

*Rules for Classification and Construction*

**I** *Ship Technology*

**1** **Seagoing Ships**

**5** **High Speed Craft**



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**The following Rules come into force on July 1<sup>st</sup>, 2002.**

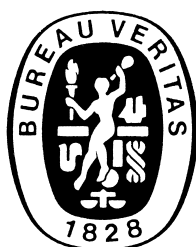
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# Rules for the Classification of High Speed Craft

These rules have been established jointly by



BUREAU  
VERITAS



GERMANISCHER  
LLOYD



REGISTRO  
ITALIANO NAVALE

as Members of  
**EEIG UNITAS**

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# **RULES FOR THE CLASSIFICATION OF HIGH SPEED CRAFT**

## **PREMISE**

### **P.1 General**

#### **P.1.1**

**.1** These rules incorporate the text in full of the “International Code of Safety for High Speed Craft” (“HSC Code”) adopted by the IMO Maritime Safety Committee, at its 73rd session, in December 2000, through Resolution MSC. 97(73). This text is printed in *italics*.

**.2** Classification requirements additional to the provisions of the HSC Code are printed in the Roman characters used for this item .2 and the relevant number is prefixed by the letter C.

In Section 10, which is subdivided into Parts, additional classification requirements not directly related to a particular HSC Code item are numbered as follows: prefix C, Section number, letter indicating the Part concerned and an incremental figure starting from 1. These additional requirements are inserted at the end of the relevant Part of the Section.

Where necessary, additional explanatory notes are given at the beginning of each Section.

**.3** Parts of the HSC Code not applicable for the purpose of classification are identified by a vertical line placed in the margin of the text.

**.4** Equipment and arrangements dealt with in the parts of the Code mentioned in item .3, such as those concerning life-saving appliances and radiocommunications, which are not subject to control by the Society, are intended to be covered by the relevant certification.

**P.1.2** In those provisions of the HSC Code that are being used for classification purposes the words “Administration” and “Code”, wherever mentioned, are to be understood as equivalent to the words “Society” and “Rules”, respectively. The Rules for the construction and classification of ships are referred to below simply as “Society Rules”.

### **P.2 Application**

#### **P.2.1 Craft for which classification only is requested**

These craft are to comply in full with the requirements of these rules, except for those identified by a vertical line placed in the margin of the text (see P.1.1.3).

#### **P.2.2 Craft for which both classification and the IMO Certification are requested**

These craft are to comply in full with the requirements of these rules.

**P.3 Class notation**

Craft complying with the classification requirements of these Rules are assigned the notation **HSC** or **High Speed Craft**, completed as specified in the Society Rules.

**P.4 Compliance with other rules**

For any items not expressly stipulated or modified for classification purposes by these Rules, the requirements of the Society Rules are to apply wherever relevant.

Classification of a craft with the Society, or more generally any Society actions and decisions, do not absolve the interested parties from compliance with additional and/or more stringent requirements and provisions for their application, issued by the Administration of the State whose flag the craft is entitled to fly and/or of the State where the base port from which the craft is intended to operate is situated.

**P.5 Novel or unusual features**

Craft presenting novel or unusual arrangements for items such as systems, apparatuses and devices, described in these rules, to which the requirements of these rules do not apply directly, either in whole or on part, may be classed on an individual basis, at the discretion of the Society.

# **PREAMBLE OF THE INTERNATIONAL CODE OF SAFETY FOR HIGH-SPEED CRAFT, 2000**

**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 time, 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 Code) 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** *This 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 such 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 Convention on Load Lines, 1966. 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.*

## Preamble of the International Code of Safety for High-Speed Craft, 2000

**8** *The above-mentioned safety concepts were originally reflected in the DSC Code and in 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 or passenger craft carrying larger numbers of passenger 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 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, 1974 is achieved. Where the application of new technology or design indicates an equivalent safety level to the strict application of this 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 this 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 should be reviewed by the Organization at intervals preferably not exceeding 4 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.*

## SECTION 1

## GENERAL COMMENTS AND REQUIREMENTS

**1.1 General comments**

*This Code shall be applied as a complete set of comprehensive requirements. It contains requirements for the design and construction of high-speed craft engaged on international voyages, the equipment which shall be provided and the conditions for their operation and maintenance. The basic aim of the Code is to set levels of safety which are equivalent to those of conventional ships required by the International Convention for the Safety of Life at Sea, 1974, as amended, (SOLAS Convention) and the International Convention on Load Lines, 1966, (Load Line Convention) by the application of constructional and equipment standards in conjunction with strict operational controls.*

*Note: Refer to MSC/Circ.652 on Application of the 1966 LL Convention to high-speed craft.*

**C1.1(a)** The attention of Shipowners, Shipdesigners and Flag Administrations is drawn to the innovative aspects of designs of High Speed Craft.

The present Rules may need to be adapted to cover particular designs.

It is assumed as a condition precedent to classification that the craft are operated with professional care and normal prudent seamanship.

**C1.1(b)** Craft satisfying the requirements of these Rules are assigned the notation HSC or High Speed Craft.

**1.2 General requirements**

*The application of the provisions of this Code is subject to the following general requirements that:*

- .1 the Code will be applied in its entirety;*
- .2 the management of the company operating the craft exercises strict control over its operation and maintenance by a quality-management system*

*Note: Refer to the International Safety Management (ISM) Code adopted by the Organization by resolution A.741(18), as may be amended.*

- .3 the management ensures that only persons qualified to operate the specific type of craft used on the intended route are employed;*

*.4 the distances covered and the worst intended conditions in which high-speed craft operations are permitted will be restricted by the imposition of operational limits;*

*.5 the craft will at all times be in reasonable proximity to a place of refuge, having due regard to the provisions of 1.3.4;*

*.6 adequate communications facilities, weather forecasts and maintenance facilities are available within the area of craft operation;*

*.7 in the intended area of operation suitable rescue facilities will be readily available;*

*.8 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;*

*.9 efficient facilities are provided for the rapid and safe evacuation of all persons into survival craft;*

*.10 all passengers and crew are provided with seats;*

*.11 no enclosed sleeping berths for passengers are provided.*

**C1.2 (a)** With reference to 1.2.2, craft managed by companies operating with a Safety Management System complying with the Society Rules are assigned a special notation. To this effect, the relevant requirements of Sections 18 and 19 are to be checked. This notation is entered in the Class Certificate and the Register Book.

**C1.2 (b)** The limitations on navigation indicated in 1.2.4 and 1.2.5 are subject to specific navigation/restriction notations in Society Rules.

**1.3 Application**

**1.3.1** *This Code applies to high speed craft as specified in 1.3.4 engaged in international voyages the keels of which are laid or which are at a similar stage of construction on or after 1 July 2002.*



**C1.3.1** In addition to the craft specified in 1.3.1, these Rules also apply to high speed craft engaged in national voyages. Exemptions from some of the requirements of the Rules may be granted when particular circumstances (e.g. restricted services) warrant this, in the opinion of the Society Head Office.

**1.3.2** For the purpose of this Code, the term “a similar stage of construction” means the stage at which:

**.1** construction identifiable with a specific craft begins; and

**.2** assembly of that craft has commenced comprising at least 50 tonnes or three per cent of the estimated mass of all material used in the structure, including superstructure and deckhouse, whichever is less.

**1.3.3** For the purpose of this Code:

**.1** the expression “craft constructed” means craft the keels of which are laid or which are at a similar stage of construction; and

**.2** a cargo craft, whenever built, which is converted to a passenger craft shall be treated as a passenger craft constructed on the date on which such a conversion commences.

**1.3.4** This Code applies to:

**.1** passenger craft which do not proceed in the course of their voyage more than four hours at operational speed from a place of refuge; and

**.2** cargo craft of 500 gross tonnage and upwards which do not proceed in the course of their voyage more than 8 h at operational speed from a place of refuge when fully laden.

**C1.3.4** In addition to the cargo craft specified in 1.3.4.2, these Rules also apply as far as appropriate to cargo craft of less than 500 tons gross tonnage.

**1.3.5** This Code, unless expressly provided otherwise, does not apply to:

**.1** craft of war and troopcraft;

**.2** craft not propelled by mechanical means;

**.3** wooden craft of primitive build;

**.4** pleasure craft not engaged in trade; and

**.5** fishing craft.

**C1.3.5** However, classification may be considered for craft referred to in 1, 2, 4 and 5 above.

**1.3.6** This Code does not apply to craft solely navigating the Great Lakes of North America and the River St. Lawrence as far east as a straight line drawn from Cap des Rosiers to West Point, Anticosti Island and, on the north side of Anticosti Island, the 63rd meridian.

**1.3.7** The application of this Code shall be verified by the Administration and be acceptable to the Governments of the States to which the craft will be operating.

**C1.3.7** The Classification of a craft, or more generally any Society acts and decisions, do not absolve the interested parties 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 provisions for their application.

## 1.4 Definitions

For the purpose of this Code, unless expressly provided otherwise, the terms used therein have the meanings defined in the following paragraphs. Additional definitions are given in the general parts of the various Sections.

**1.4.1** “Administration” means the Government of the State whose flag the craft is entitled to fly.

**1.4.2** “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.

**1.4.3** “Anniversary date” means the day and the month of each year which will correspond to the date of expiry of the relevant certificate.

**1.4.4** “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.

**1.4.5** “Auxiliary machinery spaces” are spaces containing internal combustion engines of power output up to 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.

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

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

**.1** appropriate facilities providing continuous radio communications with the craft at all times while in ports and at sea;

**.2** means for obtaining a reliable weather forecast for the corresponding region and its due transmission to all craft in operation;

**.3** for a category A craft, access to facilities provided with appropriate rescue and survival equipment; and

**.4** access to craft maintenance services with appropriate equipment.

**C1.4.7** It is the owner's responsibility to propose a base port to the Administration for approval.

**1.4.8** "Base port State" means the State in which the base port is located.

**1.4.9** "Breadth (B)" means breadth 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.

**1.4.10** "Cargo craft" 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.

**1.4.11** "Cargo spaces" are all spaces other than special category spaces and ro-ro spaces used for cargo and trunks to such spaces. For the purposes of Section 7, part D, "cargo spaces" include ro-ro spaces, special category spaces and open deck spaces.

**1.4.12** "Category A craft" is any high-speed passenger craft:

**.1** 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

**.2** carrying not more than 450 passengers.

**1.4.13** "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 any essential machinery and safety systems in any one compartment being disabled, the craft retains the capability to navigate safely. The damage scenarios considered in Section 2 should not be inferred in this respect.

**C1.4.13** With reference to 1.4.13, the term "navigate safely" means that the craft can reach the port of refuge within the period of weather forecast validity.

**1.4.14** "Company" means the company as defined in Chapter IX of the Convention.

**1.4.15** "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.

**1.4.16** "Control stations" are those spaces in which the craft's radio or navigating 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.

**1.4.17** "Convention" means the International Convention for the Safety of Life at Sea, 1974, as amended.

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

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

**1.4.20** "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.

**1.4.21** "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 requirements of Sections 2 and 3.

**1.4.22** "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.

**1.4.23** "Failure Mode and Effect Analysis (FMEA)" is an examination, in accordance with annex 4, of the craft's system and equipment to determine whether any reasonably probable failure or improper operation can result in a hazardous or catastrophic effect.

**1.4.24** "Fire Test Procedures Code (FTP Code)" means the International Code for Application of Fire Test Procedures, as defined in Chapter II-2 of the Convention.

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

**1.4.26** "Flashpoint" means a flashpoint determined by a test using the closed-cup apparatus referenced in the International Maritime Dangerous Goods (IMDG) Code.

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

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

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

**1.4.30** "High-speed craft" is a craft capable of maximum speed, in metres per second (m/s), equal to or exceeding:

$$3.7 \nabla^{0.1667}$$

where:

$\nabla$  : volume of displacement corresponding to the design waterline (m<sup>3</sup>)

excluding craft the hull of which is supported completely clear above the water surface in non-displacement mode by aerodynamic forces generated by ground effect.

**1.4.31** "Hydrofoil craft" is a craft the hull of which is supported completely clear above the water surface in non-displacement mode by hydrodynamic forces generated on foils.

**1.4.32** "Length (L)" means the overall length 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.

**1.4.33** "Lightweight" is the displacement of the craft in tonnes without cargo, fuel, lubricating oil, ballast water, fresh water and feedwater in tanks, consumable stores, passengers and crew and their effects.

**1.4.34** "Life-Saving Appliances Code (LSA Code)" means the International Life-Saving Appliance Code as defined in Chapter III of the Convention.

**1.4.35** "Machinery spaces" are spaces containing internal combustion engines with aggregate total power output of more than 110 kW, generators, oil fuel units, propulsion machinery, major electrical machinery and similar spaces and trunks to such spaces.

**1.4.36** "Maximum operational weight" means the overall weight up to which operation in the intended mode is permitted by the Administration.

**1.4.37** "Maximum speed" is the speed achieved at the maximum continuous propulsion power for which the craft is certified at maximum operational weight and in smooth water.

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

**1.4.39** "Oil fuel unit" includes any equipment for the preparation of oil fuel and delivery of oil fuel, heated or not, to boilers and engines (including gas turbines) at a pressure of more than 0,18 N/mm<sup>2</sup>.

**1.4.40** "Open ro-ro spaces" are those ro-ro spaces:

.1 to which any passengers carried have access;  
and

.2 either:

.2.1 are open at both ends; or

.2.2 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.

**1.4.41** "Operating limitations" means the craft limitations in respect of handling, controllability and performance and the craft operational procedures within which the craft is to operate.

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

**1.4.43** "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.

**1.4.44** "Operational speed" is 90% of maximum speed.

**1.4.45** "Organization" means the International Maritime Organization.

**1.4.46** "Passenger" is every person other than:

.1 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

.2 a child under one year of age.

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

**1.4.48** "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.

**1.4.49** "Public spaces" are those spaces allocated for the passengers and include bars, refreshment kiosks, smoke rooms, main seating areas, lounges, dining rooms, recreation rooms, lobbies, lavatories and similar spaces, and may include sales shops.

**1.4.50** "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.

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

**1.4.52** "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.

**1.4.53** "Service spaces" are those enclosed spaces used for pantries containing food warming equipment but no cooking facilities with exposed heating surfaces, lockers, sales shops, store-rooms and enclosed baggage rooms.

**1.4.54** "Significant wave height" is the average height of the one third highest observed wave heights over a given period.

**1.4.55** "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.

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

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

**1.4.58** "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.

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

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

**1.4.61** "Worst intended conditions" means the specified environmental conditions within which the intentional operation of the craft is provided for in the certification of the craft. This shall 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.

**C1.4.62** "Approved type" means the status conferred by the Society on a particular and clearly identified material, item of equipment or process, shown by design assessment to meet all the stipulations of Society Rules for the specified application(s).

**C1.4.63** "Small waterplane area twin hull" (SWATH) is a craft for which the weight is substantially supported by a submerged twin hull connected to the emerging part of the craft by struts with a small waterplane area.

## 1.5 Surveys

**1.5.1** Each craft shall be subject to the surveys specified below:

**.1** an initial survey before the craft is put in service or before the Certificate is issued for the first time;

**.2** a renewal survey at intervals specified by the Administration but not exceeding 5 years except where 1.8.5 or 1.8.10 is applicable;

**.3** a periodical survey within three months before or after each anniversary date of the Certificate; and

**.4** an additional survey as the occasion arises.

**C1.5.1** For the purpose of Classification, the renewal (special) survey and periodical (annual) survey include a bottom survey in dry condition.

Other surveys (e.g. tailshaft surveys, boiler surveys, surveys of additional class notations) are required according to Society Rules.

**1.5.2** The surveys referred to in 1.5.1 shall be carried out as follows:

**.1** the initial survey shall include:

**.1.1** an appraisal of the assumptions made and limitations proposed in relation to loadings, environment, speed and manoeuvrability;

**.1.2** an appraisal of the data supporting the safety of the design, obtained, as appropriate, from calculations, tests and trials;

**.1.3** a failure mode and effect analysis as required by this Code;

**.1.4** an investigation into the adequacy of the various manuals to be supplied with the craft; and

**.1.5** a complete inspection of the structure, safety equipment, radio installations and other equipment, fittings, arrangements and materials to ensure that they comply with the requirements of the Code, are in satisfactory condition and are fit for the service for which the craft is intended;

**.2** the renewal and periodical surveys shall include a complete inspection of the structure, including the outside of the craft's bottom and related items, safety equipment, radio installations and other equipment as referred to in 1.5.2.1 to ensure that they comply with the requirements of the Code, are in satisfactory condition and are fit for the service for which the craft is intended. The inspection of the craft's bottom shall be conducted with the craft out of the water under suitable conditions for close-up examination of any damaged or problem areas; and

**.3** an additional survey, either general or partial according to the circumstances, shall be made after a repair resulting from investigations prescribed in 1.7.3, or whenever any important repairs or renewals are made. The survey shall be such as to ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are in all respects satisfactory, and that the craft complies in all respects with the requirements of the Code.

**C1.5.2 (a)** With reference to 1.5.2.1.4, for classification, also refer to manuals required by it.

**C1.5.2 (b)** With reference to 1.5.2.1.5, for classification, refer to Society Rules.

**C1.5.2 (c)** With reference to 1.5.2.2, for classification, the periodical (annual) survey consists in a complete inspection of external and accessible parts of the structure.

**C1.5.2 (d)** With reference to 1.5.2.3, as regards the classification, such additional surveys also apply to any other circumstances liable to affect classification of the craft. Relevant inspections are to ensure that the necessary repairs/replacements are satisfactory for the purpose of classification.

All surveys are to be made by Society Surveyors at the request of the Owner.

**1.5.3** The periodical surveys referred to in 1.5.1.3 shall be endorsed on the High-Speed Craft Safety Certificate.

**C1.5.3** Procedures for issue or endorsement of classification certificates are stipulated in Society Rules.

**1.5.4** The inspection and survey of the craft, so far as regards the enforcement of the provisions of the Code, shall be carried out by officers of the Administration. The Administration may, however, entrust the inspections and surveys either to surveyors nominated for the purpose or to organizations recognized by it.

**1.5.5** An Administration nominating surveyors or recognizing organizations to conduct inspections and surveys as set forth in 1.5.4 shall, as a minimum, empower any nominated surveyor or recognized organization to:

**.1** require repairs to a craft; and

**.2** carry out inspections and surveys if requested by the appropriate authorities of a port State.

The Administration shall notify the Organization of the specific responsibilities and conditions of the authority delegated to nominated surveyors or recognized organizations.

**1.5.6** When a nominated surveyor or recognized organization determines that the condition of the craft or its equipment does not correspond substantially with the particulars of the Certificate or is such that the craft is not fit to operate without danger to the craft or persons on board, the surveyor or organization shall immediately ensure that corrective action is taken and shall, in due course, notify the Administration. If such corrective action is not taken, the Certificate shall be withdrawn and the Administration shall be notified immediately; and, if the craft is in an area under the jurisdiction of another Government, the appropriate authorities of the port State shall be notified immediately. When an officer of the Administration, a nominated surveyor or a recognized organization has notified the appropriate authorities of the port State, the Government of the port State concerned shall give such officer, surveyor or organization any necessary assistance to carry out their obligations under this section. When applicable, the Government of the port State concerned shall ensure that the craft shall not continue to operate until it can do so without danger to the craft or the persons on board.

**C1.5.6** With reference to 1.5.6, conditions for validity of class of craft are stipulated in the Society's Rules.

**1.5.7** In every case, the Administration shall fully guarantee the completeness and efficiency of the inspection and survey, and shall undertake to ensure the necessary arrangements to satisfy this obligation.

## **1.6 Approvals**

The owner of a craft shall accept the obligation to supply sufficient information to enable the Administration to fully assess the features of the design. It is strongly recommended that the Company and the Administration and, where appropriate, the port State or States shall commence discussions at the earliest possible stage so that the Administration may fully evaluate the design in determining what additional or alternative requirements shall be applied to the craft, to achieve the required level of safety.

**C1.6.1** Conditions of design review of the craft, for classification purposes, are stipulated in the Society's Rules.

## **1.7 Maintenance of conditions after survey**

**1.7.1** The condition of the craft and its equipment shall be maintained to conform with the provisions of this Code to ensure that the craft in all respects will remain fit to operate without danger to the craft or the persons on board.

**C1.7.1** With reference to 1.7.1, the above responsibility lies with the Owner of the craft (or his representative).

**1.7.2** After any survey of the craft under section 1.5 has been completed, no change shall be made to structure, equipment, fittings, arrangements and materials covered by the survey, without the sanction of the Administration.

**1.7.3** Whenever an accident occurs to a craft or a defect is discovered, either of which affects the safety of the craft or the efficiency or completeness of structure, equipment, fittings, arrangements and materials, the person in charge or owner of the craft shall report at the earliest opportunity to the Administration, the nominated surveyor or recognized organization responsible, who shall cause investigations to be initiated to determine whether a survey, as required by section 1.5, is necessary. If the craft is in an area under the jurisdiction of another Government, the person in charge or the owner shall also report immediately to the appropriate authorities of the port State and the nominated surveyor or recognized organization shall ascertain that such a report has been made.

**C1.7.3** With reference to 1.7.2 and 1.7.3, it is the Owner's responsibility to inform the Society of any modification, damage or repair affecting the class of the craft.

## **1.8 High-Speed Craft Safety Certificate**

**1.8.1** A Certificate called a High-Speed Craft Safety Certificate is issued after completion of an initial or renewal survey to a craft which complies with the requirements of the Code. The Certificate shall be issued or endorsed either by the Administration or by any person or organization recognized by it. In every case, that Administration assumes full responsibility for the Certificate.

**1.8.2** A Contracting Government to the Convention may, at the request of the Administration, cause a craft to be surveyed and, if satisfied that the requirements of the Code are complied with, shall issue or authorise the issue of a Certificate to the craft and, where appropriate, endorse or authorise the endorsement of a Certificate on the craft in accordance with the Code. Any Certificate so issued shall contain a statement to the effect that it has been issued at the request of the Government of the State the flag of which the craft is entitled to fly, and it shall have the same force and receive the same recognition as a Certificate issued under 1.8.1.

**1.8.3** The Certificate shall be that of the model given in the annex 1 to the Code. If the language used is not English, French or Spanish, the text shall include a translation into one of these languages.

**1.8.4** The High-Speed Craft Safety Certificate shall be issued for a period specified by the Administration which shall not exceed 5 years.

**1.8.5** Notwithstanding the requirements of 1.8.4, when the renewal survey is completed within three months before the expiry date of the existing Certificate, the new Certificate shall be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of expiry of the existing Certificate.

**1.8.6** When the renewal survey is completed after the expiry date of the existing Certificate, the new Certificate shall be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of expiry of the existing Certificate.

**1.8.7** When the renewal survey is completed more than 3 months before the expiry date of the existing Certificate, the new Certificate shall be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of completion of the renewal survey.

**1.8.8** If a Certificate is issued for a period of less than 5 years, the Administration may extend the validity of the Certificate beyond the expiry date to the maximum period specified in 1.8.4, provided that the surveys when a Certificate is issued for a period of 5 years are carried out.

**1.8.9** If a renewal survey has been completed and a new Certificate cannot be issued or placed on board the craft before the expiry date of the existing Certificate, the person or organization authorized by the Administration may endorse the existing Certificate and such a Certificate shall be accepted as valid for a further period which shall not exceed 5 months from the expiry date.

**1.8.10** If a craft, at the time when a Certificate expires, is not in the place in which it is to be surveyed, the Administration may extend the period of validity of the Certificate but this extension shall be granted only for the purpose of allowing the craft to proceed to the place in which it is to be surveyed, and then only in cases where it appears proper and reasonable to do so. No Certificate shall be extended for a period longer than one month, and a craft to which an extension is granted shall not, on its arrival in the place in which it is to be surveyed, be entitled by virtue of such extension to leave that place without having a new Certificate. When the renewal survey is completed, the new Certificate shall be valid to a date not exceeding 5 years from the date of expiry of the existing Certificate before the extension was granted.

**1.8.11** In special circumstances, as determined by the Administration, a new Certificate need not be dated from the date of expiry of the existing Certificate as required by 1.8.6 or 1.8.10. In these circumstances, the new Certificate shall be valid to a date not exceeding 5 years from the date of completion of the renewal survey.

**1.8.12** If a periodical survey is completed before the period specified in section 1.5 then:

**.1** the anniversary date shown on the relevant Certificate shall be amended by endorsement to a date which shall not be more than 3 months later than the date on which the survey was completed;

**.2** the subsequent periodical survey required by section 1.5 shall be completed at the intervals prescribed by 1.5 using the new anniversary date; and

**.3** the expiry date may remain unchanged provided one or more periodical surveys are carried out so that the maximum intervals between the surveys prescribed by 1.5.1.3 are not exceeded;

**1.8.13** A Certificate issued under 1.8.1 or 1.8.2 shall cease to be valid in any of the following cases:

**.1** if the relevant surveys are not completed within the periods specified in 1.5.1;

**.2** if the Certificate is not endorsed in accordance with 1.5.3;

**.3** upon transfer of the craft to the flag of another State. A new Certificate shall only be issued when the Government issuing the new Certificate is fully satisfied that the craft is in compliance with the requirements of 1.7.1 and 1.7.2. In the case of a transfer between Governments that are Contracting Governments to the Convention if requested within 3 months after the transfer has taken place, the Government of the State whose flag the craft was formerly entitled to fly shall, as soon as possible, transmit to the Administration a copy of the Certificate carried by the craft before the transfer and, if available, copies of the relevant survey reports.

**C1.8.13** With reference to 1.8.13.2, for classification purpose, the Society's Rules apply.

Conditions for validity of class are stipulated in the Society's Rules.

**1.8.14** The privileges of the Code may not be claimed in favour of any craft unless it holds a valid Certificate.

## **1.9 Permit to Operate High-Speed Craft**

**1.9.1** The craft shall not operate commercially unless a Permit to Operate High-Speed Craft is issued and valid in addition to the High-Speed Craft Safety Certificate. Transit voyage without passengers or cargo may be undertaken without the Permit to Operate High-Speed Craft.

**1.9.2** The Permit to Operate High-Speed Craft shall be issued by the Administration to certify compliance with 1.2.2 to 1.2.7 and stipulate conditions of the operation of the craft and drawn up on the basis of the information contained in the route operational manual specified in section 18 of this Code.

**1.9.3** Before issuing the Permit to Operate, the Administration shall consult with each port State to obtain details of any operational conditions associated with operation of the craft in that State. Any such conditions imposed shall be shown by the Administration on the Permit to Operate and included in the route operational manual.

**1.9.4** A port State may inspect the craft and audit its documentation for the sole purpose of verifying its compliance with the matters certified by and conditions associated with the Permit to Operate. Where deficiencies are shown by such an audit, the Permit to Operate ceases to be valid until such deficiencies are corrected or otherwise resolved.

**1.9.5** The provisions of 1.8 shall apply to the issue and the period of validity of the Permit to Operate High-Speed Craft.

**1.9.6** The Permit to Operate High-Speed Craft shall be that of the model given in annex 2 to this Code. If the language used is not English, French or Spanish, the text shall include a translation into one of these languages.

## **1.10 Control**

**1.10.1** The provisions of regulation I/19 of the Convention shall be applied to include the Permit to Operate High-Speed Craft in addition to the Certificate issued under 1.8.

## **1.11 Equivalents**

**1.11.1** Where this Code requires that a particular fitting, material, appliance or apparatus, or type thereof, shall be fitted or carried in a craft, or that any particular provision shall be made, the Administration may allow any other fitting, material, appliance or apparatus, or type thereof, to be fitted or carried, or any other provision to be made in the craft, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance or apparatus, or type thereof, or provision, is at least as effective as that required by this Code.

**C1.11.1** With reference to 1.11.1, for classification purpose, the Society's Rules apply.

**1.11.2** Where compliance with any of the requirements of this Code would be impractical for the particular designs of the craft, the Administration may substitute those with alternative requirements provided that equivalent safety is achieved. The Administration which allows any such substitution shall communicate to the Organization particulars of these substitutions and the reasons therefore, which the Organization shall circulate to its Member Governments for their information.

## **1.12 Information to be made available**

**1.12.1** The Administration shall ensure 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 shall include a route operational manual, craft operating manual, maintenance manual and servicing schedule. Such information shall be updated as necessary.

**1.12.2** The manuals shall contain at least the information specified in Section 18, and shall be in a language understood by the crew. Where this language is not English, a translation into English shall be provided of at least the route operational manual and the craft operating manual.

**C1.12** With reference to 1.12, the operating manual is to be considered as a class matter.

## **1.13 Further developments**

**1.13.1** It is recognized that there is much ongoing research and development in the design of high-speed craft and that new types may emerge which have different geometry to that envisaged during the formulation of this Code. It is important that this Code does not restrict this progress and the development of new designs.

**1.13.2** A design may be produced which cannot comply with the provisions of this Code. In such a case the Administration shall determine the extent to which the provisions of the Code are applicable to the design and, if necessary, develop additional or alternative requirements to provide an equivalent level of safety for the craft.

**1.13.3** The foregoing shall be considered by the Administration when assessing the granting of equivalents under the Code.



**1.14      *Circulation of safety information***

**1.14.1**      *In the event that an Administration has cause to investigate an accident involving a craft to which this Code applies, that Administration shall provide a copy of the official report to the Organization, which will invite Member States to note the existence of the report and to obtain a copy.*

**1.14.2**      *In the event that operational experience reveals structural or equipment failures affecting the safety of a design, craft owners shall inform the Administration.*

**1.15      *Review of the code***

**1.15.1**      *The Code 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.*

**1.15.2**      *Where a new development in design and technology has been found acceptable to an Administration, that Administration may submit particulars of such development to the Organization for consideration for incorporation into the Code during periodical review.*

## SECTION 2

## BUOYANCY, STABILITY AND SUBDIVISION

**Part A General****C2.0 Documents to be submitted**

**C2.0.1** The following drawings and documents are to be submitted in triplicate for approval where appropriate (in A4-size where possible). The Society reserves the right to ask for supplementary copies if deemed necessary in particular cases.

- .1 Hull, plotted and numerically;
- .2 Side contour, plotted and numerically;
- .3 Coordinates of non-watertight and non-weather-tight openings;
- .4 Hydrostatic tables;
- .5 Cross curve tables;
- .6 Data of boundaries of all subcompartments and a plan in which these compartments are stated;
- .7 Damage stability investigation, complete input and output data including initial loading conditions;
- .8 Damage control plan;
- .9 Inclining test report;
- .10 Intact stability booklet.

**C2.0.2** Further documentation may be required if deemed necessary by the Society.

**2.1 General**

**2.1.1** A craft shall be provided with:

- .1 *stability characteristics and stabilization systems adequate for safety when the craft is operated in the non-displacement mode and during the transitional mode;*
- .2 *buoyancy and stability characteristics adequate for safety where the craft is operated in the displacement mode, both in the intact condition and the damaged condition; and*
- .3 *stability characteristics in the non-displacement and transitional modes adequate to transfer the craft*

*safely to displacement mode in case of any system malfunction.*

**2.1.2** *Account shall be taken of the effect of icing in the stability calculations. An example of established practice for ice accretion allowances is given in annex 5 for the guidance of the Administration.*

**2.1.3** *For the purpose of this and other Sections, unless expressly defined otherwise, the following definitions apply:*

**.1** *“Downflooding point” means any opening through which flooding of the spaces which comprise the reserve buoyancy could take place while the craft is in the intact or damaged condition, and inclines to an angle past the angle of equilibrium.*

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

**.3** *“Monohull craft” means any craft which is not a multihull craft.*

**.4** *“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.*

**.5** *“Permeability” of a space means the percentage of the volume of that space which can be occupied by water.*

**.6** *“Skirt” means a downwardly extending, flexible structure used to contain or divide an air cushion.*

**2.1.4** *Other means of demonstrating compliance with the requirements of any part of this Section may be accepted, provided that the method chosen can be shown to provide an equivalent level of safety. Such methods may include:*

- .1 *mathematical simulation of dynamic behaviour;*
- .2 *scale model testing; and*
- .3 *full-scale trials.*

**2.1.5** *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:*

**.1** *directional instability, which is often coupled to roll and pitch instabilities;*

**.2** *broaching and bow diving in following seas at speeds near to wave speed, applicable to most types;*

**.3** *bow diving of planing monohulls and catamarans due to dynamic loss of longitudinal stability in relatively calm seas;*

**.4** *reduction in transverse stability with increasing speed of monohulls;*

**.5** *porpoising of planing monohulls, being coupled pitch and heave oscillations, which can become violent;*

**.6** *chine tripping, being a phenomenon of planing monohulls occurring when the immersion of a chine generates a strong capsizing moment;*

**.7** *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;*

**.8** *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;*

**.9** *reduction in effective metacentric height (roll stiffness) of surface effect ship (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*

**.10** *resonant rolling of SES in beam seas, which, in extreme cases, can result in capsize.*

**2.1.6** *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.*

#### **C2.1.7 Number and location of bulkheads**

**.1** At least the following watertight bulkheads are to be fitted in all craft:

- one collision bulkhead,
- one afterpeak bulkhead,
- one bulkhead at each end of the machinery space.

**.2** The distance, in m, of the collision bulkhead from the forward perpendicular is to be between  $0,05 L$  and  $0,05 L + 3$ .

**.3** The collision bulkhead is to be fitted at least in places used for providing the reserve of buoyancy used for proving compliance with the intact and damage stability requirements of the present HSC Rules. The collision bulkhead is to extend vertically up to 0,5 of the worst intended significant wave height above the most unfavourable damage waterline.

### **2.2 Intact buoyancy and watertight and weathertight integrity**

#### **2.2.1 Intact buoyancy**

**2.2.1.1** *All craft shall have a sufficient reserve of buoyancy at the design waterline to meet the intact and damage stability requirements of this Section. 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 shall be calculated by including only those compartments that are:*

**.1** *watertight and situated below the datum, or watertight or weathertight and situated above the datum.*

*In considering the stability after damage, flooding shall be assumed to occur until limited by watertight boundaries in the equilibrium condition, and weathertight boundaries in intermediate stages of flooding and within the range of positive righting lever required to satisfy the residual stability requirements.*

*Craft built in conformity with the requirements of organizations recognised by the Administration, in accordance with regulation XI/1 of the Convention may be considered to possess adequate strength and integrity.*

**2.2.1.2** *Arrangements shall be provided for checking the watertight or weathertight integrity of those compartments taken into account in 2.2.1.1, and the details incorporated in the Craft Operating Manual required by 18.2.1.*

#### **2.2.2 Openings in watertight divisions**

**2.2.2.1** *The number of openings in watertight bulkheads shall be reduced to 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.*

**2.2.2.2** *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. 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.

**2.2.2.3** Type approval may be accepted in lieu of testing individual doors, provided the approval process includes pressure testing to a head equal to, or greater, than the required head (refer to 2.2.2.2).

**2.2.2.4** All watertight doors shall be capable of being operated when the craft is inclined up to 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.

**2.2.2.5** 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.

**2.2.2.6** Watertight doors shall be capable of being closed by remote control from the operating compartment in not less than 20 s and not more than 40 s, and shall be provided with an audible alarm, distinct from other alarms in the area, which will sound for at least 5 s but no more than 10 s 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 the Convention. 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. If the Administration is satisfied that such doors are essential for the safe work of the craft, hinged watertight doors having only local control may be permitted for areas to which crew only have access, provided they are fitted with remote indicators as required by 2.2.2.4.

**2.2.2.7** 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. Valves on scuppers from weathertight compartments, included in the stability calculations, shall have arrangements for remote closing from the operating station.

**2.2.2.8** 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.

**C.2.2.2.9** No doors, manholes, or access openings are generally permitted in the collision bulkhead below the datum. The society may authorize a single manhole in the collision bulkhead, in each hull for catamaran, if deemed necessary.

## **2.2.3 Inner bow doors**

**2.2.3.1** 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:

**.1** weathertight to the deck above, which deck shall itself be weathertight forward to the bow loading opening;

**.2** 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;

**.3** forward of all positions on the vehicle deck in which vehicles are intended to be carried; and

**.4** part of a boundary designed to prevent flooding into the remainder of the craft.

**2.2.3.2** A craft shall be exempted from the requirement for such an inner bow door where one of the following applies:

**.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;

**.2** it can be demonstrated using model tests or mathematical simulations that when the craft is proceeding at a range of speeds up to 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:

**.1** the bow loading door is not reached by waves; or

**.2** having been tested with the bow loading door open to determine the maximum steady state volume of water which accumulates, it can be shown by static analysis that, with the same volume of water on the vehicle deck(s) the residual stability requirements of 2.6.11 and 2.13 or 2.15 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.*

*Where mathematical simulations are employed they shall already have been verified against full-scale or model testing;*

**.3** *bow loading openings lead to open ro-ro spaces provided with guard-rails or having freeing ports complying with 2.2.3.2.4;*

**.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 2.2.3.2.2 above or comply with the following:*

- .1**  $A \geq 0.3\ell$   
where:  
 $A$  : the total area of freeing ports on each side of the deck in m<sup>2</sup>;  
 $\ell$  : the length of the compartment in m;
- .2** *the craft shall maintain a residual freeboard to the deck of the ro-ro space of at least 1 m in the worst condition;*
- .3** *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*
- .4** *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.*

## **2.2.4 Other provisions for ro-ro craft**

**2.2.4.1** *All accesses in the ro-ro space that lead to spaces below the deck shall have a lowest point which is not less than the height required from the tests conducted according to 2.2.3.2.2 or 3 m above the design waterline.*

**2.2.4.2** *Where vehicle ramps are installed to give access to spaces below the deck of the ro-ro space, their openings shall be capable of being closed weathertight to prevent ingress of water below.*

**2.2.4.3** *Accesses in the ro-ro space that lead to spaces below the ro-ro deck and having a lowest point which is less than the height required from the tests conducted according to 2.2.3.2.2 or 3 m above the design waterline may be permitted 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.*

**2.2.4.4** *The accesses referred to in 2.2.4.2 and 2.2.4.3 above shall be fitted with alarm indicators in the operating compartment.*

**2.2.4.5** *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 unauthorised access by passengers thereto can be detected whilst the craft is underway (refer to 7.8.3.1).*

## **2.2.5 Indicators and surveillance**

### **2.2.5.1 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 systems shall be independent of the power supply for operating and securing the doors.*

### **2.2.5.2 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.*

## **2.2.6 Integrity of superstructure**

**2.2.6.1** *Where entry of water into structures above the datum would significantly influence the stability and buoyancy of the craft, such structures shall be:*

- .1** *of adequate strength to maintain the weathertight integrity and fitted with weathertight closing appliances; or*
- .2** *provided with adequate drainage arrangements; or*
- .3** *an equivalent combination of both measures.*

**2.2.6.2** *Weathertight superstructures and deck-houses 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.

### **2.2.7 Doors, windows, etc., in boundaries of weathertight spaces**

**2.2.7.1** 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 adjacent structure would experience permanent set or fail. Conformity with the requirements of organizations recognized by the Administration in accordance with regulation XI/1 of the Convention may be considered to possess adequate strength.

**2.2.7.2** For doors in weathertight superstructures, hose tests shall be carried out with a water pressure from the outside in accordance with specifications at least equivalent to those acceptable to the Organization

*Note: Refer to ISO 6042–Ships and Marine Technology–Weather-tight single-leaf steel doors, or a similar standard.*

**2.2.7.3** 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, sill heights may be reduced to the maximum which is consistent with the safe working of the craft.

**2.2.7.4** Windows shall not be permitted 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.

**2.2.7.5** Side scuttles to spaces below the datum shall be fitted with efficient hinged deadlights arranged inside so that they can be effectively closed and secured watertight.

**2.2.7.6** No side scuttle shall be fitted in a position so that its sill is below a line drawn parallel to and one metre above the design waterline.

### **2.2.8 Hatchways and other openings**

#### **2.2.8.1 Hatchways closed by weathertight covers**

The construction and the means for securing the weathertightness of cargo and other hatchways shall comply with the following:

**.1** 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, coaming heights may be reduced to the maximum which is consistent with the safe working of the craft;

**.2** the height of these coamings may be reduced, or the coamings omitted entirely, on condition that the Administration is satisfied that the safety of the ship is not thereby impaired in any sea conditions up to the worst intended conditions. Where coamings are provided, they shall be of substantial construction; and

**.3** the arrangements for securing and maintaining weathertightness shall ensure that the tightness can be maintained in any sea conditions up to the worst intended conditions.

#### **2.2.8.2 Machinery space openings**

**2.2.8.2.1** Machinery space openings shall be properly framed and efficiently enclosed by casings of ample strength and, where the casings are not protected by other structures, their strength shall be specially considered. Access openings in such casings shall be fitted with weathertight doors.

**2.2.8.2.2** 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, these heights may be reduced to the maximum which is consistent with the safe working of the craft.

**2.2.8.2.3** Machinery space ventilator openings shall comply with the requirements of 2.2.8.4.2.

#### **2.2.8.3 Miscellaneous openings in exposed decks**

**2.2.8.3.1** 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.

**2.2.8.3.2** 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.

**2.2.8.3.3** 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.

**2.2.8.3.4** 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 sill heights may be reduced to the maximum which is consistent with the safe working of the craft.

#### **2.2.8.4 Ventilators**

**2.2.8.4.1** 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, coaming heights may be reduced to the maximum which is consistent with the safe working of the craft.

**2.2.8.4.2** 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.

**2.2.8.4.3** Except as provided in 2.2.8.4.2, ventilator openings shall be provided with efficient weathertight closing appliances.

**2.2.8.4.4** Ventilator openings shall face aft or athwartships wherever practicable.

#### **2.2.9 Scuppers, inlets and discharges**

**2.2.9.1** 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 0.01 L, 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 that vertical distance exceeds 0.02 L, 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.

**2.2.9.2** Valves on scuppers from weathertight compartments included in the stability calculations shall be operable from the operating compartment.

**2.2.9.3** 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 discharges in connection with the operation of machinery shall be operable from the operating compartment.

**2.2.9.4** Scuppers leading from superstructures or deckhouses not fitted with weathertight doors shall be led overboard.

**2.2.9.5** All shell fittings and the valves required by this Code shall be of a suitable ductile material. Valves of ordinary cast iron or similar material shall not be acceptable.

#### **2.2.10 Air pipes**

**2.2.10.1** 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.

**2.2.10.2** All air pipes extending to exposed decks shall have a height from the deck to the point where water may have access below of at least 300 mm where the deck is less than 0.05 L above the design waterline, and 150 mm on all other decks.

**2.2.10.3** Air pipes may discharge through the side of the superstructure provided that this is at a height of at least 0.02 L above any waterline when the intact craft is heeled to an angle of 15°, or 0.02 L above the highest waterline at all stages of flooding as determined by the damaged stability calculations, whichever is higher.

**2.2.10.4** All air pipes shall be equipped with weather-tight closing devices that close automatically.

#### **2.2.11 Freeing ports**

**2.2.11.1** 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) on each side of the craft for each well on the weather deck of the main hull(s) shall be:

**.1** where the length of bulwark ( $\ell$ ) in the well is 20 m or less:

$$A = 0.7 + 0.035 \ell \text{ (m}^2\text{); and}$$

**.2** where  $\ell$  exceeds 20 m:

$$A = 0.07 \ell \text{ (m}^2\text{),}$$

and, in no case,  $\ell$  need be taken as greater than 0.7 L.

If the bulwark is more than 1.2 m in average height, the required area shall be increased by 0.004 square metres per metre of length of well for each 0.1 metre difference in height. If the bulwark is less than 0.9 m in average height, the required area shall be decreased by 0.004 square metres per metre of length of well for each 0.1 metre difference in height.

**2.2.11.2** 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.

**2.2.11.3** 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.

**2.2.11.4** Craft, having superstructures which are open in front or both ends, shall comply with the provisions of 2.2.11.1.

**2.2.11.5** In craft, having superstructures which are open at the aft end, the minimum freeing port area shall be:  $A = 0.3 b$  (m<sup>2</sup>) where:

$b$  : the breadth of the craft at the exposed deck (m).

**2.2.11.6** Ro-ro craft fitted with bow loading openings leading to open vehicle spaces shall comply with the provisions of 2.2.3.

### 2.3 Intact stability in the displacement mode

**2.3.1** Hydrofoil craft fitted with surface-piercing foils and/or fully submerged foils shall have sufficient stability under all permitted cases of loading to comply with the relevant provisions of annex 6 and specifically maintain a heel angle of less than 10° when subjected to the greater of the heeling moments in 1.1.2 and 1.1.4 of that annex.

**2.3.2** Subject to 2.3.4, multihull craft other than hydrofoil craft shall meet the relevant requirements of annex 7 in all permitted cases of loading.

**2.3.3** Subject to 2.3.4, monohull craft other than hydrofoil craft shall meet the relevant requirements of annex 8 in all permitted conditions of loading.

**2.3.4** Where the characteristics of multihull craft are inappropriate for application of annex 7 or the characteristics of monohull craft are inappropriate for application

of annex 8, the Administration may accept alternative criteria equivalent to those stipulated, as appropriate to the type of craft and area of operation. The requirements of annexes 7 and 8 may be applied as indicated in Table 2.3.4, where:

$B_{WL}$  : maximum waterline beam at the design waterline (m); for multihull, this shall be taken to the outside of sidehulls

$A_{WP}$  : waterplane area at the design waterline (m<sup>2</sup>)

$\nabla$  : volume of displacement at the design waterline (m<sup>3</sup>)

$GM_T$  : transverse metacentric height in the loading condition corresponding to the design waterline, corrected for free surface effects (m).

**Table 2.3.4 - Table showing application of annexes 7 and 8 to monohull and multihull craft**

$GM_T$	$B_{WL} \cdot A_{WP} / \nabla$	
	$\leq 7$	$> 7$
$\leq 3.0$	annex 8	annex 8 or annex 7
$> 3.0$	annex 8 or annex 7	annex 7

### 2.4 Intact stability in the non-displacement mode

**2.4.1** The requirements of this section and section 2.12 shall be applied on the assumption that any stabilisation systems fitted are fully operational.

**2.4.2** The roll and pitch stability on the first and/or any other craft of a series shall be qualitatively assessed during operational safety trials as required by Section 18 and annex 9. The results of such trials may indicate the need to impose operational limitations.

**2.4.3** Where craft are fitted with surface-piercing structure or appendages, precautions shall 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 shall be determined, and the limitations on the use by virtue of craft speed or attitude shall be established.

**2.4.5** In the case of an air cushion vehicle fitted with flexible skirts, it shall be demonstrated that the skirts remain stable under operational conditions.



## 2.5 **Intact stability in the transitional mode**

**2.5.1** Under weather conditions up to the worst intended conditions, the time to pass from the displacement mode to the non-displacement mode and vice versa shall be minimised unless it is demonstrated that no substantial reduction of stability occurs during this transition.

**2.5.2** Hydrofoil craft shall comply with the relevant provisions of annex 6.

## 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 volume and surface permeabilities shall be, in general, as given in Table 2.6.2.

**Table 2.6.2**

Spaces	Permeability
Appropriated to cargo or stores	60
Occupied by accommodation	95
Occupied by machinery	85
Intended for liquids	0 or 95 (1)
Appropriated for cargo vehicles	90
Void spaces	95
(1) whichever results in the more severe requirements	

**2.6.3** Notwithstanding 2.6.2, permeability determined by direct calculation shall 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** The Administration may permit the use of low-density foam or other media to provide buoyancy in void spaces, provided that satisfactory evidence is provided that any such proposed medium is the most suitable alternative and is:

.1 of closed-cell form if foam, or otherwise impervious to water absorption;

.2 structurally stable under service conditions;

.3 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 7.4.3.7); and

.4 properly secured in place and easily removable for inspection of the void spaces.

**2.6.5** The Administration may permit void bottom spaces to be fitted within the watertight envelope of the hull without the provision of a bilge system or air pipes provided that:

.1 the structure is capable of withstanding the pressure head after any of the damages required by this section;

.2 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, 2.13 and 2.15 complied with;

.3 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 Section 18; and

.4 adequate ventilation is provided for inspection of the space under consideration as required by 2.2.1.2.

**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 shall also be investigated. The shape of the damage shall be assumed to be a parallelepiped.

### 2.6.7 **Extent of side damage**

The following side damages shall be assumed anywhere on the periphery of the craft:

.1 the longitudinal extent of damage shall be:  $0.75 \nabla^{1/3}$ , or  $(3 \text{ m} + 0.225 \nabla^{1/3})$ , or 11 m, whichever is the least;

.2 the transverse extent of penetration into the craft shall 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 shall be at least  $0.12 \nabla^{1/3}$  into the main buoyancy hull or tank structure; and

.3 the vertical extent of damage shall be taken for the full vertical extent of the craft, where:

$\nabla$  : volume of displacement corresponding to the design waterline ( $\text{m}^3$ ).

### 2.6.8 Extent of bottom damage in areas vulnerable to raking damage

#### 2.6.8.1 Application

.1 Any part of the surface of the hull(s) is considered to be vulnerable to raking damage if:

- .1 it is in contact with the water at operational speed in smooth water, and
- .2 it also lies below two planes which are perpendicular to the craft centreline plane and at heights as shown in Figure 2.6.8.1, 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

For multihulls, individual hulls shall be considered separately.

.2 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 below:

.3 Damage shall not be applied at the same time as that defined in 2.6.7 or 2.6.9.

#### 2.6.8.2 Extent

.1 Two different longitudinal extents shall be considered separately:

- .1.1 55% of the length  $L$ , measured from the most forward point of the underwater buoyant volume of each hull; and
- .1.2 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 50m.

.2 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 a girth along the shell equal to  $0.1 \nabla^{1/3}$ , where  $\nabla$  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 2.6.8.1.1.

### 2.6.9 Extent of bottom damage in areas not vulnerable to raking damage

#### 2.6.9.1 Application

This applies to all parts of the hull(s) which are not defined as vulnerable to raking damage in 2.6.8.1. Damage shall not be applied at the same time as that defined in 2.6.7 or 2.6.8.

#### 2.6.9.2 Extent

The following extent of damage shall be assumed:

.1 the length of damage in the fore-and-aft direction shall be  $0.75 \nabla^{1/3}$ , or  $(3 \text{ m} + 0.225 \nabla^{1/3})$ , or 11 m whichever is the least;

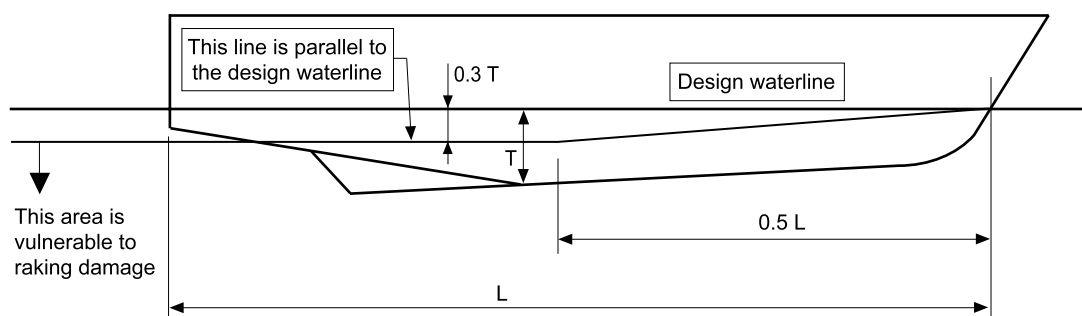
.2 the athwartships girth of damage shall be  $0.2 \nabla^{1/3}$ , and

.3 the depth of penetration normal to the shell shall be  $0.02 \nabla^{1/3}$ , where:

$\nabla$  : volume of displacement corresponding to the design waterline ( $m^3$ ).

2.6.10 In applying 2.6.8 and 2.6.9 to multihull craft, an obstruction at or below the design waterline of up to 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.

Figure 2.6.8.1



**2.6.11** Following any of the postulated damages detailed in 2.6.6 to 2.6.10, the craft in still water shall have sufficient buoyancy and positive stability to simultaneously ensure that:

**.1** for all craft other than 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 50% of the significant wave height corresponding to the worst intended conditions;

**.2** 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;

**.3** there is a positive freeboard from the damage waterline to survival craft embarkation positions;

**.4** essential emergency equipment, emergency radios, power supplies and public address systems needed for organizing the evacuation remain accessible and operational;

**.5** the residual stability of craft meets the appropriate criteria as laid out in annexes 7 and 8 according to table 2.3.4. Within the range of positive stability governed by the criteria of annexes 7 or 8, no unprotected opening shall be submerged.

**2.6.12** Downflooding openings referred to in 2.6.11.1 and 2.6.11.2 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, shall be inclined and the elements of its stability determined. When an accurate inclining is not practical, the lightweight displacement and centre of gravity shall be determined by a lightweight survey and accurate calculation.

**2.7.2** The master shall be supplied by the owner with reliable information relating to the stability of the craft in accordance with the following provisions of this paragraph. The information relating to stability shall, before issued to the master, be submitted to the Administration for approval, together with a copy thereof for their retention, and shall incorporate such additions and amendments as the Administration may in any particular case require.

**2.7.3** Where any alterations are made to a craft so as significantly to affect the stability information supplied to the master, amended stability information shall be provided. If necessary the craft shall be re-inclined.

**2.7.4** A report of each inclining or lightweight survey carried out in accordance with this Section and of the calculation therefrom of the lightweight condition particulars shall be submitted to the Administration for approval, together with a copy for their retention. The approved report shall be placed on board the craft by the owner in the custody of the master and shall incorporate such additions and amendments as the Administration may in any particular case require. The amended lightweight condition particulars so obtained from time to time shall be used by the master in substitution for such previously approved particulars when calculating the craft's stability.

**2.7.5** Following any inclining or lightweight survey, the master shall be supplied with amended stability information if the Administration so requires. The information so supplied shall be submitted to the Administration for approval, together with a copy thereof for their retention, and shall incorporate such additions and amendments as the Administration may in any particular case require.

**2.7.6** Stability information demonstrating compliance with this Section shall be furnished in the form of a stability information book which shall be kept on board the craft at all times in the custody of the master. The information shall include particulars appropriate to the craft and shall reflect the craft loading conditions and mode of operation. Any enclosed superstructures or deck-houses included in the cross curves of stability and the critical downflooding points and angles shall be identified. At the operating station there shall be plans showing clearly for each deck and hold the boundaries of the watertight compartments, the openings therein with their means of closure and position of any controls thereof.

**2.7.7** Every craft shall have scales of draughts marked clearly at the bow and stern. 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 shall also be fitted with a reliable draught-indicating system by which the bow and stern draughts can be determined.

**2.7.8** The owner or builder, as appropriate, shall ensure that the positions of the draught marks are accurately determined and that the marks are located on the hull in a permanent manner. Accuracy of the draught marks shall be demonstrated to the Administration prior to the inclining experiment.

## **2.8 Loading and stability assessment**

*On completion of loading of the craft and prior to its departure on a voyage, the master shall determine the trim and stability of the craft and also ascertain and record 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 Marking and recording of the design waterline**

**2.9.1** *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 2.9.2.2 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.*

### **2.9.2 Load line mark**

**2.9.2.1** *The load line 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 displace-*

*ment mode and at a height corresponding to the design waterline.*

**2.9.2.2** *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.*

**2.9.2.3** *Where practicable, the reference line should be related to the uppermost deck at side. Where it is not possible, the position of the reference line should be defined from the underside of keel at the longitudinal centre of flotation.*

**2.9.2.4** *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.*

**2.9.2.5** *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.*

### **2.9.3 Verification**

*The High-Speed Craft Safety Certificate shall not be delivered until the Administration has verified that the marks are correctly and permanently indicated on the sides of the craft.*

## **Part B Requirements for passenger craft**

### **2.10 General**

**2.10.1** Where compliance with this Section requires consideration of the effects of passenger weight, the following information shall be used:

- .1** The distribution of passengers is 4 persons per square metre.
- .2** Each passenger has a mass of 75 kg.
- .3** Vertical centre of gravity of seated passengers is 0.3 m above seat.
- .4** Vertical centre of gravity of standing passengers is 1.0 m above deck.
- .5** Passengers and luggage shall be considered to be in the space normally at their disposal.
- .6** Passengers shall be 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.

### **2.11 Intact stability in the displacement mode**

The craft shall have sufficient intact stability that, when in still water conditions, the inclination of the craft from the horizontal would not exceed 10° (under all permitted cases of loading and uncontrolled passenger movements as may occur).

### **2.12 Intact stability in the non-displacement mode**

**2.12.1** The total heel angle in still water due to the effect of passenger movements or due to beam wind pressure as per 1.1.4 of annex 6 shall not to exceed 10°. Passenger movement need not be considered where passengers are required to be seated whenever the craft is operating in the non-displacement mode.

**2.12.2** In all loading conditions, the outward heel due to turning shall not exceed 8°, and the total heel due to beam wind pressure as per 1.1.4 of annex 6 and due to turning shall not exceed 12°outward.

### **2.13 Buoyancy and stability in the displacement mode following damage**

**2.13.1** 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 shall have sufficient buoyancy and positive stability to simultaneously ensure that:

- .1** the angle of inclination of the craft from the horizontal does not normally exceed 10°in any direction. However, where this is clearly impractical, angles of inclination up to 15° immediately after damage but reducing to 10° within 15 min shall be permitted provided that efficient non-slip deck surfaces and suitable holding points, e.g., holes, bars, etc., are provided; and
- .2** any flooding of passenger compartments or escape routes which might occur will not significantly impede the evacuation of passengers.

**2.13.2** In addition to the requirements in 2.13.1, 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 2.6.8.2.2, to any part of the surface of the hull(s) defined in 2.6.8.1:

- .1** The angle of inclination of the craft from the horizontal shall not exceed 20° in the equilibrium condition;
- .2** the range of positive righting lever shall be at least 15° in the equilibrium condition;
- .3** the positive area under the righting lever curve shall be at least 0.015 m-rad in the equilibrium condition;
- .4** the requirements of 2.6.11.3 and 2.13.1.2 are satisfied; and
- .5** 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.

### **2.14 Inclining and stability information**

**2.14.1** At periodical intervals not exceeding 5 years, a lightweight survey shall be carried out on all passenger craft to verify any changes in lightweight displacement and longitudinal centre of gravity. The passenger craft shall 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.*

**2.14.2** A report of each inclining or lightweight survey carried out in accordance with paragraph 2.7.1 and of the calculation therefrom of the lightweight condition particulars shall be submitted to the Administration for approval, together with a copy for their retention. The approved report shall be placed on board the craft by the owner in the custody of the master and shall incorporate

*such additions and amendments as the Administration may in any particular case require. The amended lightweight condition particulars so obtained from time to time shall be used by the master in substitution for such previously approved particulars when calculating the craft's stability.*

**2.14.3** Following any inclining or lightweight survey, the master shall be supplied with amended stability information if the Administration so requires. The information so supplied shall be submitted to the Administration for approval, together with a copy thereof for their retention, and shall incorporate such additions and amendments as the Administration may in any particular case require.

**Part C** Requirements for cargo craft**2.15** **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 shall 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° in any direction. However, where this is clearly impractical, angles of inclination up to 20° immediately after damage but reducing to 15° within 15 minutes may be permitted provided that efficient non-slip deck surfaces and suitable holding points are provided.*

**2.16** **Inclining**

*Where it is satisfied by lightweight survey, weighing 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 2.14.1, when compared with a craft of the series which has been inclined, shall be regarded as being closely similar to that craft.*

**SECTION 3****STRUCTURES****C3.0 Documents to be submitted****C3.0.1 General**

**.1** Table C3.0.1 lists the structural plans that are to be submitted to the Society, in triplicate, for examination and approval.

**.2** In addition, information relative to the following is to be submitted:

- longitudinal weight distribution and position of the longitudinal centre of gravity of the craft
- design loading conditions including:
  - still water bending moments (SWBM) distribution
  - shear force (SF) distribution
  - description of corresponding loading cases
- draught and trim of the craft at sea, at rest and at its maximum speed in calm water (for SES, in both off-cushion and on-cushion conditions)
- any direct calculations performed
- results of model tests and full-scale measurements.

**C3.0.2 Additional information for fibre-reinforced plastic (FRP) craft**

**.1** For FRP craft, the drawing and documents to be submitted for examination and listed in C3.0.1 are to contain the following additional information:

- arrangement of laminate for the various structural elements: thickness, definition of successive layers of reinforcement, mass per square metre in layers of reinforcement, proportion in mass of reinforcement for each layer, directions of roving layers and unidirectional reinforcements, decreasing in thickness between layers,
- direction of laminate in relation to craft structure,
- structure of oil tanks or other liquid tanks which are integrated into the hull,
- details of connection among various structural elements and details of attachment to the hull of supplementary reinforcing elements,
- pillars.

**.2** Suppliers' technical specifications with indication of types, trademarks and references of resins and gel-coats, reinforcements and core materials are to be supplied.

**Table C3.0.1**

Plan	Containing information relevant to:
Midship section Main sections	<ul style="list-style-type: none"> <li>• moulded dimensions, maximum service speed <math>V</math>, design acceleration <math>a_{CG}</math> and, if known, limit wave height (see C3.3.4)</li> <li>• materials</li> <li>• typical structural details</li> </ul>
Longitudinal sections	
Decks	<ul style="list-style-type: none"> <li>• openings</li> <li>• deck loads, if different from Rule loads</li> </ul>
Shell expansion	<ul style="list-style-type: none"> <li>• openings</li> </ul>
Machinery space structure	<ul style="list-style-type: none"> <li>• machinery mass and position of centre of gravity</li> </ul>
Watertight bulkheads	<ul style="list-style-type: none"> <li>• openings</li> <li>• position of air vents</li> <li>• typical structural details</li> </ul>
Deckhouses	<ul style="list-style-type: none"> <li>• details of connections between different materials</li> </ul>
Rudder	<ul style="list-style-type: none"> <li>• rudder stock material</li> </ul>
Propeller shaft brackets	<ul style="list-style-type: none"> <li>• material</li> </ul>
Equipment	
Testing plan	<ul style="list-style-type: none"> <li>• position of air vents</li> </ul>



These specifications are to give the following information:

- resins: type (orthophthalic or isophthalic), specific gravity, Young's modulus, Poisson's ratio, breaking strength and elongation at break,
- reinforcements (mats, woven rovings, unidirectional reinforcements): quality (glass or other material, with specific gravity, breaking strength of the elementary fibre, Young's modulus and Poisson's ratio), mass per square metre, thickness and possibly weft-warp distribution,
- core materials: type and quality; specific gravity; tensile, compressive and shear strength and elasticity moduli.

### 3.1 General

*This Section covers those elements of hull and superstructure which provide longitudinal and other primary and local strength of the craft as a whole and also other important components such as foils and skirts which are directly associated with the hull and superstructure.*

### 3.2 Materials

*Materials used for the hull and superstructure and the other features referred to in 3.1 should be adequate for the intended use of the craft.*

### 3.3 Structural strength

*The structure should be capable of withstanding the static and dynamic loads which can act on the craft under all operating conditions in which the craft is permitted to operate, without such loading resulting in inadmissible deformation and loss of watertightness or interfering with the safe operation of the craft.*

### 3.4 Cyclic loads

*Cyclic loads, including those from vibrations (see note), which can occur on the craft should not:*

- *impair the integrity of structure during the anticipated service life of the craft or the service life agreed with the Administration;*
- *hinder normal functioning of machinery and equipment; and*
- *impair the ability of the crew to carry out its duties.*

Note: In scope of classification, the structural strength against vibrations is not checked.

The vibration check shall be performed during the sea trials of the craft. Where deemed necessary, the Society may require vibration

measurements to be carried out using suitable instruments; where appropriate, remedial measures may be required to adequately eliminate situations deemed unacceptable.

### 3.5 Design criteria

*The Administration should be satisfied that the choice of design conditions, design loads and accepted safety factors corresponds to the intended operating conditions for which certification is sought.*

### 3.6 Trials

*If the Administration consider it necessary it should require full-scale trials to be undertaken in which loadings are determined. Cognizance should be taken of the results where these indicate that loading assumptions of structural calculations have been inadequate.*

## C3.1 General

### C3.1.1 Introductory comments

.1 This section C3 contains the requirements for structural scantlings of the craft to which these Rules apply, i.e. to craft for which  $V \geq 7,16 \Delta^{1/6}$ . Craft for which  $V \geq 10 L^{0.5}$  shall be individually considered by the Society ( $V$  in knots,  $\Delta$  in tonnes).

For what concerns multihull craft, this Section provides the requirements for scantlings of twin-hull craft. Other craft will be considered in each separate case by the Society.

.2 The requirements for scantlings of hydrofoils and air-cushion vehicles are contained in Appendices C3A1 and C3A2. Unless otherwise specified, the requirements of this Section apply to such craft only as far as the provisions regarding limit operating conditions, materials and construction criteria are concerned.

.3 The scantlings indicated in the following paragraphs apply to craft constructed of steel, aluminium alloy or fibre reinforced plastic, as specified in C3.2.

### C3.1.2 Direct calculations

.1 The Society may require direct calculations to be carried out, if deemed necessary according to the provisions of C3.6.

Such calculations are to be carried out based on structural modelling, loading and checking criteria described in C3.6. Calculations based on other criteria may be accepted if deemed equivalent to those laid down by the Society.

**C3.1.3 Units**

.1 Unless otherwise specified, the following units are used in the Rules:

- thickness of plating, in mm,
- section modulus of stiffeners, in cm<sup>3</sup>,
- shear area of stiffeners, in cm<sup>2</sup>,
- span and spacing of stiffeners, in m,
- stresses, in N/mm<sup>2</sup>,
- concentrated loads, in kN,
- distributed loads, in kN/m or kN/m<sup>2</sup>.

**C3.1.4 Definitions and symbols**

.1 The definitions of the following terms and symbols are applicable throughout this Section and its Appendices and are not, as a rule, repeated in the different paragraphs. Definitions applicable only to certain paragraphs are specified therein.

- "Moulded base line": The line parallel to the summer load waterline, crossing the upper side of keel plate or the top of skeg at the middle of length L.
- "Hull": The hull is the outer boundary of the enclosed spaces of the craft, except for the deckhouses, as defined below.
- "Chine": For hulls that do not have a clearly identified chine, the chine is the hull point at which the tangent to the hull is inclined 50° to the horizontal.
- "Bottom": The bottom is the part of the hull between the keel and the chines.
- "Main deck": The main deck is the uppermost complete deck of the hull. It may be stepped.
- "Side": The side is the part of the hull between the chine and the main deck.
- "Deckhouse": The deckhouse is a decked structure located above the main deck, with lateral walls inboard of the side of more than 4 per cent of the local breadth. Structure located on the main deck and whose walls are not in the same longitudinal plane as the under side shell may be regarded as a deckhouse.
- "Cross-deck": For twin-hull craft, the cross-deck is the structure connecting the two hulls.
- "Deadrise angle  $\alpha_d$ ": For hulls that do not have a clearly identified deadrise angle,  $\alpha_d$  is the angle between the horizontal and a straight line joining the keel and the chine. For catamarans with non-symmetrical hulls (where inner and outer deadrise angles are different),  $\alpha_d$  is the lesser angle.
- "Fore end": Hull region forward of 0,9 L from the aft perpendicular.
- "Aft end": Hull region abaft of 0,1 L from the aft perpendicular.
- "Midship area": Hull region between 0,3 L and 0,7 L from the aft perpendicular.

- L : Rule length, in m, equal to  $L_{WL}$  where  $L_{WL}$  is the waterline measured with the craft at rest in calm water and, for SESs, in the off-cushion condition
- FP : forward perpendicular, i.e. the perpendicular at the intersection of the waterline at draught T and the foreside of the stem
- AP : aft perpendicular, i.e. the perpendicular located at a distance L abaft of the forward perpendicular
- B : the greatest moulded breadth, in m, of the craft
- $B_w$  : the greatest moulded breadth, in m, measured on the waterline at draught T; for catamarans,  $B_w$  is the breadth of each hull
- $B_{wm}$  : the greatest moulded breadth, in m, measured below or on the waterline at draught T; for catamarans,  $B_{wm}$  is the breadth of each hull
- D : depth, in m, measured vertically in the transverse section at the middle of length L from the moulded base line of the hull(s) to the top of the deck beam at one side of the main deck (if the main deck is stepped, D will be defined in each separate case at the discretion of the Society)
- T : draught of the craft, in m, measured vertically on the transverse section at the middle of length L, from the moulded base line of the hull(s) to the full load waterline, with the craft at rest in calm water and, for SESs, in the off-cushion condition
- $\Delta$  : moulded displacement at draught T, in sea water (mass density = 1,025 t/m<sup>3</sup>), in tonnes
- $C_B$  : total block coefficient, defined as follows:  

$$C_B = \frac{\Delta}{(1,025 \cdot L \cdot B_w \cdot T)}$$
For catamarans,  $C_B$  is to be calculated for a single hull, assuming  $\Delta$  equal to one half of the craft's displacement
- V : maximum service speed, in knots
- g : acceleration of gravity, equal to 9,81 m/s<sup>2</sup>
- LCG : longitudinal centre of gravity of the craft.

**C3.1.5 Protection against corrosion**

.1 Scantlings stipulated in C3.7 assume that the materials used are chosen and protected in such a way that the strength lost by corrosion is negligible.

.2 The Shipyard is to give the Society a document specifying all the arrangements made to protect the material against corrosion at the construction stage: coating types, number and thickness of layers, surface preparation, application conditions, control after completion, anodic protection, etc.

.3 This document must also include maintenance arrangements to be made in service to restore and maintain the efficiency of this protection, whatever the reasons of its weakening, whether incidental or not.

.4 All such maintenance operations are to be listed in a book shown to the Society surveyor at each visit.

#### C3.1.6 Rounding-off

.1 Values for thickness as deduced from formulae are to be rounded off to the nearest standard value, without such a reduction exceeding 3 per cent.

### C3.2 Materials and connections

#### C3.2.1 General requirements

.1 Materials to be used in hull and equipment construction, in delivery condition, are to comply with these requirements or with specific requirements applicable to individual cases; they are to be tested in compliance with the applicable provisions. Quality and testing requirements for materials covered here are outlined in relevant Society Rules.

.2 These requirements presume that welding and other cold or hot manufacturing processes are carried out in compliance with current sound working practice and relevant Society provisions. The latter, in particular, may include requirements concerning welding operations and techniques and other manufacturing processes (e.g., specific preheating before welding and/or welding or other cold or hot manufacturing processes followed by an appropriate heat treatment).

.3 Welding processes shall be approved for the specified type of material for which they are intended and with limits and conditions as stated in the applicable Society requirements.

#### C3.2.2 Steel structures

##### C3.2.2.1 Steels for hull structures, forgings and castings

.1 The provisions of the relevant Society Rules apply.

##### C3.2.2.2 Under thickness tolerances

.1 The following requirements apply to the under-thickness tolerances of steel plates and wide flats.

.2 The maximum permissible under thickness tolerance for structural hull plates and wide flats for both normal and high strength steels is 0,3 mm.

.3 The thickness is to be measured at random locations located at least 25 mm from an edge. Local surface depressions resulting from imperfections and ground areas resulting from the elimination of defects may be disregarded.

.4 Responsibility for maintaining the required tolerances rests with the Manufacturer, who is to carry out the necessary measurements.

#### C3.2.2.3 Material factor K for scantlings of structural members made of high strength steel

.1 The value of the material factor K to be introduced into formulae to check structures given in this Section and in the various Appendices is a function of the minimum yield stress  $R_{eH}$  value specified for the steel to be used.

.2 Table C3.2.1 shows the values of the material factor K to be taken depending on the  $R_{eH}$  value of the various high strength steels for hull structures for which  $R_{eH} \leq 390 \text{ N/mm}^2$ .

Table C3.2.1

$R_{eH}$ (N/mm <sup>2</sup> )	K
235	1,00
315	0,78
355	0,72
390	0,70

.3 The use of steels for which  $R_{eH} > 355 \text{ N/mm}^2$  will be considered in each separate case by the Society, which may stipulate special acceptance conditions.

.4 If, for special structures, the use of steels for which  $R_{eH} < 235 \text{ N/mm}^2$ , has been accepted by the Society, the material factor is to be determined by:

$$K = 235 / R_{eH}$$

.5 In the case where the use of steels with  $R_{eH}$  values which are intermediate between those indicated in Table C3.2.1 is allowed, the values of the material factor K may be determined by means of linear interpolation.

#### C3.2.3 Aluminium alloy structures

##### C3.2.3.1 Aluminium alloys for hull structures, forgings and castings

.1 The designation of aluminium alloys used here complies with the numerical designation used in RRIAD (Registration Record of International Alloy Designation).

Table C3.2.2 - Aluminium alloys for welded construction

Guaranteed mechanical characteristics (1)							
Aluminium alloy				Unwelded condition		Welded condition	
Alloy (2)	Temper (2)	Products	Thickness (mm)	$R_{p0.2}$ (N/mm <sup>2</sup> ) (4)	$R_m$ (N/mm <sup>2</sup> ) (5)	$R_{p0.2}'$ (N/mm <sup>2</sup> ) (4)	$R_m'$ (N/mm <sup>2</sup> ) (5)
5083	O / H111	rolled	$t \leq 50$	125	275	125	275
	H 321	rolled	$t \leq 40$	215	305	125	275
	O	extruded	all	110	270	110	270
5086	O / H111	rolled	all	100	240	100	240
	H 321	rolled	all	185	275	100	240
	O	extruded	all	95	240	95	240
5383	O / H111	rolled	$t \leq 40$	145	290	145	290
	H 321	rolled	$t \leq 40$	220	305	145	290
5059	O / H111	rolled	$t \leq 40$	155	300	155	300
	H 321	rolled	$t \leq 20$	270	370	155	300
		rolled	$20 < t \leq 40$	260	360	155	300
5454	O / H111	rolled	all	85	215	85	215
	F	rolled	all	100	210	100	210
5754	O / H111	rolled	$t \leq 6$	80	190	80	190
			$t > 6$	70	190	70	190
6005	T5 / T6	closed extrusions	$t \leq 6$	215	255	105	165
			$6 < t \leq 25$	200	250	100	165
		open extrusions	$t \leq 10$	215	260	95	165
			$10 < t \leq 25$	200	250	80	165
6060 (3)	T5	extruded	$t \leq 6$	150	190	65	115
			$6 < t \leq 25$	130	180	65	110
6061	T6	extruded	$t \leq 25$	240	260	115	155
6082	T6	extruded	$t \leq 15$	255	310	115	170
6106	T5	extruded	$t \leq 6$	195	240	65	130
6351	T5	extruded	$t \leq 25$	240	260	140	165

(1) The guaranteed mechanical characteristics in this Table correspond to general standard values. For more information, refer to the minimum values guaranteed by the product supplier. Higher values may be accepted on the basis of welding tests including recurrent workmanship test at the shipyard only.

(2) Other grades or tempers may be considered, subject to the Society's agreement.

(3) 6060 alloy is not to be used for structural members sustaining impact loads (e.g. bottom longitudinals). The use of alloy 6106 is recommended in that case.

(4)  $R_{p0.2}$  and  $R_{p0.2}'$  are the minimum guaranteed yield stresses at 0,2% in unwelded and welded condition respectively.

(5)  $R_m$  and  $R_m'$  are the minimum guaranteed tensile strengths in unwelded and welded condition respectively.

**.2** The characteristics of aluminium alloys to be used in the construction of aluminium craft are to comply with the relevant requirements of the Society Rules.

**.3** As a rule, series 5000 aluminium-magnesium alloys or series 6000 aluminium-magnesium-silicon alloys (see Table C3.2.2) shall be used.

**.4** The use of series 6000 alloys or extruded platings, for parts which are exposed to sea water atmosphere, will be considered in each separate case by the Society, also taking into account the protective coating applied.

**.5** The list of aluminium alloys given in Table C3.2.2 is not exhaustive. Other aluminium alloys may be considered, provided the specification (manufacture, chemical composition, temper, mechanical properties, welding, etc.) and the scope of application be submitted to the Society for review.

**.6** In the case of welded structures, alloys and welding processes are to be compatible and appropriate, to the satisfaction of the Society and in compliance with the relevant Rules.

**.7** For forgings or castings, requirements for chemical composition and mechanical properties are to be defined in each separate case by the Society.

.8 In the case of structures subjected to low service temperatures or intended for other particular applications, the alloys to be employed are to be defined in each separate case by the Society which is to state the acceptability requirements and conditions.

.9 Unless otherwise specified, the Young's modulus for aluminium alloys is equal to 70000 N/mm<sup>2</sup> and the Poisson's ratio equal to 0,33.

### C3.2.3.2 Extruded platings

.1 Extrusions with built-in plating and stiffeners, referred to as extruded plating, may be used.

.2 In general, the application is limited to decks and deckhouses. Other uses may be permitted at the discretion of the Society.

.3 Extruded plating is preferably to be oriented so that the stiffeners be parallel to the direction of main stresses.

.4 Connections between extruded plating and primary members are to be given special attention.

### C3.2.3.3 Tolerances

.1 The under-thickness tolerances of plates and rolled sections are to be in accordance with Table C3.2.3.

**Table C3.2.3**

As-built thickness (mm)	Under-thickness tolerance (mm)
$t \leq 8$	0,3
$8 < t \leq 12$	0,5
$12 < t \leq 20$	0,7
$t > 20$	1,0

.2 The under-thickness tolerances of extruded platings are to be in accordance with Table C3.2.4, but not taken greater than 7% of the as-built thickness. Otherwise, the reduced plate thickness has to be considered.

**Table C3.2.4**

As-built thickness (mm)	Under-thickness tolerance (mm)
$t \leq 6$	0,3
$6 < t \leq 10$	0,4

.3 The responsibility for maintaining the required tolerances lies with the manufacturer, who shall also inspect the surface condition.

### C3.2.3.4 Influence of welding on mechanical characteristics

.1 Welding heat input lowers locally the mechanical strength of aluminium alloys hardened by work hardening (series 5000 other than condition 0 or H111) or by heat treatment (series 6000).

.2 Consequently, where necessary, a drop in mechanical characteristics of welded structures is to be considered in the heat-affected zone, with respect to the mechanical characteristics of the parent material.

.3 The heat-affected zone may be taken to extend 25 mm on each side of the weld axis.

.4 Aluminium alloys of series 5000 in 0 condition (annealed) or in H111 condition (annealed flattened) are not subject to a drop in mechanical strength in the welded areas.

.5 Aluminium alloys of series 5000 other than condition 0 or H111 are subjected to a drop in mechanical strength in the welded areas. The mechanical characteristics to consider in welded condition are, normally, those of condition 0 or H111, except otherwise indicated in Table C3.2.2. Higher mechanical characteristics may be taken into account, provided they are duly justified.

.6 Aluminium alloys of series 6000 are subject to a drop in mechanical strength in the vicinity of the welded areas. The mechanical characteristics to be considered in welded condition are, normally, to be indicated by the supplier, if not indicated in Table C3.2.2.

### C3.2.3.5 Material factor K for scantlings of structural members made of aluminium alloy

.1 The value of the material factor K to be introduced into formulae for checking scantlings of structural members, given in this Section and the various Appendices, is determined by the following equation:

$$K = \frac{100}{R'_{lim}}$$

where:

$R'_{lim}$  : minimum guaranteed yield stress of the parent metal in welded condition  $R'_{p0,2}$ , in N/mm<sup>2</sup>, but not to be taken greater than 70% of the minimum guaranteed tensile strength of the parent metal in welded condition  $R'_m$ , in N/mm<sup>2</sup> (see Table C3.2.2).

.2 For welded constructions in hardened aluminium alloys (series 5000 other than condition 0 or H111 and series 6000), greater characteristics than those in welded condition may be considered, provided that welded connections are located in areas where stress levels are acceptable for the alloy considered in annealed or welded condition.

.3 In case of welding of two different aluminium alloys, the material factor K to be considered for the scantlings of welds is to be the greater material factor of the aluminium alloys of the assembly.

#### C3.2.3.6 Strength of welding

.1 The effective length in mm of the lines of welding is given by:

$$d_e = d - 20$$

where d is the actual length in mm of the line of welding.

#### C3.2.3.7 Riveted connections for aluminium alloy hulls

.1 Use of rivets for connecting structures is limited, in principle, only to members which do not contribute to the overall strength of the hull. Exceptions are to be supported by experimental evidence or good in-service performance.

.2 The conditions for riveted connection acceptability are to be individually stated in each particular case, depending on the type of member to be connected and the rivet material.

.3 Whenever riveted connections are to be employed, a detailed plan, illustrating the process, as well as the dimensions and location of rivets and holes, together with the mechanical and metallurgical properties of the rivets, is to be submitted for approval.

.4 The Society may, at its discretion, require tension, compression and shear tests to be carried out on specimens of riveted connections constructed under the same conditions as during actual hull construction, to be witnessed by a Society surveyor.

.5 The Society reserves the right to accept the results of tests performed by recognized bodies or other Societies.

### C3.2.4 Welding connections

#### C3.2.4.1 General requirements

.1 For welding, the requirements of relevant Society Rules apply. In particular, these provisions make the adoption of welding procedures dependent on their previous qualification by the Society. In addition, individual builders are to hold an authorization by the Society to use these procedures, employing welders qualified by the Society.

.2 For welds design and throat thicknesses, the requirements of relevant Society Rules apply. In addition, intermittent welds are not allowed in following zones:

- structure in way of waterjets or propellers
- structure in way of stabilisation devices such as foils, interceptors or tabs
- structure submitted to water impact

#### C3.2.4.2 Accessibility and edge preparation

.1 For correct execution of welded joints, sufficient accessibility is necessary, depending on the welding process adopted and the welding position.

.2 Edge cutting, to be carried out in general by machining, is to be regular and without burrs or cuts.

.3 The structural parts to be welded as well as those adjacent, even if they have been previously pickled, are to be cleaned carefully before welding, using suitable mechanical means, such as stainless steel wire brushes, so as to eliminate oxides, grease or other foreign bodies which could give rise to welding defects.

.4 Edge preparation, alignment of joints, spot-welding methods and root chipping are to be appropriate to the type of joint and welding position, and comply with Society Rule requirements for the welding procedures adopted.

#### C3.2.4.3 Inspections

.1 Inspections of welded connections by the Society surveyors are, in general, those specified in (a) to (e) below. The extent of inspection will be defined by the Society on a case by case basis.

- (a) Inspection of base materials for compliance with the requirements this Article and of structures with the approved plans.
- (b) Inspection of the use and application conditions of welding procedures for compliance with those approved and verification that qualified welders are employed.
- (c) Visual examination of edge preparations, root chipping and execution of welds in way of structural connections.
- (d) Examination of radiographs of welded joints (radiographing is to be performed, if necessary, depending on the extent of the examinations), and inspection of performance of execution of the ultrasonic or magnetic particle examinations, which may be required.
- (e) Inspection of any repairs, to be performed with procedures and inspection methods at the discretion of the Society surveyor.

.2 Irrespective of the extent of such inspections, it is the responsibility of the builder to ensure that the manufacturing procedures, processes and sequences are in compliance with relevant Society requirements, approved plans and sound working practice. For this purpose, the shipyard is to have its own production control organization.

**C3.2.4.4 Welding processes for light alloys**

**.1** In general, the welding of the hull structures is to be performed with the MIG (metal-arc inert gas) and TIG (tungsten-arc inert gas) processes using welding consumables recognized as suitable for the base material to be used. Welding processes and filler materials other than those above are to be individually considered by the Society at the time of the approval of welding procedures.

**.2** For the authorization to use welding procedures in production, the following details are to be stated:

- (a) grade and temper of parent and filler materials
- (b) weld execution procedures: type of joint (e.g. butt-joint, fillet joint); edge preparation (e.g. thicknesses, bevelling, right angle edges); welding position (e.g. flat, vertical, horizontal) and other parameters (e.g. voltage, amperage, gas flow capacity)
- (c) welding conditions (e.g. cleaning procedures of edges to be welded, protection from environmental atmosphere)
- (d) special operating requirements for butt-joints, for example for plating: welding to be started and completed on end pieces outside the joint, back chipping, arrangements for repairs consequent to possible arc restarts
- (e) type and extent of controls during production.

**C3.2.5 Corrosion protection - heterogeneous steel/aluminium alloy assembly**

**.1** Connections between aluminium alloy parts, and between aluminium alloy and steel parts, if any, are to be protected against corrosion by means of coatings applied by suitable procedures agreed by the Society.

**.2** In any case, any direct contact between steel and aluminium alloy is to be avoided (e.g. by means of zinc or cadmium plating of the steel parts and application of a suitable coating on the corresponding light alloy parts).

**.3** Any heterogeneous jointing system is subject to the Society's agreement.

**.4** The use of transition joints made of aluminium/steel-cladded plates or profiles is subject to the Society's agreement.

**.5** Transition joints are to be type-approved.

**.6** Qualifications tests for welding procedures are to be carried out for each joint configuration.

**.7** A welding booklet giving preparations and various welding parameters for each type of assembly is to be submitted for review.

**C3.2.6 Fibre-reinforced plastic (FRP) structures****C3.2.6.1 Raw materials**

**.1** The main raw materials are to be homologated by the Society.

It may be accepted as equivalent that main raw materials should be individually inspected by the Society. In such a case, each batch being used is submitted to tests, the conditions and scope of which are stipulated by the Society's surveyor.

**.2 Reinforcement fibres**

- (a) Fibres for reinforcement may be textile glass or aramid or carbon fibres or other fibres.
- (b) Products laid on a surface, such as size, binder and coupling finish, are to ensure cohesion between fibres and resins.
- (c) During manufacturing, the shipyard is to ensure that reinforcement materials are to be free from scrap matter and without defects, detrimental to their use.

**.3 Resins**

- (a) Resins are to be capable of withstanding ageing in marine environments and industrial atmospheres.
- (b) Resins are to be used within the limits fixed by the manufacturer. In this respect, the surveyor may ask for any relevant proof.

**.4 Core materials for sandwich laminates**

- (a) Expanded foams contributing to sandwich laminate strength are to be of the closed cell type and compatible with the resins used.
- (b) Expanded polystyrenes may be used only as filling or buoyancy materials.

**.5 Additives**

- (a) Fillers and pigments are to affect neither the conditions of polymerisation of the impregnation resin nor its mechanical characteristics. The percentage of both of them is not to exceed, as a rule, 10% of the mass of resin, with a maximum of 2% for thixotropic agents and 5% for flame retarders.

The use of microspheres is subject to special examination.

- (b) The type and proportions of catalyst and accelerator are to be adjusted in any case to the conditions of work (production rate) and ambient atmosphere (temperature).

In order to ensure complete curing, the builder is to respect the indications of the resin manufacturer, particularly for the ratio of catalyst.

**.6 Materials for integrated structures**

- (a) These are elements entirely covered with laminate, and used for reinforcement, moulding, or as lamination support for stiffeners, for example.
- (b) The metals used are withstand seawater and fuel corrosion; they are to be of good quality and must not have any influence on resin curing. They are to undergo appropriate preparation to improve bonding with the resin.
- (c) As a rule, wood reinforcements are to be of a plywood type with good seawater resistance. The use of timber is subject to a special examination.

**C3.2.6.2 Tests on laminates****.1 General**

- (a) The shipyard has to make samples representative of shell materials and possibly of other parts of the structure, taking into account the type and size of ship.
- (b) If sister ships are built at the same shipyard, and provided that raw materials are not changed, the frequency of samples for testing is determined by the Society.
- (c) These test samples are to be submitted to a laboratory approved by the Society to undergo mechanical and physicochemical tests, as defined below.
- (d) In general, tests are to be carried out according to the standards indicated below, or other recognized standards previously agreed upon with the Society.
- (e) These tests must show that laminate characteristics are at least equivalent to the theoretical values given by direct calculation following the method given in C3.2.6.3. Otherwise, supplementary tests may be required.
- (f) The Society reserves the right to require tests different from those defined below, if particular materials or unusual manufacturing process are used.
- (g) Tests are to be carried out on a panel, the composition of which is to be the same as that of a shell plating area, without gel-coat.
- (h) Identification of the panel is given by the following elements:
  - exact name of the resin, with its specific gravity, elasticity modulus, and breaking stress in curing state,
  - description of elementary layers,
  - characteristics of the laminate (e.g. layer type, direction),
  - direction of the panel in respect of longitudinal axis of the ship and indication of direction for warp and weft for the rovings in respect of the same axis.
- (i) Conditioning of laminate panels, preparation of testpieces, dimensional measurement of testpieces and the tests defined below are to be carried out according to recognized standards.

- (j) Tests are to be carried out on testpieces taken out of the panel in two perpendicular directions. The number of testpieces for each direction is given by the standard used for the particular test.
- (k) For each group of testpieces and for each result, the value to consider is the average obtained from the number of tested pieces, provided that the minimum value is not less than 0,9 times the mean value. Otherwise, the value to consider is determined by the Society, taking testing conditions and dispersion of results into account.
- (l) Mechanical characteristics are to be obtained from dry testpieces, i.e. not conditioned in water.

(m) In general, the following tests are to be carried out:

- single skin laminates: tensile tests, bending tests (three-point method), measurement of specific gravity and percentage of reinforcement in mass,
- sandwich laminates: bending tests (four-point method), and, for each skin, tensile tests, measurement of specific gravity and percentage of reinforcement in mass.

- (n) Bending tests are to be carried out with the load applied either on the gel-coat side or on the opposite side. The choice of the side is to be decided in accordance with the Society, so that the failure mode of the testpiece is representative of the case of scantlings of the plating.
- (o) Test results are to be shown in a test report, mentioning the tests in C3.2.6.22 to C3.2.6.24.

**.2 Tensile tests**

- (a) In general, these tests are to be carried out for single skin laminates and the skins of sandwich laminates.
- (b) The applicable standard is:  
ISO 3268.
- (c) For each testpiece, the test report is to provide the following information:
  - reference of the standard used for the test,
  - widths and thicknesses of the test-piece, in mm,
  - length between fixed ends, in mm,
  - load (in N) - elongation curve (in mm),
  - breaking load, in N,
  - tensile breaking stress, in N/mm<sup>2</sup>,
  - tangential initial elasticity modulus, in N/mm<sup>2</sup>,
  - other items of information required by the standard, if necessary.
- (d) If breaking occurs in several steps, the value taken into account is the first break obtained from the load-elongation curve.
- (e) The test report is also to indicate the mean value of the breaking load, breaking tensile strength and tangential initial elasticity modulus.



**.3 Bending tests**

- (a) In general, bending tests using the three-point method are to be carried out only for the single skin laminates.

The applicable standard is:

ISO 178.

- (b) In general, bending tests using the four-point method are to be carried out only for sandwich laminates.

The applicable standard is:

ASTM C 393.

- (c) For each testpiece, the test report is to provide the following information:

- reference of the standard used for the test,
- widths and thicknesses of the testpiece, in mm,
- length of the span between supports, in mm,
- for the four-point method: location of the points where the load is applied,
- load (in N) - deflection (in mm) curve,
- breaking load, in N, and failure mode,
- bending breaking strength, in N/mm<sup>2</sup>, for single skin laminate tests,
- bending breaking strength of skin and shear breaking strength of core for sandwich laminate tests, both in N/mm<sup>2</sup>,
- other items of information required by the standard, if necessary.

- (d) If breaking occurs in several steps, the value taken into account is the first break obtained from the load-deflection curve.

- (e) The test report is also to indicate the mean value of the breaking load and breaking strength.

**.4 Specific gravity and percentage of reinforcement**

- (a) In general, these tests are to be carried out for single skin laminates and the skins of sandwich laminates.

- (b) The applicable standards are:

ASTM D 792,

ASTM D 3171.

- (c) For each testpiece, the test report is to provide the following information:

- reference of the standard used for the test,
- dimensions, in mm, of the test-piece,
- mass of the test-piece, in g,
- mass by unit of area of the test-piece, in g/m<sup>2</sup>,
- specific density, in g/m<sup>3</sup>,
- mass of reinforcement of the test-piece, in g,

- mass of reinforcement by unit of area, in g/m<sup>2</sup>,
- percentage of reinforcement in mass,
- other items of information required by the standard, if necessary.

- (d) The test report is also to indicate the mean value of the mass by unit of area, in g/m<sup>2</sup>, specific gravity, in g/m<sup>3</sup>, mass of reinforcement by unit of area, in g/m<sup>2</sup>, and percentage of reinforcement in mass.

**C3.2.6.3 Estimation of mechanical characteristics of FRP materials**

**.1** The meanings of the symbols used below are as follows:

- $\Psi$  : content in mass of reinforcement in a layer,
- $\phi$  : content in volume of reinforcement in a layer, defined in C3.2.6.32 below,
- $\mu_0$  : vacuum content, equal to 0, if there is no available information,
- $E_1$  : Young's modulus of a layer with unidirectional fibres, parallel to fibres, in N/mm<sup>2</sup>, defined in C3.2.6.32 below,
- $E_2$  : Young's modulus of a layer with unidirectional fibres, perpendicular to fibres, in N/mm<sup>2</sup>, defined in C3.2.6.32 below,
- $\nu_{12}, \nu_{21}$  : Poisson's ratios of a layer with unidirectional fibres, defined in C3.2.6.32 below,
- $G_{12}$  : Coulomb's modulus of a layer with unidirectional fibres, in N/mm<sup>2</sup>, defined in C3.2.6.32 below,
- $\rho_v$  : specific gravity of reinforcement, in g/cm<sup>3</sup>,
- $\rho_r$  : specific gravity of resin, in g/cm<sup>3</sup>,
- $E_{1v}$  : Young's modulus of reinforcement in the direction parallel to fibres, in N/mm<sup>2</sup>,
- $E_{2v}$  : Young's modulus of reinforcement in the direction perpendicular to fibres, in N/mm<sup>2</sup>,
- $E_r$  : Young's modulus of resin, in N/mm<sup>2</sup>,
- $\nu_v$  : Poisson's ratio of reinforcement,
- $\nu_r$  : Poisson's ratio of resin,
- $G_r$  : Coulomb's modulus of resin, in N/mm<sup>2</sup>, defined in C3.2.6.32 below,
- $G_v$  : Coulomb's modulus of the reinforcement, in N/mm<sup>2</sup>, as given in Table C3.2.7.

When there is no available information, the values given in Table C3.2.7 may be considered.

Table C3.2.7

		Fibres				Resins	
		E Glass	Aramid	HS Carbon	HM Carbon	Polyester	Epoxy
Specific gravity (g/cm <sup>3</sup> )		2,54	1,45	1,80	1,90	1,20	1,20
Young's modulus (N/mm <sup>2</sup> )	parallel to fibres	73000	130000	230000	370000	3000	2600
	perpendicular to fibres	73000	5400	15000	6000	–	–
Coulomb's modulus (N/mm <sup>2</sup> )		30000	12000	50000	20000	–	–
Poisson's ratio		0,25	0,35	0,35	0,35	0,316	0,40

## .2 Elementary layer

- (a) The content in volume  $\varphi$  of reinforcement in the layer is given by the formula:

$$\varphi = \frac{\Psi \cdot (1 - \mu_0)}{\Psi + (1 - \Psi) \cdot \frac{\rho_v}{\rho_r}}$$

- (b) Whatever the type of reinforcement used in a particular layer, the elastic characteristics of a layer with unidirectional fibres having the same content of reinforcement as that layer are to be calculated first:

- Young's moduli:

- parallel to fibres

$$E_1 = \varphi \cdot E_{1v} + (1 - \varphi) \cdot E_r$$

- perpendicular to fibres

$$E_2 = \frac{E_r}{1 - v_r^2} \cdot \frac{1 + 0,85 \cdot \varphi^2}{(1 - \varphi)^{1,25} + \varphi \frac{E_r}{E_{2v}(1 - v_r^2)}}$$

- Poisson's ratios:

$$v_{12} = \varphi \cdot v_v + (1 - \varphi) \cdot v_r$$

$$v_{21} = v_{12} \cdot \frac{E_2}{E_1}$$

- Coulomb's modulus:

$$G_{12} = G_r \cdot \frac{1 + 0,6 \cdot \varphi^{0,5}}{(1 - \varphi)^{1,25} + \frac{G_r}{G_v} \cdot \varphi}$$

where:

$$G_r = \frac{E_r}{2 \cdot (1 + v_r)}$$

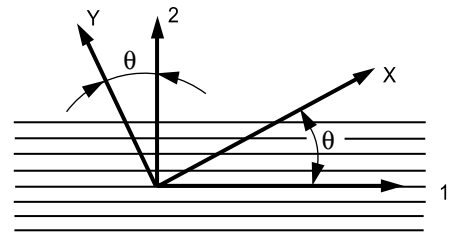
- (c) Following any direction that forms an angle  $\theta$  with the direction of fibres, the Young's moduli of the elementary layer become:

$$\frac{1}{E_x} = \frac{1}{E_1} \cdot \cos^4 \theta + \left( \frac{1}{G_{12}} - \frac{2v_{12}}{E_1} \right) \cdot \sin^2 \theta \cdot \cos^2 \theta + \frac{1}{E_2} \cdot \sin^4 \theta$$

$$\frac{1}{E_y} = \frac{1}{E_1} \cdot \sin^4 \theta + \left( \frac{1}{G_{12}} - \frac{2v_{12}}{E_1} \right) \cdot \sin^2 \theta \cdot \cos^2 \theta + \frac{1}{E_2} \cdot \cos^4 \theta$$

The values of  $E_1$ ,  $E_2$ ,  $v_{12}$  and  $G_{12}$  are calculated above, directions x and y are defined in Figure C3.2.1.

Figure C3.2.1



- (d) In general, the content in mass of reinforcement in a layer of mat is between 0,25 and 0,35.

The Young's modulus of a layer of mat may be estimated from:

$$E_M = \frac{3}{8} \cdot E_1 + \frac{5}{8} \cdot E_2$$

In this formula, the values  $E_1$  and  $E_2$  are those defined above.

- (e) Woven rovings may be taffeta, cotton serge, satin, etc., warp and weft balanced or not.

In general, the content in mass of reinforcement in a woven roving reinforced layer is between 0,4 and 0,6, and the content in mass of reinforcement in an unidirectional reinforced layer is between 0,6 and 0,7.

The direction of the warp (direction 1) is to be distinguished from that of the weft (direction 2); the elastic characteristics are:

$$E_{1R} = k \cdot E_1 + (1 - k) \cdot E_2$$

$$E_{2R} = (1 - k) \cdot E_1 + k \cdot E_2$$

where k is the woven balance coefficient equal to the ratio of warp tensile strength to the sum of tensile strengths in warp and weft,  $E_1$  and  $E_2$  being defined above.

Generally, a layer reinforced with woven rovings may be considered as made of two perpendicular unidirectional layers, and it is possible to apply directly to them the formulae laid down above, taking into account the actual content of reinforcement in the layer.

**.3 Single skin laminates**

- (a) A laminate is made of  $n$  layers. The characteristics of layer  $i$  of the laminate are:

$t_i$  : thickness, in mm, regardless of direction, given by:

$$t_i = \frac{P_{vi}}{(1 - \mu_0)} \cdot \left( \frac{1}{\rho_v} + \frac{1 - \Psi_i}{\Psi_i \cdot \rho_r} \right) \cdot 10^{-3}$$

where  $P_{vi}$  is the mass of reinforcement by unit of area in layer  $i$  in  $\text{g/m}^2$ , and  $\Psi_i$  is the content in mass of reinforcement in layer  $i$ .

$z_i$  : distance, in mm, from the neutral fibre of layer  $i$  to an edge (regardless of direction):

$$z_i = z_{i-1} + \frac{t_{i-1} + t_i}{2}$$

$E_i$  : Young's modulus of layer  $i$ , in  $\text{N/mm}^2$ , assumed to be known and experimentally verified.  $E_i$  is the lowest of the values in tension and compression.

- (b) The equivalent tensile elasticity modulus  $E_L$ , in  $\text{N/mm}^2$ , of the multi-layer laminate may be calculated by:

$$E_L = \frac{\sum E_i \cdot t_i}{\sum t_i}$$

- (c) The distance of the neutral fibre of the multi-layer laminate is, in mm:

- with regard to the edge of reference:

$$V = \frac{\sum E_i \cdot t_i \cdot z_i}{\sum E_i \cdot t_i}$$

- with regard to the other edge:

$$V' = \sum t_i - V$$

Distances from the neutral fibre of each layer to the neutral fibre of the laminate are, in mm:

$$d_i = z_i - V$$

- (d) The flexural rigidity of the multi-layer laminate  $EI$ , by millimetre of width, in  $\text{N.mm}^2/\text{mm}$ , is:

$$[EI] = \sum E_i \cdot \left( \frac{t_i^3}{12} + t_i \cdot d_i^2 \right)$$

- (e) The inertia of the multi-layer laminate, by millimetre of width, in  $\text{mm}^4/\text{mm}$ , is:

$$[I] = \sum \left( \frac{t_i^3}{12} + t_i \cdot d_i^2 \right)$$

- (f) The theoretical bending breaking strength of the multi-layer laminate, is, in  $\text{N/mm}^2$ :

$$\sigma_{br} = k \cdot \frac{[EI]}{[I]} ((1 - \mu_0)^2 \cdot 10^{-3})$$

where:

- $k$  :
- 17,0 for laminates using polyester resin,
  - 25,0 for laminates using epoxy resin,
  - 12,5 for laminates made of carbon reinforcements and epoxy resins.

When the breaking strength of the laminate, given by mechanical tests as stipulated in C3.2.6.2, is greater than the theoretical calculated value  $\sigma_{br}$ , the breaking strength obtained from tests can be taken into account to increase the preceding value of  $\sigma_{br}$ .

**.4 Sandwich laminates**

- (a) The inertia and flexural rigidity of sandwich laminates are to be calculated according to (d) and (e) above, taking into account the core as an elementary layer with its own characteristics (thickness and Young modulus of the core material).

- (b) The theoretical bending breaking strength by bending of skins of the sandwich laminate is, in  $\text{N/mm}^2$ :

$$\sigma_{br} = k \cdot \frac{[EI]}{[I]} ((1 - \mu_0)^2 \cdot 10^{-3})$$

where:

$[EI]$  : flexural rigidity of the sandwich laminate, in  $\text{N.mm}^2/\text{mm}$ ,

$[I]$  : inertia of the sandwich laminate, in  $\text{mm}^4/\text{mm}$ ,

$\mu_0$  : vacuum content of skins,

- $k$  :
- 17,0 for skins using polyester resin,
  - 25,0 for skins using epoxy resin,
  - 12,5 for skins made of carbon reinforcements and epoxy resins.

When the breaking strength of the laminate by bending of skins, given by mechanical tests as requested in C3.2.6.2, is greater than the theoretical calculated value  $\sigma_{br}$ , the breaking strength obtained from tests can be taken into account to increase the preceding value of  $\sigma_{br}$ .

- (c) The shear breaking of a sandwich laminate is to be considered in each particular case, considering the thickness and the shear breaking strength of the core material (see C3.8.4.4).

**.5 Stiffener**

- (a) In general, the characteristics of the member considered as support only for the lamination of the stiffener are not to be taken into account for estimation of the mechanical characteristics of the stiffener.

- (b) Symbols are shown in Table C3.2.8, where:

$l_b$  : width of the associated plating, defined in C3.8.4.5.

**Table C3.2.8**

	Width or height (mm)	Thickness (mm)	Young's modulus (N/mm <sup>2</sup> )	Section (mm <sup>2</sup> )
Flange	$l_s$	$t_s$	$E_s$	$S_s = t_s l_s$
Core	$H$	$t_a$	$E_a$	$S_a = t_a H$
Associated plating	$l_b$	$t_b$	$E_b$	$S_b = t_b l_b$

(c) To supplement the symbols defined in Table C3.2.8, the following elements are needed:

$z_i$  : distance from the neutral fibres of the three elements, i.e. core, flange and associated plating (index  $i$  refers to each one of them), to the outer face of the associated plating, in mm,

$V$  : distance from the stiffener neutral fibre to the outer face of the associated plating, in mm:

$$V = \frac{\sum E_i \cdot S_i \cdot z_i}{\sum E_i \cdot S_i}$$

$V'$  : distance from the stiffener neutral fibre to the outer face of the flange, in mm:  
 $V' = H - V + t_s + t_b$

$d_i$  : distances from the neutral fibre of each element to the stiffener neutral fibre, in mm:  
 $d_i = z_i - V$

$I_i$  : specific inertia of each element, in mm<sup>4</sup>.

(d) The rigidity of a stiffener  $[EI]$ , in N.mm<sup>2</sup>, is:

$$[EI] = \sum E_i \cdot (I_i + S_i \cdot d_i^2)$$

(e) The inertia of a stiffener  $[I]$ , in mm<sup>4</sup>, is:

$$[I] = \sum (I_i + S_i \cdot d_i^2)$$

(f) The theoretical bending breaking strength of the stiffener  $\sigma_{br}$ , in N/mm<sup>2</sup>, is:

$$\sigma_{br} = k \cdot \frac{[EI]}{[I]} \cdot 10^{-3}$$

where:

- $k$  :
- 17,0 for stiffeners using polyester resin,
  - 25,0 for stiffeners using epoxy resin,
  - 12,5 for skins made of carbon reinforcements and epoxy resins.

### C3.3 Design acceleration

#### C3.3.1 Vertical acceleration at LCG

.1 The design vertical acceleration at LCG,  $a_{CG}$  (expressed in g), is defined by the designer and corresponds

to the average of the 1 per cent highest accelerations in the most severe sea conditions expected, in addition to the gravity acceleration.

Generally, it is to be not less than:

$$a_{CG} = foc \cdot Soc \cdot \frac{V}{\sqrt{L}}$$

where foc and Soc values are indicated in Table C3.3.1. and Table C3.3.2.

**Table C3.3.1**

Type of service	Passenger, Ferry, Cargo	Supply	Pilot, Patrol	Rescue
foc	0,666	1	1,333	1,666

**Table C3.3.2**

Sea area	Open sea	Restricted open sea	Moderate environment (2)	Smooth sea (3)
Soc	$C_F$ (1)	0,30	0,23	0,14

(1) For passenger, ferry and cargo craft, their seaworthiness in this condition is to be ascertained. In general, Soc should not be lower than the values given in this Table, where:

$$C_F = 0,2 + \frac{0,6}{V/\sqrt{L}} \geq 0,32$$

(2) Not applicable to craft with type of service "Rescue"

(3) Not applicable to craft with type of service "Pilot, Patrol" or "Rescue"

.2 Lower  $a_{CG}$  values may be accepted at the Society's discretion, if justified, on the basis of model tests and full-scale measurements.

.3 The sea areas referred to in Table C3.3.2 are defined with reference to significant wave heights  $H_s$  which are exceeded for an average of not more than 10 percent of the year:

- Open-sea service:  
 $H_s \geq 4,0$  m
- Restricted open-sea service:  
 $2,5 \text{ m} \leq H_s < 4,0$  m
- Moderate environment service:  
 $0,5 \text{ m} < H_s < 2,5$  m
- Smooth sea service:  
 $H_s \leq 0,5$  m.

.4 If the design acceleration cannot be defined by the designer, the  $a_{CG}$  value corresponding to the appropriate values of foc and Soc reported in Table C3.3.1 and Table C3.3.2 will be assumed.

.5 An acceleration greater than  $a_{CG} = 1,5 \cdot foc$  may not be adopted for the purpose of defining limit operating conditions.

**.6** The longitudinal distribution of vertical acceleration along the hull is given by:

$$a_v = k_v \cdot a_{CG}$$

where:

$k_v$  : longitudinal distribution factor, not to be less than (see Figure C3.3.1):

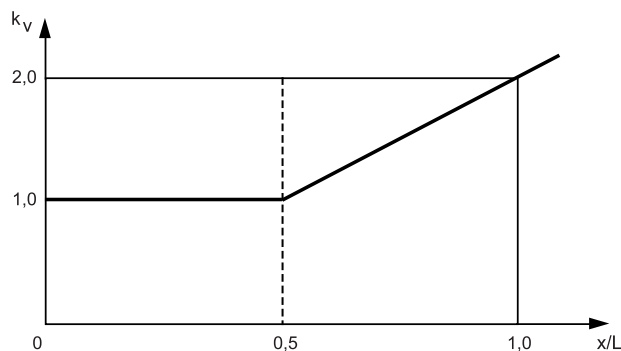
$$k_v = 1 \text{ for } x/L \leq 0,5$$

$$k_v = 2 \cdot x/L \text{ for } x/L > 0,5$$

Higher values may be requested based on pitch consideration.

$a_{CG}$  : design acceleration at LCG.

**Figure C3.3.1**



**.7** Variation of  $a_v$  in the transverse direction may generally be disregarded.

### C3.3.2 Transverse acceleration

**.1** Transverse acceleration is defined on the basis of results of model tests and full-scale measurements, considering their characteristic value as specified in C3.3.4.1.

**.2** In the absence of such results, transverse acceleration, in  $g$ , at the calculation point of the craft may be obtained from:

$$a_t = 2,5 \cdot \frac{H_{sl}}{L} \cdot \left( 1 + 5 \cdot \left( 1 + \frac{V/(\sqrt{L})}{6} \right)^2 \cdot \frac{r}{L} \right)$$

where:

$H_{sl}$  : permissible significant wave height at maximum service speed  $V$  (see C3.3.3),

$r$  : distance of the point from:

- 0,5  $D$  for monohull craft,
- waterline at draught  $T$ , for twin-hull craft.

### C3.3.3 Assessment of limit operating conditions

#### C3.3.3.1 General

**.1** "Limit operating conditions" in this paragraph are to be taken to mean sea states (characterized only by their significant wave heights) compatible with the structural design parameters of the craft, i.e. the sea states in which the craft may operate depending on its actual speed.

**.2** Limit operating conditions are derived from the restrictions presented in C3.3.3.2, C3.3.3.3 and C3.3.3.4 below.

**.3** Other specific design parameters influenced by sea state and speed could be also considered at the discretion of the Society.

**.4** It is the designer's responsibility to specify the format and the values of the limit operating conditions. Their format may be for example a relation between speed and significant wave height which ascertains actual loads less than the one used for structural design. They must include the maximum allowed significant wave height  $H_{sm}$  consistent with the structural strength.  $H_{sm}$  is not to be greater than the value calculated according to C3.3.3.1.7 below.

**.5** The limit operating conditions are defined, at the discretion of the Society, on the basis of results of model tests and full-scale measurements or by numerical simulations.

**.6** The limit operating conditions, taken as a basis for classification, are indicated in the Classification Certificate and are to be considered in defining the worst intended conditions and the critical design conditions in Section 1.

**.7** It is assumed that, on the basis of weather forecast, the craft does not encounter, within the time interval required for the voyage, sea states with significant heights, in  $m$ , greater than the following:

$$H_{sm} = 5 \cdot \frac{a_{CG}}{V/(\sqrt{L})} \cdot \frac{L}{6 + 0,14 \cdot L}$$

where vertical acceleration  $a_{CG}$  is defined in C3.3.1.

**.8** For craft with a particular shape or other characteristics, the Society reserves the right to require model tests or full-scale measurements to verify results obtained by the above formula.

**C3.3.3.2 Limitation imposed by bottom impact pressure and deck loads**

**.1** Bottom impact pressure, given in C3.5.3, and deck loads, given in C3.5.8, are explicitly or implicitly depending on the vertical acceleration at LCG. Therefore, the design values of these loads, taken as the basis for the classification, directly impose limitation on vertical acceleration level at LCG.

**.2** It is the designer's responsibility to provide for a relation between the speed and the significant wave height that provides a maximum vertical acceleration less than the design value.

**.3** Model tests if any are to be carried out in irregular sea conditions with a significant wave height corresponding to the operating conditions of the craft and a clearly specified sea spectrum. The scale effect is to be accounted for with an appropriate margin of safety. The characteristic value of acceleration and global loads to be assumed corresponds to the average of the 1 per cent highest values obtained during tests. The duration of the test is, as far as practicable, to be sufficient to guarantee that results are stationary.

**.4** Where model test results or full-scale measurements are not available, the formula contained in C3.3.3.2.5 may be used to define maximum speeds compatible with design acceleration of monohulls, depending on sea states having a significant height  $H_s$ .

**.5** The significant wave height is related to the craft's geometric and motion characteristics and to the vertical acceleration  $a_{CG}$  by the following formula:

$$a_{CG} = \frac{(50 - \alpha_{dCG}) \cdot \left(\frac{\tau}{16} + 0,75\right)}{3555 \cdot C_B} \cdot \left(\frac{H_s}{T} + 0,084 \cdot \frac{B_w}{T}\right) \cdot K_{FR} \cdot K_{HS}$$

- for units for which  $V / L^{0,5} \geq 3$  and  $\Delta / (0,01 \cdot L)^3 \geq 3500$

$$K_{FR} = \left(\frac{V_x}{\sqrt{L}}\right)^2$$

and

$$K_{HS} = 1$$

- for units for which  $V/L^{0,5} < 3$  or  $\Delta/(0,01 \cdot L)^3 < 3500$

$$K_{FR} = 0,8 + 1,6 \cdot \frac{V_x}{\sqrt{L}}$$

and

$$K_{HS} = \frac{H_s}{T}$$

where:

$H_s$  : significant wave height, in m,

$\alpha_{dCG}$  : deadrise angle, in degrees, at LCG, to be taken between  $10^\circ$  and  $30^\circ$ ,

$\tau$  : trim angle during navigation, in degrees, to be taken not less than  $4^\circ$ ,

$V$  : maximum service speed, in knots.

$V_x$  : actual craft speed, in knots.

If  $V_x$  is replaced by the maximum service speed  $V$  of the craft, the previous formula yields the significant height of the limit sea state,  $H_{sl}$ . This formula may also be used to specify the permissible speed in a sea state characterised by a significant wave height equal to or greater than  $H_{sl}$ .

**.6** On the basis of the formula indicated in C3.3.3.2.5, the limit sea state may be defined (characterised by its significant wave height  $H_{sl}$ ), i.e. the sea state in which the craft may operate at its maximum service speed. During its voyage, whenever the craft encounters waves having a significant height greater than  $H_{sl}$ , it has to reduce its speed.

**.7** For catamarans, the relation between speed, wave height and acceleration is to be justified by model test results or full-scale measurements (see also C3.3.3.3).

**.8** For craft, such as SESs, for which a speed reduction does not necessarily imply a reduction in acceleration, the speed is to be modified depending on the sea state according to criteria defined, at the discretion of the Society, on the basis of motion characteristics of the craft.

**.9** The reduction of vertical acceleration  $a_{CG}$  induced by stabilisation system if any is to be disregarded for the purpose of limit operating conditions imposed by bottom impact loads.

**C3.3.3.3 Limitation imposed by wet deck impact loads for catamarans**

**.1** Wet deck impact pressure is given in C3.5.4.

**.2** The formula in C3.5.4 may be used to define maximum speeds compatible with actual structure of wet deck, depending on sea states having a significant height  $H_s$ .

**.3** The reduction of relative impact velocity  $V_{sl}$  induced by stabilisation system if any is to be disregarded for the purpose of limit operating conditions imposed by wet deck impact loads.

**C3.3.3.4 Limitation imposed by global loads**

**.1** For monohulls and catamarans, the longitudinal bending moment and shear forces as given in C3.4.1 and C3.4.2 are explicitly or implicitly depending on vertical acceleration along the ship. Therefore, the design values of these loads, taken as the basis for classification, directly impose limitation on vertical acceleration level at LCG. The requirements of C3.3.3.2.2 to C3.3.3.2.9 apply.

**.2** For catamarans, the transverse bending moment, the torsional bending moment and the vertical shear force as given in C3.4.2 are depending on vertical acceleration  $a_{CG}$ . Therefore, the requirements of C3.3.3.2.2 to C3.3.3.2.9 apply.

.3 For SWATH craft, the global loads as given in C3.4.3 are not depending on ship motions.

.4 For ships with length greater than 100m, the relation between vertical acceleration along the ship and global loads are to be ascertained on basis of results of model tests and/or full-scale measurements or by numerical simulations, as indicated in C3.3.3.2.

.5 The reduction of vertical acceleration along the ship induced by stabilisation system if any is to be disregarded for the purpose of limit operating conditions imposed by global loads.

### C3.3.3.5 Hull monitoring

.1 The Society may require a hull monitoring system to be fitted on board, allowing to monitor and display in real time the vertical acceleration and any other sensitive parameter with respect to the strength.

.2 The information is to be available at the wheelhouse and displayed in a clear format allowing to compare with design values.

.3 When a hull monitoring system is requested, its specification is to be submitted for review.

## C3.4 Overall loads

### C3.4.1 Monohulls

#### C3.4.1.1 General

.1 As a rule, only longitudinal vertical bending moment and shear force are to be considered for monohulls.

.2 For large craft, values from model tests, or hydrodynamic calculations, may be taken into account, after agreement of the Society on the methodology, the sea conditions and the loading cases. In such cases, values given in C3.4.1.2 must be considered as short term 1/100° values.

### C3.4.1.2 Bending moment and shear force

#### .1 General

.1 The values of the longitudinal bending moment and shear force are given, in first approximation, by the formula in C3.4.1.2.2, C3.4.1.2.3 and C3.4.1.2.4.

.2 The total bending moments  $M_{bIH}$ , in hogging conditions, and  $M_{bIS}$ , in sagging conditions, in kN.m, are to be taken as the greatest of those given by the formulae in C3.4.1.2.2 and C3.4.1.2.3.

For ships having  $L > 100$  m, only the formula in C3.4.1.2.3 is generally to be applied; the formula in C3.4.1.2.2 is to be applied when deemed necessary by the Society on the basis of the motion characteristics of the ship. The total shear forces  $T_{bl}$ , in kN, is given by the formula in C3.4.1.2.4.

.3 The longitudinal distribution of the total bending moment  $M_{bIH}$  and  $M_{bIS}$  is given in C3.4.1.2.5.

.4 If the actual distribution of weights along the craft is known, a more accurate calculation may be carried out according to the procedure in C3.4.1.2.6. the Society reserves the right to require calculation to be carried out according to C3.4.1.2.6 whenever it deems necessary.

.5 Rule requirements are reminded in Table C3.4.1.

Table C3.4.1

Ships		Applicable requirements	
$L \leq 100$ m	All cases	Bending moment	C3.4.1.2.2 or C3.4.1.2.3 whichever is the greater
		Shear force	C3.4.1.2.4
$L \leq 100$ m	Alternatively, when actual distribution of weights is known	Bending moment and shear force	C3.4.1.2.6
$L > 100$ m	Normal cases	Bending moment	C3.4.1.2.3
		Shear force	C3.4.1.2.4
$L > 100$ m	Special cases (when deemed necessary by the Society)	Bending moment	C3.4.1.2.2 or C3.4.1.2.3 whichever is the greater
		Shear force	C3.4.1.2.4
$L > 100$ m	Alternatively, when actual distribution of weights is known	Bending moment and shear force	C3.4.1.2.6

**.2 Bending moment due to still water loads, wave induced loads and impact loads**

$$M_{blH} = M_{blS} = 0,55 \cdot \Delta \cdot L \cdot (C_B + 0,7) \cdot (1 + a_{CG})$$

where  $a_{CG}$  is the vertical acceleration at the LCG, defined in C3.3.1.

**.3 Bending moment due to still water loads and wave induced loads**

$$M_{blH} = M_{sH} + 0,60 \cdot Soc \cdot C \cdot L^2 \cdot B \cdot C_B$$

$$M_{blS} = M_{sS} + 0,35 \cdot Soc \cdot C \cdot L^2 \cdot B \cdot (C_B + 0,7)$$

where:

$M_{sH}$  : still water hogging bending moment, in kN.m,

$M_{sS}$  : still water sagging bending moment, in kN.m,

$Soc$  : parameter as indicated in Table C3.3.2, for the considered type of service.

$$C = 6 + 0,02 L$$

For the purpose of this calculation,  $C_B$  may not be taken less than 0,6.

**.4 Total shear force**

$$T_{bl} = \frac{3,2 \cdot M_{bl}}{L}$$

where:

$M_{bl}$  : the greatest between  $M_{blH}$  and  $M_{blS}$ , calculated according to C3.4.1.2.2 and C3.4.1.2.3, as applicable.

**.5 Longitudinal distribution of total bending moment**

The longitudinal distribution of the total bending moments is given by:

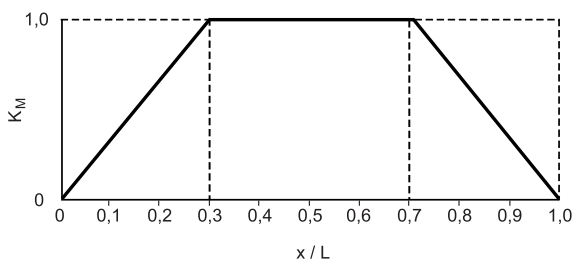
$K_M \cdot M_{blH}$  in hogging

$K_M \cdot M_{blS}$  in sagging

where:

$K_M$  : longitudinal distribution factor as shown on Figure C3.4.1.

**Figure C3.4.1**



**.6 Bending moment and shear force taking into account the actual distribution of weights**

**.1** The distribution of quasi-static bending moment and shear force, due to still water loads and wave induced loads, is to be determined from the difference in weight and buoyancy distributions in hogging and sagging for each loading or ballast condition envisaged.

**.2** For calculation purposes, the following values are to be taken for the design wave:

- wave length, in m:

$$\lambda = L$$

- wave height, in m:

$$h = \frac{L}{15 + \frac{L}{20}}$$

- wave form: sinusoidal.

**.3** In addition, the increase in bending moment and shear force, due to impact loads in the fore-body area, for the sagging condition only, is to be determined as specified below. For the purpose of this calculation, the hull is considered longitudinally subdivided into a number of intervals, to be taken, in general, equal to 20. For smaller craft, this number may be reduced to 10 if justified, at the Society's discretion, on the basis of the weight distribution, the hull forms and value of the design acceleration  $a_{CG}$ .

For twin-hull craft, the calculation below applies to one of the hulls, i.e. the longitudinal distribution of weight forces  $g_i$  and the corresponding breadth  $B_i$  are to be defined for one hull.

The total impact force, in kN, is:

$$F_{SL} = \sum q_{SLi} \cdot \Delta x_i$$

where:

$\Delta x_i$  : length of interval, in m,

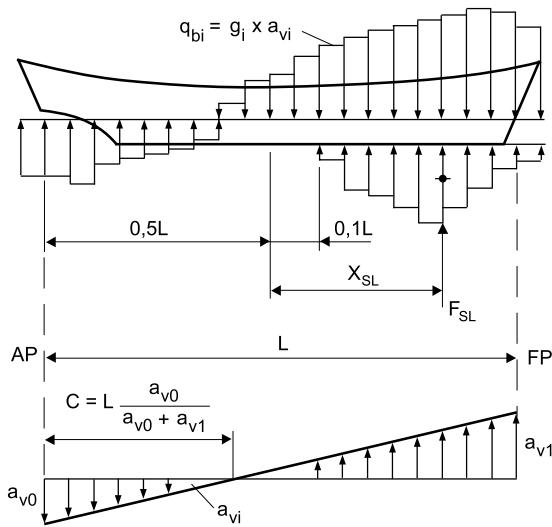
$q_{SLi}$  : additional load per unit length, in kN/m, for  $x/L \geq 0,6$  (see also Figure C3.4.2), given by:

$$q_{SLi} = p_0 \cdot B_i \cdot \sin\left(2 \cdot \pi \cdot \left(\frac{x_i}{L} - 0,6\right)\right)$$

$x_i$  : distance, in m, from the aft perpendicular,



Figure C3.4.2



$B_i$  : craft breadth, in m, at uppermost deck;  
( $x_i$  and  $B_i$  to be measured at the centre of interval  $i$ ),

$p_0$  : maximum hydrodynamic pressure, in  $\text{kN/m}^2$ , equal to:

$$p_0 = \frac{a_{v1} \cdot G \cdot (r_0^2 - x_W^2)}{f_{SL} \cdot (r_0^2 + 0,5 \cdot L \cdot (x_{SL} - x_W) - x_{SL} \cdot x_W)}$$

$a_{v1}$  : vertical design acceleration at the forward perpendicular, as defined in C3.3,

$G$  : weight force, in kN, equal to:

$$G = \sum g_i \cdot \Delta x_i$$

$g_i$  : weight per unit length, in  $\text{kN/m}$ , of interval  $i$ ; for twin-hull craft,  $g_i$  is to be defined for one hull,

$x_W$  : distance, in m, of LCG from the midship perpendicular, equal to:

$$x_W = \frac{\sum (g_i \cdot \Delta x_i \cdot x_i)}{\sum (g_i \cdot \Delta x_i)} - 0,5 \cdot L$$

$r_0$  : radius of gyration, in m, of weight distribution, equal to:

$$r_0 = \left( \frac{\sum g_i \cdot \Delta x_i \cdot (x_i - 0,5L)^2}{\sum g_i \cdot \Delta x_i} \right)^{0,5}$$

normally  $0,2 L < r_0 < 0,25 L$  (guidance value)

$x_{SL}$  : distance, in m, of centre of surface  $F_{SL}$  from the midship perpendicular, given by:

$$x_{SL} = \frac{1}{f_{SL}} \sum \Delta x_i \cdot x_i \cdot B_i \cdot \sin \left( 2\pi \cdot \left( \frac{x_i}{L} - 0,6 \right) \right) - 0,5L$$

$f_{SL}$  : surface, in  $\text{m}^2$ , equal to:

$$f_{SL} = \sum \Delta x_i \cdot B_i \cdot \sin \left( 2\pi \cdot \left( \frac{x_i}{L} - 0,6 \right) \right)$$

4 The resulting load distribution  $q_{si}$ , in  $\text{kN/m}$ , for the calculation of the impact induced sagging bending moment and shear force is:

(a) For  $x/L < 0,6$ :

$$q_{si} = q_{bi} = g_i \cdot a_{vi}$$

where:

$a_{vi}$  : total dimensionless vertical acceleration at interval  $i$ , equal to:

$$a_{vi} = a_h + a_p \cdot (x_i - 0,5L)$$

$a_h$  : acceleration due to heaving motion, equal to:

$$a_h = \frac{F_{SL}}{G} \cdot \left( \frac{r_0^2 - x_{SL} \cdot x_W}{r_0^2 - x_W^2} \right)$$

$a_p$  : acceleration due to pitching motion, in  $\text{m}^{-1}$ , equal to:

$$a_p = \frac{F_{SL}}{G} \cdot \left( \frac{x_{SL} - x_W}{r_0^2 - x_W^2} \right)$$

$a_h$  and  $a_p$  are relative to  $g$

(b) For  $x/L \geq 0,6$ :

$$q_{si} = q_{bi} - q_{SLi}$$

5 The impact induced sagging bending moment and shear force are obtained by integration of the load distribution  $q_{si}$  along the hull. They are to be added to the respective values calculated according to C3.4.1.3.1 in order to obtain the total bending moment and shear force due to still water loads, wave induced loads and impact loads.

### C3.4.2 Catamarans

#### C3.4.2.1 General

1 The values of the longitudinal bending moment and shear force are given by the formulae in C3.4.1.2.

2 For catamarans, the hull connecting structures are to be checked for load conditions specified in C3.4.2.2 and C3.4.2.3. These load conditions are to be considered as acting separately.

.3 Design moments and forces given in the following paragraphs are to be used unless other values are verified by model tests, full-scale measurements or any other information provided by the designer (see C3.3.4.1, Requirements for model tests).

.4 For craft with length  $L > 65$  m or speed  $V > 45$  knots, or for craft with structural arrangements that do not permit a realistic assessment of stress conditions based on simple models, the transverse loads are to be evaluated by means of direct calculations carried out in accordance with criteria specified in C3.6 or other criteria considered equivalent by the Society.

#### C3.4.2.2 Longitudinal bending moment and shear force

.1 Refer to C3.4.1.2.

.2 In C3.4.1.2.6, the breadth  $B_i$  is defined as below:

$B_i$  : maximum breadth of one hull at the considered longitudinal location  $x_i$ , in m.

.3 When slamming of wet-deck is expected to occur (cf. C3.5.4),  $B_i$  is to be taken as:

$B_i$  : the maximum breadth of one hull at the considered longitudinal location, in m, without being greater than  $B/2$ , multiplied by the coefficient  $f_B$ , where:  
 $f_B = 2 \cdot (1 - B_w/B)$

#### C3.4.2.3 Transverse bending moment and shear force

.1 The transverse bending moment  $M_{bt}$ , in kN.m, and shear force  $T_{bt}$ , in kN, are given by:

$$M_{bt} = \frac{\Delta \cdot b \cdot a_{CG} \cdot g}{5}$$

$$T_{bt} = \frac{\Delta \cdot a_{CG} \cdot g}{4}$$

where:

$b$  : transverse distance, in m, between the centres of the two hulls,

$a_{CG}$  : vertical acceleration at LCG, defined in C3.3.1.

#### C3.4.2.4 Transverse torsional connecting moment

.1 The catamaran transverse torsional connecting moment, in kN.m, about a transverse axis is given by:

$$M_{tt} = 0,125 \cdot \Delta \cdot L \cdot a_{CG} \cdot g$$

where  $a_{CG}$  is the vertical acceleration at LCG, defined in C3.3.1, which need not to be taken greater than 1,0 g for this calculation.

#### C3.4.3 Small waterplane area twin-hull (SWATH) craft - Forces and moments acting on twin-hull connections

##### C3.4.3.1 Side beam force

.1 The design beam side force, in kN, (see Figure C3.4.3) is given by:

$$F_Q = 12,5 \cdot T \cdot \Delta^{2/3} \cdot d \cdot L_S$$

where:

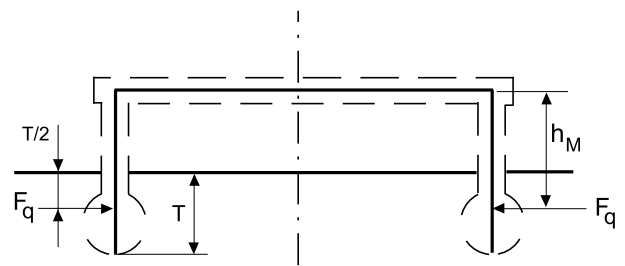
$$d = 1,55 - 0,75 \cdot \tanh\left(\frac{\Delta}{11000}\right)$$

$$L_S = 2,99 \cdot \tanh(\lambda - 0,725)$$

$$\lambda = \frac{0,137 \cdot A_{lat}}{T \cdot \Delta^{1/3}}$$

$A_{lat}$  : lateral area, in  $m^2$ , projected on a vertical plane, of one hull with that part of strut or struts below waterline at draught  $T$ .

Figure C3.4.3



.2 The lateral pressure, in  $kN/m^2$ , acting on one hull is given by:

$$p_Q = \frac{F_Q}{A_{lat}}$$

The distribution of the lateral force  $F_Q$  can be taken as constant over the effective length  $L_e = A_{lat} / T$ , in m. The constant lateral force per unit length, in  $kN/m$ , is thus given by:

$$q_Q = \frac{F_Q}{L_e}$$

##### C3.4.3.2 Bending moment

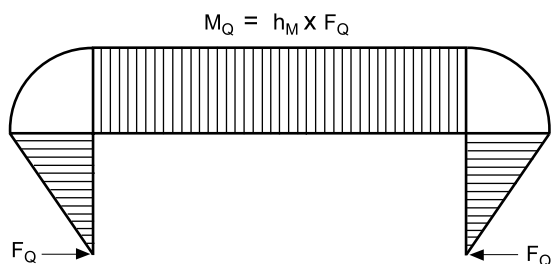
.1 The corresponding design bending moment, in kN.m, is given by:

$$M_Q = h_M \cdot F_Q$$

where:

$h_M$  : half the draught  $T$  plus the distance from the waterline at draught  $T$  to the midpoint of the cross-deck structure (see Figure C3.4.4), in m.

Figure C3.4.4



## C3.5 Local loads

### C3.5.1 Introduction

**.1** Design loads defined in this Article are to be used for the resistance checks provided for in C3.7 and C3.8 to obtain scantlings of structural elements of hull and deckhouses.

**.2** Such loads may be integrated or modified on the basis of the results of model tests or full-scale measurements. Model tests are to be carried out in irregular sea conditions with significant wave heights corresponding to the operating conditions of the craft. The scale effect is to be accounted for by an appropriate margin of safety.

**.3** The characteristic value to be assumed is defined as the average of the 1 per cent highest values obtained during testing. The length of the test is, as far as practicable, to be sufficient to guarantee that statistical results are stationary.

### C3.5.2 Loads

#### C3.5.2.1 General

**.1** The following loads are to be considered in determining scantlings of hull structures:

- impact pressures due to slamming, if expected to occur,
- sea pressures due to hydrostatic heads and wave loads,
- internal loads.

**.2** External pressure generally determines scantlings of side and bottom structures; internal loads generally determine scantlings of deck structures.

**.3** Where internal loads are caused by concentrated masses of significant magnitude (e.g. tanks,

machinery), the capacity of the side and bottom structures to withstand such loads is to be verified according to criteria stipulated by the Society. In such cases, the inertial effects due to acceleration of the craft are to be taken into account.

Such verification is to disregard the simultaneous presence of any external wave loads acting in the opposite direction to internal loads.

#### C3.5.2.2 Load points

**.1** Pressure on panels and strength members may be considered uniform and equal to the pressure at the following load points:

- for panels:
  - lower edge of the plate, for pressure due to hydrostatic head and wave load
  - geometrical centre of the panel, for impact pressure
- for strength members:
  - centre of the area supported by the element.

**.2** Where the pressure diagram shows cusps or discontinuities along the span of a strength member, a uniform value is to be taken on the basis of the weighted mean value of pressure calculated along the length.

### C3.5.3 Impact pressure on the bottom of hull

**.1** If slamming is expected to occur, the impact pressure, in kN/m<sup>2</sup>, considered as acting on the bottom of hull is not less than:

$$p_{sl} = 70 \cdot \frac{\Delta}{S_r} \cdot K_1 \cdot K_2 \cdot K_3 \cdot a_{CG}$$

where:

$\Delta$  : displacement, in tonnes (see C3.1.4). For catamaran,  $\Delta$  in the above formula is to be taken as half of the craft displacement

$S_r$  : reference area, m<sup>2</sup>, equal to:

$$S_r = 0,7 \cdot \frac{\Delta}{T}$$

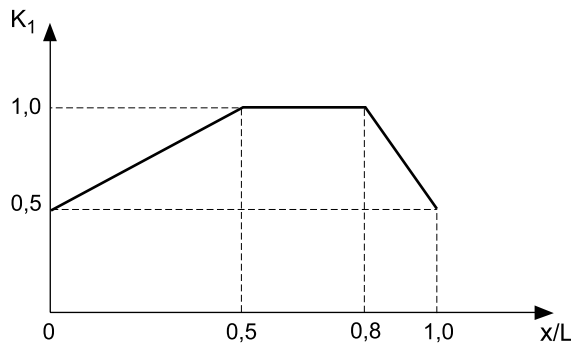
For catamaran,  $\Delta$  in the above formula is to be taken as half the craft displacement

$K_1$  : longitudinal bottom impact pressure distribution factor (see Figure C3.5.1):

- for  $x/L < 0,5$ :  $K_1 = 0,5 + x/L$
- for  $0,5 \leq x/L \leq 0,8$ :  $K_1 = 1,0$
- for  $x/L > 0,8$ :  $K_1 = 3,0 - 2,5 \cdot x/L$

where  $x$  is the distance, in m, from the aft perpendicular to the load point

Figure C3.5.1



$K_2$  : factor accounting for impact area, equal to:

$$K_2 = 0,455 - 0,35 \cdot \frac{u^{0,75} - 1,7}{u^{0,75} + 1,7}$$

with:

- $K_2 \geq 0,50$  for plating,
- $K_2 \geq 0,45$  for stiffeners,
- $K_2 \geq 0,35$  for girders and floors,

$$u = 100 \cdot \frac{s}{S_r}$$

where  $s$  is the area, in  $m^2$ , supported by the element (plating, stiffener, floor or girder). For plating, the supported area is the spacing between the stiffeners multiplied by their span, without taking for the latter more than three times the spacing between the stiffeners

$K_3$  : factor accounting for shape and deadrise of the hull, equal to:

$$K_3 = (70 - \alpha_d) / (70 - \alpha_{dCG})$$

where  $\alpha_{dCG}$  is the deadrise angle, in degrees, measured at LCG and  $\alpha_d$  is the deadrise angle, in degrees, between horizontal line and straight line joining the edges of respective area measured at the longitudinal position of the load point; values taken for  $\alpha_d$  and  $\alpha_{dCG}$  are to be between  $10^\circ$  and  $30^\circ$

$a_{CG}$  : design vertical acceleration at LCG, defined in C3.3.1.

### C3.5.4 Impact pressure on bottom of wet-deck of catamarans (including tunnel radius)

.1 Slamming on bottom of the wet deck is assumed to occur if the air gap  $H_{A,r}$ , in m, at the considered longitudinal position is less than  $z_{wd}$ , where:

- for  $L \leq 65$  m:  $z_{wd} = 0,05 \cdot L$
- for  $L > 65$  m:  $z_{wd} = 3,25 + 0,0214 \cdot (L - 65)$

In such a case, the impact pressure, in  $kN/m^2$ , considered as acting on the wet deck is not less than:

$$p_{sl} = 3 \cdot K_2 \cdot K_{WD} \cdot V_x \cdot V_{sl} \cdot \left(1 - 0,85 \cdot \frac{H_A}{H_s}\right)$$

where:

$V_{sl}$  : relative impact velocity, in m/s, equal to:

$$V_{sl} = \frac{4 \cdot H_s}{\sqrt{L}} + 1$$

$H_s$  : significant wave height,

$K_2$  : factor accounting for impact area, as defined in C3.5.3.1,

$K_{WD}$  : longitudinal wet deck impact pressure distribution factor (see Figure C3.5.2):

- for  $x/L < 0,2$ :

$$K_{WD} = 0,5 \cdot \left(1,0 - \frac{x}{L}\right)$$

- for  $0,2 \leq x/L \leq 0,7$ :

$$K_{WD} = 0,4$$

- for  $0,7 < x/L < 0,8$ :

$$K_{WD} = 6,0 \cdot \frac{x}{L} - 3,8$$

- for  $x/L \geq 0,8$ :

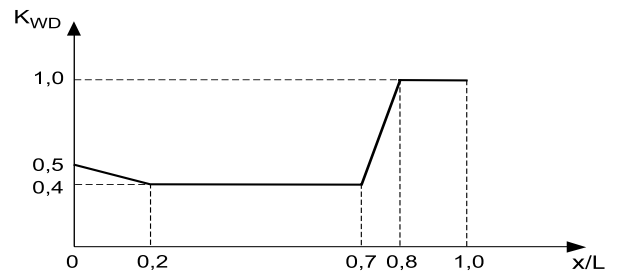
$$K_{WD} = 1,0$$

where  $x$  is the distance, in m, from the aft perpendicular to the load point,

$V_x$  : ship's speed, in knots,

$H_A$  : air gap, in m, equal to the distance between the waterline at draught  $T$  and the wet deck

Figure C3.5.2



.2 If the wet deck at a transverse section considered is not parallel to the design waterline, the impact pressure  $p_{sl}$  will be considered at the discretion of the Society.

### C3.5.5 Sea pressures

#### C3.5.5.1 Sea pressure on bottom and side shell

.1 The sea pressure, in  $kN/m^2$ , considered as acting on the bottom and side shell is not less than  $p_{smin}$ , defined in Table C3.5.1, nor less than:

- for  $z \leq T$ :

$$p_s = 10 \cdot \left(T + 0,75 \cdot S - \left(1 - 0,25 \cdot \frac{S}{T}\right) \cdot z\right)$$

- for  $z > T$ :

$$p_s = 10 \cdot (T + S - z)$$

where:

- $z$  : vertical distance, in m, from the moulded base line to load point.  $z$  is to be taken positively upwards,
- $S$  : as given, in m, in Table C3.5.1 with  $C_B$  taken not greater than 0,5.

**Table C3.5.1**

	$S$	$p_{smin}$
$x/L \geq 0,9$	$T \leq 0, 36 \cdot a_{CG} \cdot \frac{\sqrt{L}}{C_B} \leq 3, 5 \cdot T$	$20 \leq \frac{L+75}{5} \leq 35$
$x/L \leq 0,5$	$T \leq 0, 60 \cdot a_{CG} \cdot \sqrt{L} \leq 2, 5 \cdot T$	$10 \leq \frac{L+75}{10} \leq 20$

**.2** Between midship area and fore end ( $0,5 < x/L < 0,9$ ),  $p_s$  varies in a linear way as follows:

$$p_s = p_{sFP} - (2, 25 - 2, 5 \cdot x/L) \cdot (p_{sFP} - p_{sM})$$

where  $p_{sFP}$  is the sea pressure at fore end and  $p_{sM}$  in midship area.

### C3.5.5.2 Stern doors and side shell doors

**.1** The sea pressures on stern doors and side shell doors is to be taken according to C3.5.5.1 for scantlings of plating and secondary members.

**.2** The design forces, in kN, considered for the scantlings of primary members are to be not less than:

- external force:  $F_e = A \cdot p_s$
- internal force:  $F_i = F_o + 10 \cdot W$

where:

- $A$  : area, in m, of the door opening,
- $W$  : mass of the door, in t,
- $F_p$  : total packing force in kN. Packing line pressure is normally not to be taken less than 5 N/mm,
- $F_o$  : the greater of  $F_c$  and  $5 \cdot A$  (kN),
- $F_c$  : accidental force, in kN, due to loose of cargo etc., to be uniformly distributed over the area  $A$  and not to be taken less than 300 kN. For small doors, such as bunker doors and pilot doors, the value of  $F_c$  may be appropriately reduced. However, the value of  $F_c$  may be taken as zero, provided an additional structure such as an inner ramp is fitted, which is capable of protecting the door from accidental forces due to loose cargoes,
- $p_s$  : sea pressure as defined in C3.5.5.1

**.3** The design forces, in kN, considered for the scantlings of securing or supporting devices of doors opening outwards are to be not less than:

- external force:  $F_e = A \cdot p_s$
  - internal force:  $F_i = F_o + 10 \cdot W + F_p$
- where the parameters are defined in C3.5.5.2.2.

**.4** The design forces, in kN, considered for the scantlings of securing or supporting devices of doors opening inwards are to be not less than:

- external force:  $F_e = A \cdot p_s + F_p$
  - internal force:  $F_i = F_o + 10 \cdot W$
- where the parameters are defined in C3.5.5.2.2.

### C3.5.6 Sea pressures on front walls of the hull

**.1** The pressure, kN/m<sup>2</sup>, considered as acting on front walls of the hull (in case of stepped main deck), not located at the fore end, is not less than:

$$p_{sf} = 6 \cdot \left(1 + \frac{x_1}{2 \cdot L(C_B + 0, 1)}\right) (1 + 0, 045 \cdot L - 0, 38 \cdot z_1)$$

where:

- $x_1$  : distance, in m, from front walls to the midship perpendicular (for front walls aft of the midship perpendicular,  $x_1$  is equal to 0),
- $z_1$  : distance, in m, from load point to waterline at draught  $T$ .

Where front walls are inclined backwards, the pressure calculated above can be reduced to ( $p_{sf} \sin \alpha$ ), where  $\alpha$  is the angle in degree between front wall and deck.

$p_{sf}$  is not less than the greater of:

$$3 + (6, 5 + 0, 06 \cdot L) \cdot \sin \alpha$$

$$3 + 2, 4 \cdot a_{CG}$$

**.2** For front walls located at the fore end, the pressure  $p_{sf}$  will be individually considered by the Society.

### C3.5.7 Sea pressures on deckhouses

**.1** The pressure, kN/m<sup>2</sup>, considered as acting on walls of deckhouses is not less than:

$$p_{su} = K_{su} \cdot \left(1 + \frac{x_1}{2 \cdot L(C_B + 0, 1)}\right) (1 + 0, 045 \cdot L - 0, 38 \cdot z_1)$$

where:

- $K_{su}$  : coefficient equal to:
- for front walls of a deckhouse located directly on the main deck not at the fore end:  
 $K_{su} = 6, 0$
  - for unprotected front walls of the second tier, not located at the fore end:  
 $K_{su} = 5, 0$
  - for sides of deckhouses,  $b$  being the breadth, in m, of the considered deckhouse:  
 $K_{su} = 1, 5 + 3, 5 \cdot b/B$  (with  $3 \leq K \leq 5$ )
  - for the other walls:  
 $K_{su} = 3, 0$

$x_1$  : distance, in m, from front walls or from wall elements to the midship perpendicular (for front walls or side walls aft of the midship perpendicular,  $x_1$  is equal to 0),

$z_1$  : distance, in m, from load point to waterline at draught T.

**.2** The minimum values of  $p_{su}$ , in kN/m<sup>2</sup>, to be considered are:

- for the front wall of the lower tier:  
 $p_{su} = 6,5 + 0,06 \cdot L$
- for the sides and aft walls of the lower tier:  
 $p_{su} = 4,0$
- for the other walls or sides:  
 $p_{su} = 3,0$

**.3** For unprotected front walls located at the fore end, the pressure  $p_{su}$  will be individually considered by the Society.

### C3.5.8 Deck loads

#### C3.5.8.1 General

**.1** The pressure, in kN/m<sup>2</sup>, considered as acting on decks is given by the formula:

$$p_d = p (1 + 0,4 \cdot a_v)$$

where:

$p$  : uniform pressure due to the load carried, kN/m<sup>2</sup>. Minimum values are given in C3.5.8.2 to C3.5.8.6,

$a_v$  : design vertical acceleration, defined in C3.3.

**.2** Where decks are intended to carry masses of significant magnitude, including vehicles, the concentrated loads transmitted to structures are given by the corresponding static loads multiplied by  $(1 + 0,4 a_v)$ .

#### C3.5.8.2 Weather decks and exposed areas

**.1** For weather decks and exposed areas without deck cargo:

- if  $z_d \leq 2$ :  
 $p = 6,0 \text{ kN/m}^2$
- if  $2 < z_d < 3$ :  
 $p = (12 - 3 z_d) \text{ kN/m}^2$
- if  $z_d \geq 3$ :  
 $p = 3,0 \text{ kN/m}^2$

where  $z_d$  is the vertical distance, in m, from deck to waterline at draught T.

$p$  can be reduced by 20% for primary supporting members and pillars under decks located at least 4 m above the waterline at draught T, excluding embarkation areas.

**.2** For weather decks and exposed areas with deck cargo:

- if  $z_d \leq 2$ :  
 $p = (p_c + 2) \text{ kN/m}^2$ , with  $p_c \geq 4,0 \text{ kN/m}^2$
- if  $2 < z_d < 3$ :  
 $p = (p_c + 4 - z_d) \text{ kN/m}^2$ , with  $p_c \geq (8,0 - 2 z_d) \text{ kN/m}^2$
- if  $z_d \geq 3$ :  
 $p = (p_c + 1) \text{ kN/m}^2$ , with  $p_c \geq 2,0 \text{ kN/m}^2$

where:

$z_d$  : distance defined in C3.5.8.2.1,

$p_c$  : uniform pressure due to deck cargo load, in kN/m<sup>2</sup>, to be defined by the designer with the limitations indicated above.

#### C3.5.8.3 Sheltered decks

**.1** They are decks which are not accessible to the passengers and which are not subjected to the sea pressures. Crew can access such deck with care and taking account of the admissible load, which is to be clearly indicated. Deckhouses protected by such decks may not have direct access to 'tween-deck below.

For shelter decks:

$$p = 1,3 \text{ kN/m}^2$$

**.2** A lower value may be accepted, at the discretion of the Society, provided that such a value as well as the way of access to the deck are clearly specified by and agreed upon with the Owner.

#### C3.5.8.4 Enclosed accommodation decks

**.1** For enclosed accommodation decks not carrying goods:

$$p = 3,0 \text{ kN/m}^2$$

$p$  can be reduced by 20 per cent for primary supporting members and pillars under such decks.

**.2** For enclosed accommodation decks carrying goods:

$$p = p_c$$

The value of  $p_c$  is to be defined by the designer, but taken as not less than 3,0 kN/m<sup>2</sup>.

#### C3.5.8.5 Enclosed cargo decks

**.1** For enclosed cargo decks other than decks carrying vehicles:

$$p = p_c$$

where  $p_c$  is to be defined by the designer, but taken as not less than 3,0 kN/m<sup>2</sup>.

For enclosed cargo decks carrying vehicles, the loads are defined in C3.5.8.7.

**C3.5.8.6 Platforms of machinery spaces**

.1 For platforms of machinery spaces:

$$p = 15,0 \text{ kN/m}^2$$

**C3.5.8.7 Decks carrying vehicles**

.1 The scantlings of the structure of decks carrying vehicles are to be determined by taking into account only the concentrated loads transmitted by the wheels of vehicles, except in the event of supplementary requirement from the designer.

.2 The scantlings under racking effects (e.g. for combined loading condition 3 defined in C3.6.1.2.9 and C3.6.2.2.9) of the primary structure of decks carrying vehicles is to be the greater of the following cases:

- scantlings determined under concentrated loads transmitted by the wheels of vehicles,
- scantlings determined under a uniform load  $p_c$  taken not less than  $2,5 \text{ kN/m}^2$ . This value of  $p_c$  may be increased if the structural weight cannot be considered as negligible, to the satisfaction of the Society.

**C3.5.9 Pressures on tank structures**

.1 The pressure, in  $\text{kN/m}^2$ , considered as acting on tank structures is not less than the greater of:

$$p_{11} = 9,81 \cdot h_1 \cdot \rho \cdot (1 + 0,4 \cdot a_v) + 100 \cdot p_v$$

$$p_{12} = 9,81 \cdot h_2$$

where:

- $h_1$  : distance, in m, from load point to tank top,
- $h_2$  : distance, in m, from load point to top of overflow or to a point located 1,5 m above the tank top, whichever is greater,
- $\rho$  : liquid density, in  $\text{t/m}^3$  ( $1,0 \text{ t/m}^3$  for water),
- $p_v$  : setting pressure, in bars, of pressure relief valve, when fitted.

**C3.5.10 Pressures on subdivision bulkheads**

.1 The pressure, in  $\text{kN/m}^2$ , considered as acting on subdivision bulkheads is not less than:

$$p_{sb} = 9,81 \cdot h_3$$

where:

- $h_3$  : distance, in m, from load point to bulkhead top.

**C3.6 Direct calculations for monohulls and catamarans****C3.6.1 Direct calculations for monohulls****C3.6.1.1 General**

.1 Direct calculations generally require to be carried out, in the opinion of the Society, to check primary structures for craft of length  $L > 65 \text{ m}$  or speed  $V > 45 \text{ knots}$ .

.2 In addition, direct calculations are to be carried out to check scantlings of primary structures of craft whenever, in the opinion of the Society, hull shapes and structural dimensions are such that scantling formulas in C3.7 and C3.8 are no longer deemed to be effective.

.3 This may be the case, for example, in the following situations:

- elements of the primary transverse ring (beam, web and floor) have very different cross section inertiae, so that the boundary conditions for each are not well-defined,
- marked V-shapes, so that floor and web tend to degenerate into a single element,
- complex, non-conventional geometries,
- presence of significant racking effects (in general on ferries),
- structures contributing to longitudinal strength with large windows in side walls.

**C3.6.1.2 Loads**

.1 In general, the loading conditions specified in C3.6.1.2.6 to C3.6.1.2.9 below are to be considered. Condition C3.6.1.2.9 is to be checked for craft for which, in the opinion of the Society, significant racking effects are anticipated (e.g. for ferries).

.2 In relation to special structure or loading configurations, should some loading conditions turn out to be less significant than others, the former may be ignored at the discretion of the Society. In the same way, it may be necessary to consider further loading conditions specified by the Society in individual cases.

.3 The vertical and transverse accelerations are to be calculated as stipulated in C3.3.

.4 The impact pressure is to be calculated as stipulated in C3.5. For each floor, the  $K_2$ -factor which appears in the formula for the impact pressure is to be calculated as a function of the area supported by the floor itself.

.5 In three-dimensional analyses, special attention is to be paid to the distribution of weights and buoyancy and to the dynamic equilibrium of the craft. In the case of three-dimensional analyses, the longitudinal distribution of impact pressure is to be considered individually.

ally, in the opinion of the Society. In general, the impact pressure is to be considered as acting separately on each transverse section of the model, the remaining sections being subject to the hydrostatic pressure.

#### **.6 Loading conditions in still water**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- outer hydrostatic load in still water.

#### **.7 Combined loading condition 1**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the vertical acceleration  $a_v$  of the craft, considered in a downward direction.

#### **.8 Combined loading condition 2**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the vertical acceleration  $a_v$  of the craft, considered in a downward direction,
- impact pressure acting on the bottom of the craft (2 cases):
  - case 1: symmetrically and according to C3.6.1.2.5,
  - case 2: asymmetrically and acting on one side of a complete compartment between transverse bulkheads, the other side being subject to hydrostatic load in still water.

#### **.9 Combined loading condition 3**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the transverse acceleration of the craft.

### **C3.6.1.3 Structural model**

**.1** Primary structures of craft of this type may usually be modelled with beam elements, according to criteria stipulated by the Society. When, however, grounds for the admissibility of this model are lacking, or when the geometry of the structures gives reason to suspect the presence of high stress concentrations, finite element analyses are necessary.

**.2** In general, the extent of the model is to be such as to allow analysis of the behaviour of the main structural elements and their mutual effects.

**.3** In craft dealt with by these Rules, the stiffness of longitudinal primary members (girders and stringers) is, at least outside the machinery space area, generally negligible compared with the stiffness of transverse structures (beams, floors and webs), or their presence may be taken account of by suitable boundary conditions. It is therefore acceptable, in general, to examine primary members in this area of the hull by means of plane analyses of transverse rings.

**.4** In cases where such approximation is not acceptable, the model adopted is to be three-dimensional and is to include the longitudinal primary members.

**.5** When racking behaviour is investigated and loads thus act in the transverse direction (loading condition 3), special attention is to be devoted to modelling of continuous decks and platforms. Such continuous elements, if of sufficient stiffness in the horizontal plane and if sufficiently restrained by the fore- and after-bodies, may withstand transverse deformations of primary rings.

In such cases, taking for granted the provisions above, it is still permissible to examine bidimensional rings, by simulating the presence of decks and platforms with horizontal springs according to criteria specified by the Society.

### **C3.6.1.4 Boundary conditions**

**.1** Depending upon the loading conditions considered, the following boundary conditions are to be assigned:

(a) Loading condition in still water and combined loading conditions 1 and 2

- horizontal and transverse restraints, in way of the crossing point of bottom and side shells, if the angle between the two shells is less than approximately  $135^\circ$ ,
- horizontal and transverse restraints, in way of keel, if the bottom/side angle is greater than approximately  $135^\circ$ .

(b) Combined loading condition 3

The vertical and horizontal resultants of the loads, in general other than zero, are to be balanced by introducing two vertical forces and two horizontal forces at the fore and aft ends of the model, distributed on the shells according to the bidimensional flow theory for shear stresses, which are equal and opposite to half the vertical and horizontal resultants of the loads.

**.2** Where a plane model is adopted, the resultants are to be balanced by vertical and horizontal forces, distributed as specified above and acting on the plane of the model itself.



**C3.6.1.5 Checking criteria**

**.1** For metal structures, the stresses given by the above calculations are to be not greater than the following allowable values, in N/mm<sup>2</sup>:

- bending stress:

$$\sigma_{am} = \frac{150}{K \cdot f'_m \cdot f_s}$$

- shear stress:

$$\tau_{am} = \frac{90}{K \cdot f'_m \cdot f_s}$$

- Von Mises equivalent bending stress:

$$\sigma_{eq,am} = \frac{190}{K \cdot f'_m \cdot f_s}$$

where:

K : material factor defined in C3.2

f'\_m : coefficient depending on the material:

- 1,00 for steel structures
- 2,15 for aluminium alloy structures

f\_s : safety coefficient, to be assumed:

- 1,00 for combined loading conditions
- 1,25 for loading condition in still water.

**.2** The compressive values of normal stresses and shear stresses are not to exceed the values of the critical stresses for plates and stiffeners calculated according to C3.7.5.

**.3** In structural elements also subject to high longitudinal hull girder stresses, allowable and critical stresses are to be reduced, according to criteria specified by the Society.

**.4** For non-metal structures, allowable stresses are to be defined according to criteria specified by the Society.

**C3.6.2 Direct calculations for catamarans****C3.6.2.1 General**

**.1** Direct calculations generally require to be carried out, at the discretion of the Society, to check primary structures and structures connecting the two hulls for craft of length L > 65 m or speed V > 45 knots.

**.2** In addition, as specified in C3.4.2, direct calculations are to be carried out to check structures connecting the two hulls for craft in which structural arrangements do not allow a realistic assessment of their stress level, based upon simple models and on the formulae set out in C3.4.2.

**C3.6.2.2 Loads**

**.1** In general, the loading conditions specified in C3.6.2.2.6 to C3.6.2.2.9 below are to be considered.

Condition C3.6.2.2.6 applies to a still water static condition check.

Conditions C3.6.2.2.7 and C3.6.2.2.8 apply to the check on structures connecting the two hulls. Condition C3.6.2.2.8 requires checking only for craft of L > 65 m or V > 45 knots.

Condition C3.6.2.2.9 is to be checked in craft for which, in the opinion of the Society, significant racking effects are expected (e.g. ferries).

**.2** In relation to special structure or loading configurations, should some loading conditions turn out to be less significant than others, the former may be ignored, at the discretion of the Society. In the same way, it may be necessary to consider further loading conditions specified by the Society in individual cases.

**.3** Vertical and transverse accelerations are to be calculated as stipulated in C3.3.

**.4** The impact pressure is to be calculated as stipulated in C3.5. For each floor, the K<sub>2</sub>-factor which appears in the formula for the impact pressure is to be calculated as a function of the area supported by the floor itself.

**.5** In three-dimensional analyses, special attention is to be paid to the distribution of weights and buoyancy and the dynamic equilibrium of the craft.

In the case of three-dimensional analyses, the longitudinal distribution of impact pressure is to be considered individually, in the opinion of the Society. In general, the impact pressure is to be considered as acting separately on each transverse section of the model, the remaining sections being loaded by the hydrostatic pressure.

**.6 Loading conditions in still water**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- outer hydrostatic load in still water.

**.7 Combined loading condition 1**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the vertical acceleration a<sub>v</sub> of the craft, considered in a downward direction.

**.8 Combined loading condition 2**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the vertical acceleration  $a_v$  of the craft, considered in a downward direction,
- impact pressure acting hemisymmetrically on one of the two halves of the hull bottom.

**.9 Combined loading condition 3**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the transverse acceleration of the craft.

**C3.6.2.3 Structural model**

**.1** In general, primary structures of craft of this type are to be modelled with finite element schematizations adopting a medium size mesh.

In the opinion of the Society, detailed analyses with fine mesh are required for areas where stresses, calculated with medium-mesh schematizations, exceed allowable limits and the type of structure gives reason to suspect the presence of high stress concentrations.

**.2** In general, the extent of the model is to be such as to allow the analysis of the behaviour of the main structural elements and their mutual effects.

**.3** In craft dealt with by these Rules, the stiffness of longitudinal primary members (girders and stringers) is, at least outside the machinery space area, generally negligible compared with the stiffness of transverse structures (beams, floors and webs), or their presence may be taken account of by suitable boundary conditions. It is therefore permissible, in general, to examine primary members in this area of the hull by means of plane analyses of transverse rings.

**.4** In cases where such approximation is not permissible, the model adopted is to be three-dimensional and is to include the longitudinal primary members.

**.5** When racking behaviour is investigated and loads thus act in the transverse direction (loading conditions 2 and 3), special attention is to be devoted to modelling of continuous decks and platforms. Such continuous elements, if having sufficient stiffness in the horizontal plane and if sufficiently restrained by the fore- and after-bodies, may withstand transverse deformations of primary rings.

In such cases, taking for granted the provisions above, it is still permissible to examine bidimensional rings, by simulating the presence of decks and platforms with horizontal springs according to criteria specified by the Society.

**C3.6.2.4 Boundary conditions**

**.1** Depending upon the loading conditions considered, the following boundary conditions may be assigned:

**(a) Loading condition in still water**

The vertical resultant of loads, in general other than zero, is to be balanced by introducing two vertical forces at the fore and aft ends of the model, both distributed on the shells according to the bidimensional flow theory for shear stresses, which are equal and opposite to half the vertical resultant of the loads.

Where a plane model is adopted, the vertical resultant is to be balanced by a single force, distributed as specified above and acting on the plane of the model itself.

**(b) Combined loading condition 1**

A vertical restraint is to be imposed in way of the keel of each hull.

**(c) Combined loading conditions 2 and 3**

The vertical and horizontal resultants of the loads, in general other than zero, are to be balanced by introducing two vertical forces and two horizontal forces at the fore and aft ends of the model, distributed on the shells according to the bidimensional flow theory for shear stresses, which are equal and opposite to half the vertical and horizontal resultants of the loads.

**.2** Where a plane model is adopted, the resultants are to be balanced by vertical and horizontal forces, distributed as specified above and acting on the plane of the model itself.

**C3.6.2.5 Checking criteria**

**.1** For metal structures, the stresses given by the above calculations are to be not greater than the following allowable values, in N/mm<sup>2</sup>:

- bending stress:

$$\sigma = \frac{150}{K \cdot f_m \cdot f_s}$$

- shear stress:

$$\tau = \frac{90}{K \cdot f_m \cdot f_s}$$

- Von Mises equivalent stress:

$$\sigma_{all} = \frac{190}{K \cdot f_m \cdot f_s}$$

where:

$K$  : material factor defined in C3.2,

$f_m$  : coefficient depending on the material:

- 1,00 for steel structures
- 2,15 for aluminium alloy structures,

$f_s$  : safety coefficient, to be assumed:

- 1,00 for combined loading conditions
- 1,25 for loading condition in still water.

**.2** The compressive values of normal stresses and the shear stresses are not to exceed the values of the critical stresses for plates and stiffeners calculated according to C3.7.5.

**.3** In structural elements also subject to high longitudinal and transversal hull girder stresses, allowable and critical stresses are to be reduced, according to criteria specified by the Society.

**.4** For non-metal structures, allowable stresses are to be defined according to criteria specified by the Society.

### C3.7 Steel and aluminium alloy craft

#### C3.7.1 Introduction

**.1** This article stipulates requirements for the scantlings of hull structures (plating, stiffeners, primary supporting members). The loads acting on such structures are to be calculated in accordance with the provisions of C3.5.

**.2** In general, for craft length  $L > 65$  m or speed  $V > 45$  knots, the scantlings of transverse structures are to be verified also by direct calculations carried out in accordance with C3.6.

**.3** For all other craft, the Society may, at its discretion and as an alternative to the requirements of this article, accept scantlings for transverse structures of the hull based on direct calculations in accordance with C3.6.

#### C3.7.2 Definitions and symbols

**.1** The definitions and symbols used are the following ones:

rule bracket: a bracket with arms equal to  $\ell/8$ ,  $\ell$  being the span of the connected stiffener. Where the bracket connects two different types of stiffeners (frame and beam, bulkhead web and longitudinal stiffener, etc.) the value of  $\ell$  is to be that of the member with the greater span, or according to criteria specified by the Society,

$t$  : thickness, in mm, of plating and deck panels,

$Z$  : section modulus, in  $\text{cm}^3$ , of stiffeners and primary supporting members,

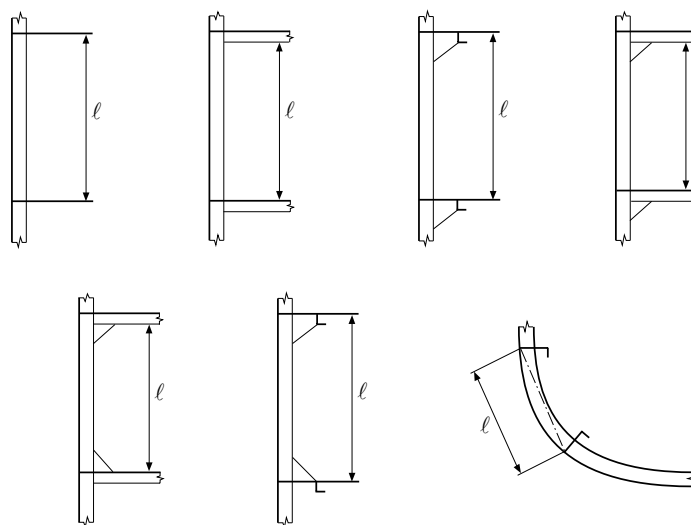
$s$  : spacing of stiffeners, in m, measured along the plating,

$\ell$  : overall span of stiffeners, in m, i.e. the distance between the supporting elements at the ends of the stiffeners (see Figure C3.7.1),

$S$  : conventional scantling span of primary supporting members, in m, to be taken as given in the examples in Figure C3.7.2. Special consideration is to be given to conditions different from those shown.

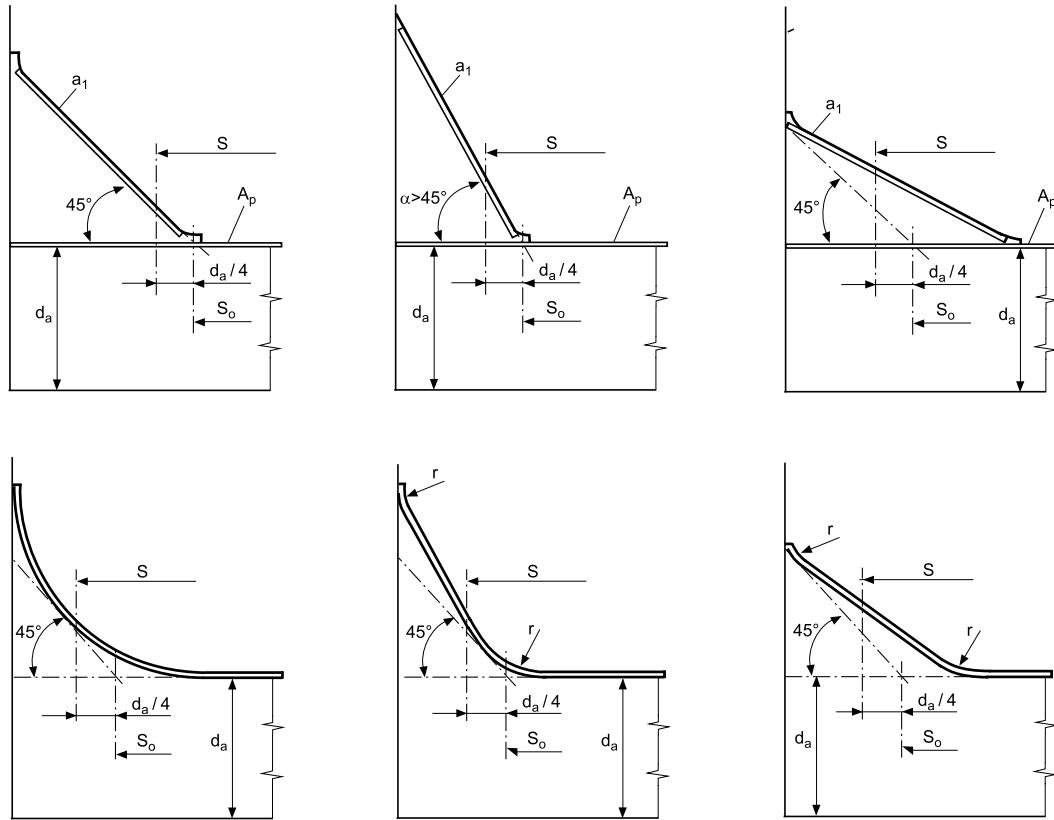
In no case is  $S$  to be less than  $(1,1 S_0)$ ,  $S_0$  being the distance between the internal ends of the conventional brackets as indicated in Figure C3.7.2 or, if there are no brackets, between the ends of the members,

**Figure C3.7.1 Examples of spans of ordinary stiffeners**



Note: the connections with end brackets shown in this Figure are relevant to end brackets with Rule dimensions.

Figure C3.7.2 Examples of conventional scantling spans of primary supporting members



$A_p$  = area of girder face plate;  $a_1$  = area of bracket face plate;  $a_1 \geq 0,5 A_p$

- b : actual surface width of the load bearing on primary supporting members; for usual arrangements  $b = 0,5 (l_1 + l_2)$ , where  $l_1$  and  $l_2$  are the spans of stiffeners supported by the primary supporting member,
- p : design pressure, in  $\text{kN/m}^2$ , calculated as defined in C3.5,
- $\sigma_{am}$  : permissible normal stress, in  $\text{N/mm}^2$ ,
- $\tau_{am}$  : permissible shear stress, in  $\text{N/mm}^2$ ,
- K : material factor defined in C3.2,
- e : ratio between permissible and actual hull girder longitudinal bending stresses (see C3.7.4.1)  
 $e = \sigma_p / \sigma_{bl}$
- $\sigma_p$  : maximum permissible stress, in  $\text{N/mm}^2$ , as defined in C3.7.4.14,
- $\sigma_{bl}$  : longitudinal bending stress, in  $\text{N/mm}^2$ , as defined in C3.7.4.14,
- $\mu$  : defined as follows:

$$\mu = \sqrt{1,1 - 0,5 \cdot \left(\frac{S}{\ell}\right)^2}$$

which needs not be taken greater than 1,0.

### C3.7.3 Overall strength

#### C3.7.3.1 Longitudinal strength

.1 In general, the scantlings resulting from local strength calculations in this article are such as to ensure adequate longitudinal strength of the hull girder for the craft with length less than or equal to 24 m.

.2 Specific longitudinal strength calculations are required for craft whose hull geometry suggests significant bending moments in still water with the craft at rest.

.3 For craft with length less than or equal to 65 m, longitudinal strength calculations are, as a rule, to be carried out at the midship section or any other section of the midship area as deemed necessary by the Society. For craft with length more than 65 m, longitudinal strength calculations are to be carried out on basis of bending moment distribution as defined in C3.4.1 or C3.4.2.

.4 Longitudinal stress, in  $\text{N/mm}^2$ , in each point of the structures contributing to the craft longitudinal strength is obtained from the following equations:

- at bottom:

$$\sigma_{bl} = \frac{M_{bl}}{W_b} \cdot 10^{-3}$$

- at main deck:

$$\sigma_{bl} = \frac{M_{bl}}{W_d} \cdot 10^{-3}$$

- at height z above the bottom:

$$\sigma_{bl} = M_{bl} \cdot \left( \frac{1}{W_b} - \left( \frac{1}{W_b} + \frac{1}{W_d} \right) \cdot \frac{z}{D} \right) \cdot 10^{-3}$$

where:

$M_{bl}$  : total bending moment, in kN.m, defined in C3.4.1 or C3.4.2,

$W_b, W_d$  : section modulus, in  $m^3$ , respectively at bottom and main deck at the stress calculation point of the craft section under consideration. In the section modulus calculation, all the elements contributing to longitudinal strength are to be considered, including long deckhouses, as appropriate.

The values of stress  $\sigma_{bl}$  are not to exceed  $\sigma_p$ , with:

- steel structures:  
 $\sigma_p = 150/K \text{ (N/mm}^2\text{)}$
- aluminium alloy structures:  
 $\sigma_p = 70/K \text{ (N/mm}^2\text{)}$ .

**.5** Moreover, the compressive values of  $\sigma$  are not to exceed the values of critical stresses for plates and stiffeners calculated according to C3.7.5 and C3.7.6.

### C3.7.3.2 Transverse strength of catamaran

**.1** The equivalent Von Mises stresses obtained for load conditions in C3.4.2.3 and C3.4.3.2 are not to exceed the following values:

- steel structures:  
 $\sigma_p = 175/K \text{ (N/mm}^2\text{)}$
- aluminium alloy structures:  
 $\sigma_p = 75/K \text{ (N/mm}^2\text{)}$ .

**.2** The compressive values of normal stresses and the shear stresses are not to exceed the values of critical stresses for plates and stiffeners calculated according to C3.7.5 and C3.7.6.

**.3** In general, the bottom of the cross-deck is to be constituted by continuous plating for its entire longitudinal and transverse extension. Alternative solutions may, however, be examined by the Society on the basis of considerations pertaining to the height of the cross-deck above the waterline and to the motion characteristics of the craft.

**.4** In the special case of catamaran, when the structure connecting both hulls is formed by a deck with single plating stiffened by n reinforced beams, the normal and shear stresses in the beams for the load condition in C3.4.2.4 can be calculated as indicated in C3.7.3.3.

**.5** For craft with  $L > 65 \text{ m}$  or speed  $V > 45 \text{ m knots}$ , or for those craft whose structural arrangements do not permit a realistic assessment of stress conditions based on simple models, the transverse strength is to be checked by means of direct calculations carried out in accordance with the criteria specified in article C3.6.

### C3.7.3.3 Transverse strength in the special case of catamaran craft when the structure connecting both hulls is formed by a deck with single plate stiffened by n reinforced beams over the deck

**.1** Referring to Figure C3.7.3, G is the centre of the stiffnesses  $r_i$  of the n beams. Its position is defined by:

$$a = \frac{\sum r_i \cdot x_i}{\sum r_i}$$

where:

a : abscissa, in m, of the centre G with respect to an arbitrarily chosen origin O,

$r_i$  : stiffness, in N/m, of the beam i, equal to:

$$r_i = \frac{12E_i I_i}{S_i^3} 10^6$$

$E_i$  : Young's modulus, in N/mm<sup>2</sup>, of the beam i,

$I_i$  : bending inertia, in m<sup>4</sup>, of the beam i,

$S_i$  : span, in m, of the beam i between the inner faces of the hulls,

$x_i$  : abscissa, in m, of the beam i with respect to the origin O.

If  $F_i$ , in N, is the force taken over by the beam i, the deflection  $y_i$ , in m, of the hull in way of the beam i, is:

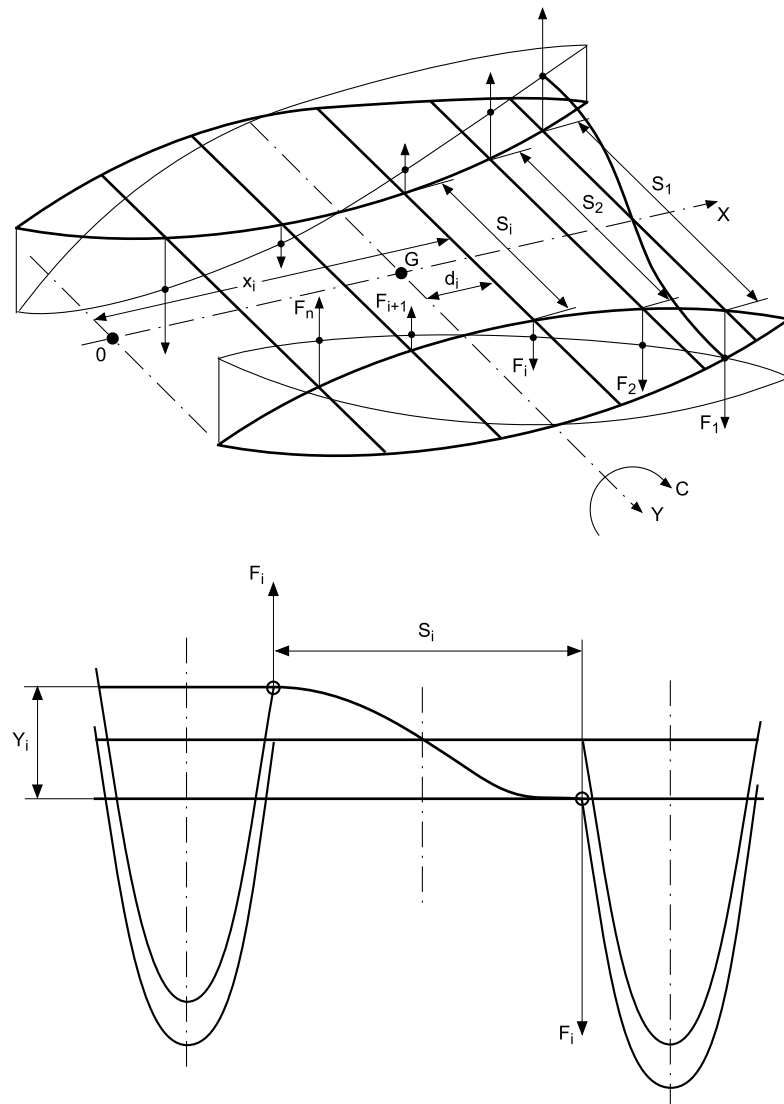
$$y_i = \frac{F_i \cdot S_i^3 \cdot 10^{-6}}{12 \cdot E_i \cdot I_i} = \frac{F_i}{r_i} = d_i \cdot \omega$$

$d_i$  : abscissa, in m, of the beam i in relation to G:

$$d_i = x_i - a,$$

$\omega$  : rotation angle, in rad, of one hull in relation to the other around a transverse axis passing through G.

Figure C3.7.3



.2 From the transverse torsional moment (cf. C3.4.2.4)  $M_{tt} = F_i \cdot d_i \cdot 10^{-3}$ , the formula for  $\omega$  may be obtained:

$$\omega = \frac{M_{tt}}{\sum r_i \cdot d_i^2} \cdot 10^3$$

.3 As  $M_{tt}$ ,  $r_i$  and  $d_i$  are known,  $\omega$  is thus deduced, then the force  $F_i$ , in N, the bending moment  $M_i$ , in N.m, and the corresponding normal and shear stresses can be evaluated in each beam:

$$F_i = \omega \cdot r_i \cdot d_i$$

$$M_i = F_i \cdot S_i / 2$$

Note: Beams calculated by the above method are assumed to be fixed in each hull as beams in way of bulkheads inside hulls. For this hypothesis to be correct, the beams are to extend over the whole breadth of both hulls and their stiffness is to be

kept the same over the overall span inside and outside the hulls.

### C3.7.4 Fatigue

#### C3.7.4.1 General

.1 The fatigue strength of structural details is to be checked, when deemed necessary by the Society. In this case, the Society's criteria are to be applied.

#### C3.7.4.2 Effect of stabilisation system

.1 The beneficial effect of stabilisation system may be considered for the purpose of fatigue analysis.

.2 In such a case, loads reductions are to be justified by designer on basis of tank tests or full scale tests.

**C3.7.5 Buckling strength of steel structural members****C3.7.5.1 Application**

.1 These requirements apply to steel plates and stiffeners subject to compressive load, to calculate their buckling strength. Other buckling rules can be accepted as agreed with the Society.

**C3.7.5.2 Elastic buckling stresses of plates****.1 Compressive stress**

The elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 0,9 \cdot m_c \cdot E \cdot \left( \frac{t}{1000 \cdot a} \right)^2$$

where:

$m_c$  : • for plating with stiffeners parallel to compressive stress:

$$m_c = \frac{8,4}{\Psi + 1,1}$$

• for plating with stiffeners perpendicular to compressive stress:

$$m_c = c \cdot \left( 1 + \left( \frac{a}{b} \right)^2 \right) \cdot \frac{2,1}{\Psi + 1,1}$$

E : Young's modulus, in N/mm<sup>2</sup>, to be taken equal to  $2,06 \cdot 10^5$  N/mm<sup>2</sup> for steel structure,

t : thickness of plating, in mm,

a : shorter side of plate, in m,

b : longer side of plate, in m,

c : • c = 1,30 when plating is stiffened by floors or deep girders  
• c = 1,21 when plating is stiffened by ordinary stiffeners with angle- or T-sections  
• c = 1,10 when plating is stiffened by ordinary stiffeners with bulb sections  
• c = 1,05 when plating is stiffened by flat bar ordinary stiffeners,

$\Psi$  : ratio between smallest and largest compressive stresses when the stress presents a linear variation across the panel ( $0 \leq \Psi \leq 1$ ).

**.2 Shear stress**

The elastic buckling stress is given by:

$$\tau_E = 0,9 \cdot m_t \cdot E \cdot \left( \frac{t}{1000 \cdot a} \right)^2$$

where:

$$m_t = 5,34 + 4 \cdot (a / b)^2$$

E, t, a and b are given in C3.7.5.2.1 above.

**C3.7.5.3 Elastic buckling stress of stiffeners****.1 Column buckling without rotation of the cross section**

For the column buckling mode (perpendicular to the plane of plating) the elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 0,001 \cdot E \cdot \frac{I_a}{A \cdot \ell^2}$$

where:

E : Young's modulus, in N/mm<sup>2</sup>, to be taken equal to  $2,06 \cdot 10^5$  N/mm<sup>2</sup> for steel structures,

$I_a$  : moment of inertia, in cm<sup>4</sup>, of the stiffener, including plate flange,

A : cross-sectional area, in cm<sup>2</sup>, of the stiffener, including plate flange,

$\ell$  : span, in m, of the stiffener.

**.2 Torsional buckling mode**

For the torsional mode, the elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = \frac{\pi^2 \cdot E \cdot I_w}{10^4 \cdot I_p \cdot \ell^2} \cdot \left( m^2 + \frac{C_K}{m^2} \right) + 0,385 \cdot E \cdot \frac{I_t}{I_p}$$

where:

E,  $\ell$  : given in C3.7.5.3.1 above,

$$C_K = \frac{C \cdot \ell^4}{\pi^4 \cdot E \cdot I_w} \cdot 10^6$$

m : number of half-waves, given in Table C3.7.1,

**Table C3.7.1 - Values of m**

$C_K$	m
$0 < C_K < 4$	1
$4 < C_K < 36$	2
$36 < C_K < 144$	3
$(m-1)^2 m^2 < C_K \leq m^2 (m+1)^2$	m

$I_t$  : St. Venant moment of inertia of profile, in cm<sup>4</sup>, without plate flange, equal to:

• for flat bars:

$$I_t = \frac{h_w \cdot t_w^3}{3} \cdot 10^{-4}$$

• for flanged profile:

$$I_t = \frac{1}{3} \cdot \left( h_w \cdot t_w^3 + b_f \cdot t_f^3 \cdot \left( 1 - 0,63 \cdot \frac{t_f}{b_f} \right) \right) \cdot 10^{-4}$$

$I_p$  : polar moment of inertia of profile, in  $\text{cm}^4$ , about connection of stiffener to plate, equal to:

- for flat bars:

$$I_p = \frac{h_w^3 \cdot t_w}{3} \cdot 10^{-4}$$

- for flanged profile:

$$I_p = \left( \frac{h_w^3 \cdot t_w}{3} + h_w^2 \cdot b_f \cdot t_f \right) \cdot 10^{-4}$$

$I_w$  : sectional moment of inertia of profile, in  $\text{cm}^6$ , about connection of stiffener to plate, equal to:

- for flat bars:

$$I_w = \frac{h_w^3 \cdot t_w^3}{36} \cdot 10^{-6}$$

- for T profiles:

$$I_w = \frac{t_f \cdot b_f^3 \cdot h_w^2}{12} \cdot 10^{-6}$$

- for angles and bulb profiles:

$$I_w = \frac{b_f^3 \cdot h_w^2 \cdot 10^{-6}}{12 \cdot (b_f + h_w)^2} \cdot (t_f \cdot (b_f^2 + 2b_f \cdot h_w + 4 \cdot h_w^2) + 3t_w \cdot b_f \cdot h_w)$$

$h_w$  : web height, in mm,

$t_w$  : web thickness, in mm,

$b_f$  : flange width, in mm,

$t_f$  : flange thickness, in mm; for bulb profiles, the mean thickness of the bulb may be used,

$C$  : spring stiffness factor, exerted by supporting plate panel, equal to:

$$C = \frac{k_p \cdot E \cdot t^3}{3s \cdot \left( 1 + \frac{1,33 \cdot k_p \cdot h_w \cdot t^3}{1000 \cdot s \cdot t_w^3} \right)} \cdot 10^{-3}$$

$t$  : plate thickness, in mm,

$s$  : spacing of stiffeners, in m,

$k_p = 1 - \eta_p$ , not to be less than zero,

$\eta_p = \sigma_a / \sigma_{Ep}$

$\sigma_a$  : calculated compressive stress in the stiffener,

$\sigma_{Ep}$  : elastic buckling stress of plate as calculated in C3.7.5.2.1

### .3 Web buckling

The elastic buckling stress, in  $\text{N/mm}^2$ , is given by:

$$\sigma_E = 3,8 \cdot E \cdot \left( \frac{t_w}{h_w} \right)^2$$

where:

$E$  : given in C3.7.5.3.1 above,

$t_w, h_w$  : given in C3.7.5.3.2 above.

### C3.7.5.4 Critical buckling stresses

#### .1 Compressive stress

The critical buckling stress in compression  $\sigma_c$ , in  $\text{N/mm}^2$ , for plates and stiffeners, is given by:

$$\sigma_c = \frac{\sigma_E}{SF_1} \quad \text{if } \sigma_E \leq \frac{R_{eH}}{2}$$

$$\sigma_c = \frac{R_{eH}}{SF_1} \cdot \left( 1 - \frac{R_{eH}}{4 \cdot \sigma_E} \right) \quad \text{if } \sigma_E > \frac{R_{eH}}{2}$$

where:

$R_{eH}$  : minimum yield stress of steel used, in  $\text{N/mm}^2$ ,

$\sigma_E$  : elastic buckling stress calculated according to C3.7.5.2.1 and C3.7.5.3.

$SF_1$  : safety factor defined in C3.7.5.4.3.

#### .2 Shear stress

The critical buckling shear stress  $\tau_c$ , in  $\text{N/mm}^2$ , for panels and stiffeners, is given by:

$$\tau_c = \frac{\tau_E}{SF_1} \quad \text{if } \tau_E \leq \frac{\tau_F}{2}$$

$$\tau_c = \frac{\tau_F}{SF_1} \cdot \left( 1 - \frac{\tau_F}{4 \cdot \tau_E} \right) \quad \text{if } \tau_E > \frac{\tau_F}{2}$$

where:

$$\tau_F = \frac{R_{eH}}{\sqrt{3}}$$

$R_{eH}$  : minimum yield stress of steel used, in  $\text{N/mm}^2$ ,

$\tau_E$  : elastic buckling stress calculated according to C3.7.5.2.2.

$SF_1$  : safety factor defined in C3.7.5.4.3

#### .3 Safety factors

The values of safety factor  $SF_1$  to be used are given below:

- Plating
  - local loads:  $SF_1 = 1,00$
  - overall loads:  $SF_1 = 1,00$
- Secondary stiffeners
  - local loads:  $SF_1 = 1,00$
  - overall loads:  $SF_1 = 1,33$
- Primary structure
  - local loads:  $SF_1 = 1,00$
  - overall loads:  $SF_1 = 1,53$



**C3.7.6 Buckling strength of aluminium alloy structural members****C3.7.6.1 Application**

.1 These requirements apply to aluminium alloy plates and stiffeners subjected to compressive load, to calculate their buckling strength. Other buckling rules can be accepted as agreed with the Society.

**C3.7.6.2 Elastic buckling stresses of plates****.1 Compressive stress**

The elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 0,9 \cdot m_c \cdot E \cdot \varepsilon \cdot \left( \frac{t}{1000 \cdot a} \right)^2$$

where:

- $m_c$  :
- for uniform compression ( $\Psi = 1$ ):  
 $m_c = (1 + \gamma^2)^2$
  - for compression-bending stress ( $0 \leq \Psi \leq 1$ ):
    - if  $\gamma < \gamma_1$ :  
 $m_c = 1 + \frac{\gamma}{\gamma_1} \cdot (m_1 - 1)$
    - if  $\gamma \geq \gamma_1$ :  
 $m_c = \frac{2,1}{1,1 + \Psi} \cdot (1 + \gamma^2)^2$

$\gamma$  :  $c/d$ , not to be greater than 1,

$c$  : unloaded side of plate, in m,

$d$  : loaded side of plate, in m,

$$\gamma_1 = \sqrt{\frac{4 - \frac{1,1 + \Psi}{0,7}}{3}}$$

$$m_1 = \frac{2,1}{1,1 + \Psi} \cdot (1 + \gamma_1^2)^2$$

$\Psi$  : ratio between smallest and largest compressive stresses when the stress presents a linear variation across the panel ( $0 \leq \Psi \leq 1$ ),

$E$  : Young's modulus, in N/mm<sup>2</sup>, to be taken equal to  $0,7 \cdot 10^5$  N/mm<sup>2</sup> for aluminium alloy structures,

$\varepsilon$  : coefficient equal to:

- for edge d stiffened by a flat bar or bulb section:
  - if  $\gamma \geq 1$ :  $\varepsilon = 1,0$
  - if  $\gamma < 1$ :  $\varepsilon = 1,1$
- for edge d stiffened by angle- or T-section:
  - if  $\gamma \geq 1$ :  $\varepsilon = 1,1$
  - if  $\gamma < 1$ :  $\varepsilon = 1,25$

$t$  : plate thickness, in mm,

$a$  : shorter side of plate, in m.

**.2 Shear stress**

The critical buckling stress, in N/mm<sup>2</sup>, is given by:

$$\tau_E = 0,9 \cdot m_t \cdot E \cdot \left( \frac{t}{1000 \cdot a} \right)^2$$

where:

$E$ ,  $t$  and  $a$  are given in C3.7.6.2.1,

$$m_t = 5,34 + 4 \left( \frac{a}{b} \right)^2$$

$b$  : longer side of plate, in m.

**C3.7.6.3 Critical buckling stresses****.1 Compressive stress**

The critical buckling stress  $\sigma_c$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_c = \frac{\sigma_E}{SF_1} \quad \text{if } \sigma_E \leq \frac{R_{p0,2}}{2}$$

$$\sigma_c = \frac{R_{p0,2}}{SF_1} \cdot \left( 1 - \frac{R_{p0,2}}{4 \cdot \sigma_E} \right) \quad \text{if } \sigma_E > \frac{R_{p0,2}}{2}$$

where:

$R_{p0,2}$  : minimum guaranteed yield stress of aluminium alloy used, in N/mm<sup>2</sup>, in delivery conditions,

$\sigma_E$  : elastic buckling stress calculated according to C3.7.6.2.1.

$SF_1$  : safety factor defined in C3.7.5.4.3

**.2 Shear stress**

The critical buckling stress  $\tau_c$ , in N/mm<sup>2</sup>, is given by:

$$\tau_c = \frac{\tau_E}{SF_1} \quad \text{if } \tau_E \leq \frac{R_{p0,2}}{2 \cdot \sqrt{3}}$$

$$\tau_c = \frac{R_{p0,2}}{SF_1 \cdot \sqrt{3}} \cdot \left( 1 - \frac{R_{p0,2}}{4 \cdot \tau_E \cdot \sqrt{3}} \right) \quad \text{if } \tau_E > \frac{R_{p0,2}}{2 \cdot \sqrt{3}}$$

where:

$R_{p0,2}$  : as defined in C3.7.6.3.1,

$\tau_E$  : elastic buckling stress calculated according to C3.7.6.2.2.

$SF_1$  : safety factor defined in C3.7.5.4.3

**C3.7.6.4 Axially loaded stiffeners****.1 Elastic flexural buckling stress**

The elastic flexural buckling stress  $\sigma_E$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 69,1 \cdot \left( \frac{r}{1000 \cdot c} \right)^2 \cdot m \cdot 10^4$$

where:

$r$  : gyration radius, in mm, equal to:

$$r = 10 \sqrt{\frac{I}{S + \varphi \cdot t \cdot 10^{-2}}}$$

- $I$  : moment of inertia of the stiffener, in  $\text{cm}^4$ , calculated with a plate flange of width equal to  $\phi$ ,
- $\phi$  : smaller of:  
800 a, and  
200 c
- $S$  : area of the cross section of the stiffener, in  $\text{cm}^2$ , excluding attached plating,
- $m$  : coefficient depending on boundary conditions:
- $m = 1$  for a stiffener simply supported at both ends,
  - $m = 2$  for a stiffener simply supported at one end and fixed at the other one,
  - $m = 4$  for a stiffener fixed at both ends.

### .2 Local elastic buckling stresses

The local elastic buckling stresses  $\sigma_E$ , in  $\text{N/mm}^2$ , are given by:

- for flat bars:

$$\sigma_E = 55 \cdot \left( \frac{t_w}{h_w} \right)^2 \cdot 10^3$$

- for built up stiffeners with symmetrical flange:

- web:

$$\sigma_E = 27 \cdot \left( \frac{t_w}{h_w} \right)^2 \cdot 10^4$$

- flange:

$$\sigma_E = 11 \cdot \left( \frac{t_f}{b_f} \right)^2 \cdot 10^4$$

where:

$h_w$  : web height, in mm,

$t_w$  : web thickness, in mm,

$b_f$  : flange width, in mm,

$t_f$  : flange thickness, in mm.

### .3 Critical buckling stress

The critical buckling stress  $\sigma_c$ , in  $\text{N/mm}^2$ , is given by:

$$\sigma_c = \frac{\sigma_E}{SF_1} \quad \text{if } \sigma_E \leq \frac{R_{p0.2}}{2}$$

$$\sigma_c = \frac{R_{p0.2}}{SF_1} \cdot \left( 1 - \frac{R_{p0.2}}{4 \cdot \sigma_E} \right) \quad \text{if } \sigma_E > \frac{R_{p0.2}}{2}$$

where:

$R_{p0.2}$  : minimum as-welded guaranteed yield stress of aluminium alloy used, in  $\text{N/mm}^2$ ,

$\sigma_E$  : either overall elastic buckling stress or local elastic buckling stress calculated according to C3.7.6.4.1 or C3.7.6.4.2, whichever is the less.

$SF_1$  : safety factor defined in C3.7.5.4.3

## C3.7.7 Plating

### C3.7.7.1 Formula

.1 The thickness, in mm, required for the purposes of resistance to design pressure, is given by the formula:

$$t = 22,4 \cdot \mu \cdot s \cdot \sqrt{\frac{p}{\sigma_{am}}}$$

Pressure  $p$ , in  $\text{kN/m}^2$ , and permissible stress  $\sigma_{am}$ , in  $\text{N/mm}^2$ , are defined in requirements stipulated in C3.7.7.3 to C3.7.7.8 for the various parts of the hull.

.2 In addition, the thicknesses of plating are to be not less than the minimum values given in Table C3.7.2, in general.

.3 Lesser thicknesses than the one given in Table C3.7.2 may be accepted provided that their adequacy in relation to strength against buckling and collapse is demonstrated to the satisfaction of the Society. Adequate provision is also to be made to limit corrosion.

Table C3.7.2

Element	Minimum thickness (mm)
Shell plating:	
• Bottom shell plating	$1,35 \cdot L^{1/3} \geq 2,5$
• Side shell plating and wet deck plating	$1,15 \cdot L^{1/3} \geq 2,5$
Deck plating	2,5
Bulkhead plating	2,5
Deckhouse side shell plating	2,5

### C3.7.7.2 Keel

.1 The thickness of keel plating is to be not less than that required for adjacent bottom plating.

.2 This requirement may be waived in the case of special arrangements for dry-docking of craft of unusual hull design in the opinion of the Society.

### C3.7.7.3 Bottom shell and bilge plating

.1 The minimum required thickness is to satisfy the requirements of the formula in C3.7.7.1 under the following two conditions:

(a)  $p$  : impact pressure  $p_{sl}$  if occurring on the bottom as defined in C3.5.3;

- $\sigma_{am}$  :
- steel structures:  
 $\sigma_{am} = 235/K$  ( $\text{N/mm}^2$ )
  - aluminium alloy structures:  
 $\sigma_{am} = 95/K$  ( $\text{N/mm}^2$ ),

(b)  $p$  : sea pressure  $p_s$  as defined in C3.5.5;

- $\sigma_{am}$  :
- steel structures:  
 $\sigma_{am} = 185/K \text{ (N/mm}^2\text{)}$
  - aluminium alloy structures:  
 $\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}$ .

.2 The thickness of bilge plating is not, in any case, to be less than that of the bottom and side adjacent, whichever is greater.

.3 The thickness of plates connected to the stern frame, or in way of propeller shaft brackets, is to be at least 1,5 times the thickness of the adjacent plating.

.4 In craft fitted with a bow thruster, the thickness of the connection with the housing of such propeller is to be considered individually by the Society.

#### C3.7.7.4 Sea intakes and other openings

.1 Sea intakes and other openings are to be well rounded at the corners and located, as far as practicable, well clear of sharp edges.

.2 Sea chests are to have scantlings as for watertight tank bulkheads (see C3.7.11), taking a design pressure  $p_t$ , in kN/m<sup>2</sup>, equal to:

$$p_t = p_s + 0,5 \cdot p_{sl}$$

where  $p_s$  and  $p_{sl}$  are as defined in C3.5.5 and C3.5.3 respectively.

#### C3.7.7.5 Plating of side shell and front walls

.1 The minimum required thickness is given by the formula in C3.7.7.1, assuming:

- $p$  :
- sea pressure  $p_s$  as defined in C3.5.5, for side shell plating,
  - sea pressure  $p_{sf}$  as defined in C3.5.6, for front wall plating,
- $\sigma_{am}$  :
- steel structures:  
 $\sigma_{am} = 185/K \text{ (N/mm}^2\text{)}$
  - aluminium alloy structures:  
 $\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}$ .

If front walls are located at the fore end of the hull, the pressure  $p_{sf}$  (see C3.5.6) and the allowable stresses are to be considered individually by the Society.

.2 The thickness of the sheerstrake is to be not less than that of the side or stringer plate.

.3 At the ends of deckhouses, the thickness of the sheerstrake is to be suitably increased.

.4 Where side scuttles or windows or other openings are located on the sheerstrake, the thickness is to be increased to compensate for the openings.

#### C3.7.7.6 Plating of wet deck (cross-deck bottom) and internal sides of catamaran

.1 The minimum required thickness for the wet deck plating is given by the formula in C3.7.7.1, assuming:

(a)  $p$  : impact pressure  $p_{sl}$  as defined in C3.5.4;

- $\sigma_{am}$  :
- steel structures:  
 $\sigma_{am} = 235/K \text{ (N/mm}^2\text{)}$
  - aluminium alloy structures:  
 $\sigma_{am} = 95/K \text{ (N/mm}^2\text{)}$ ,

(b)  $p$  : sea pressure  $p_s$  as defined in C3.5.5;

- $\sigma_{am}$  :
- steel structures:  
 $\sigma_{am} = 185/K \text{ (N/mm}^2\text{)}$
  - aluminium alloy structures:  
 $\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}$ .

.2 Moreover, the thickness of internal sides may be intermediate between that of the bottom of hulls and the bottom of the cross-deck. In any case, it is to be no less than that required in C3.7.7.5 for external sides.

#### C3.7.7.7 Deck plating

.1 The minimum required thickness is given by the formula in C3.7.7.1, assuming:

$p$  : deck pressure  $p_d$  as defined in C3.5.8;

- $\sigma_{am}$  :
- steel structures:  
 $\sigma_{am} = 185/K \text{ (N/mm}^2\text{)}$
  - aluminium alloy structures:  
 $\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}$ .

.2 The thickness, in mm, of decks intended for the carriage of vehicles is to be not less than the value calculated by the formula:

$$t = f \cdot (c \cdot P \cdot K)^{0.5}$$

where:

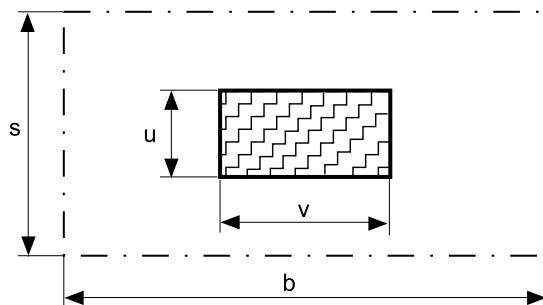
- $f$  : coefficient equal to:
- 3,9 for steel structures
  - 5,6 for aluminium alloy structures,
- $c$  : coefficient given in Table C3.7.3 as a function of the dimensions  $u$  and  $v$  of the tyre print (see Figure C3.7.4),
- $P$  : static load on the tyre print, in kN, increased by  $(1 + 0,4 \cdot a_v)$ ,  $a_v$  being the design vertical acceleration defined in C3.3.

Where there are double wheels, the tyre print consists of both.

Table C3.7.3 - Coefficient c

b/s	v/u	u/s									
		0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
1	0,5	0,242	0,174	0,138	0,113	0,094	0,080	0,077	0,060	0,052	0,045
	1,0	0,222	0,160	0,122	0,099	0,079	0,066	0,055	0,045	0,037	0,030
	2,0	0,198	0,134	0,098	0,073	0,053	–	–	–	–	–
	3,0	0,175	–	–	–	–	–	–	–	–	–
1,4	0,5	0,228	0,189	0,158	0,128	0,111	0,096	0,083	0,073	0,064	0,056
	1,0	0,217	0,177	0,143	0,116	0,098	0,082	0,070	0,060	0,051	0,043
	2,0	0,196	0,153	0,119	0,092	0,072	0,058	0,046	–	–	–
	3,0	0,178	0,134	0,100	0,072	–	–	–	–	–	–
≥ 2,5	0,5	0,232	0,196	0,163	0,135	0,117	0,100	0,087	0,077	0,067	0,059
	1,0	0,219	0,184	0,150	0,123	0,105	0,088	0,076	0,066	0,056	0,048
	2,0	0,199	0,161	0,129	0,101	0,082	0,067	0,055	0,046	0,037	0,031
	3,0	0,185	0,142	0,108	0,083	0,064	0,051	0,038	0,028	0,019	0,012

Figure C3.7.4



.3 The designer is to supply details of tyre pressure, wheel dimensions, loads on wheels and tyre print dimensions. Where this information is not available, an approximate value of the thickness, in mm, may be obtained from the following formula:

$$t = f_1 \cdot C_1 \cdot (P_1 \cdot K)^{0.5}$$

where:

$f_1$  : coefficient equal to:

- 0,28 for steel structures
- 0,38 for aluminium alloy structures,

$C_1$  : coefficient equal to:

- 3,60 for vehicles with 4 wheels per axle
- 4,45 for vehicles with 2 wheels per axle,

$P_1$  : static axle load, in kN, increased by  $(1 + 0,4 \cdot a_v)$ ,  $a_v$  being the design vertical acceleration defined in C3.3.

.4 The thickness of areas of watertight decks or flats forming steps in watertight bulkheads or the top or the bottom of a tank is also to comply with the provisions of C3.7.11.

### C3.7.7.8 Plating of deckhouse walls

.1 The minimum required thickness is given by the formula in C3.7.7.1, assuming:

$p$  : sea pressure  $p_{su}$  as defined in C3.5.7;

$\sigma_{am}$  : • steel structures:

$$\sigma_{am} = 185/K \text{ (N/mm}^2\text{)}$$

• aluminium alloy structures:

$$\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}.$$

.2 Openings (doors, windows) are to be well rounded at the corners.

.3 Where there is no access from inside deckhouses to 'tween-decks below or where one of the boundary walls concerned is in a particularly sheltered position, reduced scantlings compared with those above may be accepted, at the discretion of the Society.

.4 For unprotected front walls located at the fore end, the pressure  $p_{su}$  and allowable stresses are to be considered individually by the Society.

### C3.7.8 Ordinary stiffeners

#### C3.7.8.1 General

.1 This sub-article states the requirements to be complied with for ordinary stiffeners of the bottom, sides, decks and, for catamaran, the cross-deck and internal sides.

**.2** The section modulus  $Z$ , in  $\text{cm}^3$ , and the shear area  $A_t$ , in  $\text{cm}^2$ , required for the purpose of supporting the design pressure transmitted by the plating, are given by the following formulae:

$$Z = 1000 \cdot \frac{\ell^2 \cdot s \cdot p}{m \cdot \sigma_{am}}$$

$$A_t = 5 \cdot \frac{\ell \cdot s \cdot p}{\tau_{am}}$$

where  $m$  is a coefficient depending on the type of stiffener and on whether there are Rule brackets at the end of each individual span. The values of  $m$  are indicated in Table C3.7.4.

The pressure  $p$ , in  $\text{kN/mm}^2$ , and allowable stresses  $\sigma_{am}$  and  $\tau_{am}$ , in  $\text{N/mm}^2$ , are defined in C3.7.8.2 to C3.7.8.6 for the various regions of the hull.

**Table C3.7.4 - Coefficient  $m$**

Type of stiffener	$m$
Continuous longitudinal stiffeners without Rule brackets at the ends of span	12
Longitudinal and transverse stiffeners with Rule brackets at the ends of span	19
Longitudinal and transverse stiffeners with Rule brackets at one end of span	15
Non-continuous longitudinal stiffeners and transverse stiffeners without Rule brackets at the ends of span	8

**.3** These formulae are valid for stiffeners whose web is perpendicular to the plating, or forms an angle to the plating of less than  $15^\circ$ .

In the case of stiffeners whose web forms an angle  $\alpha > 15^\circ$  to the perpendicular to the plating, the required modulus and shear area may be obtained from the same formulae, dividing the values of  $Z$  and  $A_t$  by  $\cos(\alpha)$ .

**.4** The section modulus of ordinary stiffeners is to be calculated in association with an effective width of plating equal to the spacing of the stiffeners, without exceeding 20 per cent of the span.

**.5** For steel stiffeners, the web thickness is to be not less than:

- 1/18 of the depth, for flat bars,
- 1/50 of the depth, for other sections,

and the thickness of the face plate is to be not less than 1/15 of its width.

**.6** For aluminium alloy stiffeners, the web thickness is to be not less than:

- 1/15 of the depth, for flat bars,
- 1/35 of the depth, for other sections,

and the thickness of the face plate is to be not less than 1/20 of its width.

**.7** The ends of ordinary stiffeners are, in general, to be connected by means of rule brackets to effective supporting structures.

Ends without brackets are accepted at the penetrations of primary supporting members or bulkheads by continuous stiffeners, provided that there is sufficient effective welding section between the two elements. Where this condition does not occur, bars may be accepted instead of the brackets, at the discretion of the Society.

**.8** In general, the resistant weld section  $A_w$ , in  $\text{cm}^2$ , connecting the ordinary stiffeners to the web of primary members, is not to be less than:

$$A_w = \phi \cdot p \cdot s \cdot \ell \cdot K \cdot 10^{-3}$$

where:

- $\phi$  : coefficient as indicated in Table C3.7.5,
- $p$  : design pressure, in  $\text{kN/m}^2$ , acting on the secondary stiffeners, defined below for various hull regions,
- $s$  : spacing of ordinary stiffeners, in  $\text{m}$ ,
- $\ell$  : span of ordinary stiffeners, in  $\text{m}$ ,
- $K$  : greatest material factor of ordinary stiffener and primary member, defined in C3.2.

**Table C3.7.5 - Coefficient  $\phi$**

Case	Weld	Aluminium alloy	Steel
1	Parallel to the reaction exerted on primary member	200	100
2	Perpendicular to the reaction exerted on primary member	160	75

**.9** For aluminium alloys, when calculating the resistant connecting weld section, the fillet weld length  $d_e$ , in  $\text{mm}$ , is determined as follows (see cases 1 and 2 in Table C3.7.5):

case 1 :  $d_e = d - 20$ ,  
where  $d$  is the length of the weld, in  $\text{mm}$ ,

case 2 : for extruded T stiffeners, the lesser of:  
 $d_e = d - 20$  and  $d_e = 4t$ ,  
where  $b$ , in  $\text{mm}$ , is the flange width of the ordinary stiffener and  $t$ , in  $\text{mm}$ , is the web thickness of the primary member.

### C3.7.8.2 Bottom and bilge stiffeners

**.1** Both single and double bottoms are generally to be longitudinally framed.

**.2** The section modulus, shear area and welding section required for bottom and bilge stiffeners are given by the formulae in C3.7.8.1, assuming:

(a)  $p$  : impact pressure  $p_{sj}$  if occurring on the bottom as defined in C3.5.3;

- $\sigma_{am}$ ,  $\tau_{am}$  :
- steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
  - aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

(b)  $p$  : sea pressure  $p_s$  as defined in C3.5.5;

- $\sigma_{am}$ ,  $\tau_{am}$  :
- stiffeners contributing to the longitudinal strength:
    - steel structures:  
 $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
    - aluminium alloy structures:  
 $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),
  - stiffeners not contributing to the longitudinal strength:
    - steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
    - aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Table C3.7.6.

**.3** Bottom longitudinals are preferably continuous through the transverse elements. Where they are interrupted at a transverse watertight bulkhead, continuous

brackets are to be positioned through the bulkhead so as to connect the ends of longitudinals.

### C3.7.8.3 Side and front wall stiffeners

**.1** The section modulus, shear area and welding section are given by the formulae in C3.7.8.1, assuming:

- $p$  :
- sea pressure  $p_s$  as defined in C3.5.5, for side stiffeners,
  - sea pressure  $p_{sf}$  as defined in C3.5.6, for front wall stiffeners,

$\sigma_{am}$ ,  $\tau_{am}$  :

- side stiffeners contributing to the longitudinal strength:

- steel structures:  
 $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
- aluminium alloy structures:  
 $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),
- side stiffeners not contributing to the longitudinal strength and front wall stiffeners:

- steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
- aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Table C3.7.6.

**.2** For unprotected front walls located at the fore end, the pressure  $p_{sf}$  (see C3.5.6) and allowable stresses are to be considered individually by the Society.

**Table C3.7.6 - Coefficients  $C_s$  and  $C_A$**

L	x/L	Steel structures $C_s$	Aluminium alloy structures $C_A$
$L \leq 24$ m	$0 \leq x/L \leq 1$	1	1
$L > 24$ m (Note 2)	$0 \leq x/L \leq 1$	$1,4 - 1/e$	$1,3 - 1/e$
Alternative method for 24 m < L ≤ 65 m (Note 3)	$x/L < 0,1$	1	1
	$0,1 \leq x/L \leq 0,3$	$1 + 0,5 \cdot \left(0,4 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 1\right)$	$1 + 0,5 \cdot \left(0,3 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 1\right)$
	$0,3 < x/L < 0,7$	$1,4 - \frac{1}{e}$	$1,3 - \frac{1}{e}$
	$0,7 \leq x/L \leq 0,9$	$1 - 0,5 \cdot \left(0,4 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 9\right)$	$1 - 0,5 \cdot \left(0,3 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 9\right)$
	$0,9 < x/L \leq 1$	1	1
<b>Note 1</b> : In these formulae, the values of $C_s$ and $C_A$ are to be taken less than or equal to 1.			
<b>Note 2</b> : The ratio $e$ is to be calculated at the location $x$ , on basis of bending moment distribution defined in C3.4.1 and C3.4.2.			
<b>Note 3</b> : The ratio $e$ is to be calculated at the section comprised between $0,3 \cdot L$ and $0,7 \cdot L$ at which $e$ takes the highest value.			

### C3.7.8.4 Stiffeners of wet deck (cross-deck bottom) and internal sides of catamaran

.1 The section modulus, shear area and welding section required for bottom stiffeners of the cross-deck are given by the formulae in C3.7.8.1, assuming:

(a)  $p$  : impact pressure  $p_{si}$  as defined in C3.5.4;

- $\sigma_{am}$ ,  $\tau_{am}$  :
- steel structures:
    - $\sigma_{am} = 180/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
  - aluminium alloy structures:
    - $\sigma_{am} = 85/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

(b)  $p$  : sea pressure  $p_s$  as defined in C3.5.5;

- $\sigma_{am}$ ,  $\tau_{am}$  :
- stiffeners contributing to the longitudinal strength:
    - steel structures:
      - $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)
      - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
    - aluminium alloy structures:
      - $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)
      - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),
  - stiffeners not contributing to the longitudinal strength:
    - steel structures:
      - $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)
      - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
    - aluminium alloy structures:
      - $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)
      - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Table C3.7.6.

.2 Internal side stiffeners may have characteristics intermediate between those of the bottom of the hull and those of the bottom of the cross-deck. In any case, such characteristics are not to be less than those required in C3.7.8.3 for external sides.

### C3.7.8.5 Deck stiffeners

.1 The section modulus, shear area and welding section are given by the formulae in C3.7.8.1, assuming:

$p$  : deck pressure  $p_d$  as defined in C3.5.8,

- $\sigma_{am}$ ,  $\tau_{am}$  :
- stiffeners contributing to the longitudinal strength:
    - steel structures:
      - $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)
      - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
    - aluminium alloy structures:
      - $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)
      - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

- stiffeners not contributing to the longitudinal strength:

- steel structures:
  - $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)
  - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)

- aluminium alloy structures:
  - $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)
  - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Table C3.7.6.

.2 Where there are concentrated loads of significant magnitude, deck stiffeners are to be adequately strengthened. In particular, stiffeners of decks intended for the carriage of vehicles are to be able to support the concentrated loads transmitted by the wheels, including inertia effects.

In this case, the structural check is, in general, to be carried out adopting the static model of the continuous girder on several supports (formed by primary supporting members) and considering the most severe vehicle loading arrangement for deck stiffeners. The normal and shear stresses thus calculated are not to exceed the allowable limits defined above.

.3 The ordinary stiffeners of decks or flats constituting the top or bottom of tanks are also to comply with the requirements of C3.7.11.

.4 Where longitudinals are interrupted in way of watertight bulkheads or reinforced transverse structures, the continuity of the structure is to be maintained by means of brackets penetrating the transverse element. The Society may allow double brackets welded to the transverse element, provided that special provision is made for the alignment of longitudinals, and full penetration welding is used.

### C3.7.8.6 Stiffeners of boundary walls of deckhouses

.1 The section modulus, shear area and welding section are given by the formulae in C3.7.8.1, assuming:

$p$  : sea pressure  $p_{su}$  as defined in C3.5.7,

- $\sigma_{am}$ ,  $\tau_{am}$  :
- steel structures:
    - $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy structures:
    - $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>).

.2 If unprotected front walls are located at the fore end, the pressure  $p_{su}$  and the allowable stresses are to be considered individually by the Society.

.3 Any front or side wall vertical stiffeners of first tier deckhouses are to be connected, by means of brackets at the ends, to strengthening structures for decks or adjacent sides.

**.4** Longitudinal stiffeners are to be fitted on the upper and lower edges of large openings in the plating. The openings for doors are, in general, to be stiffened all the way round.

**.5** Where there is no access from inside deck-houses to 'tween-decks below, or where a deckhouse boundary wall is in a particularly sheltered location, reduced scantlings with respect to those stipulated above may be accepted, in the opinion of the Society.

### C3.7.9 Primary supporting members

#### C3.7.9.1 General

**.1** This article gives the requirements to be complied with for primary supporting members of the bottom, sides, decks and, for catamaran, the cross-deck.

**.2** The primary supporting members (floors, frames, beams) are to form continuous transverse frames. In general, the stiffened frame spacing, in mm, is not to exceed:

$$1200 + 10 L$$

without being greater than 2 m.

Primary supporting members with spacing other than that defined above may be required for specific parts of the hull (e.g. machinery space, under pillars), as stipulated in the provisions below.

**.3** The section modulus  $Z$ , in  $\text{cm}^3$ , and shear area  $A_t$ , in  $\text{cm}^2$ , required to support the design pressure transmitted by the ordinary stiffeners are given by the following formulae:

$$Z = 1000 \cdot \frac{S^2 \cdot b \cdot p}{m \cdot \sigma_{am}}$$

$$A_t = 5 \cdot \frac{S \cdot b \cdot p}{\tau_{am}}$$

where:

$m$  : coefficient which depends on support conditions at the ends of the girder span, generally assumed to be equal to:

- 10 for floors, bottom girders, side frames, deck beams and girders, vertical webs of superstructures
- 12 for side stringers.

In special circumstances, a different value may be taken for  $m$ , at the discretion of the Society.

The pressure  $p$ , in  $\text{kN/m}^2$ , and allowable stresses  $\sigma_{am}$  and  $\tau_{am}$ , in  $\text{N/mm}^2$ , are defined in C3.7.9.2 to C3.7.9.6 for various parts of the hull.

**.4** The above formulae are applicable where reinforced structures are not of the grillage type. Otherwise, the scantlings of reinforced structures are to be stipulated by means of direct calculations performed on the basis of criteria agreed upon with the Society.

**.5** The section modulus of primary supporting members is to be calculated in association with an attached plating, according to criteria specified by the Society.

**.6** For steel stiffeners, the following geometric ratios are to be satisfied:

- the web thickness is to be not less than 1/80 of web depth,
- the face plate thickness is to be not less than 1/30 of face plate breadth (1/15 for face plates which are not symmetrical with respect to the web).

**.7** For aluminium stiffeners, the following geometric ratios are to be satisfied, where the compressive stress is not known:

- the web thickness is to be not less than 1/35 of web depth,
- the face plate thickness is to be not less than 1/20 of face plate breadth (1/10 for face plates which are not symmetrical with respect to the web).

**.8** Particular attention is to be paid to compressive buckling strength of associated plating of transverse primary members

**.9** In case of primary structure made of floating frames and extruded panels, the flexural contribution of the extruded plating may generally be disregarded.

#### C3.7.9.2 Floors and girders of single bottom

**.1** The section modulus and shear area are given by the formulae in C3.7.9.1 for the following two conditions:

(a)  $p$  : impact pressure  $p_{si}$  if occurring on the bottom as defined in C3.5.3;

- $\sigma_{am}, \tau_{am}$  :
- steel structures:
    - $\sigma_{am} = 150/K$  ( $\text{N/mm}^2$ )
    - $\tau_{am} = 90/K$  ( $\text{N/mm}^2$ )
  - aluminium alloy structures:
    - $\sigma_{am} = 70/K$  ( $\text{N/mm}^2$ )
    - $\tau_{am} = 45/K$  ( $\text{N/mm}^2$ ),

(b)  $p$  : sea pressure  $p_s$  as defined in C3.5.5;

- $\sigma_{am}, \tau_{am}$  :
- steel floors:
    - $\sigma_{am} = 150/K$  ( $\text{N/mm}^2$ )
    - $\tau_{am} = 90/K$  ( $\text{N/mm}^2$ )
  - aluminium alloy floors:
    - $\sigma_{am} = 70/K$  ( $\text{N/mm}^2$ )
    - $\tau_{am} = 45/K$  ( $\text{N/mm}^2$ )
  - steel girders:
    - $\sigma_{am} = 150 C_s/K$  ( $\text{N/mm}^2$ )
    - $\tau_{am} = 90/K$  ( $\text{N/mm}^2$ )
  - aluminium alloy girders:
    - $\sigma_{am} = 70 C_A/K$  ( $\text{N/mm}^2$ )
    - $\tau_{am} = 45/K$  ( $\text{N/mm}^2$ ),

where  $C_s$  and  $C_A$  are given by Table C3.7.6.



.2 Floors are to be positioned in way of side and deck transverses. Intermediate floors may also be fitted provided that they are adequately connected at the ends.

.3 Manholes and other openings are not to be located at the ends of floor or girder spans, unless shear stress checks are carried out in such areas.

.4 Floors are to be fitted in machinery spaces, generally at every frame, and additional stiffeners are to be provided at bottom in way of machinery and pillars.

.5 In way of main machinery seatings, girders are to be positioned extending from the bottom to the foundation plate of main engines.

.6 A girder is, generally, to be fitted centreline for dry-docking. The height of such a girder is to be not less than that of floors amidships and the thickness less than the value  $t$ , in mm, obtained from the formula:

- for steel:

$$t = (0,05 \cdot L + 2) \cdot K^{0,5}$$

- for aluminium alloys:

$$t = (0,07 \cdot L + 2,5) \cdot K^{0,5}$$

The girder is to be fitted with a continuous face plate above the floors, its area not less than the value  $A_p$ , in  $\text{cm}^2$ , given by the formula:

- for steel:

$$A_p = 0,25 \cdot L \cdot K$$

- for aluminium alloys:

$$A_p = 0,50 \cdot L \cdot K$$

In hulls with a longitudinally framed bottom and width  $B > 8$  m, side girders are also to be positioned in such a way as to divide the floor span into approximately equal parts. In catamaran,  $B$  is to be taken as the width of a single-hull. The thickness of the web may be assumed to be equal to that of the centre girder less 1 mm, and the area of the face plate may be reduced to 60% of that of the centre girder. Where side girders are intended to support floors, a structural check of their scantlings is to be carried out as deemed necessary by the Society.

### C3.7.9.3 Primary supporting members of sides and front walls

.1 The section modulus and shear area are given by the formulae in C3.7.9.1, assuming:

- $p$  :
- sea pressure  $p_s$  as defined in C3.5.5 for primary members of sides,
  - sea pressure  $p_{sf}$  as defined in C3.5.6 for primary members of front walls,

- $\sigma_{am}, \tau_{am}$  :
- steel structures:

$$\sigma_{am} = 150/K - \sigma_a \text{ (N/mm}^2\text{)}$$

$$\tau_{am} = 90/K \text{ (N/mm}^2\text{)},$$

- aluminium alloy structures:

$$\sigma_{am} = 70/K - \sigma_a \text{ (N/mm}^2\text{)}$$

$$\tau_{am} = 45/K \text{ (N/mm}^2\text{)},$$

$\sigma_a$  being the stress induced by the normal force in side transverses due to deck loads transmitted by deck beams.

.2 For unprotected front walls located at the fore end, the pressure  $p_{sf}$  (see C3.5.6) and allowable stresses are to be considered individually by the Society.

### C3.7.9.4 Primary supporting members of the wet deck (cross-deck) and internal sides of catamaran

.1 In the most common case of cross-deck structures constituted by transverse stiffener plates enclosed between lower plating and a deck, and connected at the ends to reinforced hull structures, the scantlings are determined by transverse strength checks aimed at ensuring an adequate connection between the hulls (see C3.7.4).

.2 Where the cross-deck is formed by multiple structures, each of the latter is also to be checked for the effect of local loads, in accordance with the following provisions.

.3 The section modulus and shear area required for transverse structures of the cross-deck are given by the formulae in C3.7.9.1, for the following two conditions:

(a) lower structures of the cross-deck:

$p$  : impact pressure  $p_{si}$  as defined in C3.5.4

- $\sigma_{am}, \tau_{am}$  :
- steel structures:

$$\sigma_{am} = 180/K \text{ (N/mm}^2\text{)}$$

$$\tau_{am} = 90/K \text{ (N/mm}^2\text{)}$$

- aluminium alloy structures:

$$\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}$$

$$\tau_{am} = 45/K \text{ (N/mm}^2\text{)},$$

(b) cross-deck structures supporting decks:

$p$  : sea pressure  $p_d$  as defined in C3.5.8

- $\sigma_{am}, \tau_{am}$  :
- steel structures:

$$\sigma_{am} = 150/K \text{ (N/mm}^2\text{)}$$

$$\tau_{am} = 90/K \text{ (N/mm}^2\text{)}$$

- aluminium alloy structures:

$$\sigma_{am} = 70/K \text{ (N/mm}^2\text{)}$$

$$\tau_{am} = 45/K \text{ (N/mm}^2\text{)}.$$

.4 Where the lower structure of the cross-deck also supports a deck, such a structure is to be checked separately for conditions (a) and (b) above.

.5 The section modulus and shear area required for side transverses of internal sides are given by the formulae in C3.7.9.1 for condition (a) above.

**C3.7.9.5 Primary supporting members of decks**

**.1** In the absence of concentrated loads transmitted to the primary supporting member by pillars or other primary supporting members, the section modulus and shear area required for deck transverses and deck girders supporting longitudinals and beams, respectively, are given by the formulae in C3.7.9.1, assuming:

$p$  : deck pressure  $p_d$  as defined in C3.5.8,

- $\sigma_{am}$ ,  $\tau_{am}$  :
- steel deck transverses:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy deck transverses:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),
  - steel deck girders:  
 $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy deck girders:  
 $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Table C3.7.6.

**.2** The primary members of decks or flats constituting the top or bottom of tanks are also to comply with the requirements of C3.7.11.

**.3** When there are concentrated loads of significant magnitude (e.g. transmitted by pillars or other primary members or due to the carriage of vehicles), deck girders are to be adequately strengthened.

In this case the structural check is, generally, to be carried out by using the static model of a beam with partial clamping at its ends (clamping coefficient = 0,30).

The allowable stresses stipulated above are to be considered.

The beam section is to be kept constant over its length.

**.4** At the discretion of the Society, calculations based on different static models may be accepted, depending on the structural typology adopted.

**C3.7.9.6 Primary supporting members of deckhouse boundary walls**

**.1** The section modulus and shear area are given by the formulae in C3.7.9.1, assuming:

$p$  : sea pressure  $p_{su}$  as defined in C3.5.7,

- $\sigma_{am}$ ,  $\tau_{am}$  :
- steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>).

**.2** Where there is no access from inside deckhouses to 'tween-decks below or where a deckhouse boundary wall is in a particularly sheltered location, reduced scantlings with respect to those stipulated above may be accepted at the discretion of the Society.

**.3** For unprotected front walls located at the fore end, the pressure  $p_{su}$  and allowable stresses are to be considered individually by the Society.

**C3.7.10 Pillars****C3.7.10.1 Steel pillars**

**.1** The minimum area  $A$ , in cm<sup>2</sup>, of the section of a pillar, is to be not less than:

- for  $0 \leq \lambda \leq 1,5$

$$A = \frac{Q \cdot (1 + 0,75 \cdot \lambda^2)}{12}$$

- for  $\lambda > 1,5$

$$A = \frac{Q \cdot \lambda^2}{10}$$

where:

$\lambda$  : slenderness of the pillar, i.e. the ratio between the pillar length, in m, and the minimum radius of gyration of the pillar cross-section, in cm,

$Q$  : load acting on the pillar, in kN, equal to:

$$Q = A_{PG} \cdot p + Q_C$$

$A_{PG}$  : area of the deck acting on the pillar, in m<sup>2</sup>,

$p$  : deck load as defined in C3.5.8,

$Q_C$  : load from pillars above, if any, or any other concentrated load acting on the pillar, in kN.

**.2** The formula for the calculation of  $A$  applies in the case of solid, tubular or prismatic pillars of normal steel. Where higher tensile steel is used, the minimum area may be determined as follows:

$$A' = A \cdot (235/R_{eH}) \text{ provided } \lambda \leq 1$$

where:

$R_{eH}$  : yield stress, in N/mm<sup>2</sup>, of the steel considered.

**.3** Where possible, each pillar is to be aligned with another pillar above or below. Stiffeners ensuring efficient load distribution are to be fitted at the ends of pillars. Where, in exceptional circumstances, pillars support eccentric loads, the scantlings are to be adequately increased to withstand the bending moment due to the eccentricity of the load.

**.4** Where pillars on the inner bottom are not in way of intersections of floors and girders, partial floors or other structures are to be provided to support the load transmitted.

**.5** In general, solid or open-section pillars are to be fitted in tanks; this is compulsory for pillars located in spaces intended for products which may produce explosive gases.

**.6** Heads and heels of pillars are to be continuously welded. The welded connections of stiffeners directly involved in the arrangement of pillars are to be adequately stiffened where necessary.

**.7** The thickness of tubular or closed-section pillars is generally to be not less than 1/35 of the nominal diameter or greater dimension of the section. In no case is this thickness to be less than 3mm.

**.8** The thickness of face plates of built-up pillars is to be not less than 1/18 of the unsupported span of the face plate.

### C3.7.10.2 Pillars made of aluminium alloys

#### .1 Loads on pillars

Where pillars are aligned, the compressive load  $Q$ , in kN, is equal to the sum of loads supported by the pillar considered and those supported by the pillars located above, multiplied by a weighting factor.

The weighting factor depends on the relative position of each pillar with respect to that considered.

This coefficient is equal to:

- 1,0 for the pillar considered,
- 0,9 for the pillar immediately above (first pillar of the line),
- $0,81 = 0,9^2$  for the following pillar (second pillar of the line),
- $0,729 = 0,9^3$  for the third pillar of the line,
- in general,  $0,9^n$  for the  $n^{\text{th}}$  pillar of the line, but not less than  $0,9^7 = 0,478$ .

#### .2 Critical stress for overall buckling of pillars

For global buckling behaviour of pillars made of aluminium alloy, the critical stress,  $\sigma_c$ , in N/mm<sup>2</sup>, is given by the formula:

$$\sigma_c = \frac{R_{p0,2}'}{0,85 + 0,25 \cdot \left(\frac{f \cdot \ell}{r}\right)} \cdot C$$

where:

$R_{p0,2}'$  : minimum as-welded guaranteed yield stress of aluminium alloy used, in N/mm<sup>2</sup>,

$C$  : coefficient as given in Figure C3.7.5, and equal to:

- for alloys without heat treatment:

$$\frac{1}{1 + \lambda + \sqrt{(1 + \lambda)^2 - (0,68 \cdot \lambda)}}$$

- for alloys with heat treatment:

$$\frac{1}{1 + \lambda + \sqrt{(1 + \lambda)^2 - (3,2 \cdot \lambda)}}$$

$$\lambda = \frac{R_{p0,2}'}{\sigma_E}$$

$$\sigma_E = \frac{69,1}{\left(\frac{f \cdot \ell}{r}\right)^2}$$

$\ell$  : length of pillar, in m,

$r$  : minimum radius of gyration, in cm, of the pillar cross section, equal to:

$$r = \sqrt{\frac{I}{A}}$$

$I$  : minimum moment of inertia, in cm<sup>4</sup>, of the pillar cross section,

$A$  : area, in cm<sup>2</sup>, of the pillar cross section,

$f$  : coefficient given in Table C3.7.7 depending on the conditions of fixing of the pillar.

Table C3.7.7 - Coefficient  $f$

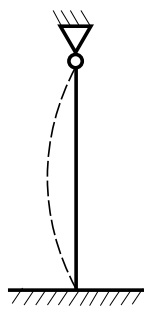

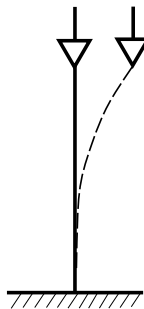
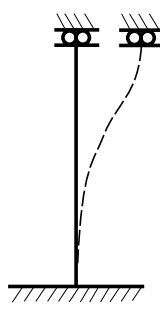
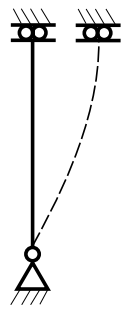
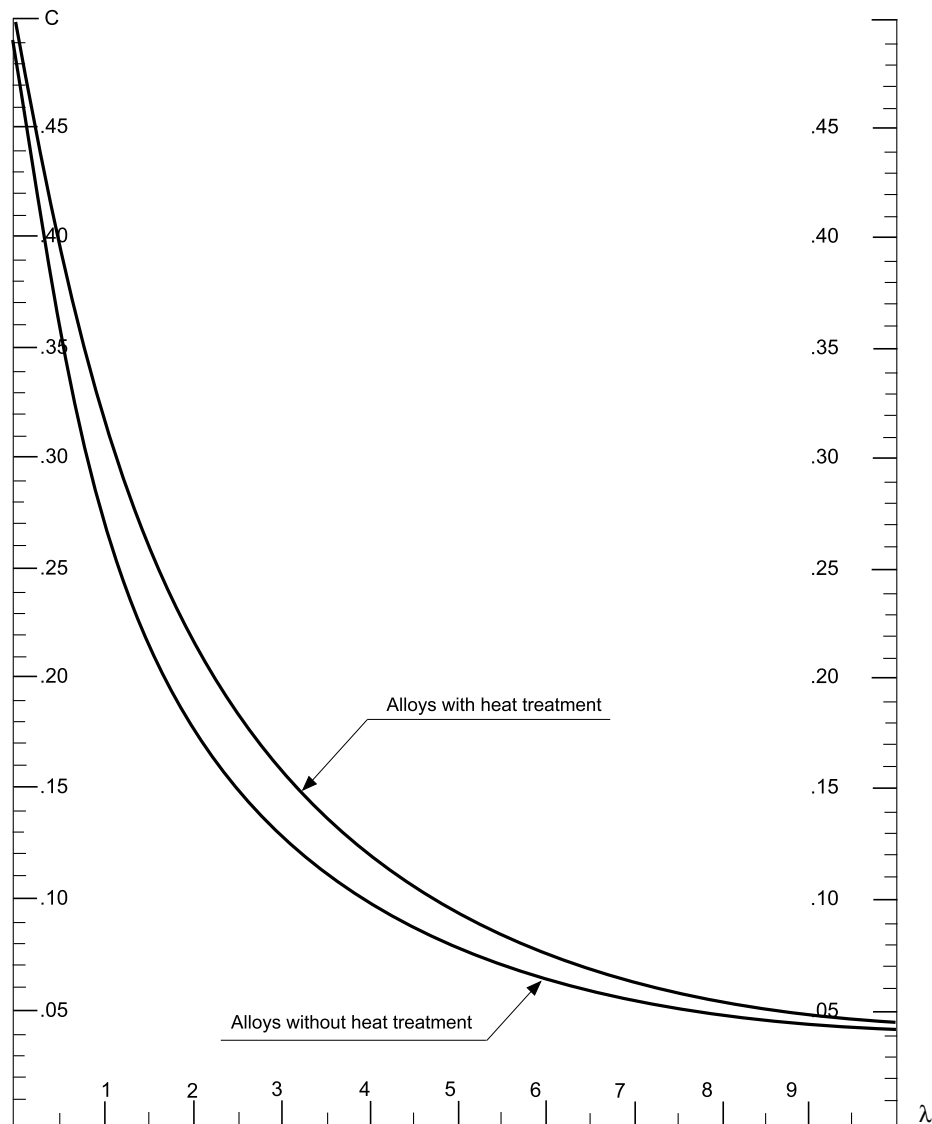
Conditions of fixity					
$f$	0,7	1,0	2,0	1,0	2,0

Figure C3.7.5 Coefficient C



### .3 Critical stress for local buckling of pillars

- (a) For local buckling behaviour of a pillars made of aluminium alloy, the admissible stress  $\sigma_{cl}$ , in N/mm<sup>2</sup>, is given by the formula:

$$\sigma_{cl} = 2 \cdot R_{p0,2}' \cdot C$$

where:

C : coefficient as defined in C3.7.10.2.2,

$$\lambda = \frac{R_{p0,2}'}{\sigma_{El}}$$

$R_{p0,2}'$  : minimum as-welded guaranteed yield stress of aluminium alloy used, in N/mm<sup>2</sup>,

$\sigma_{El}$  : stress defined below.

- (b) For tubular pillars with a rectangular cross-section, the stress  $\sigma_{El}$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_{El} = 252000 \cdot \left(\frac{t}{b}\right)^2$$

where:

b : greatest dimension of the cross-section, in mm,

t : plating thickness, in mm.

- (c) For tubular pillars with a circular cross-section, the stress  $\sigma_{El}$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_{El} = 43000 \cdot \frac{t^2}{D^2}$$

D : outer diameter, in mm,

t : plating thickness, in mm.

- (d) For pillars with I cross-sections, the stress  $\sigma_{EI}$ , in N/mm<sup>2</sup>, is the lesser of the following values:

$$\sigma_{EI} = 252000 \cdot \left(\frac{t_w}{h_w}\right)^2$$

$$\sigma_{EI} = 105000 \cdot \left(\frac{t_f}{b_f}\right)^2$$

where:

- $t_w$  : web thickness, in mm,  
 $h_w$  : web height, in mm,  
 $t_f$  : thickness of face plate, in mm,  
 $h_f$  : width of face plate, in mm.

#### .4 Scantlings of pillars

- (a) The scantlings of pillars are to comply with the following requirements:

$$\sigma \leq \sigma_c$$

$$\sigma \leq \sigma_{cl}$$

where:

- $\sigma$  : compressive stress, in N/mm<sup>2</sup>, in the pillar due to load Q,  
 $\sigma = 10 Q/A$ ,  
A being the cross-sectional area, in cm<sup>2</sup>, of the pillars,  
 $\sigma_c$  : overall buckling critical stress, as defined in C3.7.10.2.2 above,  
 $\sigma_{cl}$  : local buckling critical stress, as defined in C3.7.10.2.3 above.

- (b) The maximum allowable axial load, in kN, is the smaller of the following two values:

$$P_c = \sigma_c \cdot A \cdot 10^{-1}$$

$$P_{cl} = \sigma_{cl} \cdot A \cdot 10^{-1}$$

### C3.7.11 Tank bulkheads

#### C3.7.11.1 General

- .1 Hollow profiles are not permitted as tank walls or in tanks for flammable liquids.

#### C3.7.11.2 Plating

- .1 The required thickness, in mm, is given by the following formula:

$$t = 22,4 \cdot f_m \cdot \mu \cdot s \cdot \sqrt{\frac{p_t}{\sigma_{am}}}$$

where:

$f_m$  : coefficient depending on the material:

- $f_m = 0,80$  for steel structures
- $f_m = 0,75$  for aluminium alloy structures,

$p_t$  : design pressure, in kN/m<sup>2</sup>, as defined in C3.5.9,

- $\sigma_{am}$  : • steel structures:  
 $\sigma_{am} = 185/K$  (N/mm<sup>2</sup>)  
• aluminium alloy structures:  
 $\sigma_{am} = 85/K$  (N/mm<sup>2</sup>).

#### C3.7.11.3 Ordinary stiffeners

- .1 The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in C3.7.8.1, assuming:

$p$  : design pressure  $p_t$  as defined in C3.5.9,

$m$  : coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Table C3.7.4,

- $\sigma_{am}$ ,  $\tau_{am}$  : • steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),  
• aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>).

#### C3.7.11.4 Primary supporting members

- .1 The section modulus, shear area and welding section required for horizontal and vertical girders are given by the formulae in C3.7.9.1, assuming:

$p$  : design pressure  $p_t$  as defined in C3.5.9,

$m$  : coefficient depending on support conditions at the ends of the girder span, generally to be taken equal to 10. A value of 12 could be accepted if supported by direct calculation,

- $\sigma_{am}$ ,  $\tau_{am}$  : • steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),  
• aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>).

#### C3.7.11.5 Corrugated bulkheads

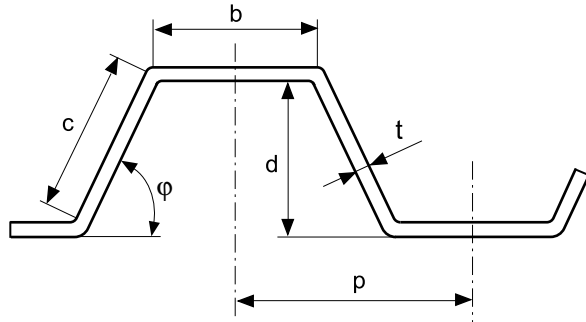
- .1 The thickness and section modulus of corrugated bulkheads, calculated as stated in C3.7.11.2 to C3.7.11.4 are to be increased by 10% and 20%, respectively.

.2 The section modulus  $W_c$ , in  $\text{cm}^3$ , of a corrugation may be derived from the following formula:

$$W_c = d t (3 b + c) / 6000$$

where the symbols are as shown in Figure C3.7.6 and are expressed in mm. In no case is the angle  $\phi$  to be less than  $40^\circ$ .

Figure C3.7.6



### C3.7.12 Subdivision bulkheads

#### C3.7.12.1 Plating

.1 The required thickness, in mm, is given by the following formula:

$$t = 22,4 \cdot f_m \cdot \mu \cdot s \cdot \sqrt{\frac{p_{sb}}{\sigma_{am}}}$$

where:

$f_m$  : coefficient depending on the material:

- $f_m = 0,75$  for steel structures
- $f_m = 0,70$  for aluminium alloy structures,

$p_{sb}$  : design pressure, in  $\text{kN/m}^2$ , as defined in C3.5.10,

$\sigma_{am}$  : • steel structures:  
 $\sigma_{am} = 235/K \text{ (N/mm}^2\text{)}$   
 • aluminium alloy structures:  
 $\sigma_{am} = 95/K \text{ (N/mm}^2\text{)}$ .

.2 The thickness of the collision bulkhead is to be calculated from the formula given in C3.7.12.1.1, multiplied by 1,15.

#### C3.7.12.2 Ordinary stiffeners

.1 The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in C3.7.8.1, assuming:

$p$  : design pressure  $p_{sb}$  as defined in C3.5.10,

$m$  : coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Table C3.7.4,

$\sigma_{am}, \tau_{am}$  : • steel structures:  
 $\sigma_{am} = 210/K \text{ (N/mm}^2\text{)}$   
 $\tau_{am} = 120/K \text{ (N/mm}^2\text{)},$   
 • aluminium alloy structures:  
 $\sigma_{am} = 95/K \text{ (N/mm}^2\text{)}$   
 $\tau_{am} = 55/K \text{ (N/mm}^2\text{)}.$

.2 The section modulus, shear area and welding section required for the ordinary stiffeners of the collision bulkhead are to be calculated from C3.7.12.2.1, considering  $\sigma_{am}$  and  $\tau_{am}$  divided respectively by 1,15 and 1,05.

#### C3.7.12.3 Primary supporting members

.1 The section modulus, shear area and welding section required for horizontal and vertical girders are given by the formulae in C3.7.9.1, assuming:

$p$  : design pressure  $p_{sb}$  as defined in C3.5.10,

$m$  : coefficient depending on support conditions at the ends of the girder span, generally to be taken equal to 10,

$\sigma_{am}, \tau_{am}$  : • steel structures:  
 $\sigma_{am} = 210/K \text{ (N/mm}^2\text{)}$   
 $\tau_{am} = 120/K \text{ (N/mm}^2\text{)},$   
 • aluminium alloy structures:  
 $\sigma_{am} = 95/K \text{ (N/mm}^2\text{)}$   
 $\tau_{am} = 55/K \text{ (N/mm}^2\text{)}.$

.2 The section modulus, shear area and welding section required for the primary supporting members of the collision bulkhead are to be calculated from C3.7.12.3.1, considering  $\sigma_{am}$  and  $\tau_{am}$  divided respectively by 1,3 and 1,2.

#### C3.7.12.4 Corrugated bulkheads

.1 The thickness and section modulus of corrugated bulkheads, calculated as stated in C3.7.12.1 to C3.7.12.3, are to be increased by 10% and 20%, respectively.

.2 The section modulus of a corrugation is to be calculated as indicated in C3.7.11.5.

#### C3.7.13 Non-tight bulkheads

.1 The thickness of plating of non-tight bulkheads which do not act as pillars is to be not less than 2 mm for steel bulkheads, and 3 mm for aluminium alloy bulkheads, and vertical stiffeners are to be not more than 900 mm apart.

**.2** Vertical stiffeners of bulkheads which do not act as pillars are to have a section modulus (calculated in association with a width of plating equal to the stiffener spacing but not exceeding 750 mm) not less than the value, in  $\text{cm}^3$ , given by the formula:

$$Z = 2 s S^2$$

**.3** The thickness of plating of non-tight bulkheads which act as pillars is to be not less than 2 mm for steel bulkheads, and 3 mm for aluminium alloy bulkheads, and vertical stiffeners are to be not more than 750 mm apart.

**.4** Vertical stiffeners of bulkheads which act as pillars are to have a section modulus (calculated in association with a width of plating equal to the stiffener spacing but not exceeding 750 mm) not less than the value, in  $\text{cm}^3$ , given by the formula:

$$Z = 2,65 s S^2$$

**.5** In addition, each vertical stiffener, in association with a width of plating equal to 50 times the plating thickness, is to comply with the requirements for pillars given in C3.7.10, the load supported being determined in accordance with the same provisions.

**.6** In the case of tanks extending from side to side, a wash bulkhead is generally to be fitted amidships; the plating thickness is to be not less than 2 mm for steel bulkheads, and 3 mm for aluminium alloy bulkheads, and it is to be strengthened by vertical stiffeners.

#### C3.7.14 Independent prismatic tanks

**.1** The required thickness for the plating of independent prismatic tanks, in mm, is given by the formula:

$$t = 1,25 \cdot f_m \cdot s \cdot \mu \cdot (p_t \cdot K)^{0,5}$$

where:

$f_m$  : coefficient depending on the material:

- $f_m = 1,0$  for steel bulkheads
- $f_m = 1,45$  for aluminium alloy bulkheads,

$p_t$  : design pressure, in  $\text{kN/m}^2$ , as defined in C3.5.9.

**.2** In no case is the thickness to be less than 2,5 mm for steel bulkheads, and 3,5 mm for aluminium alloy bulkheads.

**.3** The section modulus required for stiffeners, in  $\text{cm}^3$ , is given by the formula:

$$Z = 0,4 \cdot f'_m \cdot s \cdot \ell^2 \cdot p_t \cdot K$$

where:

$f'_m$  : coefficient depending on the material:

- $f'_m = 1,0$  for steel bulkheads
- $f'_m = 2,15$  for aluminium alloy bulkheads.

**.4** The connections to reinforced hull structures of independent tanks are to be able to withstand the dynamic loads induced by the tank weight and the acceleration  $a_v$  of the craft (see C3.3).

**.5** It is recommended that stiffener plates should be arranged so as to prevent undue movement of the liquid.

#### C3.7.15 Side and stern doors

##### C3.7.15.1 Plating

**.1** The required thickness, in mm, is given by the following formula:

$$t = 22,4 \cdot \mu \cdot s \cdot \sqrt{\frac{p_s}{\sigma_{am}}}$$

where:

$p_s$  : design pressure, in  $\text{kN/m}^2$ , as defined in C3.5.5.2.1,

- $\sigma_{am}$  :
- steel structures:  
 $\sigma_{am} = 185/K$  ( $\text{N/mm}^2$ )
  - aluminium alloy structures:  
 $\sigma_{am} = 85/K$  ( $\text{N/mm}^2$ ).

##### C3.7.15.2 Ordinary stiffeners

**.1** The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in C3.7.8.1, assuming:

$p$  : design pressure  $p_s$  as defined in C3.5.5.2.1,

$m$  : coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Table C3.7.4,

- $\sigma_{am}, \tau_{am}$  :
- steel structures:  
 $\sigma_{am} = 150/K$  ( $\text{N/mm}^2$ )  
 $\tau_{am} = 90/K$  ( $\text{N/mm}^2$ ),
  - aluminium alloy structures:  
 $\sigma_{am} = 70/K$  ( $\text{N/mm}^2$ )  
 $\tau_{am} = 45/K$  ( $\text{N/mm}^2$ ).

##### C3.7.15.3 Primary members, securing and supporting devices

**.1** The scantlings of the primary members, securing and supporting devices of side shell doors and stern doors are to be determined to withstand the design loads defined respectively in C3.5.5.2.2 and C3.5.5.2.3, using the following permissible stresses, where  $k$  is the material factor defined in C3.2.2.3 for steel (not to be taken less than 0,72) or in C3.2.3.5 for aluminium alloys:

$\sigma_{am}$  : bending stress

- steel structures:  
 $\sigma_{am} = 120/K \text{ (N/mm}^2\text{)}$
- aluminium alloy structures:  
 $\sigma_{am} = 55/K \text{ (N/mm}^2\text{)},$

$\tau_{am}$  : shear stress

- steel structures:  
 $\tau_{am} = 80/K \text{ (N/mm}^2\text{)}$
- aluminium alloy structures:  
 $\tau_{am} = 35/K \text{ (N/mm}^2\text{)},$

$\sigma_{cam}$  :  $\sigma_{cam} = \sqrt{\sigma^2 + 3 \cdot \tau^2}$

- steel structures:  
 $\sigma_{am} = 150/K \text{ (N/mm}^2\text{)}$
- aluminium alloy structures:  
 $\sigma_{am} = 70/K \text{ (N/mm}^2\text{)}.$

For multihulls, the strengths due to longitudinal bending, transverse bending and torsion are to be examined individually by the Society.

**.2** The longitudinal strength of monohull craft more than 65 m in length is to be checked.

**.3** The longitudinal strength of monohull craft more than 24 m and less than 65 m in length is to be checked when the following conditions are not simultaneously satisfied:

- $L/D \leq r_2$ ,
- no longitudinal members located at more than 0,04 D above the strength deck at side,
- in any transverse section of strength deck, the sum of the breadths of openings is less than:

$$b = \frac{65 - L}{40} \cdot B$$

Values of  $r_2$  factor are given in Table C3.8.1 depending on the type of service of the craft.

### C3.8 Fibre-reinforced plastic craft

#### C3.8.1 Introduction

**.1** This article stipulates requirements for the scantlings of hull structures (plating, stiffeners, primary supporting members). The loads acting on such structures are to be calculated in accordance with the provisions of C3.5.

**.2** In general, for craft with length  $L > 65$  m or speed  $V > 45$  knots, the scantlings of transverse structures are to be verified by direct calculations carried out in accordance with C3.6.

For all other craft, the Society may, at its discretion and as an alternative to the requirements of this article, accept scantlings for transverse structures of the hull based on direct calculations, in accordance with C3.6.

#### C3.8.2 Definitions

**.1** In addition to the definitions in C3.1, the following is to be considered:

- "Superstructure": In this article, it is a decked structure located above the uppermost continuous deck, extending from side to side of the craft, or with the side plating not inboard of the shell plating by more than 4 per cent of the local breadth.

#### C3.8.3 Longitudinal strength

##### C3.8.3.1 General

**.1** This article gives the criteria to be used for the longitudinal strength calculation of monohull ships more than 24 m in length.

**Table C3.8.1 - Factor  $r_2$**

Type of service	$r_2$
Open sea Restricted open sea	16,5
Moderate environment	18,0
Smooth sea	22,0

**.4** In general, the strength deck is the uppermost continuous complete deck or the uppermost superstructure deck contributing to the longitudinal strength, if any.

- The deck number  $n$  of a superstructure or a roof with lateral sides in line with the shell plating, at least  $5nH$  in length and located in the midship region, can be taken as the strength deck in way of the considered transverse sections, where:

$H$  : mean height, in m, of the 'tween deck.

- If such a deck is not considered as the strength deck, arrangements are to be made so that this deck does not participate in the longitudinal strength of the ship.
- Ships with shell openings such that the length of openings is greater than half the length of the shell are to be individually examined by the Society.

**.5** The section moduli at bottom, at the strength deck and at the top of longitudinal members located above the strength deck, if any, calculated according to C3.8.3.2, are not to be less than the value defined in C3.8.3.3.

##### C3.8.3.2 Calculation of strength modulus

**.1** The data given in Table C3.8.2 for plating and C3.8.3 for longitudinals are necessary for calculation of the midship section modulus.



Table C3.8.2

	Deck	Side shell	Bottom
Mean thickness, in mm	$t_p$	$t_m$	$t_f$
Young modulus, in N/mm <sup>2</sup>	$E_p$	$E_m$	$E_f$

Table C3.8.3

		Deck	Side shell (1 side)	Bottom
Flange	Thickness (mm)	$t_{ps}$	$t_{ms}$	$t_{fs}$
	Young modulus (N/mm <sup>2</sup> )	$E_{ps}$	$E_{ms}$	$E_{fs}$
	Breadth (mm)	$l_{ps}$	$l_{ms}$	$l_{fs}$
Web	Thickness equivalent to I section (mm)	$t_{pa}$	$t_{ma}$	$t_{fa}$
	Young modulus (N/mm <sup>2</sup> )	$E_{pa}$	$E_{ma}$	$E_{fa}$
	Height (m)	$H_{pa}$	$H_{ma}$	$H_{fa}$
	Number of longitudinals	$n_p$	$n_m$	$n_f$

**.2** Where there is a sandwich member, the two skins of the laminate are to be taken into account only with their own characteristics. The cores are taken into account if they offer longitudinal continuity and appreciable strength against axial tension-compression.

**.3** For each transverse section within the midship region, the section modulus, in m<sup>3</sup>, is given by:

$$W = \frac{1}{E_p} \cdot \left( C' \cdot P + \frac{C'}{6} \cdot A \cdot \left( 1 + \frac{F - P}{F + 0,5 \cdot A} \right) \right) \cdot 10^{-3}$$

where:

$$P = t_p \cdot B \cdot E_p + n_p \cdot (t_{ps} \cdot l_{ps} \cdot E_{ps} + t_{pa} \cdot H_{pa} \cdot E_{pa})$$

$$A = 2 \cdot (t_m \cdot l_m \cdot E_m + n_m \cdot (t_{ms} \cdot l_{ms} \cdot E_{ms} + t_{ma} \cdot H_{ma} \cdot E_{ma}))$$

$$F = t_f \cdot \frac{B}{2} \cdot E_f + n_f \cdot (t_{fs} \cdot l_{fs} \cdot E_{fs} + t_{fa} \cdot H_{fa} \cdot E_{fa})$$

See also Figure C3.8.1.

### C3.8.3.3 Rule section modulus

**.1** The midship section modulus at the strength deck, at the bottom and above the strength deck, if any, is not to be less, in m<sup>3</sup>, than:

$$W_m = 11 \cdot \alpha \cdot r_1 \cdot F \cdot L^2 \cdot B \cdot (C_B + 0,7) \cdot 10^{-6}$$

where:

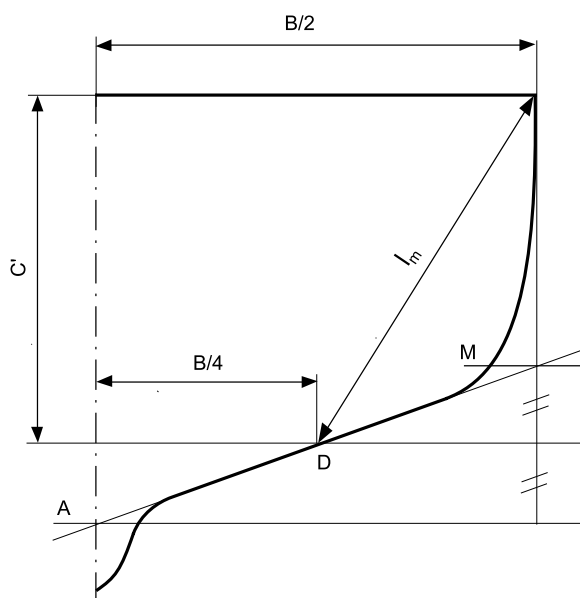
$r_1$  : value given in Table C3.8.4,

$$\alpha = \frac{L}{r_2 D} \quad \text{but not less than } 1$$

$$F = (118 - 0,36 \cdot L) \frac{L}{1000}$$

$r_2$  : value given in Table C3.8.1.

Figure C3.8.1

Table C3.8.4 - Factor  $r_1$ 

Type of service	$r_1$
Open sea	1,0
Restricted open sea	
Moderate environment	0,96
Smooth sea	0,92

### C3.8.3.4 Bending longitudinal stress

**.1** The bending stress, in N/mm<sup>2</sup>, due to the longitudinal bending moment is given by the formula:

$$\sigma_{bl} = \frac{M_{bl}}{W} \cdot 10^{-3}$$

where  $M_{bl}$  is the total bending moment, defined in C3.4.1, and  $W$  is the actual value of the midship section modulus, in m<sup>3</sup>, either at bottom or at the deck.

### C3.8.4 Structural scantling - general

#### C3.8.4.1 Main principles

**.1** Scantlings are given for the midship region and end regions. In intermediate regions, scantlings are to vary gradually from the midship region to the end regions.

**.2** Plating and stiffener scantlings are determined by the fact that the sum of stress due to local design load and longitudinal bending of the hull (if applicable) is to be less than the corresponding allowable stress of the material, i.e. the breaking strength divided by a safety factor, defined below.

.3 Scantlings may be increased where the structure is likely to be subjected to particular forces, for instance due to:

- very high speed,
- nature or uneven distribution of its loading, such as concentrated loads,
- particular conditions of operation, construction or design.

.4 When design assumptions not covered by the present Rules or unusual structural arrangements are provided, the proposed scantlings are to be backed by direct calculations carried out with an agreed method, and submitted to the Society for examination.

If so, the shipyard is to provide, to the satisfaction of the Society, all information needed to verify the calculation. The owner's agreement may be required where the Society deems it appropriate.

.5 In addition to the cases explicitly foreseen by these Rules, subject to justifications submitted for examination, the Society may consider scantlings and structural arrangement, other than those derived from the application of these Rules, in order to take special account of:

- calculation method or a method for the determination of stresses offering a high level of accuracy; calculation data and all information necessary for their assessment are to be submitted to the Society,
- development of the applied techniques, the builder's practical experience and the means he brings into use to ensure an appropriate level of quality and building consistency,
- satisfactory behaviour in service of the type of hull structure concerned,
- particular loading cases.

#### .6 Bottom - side shell boundary for catamarans

For the structure of a catamaran, the inner walls of which are nearly vertical, the limit between bottom and side shell inside the two hulls is to be taken at the level of chine for external walls, as defined in C3.1.4.

#### C3.8.4.2 Safety factors

.1 The safety factor SF is equal to the ratio between the breaking strength (bending or shear) and the allowable stress for a material.

.2 The safety factor to be considered for allowable bending stresses of platings and stiffeners is given in Table C3.8.5.

**Table C3.8.5 - Safety factor SF**

	SF
General	6,0
Members subject to impact load	4,5
Watertight transverse bulkheads	5,0
Sides and ends of superstructures and deckhouses	4,0
Members subjected to the testing pressure $p_e$	4,0

.3 The safety factor to be considered for allowable shear stress of core material of sandwiches and of web primary stiffener is given in Table C3.8.6.

**Table C3.8.6 - Safety factor SF**

		SF
Core of sandwich	General	3,0
	Sandwiches subjected to impact load	2,5
Web of primary members	General	5,0
	Stiffeners subject to impact load	3,5
	Stiffeners on watertight transverse bulk-head	4,0
	Stiffeners of sides and ends of superstructures and deckhouses	3,0
	Stiffeners calculated with the testing pressure $p_e$	3,0

.4 For ships of unusual construction and/or with special service conditions, another value of the safety factor can be defined in accordance with the yard, which is to justify the new safety factor.

#### C3.8.4.3 Single skin laminates

.1 The bending stress, in N/mm<sup>2</sup>, of the laminate is to be multiplied by the following reduction factor  $k_s$ :

$$k_s = \mu_1 \alpha r_c^2$$

where:

$$\mu_1 = 1 \quad \text{if } \ell \geq 2s$$

$$\mu_1 = 1 - 1,5 \cdot \left(1 - \frac{\ell}{2 \cdot s}\right)^2 \quad \text{if } s < \ell < 2s$$

$$\mu_1 = 0,625 \quad \text{if } \ell \leq s$$

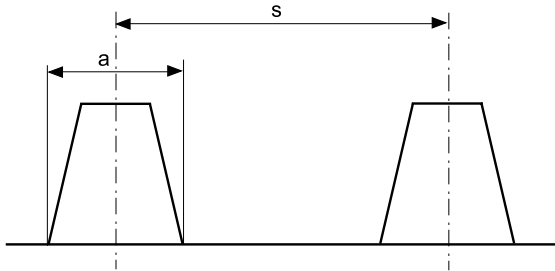
$\alpha$  and  $r_c$  are defined respectively in C3.8.4.3.2 and C3.8.4.3.3.

**.2** In case of shell plating with stiffeners with a wide base, the coefficient  $\alpha$  is given by the formula:

$$\alpha = 1 - 3 \cdot \frac{a}{s} \cdot \left(1 - \frac{a}{s}\right)$$

where  $\alpha$  is not to be less than 0,4 and  $a$  and  $s$  are defined in Figure C3.8.2.

**Figure C3.8.2**



**.3** The curvature factor  $r_c$  is given by the formula:

$$r_c = 1 - \left(0,8 \cdot \frac{f}{s}\right)$$

without being less than 0,85, where  $f$  and  $s$  are defined in Figure C3.8.3.

In the case of unstiffened shell plating with a large curvature, a relevant study of the stress is to be submitted to the Society for examination.

**.4** The minimum thicknesses of the single skin laminate platings are not to be, as a rule, less than the following values:

- for bottom and bilge platings:

$$t = 1,5 \cdot \sqrt{L + 10}$$

- for shell plating:

$$t = 1,25 \cdot \sqrt{L + 10}$$

- for other platings:

$$t = \sqrt{L + 10}$$

Lower values can be considered if a justification is submitted to the Society.

**.5** The bending stress, in N/mm<sup>2</sup>, due to the design pressure  $p$  (defined in C3.5) is given by the formula:

$$\sigma_d = k_s \cdot \frac{V}{[I]} \cdot \frac{p \cdot s^2}{12} \cdot 10^3$$

where:

$V$  : maximum distance of the neutral axis of the laminate, in mm, as defined in C3.2.6.3.3,

$[I]$  : inertia of the laminate, by mm of width, in mm<sup>4</sup>/mm, as defined in C3.2.6.3.3.

**.6** The bending stress due to the design pressure  $p$  is given by the following formula:

$$\sigma_d < \frac{\sigma_{br}}{SF} - \sigma_{bl}$$

where:

$\sigma_{br}$  : breaking bending strength of the laminate, as defined in C3.2.6.3.3,

$\sigma_{bl}$  : bending stress due to the total bending moment, as defined in C3.8.3.4.  $\sigma_{bl}$  is to be equal to zero for all platings of ships of less than 24 m in length and for longitudinal framed platings and all platings at ends of other ships,

$SF$  : safety factor, as defined in C3.8.4.2.

**.7** The bending stress  $\sigma_{de}$ , in N/mm<sup>2</sup>, calculated for the test pressure  $p_e$  is to be such that:

$$\sigma_{de} < \frac{\sigma_{br}}{SF}$$

**.8** The bending deflection, due to design pressure  $p$  (see C3.5), of a single-skin laminate between stiffeners is to be less than about 1% of the stiffener spacing. The bending deflection, in mm, of a single-skin laminate, fixed on its edges, is given by:

$$f = \frac{\mu_2}{384} \cdot \frac{p \cdot s^4}{(EI)} \cdot 10^9$$

where:

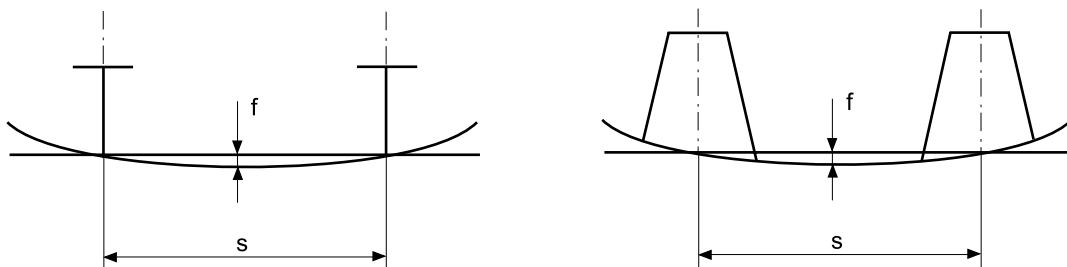
$[EI]$  : rigidity of the laminate, for 1 mm width, in N·mm<sup>2</sup>/mm, defined in C3.2.6.3.3

$$\mu_2 = 1 \quad \text{if } \ell \geq 2s$$

$$\mu_2 = 1 - 2,1 \cdot \left(1 - \frac{\ell}{2 \cdot s}\right)^2 \quad \text{if } s < \ell < 2s$$

$$\mu_2 = 0,475 \quad \text{if } \ell \leq s$$

**Figure C3.8.3**



**C3.8.4.4 Sandwich laminates**

**.1** Refer to C3.8.4.3.1 to C3.8.4.3.3.

**.2** The minimum thicknesses of each skin of sandwich laminate platings are in general not to be less than the following values:

- for bottom and bilge platings:

$$t = 0,6 \cdot \sqrt{L+10}$$

- for shell plating:

$$t = 0,5 \cdot \sqrt{L+10}$$

- for other platings:

$$t = 0,4 \cdot \sqrt{L+10}$$

Lower values can be considered if a justification is submitted to the Society.

**.3** The bending stress, in N/mm<sup>2</sup>, due to the design pressure p (defined in C3.5) is equal to:

$$\sigma_d = k_s \cdot \frac{V}{[I]} \cdot \frac{p \cdot s^2}{12} \cdot 10^3$$

where:

V : maximum distance of the neutral axis of the sandwich, in mm, as defined in C3.2.6.3.3,

[I] : inertia of the sandwich, by mm of width, in mm<sup>4</sup>/mm, as defined in C3.2.6.3.3.

**.4** The bending stress due to the design pressure p is to be such that:

$$\sigma_d < \frac{\sigma_{br}}{SF} - \sigma_{bl}$$

where:

$\sigma_{br}$  : breaking bending strength of the sandwich, as defined in C3.2.6.3.4,

$\sigma_{bl}$  : bending stress due to the total bending moment, as defined in C3.8.3.4.  $\sigma_{bl}$  is to be equal to zero for all platings of ships of less than 24 m in length and for longitudinal framed platings and all platings at ends of other ships,

SF : safety factor, as defined in C3.8.4.2.

**.5** The bending stress  $\sigma_{de}$ , in N/mm<sup>2</sup>, calculated for the test pressure  $p_e$  is to be such that:

$$\sigma_{de} < \frac{\sigma_{br}}{SF}$$

**.6** The shear stress, in N/mm<sup>2</sup>, due to the design pressure p is to be:

$$\tau_d = \frac{p \cdot s}{2 \cdot t_a}$$

where  $t_a$  is the thickness of the core, in mm.

**.7** The shear stress due to the design pressure is to be such that:

$$\tau_d < \frac{\tau_{br}}{SF}$$

where:

$\tau_{br}$  : shear breaking strength of the core material, in N/mm<sup>2</sup>,

SF : safety factor, as defined in C3.8.4.2.

**.8** The sum of the bending and shear deflections, due to the design pressure p (see C3.5), of a sandwich laminate between stiffeners is to be less than about 1% of the stiffener spacing. The total deflection, in mm, of a sandwich laminate, fixed on its edges, is given by the formula:

$$f = \frac{\mu_2}{384} \cdot \frac{p \cdot s^4}{[EI]} \cdot 10^9 + \frac{\mu_3}{8} \cdot \frac{p \cdot s^2}{t_a \cdot G} \cdot 10^3$$

where:

[EI] : rigidity of the sandwich laminate, for 1 mm width, in N · mm<sup>2</sup>/mm, as defined in C3.2.6.3.3,

$t_a$  : core thickness, in mm,

G : shear modulus of the core material, in N/mm<sup>2</sup>,

$\mu_2$  : coefficient defined in C3.8.4.3.8,

$$\mu_3 = 1 \quad \text{if } \ell \geq 2s$$

$$\mu_3 = 1 - 1,8 \cdot \left(1 - \frac{\ell}{2 \cdot s}\right)^2 \quad \text{if } s < \ell < 2s$$

$$\mu_3 = 0,550 \quad \text{if } \ell \leq s$$

**C3.8.4.5 Stiffeners**

**.1** The Rule values of stiffener stresses take account of the width  $l_b$  of the attached plating, defined below:

- for primary stiffeners,  $l_b$  is the smaller of the two values:
  - I stiffener: s or  $0,2 \ell$
  - $\Omega$  stiffener: s or  $(0,2 \ell + a)$ , where a is defined in C3.8.4.3.2,
- for ordinary stiffeners,  $l_b$  is equal to the spacing s between stiffeners.

**.2** To take account of the actual conditions of fixation of a stiffener, the following coefficient  $\epsilon$  is considered in the scantling formulae:

- if the stiffener is fixed at its ends:  $\epsilon = 1,0$
- in the other cases:  $\epsilon = 1,5$ .

**.3** Cut-outs for the passage of ordinary stiffeners are to be as small as possible. As a rule, the depth of cut-outs is not to be greater than half the web height of the primary stiffener.

**.4** The bending stress, in N/mm<sup>2</sup>, due to the design pressure p (defined in C3.5) is given by the formula:

$$\sigma_d = \epsilon \cdot \frac{p \cdot s \cdot \ell^2}{12} \cdot \frac{V}{[I]} \cdot 10^6$$

where:

V : distance from the stiffener neutral axis to the flange, in mm, as defined in C3.2.6.3.5,

[I] : inertia of the stiffener, in mm<sup>4</sup>, as defined in C3.2.6.3.5.

**.5** The bending stress due to the design pressure is to be such that:

$$\sigma_d < \frac{\sigma_{br}}{SF} - \sigma_{bl}$$

where:

$\sigma_{br}$  : breaking bending strength of the stiffener, as defined in C3.2.6.3.5,

$\sigma_{bl}$  : bending stress due to the total bending moment, as defined in C3.8.3.4.  $\sigma_{bl}$  is to be equal to zero for all stiffeners of ships of less than 24 m in length and for stiffeners not contributing to the longitudinal strength and all stiffeners at ends, for other ships,

SF : safety factor, as defined in C3.8.4.2.

**.6** The shear stress, in N/mm<sup>2</sup>, due to the design pressure p (defined in C3.5) is given by the formula:

$$\tau_d = \frac{p \cdot S \cdot \ell}{2 \cdot S_a} 10^3$$

where  $S_a$  is the total web cross-sectional area, in mm<sup>2</sup>.

**.7** For primary stiffeners, the shear stress due to the design pressure is to be:

$$\tau_d < \frac{\tau_{br}}{SF}$$

where:

$\tau_{br}$  : shear breaking strength, in N/mm<sup>2</sup>, of the laminate being the web of the primary stiffener. If a precise value of  $\tau_{br}$  obtained from tests or other agreed method is not available,  $\tau_{br}$  is to be taken equal to 60 N/mm<sup>2</sup>,

SF : safety factor, as defined in C3.8.4.2.

**.8** The bending stress  $\sigma_{de}$ , in N/mm<sup>2</sup>, calculated for the testing pressure  $p_e$  is to be such that:

$$\sigma_{de} < \frac{\sigma_{br}}{SF}$$

**.9** For primary stiffeners, the shear stress  $\tau_{de}$ , in N/mm<sup>2</sup>, calculated for the testing pressure  $p_e$  is to be:

$$\tau_{de} < \frac{\tau_{br}}{SF}$$

### C3.8.5 Bottom structure

#### C3.8.5.1 Application

**.1** The requirements of C3.8.5 apply to single or double-bottom structures with longitudinal or transverse framing.

**.2** The requirements of C3.5.8 are to be used for the scantlings of the main structural members located between the keel and the chine, as defined in C3.1.4. Refer also to C3.8.4.1.6 for catamarans.

**.3** The requirements of C3.5.8 apply also to structural members of the cross-deck of catamarans.

#### C3.8.5.2 General arrangements

**.1** In general, a continuous centreline girder is to be provided over the full length of the ship.

**.2** In the engine room, additional girders are to be fitted in order to provide a sufficient structural strength. Unless otherwise specified, the shipyard is to submit the supporting structure to the engine builder for agreement on rigidity and arrangements.

**.3** Floors are to be continuous between the centreline keelson and the bilge.

**.4** A floor or a girder is to be provided under each line of pillars.

**.5** Main engines and thrust blocks are to be secured to the hull structure by seatings with adequate strength to withstand forces transmitted by the propulsive installation.

**.6** When solid ballast is fitted, it is to be securely positioned. If necessary, intermediate floors may be fitted for the purpose.

**.7** For each member of web of floor or keelson, the height thickness ratio is not to exceed 25.

**.8** Provision is to be made for the free passage of water from all parts of the bottom to the suctions, taking into account the pumping rate required.

#### C3.8.5.3 Plating scantlings

**.1** Plating scantlings are to be calculated in accordance with C3.8.4.3 and C3.8.4.4.

**.2** The width of the keel plate, in m, is not to be less than (0,6 + 0,01 L).

#### C3.8.5.4 Stiffener scantlings

**.1** Stiffener scantlings are to be calculated in accordance with C3.8.4.5.

**.2** For the scantlings of a bottom girder, its span  $\ell$  is to be measured:

- between transverse bulkheads, if the keelson can be considered as a support, i.e. if its height is at least 1,5 times the height of the floors in the centreline, and its moment at least twice the moment of the floors in the centreline,
- between floors, if the keelson is intercostal, its height not exceeding the floor height.

**.3** For the scantlings of a floor, its span  $\ell$  is to be measured:

- between side shell platings, if the bottom is flat and supporting bottom girders or longitudinal bulkheads do not exist,
- between side shell plating and keel, if an important keel exists and supporting bottom girders or longitudinal bulkheads do not exist,
- between side shell plating and keelson, side shell plating and bulkhead, or bulkhead and bulkhead, if longitudinal bulkheads or keelson exist, the scantlings and the span of which are such that they can be considered as a support.

**.4** For ships with a rising of floors, the floor span is to be measured from the ship centreline, when the angle of the rising of floor is greater than:

- 20° in case of built-in floor at side,
- 10° in case of supported floor at side.

This being so, the floor bending stress is to be calculated in accordance with C3.8.4.5, with  $\varepsilon = 1,1$ .

**.5** When the primary structure is made of a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of the stiffeners, taking relative stiffnesses into account, is to be submitted.

#### **C3.8.5.5 Single-bottom structure**

**.1** Side girders are to be fitted. In general, their spacing is not to exceed 2,5 m.

**.2** Centre and side girders are to be extended as far aft and forward as practicable.

**.3** Where side girders are fitted in lieu of the centre girder, overlap is to be adequately extended, and additional stiffening of the centre bottom may be required.

**.4** Flanges of bottom girders and floors are to be connected.

**.5** For ships more than 40 m in length with transverse framed bottom, longitudinal stiffeners connected to floors are to be fitted between bottom girders, within the midship region. The mean spacing of longitudinal members is not to exceed 1,4 m.

#### **C3.8.5.6 Double-bottom structure**

**.1** In general, the height of the double bottom is not to be less than:

$$0,1 \cdot \sqrt{L}$$

**.2** Side girders are to be fitted. In general, their spacing is not to exceed 4,2 m.

**.3** See also C3.8.5.5 above.

#### **C3.8.6 Side shell structure**

##### **C3.8.6.1 Application**

**.1** The requirements of this sub-article apply to transversely or longitudinally framed side shell structure.

**.2** The requirements of this sub-article are to be used for the scantlings of the main structural members located between the chine, as defined in C3.1.4, and the highest continuous deck.

**.3** The requirements of this sub-article apply to structural members of inner walls of catamarans (see C3.8.4.1.6).

##### **C3.8.6.2 General arrangements**

**.1** In case of longitudinal framing, the web frames are to be located in way of floors.

**.2** In case of transverse framing, the section modulus of the web frames located in the engine room is not to be less than 4 times that of adjacent frames, and the cross-sectional area of these web frames is not to be less than twice that of adjacent frames.

**.3** In case of transverse framing, frames are to be fitted at each frame. The scantlings of main and 'tween deck frames are not to be less than those of frames located immediately above.

**.4** In general, stringers are required if the span of main and 'tween deck frames is greater than 4 m.

**.5** Web frames are to be fitted in way of beams at hatch ends.

**.6** The flanges of stringers and web frames are to be connected if necessary.

##### **C3.8.6.3 Plating scantlings**

**.1** Plating scantlings are to be calculated in accordance with C3.8.4.3 and C3.8.4.4.

**.2** The width of the sheerstrake, in m, is not to be less than:

$$b = 0,715 + 0,425 \cdot \frac{L}{100}$$

**.3** Unless otherwise specified, the thickness of the sheerstrake is not to be less than that of the adjacent side shell plating.

**.4** The thickness of the sheerstrake is to be increased by 40% in way of breaks in long superstructures occurring within the midship 0,5 L, over a length of about one sixth of the ship breadth on each side of the superstructure end.

**.5** The thickness of the sheerstrake is to be increased by 30% in way of breaks in long superstructures occurring outside the midship  $0,5 L$ , over a length of about one sixth of the ship breadth on each side of the superstructure end.

**.6** The thickness of the sheerstrake is to be increased by 15% in way of breaks in short superstructures occurring within the midship  $0,6 L$ , over a length of about one sixth of the ship breadth on each side of the superstructure end.

#### **C3.8.6.4 Stiffener scantlings**

**.1** Stiffeners scantlings are to be calculated in accordance with C3.8.4.5.

**.2** For the scantlings of a stringer, its span  $\ell$  is to be measured:

- between transverse bulkheads if the stringer can be considered as a support or if there is no vertical web,
- between vertical webs if the stringer is intercostal and cannot be considered as a support between transverse bulkheads.

**.3** For the scantlings of a vertical web frame, its span  $\ell$  is to be measured:

- between decks or between deck and bottom, if there are no stringers or if stringers are intercostal,
- between deck and stringer, bottom and stringer or between stringers if stringers can be considered as a support between transverse bulkheads.

**.4** When the primary structure is made of a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of stiffeners, taking relative stiffnesses into account, is to be submitted.

### **C3.8.7 Deck structure**

#### **C3.8.7.1 Application**

**.1** The requirements of this sub-article apply to transversely or longitudinally framed deck structure.

**.2** The requirements of this sub-article are to be used for the scantlings of the main structural members of the strength deck, lower and platform decks, accommodation decks and the decks of superstructures and deckhouses.

#### **C3.8.7.2 General arrangements**

**.1** In case of longitudinal framing, the beams are to be located in way of the vertical web frames of side shell.

**.2** In case of transverse framing, the beams are to be, in general, fitted at every frame, in line with side shell stiffeners.

**.3** In case of vertical break for the strength deck, the continuity of strength is to be ensured by a tapered structure of the two decks within a length equal to 2 to 5 frame spacing.

**.4** The transverse strength of ships with large deck openings is to be individually considered.

**.5** In the area of openings, the continuity of strength of longitudinal hatch coamings is to be ensured by underdeck girders.

**.6** Hatch girders and reinforced beams are to be fitted in way of hatch openings.

**.7** The flanges of girders and reinforced beams are to be connected, if necessary.

**.8** In case of concentrated loads on decks (e.g. pillars, winches, davits), direct calculations are to be carried out taking account of simultaneous design pressure and concentrated loads.

#### **C3.8.7.3 Plating scantlings**

**.1** Plating scantlings are to be calculated in accordance with C3.8.4.3 and C3.8.4.4.

**.2** The width of the stringer plate, in m, is not to be less than:  

$$b = 0,005 (L + 70)$$

**.3** Unless otherwise specified, the thickness of the stringer plate is not to be less than that of the adjacent plating.

**.4** The thickness of the stringer plate is to be increased by 40% in way of breaks of long superstructures occurring within the midship  $0,5 L$ , over a length of about one sixth of the ship breadth on each side of the superstructure end.

**.5** The thickness of the stringer plate is to be increased by 30% in way of breaks of long superstructures occurring outside the midship  $0,5 L$ , over a length of about one sixth of the ship breadth on each side of the superstructure end.

**.6** The thickness of the stringer plate is to be increased by 15% in way of breaks of short superstructures occurring within the midship  $0,6 L$ , over a length of about one sixth of the ship breadth on each side of the superstructure end.

**C3.8.7.4 Stiffener scantlings**

.1 Stiffener scantlings are to be calculated in accordance with C3.8.4.5.

.2 For the scantlings of a girder, its span  $l$  is to be measured:

- between transverse bulkheads, if the girder can be considered as a support, i.e. if its height is at least 1,5 times the height of the floors in the centreline, and its moment at least twice the moment of the floors in the centreline,
- between deck beams, if the girder is intercostal and used to prevent tripping instability of deck beams.

.3 For the scantlings of a deck beam, its span  $l$  is to be measured:

- between side shell platings, if there are no girders which can be considered as a support or if there are no longitudinal bulkheads,
- between side shell plating and bulkhead, side shell plating and girder, between bulkheads or girders if there are longitudinal bulkheads or girders, the scantlings and span of which are such that they can be considered as a support.

.4 Hatch beams and hatch girders are to be of reinforced scantlings, to take the interrupted stiffeners into account.

.5 The scantlings of hatch beams and girders is not to be less than those obtained in accordance with C3.8.4.5, changing  $s$  to take into account the effective supported areas.

.6 When the primary structure is made of a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of the stiffeners, taking relative stiffnesses into account, is to be submitted.

**C3.8.7.5 Deck covers**

.1 The scantlings of deck cover platings are to be determined in accordance with C3.8.4.3 and C3.8.4.4.

.2 The scantlings of the deck cover stiffeners are to be calculated in accordance with C3.8.4.5, the span  $l$  of the stiffener being measured:

- between the two edges of the cover, if the stiffener can be considered as a support for this dimension,
- between perpendicular stiffeners, if the stiffener is considered as intercostal.

.3 In case of deck cover with a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of the stiffeners, taking into account the relative stiffnesses, is to be submitted.

**C3.8.8 Bulkhead structure****C3.8.8.1 Application**

.1 The requirements of this sub-article are to be used for the scantlings of the main structural members of:

- watertight transverse or longitudinal bulkheads,
- transverse or longitudinal tank bulkheads,
- wash transverse or longitudinal bulkheads,
- cofferdam bulkheads,
- shaft tunnel bulkheads.

**C3.8.8.2 General arrangements**

.1 The scantlings of tank bulkheads which are also Rule bulkheads are not to be less than those required for a watertight bulkhead.

.2 Where bulkheads do not extend up to the uppermost continuous deck (such as the after peak bulkhead), suitable strengthening is to be provided in the extension of the bulkhead.

.3 Bulkheads are to be stiffened in way of deck girders.

.4 Floors are to be fitted in the double bottom, in way of plane transverse bulkheads.

.5 The scantlings of stiffeners on the horizontal part of stepped bulkheads are to be calculated as for beams.

.6 Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners are to be fitted on each side of the door and suitably overlapped; crossbars are to be provided to support the cut-off stiffeners.

.7 Arrangements are to be provided to avoid the buckling of large accommodation bulkheads without stiffeners.

**C3.8.8.3 Plating scantlings**

.1 Platings scantlings are to be calculated in accordance with C3.8.4.3 and C3.8.4.4.

**C3.8.8.4 Stiffener scantlings**

.1 Stiffeners scantlings are to be calculated in accordance with C3.8.4.5.



**.2** For the scantlings of a stringer, its span  $l$  is to be measured:

- between side shell platings, between longitudinal bulkheads or between side shell plating and longitudinal bulkhead, for stringers of transverse bulkheads considered as a support,
- between transverse bulkheads, for stringers of longitudinal bulkheads considered as a support,
- between vertical webs, for stringers whose scantlings are such that they cannot be considered as a support.

**.3** For the scantlings of a vertical web, its span  $l$  is to be measured:

- between decks or between deck and bottom, if the vertical web can be considered as a support,
- between horizontal stiffeners, if scantlings of the vertical web are such that it cannot be considered as a support.

**.4** When the primary structure is made of a frame of crossed stiffeners with equivalent scantlings, a calculation of the totality of the stiffeners, taking relative stiffnesses into account, is to be submitted.

#### **C3.8.8.5 Watertight doors**

**.1** The strength of a watertight door is not to be less than that of the adjacent bulkhead.

**.2** In the calculation of the scantlings of stiffeners of watertight door, stiffeners are to be considered as supported at ends.

#### **C3.8.9 Superstructure and deckhouse structures**

##### **C3.8.9.1 Application**

**.1** The requirements of this sub-article apply to the structure of superstructures and deckhouses framed transversely and longitudinally.

##### **C3.8.9.2 General arrangements**

**.1** Reduction in scantlings may be granted for:

- deckhouses not protecting openings in the freeboard and superstructure decks,
- deckhouses located above the third tier.

These reductions are to be individually examined by the Society.

**.2** Ends of superstructures and deckhouses are to be efficiently supported by bulkheads, pillars or other equivalent system.

Where hatchways are fitted close to the ends of superstructures, additional strengthening may be required.

**.3** All openings cut in the sides or decks of superstructures and deckhouses are to be stiffened and have well rounded corners. Continuous stiffeners are to be fitted below and above doors or similar openings. Where necessary, compensation for large openings may be required.

**.4** Side plating at the ends of superstructures is to be tapered into the bulwark or sheerstrake of the strength deck. Where a raised deck is fitted, this arrangement is to extend over a three-frame space.

**.5** Access openings cut in sides of enclosed superstructures are to be fitted with watertight doors, permanently attached.

The structure and attachment system of these doors are to be arranged so that the strength remains equivalent to that of a non-pierced bulkhead.

Securing devices which ensure weathertightness are to include tight gaskets, clamping dogs or other similar appliances, and to be permanently attached to the bulkheads and doors. These doors are to be arranged for operation from both sides.

**.6** As a rule, the spacing of stiffeners on sides of superstructures and deckhouses is to be the same as that of beams on supporting decks.

**.7** Partial bulkheads or web are to be arranged to support the sides and ends of superstructures and deckhouses. Scantlings of these web frames are to be individually considered.

**.8** Sides of deckhouses are to be strengthened in way of boats and the top plating is to be reinforced in way of boat davits.

**.9** Special attention is to be paid to the transfer of vertical loads between decks.

##### **C3.8.9.3 Plating scantlings**

**.1** Plating scantlings are to be calculated in accordance with C3.8.4.3 and C3.8.4.4.

**.2** When the superstructure deck is the strength deck, the scantlings of the sides of superstructures are to be determined as for the side shell plating.

**.3** The plating thickness of sides of long superstructures is to be increased by 25% over a length of about one sixth of the ship breadth on each end of the superstructure.

##### **C3.8.9.4 Stiffener scantlings**

**.1** Stiffener scantlings are to be calculated in accordance with C3.8.4.5.

**.2** Scantlings of side stiffeners of superstructures and deckhouses need not exceed those of side stiffeners of the tier immediately below, based on the same span and spacing.

.3 The Society reserves the right for a special examination of superstructure frames:

- where the decks at ends of the considered frame are not stiffened in the same way,
- where the frame span exceeds 4 m,
- for passenger ships.

.4 In the case of a superstructure or deckhouse contributing to the longitudinal strength, the vertical stiffeners between windows on the sides are to be individually examined.

### C3.8.10 Principles of buildings

#### C3.8.10.1 Definition

.1 The stiffeners with the lower spacing are defined in this Section as ordinary stiffeners.

.2 Depending on the direction of ordinary stiffeners, a structure is made of one of the following systems:

- longitudinal framing,
- transverse framing.

.3 Ordinary stiffeners are supported by structural members, defined as primary stiffeners, such as:

- keelsons or floors,
- stringers or web frames,
- reinforced beams or deck stringers.

#### C3.8.10.2 General arrangements

.1 The purpose of this sub-article is to give some structural details which may be recommended. But they do not constitute a limitation; different details may be proposed by the builders and agreed upon by the Society, provided that builders give justifications, to be defined in each special case.

.2 Arrangements are to be made to ensure the continuity of longitudinal strength:

- in areas with change of stiffener framing,
- in areas with large change of strength,
- at connections of ordinary and primary stiffeners.

.3 Arrangements are to be made to ensure the continuity of transverse strength in way of connections between hulls of catamarans and axial structure.

.4 Structure discontinuities and rigid points are to be avoided; when the strength of a structure element is reduced by the presence of an attachment or an opening, proper compensation is to be provided.

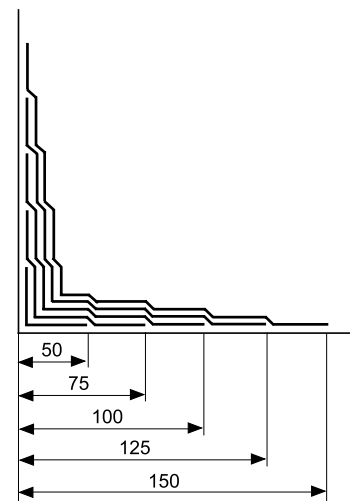
.5 Openings are to be avoided in highly stressed areas, in particular at ends of primary stiffeners, and, for webs of primary stiffeners, in way of pillars. If necessary, the shape of openings is to be designed to reduce stress concentration.

In any case, the corners of openings are to be rounded.

.6 Connections of the various parts of a hull, as well as attachment of reinforcing parts or hull accessories, can be made by moulding on the spot, by bonding separately moulded, or by mechanical connections.

.7 Bulkheads and other important reinforcing elements are to be connected to the adjacent structure by corner joints (see Figure C3.8.4) on both sides, or equivalent joint.

Figure C3.8.4



The mass by  $\text{m}^2$  of the corner joints is to be at least 50% of the mass of the lighter of the two elements to be fitted, and at least  $900 \text{ g/m}^2$  of mat or its equivalent.

The width of the layers of the corner joints is to be worked out according to the principle given in Figure C3.8.4.

.8 The connection of the various parts of the hull, as well as connection of reinforcing members to the hull, can be made by adhesives, subject to special examination by the Society.

#### C3.8.10.3 Platings

##### .1 General

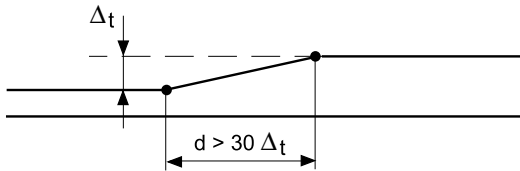
(a) The edges of the reinforcements of one layer are not to be juxtaposed but to be overlapped of at least 50 mm; these overlaps are to be offset between various successive layers.

(b) Prefabricated laminates are fitted by overlapping the layers, preferably with chamfering of edges to be connected.

The thickness at the joint is to be at least 15% higher than the usual thickness.

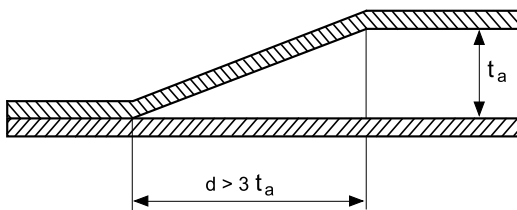
- (c) Changes of thickness for a single-skin laminate are to be made as gradually as possible and over a width which is, in general, not to be less than thirty times the difference in thickness, as shown in Figure C3.8.5.

Figure C3.8.5



- (d) The connection between a single-skin laminate and a sandwich laminate is to be carried out as gradually as possible over a width which is, in general, not to be less than three times the thickness of the sandwich core, as shown in Figure C3.8.6.

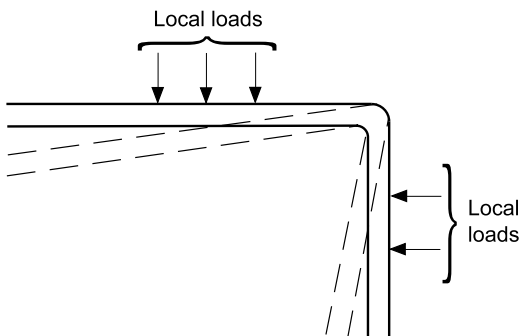
Figure C3.8.6



## .2 Deck-side shell connection

- (a) This connection is to be designed both for the bending stress shown on Figure C3.8.7, caused by vertical loads on deck and horizontal loads of seawater, and for the shear stress caused by the longitudinal bending.

Figure C3.8.7



- (b) In general, the connection is to avoid possible loosening due to local bending, and ensure longitudinal continuity. Its thickness is to be sufficient to keep shear stresses acceptable.

- (c) Figure C3.8.8 to Figure C3.8.11 give examples of deck-side shell connections.

Figure C3.8.8

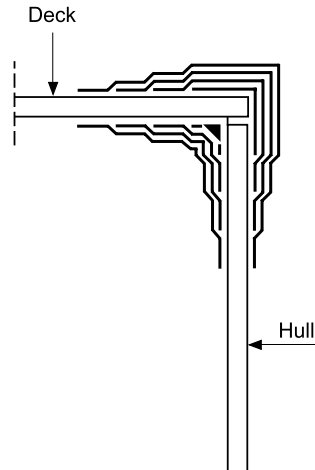


Figure C3.8.9

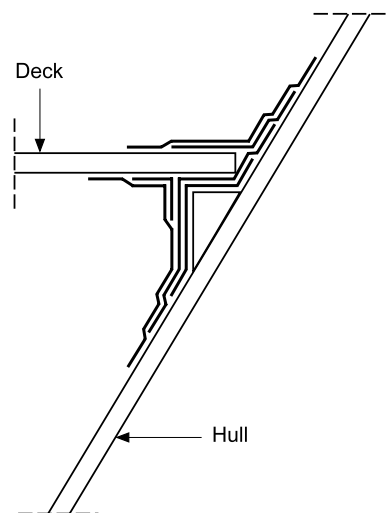


Figure C3.8.10

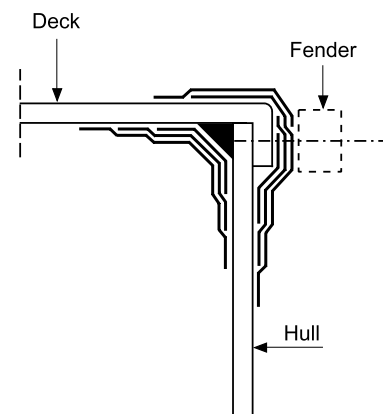
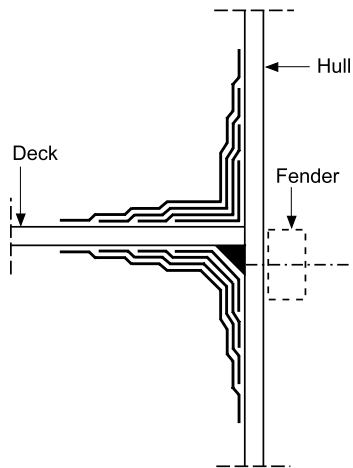


Figure C3.8.11

**.3 Bulkhead-hull connection**

- (a) In some cases, this connection is needed to distribute the local load due to the bulkhead over a sufficient length of hull. Figure C3.8.12 and Figure C3.8.13 give possible solutions. The scantlings of corner joints are determined according to the loads acting upon the connections.
- (b) The builder is to pay special attention to connections between bulkheads of integrated tanks and structural members.

Figure C3.8.12

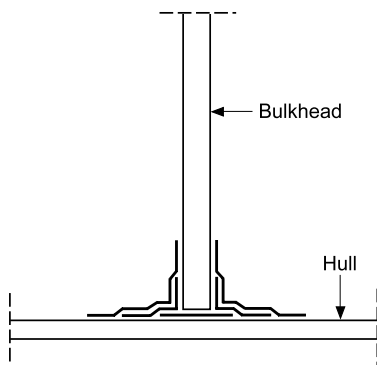
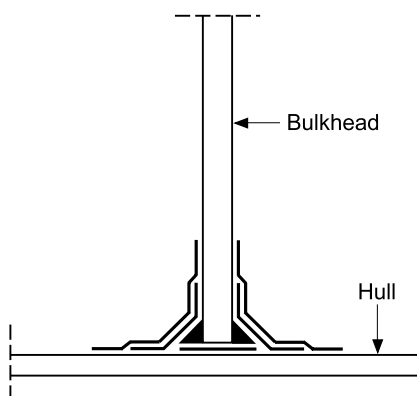


Figure C3.8.13

**.4 Passage through hull**

- (a) Passages of metal elements through the hull, especially at the level of the rudder stock, shaft brackets, shaft-line, etc., are to be strongly built, in particular when subjected to alternating loads.
- (b) Passages through hull should be reinforced by means of a plate and a counterplate connected to each other.

**.5 Passage through watertight bulkhead**

The continuous omega or rectangle stiffeners at a passage through a watertight bulkhead are to be watertight in way of the bulkhead.

**.6 Openings in deck**

The corners of deck openings are to be rounded in order to reduce local stress concentrations as much as possible, and the thickness of the deck is to be increased to maintain the stress at a level similar to the mean stress on the deck.

The reinforcement is to be made from a material identical to that of the deck.

**C3.8.10.4 Stiffeners**

**.1** Primary stiffeners are to ensure structural continuity.

**.2** Abrupt changes in web height, flange breadth, cross-section area of web and flange are to be avoided.

**.3** In general, at the intersection of two stiffeners of unequal sizes (longitudinal with web frame, floor, beam or frame with stringer, girder or keelson), the smallest stiffener (longitudinal or frame) is to be continuous, and the connection between the elements is to be made by corner joints according to the principles defined in C3.8.10.2.

**.4** Figure C3.8.14 to Figure C3.8.16 give various examples of stiffeners.

Figure C3.8.14

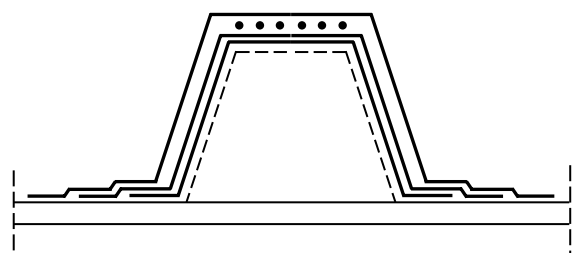


Figure C3.8.15

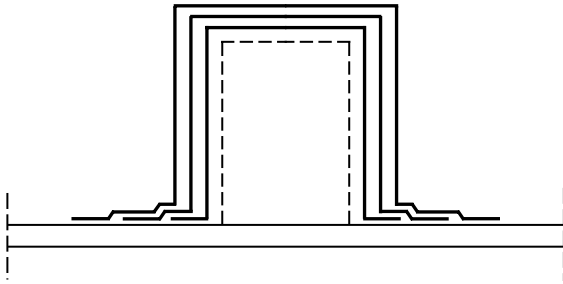
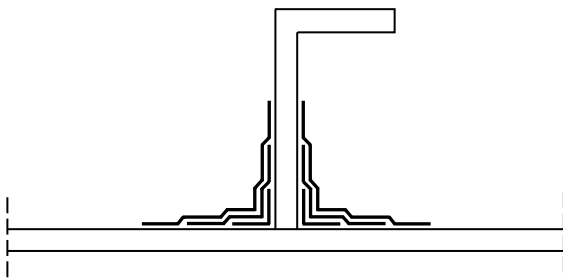


Figure C3.8.16



.5 Connections between stiffeners are to ensure good structural continuity. In particular, the connection between deck beam and frame is to be ensured by means of a flanged bracket. However, some types of connections without bracket may be accepted, provided that loads are light enough. In this case, stiffeners are to be considered as supported at their ends.

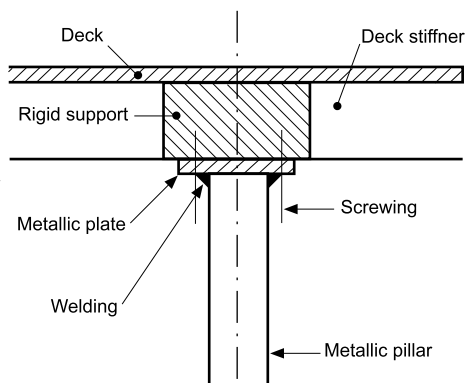
#### C3.8.10.5 Pillars

.1 Connections between metal pillars, subject to tensile loads, and the laminate structure are to be designed to avoid tearing between laminate and pillars.

.2 Connections between metal pillars, subject to compressive loads, and the laminate structure are to be carried out by means of intermediate metal plates. The welding of the pillar to the metal plate is to be carried out before fitting of the plate on board ship.

Figure C3.8.17 gives the principle for connection between the structure and pillars subject to compressive loads.

Figure C3.8.17

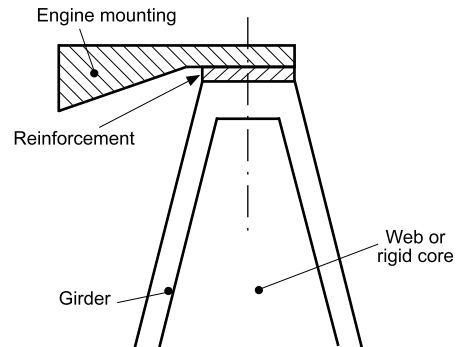


#### C3.8.10.6 Engine seating

.1 The engine seating is to be fitted on special girders suitably positioned between floors, which locally ensure sufficient strength with relation to pressure and weight loads.

.2 Figure C3.8.18 gives an example of possible seating.

Figure C3.8.18



### C3.9 Hull appendages

#### C3.9.1 Propeller shaft brackets

##### C3.9.1.1 General

.1 For certain ships, the propeller shafting is extended to the propeller bearings clear of the main hull. Propeller shafting is either enclosed in bossing or independent of the main hull and supported by shaft brackets.

##### C3.9.1.2 Shaft brackets

.1 The scantlings of bracket arms are to be calculated as indicated below. For high-powered ships, the Society may require direct calculations to be carried out.

.2 Bracket arms are to be attached to deep floors or girders of increased thickness, and the shell plating is to be increased in thickness and suitably stiffened, at the discretion of the Society. The thickness of the palm connecting the arms to the hull, if any, is to be not less than  $0,2 d_s$ , where:

$d_s$  : Rule diameter, in mm, of the propeller shaft, calculated with the actual mechanical characteristics,

and it is to be connected to the hull by means of through bolts, fitted with nut and lock nut, in way of the internal hull structures suitably stiffened.

.3 The arms of V-shaft brackets are to be perpendicular, as far as practicable.

**.4** The bearing length of the shaft bracket boss, in mm, is to be not less than  $3 d_s$ .

**.5** The thickness, in mm, of the shaft bracket boss after boring operation is to be not less than:

$$t_b = 0,2 \cdot d_s \cdot (k_1 + 0,25)$$

where:

$$k_1 = R_{ms} / R_{mb}$$

$R_{ms}$  : minimum tensile strength, in N/mm<sup>2</sup>, of the propeller shaft,

$R_{mb}$  : minimum tensile strength, in N/mm<sup>2</sup>, of the shaft bracket boss, with appropriate metallurgical temper.

**.6** Each arm of V-shaft brackets is to have a cross-sectional area, in mm<sup>2</sup>, not less than:

$$S = 87,5 \cdot 10^{-3} \cdot d_{so}^2 \cdot \left( \frac{1600 + R_{ma}}{R_{ma}} \right)$$

where:

$d_{so}$  : rule diameter, in mm, of the propeller shaft, for a carbon steel material,

$R_{ma}$  : minimum tensile strength, in N/mm<sup>2</sup>, of arms, with appropriate metallurgical temper.

**.7** Single-arm shaft brackets are to have a section modulus at ship plating level, in cm<sup>3</sup>, not less than:

$$W = \frac{30}{R_{ma}} \cdot 10^{-3} \cdot \ell \cdot d_{so}^2 \cdot \sqrt{n \cdot d_{so}}$$

where:

$\ell$  : length of the arm, in m, measured from the shell plating to the centreline of the shaft boss,

$n$  : shaft revolutions per minute.

Moreover, the cross-sectional area of the arm at the boss is not to be less than 60% of the cross-sectional area at shell plating.

### C3.9.1.3 Plated bossing

**.1** Where the propeller shafting is enclosed within a plated bossing, the aft end of the bossing is to be adequately supported.

**.2** The scantlings of end supports are to be individually considered. Supports are to be designed to transmit loads to the main structure.

**.3** End supports are to be connected to at least two deep floors of increased thickness, or connected to each other within the ship.

**.4** Stiffening of the boss plating is to be individually considered. At the aft end, transverse diaphragms are to be fitted at every frame and connected to floors of increased scantlings. At the fore end, web frames spaced not more than four frames apart are to be fitted.

### C3.9.2 Waterjets

**.1** The supporting structures of waterjets are to be able to withstand the loads thereby generated in the following conditions:

- maximum ahead thrust,
- maximum thrust at maximum lateral inclination,
- maximum reversed thrust (going astern).

Information on the above loads is to be given by the waterjet manufacturer and supported by documents.

**.2** For each waterjet, following loading cases are to be investigated:

LDC 1 : internal hydrodynamic pressure  $p_h$  in the built-in nozzle

LDC 2 : horizontal longitudinal force  $F_{x1}$  in normal service (ahead)

LDC 3 : horizontal transverse force  $F_y$  and associated moment  $M_z$  during steering operation

LDC 4 : horizontal longitudinal force  $F_{x2}$ , vertical force  $F_z$  and overturning moment  $M_y$  in crash-stop situation

**.3** The actual location of the thrust bearing is to be adequately considered (either located aft of the stem in the stator bowl or inside the waterjet compartment)

**.4** The scantlings are to be checked by direct calculations.

**.5** Table C3.9.1 indicates the loading cases to be considered for the various components of the waterjet system. Other loading cases could be considered for specific or new design.

**Table C3.9.1**

Component	LDC 1	LDC 2	LDC 3	LDC 4
Built-in nozzle:				
- plating	X (1)	X (2)		
- bending behaviour				X (3)
Ship stem		X (2)	X	X (4)
Bolting on stem			X (5)	X (5)
<b>(1)</b> : to be checked under lateral pressure and against fatigue behaviour <b>(2)</b> : buckling to be checked (100% of $F_x$ transferred by built-in nozzle in case of thrust bearing aft of the stem) <b>(3)</b> : ratio of $M_y$ directly sustained by the built-in nozzle to be estimated on basis of relative stiffnesses <b>(4)</b> : ratio of $M_y$ directly sustained by the transom structure to be estimated on basis of relative stiffnesses <b>(5)</b> : bolting calculation taking account of the actual pre-tension in bolts				

.6 The stress criteria for static analysis may be taken as the following one, in N/mm<sup>2</sup>:

- bending stress:

$$\sigma_{am} = \frac{150}{K \cdot f'_m}$$

- shear stress:

$$\tau_{am} = \frac{90}{K \cdot f'_m}$$

- Von Mises equivalent bending stress:

$$\sigma_{eq, am} = \frac{190}{K \cdot f'_m}$$

where:

K : material factor defined in C3.2

f'\_m : coefficient depending on the material:

- 1,00 for steel structures
- 2,15 for aluminium alloy structures

.7 The stress criteria for fatigue analysis are to be specified by the designer.

.8 The shell thickness in way of nozzles as well as the shell thickness of the tunnel are to be individually considered. In general, such thicknesses are to be not less than 1,5 times the thickness of the adjacent bottom plating.

.9 General principles to be followed for such structures subject to cyclic loadings are listed hereafter:

- continuous welding
- shear connections between stiffeners and transverse frames
- soft toe brackets
- no sniped ends
- no termination on plate fields
- no scallops in critical areas
- no start and stop of welding in corners or at ends of stiffeners and brackets
- possibly grinding of toes of critical welds

Note: As a guidance, the following criteria may be considered:

The bending natural frequency of plates and strength members of the hull in the area of waterjets should not be less than 2,3 times the blade frequency for structures below the design waterline and between transom and aft engine room bulkhead. Structural components (such as the casing of waterjet and accessory parts and the immersed shell area) which may transfer pressure fluctuations into the ship structure have to fulfill the requirements of the waterjet manufacturer. Especially with regard the grids installed in the inlet duct, the hydrodynamic design should assure an unproblematic operation with respect to cavitation phenomenon.

This checking is left to the manufacturers (see paragraph 3.4)

## C3.10 Rudders

### C3.10.1 General

.1 Rudders which are intended to be operated at the maximum angle of helm only during navigation at reduced speed are to comply with the provisions of this article.

.2 This article applies to rudders having a rectangular or trapezoidal blade contour without cutouts, of the types shown in Figure C3.10.1 and Figure C3.10.2. Rudders of different types is to be individually considered by the Society.

.3 Rudders which are intended to be operated at the maximum angle of helm during high speed navigation are to be designed on the basis of direct calculations to be performed by the designer. The acceptability of calculated results are to be individually considered by the Society in each separate case.

Figure C3.10.1

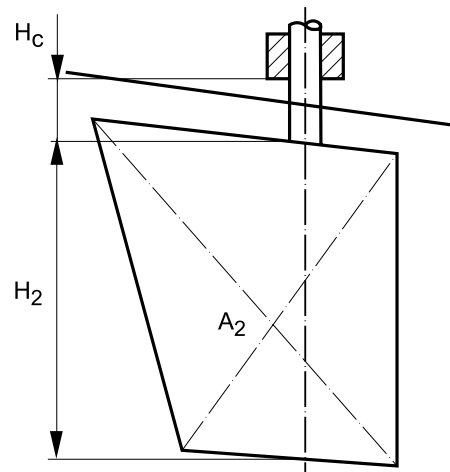
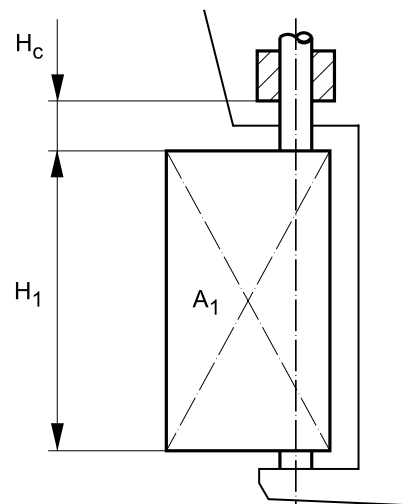
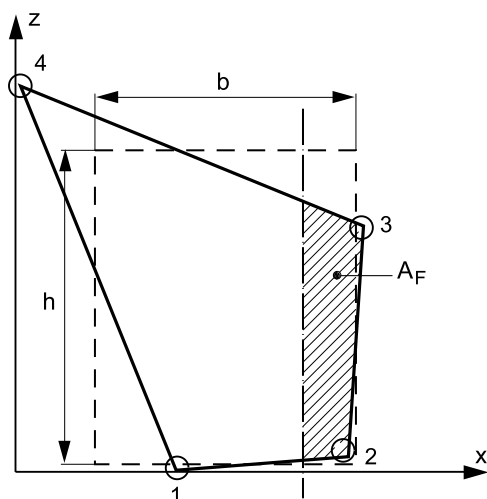


Figure C3.10.2



**C3.10.2 Definitions and symbols**

- $V_{AV}$  : maximum ahead service speed, in knots, at maximum displacement, in still water,
- $A$  : total area of rudder blade, in  $m^2$ , bounded by the blade external contour, including main-piece and the part forward of the centreline of the rudder pintles, if any,
- $A_D$  : area, in  $m^2$ , of the rudder part abaft the centreline of rudder pintles,
- $X_G$  : distance, in m, from the centroid of area  $A$  to the centreline of pintles,
- $k_1$  : shape factor, equal to:  
 $k_1 = (\Lambda + 2) / 3$
- $\Lambda$  :  $\Lambda = h^2 / A_T$   
 where  $h$  is the mean height of the rudder area, in m. In no case is the value of  $\Lambda$  to be greater than 2. Mean height  $h$  and mean breadth  $b$  of rudder blade are to be calculated according to Figure C3.10.3,
- $A_T$  : area, in  $m^2$ , obtained by adding, to the rudder blade area, the area of rudder post or rudder horn, if any, up to height  $h$ ,
- $k_2$  : factor depending on rudder profile, the value of which is given in Table C3.10.1. For high-efficiency rudders,  $k_2$  is to be equal to 1,7 for ahead condition and 1,2 for astern condition,

**Figure C3.10.3**

- $b$  : mean breadth of rudder, in m, equal to:

$$b = \frac{X_2 + X_3 - X_1}{2}$$

- $h$  : mean height of rudder, in m, equal to:

$$h = \frac{Z_3 + Z_4 - Z_2}{2}$$

- $k_3$  : factor equal to:

- $k_3 = 0,8$  for rudders outside the propeller jet
- $k_3 = 1,15$  for rudders behind a fixed propeller nozzle
- $k_3 = 1,0$  in other cases,

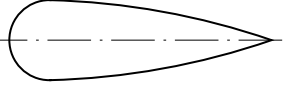
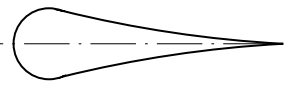
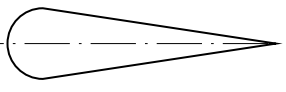
- $d_{TF}$  : rule diameter, in mm, of rudder stock subject to combined torque and bending,

- $d_T$  : rule diameter, in mm, of rudder stock subject to torque only,

- $C_R$  : rudder force, in N, i.e. force acting on the rudder blade, as defined in C3.10.5,

- $Q_R$  : rudder torque, in  $N \cdot m$ , i.e. torque acting on the rudder stock, as defined in C3.10.5.

**Table C3.10.1 - Factor  $k_2$** 

Profile type	$k_2$	
	ahead condition	astern condition
NACA-00 – Göttingen profiles 	1,10	0,80
Hollow profiles 	1,10 - 1,35	0,90
Flat side profiles 	1,10	0,90

**C3.10.3 Materials**

**.1** Rudder stocks, pintles, keys and bolts are to be made of rolled, forged or cast C-Mn steel, in accordance with the relevant requirements of the Rules.

**.2** The material used for rudder stocks, pintles, keys and bolts is to have a minimum yield stress  $R_{eH}$  of not less than 200 N/mm<sup>2</sup>.

**.3** The requirements for the determination of scantlings contained in this article apply to steels having a minimum yield stress  $R_{eH}$  equal to 235 N/mm<sup>2</sup>.



**.4** In the case of steels with a yield stress  $R_{eH}$  other than 235 N/mm<sup>2</sup>, the values of diameters and thicknesses calculated with the formulae contained in the following sub-articles are to be modified as indicated, depending on the factor  $K_1$  obtained from the following formula:

$$K_1 = \left( \frac{235}{R_{eH}} \right)^y$$

where:

$R_{eH}$  : minimum yield stress of steel employed, in N/mm<sup>2</sup>; in no case is  $R_{eH}$  to be greater than 450 N/mm<sup>2</sup> or 0,7  $R_m$ , whichever is less,

$R_m$  : minimum ultimate tensile strength of steel employed, in N/mm<sup>2</sup>,

- for  $R_{eH} > 235$  N/mm<sup>2</sup>:  $y = 0,75$
- for  $R_{eH} \leq 235$  N/mm<sup>2</sup>:  $y = 1,0$

**.5** In general, significant reductions in rudder stock diameter for the application of steels with  $R_{eH} > 235$  N/mm<sup>2</sup> may be accepted by the Society, subject to the results of a calculation to check rudder stock deformation.

**.6** Significant rudder stock deformations are to be avoided so as not to create excessive edge pressures in way of bearings.

**.7** Welded parts of rudders are to be made of rolled hull steels of a type approved by the Society.

#### C3.10.4 Arrangement

**.1** Effective means are to be provided to support the weight of the rudder without excessive bearing pressure (e.g. by means of a rudder carrier attached to the upper part of the rudder stock). The hull structure in way of the rudder carrier is to be suitably strengthened.

**.2** Suitable arrangements are to be made to prevent the rudder from accidental lifting.

**.3** In addition, structural rudder stops of suitable strength are to be provided, except where the steering gear is provided with its own rudder stopping devices.

**.4** In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and lubricant being washed away from the rudder carrier.

If the top of the rudder trunk is below the deepest waterline, two separate seals or stuffing boxes are to be provided.

#### C3.10.5 Determination of the force acting on the rudder blade and the torque acting on the rudder stock

**.1** The rudder force  $C_R$ , in N, is to be calculated by the following formula:

$$C_R = 132 \cdot A \cdot V^2 \cdot k_1 \cdot k_2 \cdot k_3$$

where:

$$V : \min[V_{AV}, 2/3 \cdot (V_{AV} + 2 \cdot L^{0.5})]$$

**.2** The rudder torque  $Q_R$ , in N · m, is to be calculated for both ahead and astern conditions according to the formula:

$$Q_R = C_R \cdot r$$

where:

$r$  : distance, in m, equal to:

$$r = b \cdot (\alpha - k_A)$$

for the ahead condition,  $r$  is to be taken not less than  $0,1 \cdot b$ ,

$b$  : mean breadth of rudder area, in m, measured in accordance with Figure C3.10.3,

$\alpha$  : • for ahead condition:  $\alpha = 0,33$   
• for astern condition:  $\alpha = 0,66$

$$k_A = A_F / A$$

$A_F$  being the area, in m<sup>2</sup>, of the rudder blade portion afore the centreline of rudder pintles (see Figure C3.10.3).

#### C3.10.6 Rudder stock

##### C3.10.6.1 Rudder stock subject to torque

**.1** Rudder stocks subject to torque are to have scantlings such that the torsional stress, in N/mm<sup>2</sup>, does not exceed the following value:

$$\tau_{T ALL} = 68/K_1$$

**.2** The rudder stock diameter is therefore to be not less than  $d_T$ , in mm, calculated by the following formula:

$$d_T = 4,2 \cdot (Q_R \cdot K_1)^{1/3}$$

##### C3.10.6.2 Rudder stock subject to combined torque and bending

**.1** Rudder stocks subject to combined torque and bending are to have scantlings such that their equivalent stress  $\sigma_e$ , in N/mm<sup>2</sup>, does not exceed the value determined by the formula:

$$\sigma_{e ALL} = 118 / K_1$$

**.2**  $\sigma_e$  is given by the formula:

$$\sigma_e = \sqrt{\sigma_B^2 + 3 \cdot \tau_T^2}$$

where:

$\sigma_B$  : bending stress component, in N/mm<sup>2</sup>, given by the formula:

$$\sigma_B = \frac{10,2 \cdot M}{d_{TF}^3} \cdot 10^3$$

$\tau_T$  : torsional stress component, in N/mm<sup>2</sup>, given by the following formula:

$$\tau_T = \frac{5,1 \cdot Q_R}{d_{TF}^3} \cdot 10^3$$

**.3** The rudder stock diameter, in mm, is therefore to be not less than the value  $d_{TF}$ , in mm, calculated according to the formula:

$$d_{TF} = d_T \cdot \left(1 + \frac{4}{3} \cdot \left(\frac{M}{Q_R}\right)^{2/3}\right)^{1/6}$$

where:

$M$  : bending moment, in N · m, which may be expressed as:

$$M = 0,866 \cdot (C_R / A) \cdot H$$

$H$  : • for spade rudders (see Figure C3.10.1):

$$H = A_2 \cdot (H_C + H_2 / 2)$$

• for rudders with 2 bearings (with solepiece) (see Figure C3.10.2):

$$H = A_1 \cdot a_1 \cdot u \cdot H_1$$

$A_1$ ,  $A_2$ ,  $H_C$ ,  $H_1$  and  $H_2$  are shown in Figure C3.10.1 and Figure C3.10.2.

The values of the coefficients  $a_1$  and  $u$  are given in Table C3.10.2 as a function of the ratio  $c$ , where:

$$c = H_1 / (H_C + H_1)$$

**Table C3.10.2 - Coefficients  $a_1$  and  $u$**

c	u	$a_1$	c	u	$a_1$
1,00	0,2490	1,000	0,74	0,2694	1,266
0,98	0,2370	1,000	0,72	0,2784	1,302
0,96	0,2294	1,000	0,70	0,2881	1,336
0,94	0,2256	1,000	0,68	0,2984	1,370
0,92	0,2242	1,000	0,66	0,3094	1,403
0,90	0,2248	1,000	0,64	0,3212	1,435
0,88	0,2270	1,000	0,62	0,3336	1,467
0,86	0,2303	1,017	0,60	0,3468	1,499
0,84	0,2348	1,064	0,58	0,3608	1,531
0,82	0,2402	1,109	0,56	0,3757	1,563
0,80	0,2464	1,151	0,54	0,3915	1,596
0,78	0,2534	1,191	0,52	0,4084	1,629
0,76	0,2610	1,229	0,50	0,4264	1,662

**.4** The Society may accept bending moments, shear forces and support reaction forces determined by a direct calculation to be performed with reference to the static schemes and loading conditions set out in Figure C3.10.4 and Figure C3.10.5.

For the rudder in Figure C3.10.4, the load per unit length  $P_R$ , in kN/m, is given by:

$$P_R = C_R \cdot \frac{10^{-3}}{\ell_{10}}$$

For the rudder in Figure C3.10.5, the maximum bending moment  $M_B$ , in N · m, and support forces  $B_3$  and  $B_2$ , in N, may be determined by the formulae:

$$M_B = C_R \cdot \left( \ell_{20} + \frac{\ell_{10} \cdot (2C_1 + C_2)}{3 \cdot (C_1 + C_2)} \right)$$

$$B_3 = M_B / l_{30}$$

$$B_2 = C_R + B_3$$

**.5** In general, the diameter of a rudder stock subject to torque and bending may be gradually tapered above the upper stock bearing, so as to reach the value of  $d$  in way of the quadrant or tiller.

**Figure C3.10.4**

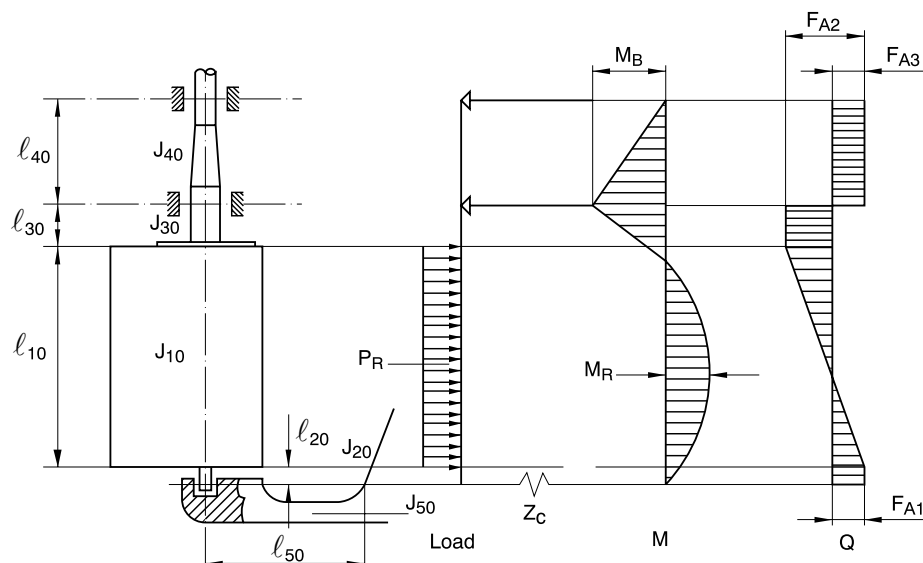
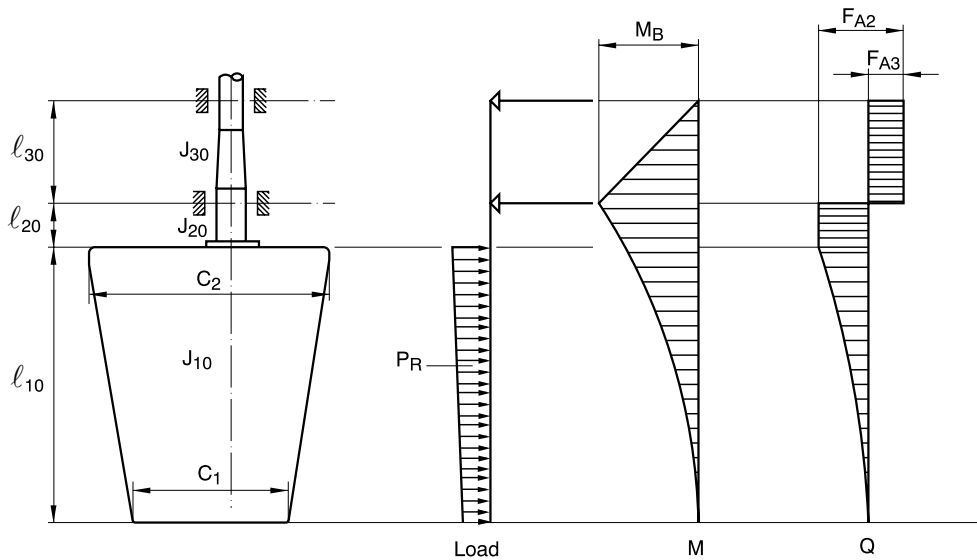


Figure C3.10.5



### C3.10.7 Rudder plating

**.1** Double-plating rudders consist of a welded plating box, stiffened by horizontal and vertical webs, which may or may not incorporate the mainpiece.

**.2** The generic horizontal cross-section of the rudder plating is to be such that stress components, in N/mm<sup>2</sup>, do not exceed the following values:

- normal bending stress:

$$\sigma_{F1} = 110 / K_1$$

- shear stress:

$$\tau = 50 / K_1$$

- equivalent stress:

$$\sigma_e = \sqrt{\sigma_{F1}^2 + 3 \cdot \tau^2} = \frac{120}{K_1}$$

**.3** The thickness of each rudder plate panel is to be not less than  $t_F$ , in mm, calculated by the following formula:

$$t_F = \left( 5,5 \cdot s \cdot \beta \cdot \sqrt{d + \frac{C_R \cdot 10^{-4}}{A}} + 2,5 \right) \cdot \sqrt{K_1}$$

where:

$d$  : draught at summer load waterline, in m,

$$\beta = \sqrt{1,1 - 0,5 \cdot \left( \frac{s}{b_L} \right)^2}$$

which need not be greater than 1,

with:

$s$  : minor side of the plating panel, in m,

$b_L$  : major side of the plating panel, in m.

**.4** Vertical webs with spacing greater than twice that of horizontal webs are not acceptable.

**.5** Web thickness is to be at least 70% of that required for rudder plating, and in no case is it to be less than 8 mm, except for the upper and lower webs. The thickness of any of these webs is to be uniform and not less than that of the web panel having the greatest thickness  $t_F$  as calculated with the above formula. In any case the thickness is not required to be increased by more than 20% compared with normal webs.

**.6** When the design of the rudder does not incorporate a mainpiece, this is to be replaced by two vertical webs closely spaced and in general not less than 1,5 times the thickness of normal webs. In rudders with an area  $A$  smaller than 5 m<sup>2</sup>, one vertical web may be accepted, provided its thickness is in general at least twice that of normal webs. As a rule, the increased thickness of such webs need not exceed 30 mm, unless otherwise required in special cases to be individually considered by the Society.

The thickness of the side plating between the two vertical webs replacing the mainpiece, or in way of the single web, is to be increased by at least 20%.

**.7** The welded connections of blade plating to vertical and horizontal webs are to comply with the requirements of C3.2.

Where internal access to the rudder is not practicable, connections are to be made by slots on a supporting flat welded to the webs, to be cut on one side of the rudder only, in accordance with C3.2.

**.8** Rudder nose plates are to have a thickness not less than 1,25  $t_F$ . In general this thickness need not exceed 22 mm, unless otherwise required in special cases to be individually considered by the Society.

**C3.10.8 Rudder pintles**

**.1** Rudder pintles are to have a diameter not less than the value  $d_A$ , in mm, calculated by the formula:

$$d_A = 0,35 \cdot (F_A \cdot K_1)^{1/2}$$

where:

$F_A$  : force, in N, acting on the pintle, calculated as specified in C3.10.8.7.

**.2** Provision is to be made for a suitable locking device to prevent the accidental loosening of pintles.

**.3** The pintle housings are in general to be tapered with the taper ranging:

- from 1:12 to 1:8 for pintles with non-hydraulic assembly and disassembly arrangements,
- from 1:20 to 1:12 for pintles with hydraulic assembly and disassembly arrangements.

The housing height is to be not less than the pintle diameter  $d_A$ .

**.4** The maximum value of the pressure acting on the gudgeons, in N/mm<sup>2</sup>, calculated by the formula:

$$p_F = \frac{F_A}{d_A \cdot h_A}$$

is not to exceed the values given in Table C3.10.3, where  $h_A$  is the length of contact between pintle and housing, taken to be not greater than 1,2  $d_A$ .

Values in excess of those given in Table C3.10.3 may be accepted by the Society on the basis of specific tests.

**Table C3.10.3**

Bearing material	$q_a$ (N/mm <sup>2</sup> )
Lignum vitae	2,5
White metal, oil lubricated	4,5
Synthetic material with hardness between 60 and 70 Shore D (1)	5,5
Steel, bronze and hot-pressed bronze-graphite materials (2)	7,0
(1) Indentation hardness test at 23°C and with 50% moisture to be performed according to a recognised standard. Type of synthetic bearing materials to be approved by the Society. (2) Stainless and wear-resistant steel in combination with stock liner approved by the Society.	

**.5** The thickness of the pintle housing in the gudgeon is to be not less than 0,25  $d_A$ .

**.6** The manufacturing tolerances, in mm, on the diameter of metal supports are to be less than:

$$d_A / 1000 + 1,0$$

In the case of non-metal supports, tolerances are to be evaluated carefully on the basis of the thermal and distortion properties of the materials employed; the tolerance on the support diameter is in no case to be less than 1,5 mm.

**.7** Where direct calculation is used to obtain the rudder stock stress components, the value  $F_A$  is also to be derived from the same calculation.

Otherwise,  $F_A$  is to be calculated from the following formula:

$$F_A = \frac{C_R}{A} \cdot A_G$$

where:

$C_R$  : force, in N, acting on the rudder blade, determined as specified in C3.10.5,

$A_G$  : part of the rudder blade area  $A$ , in m<sup>2</sup>, supported by the pintle.  $A_G$  is to be not lower than:

$$A_G = A \cdot \frac{H_C + 0,5 \cdot H_1}{H_C + H_1}$$

**C3.10.9 Rudder couplings****C3.10.9.1 Horizontal flange couplings**

**.1** Horizontal flange couplings are to be connected by a number  $n_B$  of fitted bolts not fewer than 6, and the diameter of which, in mm, is not less than  $d_B$  given by the formula:

$$d_B = 0,62 \cdot \frac{K_{1B}}{K_{1A}} \cdot \sqrt{\frac{d_1^3}{n_B \cdot e_M}}$$

**.2** The thickness of the coupling flange is to be not less than the value  $t_p$ , in mm, calculated by the following formula:

$$t_p = d_B \cdot \sqrt{\frac{K_{1P}}{K_{1B}}}$$

In any case  $t_p \geq 0,9 d_B$ ,

with  $d_B$  calculated for a number of bolts not exceeding 8.

The symbols used above have the following meaning:

$d_1$  : rule diameter  $d_T$  or  $d_{TF}$ , in mm, of the rudder stock, in compliance with the requirements in C3.10.6,

$K_{1B}$ ,  $K_{1A}$ ,  $K_{1P}$ : coefficients depending on the high-strength steel used for bolts, rudder stock and coupling flange, respectively, whose values are defined in C3.10.3,

$e_M$  : mean distance, in mm, of the bolt axes from the longitudinal axis through the coupling centre.

**.3** The distance from the bolt axes to the external edge of the coupling flange is generally to be not less than 1,2  $d_B$ .

**.4** A suitable locking device is to be provided to prevent accidental loosening of nuts.

**.5** Non-fitted bolts may be used provided that, in way of the mating plane of the coupling flanges, a key is fitted with a section of 0,25  $d_T \times 0,10 d_T$  and keyways in both the coupling flanges, and provided that at least two of the coupling bolts are fitted bolts.

**C3.10.9.2 Vertical flange couplings**

.1 Vertical flange couplings are to be connected by a number  $n_B$  of fitted bolts not fewer than 8, and the diameter of which, in mm, is not less than  $d_B$  given by the formula:

$$d_B = 0,81 \cdot d_1 \cdot \sqrt{\frac{K_{1B}}{n_B \cdot K_{1A}}}$$

$d_1$ ,  $K_{1B}$  and  $K_{1A}$  being defined in C3.10.9.1.2 above.

.2 The first moment of area of the sectional area of bolts about the vertical axis through the centre of the coupling is to be not less than the value  $M_s$ , in  $\text{cm}^3$ , obtained by the formula:

$$M_s = 0,43 d_1^3 \cdot 10^{-6}$$

.3 The thickness of the coupling flange is generally to be not less than  $d_B$ .

.4 The distance of the bolt axes from the external edge of the coupling flange is generally to be not less than  $1,2 d_B$ .

.5 A suitable locking device is to be provided to prevent the accidental loosening of nuts.

**C3.10.9.3 Cone couplings**

.1 Cone couplings of the shape shown in Figure C3.10.6 (with explanations of symbols in (a) and (b) below) are to be secured by a slugging/hydraulic nut, as the case may be, provided with an efficient locking device, and with the following dimensions:

(a) Cone couplings with hydraulic arrangements for assembling and disassembling the coupling:

$$\text{Taper: } 1/20 \leq (d_1 - d_0) / t_s \leq 1/12$$

$$t_s \geq 1,5 \cdot d_1$$

$$d_G \geq 0,65 \cdot d_1$$

$$t_N \geq 0,60 \cdot d_G$$

$$d_N \geq 1,2 \cdot d_0 \text{ and, in any case, } d_N \geq 1,2 \cdot d_G$$

A washer is to be fitted between the nut and the rudder gudgeon not less than  $0,13 \cdot d_G$  in thickness, and with an outer diameter not less than  $1,3 \cdot d_0$  or  $1,6 \cdot d_G$ , whichever is greater.

(b) Cone couplings without hydraulic arrangements for assembling and disassembling the coupling:

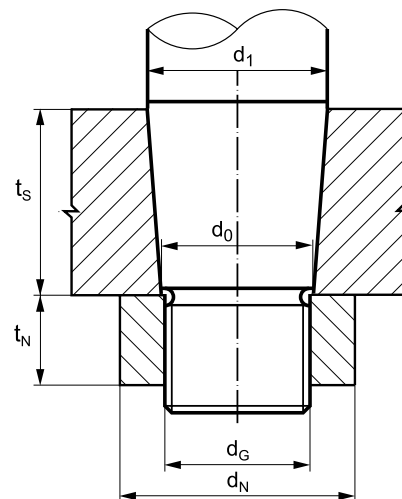
$$\text{Taper: } 1/12 \leq (d_1 - d_0) / t_s \leq 1/8$$

$$t_s \geq 1,5 \cdot d_1$$

$$d_G \geq 0,65 \cdot d_1$$

$$t_N \geq 0,60 \cdot d_G$$

$$d_N \geq 1,2 \cdot d_0 \text{ and, in any case, } d_N \geq 1,2 \cdot d_G.$$

**Figure C3.10.6**

.2 The dimensions of the locking nut, in both (a) and (b) above, are given purely for guidance, the determination of adequate scantlings being left to the responsibility of the designer.

.3 In cone couplings of type (b) above, a key is to be fitted with a cross-section  $0,025 \cdot d_1^2$  and keyways in both the tapered part and the rudder gudgeon. In cone couplings of type (a) above, the key may be omitted. In this case, the designer is to provide the Society with shrinkage calculations supplying all data necessary for the appropriate check.

.4 All necessary instructions for hydraulic assembly and disassembly of the nut, including indications of the values of all relevant parameters, are to be available on board.

**C3.10.10 Single plate rudders**

.1 The mainpiece diameter is to be calculated according to C3.10.4.2.

.2 The mainpiece diameter is to be not less than the stock diameter. For spade rudders, the lower third may taper down to 0,75 times the stock diameter.

.3 The blade thickness  $t_B$ , in mm, is to be not less than:

$$t_B = (1,5 \cdot s \cdot V_{AV} + 2,5) \cdot K_1^{1/2}$$

where:

$s$  : spacing of stiffening arms, in m, in no case to be more than 1 m.

.4 The thickness of the arms is to be not less than the blade thickness; the section modulus, in  $\text{cm}^3$ , of the generic cross-section is to be not less than:

$$Z_A = 0,5 \cdot s \cdot C_1^2 \cdot V_{AV}^2 \cdot K_1$$

where:

$C_1$  : horizontal distance, in m, from the aft edge of the rudder to the cross-section.

**C3.11 Stabilisation means****C3.11.1 General**

**.1** Two different situations are to be considered for the purpose of Section 3, depending on the main function of the stabilisation system:

Situation 1: The stabilisation system is associated with the safe operation of the craft as described in 16.1.1. In that case, the system is covered by the present Rules.

Situation 2: The stabilisation system is only a motion reduction or a ride control system. In such a situation, the system is not covered by the present Rules.

**C3.11.2 Classification process**

**.1** For situation 1, the structural design assessment process in scope of classification is given hereafter:

- the following structural parts are reviewed, on basis of design loads and safety criteria indicated by the supplier:

- structure of the stabilisation devices: foils, trim, tabs or interceptors

- ship structure supporting the stabilisation devices

- Only power activated items such as foils, trims, tabs or interceptors are assessed. The following parts are reviewed:

- hydraulic system used for activation of stabilisation system

- associated electrical devices

**.2** For situation 2, the structural design assessment process in scope of classification is given hereafter:

- only the ship strength in way of stabilisation devices is assessed. Ship structure supporting these devices is reviewed, on basis of design loads and safety criteria indicated by the supplier:

- Only possible interferences between hydraulic installation and the safety of the craft are of concern. The applicable regulations depend on the location of the hydraulic power pack. The working principles are not checked. However, the hydraulic system documentation is to be submitted.

## APPENDIX C3A1

SPECIAL REQUIREMENTS FOR SCANTLINGS OF  
HYDROFOIL HULL STRUCTURES

## C3A1.1 Foreword

**.1** The requirements of this Appendix apply to hydrofoils, i.e. craft which can sail both at high speed, with the hull emerging from the water surface, supported by the hydrodynamic lift of a system of connected underwater foil planes (foils), and as conventional floating craft during manoeuvring operations or in emergency conditions.

**.2** Where not expressly specified, the symbols used here are those already defined in this Section

**.3** This Appendix generally covers hydrofoils with a length  $L \leq 35$  m and fitted with two foils, a bow and an after foil, and a screw propeller, having a maximum sailing speed on foils of 40 knots, and intended for the carriage of passengers and, if applicable, of cargo.

**.4** Hydrofoils with characteristics other than those above, or which are not designed in accordance with these Rules, are to be individually considered.

## C3A1.2 General

**.1** The hull is to be designed with the aim of achieving safe navigation of the hydrofoil, both when emerging on foils and when floating under the different displacement, trim and stability conditions, in still water and in sea waves, which are expected in service. The designer is to establish, by calculations and, if necessary, tank tests on models, hull shapes, weights and their distribution, the position, shape and type of foils and the thrust of the propulsion system in order to ensure suitable structural strength of the hull and safe transverse and longitudinal stability of the hydrofoil, with particular reference to transient conditions of lifting from water, alighting on water and turning.

**.2** Hydrofoils covered by this Appendix generally have hard chine hulls as well as bottoms presenting a significant deadrise, bow foil within  $1/3 L$  of the bow and after foil within  $1/3 L$  of the stern. Foils may be of the partially submerged Vee (narrow or wide) self-stabilizing type, or of the completely submerged, horizontal non-self-stabilizing type fitted with automatic stabilizing devices; foils may be of the fixed or lifting type.

**.3** In the case of hydrofoils with general characteristics substantially different from those above or having special arrangements, the Society reserves the right to require appropriate additional calculations as well as tank

tests on models, followed, if necessary, by exhaustive sea trials before entry into service.

## C3A1.3 Definitions and symbols

$L$	: Rule length, in m (see C3.1),
$L_a$	: longitudinal distance, in m, between mid bow foil and mid after foil, measured parallel to $L$ ,
$L_{ft}$	: overall length, in m,
$B$	: moulded breadth, in m (see C3.1),
$B_a$	: greatest foil breadth, in m,
$D$	: depth, in m (see C3.1),
$D_a$	: greatest depth, in m, measured vertically from the lower side of the more deeply submerged foil to the corresponding top of the deck beam, at the side of the main deck,
$T$	: draught, in m (see C3.1),
$T_a$	: greatest draught, in m, of the more deeply submerged foil, measured vertically with craft at rest,
$T'_a$	: greatest draught, in m, of the more deeply submerged foil, measured vertically with full load craft on sailing trim on foils,
$f_m$	: coefficient depending on the material: <ul style="list-style-type: none"> <li>• 1,00 for steel structures</li> <li>• 1,45 for aluminium alloy structures,</li> </ul>
$f'_m$	: coefficient depending on the material: <ul style="list-style-type: none"> <li>• 1,00 for steel structures</li> <li>• 2,15 for aluminium alloy structures.</li> </ul>

## C3A1.4 Documents to be submitted

**.1** In addition to the plans and information listed in C3.0, the following calculations, specifications and plans (in triplicate) are to be submitted to the Society for approval, together with the following information:

- outer shell expansion, including stiffeners in way of foils, rudder, stern tubes and propeller shaft brackets;
- structure of foils and relevant hull connection stiffeners as well as quality of materials employed, with specification of intended heat treatments and non-destructive tests;

- (c) calculations and diagrams relevant to the longitudinal strength of the hull;
- (d) calculation of foil structure strength, including the specification of the loading conditions considered and restraints assumed.

**.2** Any other documents, calculations and plans deemed useful by the Society for the purpose of classification are also to be submitted.

### C3A1.5 Longitudinal strength

#### C3A1.5.1 General

**.1** The longitudinal strength of the hull is to be calculated for at least the two conditions specified below, adopting the more severe of the resulting scantlings.

- (a) Floating hydrofoil  
Hydrofoil floating in still water,
- (b) Emerging hydrofoil on foils
- (1) Emerging hydrofoil supported by its foils and considered on its sailing trim in still water without any additional motion, taking account, in the acting forces diagram, of the vertical components (lift) of hydrodynamic forces on the foils,
  - (2) Hydrofoil in the conditions specified in (1) but in sea waves, taking account of pitching, rolling and heaving motions, and of consequent acceleration and forces of inertia.

**.2** The calculation of the hull cross-section modulus is to include the shells and associated stiffeners which, due to their longitudinal continuity, effectively contribute to longitudinal strength.

**.3** As regards the acceleration values and wave characteristics to be assumed in the calculations, they are to include the severest sea conditions expected for the hydrofoil in service, according to the provisions in C3.3.

#### C3A1.5.2 Allowable stresses Rule values of midship section modulus Section modulus calculation

**.1** The maximum allowable bending stresses  $\sigma$  at deck and bottom and shear stress  $\tau$  at sides are generally not to exceed the values given in Table C3A1.1.

**Table C3A1.1 - Maximum allowable stresses**

Hydrofoil under conditions specified in:	$\sigma$ at bottom (N/mm <sup>2</sup> )	$\sigma$ at deck (N/mm <sup>2</sup> )	$\tau$ at sides (N/mm <sup>2</sup> )
C3A1.5.1.1 (a) C3A1.5.1.1 (b) (1)	$45 / (K \cdot f'_m)$	$45 / (K \cdot f'_m)$	$40 / (K \cdot f'_m)$
C3A1.5.1.1 (b) (2)	$85 / (K \cdot f'_m)$	$85 / (K \cdot f'_m)$	$70 / (K \cdot f'_m)$

In general, maximum  $\sigma$  stresses occur at about 0,5  $L_a$ , and maximum  $\tau$  stresses in way of the bow foil.

**.2** Attention is to be paid to scantling distribution for structures contributing to the longitudinal strength of the different hull zones, so as to avoid structural discontinuities, which would give rise to peaks in the diagrams of moments of inertia and of section moduli, with consequent abrupt variations in stresses. The structures constituting the hull are also to comply with the requirements for local hull strength, set out below.

**.3** For hydrofoils with length  $L \leq 35$ m, the Rule midship section moduli at bottom  $Z_b$  and at deck  $Z_d$ , in cm<sup>3</sup>, are given by the formula:

$$Z_b = Z_d = (6,3 \cdot L_a - 60) \cdot 10^3$$

**.4** The section modulus is, in any case, to be such as to comply with the allowable stresses given in Table C3A1.1.

**.5** The section moduli of the cross-sections  $W_b$  at bottom and  $W_d$  at deck are conventionally obtained by dividing the moment of inertia of the cross-section under consideration by the vertical distance between the horizontal neutral axis and the base line, and by the distance between this axis and the top of the deck beam, at the side, of the strength deck, respectively.

**.6** To calculate the moment of inertia of the above cross-sections, the net cross-section of continuous elements contributing to longitudinal strength, and therefore reduced for openings, manholes and other holes which are not completely compensated, is to be taken into account; in the case of riveted structures, in contrast, rivet holes in shells and bars are not required to be deducted from the strength cross-section.

### C3A1.6 Local strength

#### C3A1.6.1 General

**.1** Hull structure dimensions are to comply with the relevant requirements of this Section considering the craft as floating, and neglecting dynamic effects due to accelerations, impact and wave loads.

**.2** The structural arrangements to be adopted in these craft are specified below, together with minimum scantlings to be satisfied in any case.

**.3** The scantlings of the outer shell, decks and relevant stiffeners contributing to local hull strength are to comply with the requirements of this Appendix. They are to be increased, if necessary, depending on the longitudinal strength as required in C3A1.5.

**.4** The spacing of secondary stiffeners is, in general, not to exceed 300 mm, at least in way of foils, the machinery space and forward of the bow foil.



**.5** Primary transverse frames, consisting of floors, side transverses and deck transverses, are to be fitted both where the structure of ordinary stiffeners is of the transverse type and where it is of the longitudinal type.

In the first case, the frames give support to bottom girders, side stringers and deck girders, which in turn, support the ordinary shell stiffeners, i.e., floors, webs and beams, respectively; in the second case they support the longitudinals directly.

Structures different from the above are to be individually considered in each case.

#### C3A1.6.2 Bottom shell plating

**.1** The thickness  $t_b$ , in mm, of the bottom shell, in the area from the bow foil to the stern, is in no case to be less than:

$$3 \cdot f_m \cdot \sqrt{K}$$

**.2** The thickness  $t_k$  of the keel strake is to be, in general, at least equal to 1,2 times the thickness adopted for the bottom and in no case less than 4 mm.

**.3** The bottom thickness  $t_{bf}$  in the area forward of the bow foil is to be at least 1,2  $t_b$ , provided that the take-off speed of the hydrofoil is not greater than approximately 20 knots and the maximum sailing speed on foils is not greater than approximately 40 knots. For greater speeds, the thickness  $t_{bf}$  is to be individually considered in each case, depending on the results of calculations and, if necessary, experiments to be performed by the designer, to assess the hydrodynamic force on the shell due to water in the takeoff stage and the wave action on the shell in the sailing condition on foils at maximum service speed.

**.4** Takeoff speed is intended as the minimum speed necessary to lift the hull on foils in still water.

**.5** In way of foils, the bottom thickness is to be increased appropriately and in no case is it to be less than, in mm:

$$5 \cdot f_m \cdot \sqrt{K}$$

#### C3A1.6.3 Side shell plating

**.1** The thickness  $t_s$ , in mm, of the side shell is to be not less than:

$$3 \cdot f_m \cdot \sqrt{K}$$

**.2** The thickness  $t_s$ , in mm, from 0,1 L aft the bow foil to 0,1 L forward of such foil is to be not less than:

$$5 \cdot f_m \cdot \sqrt{K}$$

**.3** The thickness  $t_{sh}$  of the sheerstrake, for the whole hull length, is to be at least equal to that of the corresponding side.

**.4** Where, on the sheerstrake, side ports or side scuttles or other large openings are fitted, the thickness is to be increased such as to compensate these openings.

**.5** The thickness  $t_{sh}$  is also to be increased in way of end bulkheads of any castles, or, in any case, in way of steps in the strength deck.

**.6** In way of foils, the side thickness is to be suitably increased and is, in no case, to be less than, in mm:

$$5 \cdot f_m \cdot \sqrt{K}$$

#### C3A1.6.4 Deck and flat plating

**.1** The thickness  $t_d$ , in mm, of the deck plating is to be not less than:

$$3 \cdot f_m \cdot \sqrt{K}$$

**.2** The thickness  $t_{st}$  of the stringer plate of the strength deck is to be at least equal to that adopted for the sheerstrake or for the remaining deck plating, whichever is greater.

**.3** The thickness, in mm, of decks below the strength deck, generally consisting of flats, is to be not less than:

- if the 'tween deck is intended for accommodation or similar:

$$2 \cdot f_m \cdot \sqrt{K}$$

- if the deck forms a tank bottom or tank top:

$$2,5 \cdot f_m \cdot \sqrt{K}$$

#### C3A1.6.5 Bottom structure

**.1** For the bottom, longitudinal framing extending through the whole length is generally required, except for extreme stern and extreme bow areas, where the framing is generally transverse.

**.2** In way of the bow foil and after foil, ordinary floors of suitable scantlings, to be individually considered in each case, are to be fitted. In way of the fore foil, the floor spacing is generally to be one half the frame spacing.

**.3** In the machinery space, at least two girders on each side are to be fitted, at least one of which is to be fitted in way of one of the engine seating girders.

**.4** In the area forward of the bow foil, at least one girder on each side is to be fitted. The height, in general, is to be at least equal to that of the bottom transverses, and preferably located in the same plane as a deck girder, if fitted. The girder thickness is to be not less than, in mm:

$$3 \cdot f_m \cdot \sqrt{K}$$

**.5** At the bow foil and after foil, the number and scantlings of the floors are to be individually considered in each case, depending on the type of structure proposed. In any case, two floors belonging to complete transverse rings (side and deck transverses) are to be fitted, and located one forward and the other aft of the hull penetrations of the bow foil bearing arm.

Intermediate floors in this area are to be positioned, between those usually fitted at each frame spacing, and all such bottom transverses are to have a section modulus of at least 1,25 times that required for the area aft of the engine room.

**.6** In the area forward of the bow foil, the floors are generally to have a section modulus of at least 1,8 times that required for the area aft of the engine room and a spacing not greater than four web spacings. In the usual case of bottoms presenting forward a deadrise angle greater than approximately 25°, the floors are to have a horizontal upper edge and a height of at least  $0,2 \cdot D$  in the centreline.

**.7** In the case the takeoff and sailing speed of the hydrofoil are greater than those specified in C3A1.6.2.3, the scantlings of the forward floors are to be individually considered in each case.

#### **C3A1.6.6 Side structure**

**.1** This structure may be of the transverse type, i.e. consisting of ordinary webs, supported by stringers (or flats) and side transverses belonging to the primary transverse rings, or, for hydrofoils with length  $L$  greater than approximately 20 m, of the longitudinal type, i.e. consisting of longitudinals supported by side transverses belonging to these rings.

**.2** Continuity of the longitudinals is to be ensured, considering their contribution to the longitudinal strength of the hull.

**.3** Side transverses are to be fitted for the purpose of supporting the longitudinals, and side stringers (or flats), to be individually considered in each case, are to be fitted in way of and forward of the machinery space.

**.4** In way of foils, scantlings are to be individually considered in each case.

**.5** The section modulus of the side transverses forward of the bow foil is to be individually considered in each case: in any event, two side transverses are to be fitted in way of the floors located forward and aft of the hull penetrations of the bow foil bearing arm, for which in general:

$$h / S \geq 0,25$$

where  $h$  is the web height and  $S$  is the conventional span of the side transverse.

**.6** In way of the bow and after foils and in the case of side transverses supporting deck bracket-transverses, the provisions of C3A1.6.5.5 to C3A1.6.5.7 apply.

**.7** In the area forward of the bow foil, the side transverses are preferably to have an  $h/S$  ratio of at least 0,2. As regards the case of high hydrofoil speeds, the provisions of C3A1.6.5.5 to C3A1.6.5.7 are to be complied with.

#### **C3A1.6.7 Deck structure**

**.1** Strength deck stiffeners may be of the transverse type where constituted by beams supported by girders which are in turn supported by deck transverses belonging to the primary transverse rings, which may or may not be associated with pillars; such stiffeners are of the longitudinal type where they consist of longitudinals supported by the deck transverses.

The latter structure is recommended where  $L > 20$  m.

**.2** Stiffeners of decks below the strength deck and stiffeners of flats intended for passenger accommodation or forming the top of the machinery space are to have a section modulus not less than, in  $\text{cm}^3$ :

$$4 \cdot f_m \cdot K$$

**.3** Where the deck or flat forms the top of a tank for liquids, the provisions of C3.7 or C3.8 are to be complied with.

**.4** The scantlings of stiffeners fitted on account of special structural requirements, for example in way of foils, are to be individually considered in each case.

**.5** Deck transverses are to be fitted in way of side transverses, so as to constitute members of complete transverse rings.

**.6** They may instead be of the bracket type in the general case of hydrofoils for which  $L$  is less than approximately 15 m, and fitted with long deck openings; in such case, deck transverses, continuously from side to side, are to be fitted at least immediately aft and forward of the machinery space and forward of the bow foil. An intermediate flat, between bottom and deck, is to be fitted at least in the area aft of the machinery space.

**.7** The scantlings of deck transverses in way of foils and the scantlings of panting deck transverses fitted in the fore peak, at approximately mid-depth between bottom and deck, are to be individually considered in each case.

**.8** Owing to their span (roughly 0,3 to 0,5 m), deck transverses of the bracket type are generally composed of wide brackets connected to the web frame and the side stringer of the deck opening. The scantlings of such deck transverses are to be individually considered in each case.

**C3A1.6.8 Watertight bulkheads**

.1 For the hydrofoils considered in this Appendix, four watertight subdivision bulkheads are generally required to be fitted as follows:

- watertight collision bulkhead, located not less than  $0,05 \cdot L$  from the forward perpendicular and, in general, not more than  $0,08 \cdot L$  from the same perpendicular,
- fore and after watertight bulkhead of the machinery space,
- after watertight bulkhead, located, in general, about  $0,05 \cdot L$  from the aft perpendicular, but in no case more than  $0,08 \cdot L$  from the same perpendicular.

.2 In the case of hydrofoils intended for the carriage of passengers, the watertight subdivision bulkheads are also to satisfy the relevant requirements of Section 2.

**C3A1.7 Foils****C3A1.7.1 General**

.1 The type, shape and location of foils is to be determined by the designer based upon the general design provisions specified in C3A1.2, taking account of the fact that the essential function of foils is to support the hull, emerging at a sufficient height above the water surface so as to allow sailing even in waves, while ensuring the stability of the hydrofoil at the same time.

After determining these characteristics, the strength calculations for foils and relevant hull supporting connections are to be performed.

.2 In the case of hydrofoils with foil types other than those considered below, the Society reserves the right, after examining the calculations, to require special checks and tests, as specified in C3A1.2.

.3 The foil profile and shape are to comply with the provisions of the present article and, even when sailing in waves, to avoid cavitation phenomena dangerous for the stability of the hydrofoil.

.4 Calculation of the forces acting on the hydrofoil may be performed by considering the craft in sailing condition on foils in still water.

.5 The following acting forces are assumed:

- hydrofoil weight, at least in the two conditions of full load and without passengers,

- hydrodynamic resistance of the bow foil and after foil and associated lift,
- thrust of propellers.

.6 For the equilibrium, the algebraic sum of the acting forces and relevant moments with respect to the hydrofoil's centre of gravity is obviously to be equal to zero.

.7 In addition, the hydrofoil is to be considered during its turning manoeuvres. This means that water thrust on the rudder, whose action gives rise to variations in the hydrodynamic resistance and in the lift distribution on foils, as well as the forces generated by balancing flaps, are to be added to the forces above.

.8 Moreover, taking into account the most severe dynamic conditions expected for the hydrofoil in service, the above forces and, in addition, forces of inertia generated by rolling, pitching and heaving, including those during takeoff from the water and alighting on the water, are to be considered in the designer's calculations.

The characteristics of such motions, i.e. oscillation amplitude and period, and the consequent acceleration from which the forces of inertia originate, are to be considered individually by the Society in each case, based upon the experience already gained, if the hydrofoil under consideration is similar to previous ones which have given good results in service, or, otherwise, upon the results of exhaustive tank tests on models, as well as sea trials on the hydrofoil itself, before entry into service.

**C3A1.7.2 Foil strength calculations**

.1 In the case of V-type or W-type foils, each is usually connected, by quasi-vertical or vertical arms, to a horizontal member, fitted transversely with respect to the hull, and supported by special hull structures.

The foils and arms may therefore in such cases be considered, overall, as a system consisting of beams and joints supported by the hull structures.

.2 The forces acting on the foils consist of hydrodynamic resistance and lift, as well as the reactions of the structures mentioned above which balance such forces.

.3 Strength calculations are therefore to take account of the nature of the restraints from the hull on the reticular system and acting forces, in the loading conditions specified above, as well as of the mechanical properties of the materials employed, which are generally high-strength welding steels.

.4 In particular, diagrams of bending moments and axial and shear forces acting on the foils are to be plotted and the stresses deriving from them are to be calculated.

**C3A1.7.3    Foil construction**

**.1**            The foil joints are generally constituted of forged or cast steel, or are obtained from plate, while the beams are to be made of fabricated plating, and connections are to be welded.

**.2**            Since, due to the shape and dimensions of the foil profile, the foils themselves are not internally accessible, and therefore back-welding of all welded joints is not possible, the constructional plan is to specify special types of edge preparation, welding sequence and performance, to ensure the absence of defects and minimise internal stresses due to shrinkage at welds.

In particular, the number of slot-welded joints on plating is to be minimised.

**.3**            Materials are to be tested by the Society, and electrodes and welding processes are to be recognised as suitable in accordance with the Rules.

**.4**            Butt-joints are to be subjected to radiographic examination and, if inaccessible from one side, to magnetic particle or dye-penetrant examination.

**.5**            Depending on the quality of the material adopted and on welding processes, the Society reserves the right to require thermal stress-relieving in the furnace after welding.

## APPENDIX C3A2

SPECIAL REQUIREMENTS FOR SCANTLINGS OF  
AIR-CUSHION VEHICLE HULL STRUCTURES

## C3A2.1 Foreword

.1 The requirements of this Appendix apply to "flexible skirt hovercraft", i.e. air-cushion vehicles with a downwardly-extending flexible structure used to contain or divide the air cushion.

This type of air-cushion vehicle is amphibious.

.2 Unless otherwise specified, the symbols used here are those already defined in C3.1.

## C3A2.2 General

## C3A2.2.1 Definitions and symbols

## .1 Weight and masses

Light weight: the weight of the craft without cargo, fuel, lubricating oil and water in tanks, without consumable stores, passengers, crews or personal effects.

Light mass: the mass of the craft under the same conditions.

Maximum operational weight: the overall weight at which the craft is permitted to operate under normal conditions.

Maximum operational mass: the mass of the craft under the same conditions.

## .2 Dimensions

The main dimensions of an hovercraft are determined for the following situations:

- stationary,
- under maximum load,
- afloat.

L : length, in m, equal to the length of the rigid hull measured on the waterline at draught T, and not to be less than 95% of the air cushion longitudinal connection,

B : breadth, in m, equal to the broadest part of the rigid hull measured on the waterline at draught T. B is not to be less than 95% of the air cushion transverse connection,

T : draught, in m, (see C3.1),

D : depth, in m, (see C3.1).

The structure is divided into several substructures depending on the type of supported loads (overall forces, local forces, concentrated loads, etc.) and design methods.

## C3A2.2.2 Main structure

.1 The main structure comprises all structural members which contribute to overall strength, i.e. members which support the overall longitudinal and transverse bending forces as well as overall torsional forces resulting from asymmetrical loads (e.g. craft in flying or floating situation on diagonal wave).

.2 Besides its resistance to overall forces, this structure is to be capable of supporting certain local forces exerted by local loads, or loads distributed in areas of limited dimensions.

.3 It generally includes:

- platform above the air-cushion with its primary and secondary, transverse, longitudinal and diagonal stiffeners,
- watertight compartments giving buoyancy,
- decks, floors, bulkheads as well as side walls, superstructure and deckhouse shell plating rigidly connected to the platform and for buoyancy compartments.

## C3A2.2.3 Secondary structures

.1 The secondary structure completes the main structure by contributing to the safety and the protection of the craft against bad weather and wave impacts. They are designed to support only local stresses.

.2 These secondary structures comprise all members not rigidly connected to the main structure such as certain platforms, internal or external bulkheads and walls or access doors.

## C3A2.2.4 Additional structures

.1 Additional structures cover all arrangements attached to the main structure and taking a prominent part in the craft's operation and safety.

They generally create concentrated stresses in the main structure, and possibly, secondary structures.

**.2** These structures mainly comprise:

- skirt connections to the structure,
- seatings and foundations for propelling unit, ventilating plants and associated auxiliaries,
- supporting brackets for steering and trim control apparatus, which can be aerial or submerged,
- onshore or offshore anchoring and mooring as well as towing arrangements,
- landing and ground support arrangements for amphibious air-cushion vehicles,
- wheelhouse, if not integrated in the structure.

### **C3A2.3 Documents to be submitted**

#### **C3A2.3.1 Documents submitted for information**

**.1** The designer is to provide a general arrangement drawing showing the general structural layout, intended use of different spaces and tanks, and location of propelling, lifting and operating installations.

**.2** In addition to the information stipulated in C3.0, weight balances are to be provided for the following cases:

- light weight air-cushion vehicle,
- air-cushion vehicle at operating full load.

**.3** In addition, for air-cushion vehicles carrying cargo, weight balances are to be submitted for all intermediate loading cases considered by the designer and indicated in the operating manual.

**.4** Each loading case is to be indicated with the relevant position of the main masses.

#### **C3A2.3.2 Justification of scantlings**

**.1** Scantlings are to be justified by calculation notes indicating relevant loads, calculation methods and computation results.

**.2** When computer calculations are carried out, the software is to be indicated, and indications are to be communicated with regard to structure description, boundary conditions and the way loads are introduced. The results of these calculations are to be submitted to the Society.

**.3** Justification can be based on recognised experimental results: recorded for similar structures and corrected, if required, to allow for minor variations of certain parameters, the effects of which have been suitably evaluated. In that case, tested structures, test conditions, methods and results, as well as variations in the parameters and their effects on the structure in question, are to be clearly defined.

#### **C3A2.3.3 Drawings for approval**

**.1** In addition to the plans listed in Table C3.0.1, the following drawings are to be submitted to the Society for approval:

- bottoms and walls limiting air cushion,
- side shell and side walls,
- air-cushion lining and subdivision arrangements,
- seatings, foundations, supporting brackets and air pipes of lifting plant,
- skegs, rudders and control systems,
- landing, ground supporting and mooring arrangements, if any, including handling equipment,
- details of all types of assembling arrangements and scantlings of connections,
- hoisting and handling equipment, if any, used on board.

**.2** This is not an exhaustive list; other drawings may be required.

### **C3A2.4 Scantlings criteria**

#### **C3A2.4.1 General**

**.1** Each constituent part of the structure is to be designed to withstand a combination of loads which constitute the scantling criteria, without sustaining damage or distortions likely to affect the good working order of the air-cushion vehicle.

**.2** These criteria are determined on the basis of the craft's characteristics, its performances, and operational restrictions dictated by the intended type of service.

#### **C3A2.4.2 Types of stresses**

##### **.1 General stresses**

General stresses result from the overall forces applied to the structure in order to maintain the air-cushion vehicle in balance in a given situation.

These loads are, on the one hand, loads due to masses (forces of inertia) and, on the other hand, external loads created by environmental conditions, as defined in C3A2.4.3. General stresses induce distortions and overall stresses in the main structure.

##### **.2 Local stresses**

Local stresses are created by masses which are directly supported by internal forces and external loads applied locally. They modify the stress values resulting from general stresses for a specific component of the main structure. They are used as a basis for the scantlings of the components of secondary and additional structures.

**C3A2.4.3 Calculation of external loads****.1 Air-cushion vehicle flying on waves**

- (a) An air-cushion vehicle operating on rough seas, passing over a wave, is subjected to an overall force of impact, due to a combination of pressure variation and impact of green seas, whose basic value can be expressed by the formula:

$$F = C \cdot M \cdot g$$

where:

$M$  : mass of the air-cushion vehicle, in kg,

$g$  : acceleration of gravity, equal to 9,81 m/s<sup>2</sup>,

$$C = \frac{K_x \cdot K_j \cdot V_v \cdot V}{M^{1/3} \cdot (1 + r_G)^{2/3}}$$

with:

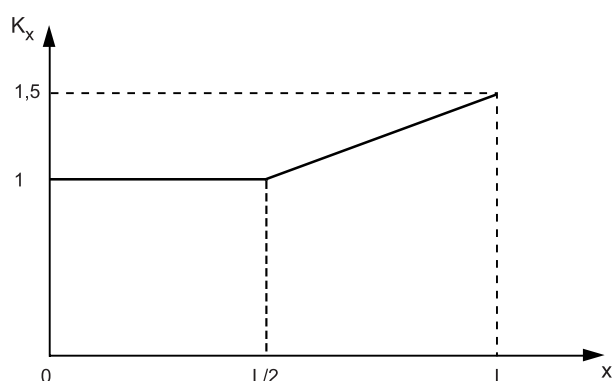
$K_x$  : coefficient depending on position  $x$  of spot of the impact and determined according to Figure C3A2.1,

$K_j$  : reduction factor depending on the type of cushion and defined in (b),

$V_v$  : vertical speed of impact, in m/s, as defined in (c),

$V$  : maximum speed of air-cushion vehicle, in m/s, for the wave height  $H$  considered. The relation between  $V$  and  $H$  is to be provided by the designer as a function of the vertical acceleration in the centre of gravity (see also C3.3.1 and C3.3.4),

$r_G$  : distance from spot of impact to centre of gravity, divided by the radius of gyration.

**Figure C3A2.1 Coefficient  $K_x$** 

- (b) In the absence of more accurate information,  $K_j$  is considered to be 0,7 for flexible skirt air-cushion vehicles. For side-wall craft,  $K_j$  can be determined only by model tests and is to be confirmed by prototype tests.

- (c) The speed  $V_v$  is given by the formula:

$$V_v = 0,6 + H \cdot \sqrt{\frac{\pi \cdot g}{2 \cdot A}}$$

where:

$H$  : wave height, in m,

$A$  : wave length, in m.

Values of  $A$  and  $H$  are defined in C3A2.4.3.2 below.

- (d) The rigid structure can be subjected to direct wave impact under the following circumstances:

- craft in flying situation under worst intended conditions,
- plough-in of cushion system,
- craft afloat, at rest or not.

The basic value of the maximum impact pressure, referred to as local pressure (governing scantlings of a secondary stiffener or shell on a frame space), in kN/m<sup>2</sup>, can be evaluated by the formula:

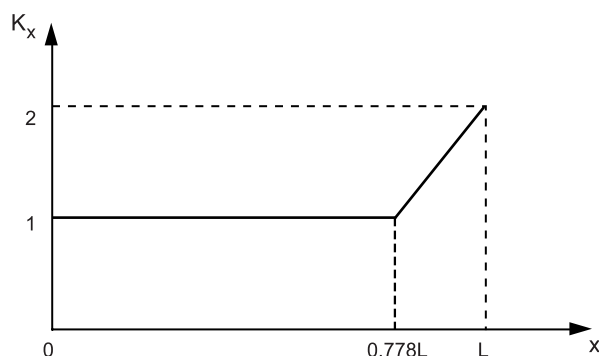
$$p_{loc} = 2,4 \cdot K'_x \cdot K_f \cdot V_v \cdot V$$

where:

$K'_x$  : coefficient depending on position  $x$  of spot of the impact and determined according to Figure C3A2.2,

$K_f$  : coefficient depending on the shape of bottoms, defined in (f),

$V_v$  and  $V$ : values defined in (a) above.

**Figure C3A2.2 Coefficient  $K'_x$** 

- (e) The average pressure, in N/m<sup>2</sup>, corresponding to the local pressure (distributed pressure determining scantlings of main stiffeners) is given by the formula:

$$p_{moy} = 1,06 \cdot K'_x \cdot K_f \cdot V_v \cdot V$$

- (f)  $K_f$  is determined by means of model tests and has to be confirmed by prototype tests. In the absence of the necessary data,  $K_f$  is considered to be equal to 1.

**.2 Air-cushion vehicles afloat**

- (a) The wave considered for scantling calculations of flexible skirt craft afloat is a sinusoidal wave of height  $H$  and length  $A$ , in metres, and confirming the following equations:

- for  $A \leq 41,50$  m:

$$H = A / 10$$

- for  $A > 41,50$  m:

$$H = 6,51 - 0,57 \cdot \left( \frac{300 - A^{3/2}}{100} \right)$$

- (b) The value H is defined by the designer on the basis of the limit operating conditions indicated in the Enclosure of the Class Certificate and on the midship section drawing (see C3.3.1 and C3.3.4).

The worst conditions are generally encountered when A is approximately equal to:

- L for head wave,
- B for beam wave.

### .3 Wind effects

- (a) Two cases are to be considered, depending on whether the craft is at rest or in operation.
- (b) When the craft is moored to the ground or afloat, each component of the entire structure has to be able to withstand the pressure and/or vacuum forces produced by a steady wind, blowing horizontally, depending on the worst direction for each component considered, at a speed of 70 knots.

More severe conditions may be required for air-cushion craft intended to operate in particularly exposed areas.

Less severe conditions can be accepted for small or medium-size craft which can easily be wind-screened.

- (c) During navigation under the worst intended conditions, it is to be checked that each constituent part of the air-cushion vehicle is capable of withstanding the pressure and vacuum forces produced by gusts increasing the true wind speed by at least 30% of its nominal value (mean value observed during 10 minutes).

This horizontal component is to obtain the most unfavourable direction for the particular constituent part.

These forces are, if applicable, to be considered together with the forces in C3A2.4.3.1 and C3A2.4.3.2 above.

- (d) If no other indications are available, the dynamic pressures, exerted by the wind on a vertical element, can be estimated by means of the following formulae, in kN/m<sup>2</sup>, depending on the altitude above sea level of the element and wind speed  $v_w$ , in knots:

- between 0 and 5 m above the sea level:

$$q_1 = 1,50 \cdot 10^{-3} \cdot v_w^2$$

- at 10 m or more:

$$q_2 = 0,16 \cdot 10^{-3} \cdot v_w^2$$

Between 5 m and 10 m, there is a linear variation of q between the two preceding values.

Note: These pressure variations depending on altitude take account of the degree of seawater saturation of the sea-air. Other corrections are to be made to these values to account for the type of forces (pressure or vacuum), the lines of the air-cushion vehicle, etc. These corrections are to be justified by the designer.

### .4 Other meteorological conditions

- (a) Besides the loads mentioned in C3A2.4.3.1 to C3A2.4.3.3, and according to the navigation area, loads resulting from the accumulation of snow and ice on certain parts such as roofs, side walls, steering and propelling installations, are to be accounted for, if applicable.
- (b) Generally, for air-cushion vehicles built in series, the most severe conditions are to be considered depending on various intended navigation areas.

### C3A2.4.4 Calculation of internal loads

#### .1 Loads on flooring (decks)

- (a) Normal static loads on various floorings are to be indicated in the builder's technical specifications.
- (b) Scantlings of floorings in compartments intended for carriage of passengers are calculated on the basis of 0,75 kN per passenger.

However, this value may be reduced to 0,60 kN if it can be justified.

- (c) For guidance, the following values can be adopted for flooring scantlings, depending on use:

- flooring of passenger compartment: even load of 2,50 kN/m<sup>2</sup> (or loads indicated in (b) with no more than 4 passengers per square metre),
- flooring of luggage compartments: density 150 kg/m<sup>3</sup> (load evenly distributed),
- flooring supporting miscellaneous cargoes: density 700 kg/m<sup>3</sup> (load evenly distributed),
- flooring supporting cars: 3,0 kN per wheel (load locally distributed on the surface on tyre tracks),
- flooring supporting commercial vehicles: 65,0 kN per wheel.

These preceding loads are nominal static loads.

- (d) When the air-cushion vehicle is afloat on waves, and a flooring is exposed to green seas, its strength is also to be checked with regard to hydrostatic pressure, according to the parameters defined in C3A2.4.3.2.

#### .2 Loads due to propelling and steering installations

- (a) These loads are applied to the structure through the connections of foundations, seatings, gantries, etc. supporting the propelling engine, the lifting installation, their auxiliaries as well as steering gear such as rudders and skegs.



- (b) For propelling and lifting plants, loads are calculated on the basis of the most critical situations to be expected (e.g. breakdowns, sudden changes in engine speed, reverse propeller pitch).
- (c) For steering arrangements, loads are either contractual loads (power rudders) or loads actually encountered. The latter can be deduced from calculations or tests. The basic contractual loads applied by the pilot on the controls are as follows:
- 0,46 kN on a control stick or control wheel ahead or reverse gear,
  - 0,28 kN on a control stick - laterally,
  - 0,185 kN on a control wheel - tangential action,
  - 0,60 kN on pedals or levers.
- (d) See also C3A2.7.8.

### .3 Loads due to tests

- (a) Tests are to be carried out to check the tightness of integrated buoyancy compartments, fuel tanks and various liquid tanks.
- Scantlings are to be such that no permanent distortion will remain after tests at the pressures indicated in (b) and (c) below (verification at yield stress).
- (b) Buoyancy compartments are generally tested with compressed air at a pressure of not more than 0,2 bar (pressure is controlled by means of a U-shape stand-pipe), after application of sealing material, if required.
- (c) Fuel tanks and liquid tanks are tested with water at a pressure equal to a stand-pipe of 2,40 m above the uppermost point of the compartment.
- Fuel and liquid tanks are also to be able, without breaking, to withstand the forces produced by the movement of liquids in case of collision as mentioned in C3A2.7.8.

## C3A2.5 Load factors

### C3A2.5.1 General

- .1 Load factors are increasing coefficients used to determine, on the basis of nominal static loads, the dynamic forces supported by the structure, referred to as basic loads.
- .2 These coefficients depend on actual movements of air-cushion vehicle, speed, acceleration, turning, etc. and on movements imposed on the craft due to external factors such as wave, wave impact or gusts of wind.
- .3 Load factors are estimated on the basis of various accelerations for which reference values are specified in C3A2.5.2 and C3A2.5.3 below.

### C3A2.5.2 Accelerations under normal service conditions

- .1 For the calculation of local forces, including those resulting from liquid loads, acceleration can be at least any of the values between the following limits:
- from 0,7 g upwards to 0,8 g downwards in addition with gravity,
  - from 0,5 g afterwards to 1,0 g forwards,
  - from 0,5 g on one side to 0,5 g on the other side.
- .2 The preceding values apply to air-cushion vehicles for "open sea" or "restricted open sea" service.
- .3 Reductions may be allowed for craft for "moderate environment" or "smooth sea" service (see C3.3.1).

### C3A2.5.3 Accelerations in the event of collision

- .1 The relevant authorities require certain installations and connections to be capable of withstanding the forces resulting from such more severe accelerations than the preceding in C3A2.5.2.
- .2 The values to be taken into account are:
- from 3 g upwards to 4 g downwards,
  - from 0 g to 6 g forwards,
  - from 0 g to 3 g afterwards,
  - from 0 g to 3 g sideways.

### C3A2.5.4 Application procedure

- .1 For certain calculations, a combination of accelerations in several directions needs to be considered, but the final acceleration value is not to exceed:
- 1 g for horizontal accelerations in normal service,
  - 6 g for accelerations in the event of collision.
- .2 The directions mentioned in C3A2.5.2, C3A2.5.3 and C3A2.5.4 refer to inertia forces which tend to displace each mass in relation to the entire air-cushion vehicle.
- .3 The vertical and transverse accelerations indicated in C3A2.5.2 can, if necessary, be modified in agreement with the Society, at the designer's request, provided that a complete file is submitted with sufficient experimental justifications.
- These values can also vary depending for which part the scantlings are to be calculated and its location in relation to the craft's centre of gravity.
- .4 In certain specific cases, the load factor can be considered as equal to 1, for example when the forces applied are constant or vary slowly (jacking operations, traversing operations at low speed, etc.).

**.5** The basic loads due to dynamic forces are loads which easily occur in service under the worst intended conditions.

They are deducted from nominal static loads by means of the appropriate load factors.

### **C3A2.6 Strength limits and safety coefficients**

#### **C3A2.6.1 General**

##### **.1 Strength limits**

- (a) Strength limits are increasing factors applied to basic loads, to account for exceptional overloads incurred by the structure under critical foreseen conditions.
- (b) Strength limits also help to provide for part of the doubt inherent in calculation theories or methods.
- (c) Basic loads multiplied by strength limits give the maximum loads that the structure has to withstand without incurring permanent distortions.

##### **.2 Safety coefficients**

- (a) Safety coefficients take into account:
  - uncertainties inherent in certain assumptions,
  - more or less accurate calculation methods,
  - flaws and allowances accepted for materials and assembling procedures,
  - residual manufacturing stresses,
  - variations, in time, in the characteristics of certain materials,
  - strength reductions due to corrosion or scoring caused by the surrounding environment.
- (b) Maximum loads multiplied by relevant safety coefficients define the most extreme loads that the structure is to be capable of withstanding without breaking or collapsing, while incurring possible permanent distortions.

#### **C3A2.6.2 Summary table**

**.1** Table C3A2.1 summarises the methods for load calculations.

**Table C3A2.1 - Load calculation methods**

1 - Nominal static load x Load factor	= basic load
2 - Basic load x Strength limit	= maximum load
3 - Maximum load x Safety coefficient	= extreme load

**.2** The basic load corresponds to the worst intended conditions. The maximum load corresponds to the critical design conditions.

#### **C3A2.6.3 Numerical values**

**.1** Values of strength limits and safety coefficients are determined by the designer in agreement with the Society.

**.2** Strength limits may vary depending on the importance of the part for which scantlings are to be calculated, and the type of loads applied.

In general, strength limits may not exceed 1,5.

**.3** In general, the safety coefficients are considered as equal to 1,5.

However, the accelerations indicated in C3A2.5.3, in the event of collisions, are the most extreme values, so that the resulting loads are also extreme loads (safety coefficient equal to 1).

Higher values may, nevertheless, be required (recommended value: 2) for parts subject to extremely concentrated forces such as hoisting, trucking, towing and anchoring points.

### **C3A2.7 Cases of scantlings**

#### **C3A2.7.1 General**

**.1** Loads to be applied to the structure are determined by considering the air-cushion vehicle in the situations outlined in C3A2.7.1.2 and C3A2.7.1.3.

**.2** Situations corresponding to normal service under specific limit conditions determine general structure scantlings.

**.3** Exceptional situations are taken into account only to determine scantlings of parts which are directly involved, and their connections to the structures.

**.4** Depending on the scantling case, the resulting loads are either basic loads or maximum loads (extreme loads in collision situations).

#### **C3A2.7.2 Flying situation**

**.1** The different flying situations are:

- on still water,
- on head waves,
- on abeam waves,
- on diagonal waves.

**.2** The transient stages, involving a changeover from one of the preceding elementary situations to another, are also to be considered.

The flying situation on still water is, in particular, to make it possible to determine the forces generated by operations under the most severe conditions, as a result of:

- speed,
- accelerations or decelerations,
- lifting height,
- turning and yawing characteristics,
- trim and heeling variations.

**.3** The envelope of maximum forces is obtained by considering all loading cases defined on the operating manual, as well as maximum speeds authorised, depending on various wave heights up to the maximum design height.

**.4** The different cases above determine:

- general forces of overall longitudinal and transverse bending, as well as overall tension and corresponding shear forces,
- local forces produced by wave impacts, gusts of wind, propelling machinery, skirt connections, etc.

#### **C3A2.7.3 Floating situation**

**.1** The different floating situations to be considered are:

- on still water,
- on head waves,
- on abeam waves,
- on diagonal waves (line of wave crests almost parallel to one of the craft's diagonals).

**.2** All loading cases defined in the operating manual are to be considered, as for flying situations.

**.3** The speed to be considered is either the maximum self-propelling speed, if this possibility exists, or else the maximum towing speed.

**.4** The above cases determine both general and corresponding local forces.

#### **C3A2.7.4 Landing**

**.1** This refers to amphibious air-cushion vehicles normally parking on land.

**.2** The worst landing case is defined by the following parameters:

- maximum lifting height,
- highest possible descending speed,
- worst mass, trim, heeling and horizontal speed conditions (e.g. asymmetrical landing supports, gusts of wind).

**.3** This case determines local forces applied to landing-gear connecting points.

It can also determine certain general forces, in particular for torsion resulting from asymmetrical landing supports.

#### **C3A2.7.5 Hoisting**

**.1** This case affects the scantlings of hoisting points and their connections to the structure (distribution of concentrated forces).

**.2** It also to be checked that this case does not generate general bending or torsional forces (asymmetrical hoisting) leading to stresses that exceed allowable values.

**.3** The maximum authorized mass for hoisting is to be determined by the designer and indicated in the maintenance manual.

#### **C3A2.7.6 Trucking**

**.1** This case determines the scantlings of the trucking contact pieces and their attachments to the structure (local forces).

**.2** The verification required in C3A2.7.5 is also to be carried out.

**.3** The maximum authorized mass for trucking is to be determined by the designer and indicated in the maintenance manual.

#### **C3A2.7.7 Anchoring - Mooring - Towage**

**.1** These situations determine the concentrated forces applied to points of ground or quay anchoring and mooring, together with towage.

**.2** They can also affect the scantlings of some parts of the structure subjected to aerodynamic forces, and loads, if any, due to accumulated snow and/or ice (see C3A2.4.3.3 and C3A2.4.3.4).

**.3** The maximum authorized forces to be applied at the preceding points are equal to the respective breaking loads of anchor, mooring and towing cable lines.

#### **C3A2.7.8 Collisions**

**.1** It is to be checked that certain parts of the structure, equipment and components are capable of withstanding the exceptional dynamic forces resulting from a collision.

**.2** These verifications comprise, without being confined, to:

- scantlings of engine foundations, seatings and gantries of propelling installation,
- structure at connecting points of these parts,

- cargo and luggage lashing points,
- vehicle wedging and securing points,
- securing arrangements of passenger seats,
- fuel and lube oil tanks, integrated or not (motions of liquids).

**.3** The forces are deduced from the accelerations mentioned in C3A2.5.3. They correspond to extreme loads.

### C3A2.8 Allowable stresses

#### C3A2.8.1 General

**.1** The maximum allowable stresses for a specific material or construction are deduced from the minimum corresponding mechanical properties, determined through tests.

**.2** The strength of the various parts of the structure and associated connections is checked by means of static strength calculations, according to yield stress, tensile strength or buckling, whichever is the most severe.

**.3** Computer calculations are to satisfy the indications in C3A2.3.2.

**.4** The various stresses in a structural part are calculated on the basis of the different cases of scantlings defined in C3A2.7.

Suitable combinations are to be operated at each point. In particular, stresses due to both general and local forces are to be considered.

**.5** Resulting stress values are to be corrected to account for:

- stress concentration around cutouts and discontinuities in plates and stiffeners,
- local deterioration of mechanical properties around connections (e.g. welded or glued joints).

#### C3A2.8.2 Verifications based on extreme loads

##### **.1 Breaking**

- Application of extreme loads to the structure allows maximum elementary stresses at each point of a structural part or a construction to be calculated.
- If the total stress resulting from the appropriate combination of elementary stresses at any point is a pulling force, it may not, under any circumstances, exceed the minimum breaking load at this point.

##### **.2 Bucking**

- If the total stress resulting from the appropriate combination of elementary stresses at any point is a compressive force, it may not, under any circumstances, exceed the collapse limit (general buckling) at this point.
- The collapse limit is to be determined, if required, on the basis of reduced elasticity modulus values of materials (corrected accordingly to the corresponding Poisson's ratio).  
The moments of inertia are, themselves, to be reduced, to take into account only the "equivalent width" of plates (width capable of bearing the general buckling rate without local buckling).

#### C3A2.8.3 Verification based on maximum loads

**.1** Application of maximum loads to the structure allows corresponding elementary stresses at each point of a structural part or a construction to be calculated.

**.2** The total stress resulting from the appropriate combination of elementary stresses at any point may not be more than the least of the following values:

- minimum conventional yield stress of the material or construction,
- minimum breaking load of the material or construction divided by 1,5.

#### C3A2.8.4 Verification based on basic loads

**.1** No systematic verification is made for basic loads.

**.2** However, since these loads are supported by the structure in normal service, they can be used to check the fatigue strength of certain components or constructions.

### C3A2.9 Distortions

#### C3A2.9.1 Distortions under maximum loads

**.1** No permanent distortions are to remain after application of maximum loads.

**.2** Each structural component is to be so designed that the distortions sustained can in no way affect the good working order of the other components of the air-cushion vehicle.

#### C3A2.9.2 Distortions under extreme loads

**.1** Permanent distortions under extreme loads may be accepted, provided that neither the craft's safety nor proper operation of its main components is affected.

**SECTION 4****ACCOMMODATION AND ESCAPE MEASURES****C4.0 Documents to be submitted**

The following plans and documents are to be submitted at least in triplicate, for approval. The Society reserves its right to ask for supplementary copies, if deemed necessary in particular cases.

- .1 Windows, arrangements and details.
- .2 Plan showing the arrangement of means of communication.
- .3 Calculation of the collision load and relevant arrangement of the accommodation spaces (containing the indication of seat characteristics, arrangement and installation, the characteristics of the safety belts).
- .4 Plans showing the means of escape and the means of access to the various craft spaces.
- .5 Evacuation procedure and evacuation time calculation.

Further documentation may be required if deemed necessary by the Society.

**4.1 General**

**4.1.1** *Public spaces and crew accommodation shall be designed and arranged so as to protect the occupants from unfavourable environmental conditions and to minimize the risk of injury to occupants during normal and emergency conditions.*

**4.1.2** *Spaces accessible to passengers shall not contain controls, electrical equipment, high-temperature parts and pipelines, rotating assemblies or other items, from which injury to passengers could result, unless such items are adequately shielded, isolated, or otherwise protected.*

**4.1.3** *Public spaces shall not contain operating controls unless the operating controls are so protected and located that their operation by a crew member shall not be impeded by passengers during normal and emergency conditions.*

**4.1.4** *Windows in passenger and crew accommodation shall be of adequate strength and suitable for the worst intended conditions specified in the Permit to Operate and be made of material which will not break into dangerous fragments if fractured.*

**4.1.5** *The public spaces, crew accommodation and the equipment therein shall be designed so that each person making proper use of these facilities will not suffer injury during craft's normal and emergency start, stop and manoeuvring in normal cruise and in failure or maloperation conditions.*

**4.2 Public address and information system**

**4.2.1** *A general emergency alarm system shall be provided. The alarm shall be audible throughout all the public spaces, corridors and stairways, crew accommodation and normal crew working spaces and open decks, and the sound pressure level shall be at least 10 dB(A) above ambient noise levels under way in normal cruise operation. The alarm shall continue to function after it has been triggered until it is normally turned off or is temporarily interrupted by a message on the public address-system.*

**4.2.2** *There shall be a public address system covering all areas where passengers and crew have access, escape routes, and places of embarkation into survival craft. The system shall be such that flooding or fire in any compartment does not render other parts of the system inoperable. The public address system and its performance standards shall be approved by the Administration having regard to the recommendations developed by the Organization.*

*Note: Refer to the Recommendations on performance standards for public address systems on passenger ships, including cabling (MSC/Circ. 808) and the Code on Alarms and Indicators, 1995 (resolution A.830(19)).*

**4.2.3** *All passenger craft shall be equipped with illuminated or luminous notices or video information system(s) visible to all sitting passengers, in order to notify them of safety measures.*

**4.2.4** *The master shall, by means of the public address system and the visual information system, be able to request passengers "please be seated" when found to be appropriate to safeguard passengers and always when the safety level 1 according to table 1 of annex 3 is exceeded.*

### 4.3 Design acceleration levels

**4.3.1** For passenger craft, superimposed vertical accelerations above 1.0 g at longitudinal centre of gravity shall be avoided unless special precautions are taken with respect to passenger safety.

**4.3.2** Passenger craft shall be designed for the collision design acceleration  $g_{coll}$  with respect to the safety in, and escape from, the public spaces, crew accommodation and escape routes, including in way of life-saving appliances and emergency source of power. The size and type of craft together with speed, displacement and building material shall be taken into consideration when the collision load is determined. The collision design condition shall be based on head-on impact at a defined collision speed.

**4.3.3** Mounting of large masses such as main engines, auxiliary engines, lift fans, transmissions and electrical equipment shall be proved by calculation to withstand, without fracturing, the design acceleration given in table 4.3.3.

**4.3.4** Collision design acceleration  $g_{coll}$  (for craft other than amphibious ACVs where  $g_{coll} = 6$ ) shall be calculated as follows:

$g_{coll} = 1.2 P / (g \cdot \Delta)$ , but not to be taken greater than 12,

where the load  $P$  shall be taken as the lesser of  $P_1$  and  $P_2$ , where:

$$P_1 = 460 (M \cdot C_L)^{2/3} (E \cdot C_H)^{1/3}$$

$$P_2 = 9000 \cdot M \cdot C_L (C_H \cdot D)^{1/2}$$

where the hull material factor  $M$  shall be taken as:

$M = 1.3$  for high tensile steel

$M = 1.0$  for aluminium alloy

$M = 0.95$  for mild steel

$M = 0.8$  for fibre-reinforced plastics,

where the length factor  $C_L$  of the craft is:

$$C_L = \frac{(165 + L)}{245} \left( \frac{L}{80} \right)^{0.4}$$

where the height factor  $C_H = (80 - L) / 45$  but not greater than 0.75 or less than 0.3,

where the kinetic energy of the craft at speed  $V_{imp}$  is:

$$E = 0.5 \Delta \cdot V_{imp}^2$$

where the main particulars of the craft are:

$L$  : craft length as defined in Section 1 (m)

$D$  : depth of the craft from the underside of keel to the top of the effective hull girder (m)

$\Delta$  : craft displacement, being the mean of the light-weight and maximum operational weight (t)

$V_{imp}$  : estimated impact speed (m/s) = two-thirds of operational speed as defined in Section 1

$g$  : acceleration due to gravity = 9.806 m/s<sup>2</sup>.

For hydrofoils, the collision design acceleration,  $g_{coll}$  shall be taken as the greater of either the  $g_{coll}$  as calculated above or:

$$g_{coll} = F / (g \cdot \Delta)$$

where:

$F$  : failure load of bow foil assembly applied at the operational waterline (kN).

**C4.3.4** For sandwich structures, the hull material factor  $M$  is taken equal to 0.8.

**4.3.5** As an alternative to the requirements of 4.3.4, the collision design acceleration  $g_{coll}$  may be determined by carrying out a collision load analysis of the craft on a vertical rock having a maximum height of 2 m above the waterline and using the same assumption for displacement  $\Delta$  and impact speed  $V_{imp}$  as described in 4.3.4. This evaluation may be carried out as part of the safety analysis. If the collision design accelerations are determined by both 4.3.4 and the collision load analysis, the lower resulting value may be used as the collision design acceleration.

**4.3.6** Compliance with the provisions of 4.1.5 and 4.3.1 shall be shown for the actual type of craft, as described in annex 9.

**4.3.7** Limiting sea states for operation of the craft shall be given in normal operation condition and in the worst intended conditions, at operational speed and at reduced speed as necessary.

**Table 4.3.3 - Design acceleration as multiples of g**

Types of craft Direction	All HSC except amphibious ACVs	Amphibious ACVs
Forward direction	$g_{coll}$	6
After direction	2 or $g_{coll}$ if less	3
Transverse direction	2 or $g_{coll}$ if less	3
Vertical direction	2 or $g_{coll}$ if less	3
Note:		
$g_{coll}$ : collision design acceleration expressed as a multiple of the acceleration due to gravity (9.806 m/s <sup>2</sup> )		

#### 4.4 Accommodation design

**4.4.1** The public spaces, control stations and crew accommodation of high-speed craft shall be located and designed to protect passengers and crew in the design collision condition. In this respect, these spaces shall not be located forward of a transverse plane (see figure 4.4.1) such that:

$A_{\text{bow}} = 0.0035 A \cdot m \cdot f \cdot V$ , but never less than 0.04 A, where:

$A_{\text{bow}}$  : the plan projected area of craft energy absorbing structure forward of the transverse plane ( $\text{m}^2$ )

A : total plan projected area of craft ( $\text{m}^2$ )

m : material factor = 0.95/M

M : appropriate hull material factor as given in 4.3.4 Where materials are mixed, the material factor shall be taken as a weighted mean, weighted according to the mass of material in the area defined by  $A_{\text{bow}}$ .

f : framing factor as follows:

- longitudinal deck and shell stiffening = 0.8
- mixed longitudinal and transverse = 0.9
- transverse deck and shell stiffening = 1.0

V : operational speed (m/s).

**4.4.2** The public spaces and crew accommodation shall be designed based on the guidelines given in table 4.4.2 or by other methods which have been proven to give equal protective qualities.

**4.4.3** Equipment and baggage in public spaces and in the operator's compartment shall be positioned and secured so that they remain in the stowed position when exposed to the collision design acceleration according to 4.3.4, 4.3.5 and table 4.3.3.

**4.4.4** Seats, life-saving appliances and items of substantial mass and their supporting structure shall not deform or dislodge under any loads up to those specified in 4.3.4, 4.3.5 and table 4.3.3 in any manner that would impede subsequent rapid evacuation of passengers.

**4.4.5** There shall be adequate handholds on both sides of any passage to enable passengers to steady themselves while moving about.

**Table 4.4.2 - Overview general design guidelines (see note)**

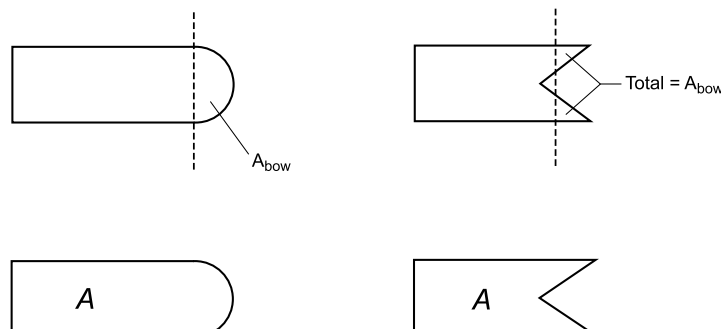
Design level 1: $g_{\text{coll}}$ less than 3	
1	Seat/seat belts
1.1	Low or high seatback
1.2	No restrictions on seating direction
1.3	Sofas allowed
1.4	No seat belts requirement
2	Tables in general allowed
3	Padding of projecting objects
4	Kiosks, bars, etc., no special restrictions
5	Baggage, no special requirements
6	Large masses, restraint and positioning

Design level 2: $g_{\text{coll}}$ = 3 to 12	
1	Seat/seat belts
1.1	High seatback with protective deformation and padding
1.2	Forward or backward seating direction
1.3	No sofas allowed as seat
1.4	Lap belt in seats when no protective structure forward
2	Tables with protective features allowed. Dynamic testing
3	Padding of projecting objects
4	Kiosks, bars, etc., on aft side of bulkheads, or other specially approved arrangements
5	Baggage placed with protection forward
6	Large masses, restraint and positioning

Note: Other arrangements may be employed if an equivalent level of safety is achieved.

**Figure 4.4.1 Plan view of two different craft styles**



## 4.5 Seating construction

**4.5.1** A seat shall be provided for each passenger and crew member for which the craft is certified to carry. Such seats shall be arranged in enclosed spaces.

**4.5.2** Seats fitted in addition to those required under 4.5.1 and which are not permitted to be used in hazardous navigational situations or potentially dangerous weather or sea conditions need not comply with 4.5 or 4.6. Such seats shall be secured according to 4.4.4 and clearly identified as not being able to be used in hazardous situations.

**4.5.3** The installation of seats shall be such as to allow adequate access to any part of the accommodation space. In particular, they shall not obstruct access to, or use of, any essential emergency equipment or means of escape.

**4.5.4** Seats and their attachments, and the structure in the proximity of the seats, shall be of a form and design, and so arranged, such as to minimize the possibility of injury and to avoid trapping of the passengers after the assumed damage in the collision design condition according to 4.4.1. Dangerous projections and hard edges shall be eliminated or padded.

**4.5.5** Seats, seat belts, seat arrangements and adjacent parts such as tables shall be designed for the actual collision design acceleration as specified in 4.3.4.

**4.5.6** All seats, their supports and their deck attachments shall have good energy-absorbing characteristics and shall meet the requirements of annex 10.

## 4.6 Safety belts

**4.6.1** One-hand-release safety belts of three-point type or with shoulder harness shall be provided for all seats from which the craft may be operated for all craft with the  $g_{coll}$  acceleration from the collision design acceleration exceeding 3g, as prescribed in 4.3.4.

**4.6.2** Safety belts shall be provided on passenger seats and crew seats, if necessary, to obtain the protective performance measures described in annex 10.

## 4.7 Exits and means of escape

**4.7.1** In order to ensure immediate assistance from the crew in an emergency situation, the crew accommodation, including any cabins, shall be located with due regard to easy, safe and quick access to the public spaces from

inside the craft. For the same reason, easy, safe and quick access from the operating compartment to the public spaces shall be provided.

**4.7.2** The design of the craft shall be such that all occupants may safely evacuate the craft into survival craft under all emergency conditions, by day or by night. The positions of all exits which may be used in an emergency, and of all life-saving appliances, the practicability of the evacuation procedure, and the evacuation time to evacuate all passengers and crew shall be demonstrated.

**4.7.3** Public spaces, evacuation routes, exits, life-jacket stowage, survival craft stowage, and the embarkation stations shall be clearly and permanently marked and illuminated as required in Section 12.

**4.7.4** Each enclosed public space and similar permanently enclosed space allocated to passengers or crew shall be provided with at least two exits as widely separated as practical. All exits shall clearly indicate the directions to the evacuation station and safe areas. On category A craft and cargo craft, at least one exit shall give access to the evacuation station serving the persons in the enclosed space considered, and all other exits shall give access to a position on the open deck from which access to an evacuation station is provided. On category B craft, exits shall provide access to the alternative safe area required by 7.11.1; external routes may be accepted providing that the requirements of 4.7.3 and 4.7.11 are complied with.

**4.7.5** Subdivision of public spaces to provide refuge in case of fire may be required in compliance with 7.4.4.1 and 7.11.1.

**4.7.6** Exit doors shall be capable of being readily operated from inside and outside the craft in daylight and in darkness. The means of operation shall be obvious, rapid and of adequate strength. Doors along escape routes should, wherever appropriate, open in the direction of escape flow from the space served.

**4.7.7** The closing, latching and locking arrangements for exits shall be such that it is readily apparent to the appropriate crew member when the doors are closed and in a safe operational condition, either in direct view or by an indicator. The design of external doors shall be such as to minimize the possibility of jamming by ice or debris.

**4.7.8** The craft shall have a sufficient number of exits which are suitable to facilitate the quick and unimpeded escape of persons wearing approved lifejackets in emergency conditions, such as collision damage or fire.

**4.7.9** Sufficient space for a crew member shall be provided adjacent to exits for ensuring the rapid evacuation of passengers.



**4.7.10** All exits, together with their means of opening, shall be adequately marked for the guidance of passengers. Adequate marking shall also be provided for the guidance of rescue personnel outside the craft.

**4.7.11** Footholds, ladders, etc., provided to give access from the inside to exits shall be of rigid construction and permanently fixed in position. Permanent handholds shall be provided whenever necessary to assist persons using exits, and shall be suitable for conditions when the craft has developed any possible angles of list or trim.

**4.7.12** At least two unobstructed evacuation paths shall be available for the use of each person. Evacuation paths shall be disposed such that adequate evacuation facilities will be available in the event of any likely damage or emergency conditions, and evacuation paths shall have adequate lighting supplied from the main and emergency sources of power.

**4.7.13** The width of corridors, doorways and stairways which form part of the evacuation paths shall be not less than 900 mm for passenger craft and 700 mm for cargo craft. This width may be reduced to 600 mm for corridors, doorways and stairways serving spaces where persons are not normally employed. There shall be no protrusions in evacuation paths which could cause injury, ensnare clothing, damage lifejackets or restrict evacuation of disabled persons.

**4.7.14** Adequate notices shall be provided to direct passengers to exits.

**4.7.15** Provision shall be made on board for embarkation stations to be properly equipped for evacuation of passengers into life-saving appliances. Such provision shall include handholds, anti-skid treatment of the embarkation deck, and adequate space which is clear of cleats, bollards and similar fittings.

**4.7.16** Main propulsion machinery spaces and ro-ro spaces shall be provided with two means of escape leading to a position outside the spaces from which a safe route to the evacuation stations is available. One means of escape from the main propulsion machinery spaces shall avoid direct access to any ro-ro space. Main propulsion machinery spaces having a length of less than 5 m and not being routinely entered or continuously manned, may be provided with a single means of escape.

## 4.8 Evacuation time

**4.8.1** The provisions for evacuation shall be designed such that the craft can be evacuated under controlled conditions in a time of one third of the structural fire

protection time (SFP) provided in 7.4.2 for areas of major fire hazard areas after subtracting a period of 7 min for initial detection and extinguishing action.

Evacuation time = (SFP – 7) / 3 (min)

where:

SFP : structural fire protection time (min).

**4.8.2** An evacuation procedure, including an evacuation analysis carried out taking into account the guidelines developed by the Organization shall be developed for the information of the Administration in connection with the approval of fire insulation plans and for assisting the owners and builders in planning the evacuation demonstration required in 4.8.3 (see note). The evacuation procedures shall include:

- .1 the emergency announcement made by the master;
- .2 contact with base port;
- .3 the donning of lifejackets;
- .4 manning of survival craft and emergency stations;
- .5 the shutting down of machinery and oil fuel supply lines;
- .6 the order to evacuate;
- .7 the deployment of survival craft and marine escape systems and rescue boats;
- .8 the bowing in of survival craft;
- .9 the supervision of passengers;
- .10 the orderly evacuation of passengers under supervision;
- .11 crew checking that all passengers have left the craft;
- .12 the evacuation of crew;
- .13 releasing the survival craft from the craft; and
- .14 the marshalling of survival craft by the rescue boat, where provided.

Note: Refer to the Guidelines to be developed by the Organization.

**4.8.3** Achievement of the required evacuation time (as ascertained in accordance with 4.8.1) shall be verified by a practical demonstration conducted under controlled conditions in the presence of the Administration, and shall be fully documented and verified for passenger craft by the Administration.

**4.8.4** Evacuation demonstrations shall be carried out with due concern for the problems of mass movement or panic acceleration likely to arise in an emergency situation when rapid evacuation is necessary. The evacuation demonstrations shall be dry shod with the survival craft initially in their stowed positions and be conducted as follows:

**.1** The evacuation time on a category A craft shall be the time elapsed from the moment the first abandon craft announcement is given, with any passengers distributed in a normal voyage configuration, until the last person has embarked in a survival craft, and shall include the time for passengers and crew to don lifejackets.

**.2** The evacuation time on a category B craft and cargo craft shall be the time elapsed from the moment the order to abandon the craft is given until the last person has embarked in a survival craft. Passengers and crew may be wearing lifejackets and prepared for evacuation, and they may be distributed among assembly stations.

**.3** For all craft the evacuation time shall include the time necessary to launch, inflate and secure the survival craft alongside ready for embarkation.

**4.8.5** The evacuation time shall be verified by an evacuation demonstration which shall be performed using the survival craft and exits on one side, for which the evacuation analysis indicates the greatest evacuation time, with the passengers and crew allocated to them.

**4.8.6** On craft where a half trial is impracticable, the Administration may consider a partial evacuation trial using a route which the evacuation analysis shows to be the most critical.

**4.8.7** The demonstration shall be carried out in controlled conditions in the following manner in compliance with the evacuation plan.

**.1** The demonstration shall commence with the craft afloat in harbour, in reasonably calm conditions, with all machinery and equipment operating in the normal seagoing condition.

**.2** All exits and doors inside the craft shall be in the same position as they are under normal seagoing condition.

**.3** Safety belts, if required, shall be fastened.

**.4** The evacuation routes for all passengers and crew shall be such that no person need enter the water during the evacuation.

**4.8.8** For passenger craft, a representative composition of persons with normal health, height and weight shall be used in the demonstration, and shall consist of different sexes and ages so far as it is practicable and reasonable.

**4.8.9** The persons, other than the crew selected for the demonstration, shall not have been specially drilled for such a demonstration.

**4.8.10** An emergency evacuation demonstration shall be carried out for all new designs of high-speed craft and for other craft where evacuation arrangements differ substantially from those previously tested.

**4.8.11** The specific evacuation procedure followed during the craft's initial demonstration on which certification is based shall be included in the craft operating manual together with the other evacuation procedures contained in 4.8.2. During the demonstration, video recordings shall be made, both inside and outside the craft, which shall form an integral part of the training manual required by 18.2.

## **4.9 Baggage, stores, shops and cargo compartments**

**4.9.1** Provision shall be made to prevent shifting of baggage, stores and cargo compartment contents, having due regard to occupied compartments and accelerations likely to arise. If safeguarding by positioning is not practicable, adequate means of restraint for baggage, stores and cargo shall be provided. Shelves and overhead shelves for storage of carry-on baggage in public spaces shall be provided with adequate means to prevent the luggage from falling out in any conditions that may occur.

**4.9.2** Controls, electric equipment, high-temperature parts, pipelines or other items, the damage or failure of which could affect the safe operation of the craft or which may require access by crew members during a voyage, shall not be located in baggage, store and cargo compartments unless such items are adequately protected so that they cannot be damaged or, where applicable, operated inadvertently by loading, by unloading or by movement of the contents of the compartment.

**4.9.3** Loading limits, if necessary, shall be durably marked in those compartments.

**4.9.4** Having regard to the purpose of the craft, the closures of the exterior openings of the luggage and cargo compartments as well as special-category spaces shall be appropriately weathertight.

**4.10 Noise levels**

**4.10.1** *The noise level in public spaces and crew accommodation shall be kept as low as possible to enable the public address system to be heard, and shall not in general exceed 75 dB(A).*

**4.10.2** *The maximum noise level in the operating compartment shall not in general exceed 65 dB(A) to facilitate communication within the compartment and external radiocommunications.*

**4.11 Protection of the crew and passengers**

**4.11.1** *Efficient guard rails or bulwarks shall be fitted on all exposed parts of decks to which crew or passengers have access. Alternative arrangements such as safety harnesses and jack-stays may be accepted if they provide an equivalent level of safety. The height of the bulwarks or guard rails shall be at least 1 m from the deck, provided that*

*where this height would interfere with the normal operation of the craft, a lesser height may be approved.*

**4.11.2** *The opening below the lowest course of the guard rails shall not exceed 230 mm. The other courses shall be not more than 380 mm apart. In the case of craft with rounded gunwales the guard rail supports shall be placed on the flat of the deck.*

**4.11.3** *Satisfactory means (in the form of guard rails, life lines, gangways or underdeck passages, etc.) shall be provided for the protection of the crew in getting to and from their quarters, the machinery space and all other parts used in the necessary work of the craft.*

**4.11.4** *Deck cargo carried on any craft shall be so stowed that any opening which is in way of the cargo and which gives access to and from the crew's quarters, the machinery space and all other parts used in the necessary work of the craft, can be properly closed and secured against the admission of water. Effective protection for the crew in the form of guard rails or life lines shall be provided above the deck cargo if there is no convenient passage on or below the deck of the craft.*

**SECTION 5****DIRECTIONAL CONTROL SYSTEMS****C5.0 Documents to be submitted**

**C5.0.1** The following drawings and documents are to be submitted in triplicate for approval. The Society reserves the right to ask for supplementary copies if deemed necessary in particular cases.

**.1** Assembly and general drawings of all directional control systems;

**.2** Diagrams of hydraulic and electric equipment;

**.3** Detail drawings of all load-transmitting components.

**C5.0.2** The drawings and other documents must contain all data necessary for verifying scantlings and power calculations as well as material specifications.

**C5.0.3** Further documentation may be required if deemed necessary by the Society.

**5.1 General**

**5.1.1** *Craft shall 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 certificated. The performance shall be verified in accordance with annex 9.*

**5.1.2** *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.*

**C5.1.2** *Any other arrangement will be given special consideration.*

**5.1.3** *For the purpose of this Section, a directional control system includes any steering device or devices, any mechanical linkages and all power or manual devices, controls and actuating systems.*

**5.1.4** *Attention is drawn to the possibility of interaction between directional control systems and stabilisation systems. Where such interaction occurs or where dual-purpose components are fitted, the requirements of 12.5 and Sections 16 and 17 are also to be complied with, as applicable.*

**C5.1.5** Steering devices are to be installed so as to be accessible at all times and to be able to be maintained without difficulty.

**C5.1.6** Steering devices are to be mounted on substantial seatings in order to transmit the force sufficiently to the hull structure.

**C5.1.7** Important load-transmitting components and components subjected to internal pressure are to be made of steel or other approved ductile material.

At the discretion of the Society, grey cast iron may be used for certain components with low stress level.

**C5.1.8** The pipes of hydraulic systems are to be made of seamless or longitudinally welded steel tubes.

At the discretion of the Society, copper may be used.

**C5.1.9** Approved high-pressure hose assemblies may be used for short pipe connections.

**C5.1.10 Testing of materials**

The materials of important load-transmitting components, including pressurized pipes and casings, are to be tested in the presence of the Surveyor in accordance with Society Rules for Materials.

**5.2 Reliability**

**5.2.1** *The probability of total failure of all directional control systems shall be extremely remote when the craft is operating normally, i.e., excluding emergency situations such as grounding, collision or a major fire.*

**C5.2.1** Guidance to probability levels is given in Annex 3.

**5.2.2** *A design incorporating a power drive or an actuation system employing powered components for normal directional control shall provide a secondary means of actuating the device unless an alternative system is provided.*

**C5.2.2** The actuation system is to be operated by power:

- for passenger craft category B,
- in any case where the maximum effective torque to be applied to the directional control device exceeds 25 kNm.

**5.2.3** *The secondary means of actuating the directional control device may be manually driven when the Administration is satisfied that this is adequate, bearing in mind the craft's size and design and any limitations of speed or other parameters that may be necessary.*

**C5.2.3.1** The 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.

**C5.2.3.2** A secondary means of actuating the device need not be installed in a craft equipped with two rudders and/or similar devices, or with two approved means for steering, provided that each system is capable of steering the craft with the other system out of operation.

**5.2.4** *The directional control systems shall 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.*

**5.2.5** *A failure mode and effect analysis shall include the directional control system.*

**5.2.6** *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, shall 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 12.2 or an emergency diesel generator according to 12.3.6.*

**5.2.7** *Directional control devices involving variable geometry of the craft or its lift system components shall, so far as is practicable, be so constructed that any failure of the drive linkage or actuating system will not significantly hazard the craft.*

**C5.2.8** The average rate of turning of the main actuation system in general is to be not less than 2.3 degrees per second. It may be reduced with the consent of the Society, if hazard to the stability of the craft can occur.

**C5.2.9** The average rate of turning of the secondary actuation system is to be not less than 0.5 degrees per second.

**C5.2.10** Steering devices are to be provided with suitable mechanical stopping arrangements at the maximum design steering device angle.

**C5.2.11** Power-operated directional control systems are to be provided with power cut-off arrangements which stop the steering device before the mechanical stoppers are reached. These arrangements are to be synchronized with the steering device itself and not with the control system.

**C5.2.12** Steering devices are to be able to be locked in any required position for maintenance purposes.

**C5.2.13** Power-operated directional control systems are to be provided with an overload protection device. This device is to be secured to prevent later adjustment by unauthorized persons. Means are to be provided for checking the setting while in service.

**C5.2.14** The pipes of hydraulically operated control systems are to be installed in such a way as to ensure maximum protection while remaining readily accessible. They are to be installed at a sufficient distance from the craft shell.

**C5.2.15** Hydraulic power supply and piping for steering is not to be used for other purposes.

At the discretion of the Society, exemptions may be permitted for water jets, azimuth thrusters and similar units.

**C5.2.16** In the event of loss of hydraulic oil, it is to be possible to isolate the damaged system in such a way that the second control system remains fully serviceable.

**C5.2.17** Tanks forming part of a hydraulic control system are to be fitted with oil level indicators.

**C5.2.18** A low-level alarm is to be provided at the craft's operating position.

**C5.2.19** Filters for cleaning the fluid are to be located in the piping system.

**C5.2.20** In power-operated hydraulic main steering control systems, an additional permanently installed storage tank is to be provided with the capacity to refill at least one of the control systems, including the service tank.

### **5.3 Demonstrations**

**5.3.1** *The limits of safe use of any of the control system devices, shall be based on demonstrations and a verification process in accordance with annex 9.*

**5.3.2** *Demonstration in accordance with annex 9 shall 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 shall be included in the craft operating manual.*

**C5.3.3** Each power unit is to be subjected to a type test in the manufacturer's workshop according to a programme accepted by the Society. During the test, no overheating, excessive vibration or other irregularities are to occur. After the test the power unit is to be dismantled and inspected.

**C5.3.4** Pressure vessels including cylinders and pipes are to be subjected to a pressure test. The test pressure is to be 1,5 times the maximum working pressure. Tightness tests are to be conducted on components for which this is appropriate.

### **5.4 Control position**

**5.4.1** *All directional control systems shall normally be operated from the craft's operating station.*

**5.4.2** *If directional control systems can also be operated from other positions, then two-way communication shall be arranged between the operating station and these other positions.*

**5.4.3** *Adequate indications shall 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 shall be independent of the system for directional control. The logic of such feedback and indications shall be consistent with the other alarms and indications so that in an emergency operators are unlikely to be confused.*

**C5.4.4** Adequate indication which other operating position is in service is to be provided at the operating station.

**C5.4.5** Controls are to be independent of one another, and so designed that the control system device cannot move unintentionally.

## SECTION 6

## ANCHORING, TOWING AND BERTHING

**C6.0 Documents to be submitted**

A detailed drawing, showing all the elements necessary for the evaluation of the equipment number of the craft, is to be submitted together with the calculations of the EN number. The anchoring equipment to be fitted on the concerned craft is to be specified.

Windlass, brake and chain stopper are subject to approval by the Society; the relevant documentation is to be submitted.

**6.1 General**

**6.1.1** *A primary assumption made in this Section is that high-speed craft will only need an anchor for emergency purposes.*

**6.1.2** *The arrangements for anchoring, towing and berthing and the local craft structure, the design of the anchor, towing and berthing arrangements and the local craft structure shall be such that risks to persons carrying out anchoring, towing or berthing procedures are kept to a minimum.*

**6.1.3** *All anchoring equipment, towing bits, mooring bollards, fairleads, cleats and eyebolts shall be so constructed and attached to the hull that, in use up to design loads, the watertight integrity of the craft will not be impaired. Design loads and any directional limitations assumed shall be listed in the craft operating manual.*

**C6.1.4** Only anchoring equipment is considered for the purpose of classification. The design of all the out-fittings used for mooring operation and their connection to the deck is out of scope of classification.

**6.2 Anchoring**

**6.2.1** *High-speed craft shall be provided with at least one anchor with its associated cable or cable and warp and means of recovery. Every craft shall be provided with adequate and safe means for releasing the anchor and its cable and warp.*

**6.2.2** *Good engineering practice shall be followed in the design of any enclosed space containing the anchor-recovery equipment to ensure that persons using the equip-*

*ment are not put at risk. Particular care shall be taken with the means of access to such spaces, the walkways, the illumination and protection from the cable and the recovery machinery.*

**6.2.3** *Adequate arrangements shall be provided for two-way voice communication between the operating compartment and persons engaged in dropping, weighing or releasing the anchor.*

**6.2.4** *The anchoring arrangements shall be such that any surfaces against which the cable may chafe (for example, hawse pipes and hull obstructions) are designed to prevent the cable from being damaged and fouled. Adequate arrangements shall be provided to secure the anchor under all operational conditions.*

**6.2.5** *The craft shall be protected so as to minimize the possibility of the anchor and cable damaging the structure during normal operation.*

**6.3 Towing**

**6.3.1** *Adequate arrangements shall be provided to enable the craft to be towed in the worst intended conditions. Where towage is to be from more than one point, a suitable bridle shall be provided.*

**6.3.2** *The towing arrangements shall be such that any surface against which the towing cable may chafe (for example, fairleads) is of sufficient radius to prevent the cable being damaged when under load.*

**6.3.3** *The maximum permissible speed at which the craft may be towed shall be included in the operating manual.*

**6.4 Berthing**

**6.4.1** *Where necessary, suitable fairleads, bits and mooring ropes shall be provided.*

**6.4.2** *Adequate storage space for mooring lines shall be provided such that they are readily available and secured against the high relative wind speeds and accelerations which may be experienced.*

**C6.5 Equipment****C6.5.1 General**

**.1** The anchoring equipment required in C6.5.2 is intended for temporary occasional mooring of a craft within a harbour or sheltered area when the craft is awaiting berth, tide, etc.

**.2** The equipment is therefore not designed to hold a craft off fully exposed coasts in rough weather or to stop a craft which is moving or drifting. In this condition the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated, particularly in large craft.

**.3** For crafts where frequent anchoring in open sea is expected, the owner's and shipyard's attention is drawn to the fact that anchoring equipment shall be provided in excess of the requirements of these Rules.

**.4** For crafts with an Equipment Number greater than 600, two anchors and two relevant chain cables are required. For such ships engaged in a regular service, the second anchor and its relevant chain cable may be held readily available in one of the home ports.

**.5** The anchoring equipment required in C6.5.2 is designed to hold a ship in good holding ground in conditions such as to avoid dragging of the anchor. In poor holding ground, the holding power of the anchors will be significantly reduced.

**.6** The Equipment Numeral (EN) formula for anchoring equipment, as stipulated in C6.5.2, is based on an assumed current speed of 2,5 m/s, wind speed of 25 m/s and a scope of chain cable between 6 and 10, the scope being the ratio between length of chain paid out and water depth.

**.7** For small craft with a length  $L \leq 25$  m, some partial exemption from the Rules may be accepted especially for what concerns anchor operation; in particular, where proper and safe anchor operation is assured, hand-operated machinery and/or absence of hawse pipe may be accepted.

**C6.5.2 Equipment number****C6.5.2.1 General**

**.1** Each craft is to be provided with anchors and relevant stud link chain cables according to its equipment number EN, as stipulated in Table C6.5.1.

**.2** When two bow anchors are fitted, the mass of each anchor, the diameter and the length of each chain cable are to comply with the requirements of the above-mentioned Table.

**C6.5.2.2 Monohull craft**

The equipment number EN is to be calculated as follows:

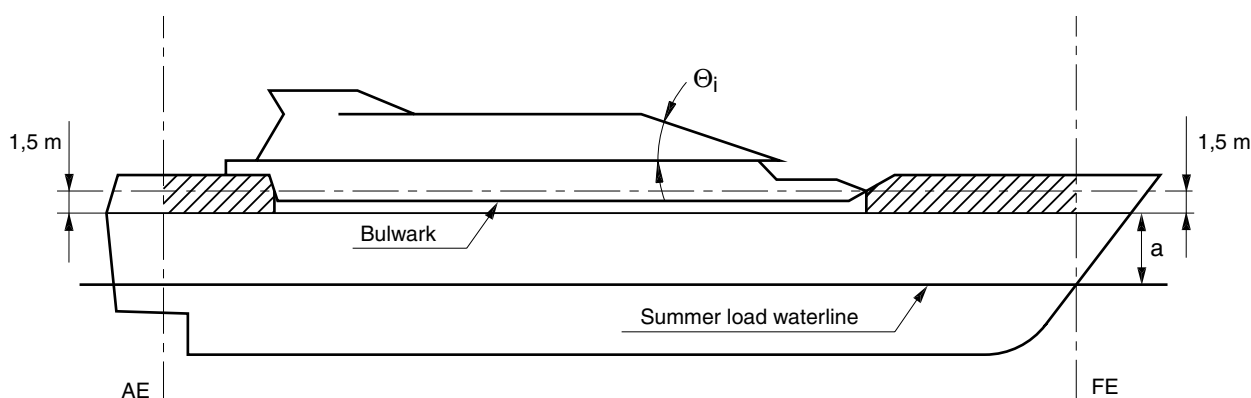
$$EN = \Delta^{2/3} + 2 \cdot \left[ a \cdot B + \sum_i (b_i \cdot h_i \cdot \sin \Theta_i) \right] + 0,1 \cdot A$$

where:

- $\Delta$  : Maximum displacement, in t
- $a$  : Distance, in m, from summer load waterline amidships to the upper deck at side
- $h_i$  : Height, in m, on the centreline of each tier of deck houses having an actual breadth  $b_i$  greater than  $B/4$ , where  $B$  is the breadth, in m, as defined in C3.1.4 of Section 3
- $\Theta_i$  : Angle of inclination aft of each front bulkhead, as shown on Figure C6.5.1
- $A$  : Area, in  $m^2$ , in profile view of the hull, superstructures and deck houses above the summer load waterline, which is within the rule length of the craft defined in C3.1.4 of Section 3 and with a breadth greater than  $B/4$ .

In the measurement of  $h_i$ , sheer and trim are to be ignored.

**Figure C6.5.1**





If a deck house broader than  $B/4$  is placed on top of another deck house equal to or less than  $B/4$  in breadth, only the widest is to be considered and the narrowest may be ignored.

Windscreens or bulwarks more than 1,5 m in height above the deck at side are to be regarded as parts of superstructures and houses when determining  $h_i$  and  $A$ . The height of hatch coamings may be ignored in the evaluation of  $h_i$  and  $A$ .

In the calculation of  $A$ , when a bulwark is more than 1,5 m in height, the cross hatched area of Figure C6.5.1 is to be considered.

### C6.5.2.3 Multihull craft

The equipment number is to be calculated as follows:

$$EN = K_m \cdot \Delta^{2/3} + 2 \cdot \left[ a \cdot B + \sum_i (b_i \cdot h_i \cdot \sin \Theta_i) - S_t \right] + 0,1 \cdot A$$

where:

- for craft with  $N$  identical hulls:  
 $K_m = N^{1/3}$   
 i.e.:
  - for catamarans:  $K_m = 1,26$
  - for trimarans:  $K_m = 1,44$
  - for quadrimarans:  $K_m = 1,59$
- for craft with one mid hull and  $2 \cdot n$  non-identical lateral hulls ( $N = 2 \cdot n + 1$ ):

$$K_m = \frac{(B_o \cdot T_o)^{2/3} + 2 \cdot \sum_{i=1}^n (B_i \cdot T_i)^{2/3}}{\left( B_o \cdot T_o + 2 \cdot \sum_{i=1}^n B_i \cdot T_i \right)^{2/3}} \quad (N \text{ odd})$$

- for craft with non-identical hulls, but of an even number ( $N = 2 \cdot n$ ):

$$K_m = 2^{1/3} \cdot \frac{\sum_{i=1}^n (B_i \cdot T_i)^{2/3}}{\left( \sum_{i=1}^n B_i \cdot T_i \right)^{2/3}} \quad (N \text{ even})$$

$S_t$  : Transverse area, amidships, of the tunnel(s) existing between the hulls and the waterline

$B_o, T_o$  : Breadth and draught, in m, of the mid full hull (if any), measured amidship (see Figure C6.5.2)

$B_i, T_i$  : Breadth and draught, in m, of the lateral hulls, measured amidship (see Figure C6.5.2)

$N$  : Total number of craft hulls

$n$  : Number of lateral hulls on one side of the longitudinal symmetry plane of the craft

$\Delta$  : Total displacement of the craft, in t.

Other symbols are defined in C6.5.2.2.

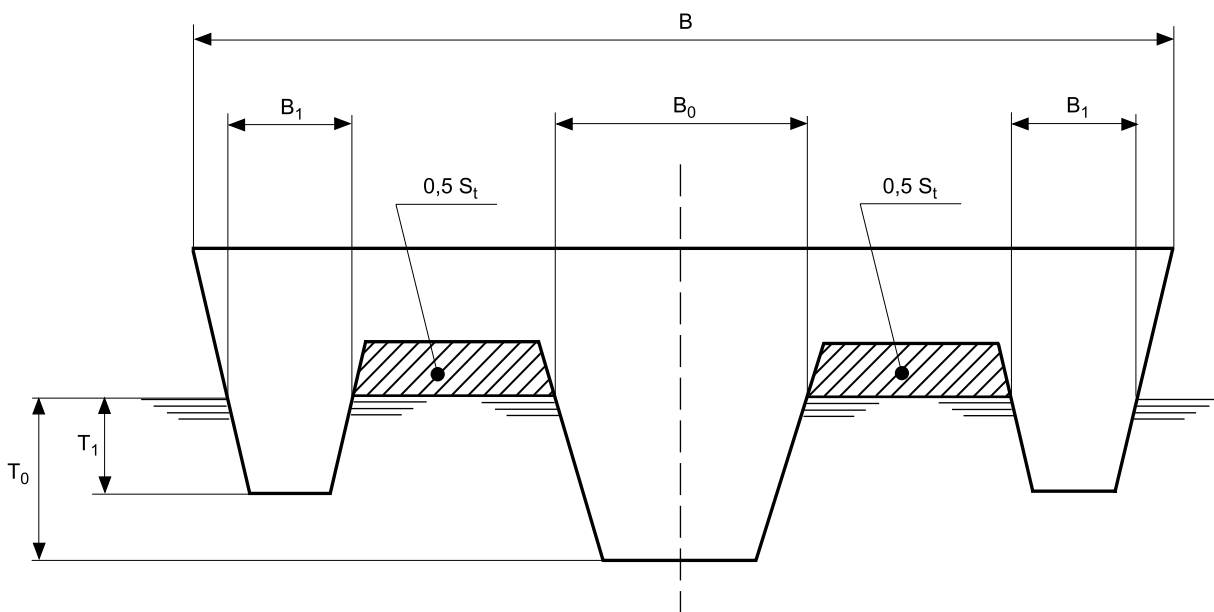
### C6.5.3 Anchors

#### C6.5.3.1 Mass of anchors

**.1** Table C6.5.1 indicates the mass of a "high holding power anchor" (HHP) i.e. anchor having a holding power greater than that of an ordinary anchor.

**.2** "Very high holding power anchors" (VHHP), i.e. anchors having a holding power equal to, at least, four times that of an ordinary anchor, may be used.

Figure C6.5.2



In this example:  $N = 3$  and  $n = 1$ . In cases where  $N$  is even:  $B_o = T_o = 0$

.3 The actual mass of each anchor may vary within (+7, -3) per cent of the value shown in the Table.

.4 The mass of a VHHP anchor is to be not less than 2/3 of the mass required for the HHP anchor it replaces.

.5 Normally HHP or VHHP anchors are to be used. Possible use of ordinary anchors will be specially considered by the Society.

#### C6.5.3.2 Anchor design

.1 Anchors are to have appropriate shape and scantlings in compliance with Society requirements and are to be constructed in compliance with Society requirements.

.2 A high or very high holding power anchor is to be suitable for use on board without any prior adjustment or special placement on the ground.

.3 For approval and/or acceptance as a high or very high holding power anchor, the anchor is to have a holding power equal, respectively, to at least twice or four times that of an ordinary stockless anchor of the same mass.

.4 Comparative tests on ordinary stockless anchors are to be carried out at sea and are to provide satisfactory results on various types of seabeds.

Alternatively sea trials by comparison with a previously approved HHP anchor may be accepted as a basis for approval.

Such tests are to be carried out on anchors whose masses are, as far as possible, representative of the full range of sizes proposed for the approval.

At least two anchors of different sizes are to be tested. The mass of the greatest anchor to be approved is not to be in excess of 10 times that of the maximum size tested and the mass of the smallest is to be not less than 0,1 times that of the minimum size tested.

Tests are normally to be carried out by means of a tug, but, alternatively, shore-based tests may be accepted.

The length of the chain cable connected to the tested anchor, having a diameter appropriate to its mass, is to be such that the pull acting on the shank remains practically horizontal. For this purpose a scope of chain cable equal to 10 is deemed normal; however lower values may be accepted.

Three tests are to be carried out for each anchor and type of ground.

The pull is to be measured by means of a dynamometer; measurements based on the bollard pull against propeller's revolutions per minute curve may be accepted instead of dynamometer readings.

Anchor stability and its ease of dragging are to be noted down, whenever possible.

.5 Upon satisfactory outcome of the above tests, the Society will issue a certificate declaring the compliance of high or very high holding power anchors with its relevant Rules.

#### C6.5.4 Chain cables

.1 Bow anchors are to be used in connection with stud link chain cables whose scantlings and steel grades are to be in accordance with the requirements of the Society.

.2 Normally grade Q2 or grade Q3 stud link chain cables are to be used with HHP anchors. In case of VHHP anchors, grade Q3 chain cables are to be used.

.3 Proposal for use of grade Q1 chain cables connected to ordinary anchors will be specially considered by the Society.

.4 For craft with an Equipment Number  $EN \leq 205$ , studless short link chain cables may be used, provided that:

(a) steel grade of the studless chain is to be equivalent to the steel grade of the stud chains it replaces, i.e., referring to ISO standard 1834:

- Class M (4) [grade 400], i.e. grade SL2 as defined in Pt D, Ch 4, Sec 1, [3] of the Rules for the Classification of Steel Ships, in lieu of grade Q2
- Class P (5) [grade 500], i.e. grade SL3 as defined in Pt D, Ch 4, Sec 1, [3] of the Rules for the Classification of Steel Ships, in lieu of grade Q3

(b) equivalence in strength is to be based on proof load (not on breaking load)

(c) the studless chain cable meets the requirements of the Society.

.5 The proof loads PL and breaking loads BL, in kN, required for the studless link chain cables are given by the following formulae, where d, in mm, is the required diameter of grade Q2 and grade Q3 stud chain cables taken from Table C6.5.1:

- grade Q2:  

$$PL_2 = 9,807 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

$$BL_2 = 2 \cdot PL_2$$
- grade Q3:  

$$PL_3 = 13,73 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

$$BL_3 = 2 \cdot PL_3$$

.6 The method of manufacture of chain cables and the characteristics of the steel used are to be approved by the Society for each manufacturer. The material from which chain cables are manufactured and the completed chain cables themselves are to be tested in accordance with the appropriate requirements.

.7 Chain cables are to be made of unit lengths ("shots") of 27,5 m minimum joined together by Dee or lugless shackles.

**C6.5.5 Steel wire ropes for anchors**

**.1** Steel wire ropes may be used as an alternative to stud link chain cables required in Table C6.5.1 when  $EN \leq 500$ , provided that the following requirements are complied with.

**.2** The length  $L_{swr}$  in m, of the steel wire rope is to be not less than:

- when  $EN \leq 130$ :  
 $L_{swr} = L_{ch}$
- when  $130 < EN \leq 500$ :  
 $L_{swr} = L_{ch} \cdot (EN + 850) / 900$

where  $L_{ch}$  is the length of stud link chain cable required by Table C6.5.1.

**.3** The effective breaking load of the steel wire rope is to be not less than the required breaking load of the chain cable it replaces.

**.4** The breaking load, in kN, of the chain cable diameters shown between parentheses in Table C6.5.1 may be derived from the following formulae:

- for grade Q2 chain cables:  
 $BL = 13,73 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$
- for grade Q3 chain cables:  
 $BL = 19,61 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$

where  $d$  is, in mm, the chain cable diameter taken from Table C6.5.1 corresponding respectively to grade Q2 and grade Q3 chain cables.

**.5** A short length of chain cable having scantlings complying with C6.5.4 is to be fitted between the steel wire rope and the bow anchor. The length of this chain part is to be not less than 12,50 m or the distance from the anchor in its stowed position to the windlass, whichever is the lesser.

**C6.5.6 Synthetic fibre ropes for anchors**

**.1** Synthetic fibre ropes may be used as an alternative to stud link chain cables required in Table C6.5.1 when  $EN \leq 130$ , provided that the following requirements are complied with.

**.2** Fibre ropes are to be made of polyamide or other equivalent synthetic fibres, excluding polypropylene.

**.3** The length  $L_{sfr}$  in m, of the synthetic fibre rope is to be not less than:

- when  $EN \leq 60$ :  
 $L_{sfr} = L_{ch}$
- when  $60 < EN \leq 130$ :  
 $L_{sfr} = L_{ch} \cdot (EN + 170) / 200$

where  $L_{ch}$  is the length of stud link chain cable required by Table C6.5.1.

**.4** The effective breaking load  $P_s$ , in kN, of the synthetic fibre rope is to be not less than the following value:

$$P_s = 2,2 \cdot B \cdot L^{8/9}$$

where  $BL$ , in kN, is the required breaking load of the chain cable replaced by the synthetic fibre rope ( $BL$  can be determined by the formulae given in C6.5.5.4).

**.5** A short length of chain cable complying with C6.5.5.5 is to be fitted between the synthetic fibre rope and the bow anchor.

**C6.5.7 Attachment pieces**

**.1** Both attachment pieces and connection fittings for chain cables are to be designed and constructed in such a way as to offer the same strength as the chain cable and are to be tested in accordance with the appropriate requirements.

**C6.5.8 Arrangement of anchors and chain cables**

**.1** The bow anchors, connected to their own chain cables, are to be so stowed as to always be ready for use.

**.2** Hawse pipes are to be of a suitable size and so arranged as to create, as far as possible, an easy lead for the chain cables and efficient housing for the anchors.

**.3** For this purpose, chafing lips of suitable form with ample lay-up and radius adequate for the size of the chain cable are to be provided at the shell and deck. The shell plating at the hawse pipes is to be reinforced as necessary.

**C6.5.9 Windlass**

**.1** The windlass is to be power driven and suitable for the size of chain cable, and is to have the characteristics stated below.

**.2** The windlass is to be fitted in a suitable position in order to ensure an easy lead of the chain cable to and through the hawse pipe; the deck, at the windlass, is to be suitably reinforced.

**.3** The windlass is to be able to supply, for at least 30 minutes, a continuous duty pull  $P_C$ , in N, corresponding to the grade of the chain cables, given by the following formulae:

- for grade Q2 chain cables:  
 $P_C = 42,5 \cdot d^2$
- for grade Q3 chain cables:  
 $P_C = 47,5 \cdot d^2$

where  $d$  is the stud link chain cable diameter of the intended steel grade, in mm.

.4 The windlass unit prime mover is to provide the necessary temporary overload capacity for breaking out the anchor.

The temporary overload capacity or "short term pull" is to be not less than 1,5 times the continuous duty pull  $P_C$  for at least two minutes.

The speed in this overload period may be lower than the nominal speed specified in C6.5.9.5.

.5 The nominal speed of the chain cable when hoisting the anchor and cable may be a mean speed only and is to be not less than 0,15 m/s.

The speed is to be measured over two shots of chain cable during the entire trip; the test is to commence with 3 shots (82,5 m) of chain fully submerged, or with the longest practicable submerged chain length where the chain length does not allow 3 shots to be paid out.

.6 The windlass is to be provided with a brake having sufficient capacity to stop chain cable and anchor when paying out, even in the event of failure of the power supply.

.7 Windlass and brake not combined with a chain stopper have to be designed to withstand a pull of 80% of the breaking load of the chain cable without any permanent deformation of the stressed parts and without brake slip.

Windlass and brake combined with a chain stopper have to be designed to withstand a pull of 45% of the breaking load of the chain cable.

.8 The stresses on the parts of the windlass, its frame and brake are to be below the yield point of the material used.

The windlass, its frame and the brake are to be efficiently anchored to the deck.

.9 Performance criteria and strength of windlasses are to be verified by means of workshop testing according to the Society Rules.

#### **C6.5.10 Chain stopper**

.1 A chain stopper is normally to be fitted between the windlass and the hawse pipe in order to relieve the windlass of the pull of the chain cable when the ship is at anchor.

.2 A chain stopper is to be capable of withstanding a pull of 80% of the breaking load of the chain cable; the deck at the chain stopper is to be suitably reinforced.

However, fitting of a chain stopper is not compulsory.

.3 Chain tensioners or lashing devices supporting the weight of the anchor when housed in the anchor pocket are not to be considered as chain stoppers.

.4 Where the windlass is at a distance from the hawse pipe and no chain stopper is fitted, suitable arrangements are to be provided to lead the chain cable to the windlass.

#### **C6.5.11 Chain locker**

.1 The chain locker is to be of a capacity adequate to stow all chain cable equipment and provide an easy direct lead to the windlass.

.2 Where two anchor lines are fitted, the port and starboard chain cables are to be separated by a steel bulkhead in the locker.

.3 The inboard ends of chain cables are to be secured to the structure by a fastening able to withstand a force not less than 15% nor more than 30% of the breaking load of the chain cable.

In an emergency, the attachments are to be easily released from outside the chain locker.

.4 Where the chain locker is arranged aft of the collision bulkhead, its boundary bulkheads are to be watertight and a drainage system provided.

#### **C6.5.12 Anchoring sea trials**

.1 The anchoring sea trials are to be carried out on board in the presence of a Society surveyor.

.2 The test is to demonstrate that the windlass complies with the requirements given in C6.5.9.5.

.3 The brake is to be tested during lowering operations.

Table C6.5.1 - Equipment

Equipment Number EN		HHP bow anchor		Stud link chain cable for bow anchor		
A < EN ≤ B		Mass of each anchor (kg)	Number of anchors	Total length (m)	Diameter (1)	
A	B				grade Q2 steel (mm)	grade Q3 steel (mm)
19	22	16	1	65,0	(6,0)	(5,5)
22	25	20	1	70,0	(6,5)	(6,0)
25	30	24	1	70,0	(7,0)	(6,5)
30	35	28	1	75,0	(7,5)	(7,0)
35	40	32	1	75,0	(8,0)	(7,5)
40	45	40	1	80,0	(8,5)	(7,5)
45	50	48	1	82,5	(9,0)	(8,0)
50	60	60	1	82,5	(10,0)	(8,5)
60	70	67	1	82,5	11,0	(9,5)
70	80	75	1	110,0	11,0	(10,0)
80	90	90	1	110,0	12,5	11,0
90	100	105	1	110,0	12,5	11,0
100	110	120	1	110,0	14,0	12,5
110	120	135	1	110,0	14,0	12,5
120	130	150	1	110,0	14,0	12,5
130	140	180	1	110,0	16,0	14,0
140	150	195	1	137,5	16,0	14,0
150	175	225	1	137,5	17,5	16,0
175	205	270	1	137,5	17,5	16,0
205	240	315	1	137,5	19,0	17,5
240	280	360	1	137,5	20,5	19,0
280	320	430	1	165,0	22,0	20,5
320	360	495	1	165,0	24,0	22,0
360	400	525	1	165,0	26,0	22,0
400	450	585	1	165,0	26,0	24,0
450	500	675	1	192,5	28,0	26,0
500	550	765	1	192,5	30,0	26,0
550	600	855	1	192,5	32,0	28,0
600	660	900	2	385,0	32,0	30,0
660	720	970	2	385,0	34,0	30,0
720	780	1080	2	440,0	36,0	32,0
780	840	1125	2	440,0	36,0	32,0
840	910	1195	2	440,0	38,0	34,0
910	980	1305	2	440,0	40,0	36,0
980	1060	1440	2	440,0	42,0	36,0
1060	1140	1575	2	440,0	42,0	38,0
1140	1220	1710	2	467,5	44,0	38,0
1220	1300	1845	2	467,5	46,0	40,0

(1) Values of chain cable diameters shown in brackets are given only to allow determination of the corresponding studless chain cable.

**SECTION 7****FIRE SAFETY****Part A General****C7.0 Documents to be submitted**

**C7.0.1** The following drawings and documents are to be submitted, at least in triplicate for approval. The Society reserves its right to ask for supplementary copies, if deemed necessary in particular cases.

**.1** Plan showing the arrangements of the fire subdivision, including doors and other closing means of openings in fire resisting divisions.

**.2** Schematic plan concerning the natural and mechanical ventilation, with indication of location of dampers and identification numbers of the fans serving each craft section.

**.3** Plan showing automatic fire detection systems and manually operated call points, including fire alarm systems.

**.4** Plan relating to the water fire-fighting system (pumps, piping, etc.).

**.5** Plan relating to the arrangement of fixed fire extinguishing systems.

**.6** Constructional plans relevant to pressure vessels or bottles serving fixed fire extinguishing systems mentioned under .5.

**.7** Plans of pumping and drainage means for the water delivered by fixed water-spraying fire extinguishing systems.

**.8** Plan relating to all other fire-fighting installations, either fixed or portable.

**C7.0.2** Further documentation may be required, if deemed necessary by the Society.

**7.1 General Requirements**

**7.1.1** *The following basic principles underlie the provisions in this Section and are embodied therein as appropriate, having regard to the category of craft and the potential fire hazard involved:*

**.1** *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** *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;*

**.3** *subdivision of the craft by fire-resisting boundaries;*

**.4** *restricted use of combustible materials and materials generating smoke and toxic gases in a fire;*

**.5** *detection, containment and extinction of any fire in the space of origin;*

**.6** *protection of means of escape and access for fire fighting; and*

**.7** *immediate availability of fire-extinguishing appliances.*

**7.1.2** *The requirements in this Section are based in the following conditions:*

**.1** *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.*

**.2** *The use of fuel with a flashpoint below 43°C is not recommended. However, fuel with a lower flashpoint, but not lower than 35°C, may be used in gas turbines only subject to compliance with the provisions specified in 7.5.1 to 7.5.6.*

**.3** *The repair and maintenance of the craft is carried out in accordance with the requirements given in Sections 18 and 19 of this Code.*

**.4** *Enclosed spaces having reduced lighting, such as cinemas, discotheques, and similar spaces are not permitted.*

**.5** *Passenger access to special category spaces and open ro-ro spaces is prohibited during the voyage except when accompanied by a crew member responsible for fire safety. Only authorised crew members shall be permitted to enter cargo spaces at sea.*

**C7.1.3** The following products are to be of approved type:

- Fire-restricting materials,
- Fire-resisting divisions (decks, bulkheads, doors),
- Penetrations of fire-resisting divisions for pipes, cables, ducts,
- Surface materials,
- Primary deck covering,
- Upholstery furniture,
- Bedding components,
- Curtains,
- Non-combustible materials,
- Oil pipes (other than steel or copper and copper alloys),
- Flexible pipes,
- Portable and mobile fire extinguishers,
- Nozzles for water spray systems or sprinkler systems,
- Fire-detection systems,
- Fire hoses and nozzles,
- Vapour detection systems,
- Non-sparking fans.

## 7.2 Definitions

**7.2.1** *"Fire-resisting divisions" are those divisions formed by bulkheads and decks which comply with the following:*

**.1** *They shall be constructed of non-combustible or fire-restricting materials which by insulation or inherent fire-resisting properties satisfy the requirements of 7.2.1.2 to 7.2.1.6.*

**.2** *They shall be suitably stiffened.*

**.3** *They shall be so constructed as to be capable of preventing the passage of smoke and flame up to the end of the appropriate fire protection time.*

**.4** *Where required they shall maintain load-carrying capabilities up to the end of the appropriate fire protection time.*

**.5** *They shall have thermal properties such that the average temperature on the unexposed side will not rise more than 140°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.*

**.6** *A test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code shall be required to ensure that it meets the above requirements.*

**C7.2.1** With reference to 7.2.1.6 test procedures for fire-resisting divisions of high speed craft adopted by the Organization by IMO Resolution MSC 45 (65) are to be applied.

**7.2.2** *"Fire-restricting materials" are those materials which have properties complying with the Fire Test Procedures Code.*

**7.2.3** *"Non-combustible material" is a 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 Fire Test Procedures Code.*

**7.2.4** *"A standard fire test" is one in which specimens of the relevant bulkheads, decks or other constructions are exposed in a test furnace by a specified test method in accordance with the Fire Test Procedures Code.*

**7.2.5** *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).*

**7.2.6** *"Low flame-spread" means that the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the Fire Test Procedures Code.*

**7.2.7** *"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.*

## 7.3 Classification of space use

**7.3.1** *For the purposes of classification of space use in accordance with fire hazard risks, the following grouping shall apply:*

**.1** "Areas of major fire hazard", referred to in tables 7.4-1 and 7.4-2 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<sup>2</sup> or greater and containing flammable liquids for sale
- trunks in direct communication with the above spaces.

**.2** "Areas of moderate fire hazard", referred to in tables 7.4-1 and 7.4-2 by B, include the following spaces:

- auxiliary machinery spaces, as defined in 1.4.4
- bond stores containing packaged beverages with alcohol content not exceeding 24% by volume
- crew accommodation containing sleeping berths
- service spaces
- sales shops having a deck area of less than 50 m<sup>2</sup> 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<sup>2</sup> or greater not containing flammable liquids
- trunks in direct communication with the above spaces.

**.3** "Areas of minor fire hazard", referred to in tables 7.4-1 and 7.4-2 by C, include the following spaces:

- auxiliary machinery spaces, as defined in 1.4.5
- 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 7.3.1.1 and 7.3.1.2
- corridors in passenger areas and stairway enclosures
- crew accommodation other than that mentioned in 7.3.1.2
- trunks in direct communication with the above spaces.

**.4** "Control stations", referred to in tables 7.4-1 and 7.4-2 by D, as defined in 1.4.15

**.5** "Evacuation Stations and external escape routes", referred to in tables 7.4-1 and 7.4-2 by E, include the 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.

**.6** "Open Spaces" referred to in tables 7.4-1 and 7.4-2 by F, include the following areas:

- open spaces locations other than evacuation stations and external escape routes and control stations.

**7.3.2** In approving structural fire protection details, the Administration shall have regard to the risk of heat transmission at intersections and terminal points of required thermal barriers.

## **7.4 Structural fire protection**

### **7.4.1 Main structure**

**7.4.1.1** The requirements below apply to all craft irrespective of construction material. The structural fire protection times for separating bulkheads and decks shall be in accordance with tables 7.4-1 and 7.4-2, and the structural fire protection times are all based on providing protection for a period of 60 min as referred to in 4.8.1. If any other lesser structural fire protection time is determined for category A craft and cargo craft by 4.8.1, then the times given below in 7.4.2.2 and 7.4.2.3 may be amended pro rata. In no case shall the structural fire protection time be less than 30 min.

**C7.4.1.1** Fire insulation may be omitted on upper side of decks provided that a fixed water spraying system delivering not less than 5 l/min/m<sup>2</sup> is installed.

**7.4.1.2** In using tables 7.4-1 and 7.4-2, it shall 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 shall be treated as spaces within the relevant category having the most stringent boundary requirement.

**7.4.1.3** The hull, superstructure, structural bulkheads, decks, deckhouses and pillars shall 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 Section are complied with and the materials are in compliance with the Fire Test Procedures Code.



**Table 7.4.1 - Structural fire protection time for separating bulkheads and decks of passenger craft**

		A	B	C	D	E	F
Areas of major fire hazard	A	60 <sup>(1,2)</sup> 60 <sup>(1,2)</sup>	30 60 <sup>(1)</sup>	(3) 60 <sup>(1,8)</sup>	(3,4) 60 <sup>(1)</sup>	(3) 60 <sup>(1)</sup>	- 60 <sup>(1,7,9)</sup>
Areas of moderate fire hazard	B		30 <sup>(2)</sup> 30 <sup>(2)</sup>	(3) 30 <sup>(8)</sup>	(3,4) 60	(3) 30	- (3)
Areas of minor fire hazard	C			(3) (3)	(3,4) 30 <sup>(8,10)</sup>	(3) (3)	- (3)
Control stations	D				(3,4) (3,4)	(3) (3,4)	- (3)
Evacuation stations and escape routes	E					(3) (3)	- (3)
Open spaces	F						-

*Note: 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 and two different structural fire protection times are required for a division in the table, only the greater one need be applied.*

**(1)** The upper side of the decks of special category spaces, ro-ro spaces and open ro-ro spaces 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 store-rooms. 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 made of non-combustible or fire restricting material is required.

**(4)** Control stations which are also auxiliary machinery spaces shall 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 table.

**(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 7.2.1.5.

**(8)** When steel construction is used, fire resisting divisions adjacent to void spaces need not comply with 7.2.1.5.

**(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 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.

**Table 7.4.2 - Structural fire protection time for separating bulkheads and decks of cargo craft**

	A	B	C	D	E	F
Areas of major fire hazard A	60 <sup>(1,2)</sup>	30	(3)	(3,4)	(3)	-
	60 <sup>(1,2)</sup>	60 <sup>(1)</sup>	60 <sup>(1,8)</sup>	60 <sup>(1)</sup>	60 <sup>(1)</sup>	60 <sup>(1,7,9)</sup>
Areas of moderate fire hazard B		(2,6)	(3)	(3,4)	(3)	-
		(2,6)	(6)	60	(6)	(3)
Areas of minor fire hazard C			(3)	(3,4)	(3)	-
			(3)	30 <sup>(8)</sup>	(3)	(3)
Control stations D				(3,4)	(3)	-
				(3,4)	(3,4)	(3)
Evacuation stations and escape routes E					(3)	-
					(3)	(3)
Open spaces F						-

*Note: 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 and two different structural fire protection times are required for a division in the table, only the greater one need be applied.*

**(1)** The upper side of the decks of special category spaces, ro-ro spaces and open ro-ro spaces 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 store-rooms. 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 made of non-combustible or fire restricting material is required.

**(4)** Control stations which are also auxiliary machinery spaces shall 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 table.

**(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 7.2.1.5.

**(8)** When steel construction is used, fire resisting divisions adjacent to void spaces need not comply with 7.2.1.5.

**(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 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.

**7.4.2 Fire-resisting divisions**

**7.4.2.1** Areas of major and moderate fire hazard shall be enclosed by fire-resisting divisions complying with the requirements of 7.2.1 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 the lightweight condition, but due regard shall 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.

**7.4.2.2** Fire-resisting bulkheads and decks shall be constructed to resist exposure to the standard fire test for a period of 30 min for areas of moderate fire hazard and 60 minutes for areas of major fire hazard except as provided in 7.4.1.1.

**7.4.2.3** Main load-carrying structures within areas of major fire hazard and areas of moderate fire hazard and structures supporting control stations shall 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. The load-carrying structure shall also comply with the requirements of 7.4.2.4 and 7.4.2.5.

**7.4.2.4** If the structures specified in 7.4.2.3 are made of aluminium alloy their installation shall 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 7.4.1.1 and 7.4.2.2.

**7.4.2.5** If the structures specified in 7.4.2.3 are made of combustible material, their insulation shall 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 Fire Test Procedures Code to such an extent that the load-carrying capability, in accordance with the times in 7.4.1.1 and 7.4.2.3, will be impaired.

**7.4.2.6** The construction of all doors, and door frames in fire-resisting divisions, with the means of securing them when closed, shall 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, electrical cables etc., arrangements shall be made to ensure that the fire-resisting integrity of the division is not impaired, and necessary testing shall be carried out in accordance with the Fire Test Procedures Code.

**7.4.3 Restricted use of combustible materials**

**7.4.3.1** All separating divisions, ceilings or linings if not a fire resisting division, shall be of non-combustible or fire restricting materials. Draught stops shall be of non-combustible or fire-restricting material.

**7.4.3.2** Where insulation is installed in areas in which it could come into contact with any flammable fluids or their vapours, its surface shall be impermeable to such flammable fluids or vapours.

**7.4.3.3** Furniture and furnishings in public spaces and crew accommodation shall comply with the following standards:

**.1** all case furniture 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<sup>2</sup> may be used on the exposed surface of such articles;

**.2** all other furniture such as chairs, sofas and tables, is constructed with frames of non-combustible or fire-restricting materials;

**.3** all draperies, curtains and other suspended textile materials have qualities of resistance to the propagation of flame, this being determined in accordance with the Fire Test Procedures Code;

**.4** all upholstered furniture has qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code;

**.5** all bedding components have qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code; and

**.6** all deck finish materials comply with the Fire Test Procedures Code.

**C7.4.3.3** Requirement 7.4.3.3.1 is applicable to furniture such as desks, wardrobes, dressing tables, bureaux and dressers.

**7.4.3.4** The following surfaces shall, as a minimum standard, be constructed of materials having low flame-spread characteristics:

**.1** 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;

**.2** 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.

**7.4.3.5** Any thermal and acoustic insulation shall 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 shall be kept to the minimum quantity practicable and their exposed surfaces shall have low flame spread characteristics.

**7.4.3.6** 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 shall 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 Fire Test Procedures Code.

**7.4.3.7** Void compartments, where low-density combustible materials are used to provide buoyancy, shall be protected from adjacent fire hazard areas by fire-resisting divisions, in accordance with tables 7.4-1 and 7.4-2. Also, the space and closures to it shall be gastight but it shall be ventilated to atmosphere.

**7.4.3.8** In compartments where smoking is allowed, suitable non-combustible ash containers shall be provided. In compartments where smoking is not allowed, adequate notices shall be displayed.

**7.4.3.9** The exhaust gas pipes shall be arranged so that the risk of fire is kept to a minimum. To this effect, the exhaust system shall be insulated and all 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, shall be constructed of non-combustible material or be shielded and insulated with non-combustible material to protect from high temperatures.

**7.4.3.10** The design and arrangement of the exhaust manifolds or pipes shall be such as to ensure the safe discharge of exhaust gases.

#### **7.4.4 Arrangement**

**7.4.4.1** 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 tables 7.4-1 and 7.4-2 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.

**7.4.4.2** Lift trunks shall be so fitted as to prevent the passage of smoke and flame from one deck to another and shall be provided with means of closing so as to permit the control of draught and smoke.

**7.4.4.3** In public spaces, crew accommodation, service spaces, control stations, corridors and stairways, air spaces enclosed behind ceilings, panelling or linings shall 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.

#### **7.5 Fuel and other flammable fluid tanks and systems**

**7.5.1** Tanks containing fuel and other flammable fluids shall be separated from passenger, crew, and baggage compartments by vapour-proof enclosures or cofferdams which are suitably ventilated and drained.

**7.5.2** Fuel oil tanks shall not be located in, be formed by any part of the structural boundary of, areas of major fire hazard. However, flammable fluids of a flashpoint not less than 60°C may be located within such areas provided the tanks are made of steel or other equivalent material.

**C7.5.2** 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.

**7.5.3** Every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank shall 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 a fire occurring in the space in which such tanks are situated.

**7.5.4** Pipes, valves and couplings conveying flammable fluids shall 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 (see note). Wherever practicable, the use of flexible pipes shall be avoided.

*Note: Refer to the Guidelines for the Application of Plastic Pipes on Ships, adopted by the Organization by resolution A.753(18).*

**7.5.5** Pipes, valves and couplings conveying flammable fluids shall 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.

**7.5.6** Fuel with a flash point below 35°C shall not be used. In every craft in which fuel with a flashpoint below 43°C is used, the arrangements for the storage, distribution and utilization of the fuel shall 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 on board is preserved. The arrangements shall comply, in addition to the requirements of 7.5.1 to 7.5.5, with the following provisions:

**.1** tanks for the storage of such fuel shall 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;

**.2** arrangements shall be made to prevent over-pressure 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 shall discharge to a position which, in the opinion of the Administration, is safe;

**.3** the spaces in which fuel tanks are located shall be mechanically ventilated, using exhaust fans providing not less than six air changes per hour. The fans shall be such as to avoid the possibility of ignition of flammable gas-air mixtures. Suitable wire mesh guards shall be fitted over inlet and outlet ventilation openings. The outlets for such exhausts shall discharge to a position which, in the opinion of the Administration is safe. "No Smoking" signs shall be posted at the entrance to such spaces;

**.4** earthed electrical distribution systems shall not be used, with the exception of earthed intrinsically safe circuits;

**.5** suitable certified safe type electrical equipment be used in all spaces where fuel leakage could occur, including the ventilation system (see note). Only electrical equipment and fittings essential for operational purposes shall be fitted in such spaces;

*Note: Refer to the Recommendations published by the International Electrotechnical Commission and, in particular, publication 60092-Electrical Installations in Ships.*

**.6** a fixed vapour-detection system shall be installed in each space through which fuel lines pass, with alarms provided at the continuously manned control station;

**.7** every fuel tanks shall, where necessary, be provided with "savealls" or gutters which would catch any fuel which may leak from such tank;

**.8** safe and efficient means of ascertaining the amount of fuel contained in any tank shall be provided. Sounding pipes shall not terminate in any space where the risk of ignition of spillage from the sounding pipe might arise. In particular, they shall not terminate in passenger or crew spaces. The use of cylindrical gauge glasses is prohibited, except for cargo craft where the use of oil-level gauges with flat glasses and self-closing valves between the gauges and fuel tanks may be permitted by the Administration. Other means of ascertaining the amount of 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 tank will not permit the release of fuel;

**.9** during bunkering operations, no passenger shall be on board the craft or in the vicinity of the bunkering station, and adequate "No Smoking" and "No Naked Lights" signs shall be posted. Vessel-to-shore fuel connections shall be of closed type and suitably grounded during bunkering operations;

**.10** the provision of fire detection and extinguishing systems in spaces where non-integral fuel tanks are located shall be in accordance with requirements of 7.7.1 to 7.7.3; and

**.11** refuelling of the craft shall be done at the approved refuelling facilities, detailed in the route operational manual, at which the following fire appliances are provided:

**.11.1** 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 500l/m for not less than 10 min;

**.11.2** dry powder extinguishers of total capacity not less than 50 kg; and

**.11.3** carbon dioxide extinguishers of total capacity not less than 16 kg.

**C7.5.6** With reference to 7.5.6.3, fans are to be of a non-sparking type in accordance with Society Rules.

## 7.6 Ventilation

**7.6.1** The main inlets and outlets of all ventilation systems shall be capable of being closed from outside the spaces being ventilated. In addition, such openings to areas of major fire hazard shall be capable of being closed from a continuously manned control station.

**7.6.2** All ventilation fans shall 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 areas of major fire hazard shall be capable of being operated from a continuously manned control station.

The means provided for stopping the power ventilation to the machinery space shall be separated from the means provided for stopping ventilation of other spaces.

**7.6.3** Areas of major fire hazard and spaces serving as assembly stations shall have independent ventilation systems and ventilation ducts. Ventilation ducts for areas of major fire hazard shall not pass through other spaces, unless they are contained within a trunk or in an extended machinery space or casing insulated in accordance with tables 7.4-1 and 7.4-2; ventilation ducts of other spaces shall not pass through areas of major fire hazard. Ventilation outlets from areas of major fire hazard shall not terminate within a distance of 1 m from any control station, evacuation station or external escape route. In addition, exhaust ducts from galley ranges shall be fitted with:

**.1** a grease trap readily removable for cleaning unless an alternative approved grease removal system is fitted;

**.2** a fire damper located in the lower end of the duct which is automatically and remotely operated, and in addition a remotely operated fire damper located in the upper end of the duct;

**.3** a fixed means for extinguishing a fire within the duct;

**.4** remote control arrangements for shutting off the exhaust fans and supply fans, for operating the fire dampers mentioned in .2 and for operating the fire-extinguishing system, which shall be placed in a position close to the entrance to the galley. Where a multi-branch system is installed, means shall be provided to close all branches exhausting through the same main duct before an extinguishing medium is released into the system; and

**.5** suitably located hatches for inspection and cleaning.

**7.6.4** Where a ventilation duct passes through a fire-resisting division, a fail safe automatic closing fire damper shall be fitted adjacent to the division. The duct between the division and the damper shall 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 shall be fitted at the penetration unless the duct which passes through the space does not serve that space.

**7.6.5** Where ventilation systems penetrate decks, the arrangements shall be such that the effectiveness of the deck in resisting fire is not thereby impaired and precautions shall be taken to reduce the likelihood of smoke and hot gases passing from one between-deck space to another through the system.

**7.6.6** All dampers fitted on fire-resisting or smoke-tight divisions shall 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 space not normally manned such as stores and toilets that may be manually operated only from outside the served spaces. All dampers shall also be capable of being remotely closed from the continuously manned control station.

**7.6.7** Ducts shall be made of non-combustible or fire restricting material. Short ducts, however, may be of combustible materials subject to the following conditions:

- .1** their cross-section does not exceed 0.02 m<sup>2</sup>;
- .2** their length does not exceed 2 m;
- .3** they may only be used at the terminal end of the ventilation system;
- .4** they shall not be situated less than 600 mm from an opening in a fire-resisting or fire-restricting division; and
- .5** their surfaces have low flame spread characteristics.

## **7.7 Fire detection and extinguishing systems**

### **7.7.1 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 shall be provided with an approved automatic smoke detection system and manually operated call points complying with the requirements of 7.7.1.1 and 7.7.1.3 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) shall in addition have detectors sensing other than smoke and be supervised by TV cameras monitored from the operating compartment. Manually operated call points shall be installed throughout the public spaces, crew accommodation, corridors and stairway enclosures, service spaces and where necessary control stations. One manually operated call point shall be located at each exit from these spaces and from areas of major fire hazard.

**7.7.1.1 General requirements**

**.1** Any required fixed fire-detection and fire alarm system with manually operated call points shall be capable of immediate operation at all times.

**.2** Power supplies and electric circuits necessary for the operation of the system shall be monitored for loss of power or fault conditions as appropriate. Occurrence of a fault condition shall initiate a visual and audible fault signal at the control panel which shall be distinct from a fire signal.

**.3** There shall be not less than two sources of power supply for the electrical equipment used in the operation of the fixed fire-detection and fire alarm system, one of which shall be an emergency source. The supply shall be provided by separate feeders reserved solely for that purpose. Such feeders shall run to an automatic change-over switch situated in or adjacent to the control panel for the fire-detection system.

**.4** Detectors and manually operated call points shall be grouped into sections. The activation of any detector or manually operated call point shall 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 shall 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.

**.5** The control panel shall be located in the operating compartment or in the main fire control station.

**.6** Indicating units shall, as a minimum, denote the section in which a detector or manually operated call point has operated. At least one unit shall 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 shall be located in the operating compartment if the control panel is located in the space other than the operating compartment.

**.7** Clear information shall be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

**.8** 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 control stations shall normally be permitted 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 shall be limited as determined by the Administration. In no case shall more than 50 enclosed spaces 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.

**.9** In passenger craft, if there is no fire-detection system capable of remotely and individually identifying each detector, a section of detectors shall not serve spaces on both sides of the craft nor on more than one deck and neither shall it be situated in more than one zone according to 7.11.1 except that the Administration, if it is satisfied that the protection of the craft against fire will not thereby be reduced, may permit such a section of detectors to serve both sides of the craft and more than one deck. In passenger craft fitted with individually identifiable fire detectors, a section may serve spaces on both sides of the craft and on several decks.

**.10** A section of fire detectors which covers a control station, a service space, a public space, crew accommodation, corridor or stairway enclosure shall not include a machinery space of major fire hazard.

**.11** Detectors shall 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 by the Administration provided that they are no less sensitive than such detectors. Flame detectors shall only be used in addition to smoke or heat detectors.

**.12** Suitable instructions and component spares for testing and maintenance shall be provided.

**.13** The function of the detection system shall 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 shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

**.14** The fire-detection system shall not be used for any other purpose, except that closing of fire doors and similar functions may be permitted at the control panel.

**.15** Fire-detection systems with a zone address identification capability shall be so arranged that:

- .1** a loop cannot be damaged at more than one point by a fire;
- .2** means are provided to ensure that any fault (e.g., power break; short circuit; earth) occurring in the loop shall render the whole loop ineffective;
- .3** all arrangements are made to enable the initial configuration of the system to be restored in the event of failure (electrical, electronic, informatic); and
- .4** the first initiated fire alarm shall not prevent any other detector to initiate further fire alarms.

**7.7.1.2 Installation requirements**

**.1** In addition to 7.7.1, manually operated call points shall 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.

**.2** 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 7.7.1.1.11 shall be installed in each such space.

**.3** Detectors shall 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 shall be avoided. In general, detectors which are located on the overhead shall be a minimum distance of 0.5 m away from bulkheads.

**.4** The maximum spacing of detectors shall be in accordance with Table 7.7.1.2.4. The Administration may require or permit other spacings based upon test data which demonstrate the characteristics of the detectors.

**Table 7.7.1.2.4**

Type of detector	Maximum floor area per detector	Maximum distance apart between centre	Maximum distance away from bulkheads
Heat	37 m <sup>2</sup>	9 m	4.5 m
Smoke	74 m <sup>2</sup>	11 m	5.5 m

**.5** Electrical wiring which forms parts of the system shall 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.

**7.7.1.3 Design requirements**

**.1** The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships.

**.2** Smoke detectors shall 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 shall operate within sensitivity limits to the satisfaction of the Administration having regard to the avoidance of detector insensitivity or over-sensitivity.

**.3** Heat detectors shall 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 shall operate within temperature limits having regard to the avoidance to detector insensitivity or over-sensitivity.

**.4** At the discretion of the Administration, the permissible temperature of operation of heat detectors may be increased to 30°C above the maximum deckhead temperature in drying rooms and similar spaces of a normal high ambient temperature.

**.5** Flame detectors corresponding to 7.7.1.1.11 shall have a sensitivity sufficient to determine flame against an illuminated space background and a false signal identification system.

**7.7.2 Fire detection for periodically unattended machinery spaces**

A fixed fire-detection and fire alarm system for periodically unattended machinery spaces shall comply with the following requirements:

**.1** The fire-detection system shall 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 systems using only thermal detectors shall not be permitted. The detection system shall 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 shall sound in a place where a responsible member of the crew is on duty.

**.2** After installation, the system shall be tested under varying conditions of engine operation and ventilation.

**7.7.3 Fixed fire-extinguishing systems**

**7.7.3.1** Areas of major fire hazard shall be protected by an approved fixed fire-extinguishing system operable from the control position which is adequate for the fire hazard that may exist. The system shall comply with 7.7.3.2 and 7.7.3.3 or with alternative arrangements approved by the Administration taking into account the recommendations and guidelines developed by the Organization and be capable of local manual control and remote control from the continuously manned control stations.

Note: Refer to MSC/Circ.668 –Alternative arrangements for halon fire-extinguishing systems in machinery spaces and pump-rooms, and amendments thereto contained in MSC/Circ.728 –Revised test method for equivalent water-based fire extinguishing systems for machinery spaces of category A and cargo pump-rooms contained



in MSC/Circ.668; and to MSC/Circ.848 –Revised Guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump-rooms.

### 7.7.3.2 General requirements

**.1** In all craft where gas is used as the extinguishing medium, the quantity of gas shall be sufficient to provide two independent discharges. The second discharge into the space shall only be activated manually from a position outside the space being protected. Where the space has a local fire-suppression system installed, based on the guidelines developed by the Organization, to protect fuel oil, lubricating oil 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 required.

*Note: Refer to the Guidelines for the approval of water-based local application of fixed fire-suppression systems, to be developed by the Organization.*

**.2** The use of a fire-extinguishing medium which, in the opinion of the Administration, 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 shall not be permitted.

**.3** The necessary pipes for conveying fire-extinguishing medium into protected spaces shall be provided with control valves so marked as to indicate clearly the spaces to which the pipes are led. Non-return valves shall be installed in discharge lines between cylinders and manifolds. Suitable provision shall be made to prevent inadvertent admission of the medium to any space.

**.4** The piping for the distribution of fire-extinguishing medium shall be arranged and discharge nozzles so positioned that a uniform distribution of medium is obtained.

**.5** Means shall be provided to close all openings which may admit air to, or allow gas to escape from, a protected space.

**.6** Where the volume of free air contained in air receivers in any space is such that, if released in such space in the event of fire, such release of air within that space would seriously affect the efficiency of the fixed fire-extinguishing system, the Administration shall require the provision of an additional quantity of fire-extinguishing medium.

**.7** Means shall be provided for automatically giving audible warning of the release of fire-extinguishing medium into any space in which personnel normally work or to which they have access. The alarm shall operate for a suitable period before the medium is released, but not less than 20 s. Visible alarm shall be arranged in addition to the audible alarm.

**.8** The means of control of any fixed gas fire-extinguishing system shall be readily accessible and simple to operate and shall 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 shall be clear instructions relating to the operation of the system, having regard to the safety of personnel.

**.9** Automatic release of fire-extinguishing medium shall not be permitted.

**.10** 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.

**.11** Pressure containers required for the storage of fire-extinguishing medium shall be located outside protected spaces in accordance with 7.7.3.2.14. Pressure containers may be located inside the space to be protected if in the event of accidental release persons will not be endangered.

**.12** Means shall be provided for the crew to safely check the quantity of medium in the containers.

**.13** Containers for the storage of fire-extinguishing medium and associated pressure components shall be designed having regard to their locations and maximum ambient temperatures expected in service.

**.14** When the fire-extinguishing medium is stored outside a protected space, it shall be stored in a room which shall be situated in a safe and readily accessible position and shall be effectively ventilated. Any entrance to such a storage room shall preferably be from the open deck and in any case shall be independent of the protected space. Access doors shall 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, shall be gas tight. Such storage rooms shall be treated as control rooms.

**.15** Spare parts for the system shall be stored on board or at a base port.

**.16** If the release of a fire extinguishing medium produces significant over or under pressurisation in the protected space, means shall be provided to limit the induced pressures to acceptable limits to avoid structural damage.

### C7.7.3.2

**(a)** With reference to 7.7.3.2.10, see also the requirements of 7.7.3.2.1.

**(b)** With reference to C7.7.3.2.13, the Rules of the Society apply.

(c) With reference to 7.7.3.2.14, storage rooms are to be provided with a mechanical ventilation system, capable of effecting at least 15 air changes per hour; if such rooms have a direct door access to open deck, natural ventilation may be sufficient.

### 7.7.3.3 Carbon dioxide systems

.1 For cargo spaces, the quantity of carbon dioxide available shall, unless otherwise provided, 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.

.2 For machinery spaces, the quantity of carbon dioxide carried shall be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

.2.1 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

.2.2 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 2,000 gross tonnage; provided also that if two or more machinery spaces are not entirely separate they shall be considered as forming one space.

.3 For the purpose of this paragraph the volume of free carbon dioxide shall be calculated at 0.56 m<sup>3</sup>/kg.

.4 For machinery spaces, the fixed piping system shall be such that 85% of the gas can be discharged into the space within 2 min.

.5 Two separate controls shall be provided for releasing carbon dioxide into a protected space and to ensure the activation of the alarm. One control shall be used to discharge the gas from its storage containers. A second control shall be used for opening the valve of the piping which conveys the gas into the protected spaces.

.6 The two controls shall 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 shall be in a break-glass type enclosure conspicuously located adjacent to the box.

### 7.7.4 Portable fire extinguishers

Control stations, public spaces, crew accommodation, corridors and service spaces shall be provided with portable fire extinguishers of approved type and design. At least five portable extinguishers shall be provided, and so positioned, as to be readily available for immediate use. In addition, at least one extinguisher suitable for machinery space fires shall be positioned outside each machinery space entrance.

C7.7.4 In the vicinity of the main switchboard and of any electrical panel of 20 kW or more, at least one portable carbon dioxide fire extinguisher or equivalent are to be provided.

### 7.7.5 Fire pumps, fire mains, hydrants and hoses

Fire pumps, and appropriate associated equipment, or alternative effective fire-extinguishing systems shall be fitted as follows:

.1 At least two independently driven pumps shall be arranged. Each pump shall have at least two-thirds the capacity of a bilge pump as determined by 10.3.5 and 10.3.6 but not less than 25 m<sup>3</sup>/h. Each fire pump shall be able to deliver sufficient quantity and pressure of water to simultaneously operate the hydrants as required by .

.2 The arrangement of the pumps shall be such that in the event of a fire in any one compartment, all the fire pumps will not be put out of action.

.3 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 shall be fitted in an easily accessible and tenable position outside the machinery spaces. The fire main shall 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. The spindles of manually operated valves shall be easily accessible and all valves shall be clearly marked.

.4 Hydrants shall be so 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 shall 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.

**.5** Each fire hose shall be of non-perishable material and have a maximum length approved by the Administration. Fire hoses, together with any necessary fittings and tools, shall be kept ready for use in conspicuous positions near the hydrants. All fire hoses in interior locations shall be connected to the hydrants at all times. One fire hose shall be provided for each hydrant as required by .4.

**.6** Each fire hose shall be provided with a nozzle of an approved dual purpose type (i.e. spray/jet type) incorporating a shutoff.

**C7.7.5** With reference to 7.7.5.1, the sufficient quantity of water is to be delivered with a discharge pressure at the nozzles of at least:

- 0,3 N/mm<sup>2</sup> for cargo craft and passenger craft of less than 4000 tons GT,
- 0,4 N/mm<sup>2</sup> for passenger craft of 4000 tons GT and above.

With reference to 7.7.5.5, the maximum length is to be 20 m.

#### **7.7.6 Protection of deep-fat cooking equipment**

Where deep-fat cooking equipment is installed, all such installations shall be fitted with:

**.1** an automatic or manual fixed extinguishing system tested to an appropriate standard acceptable to the Organization;

*Note: Refer to ISO 15371–Ships and marine technology–Fire-extinguishing systems for protection of galley deep-fat cooking equipment–Fire tests.*

**.2** a primary and back up thermostat with an alarm to alert the operator in the event of failure of either thermostat;

**.3** arrangements for automatically shutting off the electrical power to the deep-fat cooking equipment upon activation of the extinguishing system;

**.4** an alarm for indicating operation of the extinguishing system in the galley where the equipment is installed; and

**.5** controls for manual operation of the extinguishing system which are clearly labelled for ready use by the crew.

### **7.8 Protection of special category spaces and ro-ro spaces**

#### **7.8.1 Structural protection**

**7.8.1.1** Boundaries of special category spaces shall be insulated in accordance with tables 7.4-1 and 7.4-2. The standing deck of a special category space or a ro-ro space need only be insulated on the underside if required.

**7.8.1.2** Indicators shall be provided on the navigating bridge which shall indicate when any door leading to or from the special category space or ro-ro space is closed.

**7.8.1.3** Fire doors in boundaries of special category spaces leading to spaces below the vehicle deck shall be arranged with coamings of a height of at least 100 mm.

#### **7.8.2 Fixed fire-extinguishing system**

Each special category space and ro-ro space shall be fitted with an approved fixed pressure water-spraying system for manual operation which shall protect all parts of any deck and vehicle platform in such space, provided that the Administration 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 the space to be not less effective in controlling fires likely to occur in such a space.

#### **7.8.3 Patrols and detection**

**7.8.3.1** A continuous fire patrol shall be maintained in special category spaces and ro-ro spaces unless a fixed fire detection and fire alarm system, complying with the requirements of 7.7.1, and a television surveillance system are provided. The fixed fire detection system shall be capable of rapidly detecting the onset of fire. The spacing and location of detectors shall be tested taking into account the effects of ventilation and other relevant factors.

**C7.8.3.1** A fixed fire detection and alarm system, complying with the requirements of 7.7.1, and also a television surveillance system are to be provided.

**7.8.3.2** Manually operated call points shall be provided as necessary throughout the special category spaces and ro-ro spaces and one shall be placed close to each exit from such spaces. Manually operated call points shall be spaced so that no part of the space shall be more than 20 m from a manually operated call point.

**7.8.4 Fire-extinguishing equipment**

**7.8.4.1** There shall be provided in each special category space and ro-ro space:

- .1** at least three water fog applicators;
- .2** 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 20l of foam-making liquid and one spare tank. The nozzle shall be capable of producing effective foam suitable for extinguishing an oil fire of at least 1.5 m<sup>3</sup>/min. At least two portable foam applicator units shall be available in the craft for use in such space; and
- .3** portable fire extinguishers of approved type and design shall be located so 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.

**7.8.5 Ventilation system**

**7.8.5.1** There shall be provided an effective power ventilation system 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 quay-side during vehicle loading and unloading operations. The system for such spaces shall be entirely separated from other ventilation systems and shall be operating at all times when vehicles are in such spaces. Ventilation ducts serving special category spaces and ro-ro spaces capable of being effectively sealed shall be separated for each such space. The system shall be capable of being controlled from a position outside such spaces.

**7.8.5.2** The ventilation shall be such as to prevent air stratification and the formation of air pockets.

**7.8.5.3** Means shall be provided to indicate in the operating compartment any loss or reduction of the required ventilating capacity.

**7.8.5.4** Arrangements shall 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.

**7.8.5.5** Ventilation ducts, including dampers, shall be made of steel or other equivalent material. Ducts lying inside the served space may be made of non-combustible or fire-restricting material.

**7.8.6 Scuppers, bilge pumping and drainage**

**7.8.6.1** 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, scuppers shall be fitted so as to ensure that such water is rapidly discharged directly overboard. Alternatively, pumping and drainage facility shall be provided additional to the requirements of Section 10. 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.

**C7.8.6.1** Unless justificatory calculations are submitted, scuppers at least 150 mm in diameter are to be fitted every 9 m on both sides.

**7.8.7 Precautions against ignition of flammable vapours or liquids**

**7.8.7.1** 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, shall be installed at least 450 mm above the deck or platform. Electrical equipment installed at more than 450 mm above the deck or platform shall be of a type so enclosed and protected as to prevent the escape of sparks. However, if the installation of electrical equipment and wiring at less than 450 mm above the deck or platform is necessary for the safe operation of the craft, such electrical equipment and wiring may be installed provided that it is of a type approved for use in an explosive mixture of petrol and air.

**7.8.7.2** Electrical equipment and wiring, if installed in an exhaust ventilation duct, shall be of a type approved for use in explosive mixtures of petrol and air and the outlet from any exhaust duct shall be sited in a safe position, having regard to other possible sources of ignition.

**7.8.7.3** If pumping and drainage arrangements are provided, it shall be ensured that:

- .1** 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
- .2** electrical equipment fitted in tanks or other components of the drainage system shall be of a type suitable for use in explosive petrol/air mixtures.

**7.8.8 Open ro-ro spaces**

**7.8.8.1** Open ro-ro spaces shall comply with the requirements set out in 7.8.1.1, 7.8.2, 7.8.3, 7.8.4 and 7.8.6.

**7.8.8.2** For those parts of a ro-ro space which are completely open from above, the requirements set out in 7.8.2, 7.8.3.1 and 7.8.6 need not be complied with. However, a continuous fire patrol or a television surveillance system shall be maintained.

## 7.9 Miscellaneous

**7.9.1** There shall be permanently exhibited, for the guidance of the master and officers of the craft, fire control plans 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 7.5.3, 7.6.2, 7.7.1 and 7.7.3.1. The text of such plans shall be in the official language of the flag state. However, if the language is not English, French or Spanish, a translation into one of those languages shall be included.

*Note: Refer to Graphical Symbols for Fire Control Plans, adopted by the Organization by resolution A.654(16).*

**7.9.2** A duplicate set of fire control plans or a booklet containing such plans shall be permanently stored in a prominently marked weathertight enclosure outside the deckhouse for the assistance of shore-side fire-fighting personnel.

### 7.9.3 Openings in fire resisting divisions

**7.9.3.1** Except for any hatches between cargo, special category, ro-ro, store, and baggage spaces and between such spaces and the weather decks, all openings shall be provided with permanently attached means of closing which shall be at least as effective for resisting fires as the divisions in which they are fitted.

**7.9.3.2** It shall be possible for each door to be opened and closed from each side of the bulkhead by one person only.

**7.9.3.3** Fire doors bounding areas of major fire hazard and stairway enclosures shall satisfy the following requirements:

**.1** The doors shall be self-closing and be capable of closing with an angle of inclination of up to 3.5°

opposing closure. The approximate time of closure for hinged fire doors shall be no more than 40 s and no less than 10 s from the beginning of their movement 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.

**.2** Remote released sliding or power-operated doors shall be equipped with an alarm that sounds at least 5 s but no more than 10 s after the door is released from the continuously manned control station and before the door begins to move and continue sounding until the door is completely closed. Doors designed to reopen upon contacting an object in their paths shall re-open no more than 1 m from the point of contact.

**.3** All doors shall be capable of remote release from a continuously manned central control station, either simultaneously or in groups, and shall be capable of release also individually from a position at both sides of the door. Indication shall be provided at the fire door indicator panel in the continuously manned control station whether each of the remote released doors is closed. The release mechanism shall be so designed that the door will automatically close in the event of disruption of the control system or main source of electrical power. Release switches shall have an on-off function to prevent automatic resetting of the system. Hold-back hooks not subject to continuously manned control station release shall be prohibited.

**.4** A door closed remotely from the continuously manned control station shall be capable of being reopened at both sides of the door by local control. After such local opening, the door shall automatically close again.

**.5** Local power accumulators for power-operated doors shall be provided in the immediate vicinity of the doors to enable the doors to be operated after disruption of the control system or main source of electric power at least ten times (fully opened and closed) using the local controls.

**.6** Disruption at one door of the control system or main source of electric power shall not impair the safe functioning of the other doors.

**.7** Double-leaf doors equipped with a latch necessary to their fire integrity shall have a latch that is automatically activated by the operation of the doors when released by the system.

**.8** 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 .2 and .3.

**.9** The components of the local control system shall be accessible for maintenance and adjusting.

**.10** Power operated doors shall be provided with a control system of an approved type which shall be able to operate in case of fire, this being determined in accordance with the Fire Test Procedures Code. This system shall satisfy the following requirements:

- .1** the control system shall be able to operate at a temperature of at least 200°C for at least 60 min, served by the power supply;
- .2** the power supply for all other doors not subject to fire shall not be impaired; and
- .3** at temperatures exceeding 200°C the control system shall be automatically isolated from the power supply and shall be capable of keeping the door closed up to at least 945°C.

**7.9.3.4** The requirements for integrity of fire-resisting divisions of the outer boundaries facing open spaces of a craft shall not apply to glass partitions, windows and side scuttles. Similarly, the requirements for integrity of fire-resisting divisions facing open spaces shall not apply to exterior doors in superstructures and deck houses.

**7.9.3.5** Doors in smoke-tight divisions shall be self-closing. Doors which are normally kept open shall close automatically or by remote control from a continuously manned control station.

## **7.10 Firefighter's outfits**

**7.10.1** All craft other than category A passenger craft shall carry at least two firefighter's outfits complying with the requirements of 7.10.3.

**7.10.1.1** In addition, there shall be provided in category B passenger craft 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 comprising the items stipulated in 7.10.3.1.1 to 7.10.3.1.3.

**7.10.1.2** In category B passenger craft, for each pair of breathing apparatuses there shall be provided one water fog applicator, which shall be stored adjacent to such apparatus.

**7.10.1.3** The Administration may require additional sets of personal equipment and breathing apparatus, having due regard to the size and type of the craft.

**7.10.2** The firefighter's outfits or sets of personal equipment shall be so stored as to be easily accessible and ready for use and, where more than one firefighter's outfit or more than one set of personal equipment is carried, they shall be stored in widely separated positions.

**7.10.3** A firefighter's outfit shall consist of:

- .1** Personal equipment comprising:
  - .1.1** 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 shall be water-resistant;
  - .1.2** boots and gloves of rubber or other electrically non-conductive material;
  - .1.3** a rigid helmet providing effective protection against impact;
  - .1.4** an electric safety lamp (hand lantern) of an approved type with a minimum burning period of 3 h; and
  - .1.5** an axe.

**.2** A breathing apparatus of an approved type which may be either:

- .2.1** a smoke helmet or smoke mast, which shall be provided with a suitable air pump and a length of air hose sufficient to reach from the open deck, well clear of hatch or doorway, to any part of the holds or machinery spaces. If, in order to comply with this subparagraph, an air hose exceeding 36 m in length would be necessary, a self-contained breathing apparatus shall be substituted or provided in addition, as determined by the Administration; or
- .2.2** a self-contained compressed-air-operated breathing apparatus, the volume of air contained in the cylinders of which shall be at least 1,200l, or other self-contained breathing apparatus, which shall be capable of functioning for at least 30 min. A number of spare charges, suitable for use with the apparatus provided, shall be available on board.

**.3** For each breathing apparatus a fireproof lifeline of sufficient length and strength shall 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.

## **Part B** Requirements for passenger craft

### **7.11 Arrangement**

**7.11.1** For category B craft, the public spaces shall be divided into zones according to the following:

**.1** The craft shall be divided into at least two zones. The mean length of each zone shall not exceed 40 m.

**.2** For the occupants of each zone there shall be an alternative safe area to which it is possible to escape in case of fire. The alternative safe area shall 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 shall be dimensioned on the basis of one person per seat and 0.35 m<sup>2</sup> per person of the net remaining area, based on the maximum number of persons they are called to accommodate in an emergency.

**.3** The alternative safe area shall, as far as practicable, be located adjacent to the passenger zone it is intended to serve. There shall 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 shall be provided to enable all passengers and crew to be safely evacuated from the alternative safe area.

**7.11.2** Category A craft need not be divided into zones.

**7.11.3** Control stations, stowage positions of life-saving appliances, escape routes and places of embarkation into survival craft shall not, as far as practicable, be located adjacent to any areas of major or moderate fire hazard.

### **7.12 Ventilation**

Each safe zone in the public spaces shall 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 shall also be capable of being independently controlled from a continuously manned control station.

### **7.13 Fixed sprinkler system**

**7.13.1** Public spaces and service spaces, crew accommodation areas where sleeping berths are provided, storage rooms other than those containing flammable liquids, and similar spaces shall be protected by a fixed sprinkler system based on the standards developed by the Organization. Manually operated sprinkler systems shall be divided into sections of appropriate size and the valves for each section, start of sprinkler pump(s) and alarms shall be capable of being operated from two spaces separated as widely as possible, one of which shall be a continuously manned control station (see note). In category B craft, no section of the system shall serve more than one of the zones required in 7.11.

Note: Refer to the Standards for fixed sprinkler systems for high speed craft, adopted by the Organization by resolution MSC.44(65), as may be amended.

**7.13.2** Plans of the system shall be displayed at each operating station. Suitable arrangements shall be made for the drainage of water discharged when the system is activated.

**7.13.3** Category A craft need not comply with the requirements of 7.13.1 and 7.13.2 providing 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 operational speed from departure port to destination when fully laden does not exceed 2 h.

**Part C Requirements for cargo craft****7.14 Control stations**

*Control stations, life-saving appliances stowage positions, escape routes and places of embarkation into survival craft shall be located adjacent to crew accommodation areas.*

**7.15 Cargo spaces**

*Cargo spaces, except open deck areas or refrigerated holds, shall be provided with an approved automatic smoke-detection system complying with 7.7.1 to indicate at the control station the location of outbreak of a fire in all normal operating conditions of the installations and shall be protected by an approved fixed quick-acting fire-extinguishing system complying with 7.7.3.2 operable from the control station.*

**7.16 Fixed sprinkler system**

**7.16.1** *Crew accommodation where sleeping berths are provided, having a total deck area greater than 50 m<sup>2</sup> (including corridors serving such accommodation), shall be protected by a fixed sprinkler system based on the standards developed by the Organization (see note).*

*Note: Refer to the Standards for fixed sprinkler systems for high speed craft, adopted by the Organization by resolution MSC.44(65), as may be amended.*

**7.16.2** *Plans of the system shall be displayed at each operating station. Suitable arrangements shall be made for the drainage of water discharged when the system is activated.*



## **Part D** Requirements for craft and cargo spaces intended for the carriage of dangerous goods (see note 1)

### **7.17 General**

**7.17.1** In addition to complying with the requirements of paragraph 7.15 for cargo craft and with the requirements of paragraph 7.8 for both passenger and cargo craft as appropriate, craft types and cargo spaces referred to in 7.17.2 intended for the carriage of dangerous goods shall comply with the requirements of this paragraph, as appropriate, except when carrying dangerous goods in limited quantities, unless such requirements have already been met by compliance with the requirements elsewhere in this Section (see note 2). The types of craft and modes of carriage of dangerous goods are referred to in 7.17.2 and in table 7.17-1, where the numbers appearing in 7.17.2 are referred to in the top line. Cargo craft of less than 500 gross tonnage constructed on or after 1 July 2002 shall comply with this paragraph, but the Administration of the State whose flag the craft is entitled to fly may, in consultation with the port State, reduce the requirements and such reduced requirements shall be recorded in the document of compliance referred to in 7.17.4.

**Note 1 :** 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.

**Note 2 :** Refer to Chapter 3.4 of the International Maritime Dangerous Goods Code (IMDG Code) for the provisions on the carriage of "limited quantities".

### **7.17.2 Application of tables 7.17-1 and 7.17-2**

The following craft types and cargo spaces shall govern the application of tables 7.17-1 and 7.17-2:

- .1** craft and cargo spaces not specifically designed for the carriage of 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;
- .3** craft and ro-ro spaces intended for the carriage of dangerous goods; and
- .4** craft and cargo spaces intended for the carriage of solid dangerous goods in bulk.

### **7.17.3 Requirements**

Unless otherwise specified the following requirements shall govern the application of tables 7.17-1, 7.17-2 and 7.17-3

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.

#### **7.17.3.1 Water supplies**

**7.17.3.1.1** Arrangements shall 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.

**7.17.3.1.2** The quantity of water delivered shall be capable of supplying four nozzles of a size and at a pressure as specified in 7.7.5, 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 the Administration.

**7.17.3.1.3** Means of effectively cooling the designated under deck cargo-space by copious quantities of water, either by a fixed arrangement of spraying nozzles, or flooding the space with water, shall be provided. Hoses may be used for this purpose in small cargo spaces and in small areas of larger cargo-spaces at the discretion of the Administration. In any event the drainage and pumping arrangements shall 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 shall be taken into account.

**7.17.3.1.4** Provision to flood a designated under deck cargo-space with suitable specified media may be substituted for the requirements in 7.17.3.1.3 above.

#### **7.17.3.2 Sources of ignition**

Electrical equipment and wiring shall not be fitted in enclosed cargo spaces, unless it is essential for operational purposes. However, if electrical equipment is fitted in such spaces, it shall 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) (see note). Cable penetrations of the decks and bulkheads shall be sealed against the passage of gas or vapour. Through runs of cables and cables within the cargo spaces shall be protected against damage from impact. Any other equipment which may constitute a source of ignition of flammable vapour shall not be permitted.

*Note:* Refer to IEC publication 92-506 Electrical installations in ships Part 506: Special features-Ships carrying specific dangerous goods and materials hazardous only in bulk and IEC 79-Electrical apparatus for explosive gas atmospheres.

**Table 7.17-1 - Application of the requirements of 7.17.3 to different modes of carriage of dangerous goods in craft and cargo spaces**

Section 7.17.2  Section 7.17.3	Weather decks .1 to .4 inclusive	7.17.2.1	7.17.2.2	7.17.2.3		7.17.2.4
		Not specifically designed	Container cargo spaces	Ro-ro spaces	Open ro-ro spaces	Solid dangerous goods in bulk
7.17.3.1.1	x	x	x	x	x	For application of require- ments of Part D to different classes of dan- gerous goods, see table 7.17-2
7.17.3.1.2	x	x	x	x	x	
7.17.3.1.3	–	x	x	x	x	
7.17.3.1.4	–	x	x	x	x	
7.17.3.2	–	x	x	x	x	
7.17.3.3	–	x	x	x	–	
7.17.3.4.1	–	x	x (1)	x	–	
7.17.3.4.2	–	x	x (1)	x	–	
7.17.3.5	–	x	x	x	–	
7.17.3.6.1	x	x	x	x	x	
7.17.3.6.2	x	x	x	x	x	
7.17.3.7	x	x	–	–	x	
7.17.3.8.1	–	x	x	x	–	
7.17.3.8.2	–	–	–	x (2)	x	
7.17.3.9	–	–	–	x	x	
7.17.3.10	x	–	–	x	x	
<p>(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. For the purpose of this requirement a portable tank is a closed freight container.</p> <p>(2) Applies only to ro-ro spaces, not capable of being sealed.</p> <p>Note: 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 7.17-3, except as indicated by the notes.</p>						

**Table 7.17-2 - Application of the requirements of 7.17.3 to different classes of dangerous goods for craft and cargo spaces solid dangerous goods in bulk**

Section	Class	4.1	4.2	4.3 (3)	5.1	6.1	8	9
7.17.3.1.1		x	x	–	x	–	–	x
7.17.3.1.2		x	x	–	x	–	–	x
7.17.3.2		x	x (4)	x	x (5)	–	–	x (5)
7.17.3.4.1		–	x (4)	x	–	–	–	–
7.17.3.4.2		x (6)	x (4)	x	x (4) (6)	–	–	x (4) (6)
7.17.3.4.3		x	x	x	x	x	x	x
7.17.3.6		x	x	x	x	x	x	x
<p>(3) The hazards of substances in this Class which may be carried in bulk are such that special consideration must be given by the Administration to the construction and equipment of the craft involved in addition to meeting the requirements enumerated in this Table.</p> <p>(4) Only applicable to Seedcake containing solvent extractions, to Ammonium nitrate and to Ammonium nitrate fertilizers.</p> <p>(5) 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.</p> <p>(6) Only suitable wire mesh guards are required.</p>								

Table 7.17-3 - Application of the requirements of section 7.17.3 to different classes of dangerous goods except solid dangerous goods in bulk

Class	1.1-1.6 (8)	1.4 S	2.1	2.2	2.3	3.1, 3.2 liquids ≤23 °C (11)	3.3 liquids >23 °C (11) ≤61 °C	4.1	4.2	4.3	5.1 (9)	5.2	6.1 liquids	6.1 liquids ≤23 °C (11)	6.1 liquids ≤23 °C (11) ≤61 °C	6.1 solids	8 liquids	8 liquids ≤23 °C (11)	8 liquids ≤23 °C (11) ≤61 °C	8 solids	9
Section																					
7.17.3.1.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7.17.3.1.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
7.17.3.1.3	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.17.3.1.4	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.17.3.2	X	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.17.3.3	X	X	X	X	X	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	-
7.17.3.4.1	-	-	X	-	X	X	-	X (7)	X (7)	X	X (7)	-	-	-	X	X (7)	-	X	X	-	X (7)
7.17.3.4.2	-	-	X	-	-	X	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-
7.17.3.5	-	-	-	-	-	X	-	-	-	-	-	-	X	X	X	-	-	-	-	-	-
7.17.3.6	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X (10)	-
7.17.3.7	-	-	-	-	-	X	X	X	X	X	X	-	X	X	X	-	-	X	-	-	-
7.17.3.8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7.17.3.9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7.17.3.10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

(7) When "mechanically-ventilated spaces" are required by the International Maritime Dangerous Goods Code (IMDG Code), as amended.

(8) Stow 3 m horizontally away from the machinery space boundaries in all cases.

(9) Refer to the International Maritime Dangerous Goods Code.

(10) As appropriate to the goods being carried.

(11) Refer to flashpoint.

**7.17.3.3 Detection system**

Enclosed cargo spaces shall be provided with an approved automatic smoke detection system complying with 7.7.1 or with a detection system which, in the opinion of the Administration gives equivalent protection.

**7.17.3.4 Ventilation**

**7.17.3.4.1** Adequate power ventilation shall be provided in enclosed spaces. The arrangement shall 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.

**7.17.3.4.2** The fans shall be such as to avoid the possibility of ignition of flammable gas air mixtures. Suitable wire mesh guards shall be fitted over inlet and outlet ventilation openings.

**7.17.3.4.3** Natural ventilation shall be provided in enclosed spaces intended for the carriage of solid dangerous goods in bulk, where there is no provision for mechanical ventilation.

**7.17.3.5 Bilge pumping**

Where it is intended to carry flammable or toxic liquids in enclosed spaces, the bilge pumping system shall 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 shall be given to the provision of additional means of draining those spaces.

**7.17.3.6 Personnel protection**

**7.17.3.6.1** Four sets of full protective clothing resistant to chemical attack shall be provided in addition to the fire-fighter's outfits required by 7.10. The protective clothing shall cover all skin, so that no part of the body is unprotected.

**7.17.3.6.2** At least two self-contained breathing apparatuses additional to those required by 7.10 shall be provided.

**7.17.3.7 Portable fire extinguishers**

Portable fire extinguishers with a total capacity of at least 12 kg of dry powder or equivalent shall be provided for the cargo spaces. These extinguishers shall be in addition to any portable fire extinguishers required elsewhere in this Section.

**7.17.3.8 Fixed fire extinguishing system**

**7.17.3.8.1** Cargo spaces, except for open decks, shall be provided with an approved fixed fire extinguishing system complying with the provisions of 7.7.3 or with a fire extinguishing system which, in the opinion of the Administration, gives equivalent protection for the cargo carried.

*Note:* For cargoes for which a fixed gas fire extinguishing system is ineffective, refer to the List of cargoes in table 2 of MSC/Circ. 671.

**7.17.3.8.2** Each open ro-ro space having a deck above it and each ro-ro space not capable of being sealed shall be fitted with an approved fixed pressure water-spraying system for manual operation which shall protect all parts of any deck and vehicle platform in such space, except that the Administration 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 shall 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 shall be taken into account to the extent deemed necessary by the Administration in its approval of the stability information.

**7.17.3.9 Separation between ro-ro spaces and open ro-ro spaces**

A separation shall be provided between a ro-ro space and an adjacent open ro-ro space. The separation shall 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 Part D.

**7.17.3.10 Separation between ro-ro spaces and weather decks**

A separation shall be provided between a ro-ro space and the adjacent weather deck. The separation shall 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 Part D. However, a separation is still required when dangerous goods carried shall be loaded on the weather deck only.

**7.17.4 Document of compliance**

The Administration shall provide the craft with an appropriate document as evidence of compliance of construction and equipment with the requirements of this Part D.

## SECTION 8

## LIFE-SAVING APPLIANCES AND ARRANGEMENTS

**8.1 General and definitions**

**8.1.1** *Life-saving appliances and arrangements shall enable abandonment of the craft in accordance with the requirements of 4.7 and 4.8.*

**8.1.2** *Except where otherwise provided in this Code, the life-saving appliances and arrangements required by this Section shall meet the detailed specifications set out in Chapter III of the Convention and the LSA Code and be approved by the Administration.*

**C8.1.2** Davits and life saving arrangements permanently attached to the hull structure are to be examined by the Society in accordance with the applicable requirements of Chapter III of the Convention and the LSA Code.

**8.1.3** *Before giving approval to life-saving appliances and arrangements, the Administration shall ensure that such life-saving appliances and arrangements:*

**.1** *are tested to confirm that they comply with the requirements of this Section, in accordance with the recommendations of the Organization (see note); or*

**.2** *have successfully undergone, to the satisfaction of the Administration, tests which are substantially equivalent to those specified in those recommendations.*

*Note: Refer to the Revised Recommendation on Testing of Life-Saving Appliances, adopted by the Organization by resolution MSC.81(70).*

**8.1.4** *Before giving approval to novel life-saving appliances or arrangements, the Administration shall ensure that such appliances or arrangements:*

**.1** *provide safety standards at least equivalent to the requirements of this Section and have been evaluated and tested in accordance with the recommendations of the Organization (see note); or*

**.2** *have successfully undergone, to the satisfaction of the Administration, evaluation and tests which are substantially equivalent to those recommendations.*

*Note: Refer to the Code of Practice for the Evaluation, Testing and Acceptance of Prototype Novel Life-Saving Appliances and Arrangements, adopted by the Organization by resolution A.520(13).*

**8.1.5** *Before accepting life-saving appliances and arrangements that have not been previously approved by the Administration, the Administration shall be satisfied that life-saving appliances and arrangements comply with the requirements of this Section.*

**8.1.6** *Except where otherwise provided in this Code, life-saving appliances required by this Section for which detailed specifications are not included in the LSA Code shall be to the satisfaction of the Administration.*

**8.1.7** *The Administration shall require life-saving appliances to be subjected to such production tests as are necessary to ensure that the life-saving appliances are manufactured to the same standard as the approved prototype.*

**8.1.8** *Procedures adopted by the Administration for approval shall also include the conditions whereby approval would continue or would be withdrawn.*

**8.1.9** *The Administration shall determine the period of acceptability of life-saving appliances which are subject to deterioration with age. Such life-saving appliances shall be marked with a means for determining their age or the date by which they shall be replaced.*

**8.1.10** *For the purposes of this Section, unless expressly provided otherwise:*

**.1** *"Detection" is the determination of the location of survivors or survival craft.*

**.2** *"Embarkation ladder" is the ladder provided at survival craft embarkation stations to permit safe access to survival craft after launching.*

**.3** *"Embarkation station" is the place from which a survival craft is boarded. An embarkation station may also serve as an assembly station, provided there is sufficient room, and the assembly station activities can safely take place there.*

**.4** *"Float-free launching" is that method of launching a survival craft whereby the craft is automatically released from a sinking craft and is ready for use.*

**.5** *"Free-fall launching" is that method of launching a survival craft whereby the craft with its complement of persons and equipment on board is released and allowed to fall into the sea without any restraining apparatus.*

**.6** "Immersion suit" is a protective suit which reduces the body heat-loss of a person wearing it in cold water.

**.7** "Inflatable appliance" is an appliance which depends upon non-rigid, gas-filled chambers for buoyancy and which is normally kept uninflated until ready for use.

**.8** "Inflated appliance" is an appliance which depends upon non-rigid, gas-filled chambers for buoyancy and which is normally kept inflated and ready for use at all times.

**.9** "Launching appliance or arrangement" is a means of transferring a survival craft or rescue boat from its stowed position safely to the water.

**.10** "Marine evacuation system (MES)" is an appliance designed to rapidly transfer a large number of persons from an embarkation station by means of a passage to a floating platform for subsequent embarkation into associated survival craft or directly into associated survival craft.

**.11** "Novel life-saving appliance or arrangement" is a life-saving appliance or arrangement which embodies new features not fully covered by the provisions of this Section but which provides an equal or higher standard of safety.

**.12** "Rescue boat" is a boat designed to assist and rescue persons in distress and to marshal survival craft.

**.13** "Retrieval" is the safe recovery of survivors.

**.14** "Retro-reflective material" is a material which reflects in the opposite direction a beam of light directed on it.

**.15** "Survival craft" is a craft capable of sustaining the lives of persons in distress from the time of abandoning the craft.

**.16** "Thermal protective aid" is a bag or suit of waterproof material with low thermal conductance.

## **8.2 Communications**

**8.2.1** Craft shall be provided with the following radio life-saving appliances:

**.1** at least three two-way VHF radiotelephone apparatus shall be provided on every passenger high-speed craft and on every cargo high-speed craft of 500 gross tonnage and upwards. Such apparatus shall conform to performance standards not inferior to those adopted by the Organization (see note 1);

**.2** at least one radar transponder shall be carried on each side of every passenger high-speed craft and of every cargo high-speed craft of 500 gross tonnage and upwards. Such radar transponders shall conform to performance standards not inferior to those adopted by the Organization (see note 2). The radar transponders shall be stowed in such locations that they can be rapidly placed in any one of the liferafts. Alternatively, one radar transponder shall be stowed in each survival craft.

**Note 1 :** Refer to the Recommendation on Performance Standards for Survival Craft Portable Two-Way VHF Radiotelephone Apparatus, adopted by the Organization by resolution A.809(19).

**Note 2 :** Refer to the Recommendation on Performance Standards for Survival Craft Radar Transponders for Use in Search and Rescue Operations, adopted by the Organization by resolution A.802(19).

**8.2.2** Craft shall be provided with the following on-board communications and alarm systems:

**.1** an emergency means comprising either fixed or portable equipment or both for two-way communications between emergency control stations, assembly and embarkation stations and strategic positions on board;

**.2** a general emergency alarm system complying with the requirements of paragraph 7.2.1 of the LSA Code to be used for summoning passengers and crew to assembly stations and to initiate the actions included in the muster list. The system shall be supplemented by a public address system complying with the requirements of paragraph 7.2.2 of the LSA Code, or by other suitable means of communication. The systems shall be operable from the operating compartment.

## **8.2.3 Signalling equipment**

**8.2.3.1** All craft shall be provided with a portable daylight signalling lamp which is available for use in the operating compartment at all times and which is not dependent on the craft's main source of electrical power.

**8.2.3.2** Craft shall be provided with not less than 12 rocket parachute flares, complying with the requirements of paragraph 3.1 of the LSA Code, stowed in or near the operating compartment.

## **8.3 Personal life-saving appliances**

**8.3.1** Where passengers or crew have access to exposed decks under normal operating conditions, at least one lifebuoy on each side of the craft capable of quick release from the control compartment and from a position at or near where it is stowed, shall be provided with a self-igniting light and a self-activating smoke signal. The positioning and securing arrangements of the self-activating smoke signal shall be such that it cannot be released or acti-

vated solely by the accelerations produced by collisions or groundings.

**8.3.2** At least one lifebuoy shall be provided adjacent to each normal exit from the craft and on each open deck to which passengers and crew have access, subject to a minimum of two being installed.

**8.3.3** Lifebuoys fitted adjacent to each normal exit from the craft shall be fitted with buoyant lines of at least 30 m in length.

**8.3.4** Not less than half the total number of lifebuoys shall be fitted with self-igniting lights. However, the lifebuoys provided with self-igniting lights shall not include those provided with lines in accordance with 8.3.3.

**8.3.5** A lifejacket complying with the requirements of paragraph 2.2.1 or 2.2.2 of the LSA Code be provided for every person on board the craft and, in addition:

**.1** a number of lifejackets suitable for children equal to at least 10% of the number of passengers on board shall be provided or such greater number as may be required to provide a lifejacket for each child;

**.2** every passenger craft shall carry lifejackets for not less than 5% of the total number of persons on board. These lifejackets shall be stowed in conspicuous places on deck or at assembly stations;

**.3** a sufficient number of lifejackets shall be carried for persons on watch and for use at remotely located survival craft and rescue boat stations; and

**.4** all lifejackets shall be fitted with a light, which complies with the requirements of paragraph 2.2.3 of the LSA Code.

**8.3.6** Lifejackets shall be so placed as to be readily accessible and their positions shall be clearly indicated.

**8.3.7** An immersion suit, of an appropriate size, complying with the requirements of paragraph 2.3 of the LSA Code shall be provided for every person assigned to crew the rescue boat.

**8.3.8** An immersion suit or anti-exposure suit shall be provided for each member of the crew assigned, in the muster list, to duties in an MES party for embarking passengers into survival craft. These immersion suits or anti-exposure suits need not be required if the craft is constantly engaged on voyages in warm climates where, in the opinion of the Administration, such suits are unnecessary.

## **8.4 Muster list, emergency instructions and manuals**

**8.4.1** Clear instructions to be followed in the event of an emergency shall be provided for each person on board.

Note: Refer to the Guidelines for passenger safety instructions on ro-ro passenger ships (MSC/Circ.681).

**8.4.2** Muster lists complying with the requirements of regulation III/37 of the Convention shall be exhibited in conspicuous places throughout the craft including the control compartment, engine-room and crew accommodation spaces.

**8.4.3** Illustrations and instructions in appropriate languages shall be posted in public spaces and be conspicuously displayed at assembly stations, at other passenger spaces and near each seat to inform passengers of:

**.1** their assembly station;

**.2** the essential actions they must take in an emergency;

**.3** the method of donning lifejackets.

**8.4.4** Every passenger craft shall have passenger assembly stations:

**.1** in the vicinity of, and which provide ready access for all the passengers to, the embarkation stations unless in the same location; and

**.2** which have ample room for the marshalling and instruction of passengers.

**8.4.5** A training manual complying with the requirements of 18.2.3 shall be provided in each crew messroom and recreation room.

## **8.5 Operating instructions**

**8.5.1** Poster or signs shall be provided on or in the vicinity of survival craft and their launching controls and shall:

**.1** illustrate the purpose of controls and the procedures for operating the appliance and give relevant instructions and warnings:

**.2** be easily seen under emergency lighting conditions;

**.3** use symbols in accordance with the recommendations of the Organization (see note).

*Note: Refer to Symbols related to Life-Saving Appliances and Arrangements, adopted by the Organization by resolution A.760(18), as amended by resolution MSC.82(70).*

## **8.6 Survival craft stowage**

**8.6.1** Survival craft shall be securely stowed outside and as close as possible to the passenger accommodation and embarkation stations. The stowage shall be such that each survival craft can be safely launched in a simple manner and remain secured to the craft during and subsequent to the launching procedure. The length of the securing lines and the arrangements of the bowsing lines shall be such as to maintain the survival craft suitably positioned for embarkation. The Administrations may permit the use of adjustable securing and/or bowsing lines at exits where more than one survival craft is used. The securing arrangements for all securing and bowsing lines shall be of sufficient strength to hold the survival craft in position during the evacuation process.

**8.6.2** Survival craft shall be so stowed as to permit release from their securing arrangements at or near to their stowage position on the craft and from a position at or near to the operating compartment.

**8.6.3** So far as is practicable, survival craft shall be distributed in such a manner that there is an equal capacity on both sides of the craft.

**8.6.4** The launching procedure for inflatable liferafts shall, where practicable, initiate inflation. Where it is not practicable to provide automatic inflation of liferafts (for example, when the liferafts are associated with an MES), the arrangement shall be such that the craft can be evacuated within the time specified in 4.8.1.

**8.6.5** Survival craft shall be capable of being launched and then boarded from the designated embarkation stations in all operational conditions and also in all conditions of flooding after receiving damage to the extent prescribed in Section 2.

**8.6.6** Survival craft launching stations shall be in such positions as to ensure safe launching having particular regard to clearance from the propeller or waterjet and steeply overhanging portions of the hull.

**8.6.7** During preparation and launching, the survival craft and the area of water into which it is to be launched shall be adequately illuminated by the lighting supplied from the main and emergency sources of electrical power required by Section 12.

**8.6.8** Means shall be available to prevent any discharge of water on to survival craft when launched.

**8.6.9** Each survival craft shall be stowed:

**.1** so that neither the survival craft nor its stowage arrangements will interfere with the operation of any other survival craft or rescue boat at any other launching station;

**.2** in a state of continuous readiness;

**.3** fully equipped; and

**.4** as far as practicable, in a secure and sheltered position and protected from damage by fire and explosion.

**8.6.10** Every liferaft shall be stowed with its painter permanently attached to the craft and with a float free arrangement complying with the requirements of paragraph 4.1.6 of the LSA Code so that, as far as practicable, the liferaft floats free and, if inflatable, inflates automatically should the high speed craft sink.

**8.6.11** Rescue boats shall be stowed:

**.1** in a state of continuous readiness for launching in not more than 5 min;

**.2** in a position suitable for launching and recovery; and

**.3** so that neither the rescue boat nor its stowage arrangements will interfere with the operation of survival craft at any other launching station.

**8.6.12** Rescue boats and survival craft shall be secured and fastened to the deck so that they at least withstand the loads likely to arise due to a defined horizontal collision load for the actual craft and the vertical design load at the stowage position.

## **8.7 Survival craft and rescue boat embarkation and recovery arrangements**

**8.7.1** Embarkation stations shall be readily accessible from accommodation and work areas. If the designated assembly stations are other than the passenger spaces, the assembly stations shall be readily accessible from the passenger spaces, and the embarkation stations shall be readily accessible from the assembly stations.

**8.7.2** Evacuation routes, exits and embarkation points shall comply with the requirements of 4.7.



**8.7.3** Alleyways, stairways and exits giving access to the assembly and embarkation stations shall be adequately illuminated by lighting supplied from the main and emergency source of electrical power required by Section 12.

**8.7.4** Where davit-launched survival craft are not fitted, MES or equivalent means of evacuation shall be provided in order to avoid persons entering the water to board survival craft. Such MES or equivalent means of evacuation shall be so designed as to enable persons to board survival craft in all operational conditions and also in all conditions of flooding after receiving damage to the extent prescribed in Section 2.

**8.7.5** Subject to survival craft and rescue boat embarkation arrangements being effective within the environmental conditions in which the craft is permitted to operate and in all undamaged and prescribed damage conditions of trim and heel, where the freeboard between the intended embarkation position and the waterline is not more than 1.5 m, the Administration may accept a system where persons board liferafts directly.

**8.7.6** Rescue boat embarkation arrangements shall be such that the rescue boat can be boarded and launched directly from the stowed position and recovered rapidly when loaded with its full complement of persons and equipment.

**8.7.7** Launching systems for rescue boats on category B craft may be based on power supply from the craft's power supply under the following conditions:

**.1** the davit or crane shall be supplied with power from 2 sources in each independent engine room;

**.2** the davit or crane shall comply with the required launching, lowering and hoisting speeds when using only one power source; and

**.3** the davit or crane is not required to be activated from a position within the rescue boat.

**8.7.8** On multihull craft with a small  $HL_1$  angle of heel and trim, the design angles in paragraph 6.1 of the LSA Code may be changed from  $20^\circ / 10^\circ$  to the maximum angles calculated in accordance with annex 7, including heeling lever  $HL_2$ ,  $HTL$ ,  $HL_3$  or  $HL_4$ .

**8.7.9** Rescue boat davits or cranes may be designed for launching and recovering the boat with 3 persons only on the condition that an additional boarding arrangement is available on each side complying with 8.7.5.

**8.7.10** A safety knife shall be provided at each MES embarkation station.

## **8.8 Line-throwing appliance**

A line-throwing appliance complying with the requirements of paragraph 7.1 of the LSA Code shall be provided.

## **8.9 Operational readiness, maintenance and inspections**

### **8.9.1 Operational readiness**

Before the craft leaves port and at all times during the voyage, all life-saving appliances shall be in working order and ready for immediate use.

### **8.9.2 Maintenance**

**.1** Instructions for on-board maintenance of life-saving appliances complying with the requirements of regulation III/36 of the Convention shall be provided and maintenance shall be carried out accordingly.

**.2** The Administration may accept, in lieu of the instructions required by .1, a shipboard planned maintenance programme which includes the requirements of regulation III/36 of the Convention.

### **8.9.3 Maintenance of falls**

**8.9.3.1** Falls used in launching shall be turned end for end at intervals of not more than 30 months and be renewed when necessary due to deterioration of the falls or at intervals of not more than five years, whichever is the earlier.

**8.9.3.2** The Administration may accept in lieu of "end for ending" required in 8.9.3.1, periodic inspection of the falls and their renewal whenever necessary due to deterioration or at intervals of not more than four years, whichever is the earlier.

### **8.9.4 Spares and repair equipment**

Spares and repair equipment shall be provided for life-saving appliances and their components which are subject to excessive wear or consumption and need to be replaced regularly.

### **8.9.5 Weekly inspection**

The following tests and inspections shall be carried out weekly:

**.1** all survival craft, rescue boats and launching appliances shall be visually inspected to ensure that they are ready for use;

**.2** all engines in rescue boats shall be run ahead and astern for a total period of not less than 3 min provided the ambient temperature is above the minimum temperature required for starting and running the engine. During this period of time, it should be demonstrated that the gearbox and gearbox train are engaging satisfactorily. If the special characteristics of an outboard motor fitted to a rescue boat would not allow it to be run other than with its propeller submerged for a period of 3 min, it should be run for such period as prescribed in the manufacturer's hand-book; and

**.3** the general emergency alarm system shall be tested.

#### **8.9.6 Monthly inspections**

Inspection of the life-saving appliances, including survival craft equipment shall be carried out monthly using the checklist required by regulation III/36.1 of the Convention to ensure that they are complete and in good order. A report of the inspection shall be entered in the log-book.

#### **8.9.7 Servicing of inflatable liferafts, inflatable lifejackets, marine evacuation systems and inflated rescue boats**

**8.9.7.1** Every inflatable liferaft, inflatable lifejacket and MES shall be serviced:

**.1** at intervals not exceeding 12 months, provided where in any case this is impracticable, the Administration may extend this period by one month;

**.2** at an approved servicing station which is competent to service them, maintains proper servicing facilities and uses only properly trained personnel.

Note: Refer to the Recommendation on Conditions for the Approval of Servicing Stations for Inflatable Liferafts, adopted by the Organization by resolution A.761(18), as amended by resolution MSC.55(66).

#### **8.9.8 Rotational deployment of marine evacuation systems**

In addition to or in conjunction with the servicing intervals of marine evacuation systems required by 8.9.7.1, each marine evacuation system shall be deployed from the craft on a rotational basis at intervals to be agreed by the Administration provided that each system is to be deployed at least once every six years.

**8.9.9** An Administration which approves new and novel inflatable liferaft arrangements pursuant to 8.1 may allow for extended service intervals under the following conditions:

**8.9.9.1** The new and novel liferaft arrangement shall maintain the same standard, as required by testing procedure, throughout the extended service intervals.

**8.9.9.2** The liferaft system shall be checked on board by certified personnel according to paragraph 8.9.7.1.

**8.9.9.3** Service at intervals not exceeding five years shall be carried out in accordance with recommendations of the Organization.

**8.9.10** All repairs and maintenance of inflated rescue boats shall be carried out in accordance with the manufacturer's instructions. Emergency repairs may be carried out on board the craft, however, permanent repairs shall be effected at an approved servicing station.

**8.9.11** An Administration which permits extension of liferaft service intervals in accordance with 8.9.9 shall notify the Organization of such action in accordance with regulation I/5(b) of the Convention.

#### **8.9.12 Periodic servicing of hydrostatic release units**

Hydrostatic release units shall be serviced:

**.1** at intervals not exceeding 12 months, provided where in any case this is impracticable, the Administration may extend this period by one month;

**.2** at a servicing station which is competent to service them, maintains proper servicing facilities and uses only properly trained personnel.

#### **8.9.13 Marking of stowage locations**

Containers, brackets, racks and other similar stowage locations for life-saving equipment, shall be marked with symbols in accordance with the recommendations of the Organization, indicating the devices stowed in that location for that purpose. If more than one device is stowed in that location, the number of devices shall also be indicated.

#### **8.9.14 Periodic servicing of launching appliances**

**8.9.14.1** Launching appliances:

**.1** shall be serviced at recommended intervals in accordance with instructions for on-board maintenance as required by regulation III/36 of the Convention;

**.2** shall be subjected to a thorough examination at intervals not exceeding 5 years; and

*.3 shall upon completion of the examination in .2 be subjected to a dynamic test of the winch brake in accordance with paragraph 6.1.2.5.2 of the LSA Code.*

## **8.10 Survival craft and rescue boats**

**8.10.1** All craft shall carry:

*.1 survival craft with sufficient capacity as will accommodate not less than 100% of the total number of persons the craft is certified to carry, subject to a minimum of two such survival craft being carried;*

*.2 in addition, survival craft with sufficient aggregate capacity to accommodate not less than 10% of the total number of persons the craft is certified to carry;*

*.3 sufficient survival craft to accommodate the total number of persons the craft is certified to carry, even in the event that all the survival craft to one side of the craft centreline and within the longitudinal extent of damage defined in 2.6.7.1 are considered lost or rendered unserviceable;*

*.4 at least one rescue boat for retrieving persons from the water, but not less than one such boat on each side when the craft is certified to carry more than 450 passengers;*

*.5 craft of less than 30 m in length may be exempted from carrying a rescue boat, provided the craft meets all of the following requirements:*

*.5.1 the craft is arranged to allow a helpless person to be recovered from the water;*

*.5.2 recovery of the helpless person can be observed from the navigating bridge; and*

*.5.3 the craft is sufficiently manoeuvrable to close in and recover persons in the worst intended conditions.*

*.6 notwithstanding the provisions of .4 and .5 above, craft shall carry sufficient rescue boats to ensure that, in providing for abandonment by the total number of persons the craft is certified to carry:*

*.6.1 not more than nine of the liferafts provided in accordance with 8.10.1.1 are marshalled by each rescue boat; or*

*.6.2 if the Administration is satisfied that the rescue boats are capable of towing a pair of such liferafts simultaneously, not more than 12 of the liferafts provided in accordance with 8.10.1.1 are marshalled by each rescue boat; and*

*.6.3 the craft can be evacuated within the time specified in 4.8.*

**8.10.2** *Where the Administration considers it appropriate, in view of the sheltered nature of the voyages and the suitable climatic conditions of the intended area of operations, the Administration may permit the use of open reversible inflatable liferafts complying with annex 11 on category A craft as an alternative to liferafts complying with paragraph 4.2 or 4.3 of the LSA Code.*

## **8.11 Helicopter pick-up areas**

**8.11.1** *Craft operating on voyages having a duration of 2 h or more between each port of call shall be provided with a helicopter pick-up area approved by the Administration having regard to the recommendations adopted by the Organization.*

*Note: Refer to the Merchant ship search and rescue manual (MERSAR), adopted by the Organization by resolution A.229(VII), as amended.*

**SECTION 9****MACHINERY****Part A General****9.1 General**

**9.1.1** *The machinery, associated piping systems and fittings relating to main machinery and auxiliary power units shall be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design shall have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.*

**9.1.2** *All surfaces with temperatures exceeding 220°C where impingement of flammable liquids may occur as a result of a system failure shall be insulated. The insulation shall be impervious to flammable liquids and vapours.*

**9.1.3** *Special consideration shall be given to the reliability of single essential propulsion components and a separate source of propulsion power sufficient to give the craft a navigable speed, especially in the case of unconventional arrangements, may be required.*

**9.1.4** *Means shall be provided whereby normal operation of propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative. Special consideration shall be given to the malfunctioning of:*

**.1** *a generating set which serves as a main source of electrical power;*

**.2** *the fuel oil supply systems for engines;*

**.3** *the sources of lubricating oil pressure;*

**.4** *the sources of water pressure;*

**.5** *an air compressor and receiver for starting or control purposes;*

**.6** *the hydraulic, pneumatic or electrical means for control in main propulsion machinery, including controllable-pitch propellers.*

*However, having regard to overall safety considerations, a partial reduction in propulsion capability from normal operation may be accepted.*

**9.1.5** *Means shall be provided to ensure that the machinery can be brought into operation from the dead craft condition without external aid.*

**9.1.6** *All parts of machinery, hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure shall be subjected to appropriate tests including a pressure test before being put into service for the first time.*

**9.1.7** *Provision shall be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery including boilers and pressure vessels.*

**9.1.8** *The reliability of machinery installed in the craft shall be adequate for its intended purpose.*

**9.1.9** *The Administration may accept machinery which does not show detailed compliance with the Code where it has been used satisfactorily in a similar application, provided that it is satisfied:*

**.1** *that the design, construction, testing, installation and prescribed maintenance are together adequate for its use in a marine environment; and*

**.2** *that an equivalent level of safety will be achieved.*

**9.1.10** *A failure mode and effect analysis shall include machinery systems and their associated controls.*

**9.1.11** *Such information as is necessary to ensure that machinery can be installed correctly regarding such factors as operating conditions and limitations shall be made available by the manufacturers.*

**9.1.12** *Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the craft shall, as fitted in the craft, be designed to operate when the craft is upright and when inclined at any angle of list up to and including 15° either way under static conditions and 22.5° under dynamic conditions (rolling) either way and simultaneously inclined by dynamically (pitching) 7.5° by bow or stern. The Administration may permit deviation from these angles, taking into consideration the type, size and service conditions of the craft.*

**9.1.13** *All boilers, and pressure vessels and associated piping systems shall be of a design and construction adequate for the purpose intended and shall be so installed and protected as to minimise danger to persons on board. In particular, attention shall be paid to the materials used in the construction and the working pressures and temperatures at which the item will operate and the need to provide an adequate margin of safety over the stresses normally produced in service. Every boiler, pressure vessel and associated piping systems shall be fitted with adequate means to prevent over-pressures in service and be subjected to a hydraulic test before being put into service, and where appropriate at subsequent specified intervals, to a pressure suitably in excess of the working pressure.*

**C9.1.13** Pressure vessels and steam and hot water generators are to be designed, constructed, equipped and tested according to Society Rules.

For the installation of oil-fired steam and hot-water generators automatic oil, steam or air atomizing burners or rotary cup burners complying with Society Rules are to be provided.

**9.1.14** *Arrangements shall be provided to ensure that, in the event of failure in any liquid cooling system, it is rapidly detected and alarmed (visual and audible) and means instituted to minimise the effects of such failures on machinery serviced by the system.*

#### **C9.1.15 Classification**

**C9.1.15.1** Designs which deviate from the Rules may be approved provided that such designs have been examined by the Society for suitability and have been recognized as equivalent.

**C9.1.15.2** Machinery installations which have been developed on novel principles and/or which have not yet been sufficiently tested in shipboard service require the Society's special approval.

Such machinery may be designated by a suffix attached to the character of classification and be subjected to intensified survey, if sufficiently reliable proof cannot be provided of its suitability and equivalence.

**C9.1.15.3** In addition to the Rules, the Society reserves the right to impose further requirements in respect of all types of machinery, where this is unavoidable due to new findings or operational experience, or the Society may permit deviations from the Rules where these are specially warranted.

**C9.1.15.4** National rules or regulations outside the Society Rules remain unaffected.

#### **C9.1.16 Ambient conditions**

The selection, layout and arrangement of all shipboard machinery, equipment and appliances is to be such as to ensure faultless continuous operation under the ambient conditions specified in Tables C9.1 and C9.2.

#### **C9.1.17 Design and construction of machinery installation**

##### **C9.1.17.1 General**

Main propulsion and manoeuvring equipment must provide full control of speed and direction of the craft.

Every important, automatically or remote controlled system must have alternative arrangements for operation.

**Table C9.1 - Inclinations (see note)**

Installations, Components	Angle of inclinations (°) <b>(2)</b>			
	Athwartship		Fore-and-aft	
	static	dynamic	static	dynamic
Main and auxiliary machinery	15	22,5	5	7,5
Ship safety equipment, e.g. emergency power installations, emergency fire pumps and their drives	22,5	22,5	10	10
Switchgear, electrical and electronic appliances <b>(1)</b> and remote-control systems				
<b>(1)</b> Up to an angle of inclination of 45° no undesired switching operations or functional changes may occur.				
<b>(2)</b> Athwartships and fore-and-aft inclinations may occur simultaneously.				
Note: The Society may be consider deviations from these angles, taking into consideration the type, size and service condition of the craft.				

**Table C9.2 - Environmental conditions for machinery and electrical installations (see note)**

Seawater temperature +32°C	
Ambient air temperature –25°C to +45°C, relative humidity (1 bar / 45°C) 60%	
Enclosed machinery spaces	Temperature range 0°C to 55°C. Relative humidity 100%. Ability to withstand oil vapour and salt-laden air
Air-conditioned control rooms	Temperature range 0°C to 40°C. Relative humidity 80%
Open deck	Temperature range –25°C to +45°C. Ability to withstand temporary flooding with seawater and salt-laden spray
Note: The Society may approve other conditions for craft operating only in special agreed geographical areas.	

**C9.1.17.2 Materials, welding and tests**

**.1** All materials and components subject to the Rules are to be manufactured and tested in accordance with Society Rules.

**.2** The fabrication of welded components, approval of companies and testing of welders are subject to Society Rules.

**.3** Machinery and its components are subject to constructional and material tests, pressure and leakage tests and trials. All the tests prescribed in the following sections are to be conducted under the supervision of the Society.

**.4** In the case of parts produced in series, other methods of testing may be agreed with the Society instead of the tests prescribed, provided that the former are recognized as equivalent by the Society.

**.5** The Society reserves the right, where necessary, to increase the scope of the tests and also to subject to testing those parts which are not expressly required to be tested according to the Rules.

**.6** After installation on board of propulsion and auxiliary machinery, operational functioning of the machinery including the associated auxiliary equipment is to be verified. All safety equipment is to be tested, unless adequate testing has already been performed at the manufacturer's works in the presence of the Society Representative.

**.7** In addition, the entire machinery installation is to be tested during sea trials as far as possible under intended service conditions.

**C9.1.18 Shipboard trials (dock and sea trials)**

**C9.1.18.1** Dock trials are to be carried out to the satisfaction of the Society Surveyor.

**C9.1.18.2** Sea trials with propulsion engines driving fixed propellers:

**.1** At rated engine speed  $n_0$  for at least 4 hours, with gas turbines for at least 2 hours;

**.2** At minimum on-load speed;

**.3** Starting and reversing manoeuvres;

**.4** Astern trial with  $n = 0,7 \cdot n_0$  for at least 15 minutes;

**.5** Final testing of monitoring and safety systems.

**C9.1.18.3** Sea trials with propulsion engines driving controllable-pitch propellers, reversing gears or water jets:

**.1** At 100% power at engine speed  $n_0$  for at least 4 hours, with gas turbines for at least 2 hours.

**.2** Manoeuvring trials with various propeller pitches. Where provision is made for combinator operation, the combinator curves are to be plotted and verified by measurements.

**.3** Astern trial with approximately 70% power for at least 15 minutes.

**.4** Final testing of monitoring and safety systems.

**C9.1.18.4** The engines driving electrical generators are to be subjected to an operational test for at least four hours in accordance with the shipboard test programme of the Society.

**C9.1.18.5** Stopping test from full ahead is to be carried out. Time and distance are to be noted.

**9.2 Engine (general)**

**9.2.1** The engines shall be fitted with adequate safety monitoring and control devices in respect of speed, temperature, pressure and other operational functions. Control of the machinery shall be from the craft's operating compartment. Category B craft and cargo craft shall be provided with additional machinery controls in or close to the machinery space. The machinery installation shall be suitable for operation as in an unmanned machinery space, including automatic fire detection system, bilge alarm system, remote machinery instrumentation and alarm system (see note). Where the space is continuously manned, this requirement may be varied in accordance with the requirements of the Administration.

*Note: Refer to part E of Chapter II-1 of the Convention.*

**9.2.2** The engines shall be protected against overspeed, loss of lubricating oil pressure, loss of cooling medium, high temperature, malfunction of moving parts and overload. Safety devices shall not cause complete engine shutdown without prior warning, except in cases where there is a risk of complete breakdown or explosion. Such safety devices shall be capable of being tested.

**9.2.3** At least two independent means of stopping the engines quickly from the operating compartment under any operating conditions shall be available. Duplication of the actuator fitted to the engine shall not be required.

**9.2.4** The major components of the engine shall have adequate strength to withstand the thermal and dynamic conditions of normal operation. The engine shall not be damaged by a limited operation at a speed or at temperatures exceeding the normal values but within the range of the protective devices.

**9.2.5** The design of the engine shall be such as to minimise the risk of fire or explosion and to enable compliance with the fire precaution requirements of Section 7.

**9.2.6** Provision shall be made to drain all excess fuel and oil to a safe position so as to avoid a fire hazard.

**9.2.7** Provision shall be made to ensure that, whenever practical, the failure of systems driven by the engine shall not unduly affect the integrity of the major components.

**9.2.8** The ventilation arrangements in the machinery spaces shall be adequate under all envisaged operating conditions. Where appropriate, arrangements shall ensure that enclosed engine compartments are forcibly ventilated to the atmosphere before the engine can be started.

**9.2.9** Any engines shall be so installed as to avoid excessive vibration within the craft.

**9.3 Gas turbines****C9.3.0.1 Documents to be submitted**

For every gas turbine installation, the drawings and documents required in Society Rules are to be submitted in triplicate for approval by the turbine manufacturer. The Society reserves the right to ask for supplementary copies if deemed necessary in particular cases.

**C9.3.0.2** The materials of shafts, turbine and compressor wheels, guide vanes and blades, turbine and compressor casings, combustion chambers and heat exchangers are to be tested in accordance with test specifications laid down by the gas turbine manufacturer and recognized by the Society as part of the approval procedure.

**9.3.1** Gas turbines shall be designed to operate in the marine environment and shall be free from surge or dangerous instability throughout its operating range up to the maximum steady speed approved for use. The turbine installation shall be arranged to ensure that the turbine cannot be continuously operated within any speed range where excessive vibration, stalling, or surging may be encountered.

**9.3.2** The gas turbines shall be designed and installed such that any reasonably probable shedding of compressor or turbine blades will not endanger the craft, other machinery, occupants of the craft or any other persons.

**9.3.3** Requirements of 9.2.6 shall apply to gas turbines in respect of fuel which might reach the interior of the jet pipe or exhaust system after a false start or after stopping.

**9.3.4** Turbines shall be safeguarded as far as practicable against the possibility of damage by ingestion of contaminants from the operating environment. Information regarding the recommended maximum concentration of contamination shall be made available. Provision shall be made for preventing the accumulation of salt deposits on the compressors and turbines and, if necessary, for preventing the air intake from icing.

**9.3.5** In the event of a failure of a shaft or weak link, the broken end shall not hazard the occupants of the craft, either directly or by damaging the craft or its systems. Where necessary, guards may be fitted to achieve compliance with these requirements.

**9.3.6** Each engine shall be provided with an emergency overspeed shutdown device connected, where possible, directly to each rotor shaft.

**C9.3.6** Startup is to take place automatically, in a fixed sequence.

**9.3.7** *Where an acoustic enclosure is fitted which completely surrounds the gas generator and the high pressure oil pipes, a fire detection and extinguishing system shall be provided for the acoustic enclosure.*

**9.3.8** *Details of the manufacturers' proposed automatic safety devices to guard against hazardous conditions arising in the event of malfunction in the turbine installation shall be provided together with the failure mode and effect analysis.*

**9.3.9** *The manufacturers shall demonstrate the soundness of the casings. Intercoolers and heat exchangers shall be hydraulically tested on each side separately.*

**C9.3.10** The following minimum monitoring equipment is to be provided:

- .1** Air pressure and temperature at compressor inlet,
- .2** Gas pressure and temperature at gas generator outlet,
- .3** Lubricating oil pressure and temperature,
- .4** Gas generator and power turbine speeds.

**C9.3.11** Gas turbine and compressor rotors are to be dynamically balanced when in the condition ready for assembly and are to undergo an overspeed test.

**C9.3.12** Sea trials have to be carried out according to C9.1.18.

#### **9.4 Diesel engines for main propulsion and essential auxiliaries**

##### **C9.4.0.1 Documents to be submitted**

For each diesel engine type, the drawings and documents required in the Society Rules are to be submitted in triplicate to the Society for approval by the engine manufacturer. The Society reserves the right to ask for supplementary copies if deemed necessary in particular cases.

**C9.4.0.1.1** Auxiliary engines intended as prime movers for harbour generator sets with less than 50 kW are not subject to approval.

##### **C9.4.0.2 Definitions**

**C9.4.0.2.1** For the purposes of these Rules, diesel engines are reciprocating internal combustion engines.

**C9.4.0.2.2** Diesel engines are to be designed such that their rated power when running at rated speed can be delivered as continuous power.

The continuous power for which the engine is to be designed is defined as in ISO 3046/1.

**C9.4.0.2.3** Subject to the approval of the Society for propulsion plants where overload is used/required frequently, the diesel engines may be designed for a continuous power (fuel stop power) which cannot be exceeded.

**C9.4.0.2.4** Diesel engines for installation on board of high speed craft must have been type-tested by the Society. For this purpose, a type-approval test in accordance with Society Rules for diesel engines is to be performed.

**9.4.1** *Any main diesel propulsion system shall have satisfactory torsional vibration and other vibrational characteristics verified by individual and combined torsional and other vibration analyses for the system and its components from power unit through to propulsor.*

**C9.4.1** The speed ranges where excessive vibrations may be encountered are to be marked in red on the tachometer, where practicable, and an instruction plate indicating that the engine is not to be continuously operated within these speed ranges is to be fitted near each control station.

**9.4.2** *All external high-pressure fuel delivery lines between the high-pressure fuel pumps and fuel nozzles shall be protected with a jacketed tubing system capable of containing fuel from a high-pressure line failure. The jacketed tubing system shall include a means for collection of leakages and arrangements shall be provided for an alarm to be given of a fuel line failure.*

**9.4.3** *Engines of a cylinder diameter of 200 mm or a crankcase volume of 0.6 m<sup>3</sup> and above shall be provided with crankcase explosion relief valves of an approved type with sufficient relief area. The relief valves shall be arranged with means to ensure that discharge from them is directed so as to minimise the possibility of injury to personnel.*

**C9.4.3** Where crankcase venting systems are provided, their clear opening is to be as small as possible.

The vent pipes of two or more engines are not to be combined.



**9.4.4** *The lubrication system and arrangements shall be efficient at all running speeds, due consideration being given to the need to maintain suction and avoid the spillage of oil in all conditions of list and trim and degree of motion of the craft.*

**9.4.5** *Arrangements shall be provided to ensure that visual and audible alarms are activated in the event of either lubricating oil pressure or lubricating oil level falling below a safe level, considering the rate of circulation of oil in the engine. Such events shall also cause automatic reduction of engine speed to a safe level, but automatic shutdown shall only be activated by conditions leading to a complete breakdown, fire or explosion.*

**9.4.6** *Where diesel engines are arranged to be started, reversed or controlled by compressed air, the arrangement of the air compressor, air receiver and air starting system shall be such as to minimise the risk of fire or explosion.*

#### **C9.4.7 Tests and trials**

Material tests for main components of diesel engines, pressure tests and shop trials have to be conducted according to Society Rules for diesel engines.

#### **C9.4.8 Filters**

##### **C9.4.8.1 Lubricating oil filters**

Lubricating oil lines are to be fitted with lubricating oil filters of suitable size and fineness, located in the main oil flow on the delivery side of the pumps.

Steps are to be taken to ensure that main flow filters can be cleaned without interrupting operation and filtration.

##### **C9.4.8.2 Fuel filters**

The supply lines of the fuel-injection pumps are to be fitted with switch-over duplex filters.

##### **C9.4.8.3 Filters for emergency engines**

For emergency diesel generators and emergency diesel fire-extinguishing pump sets, simplex filters for fuel oil and lubricating oil are acceptable.

##### **C9.4.8.4 Filter arrangements**

Fuel and lubricating oil filters which are to be mounted directly on the engine are not to be located above rotating parts or in the immediate proximity of hot components.

Where this arrangement is not feasible, rotating parts and hot components are to be sufficiently shielded.

Drip pans of suitable size are to be mounted under fuel filters. The same applies to lubricating oil filters if oil can escape during dismantling of the filter.

#### **C9.4.9 Starting equipment**

**C9.4.9.1** The starting equipment is to enable engines to be started up from the shut-down condition using the starting equipment available in the machinery space.

**C9.4.9.2** Details of the starting equipment as well as the number of starts are to be in compliance with Society Rules.

**C9.4.9.3** Starting air compressors are to be approved according to Society Rules.

#### **C9.4.10 Control equipment**

##### **C9.4.10.1 Main engines Engine control position**

An engine control position is to be provided from which the propulsion plant (including reversing gear or controllable-pitch propeller) can be operated and monitored.

As a minimum requirement, the engine control position is to be equipped with the following indicators, which are to be clearly and logically arranged:

- .1 Speed.
- .2 Lubricating oil pressure at engine inlet.
- .3 Fuel pressure at engine inlet.
- .4 Cylinder cooling water pressure.
- .5 Starting air pressure.
- .6 Charging air pressure.
- .7 Control air pressure at engine inlet.

Indicators are to be provided directly on the engine for the following readings:

- .8 Lubricating oil temperature.
- .9 Coolant temperature.
- .10 Exhaust gas temperature, wherever the dimensions permit, at each cylinder outlet and at the turbo-charger inlet/outlet.

In case of geared transmissions or controllable-pitch propellers, the scope of the control equipment mentioned above is to be extended accordingly.

**C9.4.10.2 Auxiliary engines**

As a minimum requirement, the following indicating instruments are to be mounted in a logical manner on the engine:

- .1 Tachometer.
- .2 Pressure gauge for lubricating oil pressure.
- .3 Pressure gauge for fuel pressure.
- .4 Pressure gauge for cooling water pressure.
- .5 Thermometer for cooling water.

**9.5 Transmissions**

**C9.5.0.1** The design and arrangement of transmission components such as shaftings, couplings, clutches and gears in propulsion, manoeuvring and lifting devices are subject to approval and certification.

**C9.5.0.2** Documentation and strength calculations on the basis of Society Rules are to be submitted. Alternatively, recognized calculation procedures may be accepted.

**C9.5.0.3 Steel shaft lines**

- .1 Materials are to comply with Society's Rules.
- .2 Shaft dimensions are to comply with Society's Rules standard calculations.
- .3 Alternatively, for shafts protected from seawater (no direct contact between steel and seawater):
  - a fatigue strength calculation e.g. according to DIN 743 or similar may be accepted. This calculation is to be based on the loads (torque, bending moment, thrust etc.) acting on the shaft at MCR conditions.
  - in addition to a fatigue strength calculation, a static load calculation is required. At no location of the shaft is the von Mises (equivalent) stress to exceed the yield point of the shaft material for the torque at MCR multiplied by the safety factor  $S$ , where  $S \geq 3$ .
- .4 In any case for thin walled hollow shafts, a safety factor  $S$  against buckling is required in reference to the torque at MCR, where  $S \geq 3$ .
- .5 All relevant load and material data have to be submitted.

**C9.5.0.4 Composites shaft lines**

- .1 Materials are to comply with Society's Rules.
- .2 Mathematical analysis of the relevant types of failure (static, fatigue, buckling and vibrations) according

to classical laminate theory for a simple geometry or FEM for a complex analysis is required.

**.3** The material components and manufacturing process has to be specified and an experimental strength analysis (tests on samples and prototypes in presence of Society representative) is to be provided. The required safety factors and the validity of experimental strength analysis for the full scale component have to be agreed with the Society.

**.4** If fire protection requirements are relevant for the composites shafting, specific arrangements are to be provided at the satisfaction of the Society.

**9.5.1** *The transmission shall be of adequate strength and stiffness to enable it to withstand the most adverse combination of the loads expected in service without exceeding acceptable stress levels for the material concerned.*

**9.5.2** *The design of shafting, bearings and mounts shall be such that hazardous whirling and excessive vibration could not occur at any speed up to 105% of the shaft speed attained at the designed overspeed trip setting of the prime mover.*

**C9.5.2.1 Torsional vibrations**

Calculations for torsional vibration behaviour are to be submitted to the Society in due time. Calculations must include the equivalent mass-elastic system, natural frequencies and corresponding vibration modes, as well as the forced response for gears, couplings, shaftings. Calculations are to be checked in accordance with Society Rules.

Torsional vibration measurements may be required by the Society. Such measurements will be necessary to detect dynamic torques, especially for plants working under unclearly defined conditions. As far as such measurements aim to provide special knowledge concerning load and response characteristics, adequate measuring techniques are to be applied, by agreement with the Society.

**C9.5.2.2 Stability of the system**

The closed loop system including governor and plant must be stable under all conditions. This may be checked during sea trials for normal and misfiring conditions, clutch-in procedures, parallel connecting of units, loading of generators, etc.

In special cases, stability calculations may be required by the Society.

**C9.5.2.3 Whirling vibrations**

Calculations of natural frequencies for whirling may be required by the Society. This will regularly be the case for thin, long shaftings supported by few bearings. The calculations may be required in a simplified form (natural

frequencies), or as complete forced vibrations using methods or programmes approved by the Society.

#### **C9.5.2.4 Lateral vibrations**

Vibration calculations for resiliently mounted reciprocating main engines are to be submitted to the Society for approval. Calculations may be carried out in a simplified form, i.e. natural frequencies for the six degrees of freedom and corresponding modes, provided that no resonances excited by major engine orders are within the operational speed range.

**9.5.3** *The strength and fabrication of the transmission shall be such that the probability of hazardous fatigue failure under the action of the repeated loads of variable magnitude expected in service is extremely remote throughout its operational life. Compliance shall be demonstrated by suitably conducted tests, and by designing for sufficiently low stress levels, combined with the use of fatigue resistant materials and suitable detail design. Torsional vibration or oscillation likely to cause failure may be acceptable if it occurs at transmission speeds which would not be used in normal craft operation, and it is recorded in the craft operating manual as a limitation.*

**9.5.4** *Where a clutch is fitted in the transmission, normal engagement of the clutch shall not cause excessive stresses in the transmission or driven items. Inadvertent operation of any clutch shall not produce dangerously high stresses in the transmission or driven item.*

**9.5.5** *Provision shall be made such that a failure in any part of the transmission, or of a driven component, will not cause damage which might hazard the craft or its occupants.*

**9.5.6** *Where failure of lubricating fluid supply or loss of lubricating fluid pressure could lead to hazardous conditions, provision shall be made to enable such failure to be indicated to the operating crew in adequate time to enable them as far as practicable to take the appropriate action before the hazardous condition arises.*

### **9.6 Propulsion and lift devices**

**C9.6.0.1** The design and arrangement of propulsion and lift devices are subject to approval and certification.

**C9.6.0.2** Documentation and strength calculations on the basis of Society Rules are to be submitted. Alternatively, recognized calculation procedures may be accepted.

**C9.6.0.3** The scantlings of propellers intended for hydrofoils classed as HSC category A is to be such that the strength of the blade, at the relevant verification sections, is

not less than 4 with respect to the ultimate tensile strength of the propeller blade material. The designer is to be present the Society, together with the propeller drawings, a detailed hydrodynamic load and stress analysis at the relevant verification sections.

**9.6.1** *The requirements of this section are based on the premise that:*

**.1** *Propulsion arrangements and lift arrangements may be provided by separate devices, or be integrated into a single propulsion and lift device. Propulsion devices may be air, or water propellers or water jets and the requirements apply to all types of craft.*

**.2** *Propulsion devices are those which directly provide the propulsive thrust and include machinery items and any associated ducts, vanes, scoops and nozzles, the primary function of which is to contribute to the propulsive thrust.*

**.3** *The lift devices, for the purposes of this section, are those items of machinery which directly raise the pressure of the air and move it for the primary purpose of providing lifting force for an air-cushion vehicle.*

**9.6.2** *The propulsion and lift devices shall be of adequate strength and stiffness. The design data, calculations and trials, where necessary, shall establish the ability of the device to withstand the loads which can arise during the operations for which the craft is to be certificated, so that the possibility of catastrophic failure is extremely remote.*

**9.6.3** *The design of propulsion and lift devices shall pay due regard to the effects of allowable corrosion, electrolytic action between different metals, erosion or cavitation which may result from operation in environments in which they are subjected to spray, debris, salt, sand, icing, etc.*

**9.6.4** *The design data and testing of propulsion and lift devices shall pay due regard, as appropriate, to any pressure which could be developed as a result of a duct blockage, to steady and cyclic loadings, to loadings due to external forces and to the use of the devices in manoeuvring and reversing and to the axial location of rotating parts.*

**9.6.5** *Appropriate arrangements shall be made to ensure that:*

**.1** *ingestion of debris or foreign matter is minimised;*

**.2** *the possibility of injury to personnel from shafting or rotating parts is minimised; and*

**.3** *where necessary, inspection and removal of debris can be carried out safely in service.*

**C9.6.6** For stabilisation means:

**.1** The different situations are described in C3.11.

**.2** In case of situation 1, only power activated items such as foils, trims and tabs are assessed. The following parts are reviewed:

- hydraulic system used for activation of stabilisation system,

- associated electrical devices.

**.3** In case of situation 2, only possible interference between hydraulic/electrical installations and the safety of the craft are to be checked. The hydraulic/electrical systems documentation is to be submitted for that purpose. The applicable regulations depend on the location of the hydraulic power pack. The working principles are not checked.

### **Part B** Requirements for passenger craft

#### **9.7** Independent means of propulsion for category B craft

*Category B craft shall 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.*

#### **9.8** Means for return to a port of refuge for category B craft

*Category B craft shall be capable of maintaining the essential machinery and control so that, in the event of a fire or other casualties in any one compartment on board, the craft can return to a port of refuge under its own power.*

### **Part C** Requirements for cargo craft

#### **9.9** Essential machinery and control

*Cargo craft shall be capable of maintaining the essential machinery and control in the event of a fire or other casualties in any one compartment on board. The craft need not be able to return to a place of refuge under its own power.*

## SECTION 10

## AUXILIARY SYSTEMS

## Part A General

**C10.0 Documents to be submitted**

**C10.0.1** Diagrammatical plans for piping systems and arrangements, including all the details necessary for approval as listed below, are to be submitted in triplicate. The Society reserves the right to ask for supplementary copies if deemed necessary in particular cases.

- .1** Tank arrangement for fuel and other flammable fluids
- .2** Fuel systems (bunkering, transfer and service)
- .3** Lubricating oil systems
- .4** Cooling water systems (seawater and fresh water)
- .5** Compressed air systems (starting air, control air, working air)
- .6** Exhaust gas systems
- .7** Bilge pumping and drainage systems
- .8** Oily bilge water and oil residue systems
- .9** Ballast and antiheeling systems
- .10** Steam heating, feed water and condensate systems
- .11** Air, overflow and sounding pipes
- .12** Sanitary systems
- .13** Fittings on side and bottom
- .14** Arrangement of remote controlled valves
- .15** Hydraulic systems for hatch covers, shell closing appliances, watertight doors and hoists.

**C10.0.2** The diagrammatical plans or accompanying lists are to include the following particulars:

- .1** Outside diameters and wall thicknesses of pipes
- .2** Materials for pipes, valves and fittings
- .3** Type and capacity of pumps

**.4** Type of flexible hoses and expansion elements

**.5** Maximum working pressures

**.6** Temperature ranges

**.7** Equipment list.

**C10.0.3** Machinery arrangement plan showing the layout of machinery components such as engines, fans, heat exchangers, generators, switchboards, pumps, purifiers, excluding pipes, valves and accessories.

**C10.0.4** Further documentation may be required if deemed necessary by the Society.

**10.1 General**

**10.1.1** *Fluid systems shall be constructed and arranged so as to assure a safe and adequate flow of fluid at a prescribed flow rate and pressure under all conditions of craft operation. The probability of a failure or a leakage in any one fluid system, causing damage to the electrical system, a fire or an explosion hazard shall be extremely remote. Attention shall be directed to the avoidance of impingement of flammable liquid on hot surfaces in the event of leakage or fracture of the pipe.*

**10.1.2** *The maximum allowable working pressure in any part of the fluid system shall not be greater than the design pressure, having regard to the allowable stresses in the materials. Where the maximum allowable working pressure of a system component, such as a valve or a fitting, is less than that computed for the pipe or tubing, the system pressure shall be limited to the lowest of the component maximum allowable working pressures. Every system which may be exposed to pressures higher than the system's maximum allowable working pressure shall be safeguarded by appropriate relief devices.*

**10.1.3** *Tanks and piping shall be pressure-tested to a pressure that will assure a safety margin in excess of the working pressure of the item. The test on any storage tank or reservoir shall take into account any possible static head in the overflow condition and the dynamic forces arising from craft motions.*

**10.1.4** *Materials used in piping systems shall be compatible with the fluid conveyed and selected giving due regard to the risk of fire. Non-metallic piping material may be permitted in certain systems provided the integrity of the hull and watertight decks and bulkheads is maintained.*

*Note: Refer to the Guidelines for the Application of Plastic Pipes on Ships, adopted by the Organization by resolution A.753(18).*

### C10.1.5 Definitions

#### C10.1.5.1 Maximum allowable working pressure PB

This is the maximum allowable working pressure for components and piping systems with regard to the materials used, requirements, working temperatures and undisturbed operation.

#### C10.1.5.2 Nominal pressure PN

This is the term applied to a selected pressure/temperature ratio used for the standardization of structural components. In general, the numerical value of the nominal pressure for a standardized component made of the material specified in the standard will correspond to the maximum allowable working pressure PB at 20°C.

#### C10.1.5.3 Test pressure PP

This is the pressure to which components and piping systems are subjected for testing purposes.

#### C10.1.5.4 Design pressure PR

This is the maximum allowable working pressure PB for which components and piping systems are designed with regard to their mechanical characteristics. In general, the design pressure is the maximum allowable working pressure at which the safety equipment will intervene (e.g. activation of safety valves, opening of return lines of pumps, operating of overpressure safety arrangements, opening of relief valves) or at which the pumps will operate against closed valves.

### C10.1.6 Materials

For the testing of pipes, selection of joints, welding and heat treatment, pipes are divided into three classes, as indicated in Tables C10.1 and C10.2.

Details of approved materials are given in Table C10.3.

The Society Rules for Materials are also to be observed.

#### C10.1.6.1 Steel pipes, valves and fittings

Pipes belonging to Classes I and II are to be either of seamless drawn material, or produced by a welding procedure approved by the Society. In general, carbon and carbon-manganese steel pipes, valves and fittings are not to be used for temperatures above 400°C.

**Table C10.1 - Classification of pipes**

Medium/type of pipeline	Design pressure PR (MPa) Design temperature t (°C)		
Toxic and corrosive media Inflammable media with service temperature above the flash point Inflammable media with a flash point below 60°C	all	(1)	–
Steam	PR > 1,6 or t > 300	PR ≤ 1,6 and t ≤ 300	PR ≤ 0,7 and t ≤ 170
Air, gas Lubricating oil, hydraulic oil Boiler feedwater, condensate Seawater and fresh water or cooling brine in refrigerating plant	PR > 4,0 or t > 300	PR ≤ 4,0 and t ≤ 300	PR ≤ 1,6 and t ≤ 200
Liquid fuels	PR > 1,6 or t > 150	PR ≤ 1,6 and t ≤ 150	PR ≤ 0,7 and t ≤ 60
Refrigerants	–	all	–
Open-ended pipelines (without shutoff) e.g. drains, venting pipes, overflow lines and boiler blowdown lines	–	–	all
Pipe Class	I	II	III
(1) Classification in Class II is possible if special safety arrangements are available and structural safety precautions are arranged.			

**Table C10.2 - Approved materials and types of material certificates**

Pipe Class	Type of component	Approved material	Design temperature	Subject to testing	Type of certificate (EN 10204)		
					3.1.C (3)	3.1.B (3)	2.2 (4)
I + II	Pipes, pipe elbows, fittings	Steel, Copper, Copper alloy	–	all	x	–	–
	Valves, flanges, metal expansion joints and hoses, other components	Steel, Cast steel	> 300°C	DN > 32	x	–	–
				DN ≤ 32	–	x	–
		Steel, Cast steel, Nodular cast iron	≤ 300°C	PB x DN > 250 or DN ≥ 250	x	–	–
				PB x DN ≤ 250 or DN ≤ 250	–	x	–
		Copper, Copper alloy	> 225°C	DN > 32	x	–	–
				DN ≤ 32	–	x	–
			≤ 225°C	PB x DN > 150	x	–	–
				PB x DN ≤ 150	–	x	–
III	Pipes, valves (2), flanges, other components	Steel, Cast steel, Grey cast iron (1), Nodular cast iron, Copper, Copper alloy	–	–	–	–	x

(1) No material test in the case of grey cast iron.  
(2) Casings of valves and pipe branches fitted on ship sides are to be included in pipe class II.  
(3) Inspection certificate.  
(4) Test report.

**C10.1.6.2 Pipes, valves and fittings of aluminium and aluminium alloy**

Aluminium and aluminium alloys are to comply with Society Rules for Materials and may be used for temperatures up to 200°C.

Pipes made of aluminium may be used for the following services:

- Fresh cooling water systems
- Bilge systems outside areas of major fire hazard, as defined in 7.3.1
- Air and sounding pipes; for air and sounding pipes of tanks containing flammable liquids outside of major fire hazard areas, as defined in 7.3.1
- Pipes containing flammable liquids outside areas of major fire hazards, as defined in 7.3.1
- Pipes for non-essential services.

Seawater cooling pipes and ballast pipes and other seawater pipes made of aluminium alloys, may be accepted at the discretion of the Society.

**C10.1.6.3 Pipes, valves and fittings of non-metallic materials**

Pipes, connecting pieces, valves and fittings made of plastic materials may be used at the discretion of the Society.

Note: Plastic pipes and the application are to comply with IMO Resolution A 753(18).

Plastic pipes are to be permanently marked with the following particulars:

- Manufacturer's marking
- Standard specification number
- Outside diameter and wall thickness
- Year of manufacture.

Valves and connecting pieces made of plastic shall, as a minimum requirement, be marked with the manufacturer's marking and the nominal diameter.

**C10.1.6.4 Pipes, valves and fittings of copper and copper alloys**

Pipes of copper and copper alloys are to be of seamless drawn material, or produced by a method approved by the Society. Copper pipes for Classes I and II are to be seamless.

In general, copper and copper alloy pipelines are not to be used for media having temperatures above the following limits:

- Copper and aluminium brass: 200°C
- Copper nickel alloys: 300°C
- High-temperature bronze: 260°C.

Table C10.3 - Approved materials

Material or application		Pipe Class		
		I	II	III
Steels	Pipes	Pipes for general applications: <ul style="list-style-type: none"><li>• above 300°C: high-temperature steel pipes</li><li>• below –10°C: pipes made of steel with high low-temperature toughness, stainless steel pipes for chemicals</li></ul>	Pipes for general applications	Steel not subjected to any special quality specification, weldability in accordance with the Society Rules
	Forgings, Plates, Flanges	Steels suitable for the corresponding loading and process conditions, for temperatures > 300°C, high temperature steels, for temperatures below –10°C, steels with high low-temperature toughness		
	Bolts, Nuts	Bolts for general machinery construction: <ul style="list-style-type: none"><li>• above 300°C: high-temperature steels</li><li>• below –10°C: steels with high low-temperature toughness</li></ul>	Bolts for general machinery construction	
Castings (valves, fittings, pipes)	Cast steel	Cast steel for general applications: <ul style="list-style-type: none"><li>• above 300°C: high-temperature cast steel</li><li>• below –10°C: cast steel with high low-temperature toughness</li><li>• for aggressive media: stainless castings</li></ul>	Cast steel for general applications	
	Nodular cast iron	Only ferritic grades, elongation A <sub>5</sub> at least 15%		
	Cast iron with lamellar graphite	–	–	At least GG-20 up to 200°C, Grey cast iron is not permitted in valves and fittings on ship's side, collision bulk-head and fuel and oil tanks
Non-ferrous metals (valves, fittings, pipes)	Copper, Copper alloys	–	For seawater and alkaline water, only corrosion resistant copper and copper alloys	
	Aluminium, Aluminium alloys	–	Upon special approval of the Society	See C10.1.6.2
Non-metallic materials	Non-metallic	–	–	See C10.1.6.3

#### C10.1.6.5 Pipes, valves and fittings of nodular ferritic cast iron

Pipes, valves and fittings of nodular ferritic cast iron according to the Society Rules may be used for bilge and ballast pipes within double-bottom tanks, and tanks for other purposes approved by the Society. In special cases (applications corresponding in principle to Classes II and III) and at the Society's discretion, valves and fittings made of ferritic nodular cast iron may be accepted for temperatures up to 350°C.

#### C10.1.6.6 Pipes, valves and fittings of lamellar-graphite cast iron (grey cast iron)

Pipes, valves and fittings of grey cast iron may be used for Class III systems.

The use of grey cast iron is not permitted:

- for media at temperatures above 220°C and for pipelines subject to water hammering, severe stresses or vibration
- for valves and pipes fitted on craft sides, and for valves fitted on the collision bulkhead
- for valves on fuel and oil tanks which are subject to static head.



**C10.1.7 Testing****C10.1.7.1 Testing of materials**

Pipes, bends, fittings, valve bodies and flanges for piping systems belonging to Classes I and II are subject to tests in accordance with the Society Rules for Materials under the Society's supervision.

**C10.1.7.2 Testing prior to installation on board**

**.1** All Class I and II piping as well as all piping for compressed air and flammable liquids with a design pressure PR greater than 0,35 MPa are, after completion of manufacture but before insulation and coating, to be subjected to a hydraulic pressure test in the presence of a Surveyor at a pressure of 1,5-PR.

When technical reasons do not allow complete hydraulic pressure tests on all pre-fabricated pipe sections before assembly on board, proposals are to be submitted for approval to the Society.

**.2** When hydraulic pressure tests of piping are carried out on board, they may be conducted in conjunction with the tests required under C10.1.7.3.

**.3** Pressure testing of pipes with nominal diameters less than 15 mm may be omitted, at the Society's discretion, pending the application.

**C10.1.7.3 Testing after installation on board**

**.1** After assembly on board, all piping covered by these Rules is to be subjected to a tightness test in presence of a Surveyor.

In general, all pipe systems are to be tested for leakage under operational conditions. If necessary, alternative tests to hydraulic pressure tests may be applied.

**.2** Heating coils in tanks and piping for flammable liquids are to be tested at a pressure of 1,5 PR, but in no case at less than 0,4 MPa.

**C10.1.7.4 Testing of valves**

Valves are to be subjected to a hydraulic pressure and tightness test in the manufacturer's works, in presence of a Surveyor:

- Valves of pipe Classes I and II to 1,5 PR
- Valves and connections in the ship's side to not less than 0,5 MPa.

**C10.1.8 Minimum wall thickness**

**C10.1.8.1** Minimum pipe thicknesses are stated in Table C10.4 to Table C10.10. These minimum thicknesses may be increased if considered necessary, following stress analysis.

Slight differences in diameters and wall thicknesses based on recognized standards may be accepted.

Provided that pipes are effectively protected against corrosion, the wall thicknesses of group M steel pipes may, at the discretion of the Society, be reduced by up to 1 mm. The amount of the reduction is to be in relation to the wall thickness.

Protective coatings (e.g. hot-dip galvanizing) may be recognized as effective corrosion protection provided that its preservation during installation is guaranteed.

**Table C10.4 - Choice of minimum wall thickness for steel pipes**

Piping system	Location												
	Machinery spaces	Cofferdam / void spaces	Cargo holds	Ballast water tanks	Fuel and changeover tanks	Fresh cooling water tanks	Lubricating oil tanks	Hydraulic oil tanks	Drinking water tanks	Living quarters	Weather deck		
Bilge lines	M	M	M	–	–	X	X	X	X	M	–		
Ballast lines												X	N
Seawater lines				M								M	
Fuel lines			–	N									
Lubricating lines	N		–	X	X		N	N		X			
Hydraulic lines							–						
Drinking water lines			M				X	X	X	X	N	N	
Fresh cooling water lines													N
Note: M, N: Refer to Table C10.6; X: Pipelines are not to be installed; (–): Pipelines may be installed by special agreement with the Society.													

**Table C10.5 - Choice of minimum wall thickness for air, overflow, sounding and sanitary pipes made of steel**

Piping system or position of open pipe outlets	Location								
	Tanks with same media	Tanks with disparate media	Drain lines and scupper pipes			Air, sounding and overflow pipes		Cargo holds	Machinery spaces
			Below freeboard deck or datum		above free-board deck	above open deck	below open deck		
			without shutoff on ship's side	with shutoff on ship's side					
Air, overflow and sounding pipe	M	C	–	–	–	C	M	M	M
Scupper pipes from open deck	A	B	B	A	A	–	–	B	A
Discharge and scupper pipe leading directly overboard					–				
Discharge of pumps of sanitary systems					–				
Note: A, B, C: Refer to Table C10.10; M: Refer to Table C10.6.									

**Table C10.6 - Minimum wall thickness for steel pipes**

Group N						Group M			
d <sub>a</sub> (1) (mm)	s (mm)	d <sub>a</sub> (1) (mm)	s (mm)	d <sub>a</sub> (1) (mm)	s (mm)	d <sub>a</sub> (1) (mm)	s (mm)	d <sub>a</sub> (1) (mm)	s (mm)
from 10,2	1,6	from 114,3	3,2	from 406,4	6,3	from 21,3	3,2	from 219,1	5,9
from 13,5	1,8	from 133,0	3,6	from 660,0	7,1	from 38,0	3,6	from 244,5	6,3
from 20,0	2,0	from 152,4	4,0	from 762,0	8,0	from 51,0	4,0	from 660,4	7,1
from 48,3	2,3	from 177,8	4,5	from 864,0	8,8	from 76,1	4,5	from 762,0	8,0
from 70,0	2,6	from 244,5	5,0	from 914,0	10,0	from 177,8	5,0	from 863,6	8,8
from 88,9	2,9	from 323,9	5,6			from 193,7	5,4	from 914,4	10,0
(1) d <sub>a</sub> = outside diameter									

**Table C10.8 - Minimum wall thickness for copper and copper alloy pipes****Table C10.7 - Minimum wall thicknesses for austenitic stainless steel pipes**

Pipe outside diameter d <sub>a</sub> (mm)	Minimum wall thickness s (mm)
up to 17,2	1,0
up to 48,3	1,6
up to 88,9	2,0
up to 168,3	2,3
up to 219,1	2,6
up to 273,0	2,9
up to 406,0	3,6
over 406,0	4,0

Pipe outside diameter d <sub>a</sub> (mm)	Minimum wall thickness s (mm)	
	Copper	Copper alloys
8 - 10	1,0	0,8
12 - 20	1,2	1,0
25 - 44,5	1,5	1,2
50 - 76,1	2,0	1,5
88,9 - 108	2,5	2,0
133 - 159	3,0	2,5
193,7 - 267	3,5	3,0
273 - 457,2	4,0	3,5
(470) -	4,0	3,5
508 -	4,5	4,0

**Table C10.9 - Minimum wall thickness for aluminium and aluminium alloy pipes**

Pipe outside diameter (mm)	Minimum wall thickness (mm)
< 10	1,5
12 - 38	2,0
43 - 57	2,5
76 - 89	3,0
108 - 133	4,0
159 - 194	4,5
219 - 273	5,0
> 273	5,5
Note: For seawater pipes the wall thickness is to be not less than 5,0 mm.	

**C10.1.9 Pipe connections**

**C10.1.9.1** The following pipe connections may be used for steel pipes:

- Fully penetrating butt welds with/without provision to improve the quality of the root
- Socket welds with suitable fillet weld thickness
- Screw connection of a type approved by the Society
- Steel flanges of a recognized standard.

Screwed socket connections or similar are permitted only for subordinate systems for pipes below DN 65.

**C10.1.9.2** Flanges made of non-ferrous metals may be used in accordance with recognized standards and within the limits laid down in approvals.

**C10.1.9.3** Non-metallic pipes are to be connected by approved methods (e.g. welding, glueing or cementing) or by approved detachable connections.

**C10.1.9.4** Type-approved pipe couplings may be used in the following systems:

- Bilge and ballast lines
- Sea water lines
- Fresh and seawater cooling lines
- Firefighting and deckwash lines
- Vent, fill and sounding pipes
- Drinking water lines
- Sanitary discharge lines.

Use of pipe couplings is not permitted in:

- Bilge lines inside ballast and fuel tanks
- Ballast lines inside cargo holds and fuel tanks
- Pipes containing flammable liquids within major fire hazard areas as defined in 7.3.1, cargo holds and ballast tanks.

**Table C10.10 - Minimum wall thickness of air, overflow, sounding and sanitary pipes made of steel**

Pipe outside diameter (mm)	Minimum wall thickness (mm)		
	A	B (1)	C
38 - 82,5	4,5	7,1	6,3
88,9 -	4,5	8,0	6,3
101,6 - 114,3	4,5	8,0	7,1
127 - 139,7	4,5	8,8	8,0
152,4 -	4,5	10,0	8,8
159 - 177,8	5,0	10,0	8,8
193,7 -	5,4	12,5	8,8
219,1 -	5,9	12,5	8,8
244,5 - 457,2	6,3	12,5	8,8
(1) The pipe thickness may not be greater than the thickness of the shell plates.			

**C10.1.10 Layout, marking and installation**

**C10.1.10.1** Piping systems are to be identified according to their purpose. Valves are to be permanently marked.

**C10.1.10.2** Pipe penetrations through bulkheads and tank walls are to be water- and oil-tight. Bolts penetrating bulkheads are not permitted. Holes for set screws are not to be drilled in tank walls.

**C10.1.10.3** The installation of pipes for water or oil behind or above electric switchboards is to be avoided. If this is impracticable, pipes and valves are to be well shielded and/or located as far as possible from the switchboard.

**C10.1.10.4** Piping systems are to be so arranged that they may be completely emptied, drained and vented. Piping systems in which accumulation of liquids during operation could cause damage are to be equipped with special draining devices.

**C10.1.10.5** Pipelines laid through coated tanks are to be either effectively protected against corrosion or made of a material with low susceptibility to corrosion.

The protection against corrosion of the tanks as well as that of the pipes are to be compatible to each other.

**C10.1.10.6** Water pipes, air and sounding pipes passing through freezing chambers are to be avoided as far as practicable.

**C10.1.10.7** Piping systems are to be adequately supported, to prevent detrimental vibrations occurring in the system.

**C10.1.11 Valves****C10.1.11.1 Shutoff devices**

Shutoff devices are to comply with a recognized standard. Valves with screwed-on covers are to be secured, to prevent inadvertent loosening of the cover.

Hand-operated shutoff devices are to be closed by turning in a clockwise direction.

Valves are to be clearly marked to show whether they are open or closed.

**C10.1.11.2 Craft side valves**

**.1** Craft side valves are to be easily accessible and capable of being operated from above the floor.

Where, subject to C10.1.6.2 and C10.1.6.3, sea water pipes made of aluminium alloys or non-metallic materials are accepted by the Society, craft's side valves inside machinery spaces and other spaces with major fire hazard are to be provided with means of remote closure from outside the space.

**.2** Valves are to be of a flanged type and made of metallic ductile material.

**.3** The minimum wall thickness of pipe branches connected to the craft's hull below the datum shall be as follows:

- for steel pipes: in accordance with Table C10.10, Group B
- for aluminium pipes: at least 8 mm but not greater than the thickness of the shell plate.

**C10.1.11.3 Remote-controlled valves****.1 General**

For remote-controlled valves, failure of power supply is not to cause:

- opening of closed valves
- closing of open valves on fuel tanks and in cooling water systems for propulsion and power generating machinery.

Remote-controlled valves are to be equipped with an emergency operating arrangement.

They are to be accessible for maintenance and repair work.

**.2 Power units**

Power units for remote-controlled valves are to be equipped with at least two independent power supply units.

For the closing of valves which are not closed by spring action, power units are to be fitted with pressure accumulators.

Pneumatically operated valves may be supplied by air from the general compressed air system.

**.3 Control station**

At the control station, means are to be provided to show whether the valves are open or closed.

For visual indication of the closed position of valves, limit-position indicators approved by the Society are to be provided.

The control position is to be located in a space which is normally attended, e.g. operating compartment.

**.4 Bilge piping**

Valves and control lines for bilge systems are to be located as far as possible from the bottom and side shell of the craft.

**.5 Fuel pipes**

Valves mounted directly at fuel tanks above the double bottom are to be capable of being closed from outside the compartment in which they are installed (e.g. from craft's operating compartment or other suitable locations).

**C10.1.12 Hose assemblies and compensators of non-metallic materials****C10.1.12.1 Requirements**

Hose assemblies and compensators of non-metallic material are to be type-approved and tested according to the Society Rules.

Hose assemblies and compensators including their couplings are to be suitable for media, pressures and temperatures.

Selection of hose assemblies and compensators is to be based on the maximum allowable working pressure of the system concerned. 0,5 MPa is to be considered as the minimum working pressure.

**C10.1.12.2 Installation**

Hose assemblies are not to be longer than necessary for the application.

The minimum bending radius is not to be less than the radius specified by the manufacturer.

Hose assemblies and compensators are to be accessible.

Hoses used in fresh water systems with working pressures  $\leq 0,5$  MPa, or in charging air and scavenging air ducts, may be fastened with double clips. Hoses which are installed directly near hot surfaces are to be provided with additional heat-resistant sheathing.

**C10.1.13 Pumps****C10.1.13.1 General**

Construction, materials and tests of pumps are to comply with the Society Rules.

**C10.1.13.2 Relief valves**

Positive displacement pumps are to be fitted with relief valves which cannot be adjusted to the closed position. They are to discharge into the suction side of the pump.

**C10.1.13.3 Tests**

The pumps listed below are subject to tests carried out at the manufacturer's works, under the Society supervision:

- Fire pumps and emergency fire pumps
- Bilge pumps
- Seawater cooling pumps
- Fresh water cooling pumps
- Fuel transfer pumps
- Fuel service pumps
- Fuel injection valve cooling pumps
- Lubricating oil pumps
- Ballast pumps
- Boiler feedwater pumps
- Boiler water circulating pumps
- Other pumps considered necessary for performance of essential functions.

## **10.2 Arrangement of oil fuel, lubricating oil and other flammable oil**

**10.2.1** *The provisions of 7.1.2.2 apply to the use of oil as fuel.*

**C10.2.1** The requirements stipulated in 7.5 are to be complied with.

**10.2.2** *Oil fuel, lubricating oil and other flammable oil lines shall be screened or otherwise suitably protected to avoid, as far as practicable, oil spray or oil leakages onto hot surfaces, into machinery air intakes or other sources of ignition. The number of joints in such piping systems shall be kept to a minimum. Flexible pipes carrying flammable liquids shall be of an approved type.*

*Note: Refer to the Guidelines to Minimize Leakages from Flammable Liquid Systems for Improving Reliability and Reducing Risk of Fire (MSC/Circ. 647).*

**C10.2.2(a)** As far as practicable, flammable liquid lines are not to be arranged in the vicinity of boilers, turbines or equipment with surface temperatures greater than 220°C, nor above electrical equipment.

**C10.2.2(b)** Pumps are to be provided with shutoff valves.

**C10.2.2(c)** Filling pipes for tanks containing flammable liquids are to terminate on open deck and be arranged so that leakages are collected by suitable coamings.

Fuel-oil filling connections are, as far as practicable, to be arranged on both sides of the craft.

**10.2.3** *Fuel oil, lubricating oils and other flammable oils shall not be carried forward of public spaces and crew accommodation.*

**C10.2.3**

**C10.2.3.1** All tanks not forming part of the craft structure are to be fastened securely and arranged so that they can be readily inspected.

Free-standing fuel tanks are to be installed so as to allow free circulation of air around the tanks.

Fuel tanks for emergency diesel generators are to be located inside the emergency generator room.

**C10.2.3.2** Appliances, mountings and fittings not forming part of the fuel tank equipment may be fitted to tank walls only by means of intermediate supports. Only components forming part of the tank equipment may be fitted to freestanding tanks.

For valves and pipe connections, the tank walls are to be provided with strengthening flanges. Bolt holes are not to be drilled in tank surfaces.

Instead of strengthening flanges, short, thick pipe flange connections may be welded to the tank surfaces.

**10.2.4 Oil fuel arrangements**

*In a craft in which oil fuel is used, the arrangements for the storage, distribution and utilization of the oil fuel shall be such as to ensure the safety of the craft and persons on board and shall at least comply with the following provisions.*

**10.2.4.1** *As far as practicable, all parts of the oil fuel system containing heated oil under pressure exceeding 0,18 N/mm<sup>2</sup> shall not be placed in a concealed position such that defects and leakage cannot readily be observed. The machinery spaces in way of such parts of the oil fuel system shall be adequately illuminated.*

**C10.2.4.1** Fuel lines are not to pass through tanks containing feedwater, drinking water or lubricating oil.

**10.2.4.2** *The ventilation of machinery spaces shall be sufficient under all normal conditions to prevent accumulation of oil vapour.*

**C10.2.4.2** The provisions of Art. 10.6 and Art. 10.7 are to be complied with.

**10.2.4.3** Location of fuel tanks shall be in accordance with 7.5.2 .

**C10.2.4.3** Fuel tanks are to be separated by voids/cofferdams from tanks containing lubricating, hydraulic, thermal or edible oil and drinking water.

Fuel service tanks inside machinery spaces are to be made of steel.

**10.2.4.4** No oil fuel tank shall be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces. Reference is made to the fire safety requirements in Art. 7.5.

**10.2.4.5** Oil fuel pipes shall be fitted with cocks or valves in accordance with 7.5.3.

**C10.2.4.5(a)** The controls of such valves are to be located outside the space in which the tanks are arranged, as far as possible combined in one location, preferably the craft's operating compartment.

**C10.2.4.5(b)** Valves subject to static head are to be made of ductile material.

**C10.2.4.5(c)** Remote-controlled shutoff valves may be dispensed with for tanks with a capacity of less than 50 litres.

**10.2.4.6** Every fuel tank shall, where necessary, be provided with savealls or gutters to catch any fuel which may leak from such tanks.

**C10.2.4.6** Tanks located above the double bottom are to be fitted with self-closing drains.

**10.2.4.7** Safe and efficient means of ascertaining the amount of oil fuel contained in any oil fuel tank shall be provided.

**10.2.4.7.1** Where sounding pipes are used they shall not terminate in any space where the risk of ignition of spillage from the sounding pipe might arise. In particular, they shall not terminate in public spaces, crew accommodation or machinery spaces. Terminations shall be provided with a suitable means of closure and provision to prevent spillage during refuelling operations.

**10.2.4.7.2** Other oil-level gauges may be used in place of sounding pipes. Such means are subject to the following conditions:

**.1** In passenger craft, such means shall not require penetration below the top of the tank and their failure or overfilling of the tanks will not permit release of fuel.

**.2** The use of cylindrical gauge glasses shall be prohibited. In cargo craft, the Society may permit the use of oil-level gauges with flat glasses and self-closing valves between the gauges and fuel tanks. Such other means shall be acceptable to the Society and shall be maintained in the proper condition to ensure their continued accurate functioning in service.

**C10.2.4.7.3** Level-indicating devices which are not type-approved by the Society may be accepted if sounding pipes are provided in addition.

Sight glasses and oil gauges fitted directly on the tank wall, and cylindrical glass gauges, are not permitted.

**C10.2.4.7.4** Sounding pipes are to terminate outside main fire hazard areas and as far as possible above the open deck. However, where this is not possible, the following requirements are to be met:

- Oil-level gauges are to be provided in addition to sounding pipes.
- Sounding pipes are either to terminate in locations remote from ignition hazards or to be fitted with effective screens to prevent spillages coming into contact with a source of ignition.
- Sounding pipes are to be fitted with self-closing shutoff devices and self-closing testing devices.

**10.2.4.8** Provision shall be made to prevent overpressure in any oil tank or in any part of the fuel system, including the filling pipes. Any relief valves and air or overflow pipes shall discharge to a safe position and, for fuel of flashpoint less than 43°C, shall terminate with flame arresters in accordance with the standards developed by the Organization.

*Note: Refer to the Revised Standards for the Design, Testing and Locating of Devices to Prevent the Passage of Flame into Cargo Tanks in Tankers (MSC/Circ. 677).*

**C10.2.4.8** Lines of relief/safety valves and overflow lines are to discharge into leakage, drain or overflow tanks.

**10.2.4.9** Oil fuel pipes and their valves and fittings shall be of steel or other approved material, except that restricted use of flexible pipes shall be permissible in positions where the Society is satisfied that they are necessary (see Note). Such flexible pipes and end attachments shall be of approved fire-resisting materials of adequate strength and shall be constructed to the satisfaction of the Administration.

*Note: Refer to recommendations published by the International Organization for Standardization, in particular Publications:*

- ISO 15540:1999 on Test methods for fire resistance of hose assemblies, and
- ISO 15541:1999 on Requirements for the test bench of fire resistance of hose assemblies.

**10.2.5 Lubricating oil arrangements**

*The arrangements for the storage, distribution and utilisation of oil used in pressure lubrication systems shall be such as to ensure the safety of the craft and persons on board. The arrangements made in machinery spaces and, whenever practicable, in auxiliary machinery spaces shall at least comply with the provisions of 10.2.4.1 and 10.2.4.4 to 10.2.4.8 except that:*

**.1** *this does not preclude the use of sight-flow glasses in lubricating systems provided they are shown by test to have a suitable degree of fire resistance;*

**.2** *sounding pipes may be permitted in machinery spaces if fitted with appropriate means of closure; and*

**.3** *lubricating oil storage tanks with a capacity of less than 500 l may be permitted without remote operated valves as required in 10.2.4.5.*

**C10.2.5(a)** Flexible pipes are permissible in positions where the Society is satisfied that they are necessary. Such flexible pipes and end attachments in pressure lubricating systems located in machinery spaces and auxiliary machinery spaces as defined in Section 7 are to be of approved fire-resistant material of adequate strength and constructed to the satisfaction of the Society.

**C10.2.5(b)** Lubricating oil systems are to be constructed to ensure reliable lubrication over the whole range of speed and during run-down of the engines, and are to ensure adequate heat transfer.

**C10.2.5(c)** Independent standby pumps are to be provided for propulsion engines. For craft with more than one main engine, each provided with an independent lubricating oil system, standby pumps are not required. Engines and gears fitted with attached pumps are to be provided with an independent auxiliary lubricating pump if lubrication before starting is necessary.

**C10.2.5(d)** Equipment for suitable treatment of lubricating oil (e.g. purifiers, automatic back-flushing filters, filters, free-jet centrifuges) are to be provided.

**.1** Lubricating oil filters are to be fitted in pump pressure lines. Uninterrupted supply of filtered oil has to be ensured under maintenance conditions of filter equipment. Mesh size and filter capacity are to be in accordance with the engine manufacturer's requirements.

**.2** Main filters are to be provided with differential pressure monitoring. Back-flushing cycles of automatic filters are also to be monitored.

**.3** Engines for emergency power supply or emergency fire pumps may be provided with simplex filters.

**10.2.6 Arrangements for other flammable oils**

*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 shall be such as to ensure the safety of the craft and persons on board. In locations where means of ignition are present, such arrangements shall at least comply with the provisions of 10.2.4.4 and 10.2.4.7 and with the provisions of 10.2.4.8 and 10.2.4.9 in respect of strength and construction.*

**C10.2.6** The provisions of 10.2.4.6, 10.2.5.2 and 10.2.5.3 are to be complied with where applicable, as well as the provisions of 10.2.4.9 in respect of the approval of the fire-resistant materials of flexible pipes.

**10.2.7 Arrangements within machinery spaces**

*In addition to the requirements of 10.2.1 to 10.2.6, the oil fuel and lubricating oil systems shall comply with the following:*

**10.2.7.1** Where daily service fuel tanks are filled automatically or by remote control, means shall be provided to prevent overflow spillages.

**C10.2.7.1** Service tanks are to be fitted with high- and low-level alarms.

**10.2.7.2** Other equipment which treats flammable liquids automatically, such as oil fuel purifiers, which, whenever practicable, shall be installed in a special space reserved for purifiers and their heaters, shall have arrangements to prevent overflow spillages.

**C10.2.7.2** Purifiers for cleaning fuel and lubricating oil are to be in accordance with Society Rules.

**10.2.7.3** Where daily service oil fuel tanks or settling tanks are fitted with heating arrangements, a high temperature alarm shall be provided if the flashpoint of the oil can be reached due to failure of the thermostatic control.

**C10.2.7.3** Tanks which require preheating are to be fitted with temperature-indicating devices and, where necessary, thermal insulation.

Heating coils are to be provided with shutoff valves at tank inlet and outlet. Heating coils are also to be fitted at the tank outlet with an upstream device to test the condensate.

Heating coil connections in tanks are to be welded.

Heating coils are to be supported in such a way as not to be subjected to non-allowable stresses due to vibration, particularly at their points of clamping.

Further requirements concerning heating systems (e.g. boiler, piping layout) are to be taken into consideration.

### 10.3 Bilge pumping and drainage systems

**10.3.1** *Arrangements shall be made for draining any watertight compartment other than the compartments intended for permanent storage of liquid. Where in relation to particular compartments drainage is not considered necessary, drainage arrangements may be omitted but it shall be demonstrated that the safety of the craft will not be impaired.*

**C10.3.1(a)** Bilge suction are to be suitably arranged and fitted with mud boxes.

**C10.3.1(b)** Every machinery space is normally to be provided with at least two bilge suction, one at each side. Additional suction may be required for craft having long machinery spaces.

**C10.3.1(c)** Bilge suction are to be arranged so as not to impede the cleaning of bilges and bilge wells.

**10.3.2** *Bilge pumping arrangements shall be provided to allow every watertight compartment other than those intended for permanent storage of liquid to be drained. The capacity or position of any such compartment shall be such that flooding thereof could not affect the safety of the craft.*

**10.3.3** *The bilge pumping system shall be capable of operation under all possible values of list and trim after the craft has sustained the postulated damage in 2.6.6 and 2.6.10. The bilge pumping system shall be so designed as to prevent water flowing from one compartment to another. The necessary valves for controlling the bilge suction shall be capable of being operated from above the datum. All distribution boxes and manually operated valves in connection with the bilge pumping arrangements shall be in positions which are accessible under ordinary circumstances. The spindles of manually operated valves shall be easily accessible and all valves shall be clearly marked.*

**C10.3.3(a)** Valves in pipe connections between bilge and seawater or ballast water systems, as well as between bilge connections of different compartments, are to be arranged so that even in the event of faulty operation or intermediate positions of the valves, seawater is safely prevented from penetrating through the bilge system.

**C10.3.3(b)** To prevent penetration of ballast and seawater into the ship through the bilge system, two means of reverse-flow protection are to be fitted in the bilge connections, one of which is to be a screw-down non-return valve. One such means of protection is to be fitted in each branch line.

For emergency and direct suction, one screw-down non-return valve is sufficient.

**C10.3.3(c)** A combination of a non-return valve with positive closing device and shutoff valve may be recognized as equivalent to a screw-down non-return valve, at the discretion of the Society.

**C10.3.3(d)** Discharges below the datum are to be provided with shutoff valves located at the shell.

**10.3.4** *The power operated self-priming bilge pumps may be used for other duties such as fire fighting or general service but not for pumping fuel or other flammable liquids.*

**C10.3.4(a)** In the event of pump failure, one pump for fire fighting and one pump for bilge pumping are to remain available.

**C10.3.4(b)** Bilge ejectors are acceptable for bilge pumping arrangements if an independent supply of driving water is provided.

**10.3.5** *Each power bilge pump shall be capable of pumping water through the required bilge pipe at a speed of not less than 2 m/sec.*

**10.3.6** *The diameter (d) of the bilge main shall be calculated according to the following formula, except that the actual internal diameter of the bilge main may be rounded off to the nearest size of a recognized standard:*

$$d = 25 + 1,68 (L (B + D))^{0,5}$$

where:

d : Internal diameter of the bilge main, in mm

L : Length of the craft, in m, as defined in Section 1

B : For monohull craft: breadth of the craft, in m, as defined in Section 1  
For multi-hull craft: breadth of a hull at or below the design waterline, in m

D : Moulded depth of the craft to the datum, in m.

**10.3.7** *Internal diameters of suction branches shall meet the requirements of the Society but shall not be less than 25 mm. Suction branches shall be fitted with effective strainers.*

**C10.3.7** The diameter is given by the formula:

$$d_B = 25 + 2,15 (L_B (B_1 + d))^{0,5}$$

where:

d<sub>B</sub> : Internal diameter, in mm, of the branch pipes

L<sub>B</sub> : Length, in m, of the watertight compartment

B<sub>1</sub> : Average breadth, in m, of the compartment at or below the design waterline.



**10.3.8** *An emergency bilge suction shall be provided for each machinery space containing a propulsion prime mover. This suction shall be led to the largest available power pump other than a bilge pump, propulsion pump or oil pump.*

*Emergency bilge suction shall be provided for craft with common bilge pumping systems according to 10.3.6 and for craft with individual bilge pumps according to 10.3.13.*

**C10.3.8(a)** Emergency bilge suction are to be arranged in an accessible position, at a suitable distance from the double bottom ceiling or the craft bottom. The position is to allow the free flow of bilge water. The diameter is to be equal to the diameter of the suction line of the pump.

**C10.3.8(b)** Emergency bilge valves and the suction valves of the relevant pumps are to be capable of being operated from above the floor.

**10.3.9** *The spindles of the sea inlet valves shall extend well above the machinery space floor plates.*

**C10.3.9** The provisions of C10.1.11.2 are to be complied with.

**10.3.10** *All bilge suction piping up to the connection to the pumps shall be independent of other piping.*

**10.3.11** *Spaces situated above the water level in the worst anticipated damage conditions may be drained directly overboard through scuppers fitted with non-return valves.*

**10.3.12** *Any unattended space for which bilge pumping arrangements are required shall be provided with a bilge alarm.*

**C10.3.12** Each machinery space is normally to be provided with at least two bilge alarms.

**10.3.13** *For craft with individual bilge pumps, the total capacity  $Q$  of the bilge pumps for each hull shall not be less than 2,4 times the capacity of the pump defined in 10.3.5 and 10.3.6.*

**10.3.14** *In bilge pumping arrangements where a bilge main is not provided, then, with the exception of the spaces forward of public spaces and crew accommodation, at least one fixed submersible pump shall be provided for each space. In addition, at least one portable pump shall be provided supplied from the emergency supply, if electric, for use on individual spaces. The capacity of each submersible pump  $Q_n$  shall not be less than:*

$Q_n = Q / (N - 1)$  ton/h with a minimum of 8 tons/h where:

$N$  : Number of submersible pumps

$Q$  : Total capacity as defined in 10.3.13.

**10.3.15** *Non-return valves shall be fitted in the following components:*

**.1** *bilge valve distribution manifolds;*

**.2** *bilge suction hose connections where fitted directly to the pump or to the main bilge suction pipe; and*

**.3** *direct bilge suction pipes and bilge pump connections to main bilge suction pipe.*

**C10.3.15** For reverse-flow protections, see C10.3.3.2 and C10.3.3.3.

#### **C10.3.16 Arrangements for oily bilge water and oil residues**

Each craft is to be provided with at least:

- a collecting tank for oily bilge water, fuel and oil residues
- equipment for discharge of oil residues to reception facilities.

Note: MARPOL 73/78 as amended and national requirements are to be observed.

## **10.4 Ballast systems**

**10.4.1** *Water ballast shall not in general be carried in tanks intended for oil fuel. In craft in which it is not practicable to avoid putting water in oil fuel tanks, oily-water separating equipment shall be fitted, or other alternative means such as discharge to shore facilities shall be provided for disposing of the oily-water ballast. The provisions of this paragraph are without prejudice to the provisions of the International Convention for the Prevention of Pollution from Ships in force.*

**10.4.2** *Where a fuel transfer system is used for ballast purposes, the system shall be isolated from any water ballast system and meet the requirements for fuel systems and the International Convention for the Prevention of Pollution from Ships in force.*

#### **C10.4.3 Piping layout**

Where pipes are led through the collision bulkhead, a shut-off valve, made of ductile metallic material, is to be fitted directly at the collision bulkhead.

The valve is to be capable of being closed by remote control from the operating compartment.

## 10.5 Cooling systems

*The cooling arrangements provided shall be adequate to maintain all lubricating and hydraulic fluid temperatures within the manufacturers' recommended limits during all operations for which the craft is to be certificated.*

### C10.5.1 General

Cooling water circuits are to be provided with temperature controls in accordance with the requirements of Section 11. Control devices whose failure may impair the functional reliability of the system are to be equipped for manual operation.

### C10.5.2 Cooling water pumps

**C10.5.2.1** Main and standby cooling water pumps are to be provided for propulsion systems with one main engine, or systems with more than one engine using a common cooling water system.

For propulsion plants with more than one engine, and for auxiliary engines provided with individual cooling circuits, standby pumps may be dispensed with.

**C10.5.2.2** Standby cooling water pumps shall be driven independently.

### C10.5.3 Heat exchangers, coolers

**C10.5.3.1** For common cooling systems, the number and capacity of heat exchangers and coolers is to be considered by the Society.

**C10.5.3.2** Heat exchangers and coolers are to be provided with:

- shutoff valves at inlet and outlet
- vents and drains.

### C10.5.4 Keel coolers

Keel coolers are to be fitted with pressure gauges at the fresh water inlet and outlet.

### C10.5.5 Seawater cooling systems

**C10.5.5.1** At least two sea inlets are to be provided.

Wherever possible, sea chests are to be provided and positioned as low as possible on either side of the craft.

On multi-hull craft or craft with independent engine rooms, one sea chest or sea inlet for each hull or engine room is considered sufficient.

**C10.5.5.2** Each sea chest is to be provided with an effective vent and a connection to flush the sea chest gratings. The flushing media may not exceed the construction pressure of the sea chest.

**C10.5.5.3** The suction lines of seawater pumps are to be fitted with strainers.

Strainers are to be arranged so that they can be cleaned while the pumps are in operation.

For multiple-engine installations, single strainers are considered sufficient.

### C10.5.6 Sea valves

The provisions of C10.1.11.2 are to be complied with.

Discharge pipes for seawater cooling systems are to be fitted with a shutoff valve at the shell. If discharges are located above the datum, shutoff valves may be dispensed with.

### C10.5.7 Fresh water cooling systems

**C10.5.7.1** Where heat exchangers for fuel or lubricating oil are incorporated in cylinder cooling water circuits of propulsion engines, the entire cooling water circuit is to be monitored for fuel and oil contamination.

**C10.5.7.2** Expansion tanks are to be fitted with filling connections, aeration/de-aeration devices, water level indicators and drains.

**C10.5.7.3** Means are to be provided for preheating as required.

## 10.6 Engine air intake systems

*Arrangements shall provide sufficient air to the engine and shall give adequate protection against damage as distinct from deterioration, due to ingress of foreign matter.*

**C10.6.1** The provisions of Art. 7.6 of Section 7 and of Art. 10.7, if relevant, are to be complied with.

## 10.7 Ventilation systems

*Machinery spaces shall 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 to the spaces for the safety and comfort of personnel and the operation of the machinery. Auxiliary machinery spaces shall be adequately ventilated appropriate for the purpose of those spaces. The ventilation arrangements shall be adequate to ensure that the safe operation of the craft is not put at risk.*

**C10.7.1** The provisions of Art. 7.6 of Section 7 are to be complied with.

**C10.7.2** Each independent machinery space is to be provided with its own ventilation system.

In general, ventilation systems for machinery spaces are to be independent of each other.

**C10.7.3** The height of the coamings from the inlet and outlet openings is, as far as practicable, to comply with the requirements of LLC 66, and in no case be less than the datum.

If water traps are to be provided, air velocity is to be taken into account.

**C10.7.4** The air is to be conducted in such a way as to avoid local accumulations of heat wherever possible (e.g. by means of a secondary system of selective ventilation or by under-floor ducting of exhaust air).

**C10.7.5** The air supply is not to be directed immediately towards hot machine parts, turbine components, measuring instruments or switchboards. Electrical machinery and installations (e.g. switch cabinets) are to be protected, so that water particles penetrating into air ducts will not cause damage. Risks of this kind are to be minimized by appropriate arrangement of ducts and air outlets.

**C10.7.6** The capacity and arrangement of ventilation systems/ducts is to ensure that accumulation of oil vapour is avoided and a slight overpressure in the machinery space during normal operation is guaranteed.

Provision is to be made to remove CO<sub>2</sub>, in case of flooding of the machinery space.

**C10.7.7** Ventilation capacity is to be based on the heat radiation of equipment installed in the space.

## 10.8 Exhaust systems

**10.8.1** *All engine exhaust systems shall be adequate to assure the correct functioning of the machinery and that safe operation of the craft is not put at risk.*

**C10.8.1** Exhaust pipes are to be installed separately from each other, taking structural fire protection into account.

Account is to be taken of thermal expansion when laying out and suspending lines.

Exhaust lines and silencers are to be provided with suitable drains of adequate size.

**10.8.2** *Exhaust systems shall be so arranged as to minimize the intake of exhaust gases into manned spaces, air-conditioning systems, and engine intakes. Exhaust systems shall not discharge into air cushion intakes.*

**10.8.3** *Pipes through which exhaust gases are discharged through the hull in the vicinity of the waterline shall be fitted with erosion/corrosion resistant shutoff flaps or other devices on the shell or pipe end and acceptable arrangements made to prevent water flooding the space or entering the engine exhaust manifold.*

**C10.8.3(a)** Shutoff flaps may be omitted if the overflow point of the exhaust pipe is located above the most unfavourable damage water line.

Shutoff devices are to be fitted with means for remote controlled closing above the datum, preferably from the operating compartment. The closed position is to be indicated.

**C10.8.3(b)** The use of flexible hoses in wet exhaust systems may be accepted at the discretion of the Society, if the hoses are suitable for this purpose (media, pressure and temperature).

**C10.8.3(c)** Materials used in exhaust systems are to be resistant to sea water corrosion and exhaust products.

**10.8.4** *Gas turbine engine exhausts shall be arranged so that hot exhaust gases are directed away from areas to which personnel have access, either on board the craft or in the vicinity of the craft when berthed.*

### C10.8.5 Insulation

Exhaust lines, silencers and exhaust gas boilers are to be insulated properly.

Insulating materials are to be incombustible.

Exhaust lines inside engine rooms are to be provided with metal sheathing or other approved type of hard sheathing.

## C10.A.1 Compressed air systems

### C10.A.1.1 Starting equipment

Starting equipment (e.g. air compressors and air receivers) are to comply with Art. 9.3 of Section 9 for gas turbines and Art. 9.4 of Section 9 for diesel engines.

**C10.A.1.2 Compressed air lines**

Pressure lines connected to air compressors are to be fitted with non-return valves at the compressor outlets.

Oil and water separators are to be provided.

The starting air line to each engine is to be fitted with a non-return device and drain.

A safety valve is to be fitted behind each pressure-reducing valve.

The compressed air supply for blowing through sea chests may not exceed the design pressure of the sea chest (see C10.5.5.2).

**C10.A.1.3 Control air system**

Control air systems for essential consumers are to be provided with the necessary means of air treatment.

**C10.A.2 Steam heating, feedwater and condensate systems****C10.A.2.1 General**

For steam and hot water generators as well as for oil-fired burners, the provision of 9.1.13 of Section 9 are to be complied with.

Pipes, pumps and valves belonging to these systems are also subject to the following requirements.

**C10.A.2.2 Steam lines**

Steam lines are to be installed and supported so that expected stresses due to thermal expansion, external loads and shifting of the supporting structure under both normal and interrupted service conditions will be safely compensated. Sufficiently rigid positions are to be arranged as fixed points for the steam piping systems. Steam lines are to be provided with sufficient expansion arrangements.

Steam lines are to be installed so that water pockets will be avoided. Means are to be provided for reliable drainage of the piping system.

Steam lines are to be effectively insulated to prevent heat losses. Pipe penetrations through bulkheads and decks are to be insulated to prevent heat conduction. At points where there is a possibility of contact, the surface temperature of the insulated steam lines may not exceed 60°C. Wherever necessary, additional protection arrangements against unintended contact are to be provided.

**C10.A.2.3 Feedwater lines**

Feedwater lines are to be fitted with shutoff valves and check valves at the boiler inlet. Where shutoff and check valves are not directly connected in series, the intermediate pipe is to be fitted with a drain.

Feedwater pumps are to be fitted with shutoff valves on the suction side and screw-down non-return valves on the delivery side. The pipes are to be arranged so that each pump can supply each feedwater line.

Provision of only one feedwater line for auxiliary and exhaust gas boilers is sufficient if the preheaters and automatic regulating devices are fitted with bypass lines.

Continuous-flow boilers need not be fitted with these valves, provided that the heating of the boiler is automatically switched off if the feedwater supply fails, and that the feedwater pump supplies only one boiler.

Feedwater lines may not pass through tanks which do not contain feedwater.

**C10.A.2.4 Capacity of feedwater pumps**

Provision of only one feedwater pump is sufficient if the boiler is not intended for essential services.

Where two feedwater pumps are provided, the capacity of each is to be equivalent to at least 1,25 times the maximum permitted output of all the connected steam producers.

Where more than two feedwater pumps are installed, the capacity of all other feedwater pumps, in the event of failure of the pump with the largest capacity, is to comply with the requirements above.

For continuous-flow boilers, the capacity of the feedwater pumps is to be at least 1,0 times the maximum steam output.

Special conditions may be accepted for the capacity of the feedwater pumps, for plants incorporating a combination of oil-fired and exhaust-gas boilers or other arrangements.

**C10.A.2.5 Boiler water circulating systems**

The provision of only one circulating pump for each boiler is sufficient in the following cases:

- boilers are heated only by gases whose temperature does not exceed 400°C, or
- a common standby circulating pump is provided, which can be connected to any boiler,
- the burners of oil- or gas-fired auxiliary boilers are arranged so that they are automatically shut off if the circulating pump fails and the heat stored in the boiler does not cause any unacceptable evaporation of the available water in the boiler,
- the boiler is not intended for essential services.

**C10.A.2.6 Condensate recirculation**

The condensate of all heating systems used to heat oil (e.g. fuel, lubricating, cargo oil) is to be led to condensate observation tanks. These tanks are to be fitted with vents to the open deck.

**C10.A.3 Air, overflow and sounding pipes****C10.A.3.1 General**

The minimum wall thickness for steel pipes is to be in accordance with Table C10.5, Table C10.6 and Table C10.10.

The minimum wall thickness for pipes in material other than steel shall be at least:

- in accordance with Tables C10.7, C10.8 or C10.9 below the open deck
- increased by at least 50% above the open deck.

All compartments and tanks arranged with filling and/or drainage equipment are to be fitted with air pipes and sounding devices.

**C10.A.3.2 Air and overflow pipes**

Voids, cofferdams and tanks are to be fitted with air pipes. The arrangement is to allow total filling of tanks under normal trim conditions.

Air pipes located on open deck are to be fitted with automatic air pipe heads approved by the Society at a height not lower than 760 mm above deck.

Note: Refer to International Convention on Load Lines, 1966 Reg. 20 (LLC66) as amended.

Air pipes of tanks which contain fuel oil are to terminate on open deck to save locations with no risk of ignition (see also 10.2.4.8).

Air pipes of tanks which contain liquids other than fuel oil may terminate inside closed spaces. Means are to be provided for safe drainage in the event of overflow.

Air pipes of integral tanks located at the shell side are to terminate above the datum.

Air and overflow pipes are to be arranged in such a way that they are self-draining under normal conditions.

Where air and overflow pipes of several tanks are connected to a common line, the common line and connections are to be arranged so that, if a leakage occurs in one tank due to hull damage or listing of the ship, fuel or water cannot flow into another tank.

The minimum inner diameter of air/overflow pipes is not to be less than 40 mm.

The clear cross-sectional area of air/overflow pipes is to be at least 1,25 times the cross-sectional area of the filling pipes. However, pump capacity and pressure head are to be considered in sizing air and overflow pipes.

**C10.A.3.3 Sounding pipes**

Sounding pipes are to be provided for tanks, cofferdams and void spaces and bilge wells in spaces which are not accessible at all times. As far as possible, sounding pipes are to be laid straight and are to extend as near as possible to the bottom of the tank close to the pump suction.

Sounding pipes may not be used as filling pipes.

Where tanks are fitted with remote level indicators approved by the Society, provision of sounding pipes may be dispensed with.

Sounding pipes which terminate below the datum are to be fitted with self-closing shutoff devices. Such sounding pipes are permissible only in spaces which are accessible at all times. All other sounding pipes are to be extended to the open deck. Sounding pipe openings are always to be accessible and fitted with watertight closing devices.

Sounding pipes for tanks which contain flammable liquids are to extend to the open deck, or comply with the requirements of Art. 7.5 of Section 7 and 10.2.4.7.

Sounding pipes are to have a nominal inside diameter of at least 32 mm.

**C10.A.4 Drinking water systems**

Note: Any national rules are to be observed.

Drinking water systems are to comply with the Society Rules.

**C10.A.5 Sanitary systems****C10.A.5.1 General arrangement**

Sanitary discharge pipes are to be arranged so that, in the event of damage, undamaged compartments cannot be flooded by damaged discharge lines, even if the craft inclines temporarily.

Where discharge lines from several watertight compartments are connected to one tank, the compartments are to be separated from each other by gate or ball valves at the watertight bulkheads. Valves shall be capable of being closed by remote control from the craft operating compartment or another space above the datum. An indicator for the closed position is to be provided among the controls.

The minimum wall thicknesses of sanitary discharge pipes are to be determined in accordance with Table C10.5 and Table C10.10. Penetrations of pipes of smaller thickness, pipes of special types and plastic pipes through bulkheads or decks of type A fire integrity require Society approval.

Overboard discharges are to be fitted with means of preventing ingress of water from the sea. The Load Line Convention (LLC) as amended is to be applied analogously.

**C10.A.5.2 Sewage tanks and sewage treatment systems**

Sewage tanks are to be fitted with air pipes leading to the open deck above the datum.

Sewage tanks are to be fitted with a filling connection, a connection for flushing the tank and a level alarm. Existing overflows to the bilge or openings for adding of chemicals are considered as internal openings.

The discharge lines of sewage tanks below the datum are to be fitted with a non-return valve and a gate valve. The gate valve is to be fitted directly at the craft's shell.

A single screw-down non-return valve may be used instead of the gate and non-return valves.

The second means of reverse-flow protection may be a pipe loop with an overflow height which remains above the water level in the worst anticipated damage condition. The pipe loop is to be fitted with an automatic ventilation device located 45° below the crest of the loop.

Ballast and bilge pumps may not be used for emptying sewage tanks.

**C10.A.6 Hydraulic systems for hatch covers, shell closing appliances, watertight doors and hoists****C10.A.6.1 General**

Cylinders are preferably to be made of steel, cast steel or nodular cast iron (with a predominantly ferritic matrix).

For cylinders, where  $PB \cdot \Delta_i > 2000$ , materials are to be tested in accordance with the Society Rules ( $D_i$  being the inside diameter, in mm).

Testing of materials by the Society may be dispensed with in the case of cylinders for secondary applications, provided that evidence in the form of a works test certificate (e.g. to EN 10 204 - 2.3) is supplied.

For testing the materials of hydraulic accumulators, see Section 9.

**C10.A.6.2 Hydraulic operating equipment for hatch covers****C10.A.6.2.1 Design and construction**

Hydraulic operating equipment for hatch covers may be served either by a common power station for all hatch covers or by several power stations individually assigned to a single hatch cover. Where a common power station is used, at least two pump units are to be fitted. Where the systems are supplied individually, changeover valves or fittings are required so that operation can be maintained if one pump unit fails.

Movement of hatch covers may not be initiated by starting of the pumps. Special control stations are to be provided to control the opening and closing of hatch covers. Controls are to be so designed that, as soon as they are released, movement of the hatch covers stops immediately.

Hatches are normally to be visible from control stations. If, in exceptional cases, this is impossible, opening and closing of the hatches are to be signalled by an audible alarm. In addition, the control stations are then to be equipped with indicators to monitor movements of the hatch covers.

At control stations, the controls governing opening and closing operations are to be appropriately marked.

Suitable equipment is to be fitted in, or immediately adjacent to, each power unit (cylinder or similar) used to operate hatch covers, to enable the hatches to be closed slowly in the event of a power failure (e.g. due to a pipe rupture).

Hatch covers are to be fitted with devices which prevent them from moving into their end positions at excessive speed. Such devices are not to cause the power unit to be switched off.

**C10.A.6.2.2 Pipes**

Pipe dimensions are to be calculated according to the Society Rules.

Piping systems are to be fitted with filters to clean the hydraulic fluid.

Equipment is to be provided to enable the hydraulic systems to be vented.

The accumulator space of the hydraulic accumulator is to have permanent access to the relief valve of the connected system. The gas chamber of the accumulator may be filled only with inert gases. Gas and operating media are to be separated by accumulator bags, diaphragms or similar devices.

Connection between the hydraulic systems used for hatch cover operation and other hydraulic systems is permitted only at the discretion of the Society.

Tanks forming part of the hydraulic system are to be fitted with oil-level indicators.

**C10.A.6.2.3 Emergency operation**

Devices shall be fitted that are independent of the main system and which enable hatch covers to be opened and closed in the event of failure of the main system. Such devices may, for example, take the form of loose rings enabling hatch covers to be moved by cargo winches, warping winches etc.

**C10.A.6.3 Hydraulically operated closing appliances in the craft's shell****C10.A.6.3.1 Scope**

The following requirements apply to the power equipment of hydraulically operated closing appliances in the craft's shell, such as shell and landing doors which are not normally operated while at sea.

**C10.A.6.3.2 Design and construction**

The movement of doors and other closing devices in the shell may not be initiated by starting of the pumps at the power station.

Local control, inaccessible to unauthorized persons, is to be provided for every closing appliance in the craft's shell. As soon as the controls (push-buttons, levers or similar) are released, movement of the appliance is to be stopped immediately.

Closing appliances in the craft's shell are normally to be visible from control stations. If the movement cannot be observed, audible alarms are to be fitted. In addition, control stations are to be equipped with indicators enabling the movement to be monitored.

Closing appliances in the craft's shell are to be fitted with devices which prevent them from moving into their end positions at excessive speed. Such devices are not to cause the power unit to be switched off.

As far as necessary, mechanical means are to be provided to lock closing appliances in the open position.

Every power unit driving horizontally hinged or vertically operated closing appliances is to be fitted with throttle valves or similar devices, to prevent sudden dropping of the closing appliance.

Driving power shall be shared between at least two mutually independent pump units.

For pipes see C10.A.6.2.2.

**C10.A.6.4 Hydraulic operating systems for watertight doors**

Requirements concerning these items are given in Section 2.

**C10.A.6.5 Hoists****C10.A.6.5.1 Scope**

For the purposes of these requirements, hoists include hydraulically operated appliances such as wheelhouse hoists, lifts and similar equipment.

**C10.A.6.5.2 Design and construction**

Hoists may be operated either by a combined power station or by individual power stations.

In the case of a combined power supply, with hydraulic drive pipes connected to other hydraulic systems, a second pump unit is to be fitted.

The movement of hoists is not to be initiated merely by starting the pumps. The movement is to be controlled from special operating stations. Controls are to be so arranged that, as soon as they are released, the movement of the hoist stops immediately.

Local controls, inaccessible to unauthorized persons, are to be fitted. The movement of hoists is normally to be visible from the operating stations. If the movement cannot be observed, audible and/or visual warning devices are to be fitted. In addition, operating stations are to be equipped with indicators to monitor the movement of the hoist.

Devices are to be fitted which prevent the hoist from reaching its end position at excessive speed. Such devices are not to cause the power unit to be switched off. As far as necessary, mechanical means are to be provided to lock the hoist in its end positions.

Suitable equipment is to be fitted in, or immediately adjacent to, each power unit used to operate hoists to enable them to be lowered slowly if the power unit fails or a pipe ruptures.

For pipes see C10.A.6.2.2.

**C10.A.6.6 Tests at the manufacturer's works****C10.A.6.6.1 Testing of power units**

Power units are to undergo testing on a test bed. Factory test certificates for this testing are to be submitted at final inspection of the hydraulic system.

**C10.A.6.6.2 Pressure and tightness tests**

Pressure components are to undergo a pressure test at test pressure  $PP = 1,5 \cdot PR$ .

For the definitions of the PP and PR see C10.1.5.3 and C10.1.5.4. However, for maximum working pressures above 20 MPa, the test pressure need not exceed  $PR + 10$  MPa.

For pressure testing of pipes, their valves and fittings, see C10.1.7.

Tightness tests are to be performed on components for which this is appropriate.

**C10.A.6.6.3 Function tests**

Watertight doors are to be subjected to a functional test with an adverse list of 15°.

**C10.A.6.6.4 Shipboard trials**

After installation, the equipment is to undergo an operational test.

Operational testing of watertight doors is to include the emergency operating system and measurement of closing times.

## Part B Requirements for passenger craft

### 10.9 Bilge pumping and drainage systems

**10.9.1** For category B craft at least three and for category A craft at least two power bilge pumps shall be fitted connected to the bilge main, one of which may be driven by the propulsion machinery. Alternatively, the arrangement may be in accordance with the requirements of 10.3.14.

**10.9.2** The arrangements shall be such that at least one power bilge pump shall be available for use in all flooding conditions which the craft is required to withstand as follows:

**.1** one of the required bilge pumps shall be an emergency pump of a reliable submersible type having an emergency source of power; or

**.2** the bilge pumps and their sources of power shall be so distributed throughout the length of the craft that at least one pump in an undamaged compartment will be available.

**C10.9.2** The "emergency source" is to be located above the datum.

**10.9.3** On multi-hull craft, each hull shall be provided with at least two bilge pumps.

**10.9.4** Distribution boxes, cocks and valves in connection with the bilge pumping system shall be so arranged that, in the event of flooding, one of the bilge pumps may be operative in any compartment. In addition, damage to a pump or its pipe connecting to the bilge main shall not put the bilge system out of action. When, in addition to the main bilge pumping system, an emergency bilge pumping system is provided, it shall be independent of the main system and so arranged that a pump is capable of operating in any compartment under flooding conditions as specified in 10.3.3. In that case only the valves necessary for the operation of the emergency system need be capable of being operated from above the datum.

**10.9.5** All cocks and valves referred to in 10.9.4 which can be operated from above the datum shall have their controls at their place of operation clearly marked and shall be provided with means to indicate whether they are open or closed.

**C10.9.5** The control station for remote-controlled valves shall be located in the operating compartment as far as possible.

### C10.B.1 Operating systems for watertight doors

Requirements concerning these items are given in Section 2.

## Part C Requirements for cargo craft

### 10.10 Bilge pumping systems

**10.10.1** At least two power pumps connected to the main bilge system shall be provided, one of which may be driven by the propulsion machinery. If the Administration is satisfied that the safety of the craft is not impaired, bilge pumping arrangements may be dispensed with in particular compartments. Alternatively, the arrangement may be in accordance with the requirements of 10.3.14.

**10.10.2** On multi-hull craft each hull shall be provided with at least two power pumps, unless a bilge pump in one hull is capable of pumping bilge in the other hull. At least one pump in each hull shall be an independent power pump.

### C10.C.1 Hydraulic operating systems for watertight doors

Requirements concerning these items are given in Section 2.



## SECTION 11      REMOTE CONTROL, ALARM AND SAFETY SYSTEMS

### C11.0      Documents to be submitted

**C11.0.1**      The following drawings and documents are to be submitted in triplicate for approval. The Society reserves the right to ask for supplementary copies if deemed necessary in particular cases.

**.1**      Layout diagrams showing the location of individual components, input and output devices, control cabinets and interconnection lines between the components;

**.2**      Wiring and piping diagrams including details of their material and connecting units;

**.3**      Plans and specification showing the working principles of the system with comprehensive description;

**.4**      List of instruments stating name of manufacturers, types, working ranges, set points and application with regard to their environmental conditions;

**.5**      Plans of control and monitoring panels with details on their instrumentation and control devices;

**.6**      List of operating values of machinery and limits for alarm and safety action threshold;

**.7**      Diagrams of electric and non-electric power supply;

**.8**      System analysis of programmable electronic systems including hardware configuration, algorithms and –on special request– data structure and storage allocations; FMEA documentation as required in Annex 4 where manual intervention for averting of a danger is not possible;

**.9**      Testing programmes of the equipment in the manufacturer's works and on dock and sea trial.

**C11.0.2**      Further documentation may be required if deemed necessary by the Society.

### 11.1      Definitions

**11.1.1**      *“Remote control systems” comprise all equipment necessary to operate units from a control position where the operator cannot directly observe the effect of his actions.*

**11.1.2**      *“Back-up control systems” 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.*

### 11.2      General

**11.2.1**      *Failure of any remote or automatic control systems shall initiate an audible and visual alarm and shall not prevent normal manual control.*

**11.2.2**      *Manoeuvring and emergency controls shall permit the operating crew to perform the duties for which they are responsible in a correct manner without difficulty, fatigue or excessive concentration.*

**C11.2.2**      The operation of the remote control from the craft's operation station is to be so designed and constructed that it does under normal conditions not require the operator's particular attention of the details of the machinery.

The remote control systems consisting of steel cable links or equivalent are to be submitted to the Society for special consideration.

The equipment, to which this Section applies, shall be of state of the art design and construction and shall have proved their reliability in marine service. If evidence on the required reliability cannot be given by relevant documentation, the equipment has to be subjected to an approval according to the Rules of the Society.

**11.2.3**      *Where control of propulsion or manoeuvring is provided at stations adjacent to but outside the operating compartment, the transfer of control shall only be effected from the station which takes charge of control. Two-way voice communication shall be provided between all stations from which control functions may be exercised and between each such station and the look-out position. Failure of the operating control system or of transfer of control shall bring the craft to low speed without hazarding passengers or the craft.*

**C11.2.3**      Under normal conditions, the transfer of the control function between such control positions may only be effected if the respective control devices are in the same position or if equivalent means are provided for smooth transfer of command without significant change in the craft's speed and direction of thrust.

**11.2.4** For category B craft and cargo craft, remote control systems for propulsion machinery and directional control shall 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.

**C11.2.4** If provided so, the communication of machinery propulsion orders shall be effected by a telegraph system or equivalent means, which imply an optical indication at the such control positions of the machinery orders received from the craft's operating station.

**C11.2.5** Under all sailing conditions (including manoeuvring), the propulsion machinery, including propellers, jets, flaps or other means which affect the speed and direction of thrust of all category high speed craft, is to be controllable from the craft's operating station.

**C11.2.6** In principle the remote control is to be performed by a single control device for each independent propulsion unit with automatic performance of all associated services including, where necessary, means of preventing overload and prolonged running in critical speed ranges of the propulsion unit.

In cases where multiple propulsion units are designed to operate simultaneously, the command on their controls shall be designed for the possibility of being connected in one control device, in order to select individual or common control of the units, as necessary for the appropriate mode of operation.

Movement of the control device shall take place in the same direction as the desired motion of the ship.

**C11.2.7** Each control position is to be provided with means to indicate which of them is in control.

At any control position, from which control of craft's manoeuvring is exercised, the operating effects caused by control inputs to the propulsion unit shall continuously be indicated.

**C11.2.8** After restoration of normal conditions following an automatic shut-down, the machinery shall not start inadvertently before the control device has been reset to stop. Following an automatic slow-down—if provided—the propulsion of the craft shall not accelerate inadvertently before the control device has been reset to the actual step of speed, to which the power of the propulsion had been decreased.

Alternatively, other arrangements may be provided for the operator to consciously admit starting or acceleration of propulsion machinery.

Remote starting of a propulsion unit is to be automatically inhibited if conditions exist which may hazard the machinery, e.g. turning gear engaged, clutch engaged, shut-down activated, etc.

**C11.2.9** The power for the control system is to be supplied from the same source which supplies the essential services for the propulsion units. As an alternative, the power for the control system may be supplied from other sources of power with backing-up facilities, which are sufficient for at least 15 minutes operation of the control system, in case of failure in its normal supply.

In case of category B craft, the control system of each propulsion unit shall have its individual source of power.

### 11.3 Emergency controls

**11.3.1** 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 shall be provided, within easy reach of the crew member at that station, with controls for use in an emergency to:

- .1 activate fixed fire-extinguishing systems;
- .2 close ventilation openings and stop ventilating machinery supplying spaces covered by fixed fire-extinguishing systems, if not incorporated in .1;
- .3 shut off fuel supplies to machinery in main and auxiliary machinery spaces;
- .4 disconnect all electrical power sources from the normal distribution system (the operating control shall be guarded to reduce the risk of inadvertent or careless operation); and
- .5 stop main engine(s) and auxiliary machinery.

**C11.3.1** Unless it is considered impracticable, a single failure of the emergency controls shall not have an inadvertent effect on the system which it serves. In case of such a failure, an alarm shall 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.

**11.3.2** Where control of propulsion and manoeuvring is provided at stations outside the operating compartment, such stations shall have direct communication with the operating compartment which shall be a continuously manned control station.

**11.3.3** In addition, for category B craft, control of propulsion and manoeuvring, as well as emergency functions referred to in 11.3.1, shall be provided in a station outside the operating compartment. Such stations shall have direct communication with the operating compartment which shall be a continuously manned control station.

**11.4 Alarm system**

**11.4.1** Alarm systems shall be provided which announce at the craft's control position, by visual and audible means, malfunction or unsafe conditions. Alarms shall be maintained until they are accepted and the visual indications of individual alarms shall remain until the fault has been corrected, when the alarm shall 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 shall operate again. Alarm systems shall incorporate a test facility.

**11.4.1.1** Emergency alarms giving indication of conditions requiring immediate action shall be distinctive and in full view of crew members in the operating compartment, and shall be provided for the following:

- .1** activation of a fire detection system;
- .2** total loss of normal electrical supply;
- .3** overspeed of main engines;
- .4** thermal runaway of any permanently installed nickel-cadmium battery.

**C11.4.1.1** In addition to the alarms requested under 11.4.1.1, the following alarms, giving indication that is distinctive and in full view of crew members in the operating compartment, are to be provided:

- .1** fire (alarm to summon the crew);
- .2** general emergency alarm (alarm to summon crew and passengers to muster stations);
- .3** fire-extinguishing medium imminent release;
- .4** watertight doors imminent closing, compartment flooding.

**11.4.1.2** Alarms with a visual display distinct from that of alarms referred to in 11.4.1.1 shall indicate conditions requiring action to prevent degradation to an unsafe condition. These shall be provided for at least the following:

- .1** exceeding the limiting value of any craft, machinery or system parameter other than engine overspeed;
- .2** failure of normal power supply to powered directional or trim control devices;
- .3** operation of any automatic bilge pump;
- .4** failure of compass system;
- .5** low level of a fuel tank contents;

- .6** fuel oil tank overflow;
- .7** extinction of side, masthead or stern navigation lights;
- .8** low level of contents of any fluid reservoir the contents of which are essential for normal craft operation;
- .9** failure of any connected electrical power source;
- .10** failure of any ventilation fan installed for ventilating spaces in which inflammable vapours may accumulate;
- .11** diesel engine fuel line failure as required by 9.4.2.

**C11.4.1.2** With reference to 11.4.1.2.1 in particular, the machinery is to be monitored in the scope as listed in Table C11.4.1.2.1 to Table C11.4.1.2.6.

**Table C11.4.1.2.1 - 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 of each cylinder from average of exhaust gas temperature, or Exhaust gas temperature of each cylinder	high low + high	if cylinder power above 130 kW
Exhaust gas temperature after turbocharger	high	if cylinders not monitored individually and if cylinder power below 130 kW
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	

**Table C11.4.1.2.2 - 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	

**Table C11.4.1.2.3 - Transmission, shaft gears**

Parameter	Alarm level	Remark
Lubricating oil pressure to gears	low	
Lubricating oil temperature of gears with sliding bears	high	
Servo oil pressure of gears and transmissions	low	
Thrust bearing temperature	high	only for sliding bears
Stern tube temperature	high	

**Table C11.4.1.2.4 - 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	

**Table C11.4.1.2.5 - Auxiliary boilers**

Parameter	Alarm level	Remark
Water level	low	
Steam pressure	low + high	
Flame failure	shut down	
Safety system	failure	

**Table C11.4.1.2.6 - Miscellaneous**

Parameter	Alarm level	Remark
Remote control of propulsion	failure	
Safety system of each machinery	tripped	
Override of safety system	activated	
Power of alarm system	failure	
Electrical non-essential consumers	tripped	
Insulation resistance	low	
Emergency controls	failure	
Fire alarm system	failure	
Stand-by function of auxiliaries	start	
Machinery space bilge level	high	2 sensors at least for each machinery space
Fuel oil service tank temperature	high	if heated above flash-point
Purifier	failure	

**11.4.1.3** All warnings required by 11.4.1.1 and 11.4.1.2 shall be provided at all stations at which control functions may be exercised.

**11.4.2** The alarm system shall meet appropriate constructional and operational requirements for required alarms.

*Note: Refer to the Code on Alarms and Indicators, 1995, adopted by the Organization by resolution A.830(19).*

**11.4.3** Equipment monitoring the passenger, cargo and machinery spaces for fire and flooding shall, so far as 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.

**C11.4.4** On category B craft, alarm systems including their power supply have to be separate for each independent propulsion unit and its essential auxiliaries.

## 11.5 Safety system

**11.5.1** Where arrangements are fitted for overriding any automatic shut-down system for the main propulsion machinery in accordance with 9.2.2, they shall be such as to preclude inadvertent operation.

*When a shut-down system is activated, an audible and visual alarm shall be given at the control station and means shall be provided to override the automatic shut-down except in cases where there is a risk of complete breakdown or explosion.*

**C11.5.1** In case of need, the bridge operator may have a possibility to cancel the safety devices which could have caused the propelling machinery to stop (except for the overspeed one). Control of this device is to be such as to preclude inadvertent operation; the indication "safety devices off" shall be clearly visible.

**C11.5.2** After restoration of normal conditions following a shut-down, resetting of the safety system shall be possible at the craft's operating station and at other positions from which the control can be exercised.

**C11.5.3** 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 shall be separate for each propulsion unit.

**C11.5.4** 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 with the most effective protection of the machinery.

**C11.5.5** The power for the safety system shall 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.

## **C11.6      Stand-by systems**

**C11.6.1** Where stand-by units are required, they shall start up automatically:

- on failure of operational units
- to preserve stored energy resources (e.g. compressed air)
- on operational demand, if auxiliary machinery are operated in staggered service.

**C11.6.2** The threshold for activation of the stand-by system shall be such that normal operation is restored before the safety system is activated.

**C11.6.3** The changeover to a stand-by unit due to a fault is to be signalled visually and audibly. However, an alarm is not to be tripped in the case of machinery installations with auxiliary machines driven mechanically from the propulsion plant where the stand-by machines start up automatically in the lower speed range.

**C11.6.4** 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.

**SECTION 12****ELECTRICAL INSTALLATIONS****Part A General****C12.0 Documents to be submitted**

**C12.0.1** The following drawings and documents are to be submitted, at least in triplicate, for approval. The Society reserves its right to ask for supplementary copies, if deemed necessary in particular cases.

**.1** Single line general electric diagram of the installation (including emergency installation)

**.2** Diagram of power supplies or converters

**.3** Electrical load analysis

**.4** Calculation of short-circuit currents for each installation in which the sum of rated power of the energy sources which may be connected contemporaneously to the network is greater than 500 kVA (kW), and in each installation where selective protective devices are foreseen

**.5** List of circuits including, for each supply and distribution circuit, data concerning the nominal current, the cable type, length and cross-section, nominal and setting values of the protective and control devices

**.6** Single line and functional diagram of the main switchboard

**.7** Single line and functional diagram of the emergency switchboard

**.8** Diagram of the most important section boards

**.9** Diagram of the supply, monitoring and control systems of the steering gear

**.10** Diagram of the supply, monitoring and control systems of the propulsion plant

**.11** Diagram of the general alarm system

**.12** Diagram of the Engineers' alarm system

**.13** Diagram of the navigation-light switchboard

**.14** Electrical diagram of the gas fire extinguishing system

**.15** Electrical diagram of the sprinkler fire extinguishing system

**.16** Electrical diagram of the fire door control and monitoring

**.17** Diagram of the emergency stop systems

**.18** Diagram of the public address system or other inter-communication systems.

**C12.0.2** In addition to the documentation requested above, the following is also required:

**.1** For passenger craft:

(a) Single line diagram of the main cable runs showing cables for duplicated equipment and the location of the main distribution and emergency switchboards

(b) Diagrams of switchboards for control, indication and alarm of watertight doors.

**.2** For passenger and cargo craft with spaces intended for the carriage of motor vehicles with fuel in their tanks and/or spaces intended for the carriage of dangerous goods:

(a) Plan of dangerous spaces giving details of types of cables and safety characteristics of the equipment installed therein

(b) Diagrams of control and monitoring systems for doors, closed-circuit television or monitoring systems for flooding on passenger craft with ro-ro spaces or special category spaces

(c) Diagrams of supplementary emergency lighting systems for the craft in the previous item (b).

Further documentation may be required, if deemed necessary by the Society.

**12.1 General**

**12.1.1** *Electrical installations shall be such that:*

**.1** *all electrical auxiliary services necessary for maintaining the craft in normal operation and habitable conditions will be ensured without recourse to the emergency source of electrical power;*

**.2** *electrical services essential for safety will be ensured under various emergency conditions; and*

**.3** *the safety of passengers, crew and craft from electrical hazards will be ensured.*

*Note: Refer to the recommendations published by the International Electrotechnical Commission and, in particular, Publication 60092 - Electrical installation in ships.*

*The FMEA shall 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 installations, the analysis shall take into account the possibility of faults occurring simultaneously or consecutively.*

**12.1.2** *The electrical system shall be designed and installed so that the probability of the craft being at risk of failure of a service is extremely remote.*

**12.1.3** *Where loss of particular essential service would cause serious risk to the craft, the service shall be fed by at least two independent circuits fed in such a way that no single failure in the electrical supply or distribution systems would affect both supplies.*

**12.1.4** *The securing arrangements for heavy items, i.e. accumulator batteries, shall, as far as practicable, prevent excessive movement during the accelerations due to grounding or collision.*

**12.1.5** *Precautions shall be taken to minimize risk of supplies to essential and emergency services being interrupted by the inadvertent or accidental opening of switches or circuit breakers.*

## **12.2 Main source of electrical power**

**12.2.1** *A main source of electrical power of sufficient capacity to supply all those services mentioned in 12.1.1 shall be provided. The main source of electrical power shall consist of at least two generating sets.*

### **C12.2.1 Electrical propulsion**

For electrically propelled craft with two or more constant-voltage propulsion generating sets, the craft's service electric power may be derived from this source and additional service generators need not be fitted, provided that effective propulsion be maintained with one propulsion generator out of service.

### **C12.2.2 Shaft-driven generators**

One of the required generators may be a generator driven by a main propulsion unit (shaft generator) intended to operate at constant speed, (e.g. a system where craft speed

and direction are controlled only by varying propeller pitch).

Shaft generator installations which do not comply with this criterion may be fitted as additional source(s) of power provided that:

**.1** On loss of power from the shaft generator(s), a stand-by generating set starts up automatically

**.2** The capacity of the stand-by set is adequate for the loads necessary for craft propulsion and safety

**.3** These services are restored as quickly as practicable.

**12.2.2** *The capacity of these generating sets shall be such that, in the event of any one generating set being stopped or failing, it will still be possible to supply those services necessary to provide the normal operational conditions of propulsion and safety. Minimum comfortable conditions of habitability shall also be ensured, which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.*

### **C12.2.3**

(a) In addition to the normal operational conditions of propulsion and safety as per 12.2.2, steering conditions are also to be provided.

(b) Those services necessary to provide normal operational conditions of propulsion, steering and safety do not include services such as:

- (1) Thrusters not forming part of the main propulsion system
- (2) Windlass
- (3) Moorings
- (4) Cargo handling gear
- (5) Cargo pumps
- (6) Air conditioning.

**12.2.3** *The arrangements of the craft's main source of electrical power shall be such that the services referred to in 12.1.1.1 can be maintained regardless of the speed and direction of the propulsion machinery or shafting.*

**12.2.4** *In addition, the generating sets shall be such as to ensure that, with any one generator or its primary source of power out of operation, the remaining generating set shall be capable of providing the electrical services necessary to start the main propulsion plant from dead craft condition. The emergency source of electrical power may be used for the purpose of starting from a dead craft condition if its capability, either alone or combined with that of any other source of electrical power, is sufficient to provide at the same time those services required to be provided by 12.7.3.1 to 12.7.3.3 or 12.7.4.1 to 12.7.4.4 or 12.8.2.2.1 to 12.8.2.2.4, as appropriate.*

**12.2.5** Where transformers constitute an essential part of the electrical supply system required by this section, the system shall be so arranged as to ensure the same continuity of supply as stated in Art. 12.2.

**C12.2.5** This requirement also applies to static converters or charging units.

The following requirement also applies to these transformers.

The number, capacity and arrangement of power transformers supplying auxiliary electrical systems are to be such that, with any one transformer not in operation, the remaining transformer(s) is (are) sufficient to ensure the safe operation of those services necessary to provide normal operational conditions of propulsion and safety. Minimum comfortable conditions of habitability are also to be ensured, including at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

Each transformer required is to be located as a separate unit, with a separate enclosure or equivalent arrangement, and is to be served by separate circuits on the primary and secondary sides. Each primary circuit is to be provided with switchgear and protective devices in each phase.

Each of the secondary circuits is to be provided with a multipole isolating switch.

See the examples given in Figure C12.2.5.1.

Transformers supplying a bow thruster are excluded.

**12.2.6** A main electric lighting system which shall provide illumination throughout those parts of the craft nor-

mally accessible to and used by passengers and crew shall be supplied from the main source of electrical power.

**12.2.7** The arrangement of the main electric lighting system shall be such that a fire or other casualty, in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard, will not render inoperative the main electric lighting system required by 12.2.6.

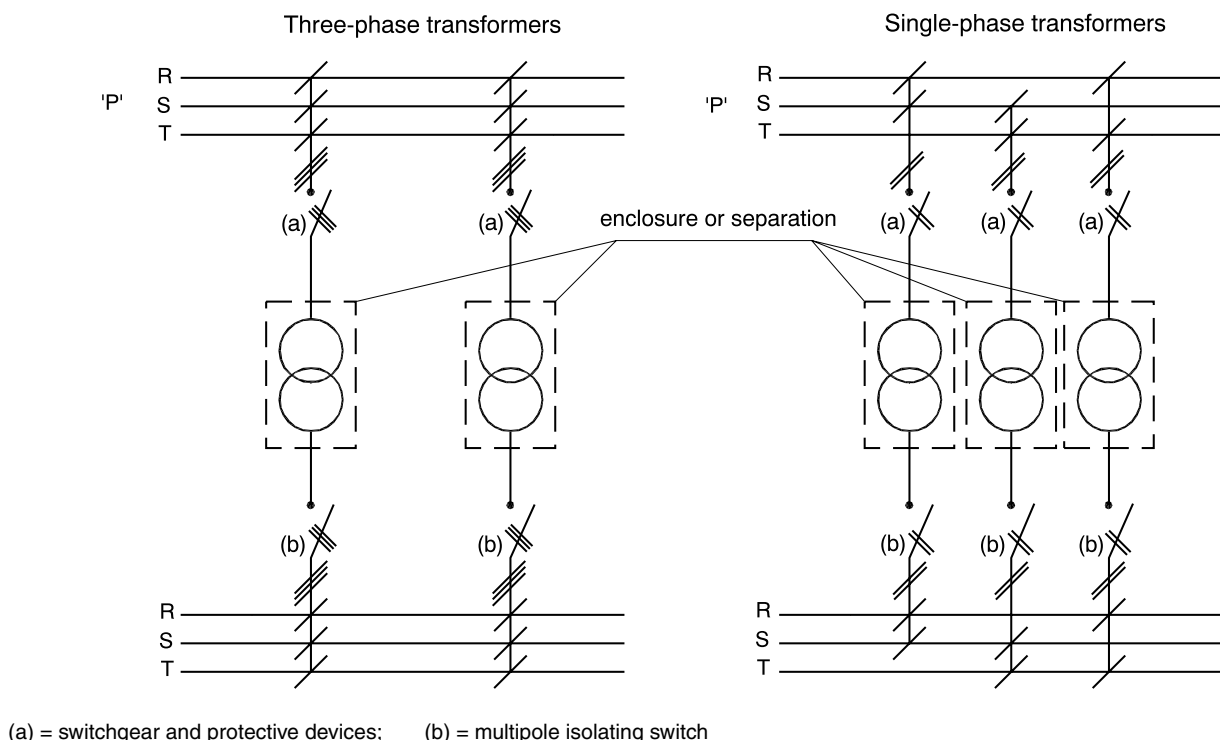
**12.2.8** The main switchboard shall be so placed relative to one main generating station that, as far as practicable, the integrity of the normal electric supply may be affected only by a fire or other casualty in one space. An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, shall not be considered as separating the switchboards from the generators.

**C12.2.8** By "main generating station" is understood one or more generating set(s).

For the purpose of classification, the Society adds the following interpretation of the above requirement:

"The main switchboard and generating sets are, in general, to be located in the same main fire zone (if any) or in the same machinery compartment. However, the main switchboard may be installed inside a machinery control room, provided that such a room be contained within the main boundaries of the engine room".

Figure C12.2.5.1





**12.2.9** The main busbars shall be subdivided into at least two parts which shall be connected by a circuit-breaker or other approved means. So far as practicable, the connection of generating sets and any other duplicated equipment shall be equally divided between the parts.

For category B craft, each part of the main busbars with its associated generators shall be arranged in separate compartments.

## **12.3 Emergency source of electrical power**

**12.3.1** A self-contained emergency source of electrical power shall be provided.

**12.3.2** The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency electrical power, emergency switchboard and emergency lighting switchboard shall be located above the waterline in the final condition of damage as referred to in Section 2, operable in that condition and readily accessible.

**12.3.3** 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 electrical lighting switchboards in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard shall 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. As far as practicable, 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 shall not be contiguous to the boundaries of the main machinery spaces or those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard.

**12.3.4** Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator, if provided, may be used exceptionally, and for short periods, to supply non-emergency circuits.

**C12.3.4** "Exceptionally" is understood to cover conditions such as:

- (1) blackout,
- (2) dead ship situation,
- (3) routine use for testing.

**12.3.5** Distribution systems shall be so arranged that the feeders from the main and emergency sources are separated both vertically and horizontally as widely as practicable.

**12.3.6** The emergency source of electrical power may be either a generator or an accumulator battery, which shall comply with the following:

**.1** Where the emergency source of electrical power is a generator, it shall be:

- .1.1** driven by a suitable prime mover with an independent supply of fuel having a flashpoint which meets the requirements of 7.1.2.2;
- .1.2** started automatically upon failure of the electrical supply from the main source of electrical power and shall be automatically connected to the emergency switchboard. Those services referred to in 12.7.5 or 12.8.3 shall then be transferred to the emergency generating set. The automatic starting system and the characteristic of the prime mover shall 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
- .1.3** provided with a transitional source of emergency electrical power according to 12.7.5 or 12.8.3.

**.2** Where the emergency source of electrical power is an accumulator battery, it shall be capable of:

- .2.1** carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage;
- .2.2** automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and
- .2.3** immediately supplying at least those services specified in 12.7.5 or 12.8.3.

**C12.3.6** With reference to 12.3.6.1.2, for the purpose of classification, the time for generator start-up and loading is not to exceed 15 s.

**12.3.7** The emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power.

**12.3.8** Where the emergency source of electrical power is a generator, the emergency switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

**12.3.9** No accumulator battery fitted in accordance with this section shall be installed in the same space as the emergency switchboard. An indicator shall be mounted in a suitable space at the craft's operating compartment to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power referred to in 12.3.6.1.3 are being discharged.

**12.3.10** The emergency switchboard shall be supplied during normal operation from the main switchboard by an interconnector feeder which shall be adequately protected at the main switchboard against overload and short circuit and which shall 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 interconnector feeder shall also be protected at the emergency switchboard at least against short circuit. Failure of the emergency switchboard, when being used in other than an emergency, shall not put at risk the operation of the craft.

**12.3.11** In order to ensure ready availability of the emergency source of electrical power, arrangements shall be made, where necessary, to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power shall be available to the emergency circuits.

**12.3.12** The emergency generator and its prime mover and any emergency accumulator battery shall be so designed and arranged as to ensure that they will function at full rated power when the craft is upright and when the craft has a list or trimming accordance with 9.1.12 including any damage cases considered in Section 2, or is in any combination of angles within those limits.

**12.3.13** Where accumulator batteries are installed to supply emergency services, provisions shall be made to charge them in situ from a reliable on-board supply. Charging facilities shall be so designed to permit the supply of services, regardless of whether battery is on charge or not. Means shall be provided to minimise the risk of overcharging or overheating the batteries. Means for efficient air ventilation shall be provided.

## **12.4 Starting arrangements for emergency generating sets**

**12.4.1** Emergency generating sets shall be capable of being readily started in their cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, provisions shall be made for heating arrangements to ensure ready starting of the generating sets.

**12.4.2** Each emergency generating set shall be equipped with starting devices with a stored energy capability of at least three consecutive starts. The source of stored energy shall 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 shall be provided for an additional three starts within 30 min, unless manual starting can be demonstrated to be effective.

**12.4.3** The stored energy shall be maintained at all times, as follows:

**.1** electrical and hydraulic starting systems shall be maintained from the emergency switchboard;

**.2** compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable nonreturn valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;

**.3** all of these starting, charging and energy-storing devices shall be located in the emergency generator space. These devices shall 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 compresses air system through the non return valve fitted in the emergency generator space.

## **12.5 Steering and stabilization**

**12.5.1** Where steering and/or stabilization of a craft is essentially dependent on one device as with a single rudder or pylon, which is itself dependent on the continuous availability of electric power, it shall be served by at least two independent circuits, one of which shall be fed either from the emergency source of electric power or from an independent power source located in such a position as to be unaffected by fire or flooding affecting the main source of power. Failure of either supply shall not cause any risk to the craft or passengers during switching to the alternative supply and such switching arrangements shall meet the requirements in 5.2.5. These circuits shall be provided with short-circuit protection and an overload alarm.

**12.5.2** Protection against excess current may be provided, in which case it shall be for not less than twice the full load current of the motor or circuit so protected and shall be arranged to accept the appropriate starting current with a reasonable margin. Where three-phase supply is used an alarm shall be provided in a readily observed position in the craft's operating compartment that will indicate failure of any one of the phases.

**12.5.3** Where such systems are not essentially dependent on the continuous availability of electric power but at least one alternative system, not dependent on the electric supply, is installed, the electrically powered or controlled system may be fed by a single circuit protected in accordance with 12.5.2

**12.5.4** The requirements of Sections 5 and 16 for power supply of the directional control system and stabilising system of the craft shall be met.

## **12.6 Precautions against shock, fire and other hazards of electrical origin**

**12.6.1.1** Exposed metal parts of electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live shall be earthed unless the machines or equipment are:

**.1** supplied at a voltage not exceeding 50 V direct current or 50 V, root-mean-square between conductors; auto-transformers shall not be used for the purpose of achieving this voltage; or

**.2** supplied at a voltage not exceeding 250 V by safety isolating transformers supplying only one consuming device; or

**.3** constructed in accordance with the principle of double insulation.

**12.6.1.2** The Administration may require additional precautions for portable electrical equipment for use in confined or exceptionally damp spaces where particular risks due to conductivity may exist.

**12.6.1.3** All electrical apparatus shall be constructed and so installed as not to cause injury when handled or touched in the normal manner.

**12.6.2** Main and emergency switchboards shall be so arranged as to give easy access, as may be needed, to apparatus and equipment, without danger to personnel. The sides and the rear and, where necessary, the front of switchboards shall be suitably guarded. Exposed live parts having voltages to earth exceeding a voltage to be specified by the Administration shall not be installed on the front of such switchboards. Where necessary, nonconducting mats or gratings shall be provided at the front and rear of the switchboard.

**C12.6.2** The voltage, mentioned in 12.6.2, specified by the Society is 50 V.

**12.6.3** When a distribution system, whether primary or secondary, for power, heating or lighting, with no connection to earth is used, a device capable of continuously monitoring the insulation level to earth and of giving an audible or visual indication of abnormally low insulation values shall be provided. For limited secondary distribution systems the Administration may accept a device for manual checking of the insulation level.

**C12.6.3** For the purpose of classification, the indication of abnormally low insulation value is required to be both audible and visual.

## **12.6.4 Cables and wiring**

**12.6.4.1** Except as permitted by the Administration in exceptional circumstances, all metal sheaths and armour of cables shall be electrically continuous and shall be earthed.

**C12.6.4.1** With reference to 12.6.4.1, exemptions are not in principle permitted for the purpose of classification.

**12.6.4.2** All electric cables and wiring external to equipment shall be at least of a flame-retardant type and shall be so installed as not to impair their original flame-retarding properties. Where necessary for particular applications, the Administration may permit the use of special types of cables such as radio-frequency cables, which do not comply with the foregoing.

**C12.6.4.2** Cables, cores and wires are normally to be of a type approved by the Society, on the basis of IEC standards, 92.3. series. Use of other cables is subject to special consideration by the Society, and to appropriate and satisfactory testing.

Where cables are bunched, provisions are to be made to limit fire propagation. This may comprise by either of the following methods:

- use of cables successfully tested according to IEC Report 332.3, or to an equivalent testing procedure,
- fitting of suitable fire-stop screens,
- use of an appropriate protective coating.

In areas attended by passengers and in service areas, only halogen-free cables shall be used for permanent installations.

Electric cables having low emission of smoke and toxic gases according to national or international standards (e.g. IEC 754-1, IEC 1034-1, IEC 1034-2) may be accepted.

Exceptions for individual cables for special purposes have to be agreed with the Society.

In all other areas of the craft, the use of halogen-free cable is recommended.

**12.6.4.3** *Cables and wiring serving essential or emergency power, lighting, internal communications or signals shall, as far as practicable, be routed clear of machinery spaces and their casings and other areas of high fire risk. Where practicable, all such cables shall be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.*

**C12.6.4.3** For fire-resistant cables, the scope of installation is as follows:

**1.** Cables for services required to be operable under fire conditions, including those for their power supplies, are to be of a fire resistant type, complying with IEC 60331 where they pass through high fire risk areas, fire zones or decks, other than those which they serve.

**.2** Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted provided their functionality can be maintained.

Note: In case of cables for services required to be operable under fire conditions, the fire resistant cables are to extend from the control monitoring panel to the nearest local distribution panel serving the relevant deck/area.

In case of power supply cables used for services required to be operable under fire conditions, the fire resistant cables are to extend from their distribution point within the space containing the emergency source of electrical power to the nearest local distribution panel serving the relevant deck/area.

**.3** Emergency services required to be operable under fire conditions include:

- Fire and general alarm system,
- Fire extinguishing systems and fire extinguisher medium alarms,
- Fire detection system,
- Control and power systems to power operated fire doors and status indication for all fire doors,
- Control and power systems to power operated watertight doors and their status indication,
- Emergency lighting,
- Public address system

**.4** The cables shall be arranged in such a way as to minimise the loss of operational availability as a result of a limited fire in any area.

**.5** The cables shall be installed as straight as possible and with strict observance of special installation requirements, e.g. permitted bending radii.

**12.6.4.4** *Where cables which are installed in hazardous areas introduce the risk of fire or explosion in the event of an electrical fault in such areas, special precautions against such risks shall be taken to the satisfaction of the Administration.*

**C12.6.4.4** "Special precautions" as per 12.6.4.4, stipulated by the Society include the following provisions:

**.1** Where there are risks of corrosion, an impervious non metal sheath is to be applied on top of the armouring;

**.2** Cables installed on deck or gangways are to be protected against mechanical damage;

**.3** Cables of intrinsically safety circuits are to be separated from the others.

**12.6.4.5** *Cables and wiring shall be installed and supported in such manner as to avoid chafing or other damage.*

**12.6.4.6** *Terminations and joints in all conductors shall be so made as to retain the original electrical, mechanical, flame-retarding and, where necessary, fire-resisting properties of the cable.*

**12.6.5.1** *Each separate circuit shall be protected against short circuit and against overload, except as permitted in 12.5 or where the Administration may exceptionally otherwise permit.*

**12.6.5.2** *The rating or appropriate setting of the overload protective device for each circuit shall be permanently indicated at the location of the protective device.*

**12.6.6** *Lighting fittings shall be so arranged as to prevent temperature rises which could damage the cables and wiring, and to prevent surrounding material from becoming excessively hot.*

**12.6.7** *All lighting and power circuits terminating in a bunker or cargo space shall be provided with a multiple-pole switch outside the space for disconnecting such circuits.*

**12.6.8.1** *Accumulator batteries shall be suitably housed, and compartments used primarily for their accommodation shall be properly constructed and efficiently ventilated.*

**12.6.8.2** *Electrical or other equipment which may constitute a source of ignition of flammable vapours shall not be permitted in these compartments except as permitted in 12.6.9.*

**12.6.8.3** *Accumulator batteries shall not be located in crew accommodation.*

**12.6.9** *No electrical equipment shall be installed in any space where flammable mixtures are liable to collect, including those in compartments assigned principally to*

accumulator batteries, in paint lockers, acetylene stores or similar spaces, unless the Administration is satisfied that such equipment is:

- .1** essential for operational purposes;
- .2** of a type which will not ignite the mixture concerned;
- .3** appropriate to the space concerned; and
- .4** appropriately certified for safe usage in the dusts, vapours or gases likely to be encountered.

**C12.6.9** The requirements of 12.6.9 apply to accumulator batteries with total power exceeding 2 kW.

**12.6.10** The following additional requirements from .1 to .7 shall be met, and requirements from .8 to .13 shall be met also for non-metallic craft:

- .1** The electrical distribution voltages throughout the craft may be either direct current or alternating current and shall not exceed:
  - .1.1** 500 V for cooking, heating and other permanently connected equipment; and
  - .1.2** 250 V for lighting, internal communications and receptacle outlets.

The Administration may accept higher voltages for propulsion purposes.

**.2** For electrical power distribution, two-wire or three-wire systems shall be used. Four-wire systems with neutral solidly earthed but without hull return may also be used. Where applicable, the requirements for 7.5.6.4 or 7.5.6.5 shall also be met.

**.3** Effective means shall be provided so that voltage may be cut off from each and every circuit and sub-circuit and from all apparatus as may be necessary to prevent danger.

**.4** Electrical equipment shall be so designed that the possibility of accidentally touching live parts, rotating or moving parts as well as heated surfaces which might cause burns or initiate fire is minimized.

**.5** Electrical equipment shall be adequately secured. The probability of fire or dangerous consequences arising from damage to electrical equipment shall be reduced to an acceptable minimum.

**.6** The rating or appropriate setting of the overload protective device for each circuit shall be permanently indicated at the location of the protection device.

**.7** 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 shall be kept as short as possible and special precautions shall 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.

**.8** In order to minimize the risk of fire, structural damage, electrical shock and radio interference due to lightning strike or electrostatic discharge, all metal parts of the craft shall be bonded together, in so far as possible in consideration of galvanic corrosion between dissimilar metals, to form a continuous electrical system, suitable for the earth return of electrical equipment and to connect the craft to the water when water-borne. The bonding of isolated components inside the structure is not generally necessary, except in fuel tanks.

**.9** Each pressure refuelling point shall be provided with a means of bonding the fuelling equipment to the craft.

**.10** Metallic pipes capable of generating electrostatic discharges, due to the flow of liquids and gases, shall be bonded so as to be electrically continuous throughout their length and shall be adequately earthed.

**.11** Primary conductors provided for lightning discharge currents shall have a minimum cross-section of 70 mm<sup>2</sup> in copper or equivalent surge-carrying capacity in aluminium.

**.12** Secondary conductors provided for the equalisation of static discharges, bonding of equipment, etc., but not for carrying lightning discharges shall have a minimum cross section of 5 mm<sup>2</sup> copper or equivalent surge current carrying capacity in aluminium.

**.13** The electrical resistance between bonded objects and the basic structure shall not exceed 0.02 Ohm except where it can be demonstrated that a higher resistance will not cause a hazard. The bonding path shall have sufficient cross-sectional area to carry the maximum current likely to be imposed on it without excessive voltage drop.

#### **C12.6.10**

- (a) With reference to 12.6.10.6, see also 12.6.5.2.
- (b) With reference to 12.6.10.11, stainless steel is also acceptable.

## Part B Requirements for passenger craft

### 12.7 General

**12.7.1** Separation and duplication of electrical supply shall be provided for duplicated consumers of essential services. During normal operation the systems may be connected to the same power-bus, but facilities for easy separation shall be provided. Each system shall be able to supply all equipment necessary to maintain the control of propulsion, steering, stabilization, navigation, lighting and ventilation, and allow starting of the largest essential electric motor at any load. Automatic load-dependent disconnection of non-essential consumers may be allowed.

### 12.7.2 Emergency source of electrical power

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 12.7.3 or 12.7.4, the requirement of 12.3.1, 12.3.2 and 12.3.4 may be considered satisfied without an additional emergency source of electrical power, provided that:

**.1** there is at least one generating set, meeting the requirements of 12.3.12 and of sufficient capacity to meet the requirements of 12.7.3 or 12.7.4 in each of at least two non-contiguous spaces;

**.2** the arrangements required by .1 in each such space are equivalent to those required by 12.3.6.1, 12.3.7 to 12.3.11 and 12.4 so that a source of electrical power is available at all times to the services required by 12.7.3 or 12.7.4; and

**.3** the generator sets referred to in .1 and their self-contained systems are installed such that one of them remains operable after damage or flooding in any one compartment.

**12.7.3** For category A craft, the emergency source of power shall be capable of supplying simultaneously the following services:

**.1** for a period of 5 h emergency lighting:

**.1.1** at the stowage, preparation, launching and deployed positions of survival craft and equipment for embarkation into those craft;

**.1.2** at all escape routes, such as alleyways, stairways, exits from accommodation and service spaces, embarkation points, etc.;

**.1.3** in the public spaces;

**.1.4** in the machinery spaces and main emergency generator spaces, including their control positions;

**.1.5** in control stations;

**.1.6** at the stowage positions for firemen's outfits; and

**.1.7** at the steering gear;

**.2** for a period of 5 h;

**.2.1** main navigation lights, except for "not under command" lights;

**.2.2** electrical internal communication equipment for announcements for passengers and crew required during evacuation;

**.2.3** fire detection and general alarm system and manual fire alarms; and

**.2.4** remote control devices of fire-extinguishing systems, if electrical;

**.3** for a period of 4 h of intermittent operation:

**.3.1** the daylight signalling lamps, if they have no independent supply from their own accumulator battery; and

**.3.2** the craft's whistle, if electrically driven;

**.4** for a period of 5 h;

**.4.1** craft radio facilities and other loads as set out in 14.13.2; and

**.4.2** essential electrically powered instruments and controls for propulsion machinery, if alternate sources of power are not available for such devices;

**.5** for a period of 12 h, the "not under command" lights; and

**.6** for a period of 10 min:

**.6.1** power drives for directional control devices, including those required to direct thrust forward and astern, unless there is a manual alternative acceptable to the Administration as complying with 5.2.3.

**C12.7.3** With reference to 12.7.3.4, in addition to the services specified in 12.7.3.4.1 and 12.7.3.4.2, the emergency source of power is to be capable of supplying:

- One of the fire pumps required by 7.7.8.1.
- Sprinkler pump and drencher pump, if fitted.
- Emergency bilge pump and all equipment essential for the operation of electrically controlled bilge valves, as required by Section 10.

**12.7.4** For category B craft, the electrical power available shall 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 shall 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 herein-after, if they depend upon an electrical source for their operation.

**.1** for a period of 12 h, emergency lighting:

- .1.1** at the stowage, preparation, launching and deployed positions of survival craft and equipment for embarkation into those craft;
- .1.2** at all escape routes, such as alleyways, stairways, exits from accommodation and service spaces, embarkation points, etc.;
- .1.3** in the passenger compartments;
- .1.4** in the machinery spaces and main emergency generating spaces including their control positions;
- .1.5** in control stations;
- .1.6** at the stowage positions for firemen's outfits; and
- .1.7** at the steering gear;

**.2** for a period of 12 h;

- .2.1** the navigation lights, and other lights required by International Regulations for Preventing Collisions at Sea in force;
- .2.2** electrical internal communication equipment for announcements for passengers and crew required during evacuation;
- .2.3** fire-detection and general alarm system and manual fire alarms; and
- .2.4** remote control devices of fire-extinguishing systems, if electrical;

**.3** for a period of 4 h on intermittent operation:

- .3.1** the daylight signalling lamps, if they have no independent supply from their own accumulator battery; and
- .3.2** the craft's whistle, if electrically driven;

**.4** for a period of 12 h;

- .4.1** the navigational equipment as required by Section 13. Where such provision is unreasonable or impracticable, the Administration may waive this requirement for craft of less than 5,000 gross tonnage;
- .4.2** essential electrically powered instruments and controls for propulsion machinery, if alternate sources of power are not available for such devices;
- .4.3** one of the fire pumps required by 7.7.5.1;
- .4.4** the sprinkler pump and drencher pump, if fitted;
- .4.5** the emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves as required by Section 10; and
- .4.6** craft radio facilities and other loads as set out in 14.13.2;

**.5** for a period of 30 min, any watertight doors, required by Section 2 to be power-operated, together with their indicators and warning signals;

**.6** 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 acceptable to the Administration as complying with 5.2.3.

#### **12.7.5 Transitional source of emergency electrical power**

The transitional source of emergency electrical power required by paragraph 12.3.6.1.3 may consist of an accumulator battery suitably located for use in an emergency which shall operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% 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:

**.1** for a period of 30 min, the load specified in 12.7.3.1, .2 and .3, or in 12.7.4.1, .2 and .3; and

**.2** with respect to the watertight doors:

- .2.1** power to operate the watertight doors, but not necessarily simultaneously, unless an independent temporary source of stored energy is provided. The power source shall have sufficient capacity to operate each door at least three times, i.e. closed-open-closed, against an adverse list of 15°; and
- .2.2** power to the control, indication and alarm circuits for the watertight doors for half an hour.

**12.7.6** The requirements of 12.7.5 may be considered satisfied without the installation of a transitional source of emergency electrical power if each of the services required by that paragraph have independent supplies, for the period specified, from accumulator batteries suitably located for use in an emergency. The supply of emergency power to the instruments and controls of the propulsion and direction systems shall be uninterruptible.

**12.7.7** In category A craft having limited public spaces, emergency lighting fittings of the type described in 12.7.9.1 as meeting the requirements of 12.7.3.1 and 12.7.5.1 may be accepted, provided that an adequate standard of safety is attained.

**12.7.8** Provisions shall be made for the periodic testing of the complete emergency system, including the emergency consumers required by 12.7.3 or 12.7.4 and 12.7.5, and shall include the testing of automatic starting arrangements.

**12.7.9** In addition to the emergency lighting required by paragraph 12.7.3.1, 12.7.4.1 and 12.7.5.1 on every craft with ro-ro spaces:

**.1** all passenger public spaces and alleyways shall be provided with supplementary electric lighting that can operate for at least three h when all other sources of electric power have failed and under any condition of heel. The illumination provided shall be such that the approach to the means of escape can be readily seen. The source of power for the supplementary lighting shall consist of accumulator batteries located within the lighting units that are continuously charged, where practicable, from the emergency switchboard. Alternatively, any other means of lighting, which is at least as effective, may be accepted by the Administration.

The supplementary lighting shall be such that any failure of the lamp will be immediately apparent. Any accumulator battery provided shall be replaced at intervals having regard to the specified service life in the ambient condition that it is subject to in service; and

**.2** a portable rechargeable battery-operated lamp shall be provided in every crew space alleyway, recreational space and every working space which is normally occupied unless supplementary emergency lighting, as required by .1, is provided.

**12.7.10** Distribution systems shall be so arranged that fire in any main vertical zone will not interfere with services essential for safety in any other such zone. This requirement will be met if main and emergency feeders passing through any such zone are separated both vertically and horizontally as widely as is practicable.



## Part C Requirements for cargo craft

### 12.8 General

**12.8.1** Separation and duplication of electrical supply shall be provided for duplicated consumers of essential services. During normal operation these consumers may be connected to the same power-bus directly or via distribution boards or group starters, but shall be separated by removable links or other approved means. Each power-bus shall be able to supply all equipment necessary to maintain the control of propulsion, steering, stabilization, navigation, lighting and ventilation, and allow starting of the largest essential electric motor at any load. However, having regard to 12.1.2, partial reduction in the capability from normal operation may be accepted. Non-duplicated consumers of essential services connected to the emergency switchboard directly or via distribution boards may be accepted. Automatic load-dependent disconnection of non-essential consumers may be allowed.

### 12.8.2 Emergency source of electrical power

**12.8.2.1** 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 12.8.2.2, the requirements of 12.3.1, 12.3.2 and 12.3.4 may be considered satisfied without an additional emergency source of electrical power, provided that:

**.1** there is at least one generating set, meeting the requirements of 12.3.12 and each of sufficient capacity to meet the requirements of 12.8.2.2, in each of at least two non-contiguous spaces;

**.2** the arrangements required by .1 in each such space are equivalent to those required by 12.3.6.1, 12.3.7 to 12.3.11 and 12.4 so that a source of electrical power is available at all times to the services required by 12.8.2; and

**.3** the generator sets are referred to in .1 and their self-contained systems are installed in accordance with 12.3.2.

**12.8.2.2** The electrical power available shall 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 shall 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:

**.1** for a period of 12 h, emergency lighting;

**.1.1** at the stowage positions of life-saving appliances;

**.1.2** at all escape routes, such as alleyways, stairways, exits from accommodation and service spaces, embarkation points, etc.;

**.1.3** in public spaces, if any;

**.1.4** in the machinery spaces and main emergency generator spaces including their control positions;

**.1.5** in control stations;

**.1.6** at the stowage positions for fire-fighter's outfits; and

**.1.7** at the steering gear;

**.2** for a period of 12 h;

**.2.1** the navigation lights, and other lights required by the International Regulations for Preventing Collisions at Sea in force;

**.2.2** electrical internal communication equipment for announcements during evacuation;

**.2.3** fire-detection and general alarm system and manual fire alarms; and

**.2.4** remote control devices of fire-extinguishing systems, if electrical;

**.3** for a period of 4 h of intermittent operation;

**.3.1** the daylight signalling lamps, if they have no independent supply from their own accumulator battery; and

**.3.2** the craft's whistle, if electrically driven;

**.4** for a period of 12 h;

**.4.1** the navigational equipment as required by Section 13. Where such provision is unreasonable or impracticable, the Administration may waive this requirement for craft of less than 5,000 gross tonnage;

**.4.2** essential electrically powered instruments and controls for propulsion machinery, if alternate sources of power are not available for such devices;

**.4.3** one of the fire pumps required by 7.7.5.1;

**.4.4** *the sprinkler pump and drencher pump, if fitted;*

**.4.5** *the emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves as required by Section 10;*

**.4.6** *craft radio facilities and other loads as set out in 14.13.2.*

**.5** *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 acceptable to the Administration as complying with 5.2.3.*

**12.8.2.3** *Provision shall be made for the periodic testing of the complete emergency system, including the emergency consumers required by 12.8.2.2 and shall include the testing of automatic starting arrangements.*

**12.8.2.4** *Where the emergency source of electrical power is a generator, a transitional source of emergency power shall be provided according to 12.8.3, unless the automatic starting system and the characteristics of the prime mover are 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 s.*

**C12.8.2.4** For the purpose of classification, the time for generator start-up and loading is not to exceed 15s.

### **12.8.3 Transitional source of emergency electrical power**

*The transitional source of emergency electrical power required by 12.8.2.4 may consist of an accumulator battery suitably located for use in an emergency which shall operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% 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:*

**.1** *for a period of 30 min, the load specified in 12.8.2.2.1, .2 and .3; and*

**.2** *with respect to watertight doors:*

**.2.1** *power to operate the watertight doors, but not necessarily simultaneously, unless an independent temporary source of stored energy is provided. The power source shall have sufficient capacity to operate each door at least three times, i.e. closed-open-closed, against an adverse list of 15°; and*

**.2.2** *power to the control, indication and alarm circuits for the watertight doors for half an hour.*

## SECTION 13

## SHIPBORNE NAVIGATIONAL SYSTEMS AND EQUIPMENT AND VOYAGE DATA RECORDERS

### 13.1 General

**13.1.1** This Section covers items of equipment which relate to the navigation of the craft as distinct from the safe functioning of the craft. The following paragraphs set out the minimum requirements.

**13.1.2** The equipment and its installation shall be to the satisfaction of the Administration. The Administration shall determine to what extent the provisions of this Section do not apply to craft below 150 gross tonnage.

**13.1.3** The information provided by navigational systems and equipment shall be so displayed that the probability of misreading is reduced to a minimum. Navigational systems and equipment shall be capable of giving readings to an optimum accuracy.

### 13.2 Compasses

**13.2.1** Craft shall be provided with a magnetic compass which is capable of operating without electrical supply, and which may be used for steering purposes. This compass shall be mounted in a suitable binnacle containing the required correcting devices and shall be suitable for the speed and motion characteristics of the craft.

**13.2.2** The compass card or repeater shall be capable of being easily read from the position at which the craft is normally controlled.

**13.2.3** Each magnetic compass shall be properly adjusted and its table or curve of residual deviations shall be available at all times.

**13.2.4** Care shall be taken in siting a magnetic compass or magnetic sensing element so that magnetic interference is eliminated or minimized as far as is practicable.

**13.2.5** Passenger craft certified to carry 100 passengers or less shall, in addition to the compass required by 13.2.1, be provided with a properly adjusted transmitting heading device, suitable for the speed and motion characteristics and area of operation of the craft, capable of transmitting a true heading reference to other equipment.

**13.2.6** Passenger craft certified to carry more than 100 passengers and cargo craft shall, in addition to the compass required in 13.2.1, be provided with a gyro-compass which shall be suitable for the speed and motion characteristics and area of operation of the craft.

### 13.3 Speed and distance measurement

**13.3.1** Craft shall be provided with a device capable of indicating speed and distance.

**13.3.2** Speed- and distance-measuring devices on craft fitted with an automatic radar plotting aid (ARPA) or automatic tracking aid (ATA) shall be capable of measuring speed and distance through the water.

### 13.4 Echo-sounding device

**13.4.1** Non-amphibious craft shall be provided with an echo-sounding device which will give an indication of depth of water to a sufficient degree of accuracy for use when the craft is in the displacement mode.

### 13.5 Radar installations

**13.5.1** Craft shall be provided with at least one azimuth-stabilized radar operating on 9 GHz.

**13.5.2** Craft of 500 gross tonnage and upwards or craft certified to carry more than 450 passengers shall also be provided with a 3 GHz radar or where considered appropriate by the Administration, a second 9 GHz radar or other means to determine and display the range and bearing of other surface craft, obstructions, buoys, shorelines and navigational marks to assist in navigation and in collision avoidance, which are functionally independent of those referred to in 13.5.1.

**13.5.3** At least one radar shall be provided with facilities for an ARPA or ATA suitable for the motion and speed of the craft.

**13.5.4** Adequate communication facilities shall be provided between the radar observer and the person in immediate charge of the craft.

**13.5.5** Each radar installation provided shall be suitable for the intended craft speed, motion characteristics and commonly encountered environmental conditions.

**13.5.6** Each radar installation shall be mounted so as to be as free as practicable from vibration.

### **13.6 Electronic positioning systems**

Craft shall be provided with a receiver for a global navigation satellite system or a terrestrial radio navigation system, or other means, suitable for use at all times throughout the intended voyage to establish and update the craft's position by automatic means.

### **13.7 Rate-of-turn indicator and rudder angle indicator**

**13.7.1** Craft of 500 gross tonnage or upwards shall be provided with a rate-of-turn indicator. A rate-of-turn indicator shall be provided in craft of less than 500 gross tonnage if the test according to annex 9 shows that the turn rate can exceed safety level 1.

**13.7.2** Craft shall be provided with an indicator showing the rudder angle. In craft without a rudder, the indicator shall show the direction of steering thrust.

### **13.8 Nautical charts and nautical publications**

**13.8.1** Craft shall be provided with nautical charts and nautical publications to plan and display the ship's route for the intended voyage and to plot and monitor positions throughout the voyage; an electronic chart display and information system (ECDIS) may be accepted as meeting the chart carriage requirements of this paragraph.

**13.8.2** Back-up arrangements shall be provided to meet the functional requirements of 13.8.1, if this function is partly or fully fulfilled by electronic means.

### **13.9 Searchlight and daylight signalling lamp**

**13.9.1** Craft shall be provided with at least one adequate searchlight, which shall be controllable from the operating station.

**13.9.2** One portable daylight signalling lamp shall be provided and maintained ready for use in the operating compartment at all times.

### **13.10 Night vision equipment**

**13.10.1** When operational conditions justify the provision of night vision equipment, such equipment shall be provided.

### **13.11 Steering arrangement and propulsion indicator(s)**

**13.11.1** The steering arrangement shall be so designed that the craft turns in the same direction as that of the wheel, tiller, joystick or control lever.

**13.11.2** Craft shall be provided with means to show the mode of the propulsion system(s).

**13.11.3** Craft with emergency steering positions shall be provided with arrangements for supplying visual compass readings to the emergency steering position.

### **13.12 Automatic steering aid (automatic pilot)**

**13.12.1** Craft shall be provided with an automatic steering aid (automatic pilot).

**13.12.2** Provision shall be made to change from the automatic to manual mode by a manual override.

### **13.13 Radar reflector**

If practicable, craft of 150 gross tonnage or below shall be provided with a radar reflector, or other means, to assist detection by ships navigating by radar at both 9 and 3 GHz.

### 13.14 Sound reception system

When the craft's bridge is totally enclosed and unless the Administration determines otherwise, craft shall be provided with a sound reception system, or other means, to enable the officer in charge of the navigational watch to hear sound signals and determine their direction.

### 13.15 Automatic identification system

**13.15.1** Craft shall be provided with an automatic identification system (AIS).

#### 13.15.2 AIS shall:

**.1** provide automatically to appropriately equipped shore stations, other vessels and aircraft information, including the craft's identity, type, position, course, speed, navigational status and other safety-related information;

**.2** receive automatically such information from similarly fitted vessels;

**.3** monitor and track vessels; and

**.4** exchange data with shore based facilities.

**13.15.3** The requirements of 13.15.2 shall not apply where international agreements, rules or standards provide for the protection of navigational information.

**13.15.4** AIS shall be operated taking into account the guidelines adopted by the Organization.

### 13.16 Voyage data recorder

**13.16.1** To assist in casualty investigations, passenger craft irrespective of size and cargo craft of 3,000 gross tonnage and upwards shall be provided with a voyage data recorder (VDR).

**13.16.2** The voyage data recorder system, including all sensors, shall be subjected to an annual performance test. The test shall be conducted by an approved testing or servicing facility to verify the accuracy, duration and recoverability of the recorded data. In addition, tests and inspections shall be conducted to determine the serviceability of all protective enclosures and devices fitted to aid location. A copy of the certificate of compliance issued by the testing facility, stating the date of compliance and the applicable performance standards, shall be retained on board the craft.

### 13.17 Approval of systems and equipment, and performance standards

**13.17.1** All equipment to which this Section applies shall be of a type approved by the Administration. Such equipment shall conform to performance standards not inferior to those adopted by the Organization.

**13.17.2** The Administration shall require that manufacturers have a quality control system audited by a competent authority to ensure continuous compliance with the type approval conditions. Alternatively, the Administration may use final product verification procedures where compliance with the type approval certificate is verified by a competent authority before the product is installed on board craft.

**13.17.3** Before giving approval to navigational systems or equipment embodying new features not covered by this Section, the Administration shall ensure that such features support functions at least as effective as those required by this Section.

**13.17.4** When equipment, for which performance standards have been developed by the Organization, is carried on craft in addition to those items of equipment required by this Section, such additional equipment shall be subject to approval and shall, as far as practicable, comply with performance standards not inferior to those adopted by the Organization.

Note: Recommendation on performance standards for magnetic compasses (resolution A.382(X));

Recommendation on performance standards for marine transmitting magnetic heading devices (TMHDs) (resolution MSC.86(70), annex 2);

Recommendation on performance standards for Gyro-compasses for high-speed craft (resolution A.821(19));

Recommendation on performance standards for devices to indicate speed and distance (resolution A.824(19), as amended by resolution MSC.96(72));

Recommendation on performance standards for echo-sounding equipment (resolution A.224(VII) as amended by MSC.74(69), annex 2);

Recommendation on performance standards for navigational radar equipment for high-speed craft (resolution A.820(19));

Recommendation on performance standards for shipborne Decca navigator receivers (resolution A.816(19));

Recommendation on performance standards for "Auto Tracking" (resolution MSC.64(67), annex 4, appendix 1);

Recommendation on performance standards for shipborne Loran-C and Chayka receivers (resolution A.818(19));

*Recommendation on performance standards for shipborne global positioning system receiver equipment (resolution A.819(19));*

*Recommendation on performance standards for shipborne GLO-NASS receiver equipment (resolution MSC.53(66));*

*Recommendation on performance standards for shipborne DGPS and DGLONASS maritime radio beacon receiver equipment (resolution MSC.64(67), annex 2);*

*Recommendation on performance standards for combined GPS/GLONASS receiver equipment (resolution MSC.74(69), annex 1);*

*Performance standards for rate-of-turn indicators (resolution A.526(13));*

*Recommendation on performance standards for night vision equipment for high-speed craft (resolution MSC.94(72));*

*Recommendation on performance standards for daylight signalling lamps (resolution MSC.95(72)); and*

*Recommendation on performance standards for automatic steering aids (automatic pilots) for high-speed craft (resolution A.822(19)).*

## **C13.18 Electric power supply-distribution panels**

**C13.18.1** Local distribution panels are to be provided for all items of electrically operated navigational equipment. These panels are to be supplied by two exclusive circuits, one fed from the main source of electrical power and one fed from an emergency source of electrical power. Each item of navigational equipment is to be connected individually to its distribution panel.

**C13.18.2** Power supplies to distribution panels are to be provided with automatic changeover facilities. Failure of the main power supply to the distribution panels is to set off an audible and visual alarm.

**C13.18.3** Following loss of power (black-out), necessary arrangements are to be made to enable all primary functions to be reinstated within 30 seconds.

## SECTION 14

## RADIOCOMMUNICATIONS

**14.1 Application**

**14.1.1** Unless expressly provided otherwise, this Section applies to all craft specified in 1.3.1 and 1.3.2.

**14.1.2** This Section does not apply to craft to which this Code would otherwise apply while such craft are being navigated within the Great Lakes of North America and their connecting and tributary waters as far east as the lower exit of the St. Lambert Lock at Montreal in the Province of Quebec, Canada.

Note: Such craft are subject to special requirements relative to radio for safety purposes, as contained in the relevant agreement between Canada and the United States.

**14.1.3** No provision in this Section shall prevent the use by any craft, survival craft or person in distress of any means at their disposal to attract attention, make known their position and obtain help.

**14.2 Terms and definitions**

**14.2.1** For the purpose of this Section the following terms shall have the meanings defined below:

**.1** "Bridge-to-bridge communications" means safety communications between craft and ships from the position from which the craft is normally navigated.

**.2** "Continuous watch" means that the radio watch concerned shall not be interrupted other than for brief intervals when the craft's receiving capability is impaired or blocked by its own communications or when the facilities are under periodical maintenance or checks.

**.3** "Digital selective calling (DSC)" means a technique using digital codes which enables a radio station to establish contact with, and transfer information to, another station or group of stations, and complying with the relevant recommendations of the International Telecommunication Union Radiocommunication Sector (ITU-R).

**.4** "Direct-printing" telegraphy means automated telegraphy techniques which comply with the relevant recommendations of the International Telecommunication Union Radiocommunication Sector (ITU-R).

**.5** "General radiocommunications" means operational and public correspondence traffic other than distress, urgency and safety messages, conducted by radio.

**.6** "Global Maritime Distress and Safety System (GMDSS) Identities" means maritime mobile services identity, the craft's call sign, Inmarsat identities and serial number identity which may be transmitted by the craft's equipment and used to identify the craft.

**.7** "Inmarsat" means the Organization established by the Convention on the International Maritime Satellite Organization (Inmarsat) adopted on 3 September 1976.

**.8** "International NAVTEX" service means the co-ordinated broadcast and automatic reception on 518 kHz of maritime safety information by means of narrow-band direct-printing telegraphy using the English language.

Note: Refer to the NAVTEX Manual approved by the Organization.

**.9** "Locating" means the finding of the ships, craft, aircraft, units or persons in distress.

**.10** "Maritime safety information" means navigational and meteorological warnings, meteorological forecasts and other urgent safety-related messages broadcast to ships and craft.

**.11** "Polar orbiting satellite service" means a service which is based on polar orbiting satellites which receive and relay distress alerts from satellite EPIRBs and which provides their position.

**.12** "Radio Regulations" mean the Radio Regulations annexed to, or regarded as being annexed to, the most recent International Telecommunication Convention which is in force at any time.

**.13** "Sea area A1" means an area within the radiotelephone coverage of at least one VHF coast station in which continuous DSC alerting is available, as may be defined by a Contracting Government to the Convention.

Note: Refer to the Provision of radio services for the global maritime distress and safety system (GMDSS), adopted by the Organization by resolution A.801(19).

**.14** "Sea area A2" means an area, excluding sea area A1, within the radiotelephone coverage of at least one MF coast station in which continuous DSC alerting is available, as may be defined by a Contracting Government to the Convention.

Note: Refer to the Provision of radio services for the global maritime distress and safety system (GMDSS), adopted by the Organization by resolution A.801(19).

**.15** "Sea area A3" means an area, excluding sea areas A1 and A2, within the coverage of an Inmarsat geostationary satellite in which continuous alerting is available.

**.16** "Sea area A4" means an area outside sea areas A1, A2 and A3.

**14.2.2** All other terms and abbreviations which are used in this Section and which are defined in the Radio Regulations and in the International Convention on Maritime Search and Rescue (SAR), 1979, as it may be amended, shall have the meanings as defined in those Regulations and the SAR Convention.

### 14.3 Exemptions

**14.3.1** It is considered highly desirable not to deviate from the requirements of this Section; nevertheless the Administration, in conjunction with the base port State, may grant partial or conditional exemptions to individual craft from the requirements of 14.7 to 14.11 provided:

**.1** such craft comply with the functional requirements of 14.5; and

**.2** the Administration has taken into account the effect such exemptions may have upon the general efficiency of the service for the safety of all ships and craft.

**14.3.2** An exemption may be granted under 14.3.1 only:

**.1** if the conditions affecting safety are such as to render the full application of 14.7 to 14.11 unreasonable or unnecessary; or

**.2** in exceptional circumstances, for a single voyage outside the sea area or sea areas for which the craft is equipped.

**14.3.3** Each Administration shall submit to the Organization, as soon as possible after the first of January in each year, a report showing all exemptions granted under 14.3.1 and 14.3.2 during the previous calendar year and giving the reasons for granting such exemptions.

### 14.4 Global maritime distress and safety system identities

**14.4.1** This section applies to all craft on all voyages.

**14.4.2** Each Administration undertakes to ensure that suitable arrangements are made for registering Global Maritime Distress and Safety System (GMDSS) Identities and for making information on these identities available to Rescue Co-ordination Centres on a 24-hour basis. Where

appropriate, international organizations maintaining a registry of these identities shall be notified by the Administration of these assignments.

### 14.5 Functional requirements

**14.5.1** Every craft, while at sea, shall be capable:

**.1** except as provided in 14.8.1.1 and 14.10.1.4.3, of transmitting ship-to-shore distress alerts by at least two separate and independent means, each using a different radiocommunication service;

**.2** of receiving shore-to-ship distress alerts;

**.3** of transmitting and receiving ship-to-ship distress alerts;

**.4** of transmitting and receiving search and rescue co-ordinating communications;

**.5** of transmitting and receiving on-scene communications;

**.6** of transmitting and, as required by 13.5, receiving signals for locating,

Note: Refer to Carriage of radar operating in the frequency band 9,300–9,500 MHz, adopted by the Organization by see resolution A.614(15).

**.7** of transmitting and receiving maritime safety information;

Note: It should be noted that craft may have a need for reception of certain maritime safety information while in port.

**.8** of transmitting and receiving general radio-communications to and from shore-based radio systems or networks subject to 14.15.8; and

**.9** of transmitting and receiving bridge-to-bridge communications.

### 14.6 Radio installations

**14.6.1** Every craft shall be provided with radio installations capable of complying with the functional requirements prescribed by 14.5 throughout its intended voyage and, unless exempted under 14.3, complying with the requirements of 14.7 and, as appropriate for the sea area or areas through which it will pass during its intended voyage, the requirements of either 14.8, 14.9, 14.10 or 14.11.

**14.6.2** Every radio installation shall:

**.1** be so located that no harmful interference of mechanical, electrical or other origin affects its proper use,



and so as to ensure electromagnetic compatibility and avoidance of harmful interaction with other equipment and systems;

**.2** be so located as to ensure the greatest possible degree of safety and operational availability;

**.3** be protected against harmful effects of water, extremes of temperature and other adverse environmental conditions;

**.4** be provided with reliable, permanently arranged electrical lighting, independent of the main sources of electrical power, for the adequate illumination of the radio controls for operating the radio installation; and

**.5** be clearly marked with the call sign, the ship station identity and other codes as applicable for the use of the radio installation.

**14.6.3** Control of the VHF radiotelephone channels, required for navigational safety, shall be immediately available on the navigating bridge convenient to the conning position, and, where necessary, facilities shall be available to permit radiocommunications from the wings of the navigating bridge. Portable VHF equipment may be used to meet the latter provision.

**14.6.4** In passenger craft, a distress panel shall be installed at the conning position. This panel shall contain either one single button which, when pressed, initiates a distress alert using all radiocommunication installations required on board for that purpose or one button for each individual installation. The panel shall clearly and visually indicate whenever any button or buttons have been pressed. Means shall be provided to prevent inadvertent activation of the button or buttons. If the satellite EPIRB is used as the secondary means of distress alerting and is not remotely activated, it shall be acceptable to have an additional EPIRB installed in the wheelhouse near the conning position.

**14.6.5** In passenger craft, information on the craft's position shall be continuously and automatically provided to all relevant radiocommunication equipment to be included in the initial distress alert when the button or buttons on the distress panel is pressed.

**14.6.6** In passenger craft, a distress alert panel shall be installed at the conning position. The distress alarm panel shall provide visual and aural indication of any distress alert or alerts received on board and shall also indicate through which radiocommunication service the distress alerts have been received.

## **14.7 Radio equipment: general**

**14.7.1** Every craft shall be provided with:

**.1** a VHF radio installation capable of transmitting and receiving:

**.1.1** DSC on the frequency 156.525 MHz (channel 70). It shall be possible to initiate the transmission of distress alerts on channel 70 from the position from which the craft is normally navigated; and

**.1.2** radiotelephony on the frequencies 156.300 MHz (channel 6), 156.650 MHz (channel 13) and 156.800 MHz (channel 16);

**.2** a radio installation capable of maintaining a continuous DSC watch on VHF channel 70 which may be separate from, or combined with, that required by 14.7.1.1.1;

**.3** a radar transponder capable of operating in the 9 GHz band, which:

**.3.1** shall be so stowed that it can be easily utilized; and

**.3.2** may be one of those required by 8.2.1.2 for a survival craft;

**.4** a receiver capable of receiving International NAVTEX service broadcasts if the craft is engaged on voyages in any area in which an International NAVTEX service is provided;

**.5** a radio facility for reception (see note 1) of maritime safety information by the Inmarsat enhanced group calling system if the craft is engaged on voyages in any area of Inmarsat coverage but in which an International NAVTEX service is not provided. However, craft engaged exclusively on voyages in areas where a HF direct printing telegraphy maritime safety information service is provided and fitted with equipment capable of receiving such service may be exempt from this requirements (see note 2).

**Note 1 :** Refer to Carriage of Inmarsat enhanced group call SafetyNET receivers under the GMDSS, adopted by the Organization by resolution A.701(17).

**Note 2 :** Refer to the Recommendation on Promulgation of Maritime Safety Information, adopted by the Organization by resolution A.705(17).

**.6** subject to the provisions of 14.8.3, a satellite emergency position indicating radio beacon (satellite EPIRB) which shall be:

**Note:** Refer to Search and rescue homing capability, adopted by the Organization by resolution A.616(15).

**.6.1** capable of transmitting a distress alert either through the polar orbiting satellite service operating in the 406 MHz band or, if the craft is engaged only on voyages within Inmarsat coverage, through the Inmarsat geostationary satellite service operating in the 1.6 GHz band;

**.6.2** installed in an easily accessible position;

**.6.3** ready to be manually released and capable of being carried by one person into a survival craft;

**.6.4** capable of floating free if the craft sinks and of being automatically activated when afloat; and

**.6.5** capable of being activated manually.

**14.7.2** Every passenger craft shall be provided with means for two-way on-scene radiocommunications for search and rescue purposes using the aeronautical frequencies 121.5 MHz and 123.1 MHz from the position from which the craft is normally navigated.

#### **14.8 Radio equipment: sea area A1**

**14.8.1** In addition to meeting the requirements of 14.7, every craft engaged on voyages exclusively in sea area A1 shall be provided with a radio installation capable of initiating the transmission of ship-to-shore distress alerts from the position from which the craft is normally navigated, operating either:

**.1** on VHF using DSC; this requirement may be fulfilled by the EPIRB prescribed by 14.8.3, either by installing the EPIRB close to, or by remote activation from, the position from which the craft is normally navigated; or

**.2** through the polar orbiting satellite service on 406 MHz; this requirement may be fulfilled by the satellite EPIRB, required by 14.7.1.6, either by installing the satellite EPIRB close to, or by remote activation from, the position from which the craft is normally navigated; or

**.3** if the craft is on voyages within coverage of MF coast stations equipped with DSC on MF using DSC; or

**.4** on HF using DSC; or

**.5** through the Inmarsat geostationary satellite service; this requirement may be fulfilled by:

**.5.1** an Inmarsat ship earth station (see note); or

**.5.2** the satellite EPIRB, required by 14.7.1.6, either by installing the satellite EPIRB close to, or by remote activation from, the position from which the craft is normally navigated.

*Note: This requirement can be met by Inmarsat ship earth stations capable of two-way communications, such as Inmarsat-A and -B (resolution A.808(19)) or Inmarsat-C (resolution A.807(19) and MSC.68(68), annex 4) ship earth stations. Unless otherwise specified, this footnote applies to all requirements for an Inmarsat ship earth station prescribed by this Section.*

**14.8.2** The VHF radio installation, required by 14.7.1.1, shall also be capable of transmitting and receiving general radiocommunications using radiotelephony.

**14.8.3** Craft engaged on voyages exclusively in sea area A1 may carry, in lieu of the satellite EPIRB required by 14.7.1.6, an EPIRB which shall be:

**.1** capable of transmitting a distress alert using DSC on VHF channel 70 and providing for locating by means of a radar transponder operating in the 9 GHz band;

**.2** installed in an easily accessible position;

**.3** ready to be manually released and capable of being carried by one person into a survival craft;

**.4** capable of floating free if the craft sinks and of being automatically activated when afloat; and

**.5** capable of being activated manually.

#### **14.9 Radio equipment: sea areas A1 and A2**

**14.9.1** In addition to meeting the requirements of 14.7, every craft engaged on voyages beyond sea area A1, but remaining within sea area A2, shall be provided with:

**.1** an MF radio installation capable of transmitting and receiving, for distress and safety purposes, on the frequencies:

**.1.1** 2,187.5 kHz using DSC; and

**.1.2** 2,182 kHz using radiotelephony;

**.2** a radio installation capable of maintaining a continuous DSC watch on the frequency 2,187.5 kHz which may be separate from, or combined with, that required by 14.9.1.1.1; and

**.3** means of initiating the transmission of ship-to-shore distress alerts by a radio service other than MF, operating either:

**.3.1** through the polar orbiting satellite service on 406 MHz; this requirement may be fulfilled by the satellite EPIRB, required by 14.7.1.6, either by installing the satellite EPIRB close to, or by remote activation from, the position from which the craft is normally navigated; or

**.3.2** on HF using DSC; or

**.3.3** through the Inmarsat geostationary satellite service; this requirement may be fulfilled by:

**.3.3.1** the equipment specified in 14.9.3.2; or

**.3.3.2** the satellite EPIRB, required by 14.7.1.6, either by installing the satellite EPIRB close to, or by remote activation from, the position from which the craft is normally navigated.

**14.9.2** It shall be possible to initiate transmission of distress alerts by the radio installations specified in 14.9.1.1 and 14.9.1.3 from the position from which the craft is normally navigated.

**14.9.3** The craft shall, in addition, be capable of transmitting and receiving general radiocommunications using radiotelephony or direct-printing telegraphy by either:

**.1** a radio installation operating on working frequencies in the bands between 1,605 kHz and 4,000 kHz or between 4,000 kHz and 27,500 kHz; this requirement may be fulfilled by the addition of this capability in the equipment required by 14.9.1.1; or

**.2** an Inmarsat ship earth station.

#### **14.10 Radio equipment: sea areas A1, A2 and A3**

**14.10.1** In addition to meeting the requirements of 14.7, every craft engaged on voyages beyond sea areas A1 and A2, but remaining within sea area A3, shall, if it does not comply with the requirements of 14.10.2, be provided with:

**.1** an Inmarsat ship earth station capable of:

**.1.1** transmitting and receiving distress and safety communications using direct-printing telegraphy;

**.1.2** initiating and receiving distress priority calls;

**.1.3** maintaining watch for shore-to-ship distress alerts, including those directed to specifically defined geographical areas; and

**.1.4** transmitting and receiving general radiocommunications, using either radiotelephony or direct-printing telegraphy;

**.2** an MF radio installation capable of transmitting and receiving, for distress and safety purposes, on the frequencies:

**.2.1** 2,187.5 kHz using DSC; and

**.2.2** 2,182 kHz using radiotelephony;

**.3** a radio installation capable of maintaining a continuous DSC watch on the frequency 2,187.5 kHz which may be separate from, or combined with, that required by 14.10.1.2.1; and

**.4** means of initiating the transmission of ship-to-shore distress alerts by a radio service operating either:

**.4.1** through the polar orbiting service on 406 MHz; this requirement may be fulfilled by the satellite EPIRB, required by 14.7.1.6, either by installing the satellite EPIRB close to, or by remote activation from, the position from which the craft is normally navigated; or

**.4.2** on HF using DSC; or

**.4.3** through the Inmarsat geostationary satellite service, by an additional ship earth station or by the satellite EPIRB required by 14.7.1.6, either by installing the satellite EPIRB close to, or by remote activation from, the position from which the craft is normally navigated.

**14.10.2** In addition to meeting the requirements of 14.7, every craft engaged on voyages beyond sea areas A1 and A2, but remaining within sea area A3, shall, if it does not comply with the requirements of 14.10.1, be provided with:

**.1** an MF/HF radio installation capable of transmitting and receiving, for distress and safety purposes, on all distress and safety frequencies in the bands between 1,605 kHz and 4,000 kHz and between 4,000 kHz and 27,500 kHz:

**.1.1** using DSC;

**.1.2** using radiotelephony; and

**.1.3** using direct-printing telegraphy;

**.2** equipment capable of maintaining a DSC watch on 2,187.5 kHz, 8,414.5 kHz and on at least one of the distress and safety DSC frequencies 4,207.5 kHz, 6,312 kHz, 12,577 kHz or 16,804.5 kHz at any time, it shall be possible to select any of these DSC distress and safety frequencies. This equipment may be separate from, or combined with, the equipment required by 14.10.2.1;

**.3** means of initiating the transmission of ship-to-shore distress alerts by a radiocommunication service other than HF operating either:

**.3.1** through the polar orbiting satellite service on 406 MHz; this requirement may be fulfilled by the satellite EPIRB required by 14.7.1.6, either by installing the satellite EPIRB close to, or by remote activation from, the position from which the craft is normally navigated; or

**.3.2** through the Inmarsat geostationary satellite service, this requirement may be fulfilled by:

**.3.2.1** an Inmarsat ship earth station; or

**.3.2.2** the satellite EPIRB, required by 14.7.1.6, either by installing the satellite EPIRB close to, or by remote activation from, the position from which the craft is normally navigated; and

**.4** in addition, the craft shall be capable of transmitting and receiving general radiocommunications using radiotelephony or direct-printing telegraphy by an MF/HF radio installation operating on working frequencies in the bands between 1,605 kHz and 4,000 kHz and between 4,000 kHz and 27,500 kHz. This requirement may be fulfilled by the addition of this capability in the equipment required by 14.10.2.1.

**14.10.3** It shall be possible to initiate transmission of distress alerts by the radio installations specified in 14.10.1.1, 14.10.1.2, 14.10.1.4, 14.10.2.1 and 14.10.2.3 from the position from which the craft is normally navigated.

#### **14.11 Radio equipment: sea areas A1, A2, A3 and A4**

**14.11.1** In addition to meeting the requirements of 14.7, craft engaged on voyages in all sea areas shall be provided with the radio installations and equipment required by 14.10.2, except that the equipment required by 14.10.2.3.2 shall not be accepted as an alternative to that required by 14.10.2.3.1, which shall always be provided. In addition, craft engaged on voyages in all sea areas shall comply with the requirements of 14.10.3.

#### **14.12 Watches**

**14.12.1** Every craft, while at sea, shall maintain a continuous watch:

**.1** on VHF DSC channel 70, if the craft, in accordance with the requirements of 14.7.1.2, is fitted with a VHF radio installation;

**.2** on the distress and safety DSC frequency 2,187.5 kHz, if the craft, in accordance with the requirements of 14.9.1.2 or 14.10.1.3, is fitted with an MF radio installation;

**.3** on the distress and safety DSC frequencies 2,187.5 kHz and 8,414.5 kHz and also on at least one of the distress and safety DSC frequencies 4,207.5 kHz, 6,312 kHz, 12,577 kHz or 16,804.5 kHz, appropriate to the time of day and the geographical position of the craft, if the craft, in accordance with the requirements of 14.10.2.2 or 14.11.1, is fitted with an MF/HF radio installation. This watch may be kept by means of a scanning receiver; and

**.4** for satellite shore-to-ship distress alerts, if the craft, in accordance with the requirements of 14.10.1.1, is fitted with an Inmarsat ship earth station.

**14.12.2** Every craft, while at sea, shall maintain a radio watch for broadcasts of maritime safety information on the appropriate frequency or frequencies on which such information is broadcast for the area in which the craft is navigating.

**14.12.3** Until 1 February 2005, every craft, while at sea shall continue to maintain, when practicable, a continuous listening watch on VHF channel 16. This watch shall be kept at the position from which the craft is normally navigated.

#### **14.13 Sources of energy**

**14.13.1** There shall be available at all times, while the craft is at sea, a supply of electrical energy sufficient to operate the radio installations and to charge any batteries used as part of a reserve source of energy for the radio installations.

**14.13.2** Reserve and emergency sources of energy shall be provided on every craft to supply radio installations, for the purpose of conducting distress and safety radiocommunications, in the event of failure of the craft's main and emergency sources of electrical power. The reserve source of energy shall be capable of simultaneously operating the VHF radio installation required by 14.7.1.1 and, as appropriate for the sea area or sea areas for which the craft is equipped, either the MF radio installation required by 14.9.1.1, the MF/HF radio installation required by 14.10.2.1 or 14.11.1 or the Inmarsat ship earth station required by 14.10.1.1 and any of the additional loads mentioned in 14.13.5 and 14.13.8 for a period of at least 1 h.

**14.13.3** The reserve source of energy shall be independent of the propelling power of the craft and the craft's electrical system.

**14.13.4** Where, in addition to the VHF radio installation, two or more of the other radio installations referred to in 14.13.2 can be connected to the reserve source or sources of energy, they shall be capable of simultaneously supplying, for the period specified in 14.13.2, the VHF radio installation and:

**.1** all other radio installations which can be connected to the reserve source of energy at the same time; or

**.2** whichever of the radio installations will consume the most power, if only one of the other radio installations can be connected to the reserve source of energy at the same time as the VHF radio installation.

**14.13.5** The reserve source of energy may be used to supply the electrical lighting required by 14.6.2.4.

**14.13.6** Where a reserve source of energy consists of a rechargeable accumulator battery or batteries:

**.1** a means of automatically charging such batteries shall be provided which shall be capable of recharging them to minimum capacity requirements within 10 h; and

**.2** the capacity of the battery or batteries shall be checked, using an appropriate method at intervals not exceeding 12 months, when the craft is not at sea.

*Note: One method of checking the capacity of an accumulator battery is to fully discharge and recharge the battery, using normal operating current and period (e.g. 10 h). Assessment of the charge condition can be made at any time, but it should be done without significant discharge of the battery when the craft is at sea.*

**14.13.7** The siting and installation of accumulator batteries which provide a reserve source of energy shall be such as to ensure:

**.1** the highest degree of service;

**.2** a reasonable lifetime;

**.3** reasonable safety;

**.4** that the battery temperatures remain within the manufacturer's specifications whether under charge or idle; and

**.5** that when fully charged, the batteries will provide at least the minimum required hours of operation under all weather conditions.

**14.13.8** If an uninterrupted input of information from the craft's navigational or other equipment to a radio installation required by this Section is needed to ensure its proper performance, including the navigation receiver referred to in 14.18, means shall 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.

## **14.14 Performance standards**

**14.14.1** All equipment to which this Section applies shall be of a type approved by the Administration. Such equipment shall conform to appropriate performance standards not inferior to those adopted by the Organization.

*Note: Refer to the following resolutions adopted by the Organization:*

- (1) Resolution A.525(13): Performance Standards for Narrow-Band Direct-Printing Telegraph Equipment for the Reception of Navigational and Meteorological Warnings and Urgent Information to Ships.
- (2) Resolution A.694(17): General Requirements for Shipborne Radio Equipment Forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids.
- (3) Resolution A.808(19): Performance Standards for Ship Earth Stations Capable of Two-Way Communications, and resolution A.570(14), Type Approval of Ship Earth Stations.
- (4) Resolutions A.803(19): and MSC.68(68), annex 1: Performance Standards for Shipborne VHF Radio Installations Capable of Voice Communication and Digital Selective Calling.
- (5) Resolutions A.804(19) and MSC.68(68), annex 2: Performance Standards for Shipborne MF Radio Installations Capable of Voice Communication and Digital Selective Calling.
- (6) Resolutions A.806(19) and MSC.68(68), annex 3: Performance Standards for Shipborne MF/HF Radio Installations Capable of Voice Communication, Narrow-Band Direct Printing and Digital Selective Calling.
- (7) Resolutions A.810(19) and MSC.56(66): Performance Standards for Float-Free Satellite Emergency Position-Indicating Radio Beacons (EPIRBs) Operating on 406 MHz (see also Assembly resolution A.696(17): Type Approval of Satellite Emergency Position-Indicating Radio Beacons (EPIRBs) Operating in the COSPAS-SARSAT System).
- (8) Resolution A.802(19): Performance Standards for Survival Craft Radar Transponders for Use in Search and Rescue Operations.
- (9) Resolution A.805(19): Performance Standards for Float-Free VHF Emergency Position-Indicating Radio Beacons.
- (10) Resolutions A.807(19) and MSC.68(68), annex 4: Performance Standards for Inmarsat Standard-C Ship Earth Stations Capable of Transmitting and Receiving Direct-Printing Communications, and resolution A.570(14), Type Approval of Ship Earth Stations.
- (11) Resolution A.664(16): Performance Standards for Enhanced Group Call Equipment.
- (12) Resolution A.812(19): Performance Standards for Float-Free Satellite Emergency Position-Indicating Radio Beacons Operating Through the Geostationary Inmarsat Satellite System on 1.6 GHz.
- (13) Resolution A.662(16): Performance Standards for Float-Free Release and Activation Arrangements for Emergency Radio Equipment.
- (14) Resolution A.699(17): System Performance Standard for the Promulgation and Co-ordination of Maritime Safety Information Using High-Frequency Narrow-Band Direct Printing.
- (15) Resolution A.700(17): Performance Standards for Narrow-Band Direct-Printing Telegraph Equipment for the Reception of Navigational and Meteorological Warnings and Urgent Information to Ships (MSI) by HF.
- (16) Resolution MSC.80(70): Recommendation on Performance Standards for on-scene (Aeronautical) Portable Two-Way VHF Radiotelephone Apparatus.

**14.15 Maintenance requirements**

**14.15.1** Equipment shall be so designed that the main units can be replaced readily without elaborate recalibration or readjustment.

**14.15.2** Where applicable, equipment shall be so constructed and installed that it is readily accessible for inspection and on-board maintenance purposes.

**14.15.3** Adequate information shall be provided to enable the equipment to be properly operated and maintained, taking into account the recommendations of the Organization.

*Note: Refer to the Recommendation on General Requirements for Shipborne Radio Equipment Forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids, adopted by the Organization by resolution A.694(17).*

**14.15.4** Adequate tools and spares shall be provided to enable equipment to be maintained.

**14.15.5** The Administration shall ensure that radio equipment required by this Section is maintained to provide the availability of the functional requirements specified in 14.5 and to meet the recommended performance standards of such equipment.

**14.15.6** On craft engaged on voyages in sea areas A1 and A2, the availability shall be ensured by using such methods as duplication of equipment, shore-based maintenance or at-sea electronic maintenance capability, or a combination of these, as may be approved by the Administration.

**14.15.7** On craft engaged on voyages in sea areas A3 and A4, the availability shall be ensured by using a combination of at least two methods, such as duplication of equipment, shore-based maintenance or at-sea electronic maintenance capability, as may be approved by the Administration, taking into account the recommendations of the Organization.

*Note: Administrations should take account of the Radio Maintenance Guidelines for the Global Maritime Distress and Safety System (GMDSS) related to Sea Areas A3 and A4, adopted by the Organization by resolution A.702(17).*

**14.15.8** However, for craft operating solely between ports where adequate facilities for shorebased maintenance of the radio installations are available and provided no journey between two such ports exceeds six hours, then the Administration may exempt such craft from the requirement to use at least two maintenance methods. For such craft at least one maintenance method shall be used.

**14.15.9** While all reasonable steps shall be taken to maintain the equipment in efficient working order to ensure compliance with all the functional requirements specified in 14.5, malfunction of the equipment for providing the general radiocommunications, required by 14.8, shall not be considered as making a craft unseaworthy or as a reason for delaying the craft in ports where repair facilities are not readily available, provided the craft is capable of performing all distress and safety functions.

**14.15.10** Satellite EPIRBs shall be tested at intervals not exceeding 12 months for all aspects of operational efficiency with particular emphasis on frequency stability, signal strength and coding. However, in cases where it appears proper and reasonable, the Administration may extend this period to 17 months. The test may be conducted on board the ship or at an approved testing or servicing station.

**14.16 Radio personnel**

**14.16.1** Every craft shall carry personnel qualified for distress and safety radiocommunication purposes to the satisfaction of the Administration. The personnel shall be holders of certificates specified in the Radio Regulations as appropriate, any one of whom shall be designated to have primary responsibility for radiocommunications during distress incidents.

**14.16.2** In passenger craft, at least one person qualified in accordance with sub-paragraph .1 shall be assigned to perform only radiocommunication duties during distress incidents.

**14.17 Radio records**

A record shall be kept, to the satisfaction of the Administration and as required by the Radio Regulations, of all incidents connected with the radiocommunication service which appear to be of importance to safety of life at sea.

**14.18 Position-updating**

All two-way communication equipment carried on board craft to which this Section applies which is capable of automatically including the craft's position in the distress alert shall be automatically provided with this information from an internal or external navigation receiver, if either is installed. If such a receiver is not installed, the craft's position and the time that position was correct shall be manually updated at intervals not exceeding four hours, while the craft is underway, so that it is always ready for transmission by the equipment.

**SECTION 15****OPERATING COMPARTMENT LAYOUT****15.1 Definitions**

**15.1.1** "Operating area" is the operating compartment and those parts of the craft on both sides of, and close to, the operating compartment which extend to the craft's side.

**15.1.2** "Workstation" is a position at which one or several tasks constituting a particular activity are carried out.

**15.1.3** "Docking workstation" is a place equipped with necessary means for docking the craft.

**15.1.4** "Primary controls" are all control equipment necessary for the safe operation of the craft when it is under way, including those required in an emergency situation.

**15.2 General**

The design and layout of the compartment from which the crew operate the craft shall be such as to permit operating crew members to perform their duties in a correct manner without unreasonable difficulty, fatigue or concentration, and to minimize the likelihood of injury to operating crew members in both normal and emergency conditions.

**15.3 Field of vision from the operating compartment**

**15.3.1** The operating station shall be placed above all other superstructures so that the operating crew are able to gain a view all round the horizon from the navigating workstation. Where it is impractical to meet the requirements of this paragraph from a single navigating workstation, the operating station shall be designed so that an all-round view of the horizon is obtained by using two navigating workstations combined or by any other means to the satisfaction of the Administration.

**15.3.2** Blind sectors shall be as few and as small as possible, and not adversely affect the keeping of a safe look-out from the operating station. If stiffeners between windows are to be covered, this shall not cause further obstruction inside the wheelhouse.

**15.3.3** The total arc of blind sectors from right ahead to 22.5° abaft the beam on either side shall not exceed 20°. Each individual blind sector shall not exceed 5°. The clear sector between two blind sectors shall not be less than 10°.

**15.3.4** Where it is considered necessary by the Administration, the field of vision from the navigating workstation shall permit the navigators from this position to utilize leading marks astern of the craft for track monitoring.

**15.3.5** The view of the sea surface from the operating station, when the navigators are seated, shall not be obscured by more than one craft length forward of the bow to 90° on either side irrespective of the craft's draught, trim and deck cargo.

**15.3.6** The field of vision from the docking workstation, if remote from the operating station, shall permit one navigator to safely manoeuvre the craft to a berth.

**15.4 Operating compartment**

**15.4.1** The design and arrangement of the operating compartment, including location and layout of the individual workstations, shall ensure the required field of vision for each function.

**15.4.2** The craft's operating compartment shall not be used for purposes other than navigation, communications and other functions essential to the safe operation of the craft, its engines, passengers and cargo.

**15.4.3** The operating compartment shall be provided with an integrated operating station for command, navigation, manoeuvring and communication and so arranged that it can accommodate those persons required to navigate the craft safely.

**15.4.4** The arrangement of equipment and means for navigation, manoeuvring, control, communication and other essential instruments shall be located sufficiently close together to enable both the officer in charge and any assisting officer to receive all necessary information and to use the equipment and controls, as required, while they are seated. If necessary, the equipment and means serving these functions shall be duplicated.

**15.4.5** If a separate workstation for supervision of engine performance is placed in the operating compartment, the location and use of this workstation shall not interfere with the primary functions to be performed in the operating station.

**15.4.6** The location of the radio equipment shall not interfere with the primary navigational functions in the operating station.

**15.4.7** The design and layout of the compartment from which the crew operate the craft and the relative positions of the primary controls shall be assessed against the essential operational manning level. Where minimum manning levels are proposed, the design and layout of the primary and communication controls shall form an integrated operational and emergency control centre from which the craft can be controlled under all operational and emergency events by the operating crew without the necessity for any crew member to vacate the compartment.

**15.4.8** The relative positions of the primary controls and the seats shall be such that each operating crew member, with the seat suitably adjusted and without prejudicing compliance with 15.2, can:

**.1** without interference, produce full and unrestricted movement of each control both separately and with all practical combinations of movement of other controls; and

**.2** at all workstations, exert adequate control forces for the operation to be performed.

**15.4.9** When a seat at a station from which the craft may be operated has been adjusted so as to suit the occupant, subsequent change of seat position to operate any control shall not be acceptable.

**15.4.10** In craft where the Administration considers the provision of a safety belt necessary for use by the operating crew, it shall be possible for those operating crew members, with their safety belts correctly worn, to comply with 15.4.4 except in respect of controls which it can be shown will only be required on very rare occasions and which are not associated with the need for safety restraint.

**15.4.11** The integrated operating station shall contain equipment which provides relevant information to enable the officer in charge and any assisting officer to carry out navigational and safety functions safely and efficiently.

**15.4.12** Adequate arrangements shall be made to prevent passengers from distracting the attention of the operating crew.

## **15.5 Instruments and chart table**

**15.5.1** Instruments, instrument panels and controls shall be permanently mounted in consoles or other appropriate places, taking into account operation, maintenance and environmental conditions. However, this shall not prevent the use of new control or display techniques, provided the facilities offered are not inferior to recognized standards.

**15.5.2** All instruments shall be logically grouped according to their functions, in order to reduce to a minimum the risk of confusion, instruments shall not be rationalized by sharing functions or by inter-switching.

**15.5.3** Instruments required for use by any member of the operating crew shall be plainly visible and easily read:

**.1** with minimum practicable deviation from his normal seating position and line of vision; and

**.2** with the minimum risk of confusion under all likely operating conditions.

**15.5.4** Instruments essential for the safe operation of the craft shall be clearly marked with any limitation if this information is not otherwise clearly presented to the operating crew. The instrument panels forming the emergency control for the launching of liferafts and the monitoring of the fire-fighting systems shall be in separate and clearly defined positions within the operating area.

**15.5.5** The instruments and controls shall be provided with means for screening and dimming in order to minimize glare and reflections and prevent them being obscured by strong light.

**15.5.6** The surfaces of console tops and instruments shall have dark glare-free colours.

**15.5.7** Instruments and displays providing visual information to more than one person shall be located for easy viewing by all users concurrently. If this is not possible, the instrument or display shall be duplicated.

**15.5.8** If considered necessary by the Administration, the operating compartment shall be provided with a suitable table for chart work. There shall be facilities for lighting the chart. Chart-table lighting shall be screened.



## **15.6 Lighting**

**15.6.1** A satisfactory level of lighting shall be available to enable the operating personnel to adequately perform all their tasks both at sea and in port, by day and night. There shall be only a limited reduction in the illumination of essential instruments and controls under likely system fault conditions.

**15.6.2** Care shall be taken to avoid glare and stray image reflection in the operating area environment. High contrast in brightness between work area and surroundings shall be avoided. Non-reflective or matt surfaces shall be used to reduce indirect glare to a minimum.

**15.6.3** A satisfactory degree of flexibility within the lighting system shall be available to enable the operating personnel to adjust the lighting intensity and direction as required in the different areas of the operating compartment and at individual instruments and controls.

**15.6.4** Red light shall be used to maintain dark adaptation whenever possible in areas or on items of equipment requiring illumination in the operational mode, other than the chart table.

**15.6.5** During hours of darkness, it shall be possible to discern displayed information and control devices.

**15.6.6** Reference is made to additional requirements on lighting in 12.7 and 12.8.

## **15.7 Windows**

**15.7.1** Divisions between windows, located in the front, on the sides and in the doors shall be kept to a minimum. No division shall be installed immediately forward of the operating stations.

**15.7.2** Administrations shall be satisfied that a clear view through the operating compartment windows is provided at all times regardless of weather conditions. The means provided for maintaining the windows in a clear condition shall be so arranged that no reasonably probable single failure can result in a reduction of the cleared field of vision such as to interfere seriously with the ability of the operating crew to continue the operation and bring the craft to rest.

**15.7.3** Arrangements shall be provided so that the forward view from operating stations is not adversely affected by solar glare. Neither polarized nor tinted window glass shall be fitted.

**15.7.4** Operating compartment windows shall be angled to reduce unwanted reflection.

**15.7.5** The windows shall be made of material which will not break into dangerous fragments if fractured.

## **15.8 Communication facilities**

**15.8.1** Such means as are necessary shall be provided to enable the crew to communicate between, and have access to, each other and with other occupants of the craft in both normal and emergency conditions.

**15.8.2** Means to communicate between the operating compartment and spaces containing essential machinery, including any emergency steering position, irrespective of whether the machinery is remotely or locally controlled, shall be provided.

**15.8.3** Means for making public address and safety announcements from control stations to all areas to which passengers and crew have access shall be provided.

**15.8.4** Provisions shall be made for means to monitor, receive and transmit radio safety messages at the operating compartment.

## **15.9 Temperature and ventilation**

The operating compartment shall be equipped with adequate temperature and ventilation control systems.

## **15.10 Colours**

The surface materials inside the operating compartment shall have a suitable colour and finish to avoid reflections.

## **15.11 Safety measures**

The operating area shall be free of physical hazard to the operating personnel and have non-skid flooring in dry and wet conditions and adequate handrails. Doors shall be fitted with devices to prevent them moving, whether they are open or closed.

**SECTION 16****STABILIZATION SYSTEMS****16.1 Definitions**

**16.1.1** “Stabilization control 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:

**.1** devices such as rudders, foils, flaps, skirts, fans, water jets, tilting and steerable propellers, pumps for moving fluids;

**.2** power drives actuating stabilization devices;  
and

**.3** stabilization equipment for accumulating and processing data for making decisions and giving commands such as sensors, logic processors and automatic safety control.

**16.1.2** “Self-stabilization” of the craft is stabilization ensured solely by the craft’s inherent characteristics.

**16.1.3** “Forced stabilization” of the craft is stabilization achieved by:

**.1** an automatic control system; or

**.2** a manually assisted control system; or

**.3** a combined system incorporating elements of both automatic and manually assisted control systems.

**16.1.4** “Augmented stabilization” is a combination of self-stabilization and forced stabilization.

**16.1.5** “Stabilization device” means a device as enumerated in 16.1.1.1 with the aid of which forces for controlling the craft’s position are generated.

**16.1.6** “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.

**16.2 General requirements**

**16.2.1** Stabilization systems shall 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 the 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.

**16.2.2** In case of failure of any automatic equipment or stabilization device, or of its power drive, the parameters of craft motion shall remain within safe limits.

**16.2.3** Craft fitted with an automatic stabilization system shall be provided with an automatic safety control unless the redundancy in the system provides equivalent safety. Where an automatic safety control is fitted, provision shall be made to override it and to cancel the override from the main operating station.

**16.2.4** 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 shall 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.

**16.2.5** The parameters and the degree of stabilization of the craft provided by the automatic stabilization system shall be satisfactory, having regard to the purpose and service conditions of the craft.

**16.2.6** Failure mode and effect analysis shall include the stabilization system.

**16.3 Lateral and height control systems**

**16.3.1** Craft fitted with an automatic control system shall be provided with an automatic safety control. Probable malfunctions shall have only minor effects on automatic control system operation and shall be capable of being readily counteracted by the operating crew.

**16.3.2** *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 shall take account of the safety levels as given in section 2.4 of annex 3 and of the safe values of motions appropriate to the particular craft and service.*

#### **16.4        *Demonstrations***

**16.4.1** *The limits of safe use of any of the stabiliza-*

*tion control system devices shall be based on demonstrations and a verification process in accordance with annex 9.*

**16.4.2** *Demonstration in accordance with annex 9 shall 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 shall be included in the craft operating manual.*

**SECTION 17****HANDLING, CONTROLLABILITY AND PERFORMANCE****17.1 General**

*The operational safety of the craft in normal service conditions and in equipment failure situations of a craft to which this Code applies shall be documented and verified by full-scale tests, supplemented by model tests where appropriate, of the prototype craft. The objective of tests is to determine information to be included in the craft operating manual in relation to:*

- .1 operating limitations;*
- .2 procedures for operation of the craft within the limitations;*
- .3 actions to be taken in the event of prescribed failure; and*
- .4 limitations to be observed for safe operation subsequent to prescribed failures.*

*Operational information shall be available on board for guidance, or the craft shall have an instrument system for on-line check of operational performance which shall be approved by the Administration taking into account the standards for the processing and presentation of measurements developed by the Organization. As a minimum, the system shall measure accelerations in three axes close to the craft longitudinal centre of gravity.*

**17.2 Proof of compliance**

**17.2.1** *The information on controllability and manoeuvrability which shall be contained in the craft operating manual shall include the characteristics under 17.5 as applicable, the list of parameters of the worst intended conditions affecting the controllability and manoeuvrability according to 17.6, information on safe maximum speeds as described in 17.9 and the performance data verified in accordance with annex 9.*

**17.2.2** *The information on operating limitations which shall be contained in the route operational manual shall include the characteristics under 17.2.1, 17.5.4.1 and 17.5.4.2.*

**17.3 Weight and centre of gravity**

*Compliance with each of the handling, controllability and performance requirements shall be established for all combinations of weight and centre of gravity position significant for the operational safety in the range of weights up to the maximum permissible weight.*

**C17.3** For the purpose of classification, controllability is to be established in the way defined in 17.3.

**17.4 Effect of failures**

*The effect of any likely failure in handling and control devices, services or components (e.g. power operation, power assistance, trimming and stability augmentation) shall be assessed in order that a safe level of craft operation can be maintained. Effects of failure identified as being critical according to annex 4 shall be verified in accordance with.*

**17.5 Controllability and manoeuvrability**

**17.5.1** *Instructions to crew members shall be provided in the craft operating manual regarding required actions and craft limitations subsequent to prescribed failures.*

**17.5.2** *It is necessary to ensure that the effort required to operate the controls in the worst intended conditions is not such that the person at the control will be unduly fatigued or distracted by the effort necessary to maintain the safe operation of the craft.*

**17.5.3** *The craft shall be controllable and be capable of performing those manoeuvres essential to its safe operation up to the critical design conditions.*

**17.5.4.1** *When determining the operating limitations of a craft, particular attention shall be paid to the following aspects during normal operation and during failures and subsequent to failures:*

- .1 yawing;*
- .2 turning;*

- .3** *automatic pilot and steering performance;*
- .4** *stopping in normal and emergency conditions;*
- .5** *stability in the non-displacement mode about three axes and in heave;*
- .6** *trim;*
- .7** *roll;*
- .8** *plough in;*
- .9** *lift power limitations;*
- .10** *broaching;*
- .11** *slamming; and*
- .12** *bow diving.*

**17.5.4.2** The terms in 17.5.4.1.2, .8, .9 and .11 are defined as follows:

- .1** *“Turning” is the rate of change of direction of a craft at its normal maximum operating speed in specified wind and sea conditions.*
- .2** *“Plough in” is an involuntary motion involving sustained increase in drag of an air-cushion vehicle at speed, usually associated with partial collapse of the cushion system.*
- .3** *“Lift power limitations” are those limitations imposed upon the machinery and components which provide the lift.*
- .4** *“Slamming” is the water impact on the underside of the hull in the bow area of the craft.*

#### **17.6 Change of operating surface and mode**

*There shall be no unsafe change in the stability, controllability or attitude of the craft during transition from one type of operating surface or mode to another. Information on change in the behaviour characteristics of the craft during transition shall be available to the master.*

#### **17.7 Surface irregularities**

*Factors which limit the ability of the craft to operate over sloping ground and steps or discontinuities shall be determined, as applicable, and made available to the master.*

#### **17.8 Acceleration and deceleration**

*The Administration shall be satisfied that the worst likely acceleration or deceleration of the craft, due to any likely failure, emergency stopping procedures or other likely causes, would not hazard the persons on the craft.*

#### **17.9 Speeds**

*Safe maximum speeds shall be determined, taking account of the limitations from 4.3.1, modes of operation, wind force and direction and the effects of possible failures of any one lift or propulsion system over calm water, rough water and over other surfaces, as appropriate to the craft.*

#### **17.10 Minimum depth of water**

*The minimum depth of water and other appropriate information required for operations in all modes shall be determined.*

#### **17.11 Hard structure clearance**

*For amphibious craft, when cushion-borne, clearance of the lowest point of the hard structure above a hard flat surface shall be determined.*

#### **17.12 Night operation**

*The schedule of tests shall include sufficient operation to evaluate the adequacy of internal and external lighting and visibility under conditions of normal and emergency electrical power supply during service, cruising and docking manoeuvres.*

## SECTION 18

## OPERATIONAL REQUIREMENTS

**Part A General****C18.0 Documents to be submitted**

The craft operating manuals and route operational manual are to be transmitted to the Society for information.

**18.1 Craft operational control**

**18.1.1** *The High-Speed Craft Safety Certificate, the Permit to Operate High-Speed Craft or certified copies thereof, and copies of the route operational manual, craft operating manual, and a copy of such elements of the maintenance manual as the Administration may require shall be carried on board.*

**C18.1.1** Classification certificates and annexed documents issued by the Society for the craft are to be kept on board in a safe location and made available on request to the Society Surveyor.

**18.1.2** *The craft shall not be intentionally operated outside the worst intended conditions and limitations specified in the Permit to Operate High-Speed Craft, in the High-Speed Craft Safety Certificate, or in documents referred to therein.*

**C18.1.2** When the craft is operated under conditions not covered by the service and navigation notations described in the certificate, class is normally suspended in accordance with Society Rules.

**18.1.3** *The Administration shall issue a Permit to Operate High-Speed Craft when it is satisfied that the operator has made adequate provisions from the point of view of safety generally, including the following matters specifically, and shall revoke the Permit to Operate if such provisions are not maintained to its satisfaction:*

**.1** *the suitability of the craft for the service intended, having regard to the safety limitations and information contained in the route operational manual;*

**.2** *the suitability of the operating conditions in the route operational manual;*

**.3** *the arrangements for obtaining weather information on the basis of which the commencement of a voyage may be authorized;*

**.4** *provision in the area of operation of a base port fitted with facilities in accordance with 18.1.4;*

**.5** *the designation of the person responsible for decisions to cancel or delay a particular voyage, e.g. in the light of the weather information available;*

**.6** *sufficient crew complement required for operating the craft, deploying and manning survival craft, the supervision of passengers, vehicles and cargo in both normal and emergency conditions as defined in the Permit to Operate. The crew complement shall be such that two officers are on duty in the operating compartment when the craft is under way, one of whom may be the master;*

**.7** *crew qualifications and training, including competence in relation to the particular type of craft and service intended, and their instructions in regard to safe operational procedures;*

**.8** *restrictions with regard to working hours, rostering of crews and any other arrangements to prevent fatigue, including adequate rest periods;*

**.9** *the training of crew in craft operation and emergency procedures;*

**.10** *the maintenance of crew competence in regard to operation and emergency procedures;*

**.11** *safety arrangements at terminals and compliance with any existing safety arrangements, as appropriate;*

**.12** *traffic control arrangements and compliance with any existing traffic control, as appropriate;*

**.13** *restrictions and/or provisions relating to position fixing and to operation by night or in restricted visibility, including the use of radar and/or other electronic aids to navigation, as appropriate;*

**.14** *additional equipment which may be required, due to the specific characteristics of the service intended, for example, night operation;*

**.15** communication arrangements between craft, coast radio stations, base ports radio stations, emergency services and other ships, including radio frequencies to be used and watch to be kept;

**.16** the keeping of records to enable the Administration to verify:

**.16.1** that the craft is operated within the specified parameters;

**.16.2** the observance of emergency and safety drills/procedures;

**.16.3** the hours worked by the operating crew;

**.16.4** the number of passengers on board;

**.16.5** compliance with any law to which the craft is subject;

**.16.6** craft operations; and

**.16.7** maintenance of the craft and its machinery in accordance with approved schedules;

**.17** arrangements to ensure that equipment is maintained in compliance with the Administration's requirements, and to ensure co-ordination of information as to the serviceability of the craft and equipment between the operating and maintenance elements of the operator's organization;

**.18** the existence and use of adequate instructions regarding:

**.18.1** loading of the craft so that weight and centre of gravity limitations can be effectively observed and cargo is, when necessary, adequately secured;

**.18.2** the provision of adequate fuel reserves;

**.18.3** action in the event of reasonable foreseeable emergencies; and

**.19** provision of contingency plans by operators for foreseeable incidents including all land-based activities for each scenario. The plans shall provide operating crews with information regarding search and rescue (SAR) authorities and local administrations and organizations which may complement the tasks undertaken by crews with the equipment available to them.

*Note: Refer to the IMO Search and Rescue Manual (IMOSAR), adopted by the Organization by resolution A.439(XI), and Use of Radar Transponders for Search and Rescue Purposes, adopted by resolution A.530(13).*

**18.1.4** The Administration shall determine the maximum allowable distance from a base port or place of refuge after assessing the provisions made under 18.1.3.

**18.1.5** The master shall ensure that an effective system of supervision and reporting of the closing and opening of accesses referred to in 2.2.4.2 and 2.2.4.3 is implemented.

## **18.2 Craft documentation**

The company shall ensure that the craft is provided with adequate information and guidance in the form of technical manual(s) to enable the craft to be operated and maintained safely. The technical manual(s) shall consist of a route operational manual, craft operating manual, training manual, maintenance manual and servicing schedule. Arrangements shall be made for such information to be updated as necessary.

### **18.2.1 Craft operating manual**

The craft operating manual shall contain at least the following information:

**.1** leading particulars of the craft;

**.2** description of the craft and its equipment;

**.3** procedures for checking the integrity of buoyancy compartments;

**.4** details arising from compliance with the requirements of Section 2 likely to be of direct practical use to the crew in an emergency;

**.5** damage control procedures (e.g. information in a damage control plan required by SOLAS regulation II-1/23 or II-1/25-8.2, as appropriate);

**.6** description and operation of machinery systems;

**.7** description and operation of auxiliary systems;

**.8** description and operation of remote control and warning systems;

**.9** description and operation of electrical equipment;

**.10** loading procedures and limitations, including maximum operational weight, centre of gravity position and distribution of load, including any cargo or car securing arrangement and procedures depending on operational restrictions or damaged conditions. Such arrangement and procedures shall not be included as a separate Cargo Securing Manual as required by Chapter VI of the Convention;

**.11** description and operation of fire-detection and fire-extinguishing equipment;

**.12** drawings indicating the structural fire protection arrangements;

**.13** description and operation of radio equipment and navigational aids;

**.14** information regarding the handling of the craft as determined in accordance with Section 17;

**.15** maximum permissible towing speeds and towing loads, where applicable;

**.16** procedure for dry-docking or lifting, including limitations;

**.17** in particular, the manual shall provide information, in clearly defined sections relating to:

**.17.1** indication of emergency situations or malfunctions jeopardizing safety, required actions to be taken and any consequential restrictions on operation of the craft or its machinery;

**.17.2** evacuation procedures;

**.17.3** the worst intended conditions;

**.17.4** limiting values of all machinery parameters requiring compliance for safe operation.

In regard to information on machinery or system failures, data shall take into account the results of any FMEA reports developed during the craft design.

#### **18.2.2 Route operational manual**

The route operational manual shall include at least the following information:

**.1** evacuation procedures;

**.2** operating limitations, including the worst intended conditions;

**.3** procedures for operation of the craft within the limitations of .2;

**.4** the elements of applicable contingency plans for primary and secondary rescue assistance in the case of foreseeable incidents, including land-based arrangements and activities for each incident;

**.5** arrangements for obtaining weather information;

**.6** identification of the "base port(s)";

**.7** identification of the person responsible for decisions to cancel or delay voyages;

**.8** identification of crew complement, functions and qualifications;

**.9** restrictions on working hours of crew;

**.10** safety arrangements at terminals;

**.11** traffic control arrangements and limitations, as appropriate;

**.12** specific route conditions or requirements relating to position fixing, operations by night and in restricted visibility, including the use of radar or other electronic aids to navigation; and

**.13** communication arrangements between craft, coast radio stations, base ports radio stations, emergency services and other ships, including radio frequencies to be used and watch to be kept.

**C18.2.2** 18.2.2.2 is to be in accordance with assumptions made for the purpose of classification.

#### **18.2.3 Training manual**

The training manual, which may comprise several volumes, shall contain instructions and information, in easily understood terms, illustrated wherever possible, on evacuation, fire and damage control appliances and systems and on the best methods of survival. Any part of such information may be provided in the form of audio-visual aids in lieu of the manual. Where appropriate, the contents of the training manual may be included in the craft operating manual. The following shall be explained in detail:

**.1** donning lifejackets and immersion suits, as appropriate;

**.2** muster at the assigned stations;

**.3** boarding, launching and clearing the survival craft and rescue boats;

**.4** method of launching from within the survival craft;

**.5** release from launching appliances;

**.6** methods and use of devices for protection in launching areas, where appropriate;

**.7** illumination in launching areas;

**.8** use of all survival equipment;

**.9** use of all detection equipment;

**.10** with the assistance of illustrations, the use of radio life-saving appliances;

**.11** use of drogues;

**.12** use of engine and accessories;

**.13** recovery of survival craft and rescue boats, including stowage and securing;

**.14** hazards of exposure and the need for warm clothing;



**.15** *best use of the survival craft facilities in order to survive;*

**.16** *methods of retrieval, including the use of helicopter rescue gear (slings, baskets, stretchers), breeches-buoy and shore life-saving apparatus and craft's line-throwing apparatus;*

**.17** *all other functions contained in the muster list and emergency instructions;*

**.18** *instructions for emergency repair of the life-saving appliances;*

**.19** *instructions in the use of fire protection and fire-extinguishing appliances and systems;*

**.20** *guidelines for use of firefighter's outfit in a fire, if fitted;*

**.21** *use of alarms and communications associated with fire safety;*

**.22** *methods for surveying damage;*

**.23** *use of damage control appliances and systems, including operation of watertight doors and bilge pumps; and*

**.24** *for passenger craft, control of and communication with passengers in an emergency.*

#### **18.2.4 Maintenance and servicing manual/system**

*The craft maintenance and servicing manual/system shall contain as a minimum:*

**.1** *detailed, illustrated description of all craft structure, machinery installations and all installed equipment and systems required for safe operation of the craft;*

**.2** *specifications and quantities of all replenishable fluids and of structural materials which may be required for repairs;*

**.3** *operational limitations of machinery in terms of values of parameters, vibration and consumption of replenished fluids;*

**.4** *limitations of wear of structure of machinery components, including lives of components requiring calendar or operating time replacement;*

**.5** *detailed description of procedures, including any safety precautions to be taken or special equipment required, to remove and install main and auxiliary machinery, transmissions, propulsion and lift devices and flexible structure components;*

**.6** *test procedures to be followed subsequent to replacement of machinery or system components or for malfunction diagnosis;*

**.7** *procedure for lifting or dry-docking the craft, including any weight or attitude limitations;*

**.8** *procedure for weighing the craft and establishing the position of longitudinal centre of gravity (LCG);*

**.9** *where craft may be dismantled for transportation, instructions shall be provided for dismantling, transport and re-assembly;*

**.10** *a servicing schedule, included in the maintenance manual or published separately, detailing the routine servicing and maintenance operations required to maintain the operational safety of the craft and its machinery and systems.*

**C18.2.4** The Society's survey requirements cannot be considered as a substitute to definition and acceptance of repair and maintenance which remains the responsibility of the Owner.

#### **18.2.5 Information on passengers**

**18.2.5.1** *All persons on board passenger craft shall be counted prior to departure.*

**18.2.5.2** *Details of persons who have declared a need for special care or assistance in emergency situations shall be recorded and communicated to the master prior to departure.*

**18.2.5.3** *The names and gender of all persons on board, distinguished between adults, children and infants shall be recorded for search and rescue purposes.*

**18.2.5.4** *The information required by 18.2.5.1, 18.2.5.2 and 18.2.5.3 shall be kept ashore and made readily available to search and rescue services when needed.*

**18.2.5.5** *The Administration may exempt from the requirements of 18.2.5.3 passenger craft operating on voyages having a duration of 2 h or less between each port of call.*

#### **18.3 Training and qualifications**

**18.3.1** *The level of competence and the training considered necessary in respect of the master and each crew member shall be laid down and demonstrated in the light of the following guidelines to the satisfaction of the company in respect of the particular type and model of craft concerned and the service intended. More than one crew member shall be trained to perform all essential operational tasks in both normal and emergency situations.*

**18.3.2** The Administration shall specify an appropriate period of operational training for the master and each member of the crew and, if necessary, the periods at which appropriate retraining shall be carried out.

**18.3.3** The Administration shall issue a type rating certificate to the master and all officers having an operational role following an appropriate period of operational/simulator training and on the conclusion of an examination including practical test commensurate with the operational tasks on board the particular type and model of craft concerned and the route followed. The type rating training shall cover at least the following items:

- .1** knowledge of all on-board propulsion and control systems, including communication and navigational equipment, steering, electrical, hydraulic and pneumatic systems and bilge and fire pumping;
- .2** the failure mode of the control, steering and propulsion systems and proper response to such failures;
- .3** handling characteristics of the craft and the limiting operational conditions;
- .4** bridge communication and navigation procedures;
- .5** intact and damage stability and survivability of the craft in damage condition;
- .6** location and use of the craft's life-saving appliances, including survival craft equipment;
- .7** location and use of escapes in the craft and the evacuation of passengers;
- .8** location and use of fire protection and fire-extinguishing appliances and systems in the event of fire on board;
- .9** location and use of damage control appliances and systems, including operation of watertight doors and bilge pumps;
- .10** cargo and vehicle stowage and securing systems;
- .11** methods for control of and communication with passengers in an emergency; and
- .12** location and use of all other items listed in the training manual.

**18.3.4** The type rating certificate for a particular type and model of craft should only be valid for service on the route to be followed when it is so endorsed by the Administration following the completion of a practical test over that route.

**18.3.5** The type rating certificate shall be re-validated every two years and the Administration shall lay down the procedures for re-validation.

**18.3.6** All crew members shall receive instructions and training, as specified in 18.3.3.6 to 18.3.3.12.

**18.3.7** The Administration shall specify standards of physical fitness and frequency of medical examinations, having regard to the route and craft concerned.

**18.3.8** The Administration of the country in which the craft is to operate, if other than the flag State, shall be satisfied with the training, experience and qualifications of the master and each crew member. A valid certificate of competency or a valid license appropriately endorsed, in accordance with the provisions of the International Convention on Standards of Training, Certification and Watchkeeping (STCW), 1978 as amended, held by the master or crew member, shall be acceptable as evidence of satisfactory training and qualification to the Administration of the country in which the craft is to operate.

## **18.4 Manning of survival craft and supervision**

The company and the master shall ensure that:

- .1** a sufficient number of trained persons are on board for mustering and assisting untrained persons;
- .2** a sufficient number of crew members, who may be deck officers or certificated persons, are on board for operating the survival craft, rescue boats and launching arrangements required for abandonment by the total number of persons on board;
- .3** a deck officer or certificated person is placed in charge of each survival craft to be used recognizing, however, that the Administration, having due regard to the nature of the voyage, the number of persons on board and the characteristics of the craft, may permit a deck officer, certificated person or persons practised in the handling and operation of liferafts to be placed in charge of each liferaft or group of liferafts;
- .4** the person in charge of survival craft has a list of the survival craft crew and sees that those crew members are acquainted with their duties;
- .5** every rescue boat and lifeboat has a person assigned who is capable of operating the engine and carrying out minor adjustments; and
- .6** the persons referred to in .1 to .3 are equitably distributed among the craft's survival craft.

**18.5 Emergency instructions and drills**

**18.5.1** The company shall ensure that the emergency instructions and drills referred to in 18.5.1 to 18.5.10 are implemented, and the master shall be responsible for the enforcement of these instructions and drills on board. On or before departure, passengers shall be instructed in the use of lifejackets and the action to be taken in an emergency. The attention of the passengers shall be drawn to the emergency instructions required by 8.4.1 and 8.4.3.

**18.5.2** Emergency fire and evacuation drills for the crew shall be held on board the craft at intervals not exceeding one week for passenger craft and one month for cargo craft.

**18.5.3** Each member of each crew shall participate in at least one evacuation, fire and damage control drill per month.

**18.5.4** On-board drills shall, as far as practicable, be conducted to simulate an actual emergency. Such simulations shall include instruction and operation of the craft's evacuation, fire and damage control appliances and systems.

**18.5.5** On-board instruction and operation of the craft's evacuation, fire and damage control appliances and systems shall include appropriate cross-training of crew members.

**18.5.6** Emergency instructions including a general diagram of the craft showing the location of all exits, routes of evacuation, assigned assembly stations, emergency equipment, life-saving equipment and appliances and illustration of lifejacket donning shall be available to each passenger and crew member in appropriate languages. It shall be placed near each passenger and crew seat and conspicuously displayed at assembly stations and other passenger spaces.

**18.5.7 Records**

**18.5.7.1** The date when musters are held, details of abandon craft drills and fire drills, drills of other life-saving appliances and on-board training shall be recorded in such log-book as may be prescribed by the Administration. If a full muster, drill or training session is not held at the appointed time, an entry shall be made in the log-book stating the circumstances and the extent of the muster, drill or training session held. A copy of such information shall be forwarded to the operator's management.

**18.5.7.2** The master shall ensure, before the craft leaves the berth on any voyage, that a record is made of the time of the last closing of the accesses referred to 2.2.4.2 and 2.2.4.3.

**18.5.8 Evacuation drills**

**18.5.8.1** Evacuation drill scenarios shall vary each week so that different emergency conditions are simulated.

**18.5.8.2** Each evacuation craft drill shall include:

**.1** summoning of crew to assembly stations with the alarm required by 8.2.2.2 and ensuring that they are made aware of the order to abandon craft specified in the muster list;

**.2** reporting to stations and preparing for the duties described in the muster list;

**.3** checking that crew are suitably dressed;

**.4** checking that lifejackets are correctly donned;

**.5** operation of davits if any used for launching liferafts;

**.6** donning of immersion suits or thermal protective clothing by appropriate crew members;

**.7** testing of emergency lighting for mustering and abandonment; and

**.8** giving instructions in the use of the craft's life-saving appliances and in survival at sea.

**18.5.8.3 Rescue boat drill**

**.1** As far as is reasonable and practicable, rescue boats shall be launched each month as part of the evacuation drill, with their assigned crew aboard, and manoeuvred in the water, in all cases this requirement shall be complied with at least once every three months.

**.2** If rescue boat launching drills are carried out with the craft making headway, such drills shall, because of the dangers involved, be practised in sheltered waters only and under the supervision of an officer experienced in such drills.

*Note: Refer to the Guidelines on training for the purpose of launching lifeboats and rescue boats from ships making headway through the water, adopted by the Organization by resolution A.624(15).*

**18.5.8.4** Individual instructions may cover different parts of the craft's life-saving system, but all the craft's life-saving equipment and appliances shall be covered within any period of one month on passenger craft and two months on cargo craft. Each member of the crew shall be given instructions which shall include but not necessarily be limited to:

**.1** operation and use of the craft's inflatable liferafts;

**.2** problems of hypothermia, first-aid treatment of hypothermia and other appropriate first-aid procedures; and

**.3** special instructions necessary for use of the craft's life-saving appliances in severe weather and severe sea conditions.

**18.5.8.5** On-board training in the use of davit-launched liferafts shall take place at intervals of not more than four months on every craft fitted with such appliances. Whenever practicable, this shall include the inflation and lowering of a liferaft. This liferaft may be a special liferaft intended for training purposes only, which is not part of the craft's life-saving equipment. Such a special liferaft shall be conspicuously marked.

#### **18.5.9 Fire drills**

**18.5.9.1** Fire drill scenarios shall vary each week so that emergency conditions are simulated for different craft compartments.

**18.5.9.2** Each fire drill shall include:

- .1** summoning of crew to fire stations;
- .2** reporting to stations and preparing for the duties described in the muster list;
- .3** donning of firefighter's outfits;
- .4** operation of fire doors and fire dampers;

**.5** operation of fire pumps and fire-fighting equipment;

**.6** operation of communication equipment, emergency signals and general alarm;

**.7** operation of fire-detection system; and

**.8** instruction in the use of the craft's fire-fighting equipment and sprinkler, and drencher systems, if fitted.

#### **18.5.10 Damage control drills**

**18.5.10.1** Damage control drill scenarios shall vary each week so that emergency conditions are simulated for different damage conditions.

**18.5.10.2** Each damage control drill shall include:

- .1** summoning of crew to damage control stations;
- .2** reporting to stations and preparing for the duties described in the muster list;
- .3** operation of watertight doors and other watertight closures;
- .4** operation of bilge pumps and testing of bilge alarms and automatic bilge pump starting systems; and
- .5** instruction in damage survey, use of the craft damage control systems and passenger control in the event of an emergency.

### **Part B Requirements for passenger craft**

#### **18.6 Type rating training**

**18.6.1** The company shall ensure that the type rating training is implemented. For all crew members, the type rating training shall cover the control and evacuation of passengers additionally to 18.3.5.

**18.6.2** When a craft carries cargoes, the craft shall comply with the requirements of part C of this Section in addition to this part.

#### **18.7 Emergency instructions and drills**

**18.7.1** The company shall ensure that the emergency instructions are implemented, and the master shall be responsible for communicating the provisions of the emergency instructions to passenger upon boarding.

**Part C** *Requirements for cargo craft***18.8** *Type rating training*

*The company shall ensure that type rating training is implemented as provided in 18.3. For all crew members, the type rating training shall cover knowledge of cargo and vehicles storage area securement systems.*

**SECTION 19****INSPECTION AND MAINTENANCE REQUIREMENTS**

**19.1** *The Administration shall be satisfied with the operator's organization or any organization on which he may call in the maintenance of his craft and shall specify the scope of the duties which any part of the organization may carry out, having regard to the number and competence of its staff, facilities available, arrangements for calling on specialist assistance should it be necessary, record-keeping, communication and allocation of responsibilities.*

**19.2** *The craft and equipment shall be maintained to the satisfaction of the Administration; in particular:*

**.1** *routine preventive inspection and maintenance shall be performed to a schedule approved by the Administration, which shall have regard at least in the first instance to the manufacturer's schedule;*

**.2** *in the performance of maintenance tasks, due regard shall be paid to maintenance manuals, service bulletins acceptable to the Administration and to any additional instructions of the Administration in this respect;*

**.3** *all modifications shall be recorded and their safety aspects investigated. Where it could have any effect on safety, the modification, together with its installation, shall be to the satisfaction of the Administration;*

**.4** *appropriate arrangements shall be provided for informing the master of the serviceability state of his craft and its equipment;*

**.5** *the duties of the operating crew in respect of maintenance and repairs and the procedure for obtaining assistance with repairs when the craft is away from the base port shall be clearly defined;*

**.6** *the master shall report to the maintenance organization any defects and repairs which are known to have occurred during operations;*

**.7** *records of defects and their correction shall be maintained and those defects of recurrent nature, or those which adversely affect craft or personal safety, shall be reported to the Administration.*

**C19.2** *It is the Owner's responsibility to apply to the Society concerning any modification, damage or repair affecting the class of the ship.*

**19.3** *The Administration shall be satisfied that arrangements are provided for ensuring adequate inspection, maintenance and recording of all life-saving appliances and distress signals carried.*

## ANNEX 1

# FORM OF HIGH-SPEED CRAFT SAFETY CERTIFICATE AND RECORD OF EQUIPMENT

## HIGH - SPEED CRAFT SAFETY CERTIFICATE

*This Certificate shall be supplemented by a Record of Equipment*

(Official seal)

(State)

*Issued under the provisions of the*  
**INTERNATIONAL CODE OF SAFETY FOR HIGH-SPEED CRAFT, 2000**  
*(resolution MSC.97(73))*

*under the authority of the Government of*

.....

*(full designation of the State)*

by .....

*(full official designation of the competent person or  
organization authorized by the Administration)*

### Particulars of craft <sup>1</sup>

Name of craft .....

Manufacturer's model and hull number .....

Distinctive number of letters .....

IMO number <sup>2</sup> .....

Port of registry.....

Gross tonnage.....

Sea areas in which the craft is certified to operate (paragraph 14.2.1) .....

Design waterline corresponding to a height of ..... below the reference line at the longitudinal centre of flotation, and  
 draughts at the draught marks of ..... forward and ..... aft.

1. Alternatively, the particulars of the craft may be placed horizontally in boxes.

2. In accordance with the IMO ship identification number scheme, adopted by the Organization by resolution A.600(15).

The upper edge of the reference line is ..... at  
 (..... mm below uppermost deck at side) <sup>1</sup>  
 (..... mm above the underside of keel) <sup>1</sup> at longitudinal centre of flotation.

Category ..... category A passenger craft / category B passenger craft / cargo craft<sup>1</sup>

Craft type ..... air-cushion vehicle/surface- effect ship/hydrofoil/monohull/multihull/ other  
 (give detail ..... )<sup>1</sup>

Date on which keel was laid or craft was at  
 a similar stage of construction or on which  
 a major conversion was commenced .....

#### THIS IS TO CERTIFY

- 1 That the above-mentioned craft has been duly surveyed in accordance with the applicable provisions of the International Code of Safety for High Speed Craft, 2000.
- 2 That the survey showed that the structure, equipment, fittings, radio station arrangements and materials of the craft and the condition thereof are in all respects satisfactory and that the craft complies with the relevant provisions of the Code.
- 3 That the life-saving appliances are provided for a total number of persons and no more as follows:  
 .....  
 .....
- 4 That, in accordance with 1.11 of the Code, the following equivalents have been granted in respect of the craft:  
 paragraph ..... equivalent arrangement .....  
 ..... .....

This certificate is valid until<sup>2</sup> .....

Issued at .....

(Place of issue of the certificate)

.....

(Date of issue)

.....

(Signature of authorized official issuing the certificate)

.....

(Seal or stamp of the issuing authority, as appropriate)

1. Delete as appropriate.

2. Insert the date of expiry as specified by the Administration in accordance with 1.8.4 of the Code. The day and the month of this date correspond to the anniversary date as defined in 1.4.3 of the Code, unless amended in accordance with 1.8.12.1 of the Code.



Endorsement for periodical surveys

This is to certify that, at a survey required by 1.5 of the Code, this craft was found to comply with the relevant provisions of the Code.

Periodical survey: Signed: .....  
.....  
(Signature of authorized official)  
Place: .....  
Date: .....  
.....  
(Seal or stamp of Authority, as appropriate)

Periodical survey: Signed: .....  
.....  
(Signature of authorized official)  
Place: .....  
Date: .....  
.....  
(Seal or stamp of Authority, as appropriate)

Periodical survey: Signed: .....  
.....  
(Signature of authorized official)  
Place: .....  
Date: .....  
.....  
(Seal or stamp of Authority, as appropriate)

Periodical survey: Signed: .....  
.....  
(Signature of authorized official)  
Place: .....  
Date: .....  
.....  
(Seal or stamp of Authority, as appropriate)

**Endorsement to extend the Certificate if valid for less than 5 years where 1.8.8 of the Code applies**

*This craft complies with the relevant requirements of the Code, and this Certificate shall, in accordance with 1.8.8 of the Code, be accepted as valid until .....*

*Signed: .....*

*(Signature of authorized official)*

*Place: .....*

*Date: .....*

*.....*  
*(Seal or stamp of Authority, as appropriate)*

**Endorsement where the renewal survey has been completed and 1.8.9 of the Code applies**

*This craft complies with the relevant requirements of the Code, and this Certificate shall, in accordance with 1.8.9 of the Code, be accepted as valid until .....*

*Signed: .....*

*(Signature of authorized official)*

*Place: .....*

*Date: .....*

*.....*  
*(Seal or stamp of Authority, as appropriate)*

**Endorsement to extend the validity of the Certificate until reaching the port of survey where 1.8.10 of the Code applies**

*This Certificate shall, in accordance with 1.8.10 of the Code, be accepted as valid until .....*

*Signed: .....*

*(Signature of authorized official)*

*Place: .....*

*Date: .....*

*.....*  
*(Seal or stamp of Authority, as appropriate)*

**Endorsement for the advancement of the anniversary date where 1.8.12 of the Code applies**

*In accordance with 1.8.12 of the Code, the new anniversary date is*

*Signed:.....*  
*(Signature of authorized official)*  
*Place:.....*  
*Date: .....*  
  
*.....*  
*(Seal or stamp of Authority, as appropriate)*

*In accordance with 1.8.13 of the Code, the new anniversary date is .....*

*Signed:.....*  
*(Signature of authorized official)*  
*Place:.....*  
*Date: .....*  
  
*.....*  
*(Seal or stamp of Authority, as appropriate)*

**RECORD OF EQUIPMENT FOR  
HIGH-SPEED CRAFT SAFETY CERTIFICATE**

*This Record shall be permanently attached to the  
High-Speed Craft Safety Certificate*

**RECORD OF EQUIPMENT FOR COMPLIANCE WITH THE  
INTERNATIONAL CODE OF SAFETY  
FOR HIGH-SPEED CRAFT, 2000**

**1 Particulars of craft**

Name of craft .....

Manufacturer's model and hull number .....

Distinctive number of letters .....

IMO Number<sup>1</sup> .....

Category: category A passenger craft / category B passenger craft / cargo craft<sup>2</sup>

Craft type: air-cushion vehicle / surface effect ship / hydrofoil / monohull / multihull / other  
(give detail.....)<sup>2</sup>

Number of passengers for which certified .....

Minimum number of persons with the required qualifications to operate the radio installations .....

---

1. In accordance with the IMO ship identification number scheme adopted by the Organization by resolution A.600(15)  
2. Delete as appropriate.

**2 Details of life-saving appliances**

1	Total number of persons for which life-saving appliances are provided	
2	Total number of lifeboats	
2.1	Total number of persons accommodated by them	
2.2	Number of partially enclosed lifeboats complying with section 4.5 of the LSA Code	
2.3	Number of totally enclosed lifeboats complying with sections 4.6 and 4.7 of the LSA Code	
2.4	Other lifeboats	
2.4.1	Number	
2.4.2	Type	
3	Number of rescue boats	
3.1	Number of rescue boats which are included in the total lifeboats shown above	
4	Liferafts complying with sections 4.1 to 4.3 of the LSA Code for which suitable means of launching are provided	
4.1	Number of liferafts	
4.2	Number of persons accommodated by them	
5	Open reversible liferafts (Annex 11 of the Code)	
5.1	Number of liferafts	
5.2	Number of persons accommodated by them	
6	Number of Marine Evacuation System (MES)	
6.1	Number of persons served by them	
7	Number of lifebuoys	
8	Number of lifejackets	
8.1	Number suitable for adults	
8.2	Number suitable for children	
9	Immersion suits	
9.1	Total number	
9.2	Number of suits complying with the requirements for lifejackets	
10	Number of anti-exposure suits	
10.1	Total number	
10.2	Number of suits complying with the requirements for lifejackets	
11	Radio installations used in life-saving appliances	
11.1	Number of radar transponders	
11.2	Number of two-way VHF radiotelephone apparatus	

**3 Details of navigational systems and equipment**

1.1	Magnetic compass	
1.2	Transmitting heading device (THD)	
1.3	Gyro-compass	
2	Speed and distance measuring device	
3	Echo-sounding device	
4.1	9 GHz radar	
4.2	Second radar (3 GHz/9 GHz <sup>1</sup> )	
4.3	Automatic radar plotting aid (ARPA)/ Automatic tracking aid (ATA) <sup>1</sup>	
5	Receiver for global navigation satellite system/ Terrestrial navigation system/ Other means of position fixing 1, 2	
6.1	Rate of turn indicator	
6.2	Rudder angle indicator/Direction of steering thrust indicator <sup>1</sup>	
7.1	Nautical charts/Electronic Chart Display and Information System (ECDIS) <sup>1</sup>	
7.2	Back-up arrangements for ECDIS	
7.3	Nautical publications	
7.4	Back-up arrangement for nautical publications	
8	Search light	
9	Daylight signalling lamp	
10	Night vision equipment	
11	Means to show the mode of the propulsion systems	
12	Automatic steering aid (Automatic pilot)	
13	Radar reflector/ Other means <sup>1,2</sup>	
14	Sound reception system	
15	Automatic identification system (AIS)	
16	Voyage data recorder (VDR)	

**4 Details of radio facilities**

Item	Actual provision
1 Primary systems	
1.1 VHF radio installation:	
1.1.1 DSC encoder	
1.1.2 DSC watch receiver	
1.1.3 Radiotelephony	
1.2 MF radio installation:	
1.2.1 DSC encoder	
1.2.2 DSC watch receiver	
1.2.3 Radiotelephony	
1.3 MF/HF radio installation:	
1.3.1 DSC encoder	
1.3.2 DSC watch receiver	
1.3.3 Radiotelephony	
1.3.4 Direct-printing radiotelegraphy	
1.4 INMARSAT ship earth station	
2 Secondary means of alerting	
3 Facilities for reception of maritime safety information	
3.1 NAVTEX receiver	
3.2 EGC receiver	
3.3 HF direct-printing radiotelegraph receiver	
4 Satellite EPIRB	
4.1 COSPAS-SARSAT	
4.2 INMARSAT	
5 VHF EPIRB	
6 Ship's radar transponder	

**5 Methods used to ensure availability or radio facilities**  
(paragraphs 14.15.6, 14.15.7 and 14.15.8 of the Code)

5.1 Duplication of equipment .....

5.2 Shore-based maintenance .....

5.3 At-sea maintenance capability .....

**THIS IS TO CERTIFY** that this Record is correct in all respects

Issued at .....  
(Place of issue of Record)

.....  
(Date of issue)

.....  
(Signature of duly authorized official  
issuing the record)

.....  
(Seal or stamp of the issuing authority, as appropriate)



**ANNEX 2****FORM OF PERMIT TO OPERATE HIGH-SPEED CRAFT*****PERMIT TO OPERATE HIGH-SPEED CRAFT****Issued under the provision of the****INTERNATIONAL CODE OF SAFETY FOR HIGH-SPEED CRAFT, 2000****(resolution MSC.97(73))*

- 1 Name of craft.....
- 2 Manufacturer's model and hull number .....
- 3 Distinctive number of letters .....
- 4 IMO number<sup>1</sup> .....
- 5 Port of registry .....
- 6 Category of craft category A passenger craft / category B passenger  
craft / cargo craft<sup>2</sup>
- 7 Name of operator .....
- 8 Areas or routes of operation.....  
.....  
.....
- 9 Base port(s) .....
- 10 Maximum distance from place of refuge.....  
.....
- 11 Number of:
- .1 passengers maximum permitted .....
- .2 manning scale required.....

1. In accordance with the IMO ship identification number scheme, adopted by the Organization by resolution A.600(15).

2. Delete as appropriate.

12 Worst intended conditions .....

.....

.....

13 Other operational restrictions.....

*This permit confirms that the service mentioned above has been found to be in accordance with the general requirements of 1.2.2 to 1.2.7 of the Code.*

*THIS PERMIT is issued under the authority of the Government of .....*

.....

*THIS PERMIT is valid until .....  
subject to the High-Speed Craft Safety Certificate remaining valid*

*Issued at .....*

*(Place of issue of permit)*

.....

*(Date of issue)*

.....

*(Signature of duly authorized official  
issuing the permit)*

.....

*(Seal or stamp of the Issuing authority, as appropriate)*

## ANNEX 3

## USE OF PROBABILITY CONCEPT

**1 General**

**1.1** Absolute safety cannot be achieved in any human activity. Naturally, this fact shall be taken into account in developing safety requirements, which means that requirements shall 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 shall 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 shall 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 in which a part, or parts, of the craft fail or malfunction, e.g. runaway. A failure includes:

- .1** a single failure;

**.2** independent failures in combination within a system;

**.3** independent failures in combinations involving more than one system, taking into account:

- .3.1** any undetected failure that is already present;
- .3.2** such further failures (see note) as would be reasonably expected to follow the failure under consideration; and

**.4** common cause failure (failure of more than one component or system due to the same cause).

*Note: In assessing the further failures which follow, account shall be taken of any resulting more severe operating conditions for items that have not up to that time failed.*

**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 shall be considered as being possible.

**2.2.6** "Extremely improbable" is one which is so extremely remote that it shall 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 2.1.2, 2.1.3, 2.1.4, which can be readily compensated for by the operating crew. It may involve:

**.1** a small increase in the operational duties of the crew or in their difficulty in performing their duties; or

**.2** a moderate degradation in handling characteristics; or

**.3** slight modification of the permissible operating conditions.

**2.3.3** "Major effect" is an effect which produces:

**.1** a significant increase in the operational duties of the crew or in their difficulty in performing their duties which by itself shall not be outside the capability of a competent crew provided that another major effect does not occur at the same time; or

**.2** significant degradation in handling characteristics; or

**.3** 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:

**.1** 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

**.2** dangerous degradation of handling characteristics; or

**.3** dangerous degradation of the strength of the craft; or

**.4** marginal conditions for, or injury to, occupants; or

**.5** 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 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 shall be as defined in Table 1.

**Table 1**

Effect	Criteria not to be exceeded		Comments
	Type of load	Value	
LEVEL 1 MINOR EFFECT Moderate degradation of safety	Maximum acceleration measured horizontally <b>(1)</b>	0.20 g	0.08 g : Elderly person will keep balance when holding 0.15 g : Mean person will keep balance when holding 0.15 g : Sitting person will start holding
LEVEL 2 MAJOR EFFECT Significant degradation of safety	Maximum acceleration measured horizontally <b>(1)</b>	0.35 g	0.25 g : Maximum load for mean person keeping balance when holding 0.45 g : Mean person falls out of 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	Ref. 4.3.3 Ref. 4.3.1	Risk of injury to passengers; safe emergency operation after collision 1.0 g : Degradation of passenger safety
LEVEL 4 CATASTROPHIC EFFECT			Loss of craft or/and fatalities
<b>(1)</b> The accelerometers used shall have an accuracy of at least 5% full scale and shall not have a frequency response of less than 20Hz. The sampling frequency should not be less than 5 times the maximum frequency response. Anti-aliasing filters, if used, should have a passband equal to the frequency response. g : gravity acceleration (9.81 m/s <sup>2</sup> ).			

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 shall be on an hourly or per-journey basis, depending on which is more appropriate to the assessment in question.

Table 2

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 shall be substantially less than $10^{-9}$
Note: Different occurrences may have different acceptable probabilities, according to the severity of their consequences (see Table 3).	

Table 3

Safety Level	1	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 workload or environmental conditions; serious injury to a small number of occupants.	Deaths, usually with loss of craft.	
F.A.R. <sup>1</sup> Probability (reference only)	↓	↓ Probable	↓	↓	↓ Improbable	↓	↓ Extremely Improbable
JAR-25 <sup>2</sup> Probability	↓	↓ Probable	↓	↓	↓ Improbable	↓	↓ Extremely Improbable
	↓ Frequent	↓ Reasonably Probable	↓ Remote	↓ Extremely Remote			
	10 <sup>-0</sup>	10 <sup>-1</sup>	10 <sup>-2</sup>	10 <sup>-3</sup>	10 <sup>-4</sup>	10 <sup>-5</sup>	10 <sup>-6</sup>
Category of Effect	↓	↓ Minor	↓	↓ Major	↓ Hazardous	↓ Catastrophic	
(1) United States Federal Aviation Regulations (2) European Joint Airworthiness Regulations							

## ANNEX 4

## PROCEDURES FOR FAILURE MODE AND EFFECTS ANALYSIS

**C0 Document to be submitted**

FMEA report, including FMEA worksheets.

**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 shall 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:*

- .1** *explaining basic principles;*
- .2** *providing the procedural steps necessary to perform an analysis;*
- .3** *identifying appropriate terms, assumptions, measures and failure modes; and*
- .4** *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 shall 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 shall be drawn 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:*

- .1** *provide the Administration with the results of a study into the craft's failure characteristics so as to assist in an assessment of the levels of safety proposed for the craft's operation;*
- .2** *provide craft operators with data to generate comprehensive training, operational and maintenance programmes and documentation; and*
- .3** *provide craft and system designers with data to audit their proposed designs.*

**3 Scope of application**

**3.1** *FMEA shall be conducted for each high-speed craft, before its entry into service, in respect of the systems as required under the provisions of 5.2, 9.1.10, 12.1.1 and 16.2.6 of this Code.*

**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 shall be subject to the same FMEA conclusion trials.*

## 4 System failure mode and effects 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 shall be considered:

- .1** normal seagoing conditions at full speed;
- .2** maximum permitted operating speed in congested waters; and
- .3** manoeuvring alongside.

**4.3** The functional interdependence of these systems shall 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:

- .1** complete loss of function;
- .2** rapid change to maximum or minimum output;
- .3** uncontrolled or varying output;
- .4** premature operation;
- .5** failure to operate at a prescribed time; and
- .6** 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 shall be followed. Results of the system functional failure analysis shall 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:

**.1** 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;

**.2** 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

**.3** the redundant system may share the same power source as the system. In such case an alternative power source shall be readily available with regard to the requirement of .1.

The probability and effects of operator error to bring in the redundant system shall also be considered.

## 5 Equipment failure mode and effects analysis

The systems to be subject to a more detailed FMEA investigation at this stage shall 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

The following steps are necessary to perform FMEA:

- .1** to define the system to be analysed;
- .2** to illustrate the interrelationships of functional elements of the system by means of block diagrams;
- .3** to identify all potential failure modes and their causes;
- .4** to evaluate the effects on the system of each failure mode;
- .5** to identify failure detection methods;
- .6** to identify corrective measures for failure modes;
- .7** to assess the probability of failures causing hazardous or catastrophic effects, where applicable;
- .8** to document the analysis;
- .9** to develop a test programme;
- .10** to prepare FMEA report.



## 7 System definition

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 shall be drawn up including the following information:

- .1 general description of system operation and structure;
- .2 functional relationship among the system elements;
- .3 acceptable functional performance limits of the system and its constituent elements in each of the typical operational modes; and
- .4 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 shall contain:

- .1 breakdown of the system into major sub-systems or equipment;
- .2 all appropriate labelled inputs and outputs and identification numbers by which each sub-system is consistently referenced; and
- .3 all redundancies, alternative signal paths and other engineering features which provide "fail-safe" measures.

An example of a system block diagram is given at Appendix 1.

8.2 It may be necessary to have a different set of block diagrams prepared for each operational mode.

## 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 poten-

tial 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 shall be considered in a top-down approach, starting from the system's functional output, and failure shall 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 shall 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 shall 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 shall 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 shall be evaluated and their severity classified in accordance with the following categories:

- .1 catastrophic;
- .2 hazardous;
- .3 major; and
- .4 minor.

The definitions of these four categories of failure effects are given in 2.3 of annex 3 of this Code.

**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 shall 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 shall 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 a system element or equipment, shall 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 standby items or systems, shall be described. Corrective design provisions include:

- .1** redundancies that allow continued and safe operation;
- .2** safety devices, monitoring or alarm provisions, which permit restricted operation or limit damage; and
- .3** alternative modes of operation.

**12.3** Provisions which require operator action to circumvent or mitigate the effects of the postulated failure shall be described. The possibility and effect of operator

error shall 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 shall 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 shall meet the following criteria of acceptance:

- .1** a failure mode which results in a catastrophic effect shall be assessed to be extremely improbable;
- .2** a failure mode assessed as extremely remote shall not result in worse than hazardous effects; and
- .3** a failure mode assessed as either frequent or reasonably probable shall not result in worse than minor effects.

**13.2** Numerical values for various levels of probabilities are laid down in section 3 of annex 3 of this Code. In areas where there are no data from craft to determine the level of probabilities of failure other sources can be used such as:

- .1** workshop test, or
- .2** history of reliability used in other areas under similar operating conditions, or
- .3** mathematical model if applicable.

## 14 Documentation

**14.1** It is helpful to perform FMEA on worksheet(s) as shown in appendix 2.

**14.2** The worksheet(s) shall 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 shall be drawn up to prove the conclusions of FMEA. It is recommended that the test programme shall include all systems or system elements whose failure would lead to:

- .1 major or more severe effects;
- .2 restricted operations; and
- .3 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 shall also include investigations into:

- .1 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;
- .2 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

.3 the effects of the main failure modes as prescribed in the theoretical analysis.

**15.3** The FMEA tests on board shall be conducted in conjunction with provisions specified in 5.3, 16.4 and 17.4 of this Code, before the craft enters into service.

## 16 FMEA Report

The FMEA report shall 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 shall be included, where appropriate. The report shall contain a summary of conclusions and recommendations for each of the systems analysed in the system failure analysis and the equipment failure analysis. It shall 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 shall 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		

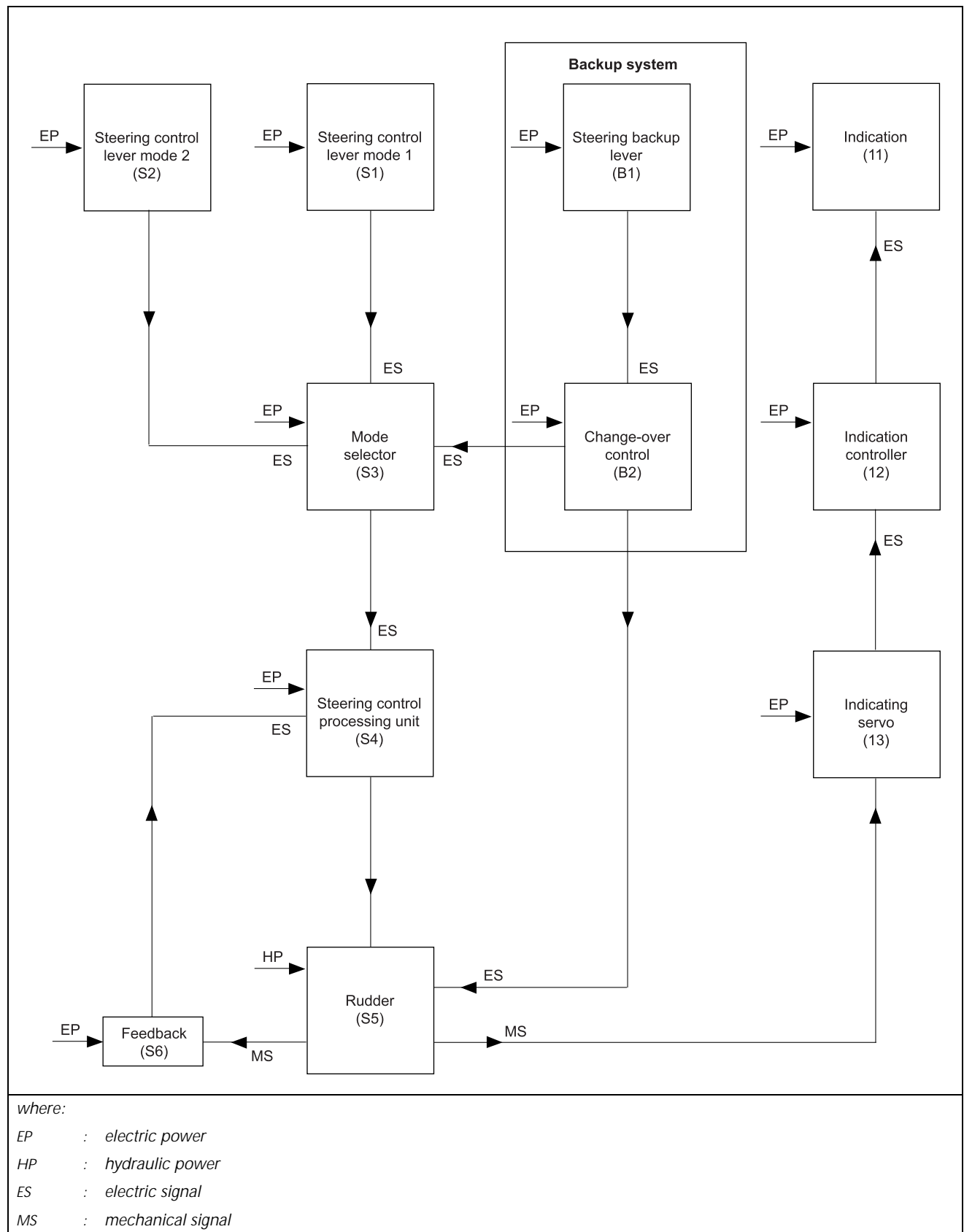
Refer to IEC Publication: IEC 812 (1985), Analysis techniques for system reliability—procedure for failure mode and effects analysis (FMEA).

**Appendix 1 - Example of a system block diagram**

Steering control system

Date: .....

Analyst: .....



Appendix 2 - FMEA worksheet

Name of system .....  
Mode of operation .....  
Sheet No .....  
Date .....  
Name of analyst .....

References .....  
System block diagrams .....  
.....  
Drawings .....

Equipment name or number	Function	Ident. No.	Failure mode	Failure cause	Failure effect		Failure detection	Corrective action	Severity of failure effect	Probability of failure (if applicable)	Remarks
					Local effect	End effect					

**ANNEX 5****ICE ACCRETION APPLICABLE TO ALL TYPES OF CRAFT****1 Icing allowances**

**1.1** For craft operating in areas where ice accretion is likely to occur, the following icing allowance shall be made in the stability calculations.

**.1** 30 kg/m<sup>2</sup> on exposed weather decks and gangways;

**.2** 7.5 kg/m<sup>2</sup> for projected lateral area of each side of the craft above the waterplane;

**.3** the projected lateral area of discontinuous surfaces of rail, sundry booms, spars (except masts) and rigging and the projected lateral area of other small objects shall be computed by increasing the total projected area of continuous surfaces by 5% and the static moments of this area by 10%;

**.4** reduction of stability due to asymmetric ice accumulations in cross-structure.

**1.2** For craft operating in areas where ice accretion may be expected:

**.1** Within the areas defined in 2.1, 2.3, 2.4 and 2.5 known to have icing conditions significantly different from those in 1.1, ice accretion requirements of one half to twice the required allowance may be applied.

**.2** Within the area defined in 2.2, where ice accretion in excess of twice the allowance required by 1.1 may be expected, more severe requirements than those given in 1.1 may be applied.

**1.3** Information shall be provided in respect of the assumptions made in calculating the condition of the craft in each of the circumstances set out in this annex for the following:

**.1** duration of the voyage in terms of the period spent in reaching the destination and returning to port; and

**.2** consumption rates during the voyage for fuel, water, stores and other consumables.

**2 Areas of icing conditions**

In the application of 1, the following icing areas shall apply:

**.1** The area north of latitude 65° 30' N, between longitude 28° W and the west coast of Iceland; north of the north coast of Iceland;

north of the rhumb line running from latitude 66° N, longitude 15° W to latitude 73° 30' N, longitude 15° E, north of latitude 73° 30' N between longitude 15° E and 35° E, and east of longitude 35° E, as well as north of latitude 56° N in the Baltic Sea.

**.2** The area north of latitude 43° N bounded in the west by the North American coast and the east by the rhumb line running from latitude 43° N, longitude 48° W to latitude 63° N, longitude 28° W and thence along longitude 28° W.

**.3** All sea areas north of the North American continent, west of the areas defined in subparagraphs .1 and .2 of this paragraph.

**.4** The Bering and Okhotsk Seas and the Tartary Strait during the icing season.

**.5** South of latitude 60° S.

A chart to illustrate the areas is attached.

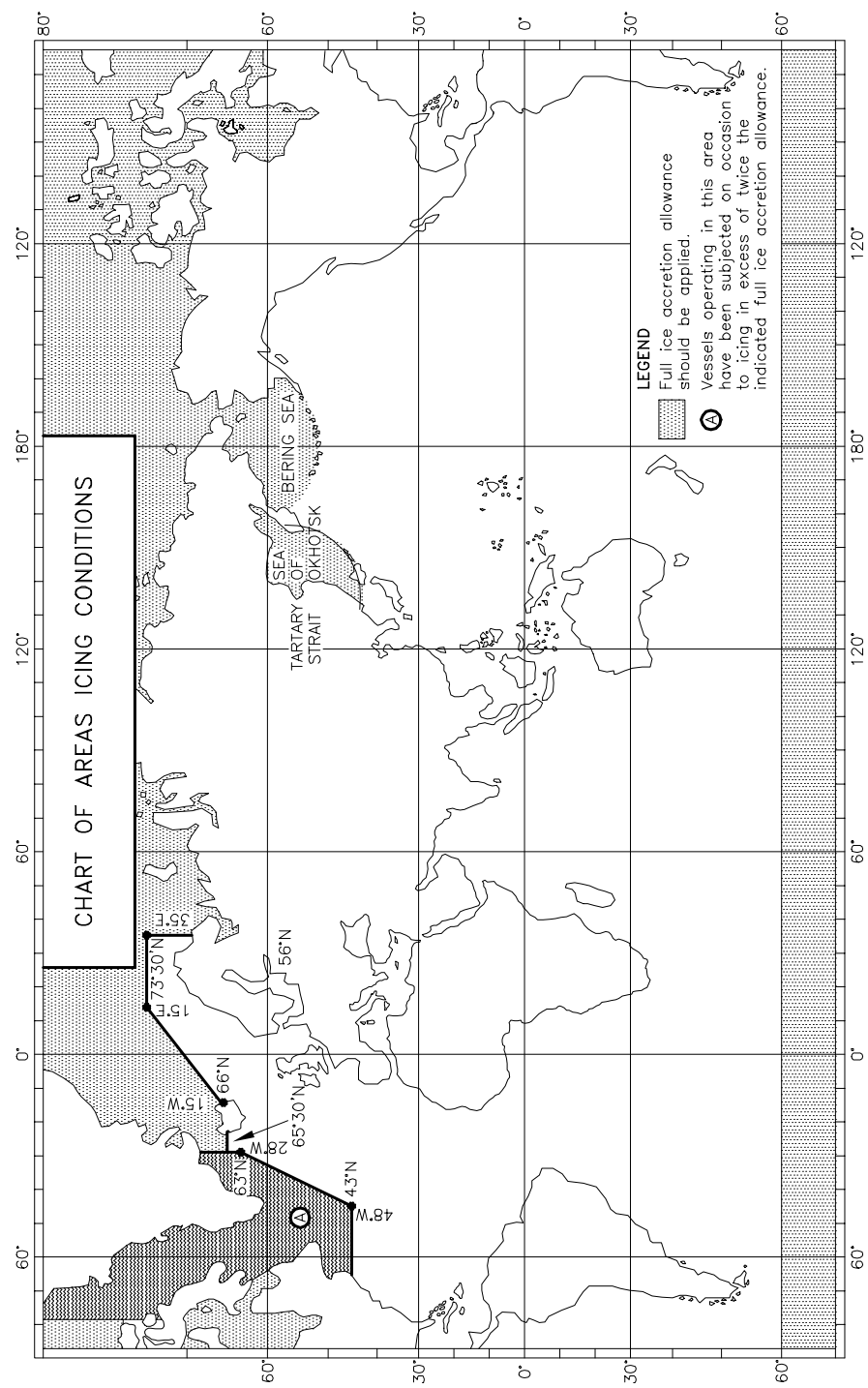
**3 Special requirements**

Craft intended for operation in areas where ice accretion is known to occur shall be:

**.1** designed to minimize the accretion of ice; and

**.2** equipped with such means for removing ice as the Administration may require.

Figure 1



## ANNEX 6

## STABILITY OF HYDROFOIL CRAFT

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.

## 1 Surface-piercing hydrofoils

### 1.1 Hull-borne mode

**1.1.1** The stability shall be sufficient to satisfy the provisions of 2.3, 2.4 and 2.6 of this Code.

### 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:

$$M_R = 0,196 \cdot \frac{V_o^2}{L} \cdot \Delta \cdot KG$$

where:

- $M_R$  : moment of heeling (kN.m);
- $V_o$  : speed of the craft in the turn (m/s);
- $\Delta$  : 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:

$$K = M_c / M_v \geq 1$$

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:

$$M_v = 0.001 P_v A_v Z \text{ (kN.m)}$$

where:

- $P_v$  : wind pressure =  $750 (V_w/26)^2$  (N/m<sup>2</sup>)
- $A_v$  : windage area including the projections of the lateral surfaces of the hull, superstructure and various structures above the waterline (m<sup>2</sup>)
- $Z$  : windage area lever (m) = the vertical distance to the geometrical centre of the windage area from the waterline
- $V_w$  : the wind speed corresponding to the worst intended conditions (m/s).

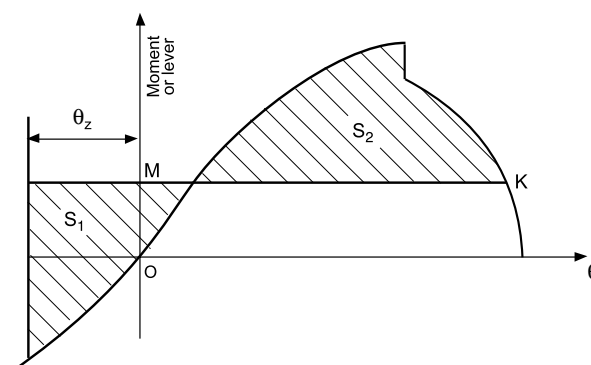
### 1.1.5 Evaluation of the minimum capsizing moment $M_c$ in the displacement mode

The minimum capsizing moment is determined from the static and dynamic stability curves taking rolling into account.

**1.1** 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 figure 1, where  $\theta_z$  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.

- if the scale of ordinates represents moments:  
 $M_c = OM$
- if the scale of ordinates represents levers:  
 $M_c = OM \times \text{displacement}$

Figure 1 Static stability curve

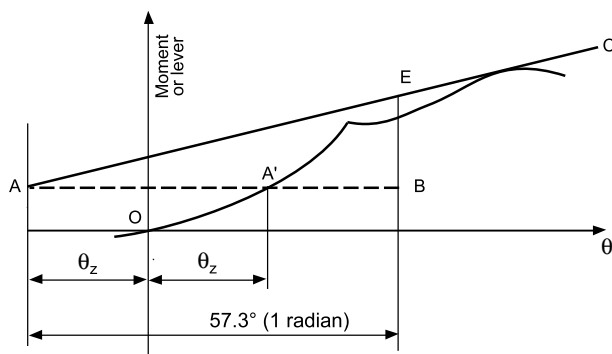




**.2** When the dynamic stability curve is used, first an auxiliary point A shall be determined. For this purpose the amplitude of heeling is plotted to the right along the abscissa axis and a point A' is found (see figure 2). A line AA' is drawn parallel to the abscissa axis equal to the double amplitude 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 ( $57.3^\circ$ ). From the point B a perpendicular is drawn to intersect with the tangent in point E. The distance  $\overline{BE}$  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,  $\overline{BE}$  is then the capsizing lever, and in this case the capsizing moment  $M_c$  is determined by multiplication of ordinate  $\overline{BE}$  (in metres) by the corresponding displacement in tonnes

$$M_c = 9.81 \Delta \overline{BE} \text{ (kN.m)}$$

**Figure 2 Dynamic stability curve**



**.3** The amplitude of rolling  $\theta_z$  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  $90^\circ$  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  $15^\circ$ .

**.4** The effectiveness of the stability curves shall be limited to the angle of flooding.

## 1.2 Transitional and foil-borne modes

**1.2.1** The stability shall satisfy the provisions of 2.4 and 2.5 of this Code.

**1.2.2.1** The stability in the transitional and foil-borne modes shall be checked for all cases of loading for the intended service of the craft.

**1.2.2.2** 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 shall be verified by full-scale tests by 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 set-

ting 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.

**1.2.2.3** The angle of heel in the foil-borne mode caused by the concentration of passengers at one side shall not exceed  $8^\circ$ . During the transitional mode the angle of heel due to the concentration of passengers on one side shall not exceed  $12^\circ$ . The concentration of passengers shall be determined by the Administration, having regard to the guidance given at annex 7 to this Code.

**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 figure 3.

$$GM = n_B \cdot \left( \frac{L_B}{2 \cdot \tan I_B} - S \right) + n_H \cdot \left( \frac{L_H}{2 \cdot \tan I_H} - S \right)$$

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
- $I_B$  : angle at which front foil is inclined to horizontal
- $I_H$  : 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

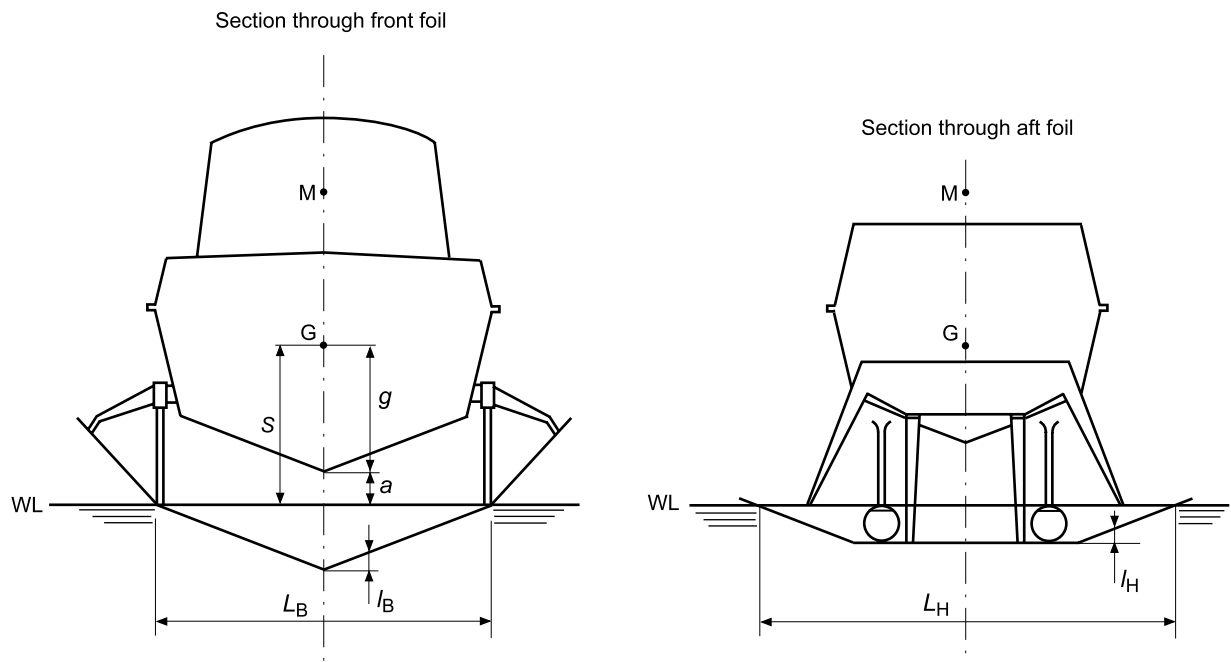
**2.1.1** The stability in the hull-borne mode shall be sufficient to satisfy the provisions of 2.3 and 2.6 of this Code.

**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 shall 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 shall be examined.

**Figure 3****2.3 Foil-borne mode**

The stability of the craft in the foil-borne mode shall be in compliance with the provisions of 2.4 of this Code. The provisions of paragraph 2.2 of this annex shall also apply.

**2.4** Paragraphs 1.2.2.1, 1.2.2.2 and 1.2.2.3 of this annex shall be applied to this type of craft as appropriate and any computer simulations or design calculations shall be verified by full-scale tests.

## ANNEX 7

## STABILITY OF MULTIHULL CRAFT

**1 Stability criteria in the intact condition**

A multihull craft, in the intact condition, shall 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 shall be considered to be sufficient provided compliance with this paragraph is achieved.

**1.1 Area under the GZ curve**

The area ( $A_1$ ) under the GZ curve up to an angle  $\theta$  shall be at least:

$$A_1 = 0.055 \times 30^\circ / \theta \text{ (m.rad)}$$

where  $\theta$  is the least of the following angles:

- .1 the downflooding angle;
- .2 the angle at which the maximum GZ occurs;
- and
- .3  $30^\circ$

**1.2 Maximum GZ**

The maximum GZ value shall occur at an angle of at least  $10^\circ$ .

**1.3 Heeling due to wind**

The wind heeling lever shall be assumed constant at all angles of inclination and shall be calculated as follows:

$$HL_1 = P_i A Z / (9800 \Delta) \text{ (m)}$$

$$HL_2 = 1.5 HL_1 \text{ (m) (see figure 1)}$$

where:

$$P_i = 500 (V_w / 26)^2 \text{ (N/m}^2\text{)}$$

where:

$V_w$  : wind speed corresponding to the worst intended conditions (m/s)

$A$  : projected lateral area of the portion of the craft above the lightest service waterline ( $\text{m}^2$ )

$Z$  : vertical distance from the centre of  $A$  to a point one half the lightest service draught (m)

$\Delta$  : 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, shall be applied in combination with the heeling lever due to wind ( $HL_2$ ).

**1.4.1 Heeling due to passenger crowding**

When calculating the magnitude of the heel due to passenger crowding, a passenger crowding lever shall be developed using the assumptions stipulated in 2.10 of this Code.

**1.4.2 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 shall be developed using either the following formula or an equivalent method specifically developed for the type of craft under consideration, or trials or model test data:

$$TL = \frac{1}{g} \cdot \frac{V_o^2}{R} \cdot \left( KG - \frac{d}{2} \right)$$

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.

**1.5 Rolling in waves (figure 1)**

The effect of rolling in a seaway upon the craft's stability shall be demonstrated mathematically. In doing so, the residual area under the GZ curve ( $A_2$ ), i.e. beyond the angle of heel ( $\theta_h$ ), shall be at least equal to  $0.028 \text{ m.rad}$  up to the angle of roll  $\theta_r$ . In the absence of model test or other data  $\theta_r$  shall be taken as  $15^\circ$  or an angle of  $(\theta_a - \theta_h)$ , whichever is less.

Figure 1 Intact stability

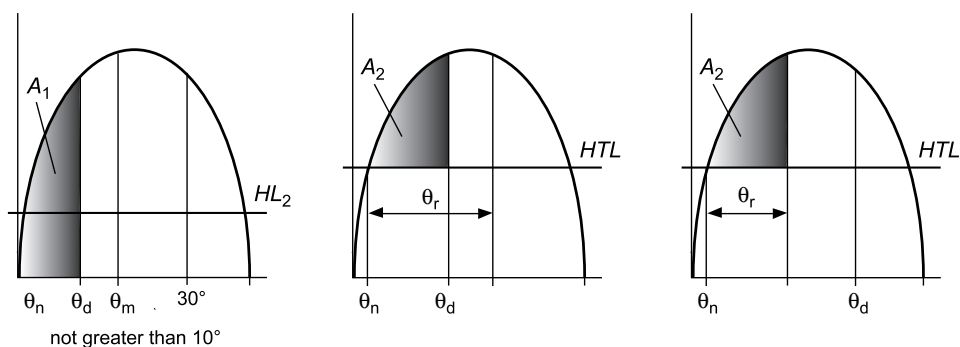
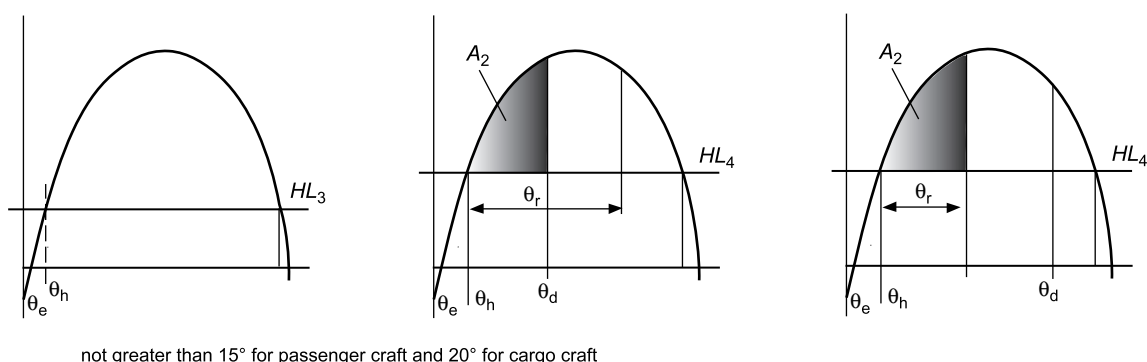


Figure 2 Damage stability



not greater than 15° for passenger craft and 20° for cargo craft

## 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 shall be considered to have an adequate standard of residual stability provided:

**.1** the required area  $A_2$  shall be not less than 0.028 m.rad (figure 2 refers); and

**.2** there is no requirement regarding the angle at which the maximum GZ value shall occur.

**2.2** The wind heeling lever for application on the residual stability curve shall be assumed constant at all angles of inclination and shall be calculated as follows:

$$HL_3 = P_d A Z / (9800 \Delta)$$

where:

$$P_d = 120 (V_w / 26)^2 \text{ (N/m}^2\text{)}$$

$V_w$  : 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 ( $\text{m}^2$ )

$Z$  : vertical distance from the centre of  $A$  to a point one half of the lightest service draught (m)

$\Delta$  : displacement (t).

**2.3** The same values of roll angle shall be used as for the intact stability.

**2.4** The downflooding point is important and is regarded as terminating the residual stability curve. The area  $A_2$  shall therefore be truncated at the downflooding angle.

**2.5** The stability of the craft in the final condition after damage shall be examined and shown to satisfy the criteria, when damaged as stipulated in 2.6 of this Code.

**2.6** In the 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 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 shall be considered:

**3.1.1** for intact condition:

**.1** wind heeling lever (including gusting effect) ( $HL_2$ ); and

**.2** 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:

**.1** wind heeling lever—steady wind ( $HL_3$ ); and

**.2** wind heeling lever plus heeling lever due to passenger crowding ( $HL_4$ )

### 3.2 Angles of heel due to steady wind

**3.2.1** The angle of heel due to a wind gust when the heeling lever  $HL_2$ , obtained as in 1.3, is applied to the intact stability curve shall not exceed 10°.

**3.2.2** The angle of heel due to a steady wind when the heeling lever  $HL_3$ , obtained as in 2.2, is applied to the residual stability curve after damage, shall not exceed 15° for passenger craft and 20° for cargo craft.

Abbreviations used in figures 1 and 2

$A_1$  :  $\geq$  Area required by 1.1

$A_2$  :  $\geq 0.028$  m.rad.

$HL_2$  : Heeling lever due to wind + gusting

HTL : Heeling lever due to wind + gusting + (passenger crowding or turning)

$HL_3$  : Heeling lever due to wind

$HL_4$  : Heeling lever due to wind + passenger crowding

$\theta_m$  : Angle of maximum GZ

$\theta_d$  : Angle of downflooding

$\theta_r$  : Angle of roll

$\theta_e$  : Angle of equilibrium, assuming no wind, passenger crowding or turning effects

$\theta_h$  : Angle of heel due to heeling lever  $HL_2$ , HTL,  $HL_3$  or  $HL_4$

## ANNEX 8

## STABILITY OF MONOHULL CRAFT

**1 Stability criteria in the intact condition**

**1.1** The weather criterion contained in paragraph 3.2 of the Intact Stability Code shall apply (see note). In applying the weather criterion the value of wind pressure  $P$  (N/m<sup>2</sup>) shall be taken as  $(500\{V_w / 26\}^2)$ , where  $V_w$  = wind speed (m/s) corresponding to the worst intended conditions. In applying the weather criterion account shall also be taken of the roll damping characteristics of individual craft in assessing the assumed roll angle  $\Theta_1$ , which may alternatively be derived from model or full-scale tests. 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°.

Note: 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).

**1.2** The area under the righting lever curve (GZ curve) shall not be less than 0.07 m.rad up to  $\Theta = 15^\circ$  when the maximum righting lever (GZ) occurs at  $\Theta = 15^\circ$ , and 0.055 m.rad up to  $\Theta = 30^\circ$  when the maximum righting lever occurs at  $\Theta = 30^\circ$  or above. Where the maximum righting lever occurs at angles of between  $\Theta = 15^\circ$  and  $\Theta = 30^\circ$ , the corresponding area under the righting lever curve shall be:

$$A = 0.055 + 0.001 (30^\circ - \Theta_{\max}) \text{ (m.rad)}$$

where:

$\Theta_{\max}$  : 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  $\Theta = 30^\circ$  and  $\Theta = 40^\circ$  or between  $\Theta = 30^\circ$  and the angle of flooding  $\Theta_f$  if this angle is less than 40°, shall not be less than 0.03 m.rad.

Note: In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as 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 righting 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:  
15 / range  
where the range is expressed in degrees.

**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:

- .1 the angle at which progressive flooding occurs; and
- .2 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:

- .1 the crowding of all passengers towards one side;
- .2 the launching of all fully loaded davit-launched survival craft on one side; and
- .3 due to wind pressure,

as calculated by the formula:

$$GZ = \text{heeling moment} / (\text{displacement}) + 0.04 \text{ (m)}$$

However, in no case, this righting lever shall 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:

- .1 Moments due to crowding of passengers. This should be calculated in accordance with paragraph 2.10 of the Code.

**.2** Moments due to launching of all fully loaded davit-launched survival craft on one side:

- .2.1** all lifeboats and rescue boats fitted on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out fully loaded and ready for lowering;
- .2.2** for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken;
- .2.3** a fully loaded davit-launched liferaft attached to each davit on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out ready for lowering;
- .2.4** persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment; and
- .2.5** life-saving appliances on the side of the ship opposite to the side to which the ship has heeled shall be assumed to be in a stowed position.

**.3** Moments due to wind pressure:

- .3.1** the wind pressure shall be taken as  $(120 \{V_w / 26\}^2) \text{ (N/m}^2\text{)}$ , where  $V_w$  = wind speed (m/s), corresponding to the worst intended condition;
- .3.2** the area applicable shall be the projected lateral area of the ship above the waterline corresponding to the intact condition; and
- .3.3** 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 centre of gravity 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.

**ANNEX 9****DEFINITIONS, REQUIREMENTS AND COMPLIANCE  
CRITERIA RELATED TO OPERATIONAL AND SAFETY  
PERFORMANCE**

*This annex applies to all types of craft. Tests to evaluate operational safety shall 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 shall 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 shall 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.*

**C0** Tests required by the Administration in pursuance of annex 9 are to be carried out in the presence of the Society Surveyor.

The following procedures are outlined as requirements in dealing with verification of craft performance.

**1 Performance****1.1 General**

**1.1.1** *The craft shall meet the applicable operational requirements in Section 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 shall 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 shall be in accordance with procedures established by the applicant for operation in service. Procedures to be established shall be start procedure, cruise procedures, normal and emergency stop and manoeuvre procedures.*

**1.1.3** *The procedures established under 1.1.2 shall:*

**.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 shall be conducted over water of sufficient depth such that craft performance will not be affected.*

**1.1.5** *Tests shall be conducted at minimum practicable weight and additional testing shall 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 transitional mode speed.*

**2.2** *The tests referred to in 2.1.1 and 2.1.2 shall 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 shall be modified in order to avoid exceedance or passengers shall 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 shall include detailed information of how to avoid exceedance or the control system shall be modified to avoid exceedance.*



**2.3** The test referred to in 2.1.3 shall 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 shall include a warning that it is a risk to passengers being injured, if a crash stop is performed.

**2.4** Other tests shall 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 1.4.57 of this Code, are those in which it shall 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 shall also be established at displacement mode during operation in the worst intended condition.

**3.2** Operation levels, as defined in 3.1, shall be established and documented by full-scale tests in at least two relevant sea conditions and in head, beam and following seas. It shall be shown that the period of every test (run) and the number of series are sufficient for achieving reliable measurements. In every sea state tested, the aggregate time in each direction shall not be less than 15 min. Model tests and mathematical simulations could be used to verify the performance in the worst intended conditions.

Limits for normal operation condition shall 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 shall be made to the maximum extent practicable.

Limits for worst intended condition shall 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

$$C = \sqrt{2 \cdot \ln N}$$

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 shall 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 shall document the limiting seas for safe operation of the craft:

**.1** in normal operation at maximum operational speed the accelerations shall not exceed safety level 1 in annex 3 with an average of one per 5-min period. The craft operating manual shall include detailed description of the effects of speed reduction or change of heading to the waves in order to prevent exceedance;

**.2** in the worst intended conditions, with reduced speed as necessary, the accelerations shall not exceed safety level 2 in annex 3 with an average of one per 5-min period, nor shall 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 shall 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 shall 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 shall 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 shall be examined and developed as a result of full-scale trials conducted by simulating possible equipment failures.

The failures to be examined shall be those leading to major or more severe effects as determined from evaluation of FMEA or similar analysis.

Failures to be examined shall be agreed between the craft manufacturer and the Administration and each single failure shall be examined in a progressive manner.

### 4.2 Objects of tests

Examination of each failure shall 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 shall include, but not be limited to, the following:

- .1 total loss of propulsion power;
- .2 total loss of lift power (for ACV and SES);
- .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 shall be fully representative of service conditions and shall 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 shall 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 shall 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.

## ANNEX 10

CRITERIA FOR TESTING AND EVALUATION OF  
REVENUE AND CREW SEATS**1 Purpose and scope**

The purpose of these criteria is to provide requirements for revenue and crew seats, seat anchorage and seat accessories and their installation to minimize occupant injury and/or disruption of egress/ingress if the craft suffers a collision.

**2 Static seat tests**

**2.1** The requirements of this section are applicable to all crew and revenue seats.

**2.2** All seats to which this paragraph applies, along with their supports and deck attachments, shall be designed to withstand at least the following static forces applied in the direction of the craft:

- .1** Forward direction: a force of 2.25 kN,
- .2** After direction: a force of 1.5 kN,
- .3** Transverse direction: a force of 1.5 kN,
- .4** Vertically downward: a force of 2.25 kN, and
- .5** Vertically upward: a force of 1.5 kN.

A seat shall comprise a frame, bottom and back. Forces applied in the fore or aft direction of the seat shall be applied horizontally to the seat back 350 mm above the seat bottom. Forces applied in the transverse seat direction shall be applied horizontally to the seat bottom. Vertical upward forces shall be evenly distributed to the corners of the seat bottom frame. Vertical downward forces shall be uniformly distributed over the seat bottom.

If a seating unit consists of more than one seating position, these forces shall be applied at each seating position concurrently during the tests.

**2.3** When the forces are applied to a seat, consideration shall be given to the direction in which the seat is to face in the craft. For example, if the seat faces sideways, the transverse craft force would be applied fore and aft on the seat and the forward craft force would be applied transversely on the seat.

**2.4** Each seating unit to be tested shall be attached to the support structure similar to the manner in which it will be attached to the deck structure in the craft.

Although a rigid support structure can be used for these tests, a support structure, having the same strength and stiffness as the support structure in the craft, is preferred.

**2.5** The forces described in 2.2.1 to 2.2.3 shall be applied to the seat through a cylindrical surface having a radius of 80 mm and a width at least equal to the width of the seat. The surface shall be equipped with at least one force transducer able to measure the forces applied.

**2.6** The seat shall be considered acceptable if:

- .1** under the influence of the forces referred to in 2.2.1 to 2.2.3, the permanent displacement measured at the point of application of the force is not more than 400 mm;
- .2** no part of the seat, the seat mountings or the accessories become completely detached during the tests;
- .3** the seat remains firmly held, even if one or more of the anchorages is partly detached;
- .4** all of the locking systems remain locked during the entire test but the adjustment and locking systems need not be operational after the tests; and
- .5** rigid parts of the seat with which the occupant may come into contact shall present a curved surface with a radius of at least 5 mm.

**2.7** The requirements of section 3 may be used in lieu of the requirements of this section provided that the accelerations used for the tests are at least 3 g.

**3 Dynamic seat tests**

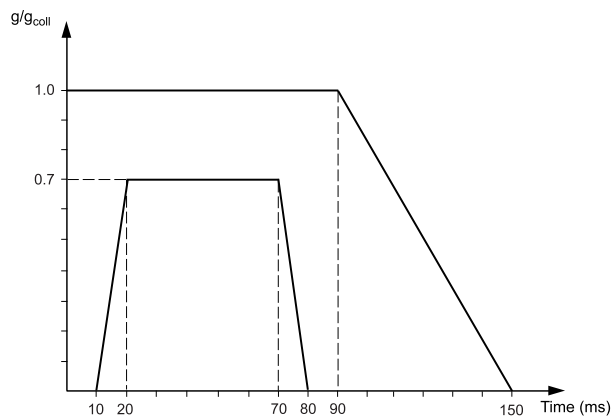
**3.1** The requirements of this section are applicable in addition to those in 2.1 for crew and revenue seats in craft having a design collision load of 3 g or greater.

**3.2** All seats for which this section applies, the seat supporting structure, the attachment to the deck structure, the lap belt, if installed, and shoulder harness, if installed, shall be designed to withstand the maximum acceleration force that can be imposed upon them during a design collision. Consideration shall be given to the orientation of the seat relative to the acceleration force (i.e. whether the seat is forward-, aft-, or side-facing).

**3.3** The acceleration pulse to which the seat is subjected shall be representative of the collision time-history of the craft. If the collision time-history is not known, or cannot be simulated, the acceleration time-history envelope shown in the figure can be used.

**3.4** In the test frame, each seat unit and its accessories (e.g., lap belts and shoulder harnesses) shall be attached to the support structure similar to the manner in which it will be attached in the craft. The support structure can be a rigid surface; however, a support structure having the same strength and stiffness as the support structure in the craft is preferred. Other seats and/or tables with which an occupant may come in contact during a collision shall be included in the test frame in an orientation and with a method of attachment typical of that in the craft.

**Figure 1 Acceleration time-history envelope**



**3.5** During the dynamic seat test, a fiftieth percentile anthropomorphic test dummy, suitable for the test being conducted, shall be placed in the seat in an upright seating position. If a typical seating unit is composed of more than one occupant seat, a test dummy shall be placed in each occupant seat in the unit. The dummy, or dummies, shall be secured in the seat unit in accordance with procedures of recognized national standards (see note) and be secured using only the lap belt and shoulder harness if they are installed. Tray tables and other such devices shall be placed in the position that would cause the greatest potential for an occupant to become injured.

Note: Refer to ECE 80 with addendum 79. Other national standards may be acceptable.

**3.6** The test dummy shall be instrumented and calibrated, in accordance with the requirements of a recognized national standard, so as to permit, as a minimum, calculation of the head injury criterion, calculation of the thoracic trauma index, measurement of force in the femur, and measurement, if possible, of extension and flexion of the neck.

**3.7** If more than one dummy is used in the tests, the dummy located in the seat having the highest potential

for an occupant to be injured shall be the one instrumented. The other dummy or dummies need not be instrumented.

**3.8** The tests shall be conducted and the instrumentation shall be sampled at a rate sufficient to reliably show response of the dummy in accordance with the requirements of a recognized national standard.

Note: Refer to the specifications of International Standard ISO 6487-Technique of measurement in impact tests (1987) or SAE J211-Instrumentation.

**3.9** The seat unit tested in accordance with the requirements of this section shall be considered acceptable if:

**.1** the seat unit and tables installed in the seat unit or area do not become dislodged from the supporting deck structure and do not deform in a manner that would cause the occupant to become trapped or injured;

**.2** the lap belt, if installed, remains attached and on the test dummy's pelvis during the impact. The shoulder harness, if installed, remains attached and in the immediate vicinity of the test dummy's shoulder during the impact. After the impact, the release mechanisms of any installed lap belt and shoulder harness shall be operative;

**.3** the following acceptability criteria are met:

**.3.1** the head injury criterion (HIC), calculated in accordance with the formula, does not exceed 500

$$HIC = (t_2 - t_1) \left[ \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t) dt \right]^{2.5}$$

where:

$t_1$  and  $t_2$  are the beginning and ending times (in seconds) of the interval in which the HIC is a maximum. The term  $a(t)$  is the resultant measured acceleration in the head of the dummy in  $g$ ;

**.3.2** the thoracic trauma index (TTI), calculated in accordance with the formula, does not exceed 30  $g$  except for periods totalling less than 3 ms

$TTI = (g_R + g_{LS}) / 2$  or acceleration at the centre of gravity

where:

$g_R$  : is the acceleration in  $g$  of either the upper or lower rib;

$g_{LS}$  : is the acceleration in  $g$  of the lower spine; and

**.3.3** the force in the femur does not exceed 10 kN except that it cannot exceed 8 kN for periods totalling more than 20 ms; and

**.4** loads on the upper torso harness straps do not exceed 7.8 kN or a total of 8.9 kN if dual straps are used.

## ANNEX 11

## OPEN REVERSIBLE LIFERAFTS

**1 General**

**1.1** All open reversible liferafts shall:

- .1** be constructed with proper workmanship and materials;
- .2** not be damaged in stowage throughout the air temperature range of  $-18^{\circ}\text{C}$  to  $+65^{\circ}\text{C}$ ;
- .3** be capable of operating throughout an air temperature range of  $-18^{\circ}\text{C}$  to  $+65^{\circ}\text{C}$  and a seawater temperature range of  $-1^{\circ}\text{C}$  to  $+30^{\circ}\text{C}$ ;
- .4** be rot-proof, corrosion-resistant and not be unduly affected by seawater, oil or fungal attack;
- .5** be stable and maintain their shape when inflated and fully laden; and
- .6** be fitted with retro-reflective material, where it will assist in detection, and in accordance with the recommendations adopted by the Organization.

*Note: Refer to the Recommendation on the Use and Fitting of Retro-Reflective Materials on Life-Saving Appliances, adopted by the Organization by resolution A.658(16).*

**2 Construction**

**2.1** The open reversible liferaft shall be so constructed that when it is dropped into the water in its container from a height of 10 m, the liferaft and its equipment will operate satisfactorily. If the open reversible liferaft is to be stowed at a height of more than 10 m above the waterline in the lightest seagoing condition, it shall be of a type which has been satisfactorily drop-tested from at least that height.

**2.2** The open reversible floating liferaft shall be capable of withstanding repeated jumps on to it from a height of at least 4.5 m.

**2.3** The open reversible liferaft and its fittings shall be so constructed as to enable it to be towed at a speed of 3 knots in calm water when loaded with its full complement of persons and equipment, with the sea-anchor deployed.

**2.4** The open reversible liferaft when fully inflated shall be capable of being boarded from the water whichever way up it inflates.

**2.5** The main buoyancy chamber shall be divided into:

- .1** not less than two separate compartments, each inflated through a nonreturn inflation valve on each compartment; and
- .2** the buoyancy chambers shall be so arranged that in the event of one of the compartments being damaged or failing to inflate, the intact compartment shall be able to support, with positive freeboard over the open reversible liferaft's entire periphery, the number of persons which the liferaft is permitted to accommodate, each having a mass of 75 kg and seated in their normal positions.

**2.6** The floor of the open reversible liferaft shall be waterproof.

**2.7** The open reversible liferaft shall be inflated with a non-toxic gas by an inflation system complying with the requirements of paragraph 4.2.2 of the LSA Code. Inflation shall be completed within the period of one minute at an ambient temperature of between  $18^{\circ}\text{C}$  and  $20^{\circ}\text{C}$  and within a period of three minutes at an ambient temperature of  $-18^{\circ}\text{C}$ . After inflation the open reversible liferaft shall maintain its form when loaded with its full complement of persons and equipment.

**2.8** Each inflatable compartment shall be capable of withstanding a pressure equal to at least three times the working pressure and shall be prevented from reaching a pressure exceeding twice the working pressure either by means of relief valves or by a limited gas supply. Means shall be provided for fitting the topping-up pump or bellows.

**2.9** The surface of the buoyancy tubes shall be of non-slip material. At least 25% of these tubes shall be of a highly visible colour.

**2.10** The number of persons which an open reversible liferaft shall be permitted to accommodate shall be equal to the lesser of:

- .1** the greatest whole number obtained by dividing by 0.096 the volume, measured in cubic metres, of the main buoyancy tubes (which for this purpose shall not include the thwarts, if fitted) when inflated; or

**.2** the greatest whole number obtained by dividing by 0.372 the inner horizontal cross-sectional area of the open reversible liferaft measured in square metres (which for this purpose may include the thwart or thwarts, if fitted) measured to the innermost edge of the buoyancy tubes; or

**.3** the number of persons having an average mass of 75 kg, all wearing lifejackets, that can be seated inboard of the buoyancy tubes without interfering with the operation of any of the liferaft's equipment.

### **3 Open reversible liferaft fittings**

**3.1** Lifelines shall be securely becketed around the inside and outside of the open reversible liferaft.

**3.2** The open reversible liferaft shall be fitted with an efficient painter of a length suitable for automatic inflation on reaching the water. For open reversible liferafts accommodating more than 30 persons an additional bows-in line shall be fitted.

**3.3** The breaking strength of the painter system, including its means of attachment to the open reversible liferaft, except the weak link required by paragraph 4.1.6.2 of the LSA Code, shall be:

**.1** 7.5 kN for open reversible liferafts accommodating up to 8 persons;

**.2** 10.0 kN for open reversible liferafts accommodating 9 to 30 persons; and

**.3** 15.0 kN for open reversible liferafts accommodating more than 30 persons.

**3.4** The open reversible liferaft shall be fitted with at least the following number of inflated ramps to assist boarding from the sea whichever way up the raft inflates:

**.1** one boarding ramp for open reversible liferafts accommodating up to 30 persons; or

**.2** two boarding ramps for open reversible liferafts accommodating more than 30 persons; such boarding ramps shall be 180° apart.

**3.5** The open reversible liferaft shall be fitted with water pockets complying with the following requirements:

**.1** the cross-sectional area of the pockets shall be in the shape of an isosceles triangle with the base of the triangle attached to the buoyancy tubes of the open reversible liferaft;

**.2** the design shall be such that the pockets fill to approximately 60% of capacity within 15 s to 25 s of deployment;

**.3** the pockets attached to each buoyancy tube shall normally have aggregate capacity of between 125 l and 150 l for inflatable open reversible liferafts up to and including the 10-person size;

**.4** the pockets to be fitted to each buoyancy tube on liferafts certified to carry more than 10 persons shall have, as far as practicable, an aggregate capacity of 12 N litres, where N is the number of persons carried;

**.5** each pocket on a buoyancy tube shall be attached so that when the pocket is in the deployed position it is attached along the full length of its upper edges to, or close to, the lowest part of the lower buoyancy tube; and

**.6** the pockets shall be distributed symmetrically round the circumference of the liferaft with sufficient separation between each pocket to enable air to escape readily.

**3.6** At least one manually controlled lamp complying with the requirements shall be fitted on the upper and lower surfaces of the buoyancy tubes.

**3.7** Suitable automatic drain arrangements shall be provided on each side of the floor of the liferaft in the following manner:

**.1** one for open reversible liferafts accommodating up to 30 persons; or

**.2** two for open reversible liferafts accommodating more than 30 persons.

**3.8** The equipment of every open reversible liferaft shall consist of:

**.1** one buoyant rescue quoit, attached to not less than 30 m of buoyant line with a breaking strength of at least 1 kN;

**.2** two safety knives of the non-folding type, having a buoyant handle, shall be fitted attached to open reversible liferaft by light lines. They shall be stowed in pockets so that, irrespective of the way in which the open reversible liferaft inflates, one will be readily available on the top surface of the upper buoyancy tube in a suitable position to enable the painter to be readily cut;

**.3** one buoyant bailer;

**.4** two sponges;

**.5** one sea-anchor permanently attached to the open reversible liferaft in such a way as to be readily deployable when the open reversible liferaft inflates. The position of the sea-anchor shall be clearly marked on both buoyancy tubes;

- .6 two buoyant paddles;
- .7 one first-aid outfit in a waterproof case capable of being closed tightly after use;
- .8 one whistle or equivalent sound signal;
- .9 two hand flares;
- .10 one waterproof electric torch suitable for Morse signalling together with one spare set of batteries and one spare bulb in a waterproof container;
- .11 one repair outfit for repairing punctures in buoyancy compartments; and
- .12 one topping-up pump or bellows.

**3.9** The equipment specified in 3.8 is designated an HSC Pack.

**3.10** Where appropriate, the equipment shall be stowed in a container which, if it is not an integral part of, or permanently attached to, the open reversible liferaft, shall be stowed and secured to the open reversible liferaft and be capable of floating in water for at least 30 min without damage to its contents. Irrespective of whether the equipment container is an integral part of, or is permanently attached to, the open reversible liferaft, the equipment shall be readily accessible irrespective of which way up the open reversible liferaft inflates. The line which secures the equipment container to the open reversible liferaft shall have a breaking strength of 2 kN or a breaking strength of 3:1 based on the mass of the complete equipment pack, whichever is the greater.

#### **4 Containers for open reversible inflatable liferafts**

**4.1** The open reversible liferafts shall be packed in a container that is:

- .1 so constructed as to withstand conditions encountered at sea;
- .2 of sufficient inherent buoyancy, when packed with the liferaft and its equipment, to pull the painter from within and to operate the inflation mechanism shall the craft sink; and
- .3 as far as practicable, watertight, except for drain holes in the container bottom.

**4.2** The container shall be marked with:

- .1 maker's name or trademark;

- .2 serial number;
- .3 the number of persons it is permitted to carry;
- .4 non-SOLAS reversible;
- .5 type of emergency pack enclosed;
- .6 date when last serviced;
- .7 length of painter;
- .8 maximum permitted height of stowage above waterline (depending on drop-test height); and
- .9 launching instructions.

#### **5 Markings on open reversible inflatable liferafts**

The open reversible liferafts shall be marked with:

- .1 maker's name or trademark;
- .2 serial number;
- .3 date of manufacture (month and year);
- .4 name and place of service station where it was last serviced; and
- .5 number of persons it is permitted to accommodate on the top of each buoyancy tube, in characters not less than 100 mm in height and of a colour contrasting with that of the tube.

#### **6 Instructions and information**

Instructions and information required for inclusion in the craft's training manual and in the instructions for on-board maintenance shall be in a form suitable for inclusion in such training manual and instructions for on-board maintenance. Instructions and information shall be in a clear and concise form and shall include, as appropriate, the following:

- .1 general description of the open reversible liferaft and its equipment;
- .2 installation arrangements;
- .3 operational instructions, including use of associated survival equipment; and
- .4 servicing requirements.

**7            Testing of open reversible  
              inflatable liferafts**

**7.1**            When testing open reversible liferafts in accordance with the recommendations of resolution MSC.81(70), part 1:

**.1**            tests No. 5.5, 5.12, 5.16, 5.17.2, 5.17.10, 5.17.11, 5.17.12, 5.18 and 5.20 may be omitted;

**.2**            the part of test No. 5.8 regarding closing arrangement may be omitted,

**.3**            the temperature -30° C in test No. 5.17.3 and 5.17.5 may be substituted with -18° C; and

**.4**            the drop height of 18 m in test No. 5.1.2 may be substituted with 10 m.

Omissions and substitution, as described above, shall be reflected in the type approval certificate.