamped to a copper rope of not less than 13 mm diameter. This copper rope is to be lead down the shrouds and is to be securely clamped to a copper plate not less than 0.2 m^2 in area, fixed well below the light waterline and attached to the ship’s side in such a manner that it is to be immersed under all conditions of heel.

17.3.2 In wood and composite vessels fitted with steel masts, each mast is to be connected to a copper plate in accordance with 17.3.1, the copper rope being securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

17.3.3 In steel vessels fitted with wooden masts, the lightning conductors are to be composed of copper tape or rope terminating in a spike, as set forth in 17.3.1. At the lower end this copper tape or rope is to be securely clamped to the nearest metal forming part of the hull of the ship.

17.3.4 Lightning conductors are to be run as straight as possible and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type and efficiently locked. No connection is to be dependent on a soldered joint.

17.3.5 The resistance of the lightning conductor, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0.02 ohms.

Section 18

Small Crafts Not Required to Comply With HSC Notation

18.1 General requirements

18.1.1 The requirements of this section are applicable to the electrical installations in non HSC small craft as defined in 1.1.1 where the voltage of supply does not exceed 440 volts ac or dc.

18.1.2 The electrical installations for propulsion and auxiliary service where the voltage of supply exceeds 440 volts are to be constructed and installed in accordance with Sections 1 to 17.

18.1.3 Alternative arrangements will be given special consideration.

18.2 Plans

18.2.1 The following plans and details for electrical installation are to be submitted in triplicate for approval.

18.2.2 Single line diagram of main power and lighting systems which is to include:

a) rating of machines; transformers; batteries and semi-conductor converters;
b) all feeders connected to the main switchboard;
c) section boards and distribution boards;
d) insulation type, size and current loadings of cables;
e) make, type and rating of circuit breakers and fuses.

18.2.3 Simplified diagrams of generator circuits and feeder-circuits showing:

a) protective devices;
b) instrumentation and control devices;
c) preference tripping;
d) earth fault indication/protection.

18.2.4 Calculations of prospective short circuit current of main busbars and secondary side of transformers. (Additionally load schedule is to be submitted for information.)

18.2.5 Details of electrically operated personnel safety systems which are to include single line diagrams and a general arrangement plan of the vessel showing location and cable routes of:

a) fire detection, alarm and extinction systems;
b) internal communication and alarm systems.

18.3 Survey

18.3.1 The installation is to be inspected and tested by the Surveyors, in accordance with the requirements of section 19, as appropriate, and is to be to their satisfaction.

18.4 Addition or alterations

18.4.1 The requirements for addition or alteration as given in Section 1.15 are to be complied with.

18.5 Location and construction of equipment

18.5.1 Electrical equipment is to be accessibly placed, clear of flammable material in well ventilated, adequately lighted spaces, in which flammable gases cannot accumulate and where it is not exposed to risk of mechanical damage or damage from water, steam or oil. Where necessarily exposed to such risks, the equipment is to be suitably constructed or enclosed. Equipment is to be accessible for maintenance.

18.5.2 Insulating materials and insulated windings are to be flame retardant and resistant to tracking, moisture, sea air and oil vapour unless special precautions are taken to protect them.

18.5.3 Securing arrangements used in connection with current carrying parts are to be effectively locked.

18.5.4 The operation of all electrical equipment is to be satisfactory under such conditions of vibrations, movements and shock as may arise in normal practice.

18.5.5 The design and installation of electrical equipment is to be such that the risk of fire due to its failure is minimised. It is, as a minimum, to comply with a National or International Standard revised where necessary for ambient conditions. Equipment is to be tested at the manufacturers works and a certificate of tests issued by the manufacturer.

18.6 Systems of distribution

18.6.1 The requirement of generation and distribution as given in Section 5.1.1 are to be complied with.

18.6.2 The arrangement of the sources of electrical power, generators or batteries, is to be such that a casualty in any one space does not result in loss of electrical power to circuits serving any safety, essential lighting or communication equipment. In non-passenger type service craft any batteries provided for this duty are to be rated for at least 12 hours and in patrol and pilot craft the batteries are to be rated for five hour.

18.6.3 A device(s) is to be installed for every insulated distribution system, whether primary or secondary, for power, heating and lighting circuits to continuously monitor the insulation level to earth.

18.7 Earthing

18.7.1 The requirements for earthing as given in Section 1.11.1 and 1.11.2 are to be complied with.

18.7.2 With wood and other non metallic hull constructions earthing connections are to be made to the general frame, engine, bed plate and earthing plate. Earthing connections are not to be made to hull sheathing, skin, fittings or plumbing.

18.8 Protection

18.8.1 Installations are to be protected against over-currents including short circuits. The tripping/fault clearance times of protective devices are to provide complete and co-ordinated protection to ensure:

a) availability of services not affected by the faulty circuit;
b) elimination of the fault to reduce damage to the system and hazard of fire.

18.8.2 Short circuit protection and a means of complete isolation is to be provided for each source of power.

18.8.3 Protection for battery circuits is to be provided at a position external and adjacent to the battery compartments; batteries used solely for engine starting may be provided with only a means of isolation.

18.8.4 Short circuit and overload protection together with a means of isolation is to be provided in each non-earthed outgoing circuit of the main switchboard and each distribution board.

18.8.5 Each final sub-circuit is to be provided with short circuit protection and a means of isolation in each non-earthed line.

18.8.6 Lighting circuits are to be supplied by circuits separate from those for power.

18.8.7 Control circuits for engine monitoring and other services are to be provided with short circuit protection.

18.8.8 Protective devices are not to be fitted in any earthed line of a distribution system.

18.8.9 Circuit breakers and fuses are to have a certified fault rating adequate for the installation and are to comply with a National or International Standard.

18.9 Quality of power supplies

18.9.1 Unless specified otherwise electrical equipment, other than that supplied by battery systems, is to operate satisfactorily with the following simultaneous variations, from their nominal value, when measured at the consumer input terminals:

a) Voltage:
Permanent variations + 6%, -10%
Transient recovery +20%, -15%
Recovery time 1.5 seconds.

b) Frequency:
Permanent variations ±5% transient
Variation ±10%
Recovery time 5 seconds.

18.9.2 Generator voltage regulators and engine governors are to be such as to ensure that the above supply variations are not exceeded.

18.10 Generators

18.10.1 For crafts with service type notation ‘Cargo’ or ‘Supply’, number and rating of generators is to be in accordance with 18.10.2 to 18.10.4.

18.10.2 The number and rating of electrical generators are to be sufficient to provide for normal seagoing loads even when one generator is out of action.

18.10.3 If generators are intended to operate in parallel there is to be appropriate protection and synchronising equipment.

18.10.4 The generator(s) are to be sufficient to supply the normal loads.

18.10.5 If with one generator out of action the remaining generator(s) is not capable of supplying the circuits serving safety, essential lighting and communications equipment then an alternative source of electrical power of five hour duration is to be provided for these services.

18.11 Cables

18.11.1 Cables and cable installations are to be in accordance with the requirements of Section 10.

18.12 Batteries

18.12.1 Batteries and battery installations are to be in accordance with the requirements of Section 11.

18.13 Lightning conductors

18.13.1 If fitted, lightning conductors are to comply with the requirements of 17.3.

Section 19

Trials

19.1 General

19.1.1 Before a new installation, or any alteration or addition to an existing installation, is put into service the tests and trials specified in this section are to be carried out. These tests and trials are intended to demonstrate the general condition of the installation at the time of completion. They are in addition to any acceptance tests which may have been carried out at the manufacturer’s works.

19.2 Insulation resistance measurement

19.2.1 Insulation resistance is to be measured using a self-contained instrument such as a direct reading ohm-meter of the generator type applying a voltage of at least 500 V. Where a circuit incorporates capacitors of more than 2μF total capacitance, a constant-voltage type instrument is to be used to ensure accurate test readings.

19.2.2 *Power and light circuits* : The insulation resistance between all insulated poles and earth and where practicable, between poles, is to be at least 1 MΩ. The installation may be subdivided and appliances may be disconnected if initial tests produce results less than this figure.

19.2.3 *Internal communication circuits* : Circuits operating at 55 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 MΩ. Circuits operating at less than 55V are to have an insulation resistance of at least 0.33 MΩ.

19.2.4 *Switchboards, section boards and distribution boards* : The insulation resistance is to be at least 1 MΩ when measured between each busbar and earth and between busbars. This test may be made with all circuit-breakers and switches open, all fuse links for pilot lamps, earth fault-indicating lamps, voltmeters, etc., removed and voltage coils temporarily disconnected, where otherwise damage may result.

19.2.5 *Generators and motors* : The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded. The test should be carried out with the machine hot, if possible. The insulation resistance of generator and motor cables, field windings and control gear is to be at least 1 MΩ.

19.3 Earth continuity

19.3.1 Tests are to be made to verify that all earth continuity conductors are effective and that the bonding and earthing of metallic conduit and/or sheathing of cables is effective.

19.4 Performance

19.4.1 It is to be established that the provisions of the Rules have been complied with respect to the following:

- Temperatures of joints, connections, circuit-breakers and fuses.

- The operation of engine governors, synchronising aids and devices, overspeed trips, reverse-current, reverse-power, over-current and under-voltage trips and other safety devices.

- Satisfactory commutation, excitation and performance of each generator throughout a run at full rated load.

- Voltage regulation of every generator when full rated load is suddenly thrown off.

19.4.2 For alternating current and direct current generators, satisfactory parallel operation and [kW] load sharing of all generators capable of being operated in parallel at all loads upto normal working load. For alternating current generators satisfactory parallel operation and kVA load sharing of all generators capable of being operated in parallel at all loads upto normal working load.

19.4.3 All essential motors and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously, for a sufficient length of time to demonstrate that they are satisfactory.

19.4.4 Normal and emergency lighting, heating and various appliances (galley, pantry etc.) and corresponding electrical circuits are to be tested, as far as practicable, under normal working conditions.

19.4.5 Operation of the emergency source of power is to be checked. The working of any apparatus intended to be fed by this source is to be checked as well as automatic change-over switches.

End Of Chapter

Chapter 14

Remote Control and Safety Systems

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2	System Arrangements
3	Directional Control System
4	Stabilization Systems
5	Requirements for Craft with ‘LC’ or ‘HSLC’ Notation
6	Tests and Trials

Section 1

General

1.1 Scope

1.1.1 The requirements of this chapter apply to control and monitoring of:

- Propulsion;
- Directional control
- Stabilization systems
- Auxiliary systems

including remote control to ensure safe operation of the craft from the control station(s), in the operating compartment (and/or other control stations) in all sailing conditions, including manoeuvring, berthing and for unattended machinery spaces.

1.2 Definitions

1.2.1 **Remote control system** - comprise all equipment necessary to operate units from a control position where the operator cannot directly observe the effect of his actions.

1.2.2 **Backup control system** – comprise all equipment necessary to maintain control of essential functions required for the craft’s safe operation when the main control systems have failed or malfunctioned.

1.2.3 **Local control system** – comprise all equipment necessary to operate units from a control position in or close to the machinery space.

1.2.4 **Directional control system** – For the purpose of this chapter, a directional control system includes any steering device or devices, any mechanical linkages and all power or manual devices, controls and actuating systems.

Directional control may be achieved by means of air or water rudders, foils, flaps, steerable propellers or jets, yaw control ports or side thrusters, differential propulsive thrust, variable geometry of the craft or its lift system components or by a combination of these devices.

1.2.5 **Stabilization system** – is a system intended to stabilize the main parameters of the craft’s attitude; heel, trim, course and height and control the craft’s motions; roll, pitch, yaw and heave. This term excludes devices not associated with the safe operation of the craft, e.g. motion reduction or ride control systems.

The main elements of a stabilization control system may include the following:

a) Devices such as rudders, foils, flaps, skirts, fans, water jets, tilting and steerable propellers; pumps for moving fluids;

b) Power drives actuating stabilization devices; and

c) Stabilization equipment for accumulating and processing data for making decisions and giving commands such as sensors, logic processors and automatic safety control.

"Self-stabilization" of the craft is stabilization ensured solely by the craft's inherent characteristics.

"Forced stabilization" of the craft is stabilization achieved by:

- An automatic control system; or
- A manually assisted control system; or
- A combined system incorporating elements of both automatic and manually assisted control systems.

"Augmented stabilization" is a combination of self-stabilization and forced stabilization.

"Stabilization device" means a device as enumerated in 1.2.5(a) with the aid of which forces for controlling the craft's position are generated.

"Automatic safety control" is a logic unit for processing data and making decisions to put the craft into the displacement or other safe mode if a condition impairing safety arises.

1.3 Plans and particulars

1.3.1 Plans and specifications for the control systems, are to be submitted in triplicate, for approval giving at least the following in formation:

a) layout diagrams showing the location of individual components, input and output devices, control cabinets and interconnection lines between the components;
b) wiring and piping diagrams including details of their material and connecting units;
c) plans and specification showing the working principles of the system with comprehensive description;
d) list of instruments stating name of manufacturers, types, working ranges, set points and application with regard to their environmental conditions;
e) plans of control and monitoring panels with details on their instrumentation and control devices;
f) list of operating values of machinery and limits for alarm and safety action threshold;
g) diagrams of electric and non-electric power supply;
h) system analysis of programmable electronic systems including hardware configuration, algorithms and on special request – data structure and storage allocations. FMEA documentation as required in Annexure 3 of the Rules, where manual intervention for averting of a danger is not possible;
i) testing programmes of the equipment in the manufacturer's works and on dock and sea trial.

1.4 Failure mode and effect analysis

A failure mode and effect analysis is to include machinery systems and their associated controls the stabilization system and the directional control system.

Section 2

System Arrangements

2.1 System design

2.1.1 The machinery installation is to be suitable for operation as in an unmanned machinery space (refer to part E of Chapter II-1 of the SOLAS Convention) including automatic fire detection system, bilge alarm system, remote machinery instrumentation and alarm system. Where the space is continuously manned, this requirement may be varied subject to approval of Administration.

2.1.2 Where control of propulsion or manoeuvring is provided at stations adjacent to but outside the operating compartment, the transfer of control is to be only effected from the station which takes charge of control. Two-way voice communication is to be provided between all stations from which control functions may be exercised and between each such station and the look-out position.

2.1.3 For category B craft and cargo craft, remote control systems for propulsion machinery and directional control are to be equipped with back-up systems controllable from the operating compartment. For cargo craft, instead of a back-up system described above, a back-up system controllable from an engine control space such as an engine control room outside the operating compartment is acceptable.

2.1.4 Category B craft is to be provided with at least two independent means of propulsion so that the failure of one engine or its support systems would not cause the failure of the other engine or engine systems and with additional machinery controls in or close to the machinery space (local control system).

2.1.5 The systems are to be arranged to ensure maintenance of the main functions and safety systems of the craft, including propulsion and control, fire detection, alarms and extinguishing capability of unaffected spaces, after fire in any one compartment on board.

2.2 Alarm system

2.2.1 Alarm systems are to be provided which announce at the craft's control position, by visual audible means, malfunction or unsafe conditions. Alarms should be maintained until they are accepted and the visual indications of individual alarms should remain until the failure has been corrected, when the alarm should automatically reset to the normal operating condition. If an alarm has been accepted and a second fault occurs before the first is rectified, the audible and visual alarms should operate again. Alarm systems should incorporate a test facility.

2.2.2 Alarms giving indication of conditions requiring immediate action are to be distinctive and in full view of crew members in the operating compartment and are to be provided for the following:

- activation of a fire detection system;
- total loss of normal electrical supply;
- overspeed of main engines;
- thermal run-away of any permanently installed nickel cadmium battery.

2.2.3 In addition to the alarms mentioned under 2.2.2 the following alarms giving indication that is distinctive and in full view of crew members in the operating compartment, are to be provided:

- fire (alarm to summon the crew);
- general emergency alarm (alarm to summon crew and passengers to muster stations);
- fire-extinguishing medium imminent release;
- imminent closing of watertight doors, flooding of compartment.

2.2.4 Alarms with a visual display distinct from that of alarms referred to in 2.2.2 are to indicate conditions requiring action to prevent degradation to an unsafe condition. These should be provided for at least the following:

- exceeding the limiting value of any craft, machinery or system parameter other than engine overspeed;
- failure of normal power supply to powered directional or trim control devices;
- abnormal operation of any automatic bilge pump;
- detection of bilge water in each watertight compartment below the design waterline;
- failure of compass system;
- low level of a fuel tank contents;
- fuel oil tank overflow;
- extinction of side, masthead or stern navigation lights;
- low level of contents of any fluid reservoir the contents of which are essential for normal craft operation;
- failure of any connected electrical power source;
- failure of any ventilation fan installed for ventilating spaces in which inflammable vapours may accumulate;
- diesel engine fuel line failure as required by Chapter 12, Section 3, Clause 3.1.4.2.2.

2.2.5 Alarms referred above are to be monitored as listed in the Table 2.2.5.

2.2.6 All warnings required by 2.2.2 and 2.2.3 are to be provided at all stations at which control functions are exercised.

2.2.7 The alarm system is to meet appropriate constructional and operational requirements of the alarms.

2.2.8 Equipment monitoring the passenger, cargo and machinery spaces for fire and flooding should, so far as is practicable, form an integrated sub-centre incorporating monitoring and activation controls for all emergency situations. This sub-centre may require feed-back instrumentation to indicate that actions initiated have been fully implemented.

2.2.9 Any unattended space for which bilge pumping arrangements are required is to be provided with a bilge alarm.

Table 2.2.5 : Propulsion diesel engines

Parameter	Alarm level	Remark
Lubricating oil pressure	Low	
Lubricating oil temperature inlet	High	
Differential pressure across lubricating oil filter	High	
Pressure or flow of cooling water	Low	
Temperature of cooling water outlet	High	
Level in cooling water expansion tank	Low	
Deviation or each cylinder from average of exhaust gas temperature or	High	If cylinder power above 130 kw
Exhaust gas temperature of each cylinder	Low + High	
Exhaust gas temperature after each cylinder	High	If cylinders not monitored individually
Pressure of fuel oil to engine	Low	If supplied by electrical pumps
Temperature of fuel oil to engine	Low + High	If heated
Pressure of control air	Low	
Pressure of starting air	Low	
Safety system	failure	

Main diesel generator sets

Parameter	Alarm level	Remark
Lubricating oil pressure	Low	
Pressure or flow of cooling water	Low	
Temperature of cooling water outlet	High	
Starting power capacity	Low	
Voltage	Low	
Frequency	Low	
Overspeed	Tripped	
Safety system	failure	

Propulsion gas turbines

Parameter	Alarm level	Remark
Lubricating oil pressure	Low	
Lubricating oil temperature	High	
Differential pressure across lubricating oil filter	High	
Bearing temperature	High	
Exhaust gas temperature outlet	High	
Vibrations	High	
Axial displacement	High	
Combustion / ignition	Failure	
Hydraulic service oil pressure	Low	
Safety system	Failure	

Transmission, shaft gears

Parameter	Alarm level	Remark
Lubricating oil, pressure to gears	Low	
Lubricating oil temperature of gears with sliding bearings	High	
Servo oil pressure of gears and transmissions	Low	
Thrust bearing temperature	High	
Stern tube temperature	High	

Auxiliary boilers

Parameter	Alarm level	Remark
Water level	Low	
Steam pressure	Low + High	
Burner operation	Shut down	
Safety system	Failure	

2.3 Emergency controls

2.3.1 In all craft, the station or stations in the operating compartment from which control of craft manoeuvring and/or of its main machinery is exercised are to be provided, within easy reach of the crew member at that station, with controls for use in an emergency to:

- activate fixed fire-extinguishing systems;
- close ventilation openings and stop ventilating machinery supplying air to spaces covered by fixed fire extinguishing systems, if not incorporated above;
- shut off fuel oil supplies to machinery in main and auxiliary machinery spaces;
- disconnect all electrical power sources from the normal power distribution system (the operating control should be guarded to reduce the risk of inadvertent or careless operation); and
- stop main engine(s) and auxiliary machinery.

2.3.2 Unless it is considered impracticable a single failure of the emergency controls is not to have an inadvertent effect on the system which it serves. In case of such a failure an alarm is to be given in the craft's operating compartment.

The stopping device for main engine(s) is to be independent from the remote control system at the craft's operating station.

2.3.3 In all crafts where the control of propulsion and manoeuvring is provided at stations outside the operating compartment, such stations are to have direct communication with the operating compartment. The operating compartment should be a continuously manned control station.

2.3.4 In addition, for category B craft control of propulsion and manoeuvring as well as emergency functions referred to in 2.3.1 shall be provided at one or more stations outside the operating compartment. Such stations shall have direct communication with the operating compartment which shall be a continuously manned control station.

2.4 Safety systems

2.4.1 Automatic shut down of propulsion and auxiliary machinery.

2.4.1.1 Safety devices are to not cause complete engine shut-down without prior warning, except in cases where there is a risk of complete breakdown or explosion. Such safety devices should be capable of being tested.

2.4.1.2 Where arrangements are fitted for overriding any automatic shutdown system for the main propulsion machinery in accordance with Chapter 12, Section 3, Clause 3.1.5.4 and Tables 3.1.4.1 and 3.1.4.2 they should be such as to preclude inadvertent operation. When a shut down system is activated, an audible and visual alarm is to be given at the control station and means are to be provided to override the automatic shutdown except in cases where there is a risk of complete breakdown or explosion.

2.4.1.3 After restoration of normal conditions following a shutdown, resetting of the safety system is to be possible at the craft's operating station and at other positions, from which the control can be exercised.

2.4.1.4 Safety systems are to be designed as far as practicable to be independent of the alarm and control system and their power supply, such that a failure or malfunction in these systems will not prevent the safety system from operating. Safety systems including their power supply should be separate for each propulsion unit.

2.4.1.5 Electrical circuits of safety systems for propulsion machinery and essential systems, which in case of their failure have sudden effect on the availability of the propulsion and directional control of the craft shall be such, that a single failure in the system does not result, as far as practicable, in a loss of propulsion and directional control. The electrical circuits of safety systems for other machinery, which have no sudden effect on the availability of the propulsion and steering, may be designed as suitable for their purpose for the most effective protection of the machinery.

2.4.1.6 The power for the safety system is to be supplied from the main source of electrical power. Provisions are to be made for supplying power uninterrupted to the safety system for at least 15 minutes following a failure of the ship's main source of electrical power. The electric and pneumatic supplies are to be monitored

2.5 Standby systems

2.5.1 Where stand-by units are required, they are to start-up automatically:

- on failure of operational units;
- to preserve stored energy resources (e.g. compressed air);
- following restoration of the power supply after an interruption to service due to a failure of the ship's main source of electric power;
- on operational demand, if auxiliary machinery is operated in staggered service.

2.5.2 The threshold for activation of the standby system is to be such, that normal operation is restored before the safety system is activated.

2.5.3 The changeover to a standby unit due to a fault is to be signalled visually and audibly. However, an alarm must not be tripped in the case of machinery installations with auxiliary machines driven mechanically from the propulsion plant where the standby machines start-up automatically in the lower speed range.

2.5.4 Sets which have suffered a malfunction and have shut down automatically may only be provided for restart after manual reset independent of the alarm acknowledgement.

2.6 Fire detection and fire alarm system

2.6.1 An automatic fire detection and fire alarm system in accordance with the requirements of chapter 10 is to be fitted in the machinery spaces.

2.7 Remote control

2.7.1 Where control systems are provided, the requirements of 2.7.2 to 2.7.12 are to be satisfied.

2.7.2 Control systems for machinery operations are to be stable throughout their operating range.

2.7.3 The control system is to be designed such that normal operation of the controls cannot induce detrimental mechanical or thermal overloads in the machinery.

2.7.4 When control systems are provided with means to adjust their sensitivity or set point, the arrangements are to be such that the final settings can be readily identified.

2.7.5 Control systems are to be designed to 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated on the basis not only of the control system and its associated machinery, but also the complete installation.

2.7.6 Failure of any power supply to a control system is to operate an audible and visual alarm.

2.7.7 Where machinery is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, it is to be provided with the alarms and safety arrangements required by the appropriate chapter(s). Alternative arrangements which provide equivalent safeguards will be considered.

2.7.8 Remote or automatic controls are to be provided with sufficient instrumentation at the relevant control stations to ensure effective control and indicate that the system is functioning correctly.

2.7.9 Where machinery is arranged to start automatically or from a remote control station, interlocks are to be provided to prevent start up under conditions which could hazard the machinery.

2.7.10 Where machinery, controlled in accordance with 2.7.7, is required to be provided with a standby pump, the standby pump is to start automatically if the discharge pressure from the working pumps falls below a predetermined value.

2.7.11 Arrangements are to be such that machinery may be operated with the system of remote or automatic controls out of action. This may be achieved by manual control or redundancy arrangements within the control system,. Instrumentation is to be provided at local manual control stations to ensure effective operation of the machinery.

2.7.12 Failure of the operating control system or of transfer of control should bring the craft to low speed without endangering the safety of passengers or the craft.

Section 3

Directional Control System

3.1 General

3.1.1 Craft is to be provided with means for directional control of adequate strength and suitable design to enable the craft's heading and direction of travel to be effectively controlled to the maximum extent possible in the prevailing conditions and craft speed without undue physical effort at all speeds and in all conditions for which the craft is to be certified.

3.1.2 Attention is drawn to the possibility of interaction between directional control systems and stabilization systems. Where such interaction occurs or where dual purpose components are fitted, the requirements of Chapter 13, Section 14 and Sections 4 and 5 of this chapter are also to be complied with as applicable.

3.2 Reliability

3.2.1 The probability of total failure of all directional control systems is to be extremely remote when the craft is operating normally, i.e. excluding emergency situations such as grounding, collision or a major fire.

3.2.2 A design incorporating a power drive or an actuation system employing powered components for normal directional control is to provide a secondary means of actuating the device unless an alternative system is provided.

3.2.3 The secondary means of actuating the directional control device may be manually driven bearing in mind the craft's size and design and any limitations of speed or other parameters that may be necessary subject to the approval of the Administration.

3.2.4 The directional control systems is to be constructed so that a single failure in one drive or system, as appropriate, will not render any other drive or system inoperable or unable to bring the craft to a safe situation. A short period of time to permit the connection of a secondary control device may be allowed subject to approval of Administration when the design of the craft is such that the delay will not hazard the craft.

3.2.5 If it is necessary to bring the craft to a safe condition, power drives for directional control devices, including those required to direct thrust forward or astern, are to become operative automatically, and respond correctly, within 5 s of power or other failure. Back-up electrical systems may be required for the starting up time of an auxiliary diesel according to Chapter 13, Section 2 or an emergency diesel generator according to Chapter 13, Section 3.

3.2.6 Directional control devices involving variable geometry of the craft or its lift system components are to, so far as is practicable, be so constructed that any failure of the drive linkage or actuating system will not put the craft in significantly hazardous situation.

3.3 Control position

3.3.1 All directional controls systems should normally be operated from the craft's operating station.

3.3.2 If directional control systems can also be operated from other positions, then two way communication should be arranged between the operating station and these other positions.

3.3.3 Adequate indications are to be provided at the operating station and these other positions to provide the person controlling the craft with verification of the correct response of the directional control device to this demand, and also to indicate any abnormal responses or malfunction. The indications of steering response or rudder angle indicator are to be independent of the system for directional control. The logic of such feedback and indications are to be consistent with the other alarms and indications so that in an emergency operators are unlikely to be confused.

3.4 Demonstrations

3.4.1 The limits of safe use of any of the control system devices are to be based on demonstrations and a verification process in accordance with Annexure 6 of these Rules.

3.4.2 Demonstration in accordance with Annexure 6 of these Rules is to determine any adverse effects upon safe operation of the craft in the event of an uncontrollable total deflection of any one-control device. Any limitation on the operation of the craft as may be necessary to ensure that the redundancy or safeguards in the systems provide equivalent safety is to be included in the craft operation manual.

Section 4

Stabilization Systems

4.1 General

4.1.1 Stabilization systems is to be so designed that in case of failure or malfunctioning of any one of the stabilization devices or equipment, it would be possible either to ensure maintaining the main parameters of craft's motion within safe limits with the aid of working stabilization devices or to put the craft into the displacement or other safe mode.

4.1.2 In case of failure of any automatic equipment or stabilization device, or its power drive, the parameters of craft motion should remain within safe limits.

4.1.3 Craft fitted with an automatic stabilization system are to be provided with an automatic safety control unless the redundancy in the system provides equivalent safety. Where an automatic safety control is fitted, provision is to be made to override it and to cancel the override from the main operating station.

4.1.4 The parameters and the levels at which any automatic safety control gives the command to decrease speed and put the craft safely in the displacement or other safe mode should take account of the safe values of heel, trim, yaw and combination of trim and draught appropriate to the particular craft and service; also to the possible consequences of power failure for propulsion, lift or stabilization devices.

4.1.5 The parameters and the degree of stabilization of the craft provided by the automatic stabilization system should be satisfactory having regard to the purpose and service conditions of the craft.

4.1.6 The requirements for control systems and warning devices are given in Section 1 and 2 of this chapter.

4.1.7 Failure mode and effect analysis is to include the stabilization system.

4.2 Lateral and height control systems

4.2.1 Craft fitted with an automatic control system should be provided with an automatic safety control. Probable malfunctions should have only minor effects on automatic control system operation and is to be capable of being readily counteracted by the operating crew.

4.2.2 The parameters and levels at which any automatic control system gives the command to decrease speed and put the craft safely into the displacement or other safe mode are to take account of the safety levels as given in 2.4 of Annexure 2 of these Rules and of the safe values of motions appropriate to the particular craft and service.

4.3 Demonstrations

4.3.1 The limits of safe use of any of the stabilization control system devices are to be based on demonstrations and a verification process in accordance with Annexure 6 of these Rules.

4.3.2 Demonstration in accordance with Annexure 6 of these Rules is to determine any adverse effects upon safe operation of the craft in the event of an uncontrollable total deflection of any one control device. Any limitation on the operation of the craft as may be necessary to ensure that the redundancy or safeguards in the systems provide equivalent safety is to be included in the craft operating manual.

Section 5

Requirements for Craft with 'LC' or 'HSLC' Notation

5.1 General

5.1.1 The relevant requirements of Section 1 and 2 are to be complied with. All non-passenger crafts of less than 500 GT with 'LC' or 'HSLC' notation are to comply with the requirements of this section. Other crafts with 'LC' or 'HSLC' notation are to comply with the requirements of 'Rules and Regulations for the Construction and Classification of Steel Ships'.

5.2 Plans and information

5.2.1 Plans are required to be submitted in accordance with 1.3 only for the machinery items applicable to these craft.

5.3 Remote control of propulsion machinery

5.3.1 Where remote control of propulsion machinery from the navigating bridge is provided and the machinery spaces are intended to be manned, the following is to apply:

a) The speed, direction of thrust and, if applicable, the pitch of the propeller are to be fully controllable from the navigating bridge under all sailing conditions, including manoeuvring;

b) The remote control is to be performed, for each independent propeller by a control devices so designed and constructed that its operation does not require particular attention to the operational details of the machinery. Where multiple propellers are designed to operate simultaneously, they may be controlled by one control device;

c) The main propulsion machinery is to be provided with an emergency stopping device on the navigating bridge which is to be independent of the navigating bridge control system;

d) Propulsion machinery orders from the navigating bridge are to be indicated in the main machinery control room or at the manoeuvring platform as appropriate;

e) Remote control of the propulsion machinery is to be possible only from one location at a time; at such locations interconnected control positions are permitted. At each location there is to be an indicator showing which location is in control of the propulsion machinery. The transfer of control between the navigating bridge and machinery spaces is to be possible only in the main machinery space or the main machinery control room. This system is to include means to prevent the propelling thrust from altering significantly when transferring control from one location to another;

f) It is to be possible to control the propulsion machinery locally, even in the case of failure in any part of the remote control system;

g) The design of the remote control system is to be such that in case of its failure an alarm will be given. The preset speed and direction of thrust of the propellers is to be maintained until local control is in operation unless it is impracticable to do so;

h) Indicators should be fitted on the navigating bridge for:

- Propeller speed and direction of rotation in the case of fixed pitch propellers;
- Propeller speed and pitch position in the case of controllable pitch propellers;

i) An alarm should be provided on the navigating bridge and in the machinery space to indicate low starting air pressure or low electrical power which should be set at a level to permit further main engine starting operation. If the remote control systems of the propulsion machinery is designed for automatic starting, the number of automatic consecutive attempts which fail to produce a start is to be limited in order to safeguard sufficient starting air pressure or adequate electrical power for starting locally.

5.3.2 In all ships where the main propulsion and associated machinery, including main electrical supply, are provided with various degrees of automatic or remote control and are under continuous manual supervision from a control room, the arrangements and control are to be so designed, equipped and installed that the machinery operation will be as safe and effective as if it were under direct supervision. Particular consideration is to be given to protect such spaces against fire and flooding.

5.4 Periodically unattended machinery spaces (if installed)

5.4.1 Ships having periodically unattended machinery spaces are to as far as practicable and reasonable, comply with the applicable requirements of Part 5, Chapter 22 of the 'Rules and Regulations for the Construction and Classification of Steel Ships' for such machinery spaces.

5.4.2 The alternative arrangements provided are to ensure that, the safety of the ship in all sailing conditions, including manoeuvring, is equivalent to that of a ship having manned machinery spaces.

Section 6

Tests and Trials

6.1 General

6.1.1 These tests and trials are conducted to demonstrate their suitability for the intended service.

6.1.2 The tests and trials are to be conducted in accordance with the requirements given in Part 4, Chapter 7, Section 4 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

6.2 Directional control system

6.2.1 The performance is to be verified in accordance with Annexure 6 of these Rules.

6.3 Stabilization system

6.3.1 The limits of safe use of any of the stabilization control system devices are to be based on demonstrations and verification process in accordance with Annexure 6 of these Rules.

6.3.2 Demonstration in accordance with Annexure 6 of these Rules should determine any adverse effects upon safe operation of the craft in the event of an uncontrollable total deflection of any one-control device. Any limitation on the operation of the craft as may be necessary to ensure that the redundancy or safeguards in the systems provide equivalent safety is to be included in the craft operating manual.

End Of Chapter

Annexure - 1

Preamble of the HSC Code

1. The international conventions ratified in respect of conventional ships and the regulations applied as a consequence of such conventions have largely been developed having in mind the manner in which conventional ships are constructed and operated. Traditionally, ships have been built of steel and with the minimum of operational controls. The requirements for ships engaged on long international voyages are therefore framed in such a way that, providing the ship is presented for survey and a ship safety certificate is issued, the ship may go anywhere in the world without any operational restrictions being imposed. Providing the ship is not involved in a casualty, all that is needed is that it is made available to the Administration for the purpose of a satisfactory resurvey before the ship safety certificate expires and the certificate will be reissued.

2. The traditional method of regulating ships should not be accepted as being the only possible way of providing an appropriate level of safety. Nor should it be assumed that another approach, using different criteria, could not be applied. Over a long period of years, numerous new designs of marine vehicles have been developed and have been in service. While these do not fully comply with the provisions of the international conventions relating to conventional ships built of steel, they have demonstrated an ability to operate at an equivalent level of safety when engaged on restricted voyages under restricted operational weather conditions and with approved maintenance and supervision schedules.

3. The High Speed Craft Code, 1994 (1994 HSC Code) was derived from the previous Code of Safety for Dynamically Supported Craft (DSC) adopted by IMO in 1977, recognizing that safety levels can be significantly enhanced by the infrastructure associated with regular service on a particular route, whereas the conventional ship safety philosophy relies on the ship being self-sustaining with all necessary emergency equipment being carried on board.

4. The safety philosophy of this Code is based on the management and reduction of risk as well as the traditional philosophy of passive protection in the event of an accident. Management of risk through accommodation arrangement, active safety systems, restricted operation, quality management and human factors engineering should be considered in evaluating safety equivalent to current conventions. Application of mathematical analysis should be encouraged to assess risk and determine the validity of safety measures.

5. The Code takes into account that a high speed craft is of a light displacement compared with a conventional ship. This displacement aspect is the essential parameter to obtain fast and competitive sea transportation and consequently this Code allows for use of non-conventional shipbuilding materials, provided that a safety standard at least equivalent to conventional ships is achieved.

6. To clearly distinguish craft, criteria based on speed and volumetric Froude number have been used to delineate those craft to which this Code applies from other, more conventional, craft.

7. The Code requirements also reflect the additional hazards which may be caused by the high speed compared with conventional ship transportation. Thus, in addition to the normal requirements including life-saving appliances, evacuation facilities, etc., provided in case of an accident occurring, further emphasis is placed on reducing the risk of hazardous situations arising. Some advantages result from the high speed craft concept, i.e. the light displacement provides a large reserve buoyancy in relation to displacement, reducing the hazards addressed by the international Load Line Convention. The consequences of other hazards such as of collision at high speed are balanced by more stringent navigational and operational requirements and specially developed accommodation provisions.

8. The above mentioned safety concepts were originally reflected in the DSC Code and the 1994 HSC Code. The development of novel types and sizes of craft has led to the development of pressures within the maritime industry for craft which are not dynamically supported cargo craft, passenger craft carrying larger numbers of passengers or operating further afield than permitted by that Code to be *certified according to those concepts. Additionally, improvements of maritime safety standards since 1994 were required to be reflected in the revisions of the 1994 HSC Code to maintain safety equivalence with conventional ships.*

9. Accordingly, two differing principles of protection and rescue were embodied in the 1994 HSC Code.

10. The first of these recognizes the craft which were originally foreseen at the time of development of the DSC Code. Where rescue assistance is readily available and the total number of passengers is limited, a reduction in passive and active protection may be permitted. Such craft are called "assisted craft" and form the basis for "category A passenger craft" of this Code.

11. The second concept recognizes the further development of high speed craft into larger craft. Where rescue assistance is not readily available or the number of passengers is unlimited, additional passive and active safety precautions are required. These additional requirements provide for an area of safe refuge on board, redundancy of vital systems, increased watertight and structural integrity and full fire extinguishing capability. Such craft are called "unassisted craft" and form the basis for "cargo craft" and "category B passenger craft" of this Code.

12. These two concepts of the Code have been developed as a unified document on the basis that an equivalent level of safety to that normally expected on ships complying with the International Convention for the Safety of Life at Sea is achieved. Where the application of new technology or design indicates an equivalent safety level to the strict application of the Code, the Administration is permitted to formally recognize such equivalence.

13. It is important that an Administration, in considering the suitability of a high speed craft under this Code, should apply all sections of the Code because non-compliance with any part of the Code could result in an imbalance which would adversely affect the safety of the craft, passengers and crew. For a similar reason, modifications to existing craft, which may have an effect on safety, should be approved by the Administration.

14. In developing the Code, it has been considered desirable to ensure that high speed craft do not impose unreasonable demands on existing users of the environment or conversely suffer unnecessarily through lack of reasonable accommodation by existing users. Whatever burden of compatibility there is, it should not necessarily be laid wholly on the high speed craft.

15. Paragraph 1.15.1 of the 1994 HSC Code states that it shall be reviewed by the Organization at intervals preferably not exceeding four years to consider revision of existing requirements to take account of new developments in design and technology. Experience gained with the application of the 1994 HSC Code since it entered into force in 1996 has led to the recognition that it needed to be revised and updated. Subsequent work in the Organization has resulted in the development of the present Code to ensure that safety is not compromised as a result of continuous introduction of state-of-the-art technology and innovative developments into the new and generally much larger and faster high-speed craft.

End Of Chapter

Annexure - 2

Use of Probability Concept
(Annex 3 of HSC Code)

1. General

1.1 Absolute safety cannot be achieved in any human activity. Naturally, this fact has to be taken into account in developing safety requirements, which means that requirements should not imply that safety is absolute. In the case of traditional craft, it has frequently been possible to specify certain aspects of design or construction in some detail, in a way which was consistent with some level of risk which had over the years been intuitively accepted without having to be defined.

1.2 For high speed craft, however, it would often be too restrictive to include engineering specifications into the Code. Requirements therefore need to be written (where this question arises) in the sense of .. <the Administration should be satisfied on the basis of tests, investigations and past experience that the probability of … is (acceptably low)>. Since different undesirable events may be regarded as having different general orders of acceptable probability (e.g. temporary impairment of propulsion as compared with an uncontrollable fire), it is convenient to agree on a series of standardized expressions which can be used to convey the relative acceptable probabilities of various incidents, i.e. to perform a qualitative ranking process. A vocabulary is given below which is intended to ensure consistency between various requirements, where it is necessary to describe the level of risk which should not be exceeded.

2. Terms associated with probabilities

Different undesirable events may have different orders of acceptable probability. In connection with this, it is convenient to agree on standardized expressions to be used to convey the relatively acceptable probabilities of various occurrences, i.e. to perform a qualitative ranking process.

2.1 Occurrences

2.1.1 ***Occurrence*** *is a condition involving a potential lowering of the level of safety.*

2.1.2 ***Failure*** *is an occurrence is which a part, or parts, of the craft fail or malfunction, e.g. runaway. A failure includes:*

a) a single failure;

b) independent failures in combinations within a system; and

c) independent failures in combinations involving more than one system, taking into account:

- *any undetected failure that is already present;*
- *such further failures as would be reasonably expected to follow the failure under consideration; and*

Note : in assessing the further failures which follow, account should be taken of any resulting more severe operating conditions for items that have not up that time failed.

d) common cause failure (failure of more than one component or system due to the same cause).

2.1.3 ***Event*** *is an occurrence, which has its origin outside the craft (e.g. waves).*

2.1.4 ***Error*** *is an occurrence arising as a result of incorrect action by the operating crew or maintenance personnel.*

2.2 Probability of occurrences

2.2.1 ***Frequent*** *is one which is likely to occur often during the operational life of a particular craft.*

2.2.2 ***Reasonably probable*** *is one which is unlikely to occur often but which may occur several times during the total operational life of a particular craft.*

*2.2.**3 Recurrent*** *is a term embracing the total range of frequent and reasonably probable.*

2.2.4 ***Remote*** *is one which is unlikely to occur to every craft but may occur to a few craft of a type* *over the total operational life of a number of craft of the same type.*

2.2.5 ***Extremely remote*** *is one which is unlikely to occur when considering the total operational life of a number of craft of the type, but nevertheless should be considered as being possible.*

2.2.6 ***Extremely improbable*** *is one which is so extremely remote that it should not be considered as possible to occur.*

2.3 Effects

2.3.1 ***Effect*** *is a situation arising as a result of an occurrence.*

2.3.2 ***Minor effect*** *is an effect which may arise from a failure, an event, or an error (as defined in 2.1.1, 2.1.2, 2.1.3 of this annex) which can be readily compensated for by the operating crew; it may involve:*

a) a small increase in the operational duties of the crew or in their difficulty in performing their duties; or
b) a moderate degradation in handling characteristics; or
c) slight modification of the permissible operating conditions.

2.3.3 ***Major effect*** *is an effect which produces:*

a) a significant increase in the operational duties of the crew or in their difficulty in performing their duties which by itself should not be outside the capability of a competent crew provided that another major effect does not occur at the same time; or

b) significant degradation in handling characteristics; or

c) significant modification of the permissible operating conditions, but will not remove the capability to complete a safe journey without demanding more than normal skill on the part of the operating crew.

2.3.4 ***Hazardous effect*** *is an effect which produces:*

a) a dangerous increase in the operational duties of the crew or in their difficulty in performing their duties of such magnitude that they cannot reasonably be expected to cope with them and will probably require outside assistance; or

b) dangerous degradation of handling characteristics; or

c) dangerous degradation of the strength of the craft; or

d) marginal conditions for, or injury to, occupants; or

e) an essential need for outside rescue operations.

2.3.5 ***Catastrophic effect*** *is an effect which results in the loss of the craft and/or in fatalities.*

2.4 Safety level

Safety level *is a numerical value characterizing the relationship between craft performance represented as horizontal single amplitude acceleration (g) and rate of acceleration (g/s) and the severity of acceleration load effects on standing and sitting humans.*

The safety levels and the corresponding severity of effects on passengers and safety criteria for craft performance should be as defined in Table 1.

3. Numerical values

Where numerical probabilities are used in assessing compliance with requirements using the terms similar to those given above, the following approximate values may be used as guidelines to assist in providing a common point of reference. The probabilities quoted should be on an hourly or per journey basis, depending on which is more appropriate to the assessment in question:

Frequent	*More than* 10^{-3}
Reasonably probable	10^{-3} *to* 10^{-5}
Remote	10^{-5} *to* 10^{-7}
Extremely remote	10^{-7} *to* 10^{-9}
Extremely improbable	*Whilst no approximate numerical probability is given for this, the figures used should be substantially less than* 10^{-9}
Note : different occurrences may have different acceptable probabilities, according to the severity of their consequences (see Table 2).	

Table 1

EFFECT	***CRITERIA NOT TO BE EXCEEDED*** ***Type of load***	***VALUE***	***COMMENT***
LEVEL 1 *MINOR EFFECT* *Moderate degradation of safety*	*Maximum acceleration measured horizontally (1)*	*0.20 g (2)*	*0.08g and 0.20g/s (3): elderly person will keep balance when holding* *0.15g and 0.20g/s: mean person will keep balance when holding* *0.15g and 0.80g/s: sitting person will start holding*
LEVEL 2 *MAJOR EFFECT* *Significant degradation of safety*	*Maximum acceleration measured horizontally (1)*	*0.35g*	*0.25g and 2.0g/s: maximum load for mean person keeping balance when holding* *0.45g and 10g/s: mean person falls out seat when not wearing seat belts*
LEVEL 3 *HAZARDOUS EFFECT* *Major degradation of safety*	*Collision design condition calculated* *Maximum structural design load, based on vertical acceleration at centre of gravity*	*Collision load* *Ref. Ch.4, 2.1*	*Risk of injury to passengers, safe emergency operation after collision* *1.0g : degradation of passenger safety*
LEVEL 4 *CATASTROPHIC EFFECT*			*Loss of craft or/and fatalities*

1) The recording instruments used shall be such that acceleration accuracy is better than 5% of the real value and frequency response should be minimum 20 Hz. Antialiasing filters with maximum passband attenuation 1 ± 5% should be used.
2) g = gravity acceleration (9.81 m/s2).
3) g-rate or jerk may be evaluated from acceleration/time curves.

Table 2

SAFETY LEVEL	***1***	***1***	***1***	***2***	***3***	***4***
EFFECT ON CRAFT AND OCCUPANTS	*Normal*	*Nuisance*	*Operating limitations*	*Emergency procedures; significant reduction in safety margins; difficult for crew to cope with adverse conditions; passenger injuries*	*Large reduction in safety margins; crew over-burden because of work-load or environmental conditions; serious injury to small number of occupants*	*Deaths usually, with loss of craft*
F.A.R. (5) PROBABILITY (REF. ONLY)	*Probable*			*Improbable*		*Extremely Improbable*
JAR-25 (6) PROBABILITY	*Probable*			*Improbable*		*Extremely Improbable*
	Frequent		*Reasonably Probable*	*Remote*	*Extremely Remote*	
	10^{-0} 10^{-1} 10^{-2}		10^{-3} 10^{-4}	10^{-5} 10^{-6}	10^{-7} 10^{-8}	10^{-9}
CATEGORY OF EFFECT	*MINOR*			*MAJOR*	*HAZARDOUS*	*CATASTRO-PHIC*

(5) The United States Federal Aviation Regulations
(6) European Joint Airworthiness Regulations

End Of Chapter

Annexure - 3

Procedures for Failure Mode and Effects Analysis
(Annex 4 of HSC Code)

1. Introduction

1.1 In the case of traditional craft, it has been possible to specify certain aspects of design or construction in some level of detail, in a way which was consistent with some level of risk which had over the years been intuitively accepted without having to be defined.

1.2 With the development of large high speed craft, this required experience has not been widely available. However, with the now broad acceptance of the probabilistic approach to safety assessments within industry as a whole, it is proposed that an analysis of failure performance may be used to assist in the assessment of the safety of operation of high speed craft.

1.3 A practical, realistic and documented assessment of the failure characteristics of the craft and its component systems should be undertaken with the aim of defining and studying the important failure conditions that may exist.

1.4 This annex describes a failure mode and effects analysis (FMEA) and gives guidance as to how it may be applied by:

- *a) explaining basic principles;*
- *b) providing the procedural steps necessary to perform an analysis;*
- *c) identifying appropriate terms, assumptions, measures and failure modes; and*
- *d) providing examples of the necessary worksheets.*

1.5 FMEA for high speed craft is based on a single failure concept under which each system at various levels of a system's functional hierarchy is assumed to fail by one probable cause at a time. The effects of the postulated failure are analysed and classified according to their severity. Such effects may include secondary failures (or multiple failures) at other level(s). Any failure mode which may cause a catastrophic effect to the craft should be guarded against by system or equipment redundancy unless the probability of such failure is extremely improbable (refer to section 13). For failure modes causing hazardous effects corrective measures may be accepted in lieu. A test programme should be drawn up to confirm the conclusions of FMEA.

1.6 Whilst FMEA is suggested as one of the most flexible analysis techniques, it is accepted that there are other methods which may be used and which in certain circumstances may offer an equally comprehensive insight into particular failure characteristics.

2. Objectives

2.1 The primary objective of FMEA is to provide a comprehensive, systematic and documented investigation which establishes the important failure conditions of the craft and assesses their significance with regard to the safety of the craft, its occupants and the environment.

2.2 The main aims of undertaking the analysis are to:

- *a) provide the Administration with the results of a study into craft's failure characteristics so as to assist in an assessment of the levels of safety proposed for the craft's operation;*
- *b) provide craft operators with data to generate comprehensive training, operational and maintenance programmes and documentation; and*
- *c) provide craft and system designers with data to audit their proposed designs.*

3. Scope of Application

3.1 FMEA should be conducted for each high speed craft, before its entry into service, in respect of the systems as required under the provisions of Chapter 8, Section 6, Chapter 12, Section 1 and Chapter 13, Section 1 of these Rules.

3.2 For craft of the same design and having the same equipment, one FMEA on the lead craft will be sufficient, but each of the craft should be subject to the same FMEA conclusion trials.

4. System failure mode and effect analysis

4.1 Before proceeding with a detailed FMEA into the effects of the failure of the system elements on the system functional output, it is necessary to perform a functional failure analysis of the craft's important systems. In this way only systems which fail the functional failure analysis need to be investigated by a more detailed FMEA.

4.2 When conducting a system FMEA the following typical operational modes within the normal design environmental conditions of the craft should be considered:

a) normal seagoing conditions at full speed;

b) maximum permitted operating speed in congested waters; and

c) manoeuvring alongside.

4.3 This functional interdependence of these systems should also be described in either block diagrams or fault tree diagrams or in a narrative format to enable the failure effects to be understood. As far as applicable, each of the systems to be analysed is assumed to fail in the following failure modes:

a) complete loss of function;
b) rapid change to maximum or minimum output;
c) uncontrolled or varying output;
d) premature operation;
e) failure to operate at a prescribed time; and
f) failure to cease operation at a prescribed time.

Depending on the system under consideration other failure modes may have to be taken into account.

4.4 If a system can fail without any hazardous or catastrophic effect, there is no need to conduct a detailed FMEA into the system architecture. For systems whose individual failure can cause hazardous or catastrophic effects and where a redundant system is not provided, a detailed FMEA as described in the following paragraphs should be followed. Results of the system functional failure analysis should be documented and confirmed by a practical test programme drawn up from the analysis.

4.5 Where a system, the failure of which may cause a hazardous or catastrophic effect, is provided with a redundant system, a detailed FMEA may not be required provided that:

a) the redundant system can be put into operation or can take over the failed system within the time-limit dictated by the most onerous operational mode in 4.2 without hazarding the craft;

b) the redundant system is completely independent from the system and does not share any common system element the failure of which would cause failure of both the system and the redundant system. Common system element may be acceptable if the probability of failure complies with section 13; and

c) the redundant system may share the same power source as the system. In such case an alternative power source should be readily available with regard to the requirement of a).

The probability and effects of operator error to bring in the redundant system should also be considered.

5. Equipment failure mode and effects analysis

The systems to be subject to a more detailed FMEA investigation at this stage should include all those that have failed the system FMEA and may include those that have a very important influence on the safety of the craft and its occupants and which require an investigation at a deeper level than that undertaken in the system functional failure analysis. These systems are often those which have been specifically designed or adapted for the craft, such as the craft's electrical and hydraulic systems.

6. Procedures

6.1 The following steps are necessary to perform an FMEA:

a) to define the system to be analysed:
b) to illustrate the interrelationships of functional elements of the system, by means of block diagrams;
c) to identify all potential failure modes and their causes;
d) to evaluate the effects on the system of each failure mode;
e) to identify failure detection methods;
f) to identify corrective measures for failure modes;

g) to assess the probability of failures causing hazardous or catastrophic effects where applicable;
h) to document the analysis;
i) to develop a test programme;
j) to prepare FMEA report.

7. System definition

7.1 The first step in an FMEA study is a detailed study of the system to be analysed, through the use of drawings and equipment manuals. A narrative description of the system and its functional requirements should be drawn up including the following information:

a) general description of system operation and structure;
b) functional relationship among the system elements;
c) acceptable functional performance limits of the system and its constituent elements in each of the typical operational modes; and
d) system constraints.

8. Development of system block diagrams

8.1 The next step is to develop block diagram(s) showing the functional flow sequence of the system, both for technical understanding of the functions and operation of the system and for the subsequent analysis. As a minimum the block diagram should contain:

a) breakdown of the system into major sub-systems or equipment;

b) all appropriate labelled inputs and outputs and identification numbers by which each subsystem is consistently referenced; and

c) all redundancies, alternative signal paths and other engineering features which provide fail-safe measures.

An example of a system block diagram is given in Fig.1.

8.2 It may be necessary to have a different set of block diagrams prepared for each different operational modes.

9. Identification of failure modes, causes and effects

9.1 Failure mode is the manner by which a failure is observed. It generally describes the way the failure occurs and its impact on the equipment or system. As an example, a list of failure modes is given in Table 1. The failure modes listed in Table 1 can describe the failure of any system element in sufficiently specific terms. When used in conjunction with performance specifications governing the inputs and outputs on the system block diagram, all potential failure modes can be thus identified and described. Thus, for example, a power supply may have a failure mode described as loss of output (29) and a failure cause open (electrical) (31).

9.2 A failure mode in a system element could also be the failure cause of a system failure. For example, the hydraulic line of a steering gear system might have a failure mode of external leakage (10). This failure mode of the hydraulic line could become a failure cause of the steering gear system's failure mode loss of output (29).

9.3 Each system should be considered in a top-down approach, starting from the system's functional output, and failure should be assumed by one possible cause at a time. Since a failure mode may have more than one cause, all potential independent causes for each failure mode should be identified.

9.4 If major systems can fail without any adverse effect there is no need to consider them further unless the failure can go undetected by an operator. To decide that there is no adverse effect does not mean just the identification of system redundancy. The redundancy should be shown to be immediately effective or brought on line with negligible time lag. In addition, if the sequence is failure – alarm – operator action – start of back up – back up in service, the effects of delay should be considered.

10. Failure effects

10.1 The consequence of a failure mode on the operation, function or status of an equipment or a system is called a failure effect. Failure effects on a specific sub system or equipment under consideration are called local failure effects. The evaluation of local failure effects will help to determine the effectiveness of any redundant equipment or corrective action at that system level.

In certain instances, there may not be a local effect beyond the failure mode itself.

10.2 The impact of an equipment or sub-system failure on the system output (system function) is called an end effect. End effects should be evaluated and their severity classified in accordance with the following categories:

a) *catastrophic;*
b) *hazardous;*
c) *major; and*
d) *minor.*

The definition of these four categories of failure effects is at paragraph 2.3 of Annexure 2 of these Rules.

10.3 If the end effect of a failure is classified as hazardous or catastrophic, back-up equipment is usually required to prevent or minimize such effect. For hazardous failure effects corrective operational procedures may be accepted.

11. Failure detection

11.1 The FMEA study in general only analyses failure effects based on a single failure in the system and therefore a failure detection means, such as visual or audible warning devices, automatic sensing devices, sensing instrumentation or other unique indications, should be identified.

11.2 Where the system element failure is non-detectable (i.e. a hidden fault or any failure which does not give any visual or audible indication to the operator) and the system can continue with its specific operation, the analysis should be extended to determine the effects of a second failure, which in combination with the first undetectable failure may result in a more severe failure effect e.g. hazardous or catastrophic effect.

12. Corrective measures

12.1 The response of any back-up equipment, or any corrective action initiated at a given system level to prevent or reduce the effect of the failure mode of system element or equipment, should also be identified and evaluated.

12.2 Provisions which are features of the design at any system level to nullify the effects of a malfunction or failure, such as controlling or deactivating system elements to halt generation or propagation of failure effects, or activating back-up or standly items or systems, should be described. Corrective design provisions include:

a) *redundancies that allow continued and safe operation;*
b) *safety devices, monitoring or alarm provisions, which permit restricted operation or limit damage;*
c) *alternative modes of operation.*

12.3 Provisions which require operator action to circumvent or mitigate the effects of the postulated failure should be described. The possibility and effect of operator error should be considered, if the corrective action or the initiation of the redundancy requires operator input, when evaluating the means to eliminate the local failure effects.

12.4 It should be noted that corrective responses acceptable in one operational mode may not be acceptable at another, e.g a redundant system element with considerable time lag to be brought into line, while meeting the operational mode normal seagoing conditions at full speed may result in a catastrophic effect in another operational mode, e.g. maximum permitted operating speed in congested water.

13. Use of probability concept

13.1 If corrective measures or redundancy as described in preceding paragraphs are not provided for any failure, as an alternative the probability of occurrence of such failure should meet the following criteria of acceptance:

a) *a failure mode which results in a catastrophic effect should be assessed to be extremely improbable;*

b) *a failure mode assessed as extremely remote should not result in worse than hazardous effects; and*

c) *a failure mode assessed as either frequent or reasonably probable should not result in worse than minor effects.*

13.2 Numerical values for various levels of probabilities are laid down in Section 3 of Annexure 2 of these Rules. In areas where there is no data from craft to determine the level of probabilities of failure other sources can be used such as:

a) workshop test, or
b) history of reliability used in other areas under similar operating conditions, or
c) mathematical model if applicable.

14. Documentation

14.1 It is helpful to perform FMEA on worksheet(s) as shown in Table 2.

14.2 The worksheet(s) should be organized to first display the highest system level and then proceed down through decreasing system levels.

15. Test programme

15.1 An FMEA test programme should be drawn up to prove the conclusions of FMEA. It is recommended that the test programme should include all systems or system elements whose failure would lead to:

a) major or more severe effects;
b) restricted operations; and
c) any other corrective action.

For equipment where failure cannot be easily simulated on the craft, the results of other tests can be used to determine the effects and influences on the systems and craft.

15.2 The trials should also include investigations into:

a) the layout of control stations with particular regard to the relative positioning of switches and other control devices to ensure a low potential for inadvertent and incorrect crew action, particularly during emergencies and the provision of interlocks to prevent inadvertent operation for important system operation;

b) the existence and quality of the craft's operational documentation with particular regard to the pre-voyage checklists. It is essential that these checks account for any unrevealed failure modes identified in the failure analysis; and

c) the effects of the main failure modes as prescribed in the theoretical analysis.

15.3 The FMEA tests on board should be conducted in conjunction with provisions specified in Chapter 14, Section 3, 4 of these Rules and Chapter 17, Section 17.4 of the HSC Code, before the craft enters into service.

16. FMEA report

16.1 The FMEA report should be a self-contained document with a full description of the craft, its systems and their functions and the proposed operation and environmental conditions for the failure modes, causes and effects to be understood without any need to refer to other plans and documents not in the report. The analysis assumptions and system block diagrams should be included, where appropriate. The report should contain a summary of conclusions and recommendations for each of the systems analysed in the system failure analysis and the equipment failure analysis. It should also list all probable failures and their probability of failure where applicable; the corrective actions or operational restrictions for each system in each of the operational modes under analysis. The report should contain the test programme, reference any other test reports and the FMEA trials.

Table 1 : Example of a set of failure modes

1	*Structural failure (rupture)*	*18*	*False actuation*
2	*Physical binding or jamming*	*19*	*Fails to stop*
3	*Vibration*	*20*	*Fails to start*
4	*Fails to remain (in position)*	*21*	*Fails to switch*
5	*Fails to open*	*22*	*Premature operation*
6	*Fails to close*	*23*	*Delayed operation*
7	*Fails open*	*24*	*Erroneous input (increased)*
8	*Fails closed*	*25*	*Erroneous input (decreased)*
9	*Internal leakage*	*26*	*Erroneous output (increased)*
10	*External leakage*	*27*	*Erroneous output (decreased)*
11	*Fails out of tolerance (high)*	*28*	*Loss of input*
12	*Fails out of tolerance (low)*	*29*	*Loss of output*
13	*Inadvertent operation*	*30*	*Shorted (electrical)*
14	*Intermittent operation*	*31*	*Open (electrical)*
15	*Erratic operation*	*32*	*Leakage (electrical)*
16	*Erroneous indication*	*33*	*Other unique failure conditions as applicable to the system characteristics, requirements and operational constraints*
17	*Restricted flow*		
Reference from publication 812 IEC 1985.			

Table 2 : FMEA Worksheet

Name of system ____________________________ *References:* ________________________________

Mode of operation __________________________ *System block diagram* ________________________

Sheet No. _________________________________ ____

Date ______________________________________ ____

Name of analyst ____________________________ *Drawings* __________________________________

Equipment name or number	***Func-tion***	***Ident. No.***	***Failure mode***	***Failure cause***	***Failure effect***		***Failure detec-tion***	***Correcti ve action***	***Severity of failure effect***	***Probability of failure (if applicable)***	***Remarks***
					Local effect	***End effect***					

STEERING CONTROL SYSTEM *Date* ______________________________

Analyst ____________________________

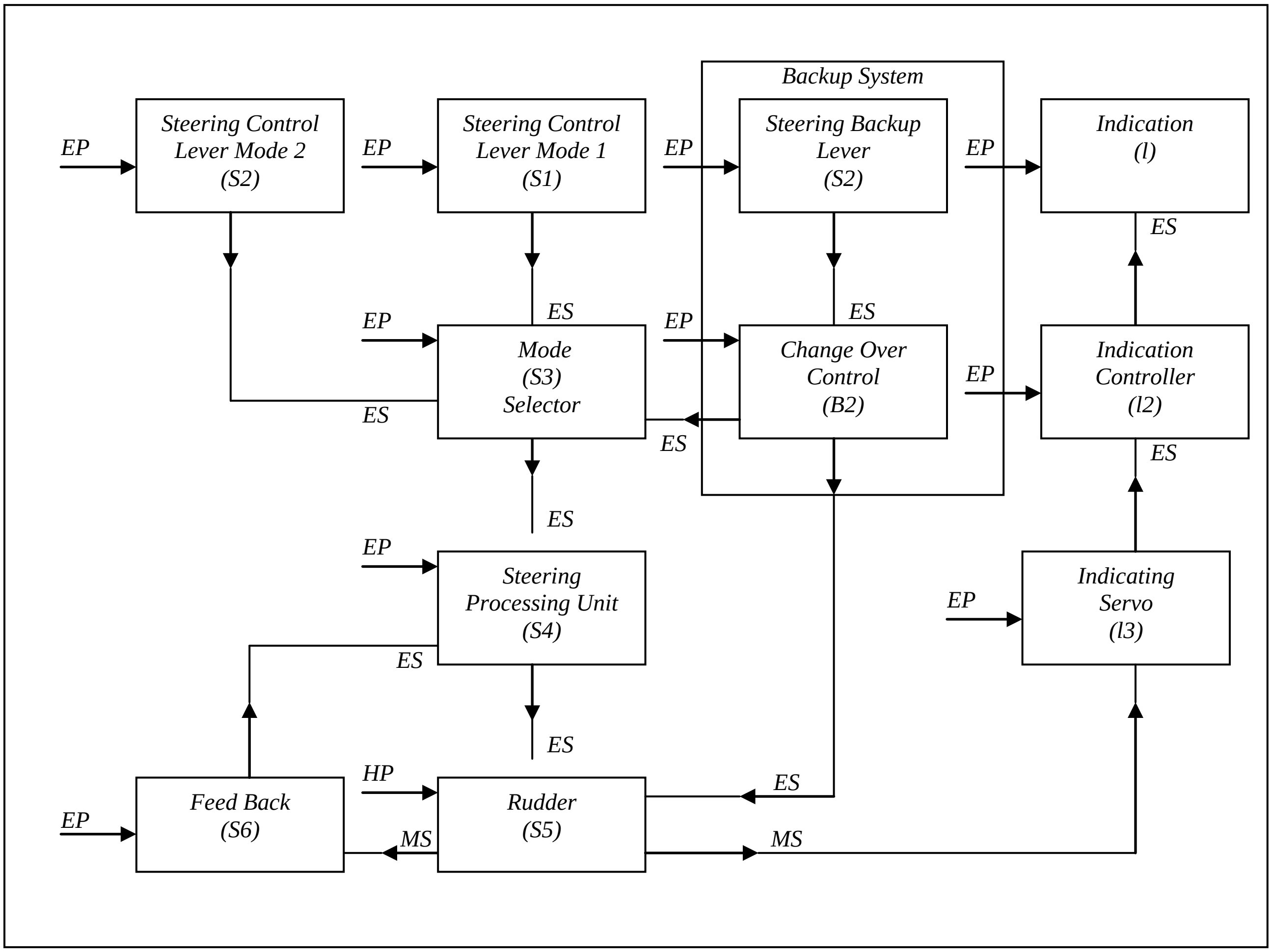

Fig.1 : Example of a system block diagram

Where,

EP – electric power
HP – hydraulic power
ES – electrical signal
MS – mechanical signal

End Of Chapter

Annexure - 4

Stability of Hydrofoil Craft
(Annex 6 of HSC Code)

The stability of these craft shall be considered in the hull-borne, transitional and foil borne modes. The stability investigation shall also take into account the effects of external forces. The following procedures are outlined for guidance in dealing with stability.

As required by Chapter 5, 2.3.1, the stability of hydrofoil craft shall be assessed under all permitted conditions of loading.

The term "hull-borne mode" has the same meaning as "displacement mode" defined in Chapter 1, 2.2.19.

The term "foil-borne mode" has the same meaning as "non-displacement mode" defined in Chapter 1, 2.2.36.

1. Surface piercing hydrofoils

1.1 Hull-borne mode

1.1.1 The stability should be sufficient to satisfy the provisions of Chapter 5, Section 2.3 and 2.4 of these Rules.

1.1.2 Heeling moment due to turning

The heeling moment developed during manoeuvring of the craft in the displacement mode may be derived from the following formula:

$$M_R = 0.196 \frac{V_o^2}{L} \Delta\ KG\ [kNm]$$

where,

M_R : *moment of heeling*
V_o : *speed of the craft in the turn [m/s]*
Δ : *displacement [t]*
L : *length of the craft on the waterline [m]*
KG : *height of the centre of gravity above keel [m].*

This formula is applicable when the ratio of the radius of the turning circle to the length of the craft is 2 to 4.

1.1.3 Relationship between the capsizing moment and heeling moment to satisfy the weather criterion.

The stability of a hydrofoil boat in the displacement mode can be checked for compliance with the weather criterion K as follows:

$$K = \frac{M_c}{M_v} \geq 1$$

where,

M_c : *minimum capsizing moment as determined when account is taken of rolling;*

M_v : *dynamically applied heeling moment due to the wind pressure.*

1.1.4 Heeling moment due to wind pressure

The heeling moment M_v, shall be taken as constant during the whole range of heel angles and calculated by the following expression:

$$M_v = 0.001\ P_v\ A_v\ Z \quad [kNm]$$

P_V = *wind pressure* = $750\ (V_W/26)^2\ [N/m^2]$

A_V = *windage area including the projections of the lateral surfaces of the hull, superstructure and various structures above the waterline.*

Z = *The windage area lever = vertical distance to the geometrical centre of the windage area from the waterline [m].*

V_W = *The wind speed corresponding to the worst intended conditions [m/s].*

1.1.5 Evaluation of the minimum capsizing moment M_c in the displacement mode

The minimum capsizing moment is determined from the static and dynamic stability curves taking rolling into account.

a) When the static stability curve is used, M_c is determined by equating the areas under the curves of the capsizing and righting moments (or levers) taking rolling into account, as indicated by Fig.1, where θ_z is the amplitude of roll and MK is a line drawn parallel to the abscissa axis such that the shaded areas S_1 and S_2 are equal.

M_c = OM, if the scale of ordinates represents moments.

M_c = OM x Displacement, if the scale of ordinates represents levers.

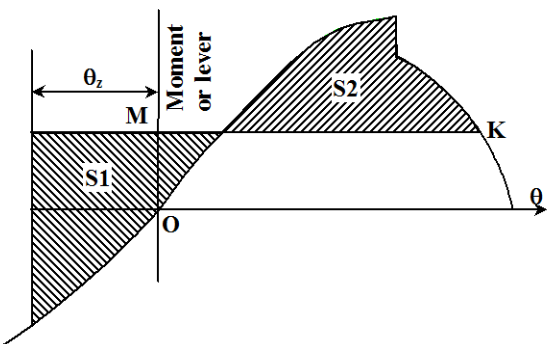

Fig.1 : Static stability curve

b) When the dynamic stability curve is used, first an auxiliary point A should be determined. For this purpose the amplitude of heeling is plotted to the right along the abscissa axis and a point A' is found (see Fig.2). A line AA' is drawn parallel to the abscissa axis equal to the double amplitude of heeling (AA' = $2\theta_z$) and the required auxiliary point A is found. A tangent AC to the dynamic stability curve is drawn. From the point A the line AB is drawn parallel to the abscissa axis and equal to 1 radian (57.3^o). From the point B a perpendicular is drawn to intersect with the tangent in point E. The distance BE is equal to the capsizing moment if measured along the ordinate axis of the dynamic stability curve. If, however, the dynamic stability levers are plotted along this axis, BE is then the capsizing lever, and in this case the capsizing moment M_c is determined by multiplication of ordinate BE (in metres) by the corresponding displacement in tonnes.

$$M_c = 9.81\ \Delta\ \overline{BE}\ \ [kNm]$$

c) The amplitude of rolling θ_z is determined by means of model and full-scale tests in irregular seas as a maximum amplitude of rolling of 50 oscillations of a craft travelling at 90^o to the wave direction in sea state for the worst design condition. If such data are lacking the amplitude is assumed to be equal to 15^o.

d) The effectiveness of the stability curves should be limited to the angle of flooding.

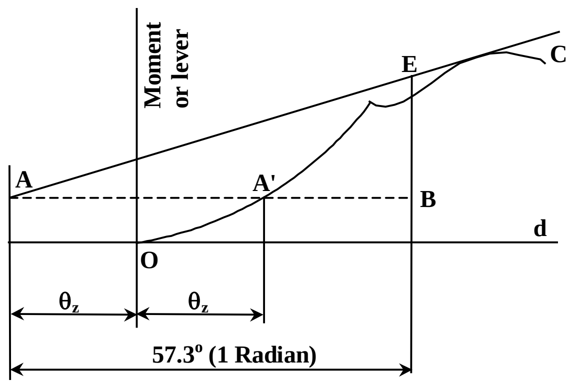

Fig.2 : Dynamic stability curve

1.2 Transitional and foil-borne modes

1.2.1 The stability should satisfy the provisions of Chapter 5, Section 2.4 and 2.5 of these Rules.

1.2.2a) The stability in the transitional and foil-borne modes should be checked for all cases of loading for the intended service of the craft.

1.2.2b) The stability in the transitional and foil-borne modes may be determined either by calculation or on the basis of data obtained from model experiments and should be verified by full scale tests by the imposition of a series of known heeling moments by off centre ballast weights, and recording the heeling angles produced by these moments. When taken in the hull-borne, take-off, steady foil-borne, and settling to hull-borne modes, these results will provide an indication of the values of the stability in the various situations of the craft during the transitional condition.

1.2.2c) The angle of heel in the foil-borne mode caused by the concentration of passengers at one side should not exceed 8^o. During the transient mode the angle of heel due to the concentration of passengers on one side should not exceed 12^o. The concentration of passengers should be determined by the Administration, having regard to the guidance given at Annex 7 to the HSC Code (Annexure 5 of these Rules).

1.2.3 One of the possible methods of assessing foil-borne metacentric height (GM) in the design stage for a particular foil configuration is given in Fig.3.

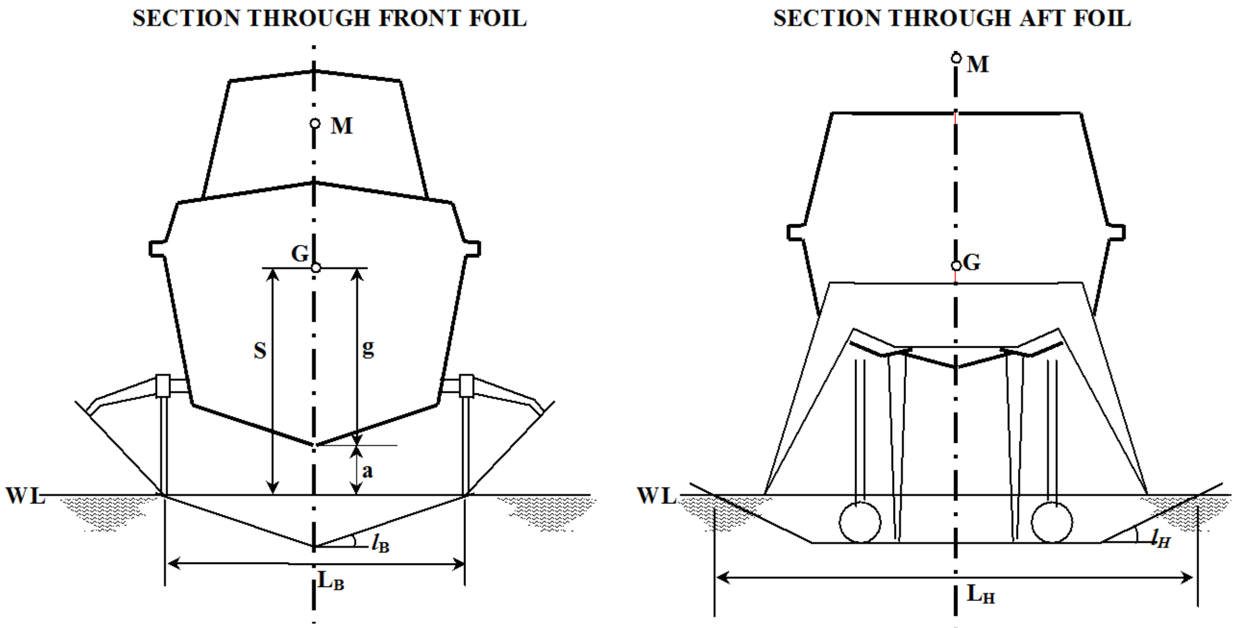

Fig.3

$$GM = n_B\left(\frac{L_B}{2\ \tan l_B} - S\right) + n_H\left(\frac{L_H}{2\tan l_H} - S\right)$$

where,

n_B	*: percentage of hydrofoil load borne by front foil.*
n_H	*: percentage of hydrofoil load borne by aft foil*
L_B	*: clearance width of front foil*
L_H	*: clearance width of aft foil*
a	*: clearance between bottom of keel and water*
g	*: height of centre of gravity above bottom of keel*
l_B	*: angle at which front foil is inclined to horizontal*
l_H	*: angle at which aft foil is inclined to horizontal*
S	*: height of centre of gravity above water.*

2. Fully submerged hydrofoils

2.1 Hull-borne mode

2.1.1 The stability in the hull-borne mode should be sufficient to satisfy the provisions of Chapter 5, Section 2.3 and 2.6 of these Rules.

2.1.2 Paragraphs 1.1.2 to 1.1.5 of this Annex are appropriate to this type of craft in the hull-borne mode.

2.2 Transitional mode

2.2.1 The stability should be examined by the use of verified computer simulations to evaluate the craft's motions, behaviour and responses under the normal conditions and limits of operation and under the influence of any malfunction.

2.2.2 The stability conditions resulting from any potential failures in the systems or operational procedures during the transitional stage which could prove hazardous to the craft's watertight integrity and stability should be examined.

2.3 Foil-borne mode

2.3.1 The stability of the craft in the foil-borne mode should be in compliance with the provisions of Chapter 5, Section 2.4 of these Rules. The provisions of paragraph 2.2 of this Annex should also apply.

2.4 Paragraph 1.2.2 of this Annex should be applied to this type of craft as appropriate and any computer simulations or design calculations should be verified by full scale tests.

End Of Chapter

Annexure - 5

Stability of Multi-Hull Craft
(Annex 7 of HSC Code)

1. Stability criteria in the intact condition

A multihull craft, in the intact condition, should have sufficient stability when rolling in a seaway to successfully withstand the effect of either passenger crowding or high speed turning as described in 1.4. The craft's stability should be considered to be sufficient provided compliance with this paragraph is achieved.

1.1 Area under the GZ curve

The area (A1) under the GZ curve upto an angle θ should be at least:

$A1 = 0.055 \times 30^o/\theta$ *[m-rad]*

Where θ is the least of the following angles [deg.]:

a) *the down flooding angle;*
b) *the angle at which the maximum GZ occurs; and*
c) *30^o.*

1.2 Maximum GZ

The maximum GZ value should occur at an angle of at least 10^o.

1.3 Heeling due to wind

The wind heeling lever should be assumed constant at all angles of inclination and should be calculated as follows:

$$HL1 = \frac{P_i \; A Z}{9800\,\Delta}\;[m]$$

$$HL2 = 1.5\ HL1\ [m] \text{ (see Fig.1)}$$

where,

P_i : $500 (V_W / 26)^2$ *[N/m²]*
V_W : *wind speed corresponding to the worst intended conditions [m/s]*
A : *projected lateral area of the portion of the ship above the lightest service waterline [m²]*
Z : *vertical distance from the centre of A to a point one half the lightest service draught [m]*
Δ : *displacement [t].*

1.4 Heeling due to passenger crowding or high speed turning

Heeling due to the crowding of passengers on one side of the craft or to high speed turning, whichever is the greater should be applied in combination with the heeling lever due to wind (HL2).

a) *Heeling due to passenger crowding.*

When calculating the magnitude of the heel due to passenger crowding, a passenger crowding lever should be developed using the assumptions stipulated in Chapter 5, Section 3.1 of these Rules.

b) *Heeling due to high speed turning.*

When calculating the magnitude of the heel due to the effects of high speed turning, a high speed turning lever should be developed using the following formula:

$$TL = \frac{V_o^{\,2}}{g\;R}\left(KG - \frac{d}{2}\right)[m]$$

where,

TL : *turning lever [m]*
V_o : *speed of craft in the turn [m/s]*
R : *turning radius [m]*
KG : *height of vertical centre of gravity above keel [m]*
d : *mean draught [m].*
g : *acceleration due to gravity [m/s²]*

Alternatively, another method of assessment may be employed, as provided for in Chapter 5, 2.1.2.

1.5 Rolling in waves (Fig.1)

The effect of rolling in a seaway upon the craft's stability should be demonstrated mathematically. In doing so, the residual area under the GZ curve (A2), i.e. beyond the angle of heel (θ_h), should be at least equal to 0.028 [m-rad] up to the angle of roll θ_r. In the absence of model test or other data θ_r should be taken as 15^o or an angle of (θ_d - θ_h), whichever is less.

The determination of θ_r using model test or other data shall be made using the method for determining θ_r in 1.1.5c) of Annexure 4.

2. Criteria for residual stability after damage

2.1 The method of application of criteria to the residual stability curve is similar to that for intact stability except that the craft in the final condition after damage should be considered to have an adequate standard of residual stability provided:

- *a) the required area A2 should be not less than 0.028 [m-rad] (Fig.2 refers); and*
- *b) there is no requirement regarding the angle at which the maximum GZ value should occur.*

2.2 The wind heeling lever for application on the residual stability curve should be assumed constant at all angles of inclination and should be calculated as follows:

$$HL3 = \frac{P_d\ AZ}{9800\ \Delta}\ [\mathrm{m}]$$

where,

- P_d : $120 \times (V_W/26)^2$ [N/m^2]
- *A : projected lateral area of the portion of the ship above the lightest service waterline* [m^2]
- *Z : vertical distance from the centre of A to a point one half of the lightest service draught [m]*
- Δ : *displacement [t].*

2.3 The same values of roll angle should be used as for the intact stability.

2.4 The down-flooding point is important and is regarded as terminating the residual stability curve. The area A2 should therefore be truncated at the down-flooding angle.

2.5 The stability of the craft in the final condition after damage should be examined and shown to satisfy the criteria, when damaged as stipulated in Chapter 5, Section 2.6.5 to 2.6.8 of these Rules.

2.6 In the intermediate stages of flooding, the maximum righting lever should be at least 0.05 [m] and the range of positive righting lever should be at least 7^o. In all cases, only one breach in the hull and only one free surface need to be assumed.

3. Application of heeling levers

3.1 In applying the heeling levers to the intact and damaged curves the following should be considered:

3.1.1 for intact condition:

- *a) wind heeling lever (including gusting effect) (HL2); and*
- *b) wind heeling lever (including gusting effect) plus either the passenger crowding or speed turning levers whichever is the greater (HTL).*

3.1.2 for damage condition:

- *a) wind heeling lever – steady wind (HL3); and*
- *b) wind heeling lever plus heeling lever due to passenger crowding (HL4).*

3.2 Angle of heel due to steady wind

- *a) The angles of heel due to a wind gust when the heeling lever HL2, obtained as in 1.3, is applied to the intact stability curve, should not exceed 10^o; and*

- *b) The angle of heel due to steady wind when the heeling lever HL3, obtained as in 2.2, is applied to the residual stability curve, after damage, should not exceed 15^o for passenger craft and 20^o for cargo craft.*

Abbreviations used in figures 1 and 2:

- *HL2 : Heeling lever due to wind + gusting*
- *HTL : Heeling lever due to wind + gusting + (passenger crowding or turning)*
- *HL3 : Heeling lever due to wind*
- *HL4 : Heeling lever due to wind + passenger crowding*

θ_m : *Angle of maximum GZ*
θ_d : *Angle of down-flooding*
θr : *Angle of roll*
θ_e : *Angle of equilibrium, assuming no wind, passenger crowding or turning effects*
θ_h : *Angle of heel due to heeling lever HL2, HTL, HL3 or HL4*

A1 $\geq$ Area required by 1.1
A2 $\geq$ 0.028 m rad.

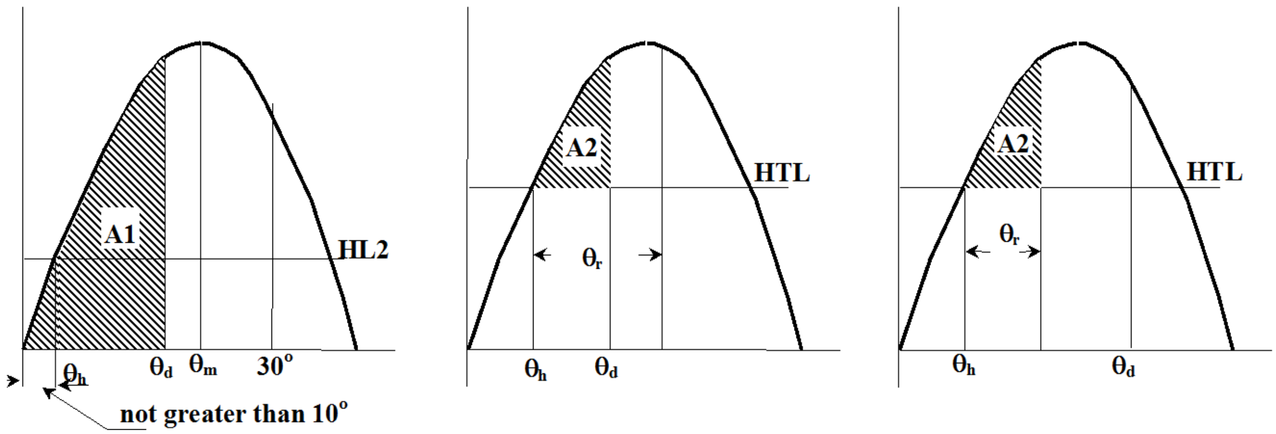

Fig.1 : Intact Stability

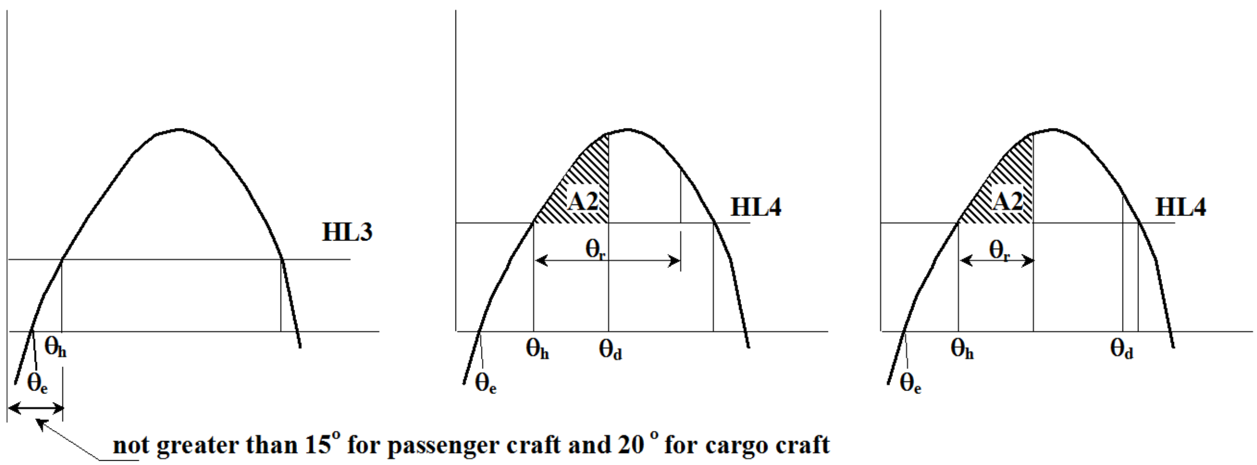

Fig. 2 : Damage Stability

End Of Chapter

Annexure - 6

Stability of Monohull Craft (Annex 8 of HSC Code)

1. Stability criteria in the intact condition

1.1 The weather criterion contained in paragraph 3.2 of the Intact Stability Code (Refer to the Code on Intact Stability for all types of ships covered by IMO instruments, adopted by the Organization by Resolution A.749(18), as amended by Resolution MSC.75(69)) shall apply (In applying this criterion, small openings through which progressive flooding cannot take place need not be considered open). In applying the weather criterion, the value of wind pressure P[N/m^2] shall be taken as (500 $(V_W/26)^2$), where V_W = wind speed [m/s] corresponding to the worst intended conditions.

The angle of heel due to wind, in applying paragraph 3.2.2.1.2 of the Intact Stability Code, shall not exceed 16° or 80% of the angle of deck-edge immersion (whichever is less). Where the angle of heel due to wind exceeds 10°, efficient non-slip deck surfaces and suitable holding points shall be provided, in accordance with paragraph 3.4.1a) of Chapter 5.

In applying the weather criterion, account shall also be taken of the roll damping characteristics of individual craft in assessing the assumed roll angle θ_T, which may alternatively be derived from model or full-scale tests using the method for determining θ_z in 1.1.5c) of Annex 4. Hulls with features which greatly increase damping, such as immersed sidehulls, substantial arrays of foils, or flexible skirts or seals, are likely to experience significantly smaller magnitudes of roll angle. For such craft, therefore, the roll angle shall be derived from model or full-scale tests or in the absence of such data shall be taken as 15°.

1.2 The area under the righting lever curve (GZ curve) shall not be less than 0.07 [m-rad] upto θ = 15° when the maximum righting lever (GZ) occurs at θ = 15° and 0.055 [m-rad] upto θ = 30° when the maximum righting lever occurs at θ = 30° or above. Where the maximum righting lever occurs at angles of between θ = 15° and θ = 30°, the corresponding area under the righting lever curve shall be:

$$A = 0.055 + 0.001\,(30° - \theta_{max}) \quad [m\text{-}rad]$$

where,

θ_{max} is the angle of heel, in degrees, at which the righting lever curve reaches its maximum.

1.3 The area under the righting lever curve between θ = 30° and θ = 40° or between θ = 30° and the angle of flooding θ_F if this angle is less than 40°, shall not be less than 0.03 [m-rad]. (In applying this criterion, small openings through which progressive flooding cannot take place need not be considered open).

1.4 The righting lever GZ shall be at least 0.2 [m] at an angle of heel equal to or greater than 30°.

1.5 The maximum righting lever shall occur at an angle of heel not less than 15°.

1.6 The initial metacentric height GM_T shall not be less than 0.15 [m].

2. Criteria for residual stability after damage

2.1 The stability required in the final condition after damage and after equalization where provided, shall be determined as specified in 2.1.1 to 2.1.4.

2.1.1 The positive residual lever curve shall have a minimum range of 15° beyond the angle of equilibrium. This range may be reduced to a minimum of 10°, in the case where the area under the righting lever curve is that specified in 2.1.2, increased by the ratio:

$$\frac{15}{\text{range}}$$

where the range is expressed in degrees.

The range shall be taken as the difference between the equilibrium heel angle and the heel angle at which the residual righting lever subsequently *becomes negative or the angle at which progressive flooding occurs, whichever is less.*

2.1.2 The area under the righting lever curve shall be at least 0.015 [m-rad], measured from the angle of equilibrium to the lesser of:

a) *the angle at which progressive flooding occurs; and*
b) *27° measured from the upright.*

2.1.3 A residual righting lever shall be obtained within the range of positive stability, taking into account the greatest of the following heeling moments:

a) *the crowding of all passengers towards one side;*
b) *the launching of all fully loaded davit-launched survival craft on one side;*
c) *due to wind pressure,*

as calculated by the formula:

$$GZ = \frac{heeling\ moment}{displacement} + 0.04\ \ [m]$$

However, in no case shall this righting lever be less than 0.1 [m].

2.1.4 For the purpose of calculating the heeling moments referred to in 2.1.3, the following assumptions shall be made:

2.1.4.1 Moments due to crowding of passengers. This should be calculated in accordance with Ch.5, Sec.3.1 of these rules.

2.1.4.2 Moments due to launching of all fully loaded davit-launched survival craft on one side:

a) *all lifeboats and rescue boats fitted on the side to which the craft has heeled after having sustained damage shall be assumed to be swung out fully loaded and ready for lowering;*

b) *for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken;*

c) *a fully loaded davit-launched liferaft attached to each davit on the side to which the craft has heeled after having sustained damage shall be assumed to be swung out ready for lowering;*

d) *persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment; and*

e) *life-saving appliances on the side of the craft opposite to the side to which the craft has heeled shall be assumed to be in a stowed position.*

2.1.4.3 Moments due to wind pressure:

a) *the wind pressure shall be taken as* $(120\ (V_W/26)^2)\ [N/m^2]$*, where* V_W *= wind speed [m/s], corresponding to the worst intended condition;*

b) *the area applicable shall be the projected lateral area of the craft above the waterline corresponding to the intact condition; and*

c) *the moment arm shall be the vertical distance from a point at one half of the mean draught corresponding to the intact condition to the geometrical centre of the lateral area.*

2.2 In intermediate stages of flooding, the maximum righting lever shall be at least 0.05 [m] and the range of positive righting levers shall be at least 7°. In all cases, only one breach in the hull and only one free surface need be assumed.

End Of Chapter

Annexure - 7

Definitions, Requirements and Compliance Criteria Related to Operational and Safety Performance (Annex 9 of HSC Code)

This annex applies to all types of craft. Tests to evaluate operational safety should be conducted on the prototype craft of a new design or of a design incorporating new features which may modify the results of a previous testing. The tests should be carried out to a schedule agreed between the Administration and the manufacturer. Where conditions of service warrant additional testing (e.g. low temperature), the Administration or base Port State authorities as appropriate may require further demonstrations. Functional descriptions, technical and system specifications relevant to the understanding and evaluation of craft performance should be available.

The objective of these tests is to provide essential information and guidance to enable the craft to be operated safely under normal and emergency conditions within the design speed and environmental envelope.

The following procedures are outlined as requirements in dealing with verification of craft performance.

1. Performance

1.1 General

1.1.1 The craft should meet the applicable operational requirements in Chapter 17 of this Code and this annex for all extremes of passenger and load configurations for which certification is required. The limiting Sea State related to the different modes of operation should be verified by tests and analyses of a craft of the type for which certification is requested.

1.1.2 Operational control of the craft should be in accordance with procedures established by the applicant for operation in service. Procedures to be established should be start procedure, cruise procedures, normal and emergency stop and manoeuvre procedures.

1.1.3 The procedures established under 1.1.2 should:

.1 demonstrate that normal manoeuvres and craft responses to failures are consistent in performance;

.2 use methods or devices that are safe and reliable; and

.3 include allowance for any time lag in the execution of procedures that may reasonably be expected in service.

1.1.4 Procedures required by this annex should be conducted over water of sufficient depth such that craft performance will not be affected.

1.1.5 Tests should be conducted at minimum practicable weight and additional testing should be conducted at maximum weight sufficient to establish the need for additional restrictions and for testing to examine the effect of weight.

2. Stopping

2.1 This test is to establish the acceleration experienced when stopping the craft in calm water with no passenger load or cargo load during the following conditions:

.1 normal stop for maximum operational speed;

.2 emergency stop for maximum operational speed; and

.3 crash stop from maximum operational speed and from any transient mode speed.

2.2 The tests referred to in 2.1.1 and 2.1.2 should document that the accelerations do not exceed safety level 1 in Annex 3 when control levers are used in accordance to written procedures as given in the craft operating manual or in an automatic mode. Should safety level 1 be exceeded during normal stop, control systems should be modified in order to avoid exceedance or passengers should be required *to be seated during normal stop. Should safety level 1 be exceeded during emergency stop, then written procedures in the craft operating manual should include detailed information of how to avoid exceedance or the control system should be modified to avoid exceedance.*

2.3 The test referred to in 2.1.3 should document that the accelerations do not exceed safety level 2 in Annex 3 when control levers of automatic modes are used in a manner which will give the highest accelerations. If safety level 2 is exceeded then the craft operating manual should include a warning that it is a risk to passengers being injured, if a crash stop is performed.

2.4 Other tests should be repeated during craft turning to establish the need or otherwise to impose any speed-related restrictions during manoeuvres.

3. Cruise performance

3.1 This test is to establish the craft performance and accelerations experienced during cruise modes with no passenger load or cargo load during the following conditions:

.1 normal operation conditions are those in which the craft will safely cruise at any heading while manually operated, auto-pilot assisted operated or operated with any automatic control system in normal mode; and

.2 worst intended conditions, referred to in Chapter 1, 2.2.49 of these Rules, are those in which it should be possible to maintain safe cruise without exceptional piloting skill. However, operations at all headings relative to the wind and sea may not be possible. For type of craft having a higher performance standard in non-displacement mode, the performance and accelerations should also be established at displacement mode during operation in the worst intended condition.

3.2 Operation levels, as defined in 3.1, should be established and documented by full-scale tests in at least two relevant sea conditions and in head, beam and following seas. Test periods should be at least 15 minutes. Model tests and mathematical simulations could be used to verify the performance in the worst intended conditions.

Limits for normal operation condition should be documented by measurements of craft speed, heading to the wave and interpolation of measurements of maximum horizontal accelerations in accordance with 2.4 of Annex 3. Measurement of wave height and period should be made to the maximum extent practicable.

Limits for worst intended condition should be documented by measurements of craft speed, wave height and period, heading to the wave and by root mean square (RMS) values of horizontal accelerations in accordance with 2.4 of Annex 3 and of vertical accelerations close to the craft longitudinal centre of gravity. RMS values could be used for extrapolation of peak values. To obtain the expected peak values related to structural design load and safety levels (one per 5-min exceedance), multiply the RMS values by 3.0 or

$$C = \sqrt{2 \ln N}$$

where,

N is the number of successive amplitudes within the relevant period.

If not otherwise verified by model tests or by mathematical calculations, it might be assumed a linear relation between wave height and accelerations based on measurements in the two sea conditions. Limits for worst intended condition should be documented both related to passenger safety in accordance with 2.4 of Annex 3 and related to the actual structural design load of the craft.

3.3 The tests and verification process should document the limiting seas for safe operation of the craft:

.1 in normal operation at maximum operational speed the accelerations should not exceed safety level 1 in Annex 3 with an average of one per 5-min period. The craft operating manual should include detailed description of the effects of speed reduction or change of heading to the waves n order to prevent exeedance;

.2 in the worst intended conditions, with reduced speed as necessary, the accelerations should not exceed safety level 2 in Annex 3 with an average of one per 5-min period, nor should any other craft characteristic motion as pitch, roll and yaw exceed levels that could impede the safety of passengers. In worst intended conditions, with reduced speed as necessary, craft should be safely manoeuvrable and provide adequate stability in order that the craft can

continue safe operation to the nearest place of refuge, provided caution is exercised in handling. Passengers should be required to be seated when safety level 1 in Annex 3 is exceeded; and

.3 within the actual structural design load for the craft, with reduced speed and change of heading, as necessary.

3.4 Turning and manoeuvrability

The craft should be safely controllable and manoeuvrable during:

.1 hull-borne operation;
.2 operation in non-displacement mode;
.3 take-off, landing;
.4 any intermediate or transition modes, as applicable; and
.5 berthing operations, as applicable.

4. Effects of failures or malfunction

4.1 General

The limits of safe operation, special handling procedures and any operational restrictions should be examined and developed as a result of full-scale trials conducted by simulating possible equipment failures.

The failures to be examined should be those leading to major or more severe effects as determined from evaluation of FMEA or similar analysis.

Failures to be examined should be agreed between the craft manufacturer and the Administration and each single failure should be examined in a progressive manner.

4.2 Objects of tests

Examination of each failure should result in:

.1 determining safe limits of craft operation at the time of failure, beyond which the failure will result in degradation beyond safety level 2;

.2 determining crew member's actions, if any, to minimize or counter the effect of the failure; and

.3 determining craft or machinery restrictions to be observed to enable the craft to proceed to a place of refuge with the failure present.

4.3 Failures to be examined

Equipment failures should include, but not be limited to, the following:

.1 total loss of propulsion power;

.2 total loss of lift power (for ACV and SS);

.3 total failure of control of one propulsion system;

.4 involuntary application of full propulsion thrust (positive or negative) on one system;

.5 failure of control of one directional control system;

.6 involuntary full deflection of one directional control system;

.7 failure of control of trim control system;

.8 involuntary full deflection of one trim control system element; and

.9 total loss of electrical power.

Failures should be fully representative of service conditions and should be simulated as accurately as possible in the most critical craft manoeuvre where the failure will have maximum impact.

4.4 "Dead ship" test

In order to establish craft motions and direction of laying to wind and waves, for the purposes of determining the conditions of a craft evacuation, the craft should be stopped and all main machinery shut down for sufficient time that the craft's heading relative to wind and waves has stabilized. This test should be carried out on an opportunity basis to establish patterns of the design's "dead ship" behaviour under a variety of wind and sea states.

End Of Chapter

Annexure - 8

Factors to be considered in Determining Craft Operating Limitations (Annex 12 of HSC Code)

1. Purpose and scope

The purpose of this annex is to identify the parameters to which consideration will be given when determining the worst intended conditions (defined in Chapter 1, 2.2.5.7) and other operational limitations for insertion into the Permit to Operate. (See Annex 2 of IMO HSC Code).

2. Factors to be considered

As a minimum, the following factors will be considered:

- *a) The maximum distance from refuge implied by Chapter 2, 2.1.1.*
- *b) The availability of rescue resources to comply with Chapter 1, 2.2.11 (Category A craft only).*
- *c) Minimum air temperature (susceptibility to icing), visibility and depth of water for safe operation as addressed by Chapter 1, 2.2.57.*
- *d) The significant wave height and maximum mean wind speed used when applying the requirements for stability and buoyancy in chapter 5 and associated annexes.*
- *e) The safe seakeeping limitations (especially significant wave height) considering the known stability hazards listed in Chapter 5, 2.1.2, the operating conditions on the intended route (See HSC Code Chapter 18) and the motions experienced during operation defined in 3.3 of Annex 9.*
- *f) The structural safety of the craft in critical design conditions.*
- *g) The safe deployment and operation of evacuation systems and survival craft as required by Chapter 8 of HSC Code.*
- *h) The safe handling limitations determined in accordance with the sea trials required by Chapter 17 of HSC Code and Annexure 2 and 7 of these Rules, identifying any limitations on weight and center-of-gravity position and the effects of failures and malfunctions according to Chapter 17 of the HSC Code*

End Of Chapter