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## Rules For Classification And Construction

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### Part 3 Special Ships

Volume III

# RULES FOR HIGH SPEED CRAFT

2022

Biro Klasifikasi Indonesia



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2022

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**The following Rules come into force on 1<sup>st</sup> October 2022.**

**Amendments to the preceding Edition are marked by red color and expanded text.**

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## **Foreword**

This Rules 2022 edition supersedes the Rules for High Speed Craft (Pt.1, Vol.III) 2021. In this edition, there are some changes that have been made in the list of changes as shown on the page "Rules Amendment Notice" including the effective dates from which these changes were applicable .

This Edition gives new additions and amendments to the preceding Edition marked by red color and expanded text. The amendments cover the IMO HSC Code and additional BKI requirements intended to Classification crafts have high speed or speed that met of criteria the HSC Code.

This rules is available to be downloaded at [www.bki.co.id](http://www.bki.co.id). Once downloaded, this Rules will be uncontrolled copy. Please check the latest version on the website.

Further queries or comments concerning this Rules are welcomed through communication to BKI Head Office.

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## Rules Amendment Notice

These pages contain the amendments and corrigenda within the following Sections of the Rules.

**These amendments will come into force on 1<sup>st</sup> October 2022.**

Paragraph	Title/Subject	Status/Remark
Annex 1 and 2 are deleted therefore if any paragraph refers to Annex 3 to 12 are renumbered to Annex 1 to 10 and arranged accordingly		
<b>Premise</b>		
1.1.1	-	Changes HSC code redaction that is incorporated in this rules is printed in normal text and adding a list of MSC Resolution that covered in the rules
2.1	Craft for which Classification only is requested	To accommodate national regulation
2.2	Craft for which both Classification and the IMO Certification are requested or when BKI is authorized by Administration to issue on their behalf the "certificate of high speed craft"	To confirm application when the issue of IMO HSC certificate is conducted by BKI
3.1	-	To provide a detail explanation regarding Ship type notation "HSC"
3.2	-	To provide a detailed explanation regarding the application of HSDE notation
3.3	-	To provide information regarding BKI Class Notations.
<b>Preamble</b>		
15	-	Corrigenda
<b>Section 1. General Comments and Requirements</b>		
1.4.41	-	Corrigenda
1.8.3	-	Corrigenda
1.9.6	-	Corrigenda
<b>Section 2. Buoyancy, Stability and Subdivision</b>		
2.2.1	Buoyant spaces	To add footnote according to HSC Code 2000
2.2.3.2.2	-	To add footnote according to HSC Code 2000
2.2.8.1.1	-	To add footnote according to HSC Code 2000
2.2.8.2.1	-	To add footnote according to HSC Code 2000
Table 2.3.4	Application of Annexes 5 and 6 to monohull and multihull craft	To add footnote according to HSC Code 2000
2.6.4.1	-	To add footnote according to HSC Code 2000
2.11	Intact Stability in the displacement mode	To add footnote according to HSC Code 2000
2.13.1	-	To add footnote according to HSC Code 2000
<b>Section 3. Structures</b>		
C.3.1.4	Documents for Approval	Deleted requirement regarding submission document system to BKI in paper form
C.3.2.3.1	General	Corrigenda
C.3.3.3.2.4	-	To add new requirement for reduction in acceleration
C.3.3.3.2.5	-	To add new requirement for the reduction vertical acceleration aCG
C.3.4.3.1	Side beam force	Formula correction
C3.5.1	General	Corrigenda

Paragraph	Title/Subject	Status/Remark
Annex 1 and 2 are deleted therefore if any paragraph refers to Annex 3 to 12 are renumbered to Annex 1 to 10 and arranged accordingly		
C3.5.3.3.1	-	Corrigenda
C3.6.1.2.4.4.5	-	To add requirement for doubling plate in tanks for flammable liquids
C3.6.1.2.5	Intersecting members, stress in the thickness direction	To add sub subtitle
C3.6.1.2.5.1	-	To add requirement for intersecting members, stress in the thickness direction
C3.6.1.2.5.2	-	To add requirement for rudder measurement
C3.6.1.3.3.9	-	Corrigenda
Fig. C3.6.17	Joints uniting section ends and plates	Corrigenda
C3.6.2.2.1	-	Corrigenda
C3.6.2.2.6.1	-	Corrigenda
C3.6.2.2.6.2	-	Corrigenda
Table C3.7.6	Coefficient CS and CA	Corrigenda
C3.8.2.4	-	Corrigenda
C3.8.2.5.1.a)	Single skin laminates	Corrigenda
C3.8.2.5.1.c)	Single skin laminates	Corrigenda
C3.8.3.2.5	Effective aspect ratio	Corrigenda
C3.8.5.2.1	In-plane uniaxial strains	Corrigenda
C3.8.6.2.1	Considerations and limitations	Corrigenda
Table C3.9.1	-	Corrigenda
C3.9.2.9	Note	Corrigenda
C3.10.4	Definitions	To add new definition of mean height of rudder area
C3.10.7.2.1.3	-	To add new reference
C3.10.8.3.2	-	Corrigenda
<b>App C3A1. Special Requirements for Scantlings of Hydrofoil Hull Structure</b>		
C3A1.4.1	Documents to be submitted	To add new information and corrigenda
<b>App C3A2. Requirements for Scantlings of Air-cushion Vehicle Hull Structures</b>		
C3A2.4.1.3	Determination of weight distribution, LCG and radius of gyration	Corrigenda
C3A2.4.1.6	Superimposing of accelerations	Corrigenda
C3A2.4.1.7	Forces acting on each section	Corrigenda
C3A2.5.1.3	Increased pressures in bow section	Corrigenda
<b>Section 4. Accommodation and Escape Measures</b>		
C4.0	Documents to be submitted	Deleted due to adjust to classification operations
4.3.4	-	Corrigenda
4.3.5	-	Corrigenda
4.8.1	-	Corrigenda
4.8.2	-	To add new reference
<b>Section 5. Direction Control Systems</b>		
C5.0.1	-	Deleted requirement regarding submission document system to BKI in paper form
<b>Section 7 Fire and Safety</b>		
C7.0.1	-	Deleted requirement regarding submission document system to BKI in paper form
7.1.2.3	-	Corrigenda

Paragraph	Title/Subject	Status/Remark
Annex 1 and 2 are deleted therefore if any paragraph refers to Annex 3 to 12 are renumbered to Annex 1 to 10 and arranged accordingly		
7.7.3.1	-	Changed reference according to HSC Code 2000
7.7.3.3.1	-	Changed reference according to HSC Code 2000
7.7.3.4.2.2	-	To add new requirement from HSC Code 2000
7.10.1.5	-	Corrigenda
Part D	-	Update reference
7.17.1	-	To change paragraph position
Table 7.17-1	-	Uncheck at column Open ro-ro spaces, row spaces 7.17.3.4.1 and 7.17.3.4.2
Table 7.17-2		Deleted number "4" on x <sup>4,7</sup> at column 4.2, rows 7.17.3.4.2
7.17.3.1.3		To add new footnote
7.17.3.1.4		Corrigenda
7.17.3.2		Change new reference
7.17.3.4.2		To add new footnote
7.17.4		To add new footnote
<b>Section 8. Life-Saving Appliances and Arrangements</b>		
8.1.10.10	-	To add new footnote
8.11	<b>Helicopter Pick-up areas</b>	Update reference
<b>Section 9. Machinery</b>		
9.1.5	-	Deleted paragraph related to protection requirement of piping installation and its fitting and adding a footnote
C9.5.0.5	Protection of Propeller Shafts	Update requirement to the relevant BKI Rules
<b>Section 10. Auxiliary Systems</b>		
C10.0.1	-	Deleted requirement regarding submission document system to BKI in paper form
10.2.4.9	-	To add new footnote according to HSC Code 2000
<b>Section 11. Remote Control, Alarm and Safety Systems</b>		
C11.0.1		Deleted requirement regarding submission document system to BKI in paper form
<b>Section 12. Electrical Installations</b>		
C12.0.1	-	Deleted requirement regarding submission document system to BKI in paper form
<b>Section 13. Shipborne Navigational System and Equipment and Voyage Date Recorders</b>		
13.15.2	-	To add new paragraph and renumbering
<b>Section 14. Radiocommunications</b>		
14.2.6	-	To change requirement according to HSC Code 2000
14.2.17	-	Added new requirement regarding Recognized mobile satellite
14.3.2	-	Renumbering
14.3.3	-	Renumbering
14.7.1.5	-	To change requirement according to HSC Code 2000
14.8.1.5	-	To change requirement according to HSC Code 2000
14.9.1.3.3	-	To change requirement according to HSC Code 2000

Paragraph	Title/Subject	Status/Remark
Annex 1 and 2 are deleted therefore if any paragraph refers to Annex 3 to 12 are renumbered to Annex 1 to 10 and arranged accordingly		
14.9.3.2	-	To change requirement according to HSC Code 2000
14.10.1.1	-	To change requirement according to HSC Code 2000
14.10.1.4.3	-	To change requirement according to HSC Code 2000
14.10.2.3.2	-	To change requirement according to HSC Code 2000
14.12.1.4	-	To change requirement according to HSC Code 2000
14.15.10.1	-	To change requirement according to HSC Code 2000
<b>Section 15. Operating Compartment Layout</b>		
15.1.1	-	To add new reference according to HSC Code 2000
<b>Section 17. Handling, Controllability and Performance</b>		
17.5.4.2	-	Corrigenda
Annex 1	<b>Form of High-Speed Craft Safety Certificate and Record of Equipment</b>	Deleted to avoid the form being obsolete or mismatched with the national regulation form
Annex 2	<b>Form of High-Speed Craft Safety Certificate and Record of Equipment</b>	
Annex 3-1	Use of Probability Concept	Renumbering
Annex 4 2	Procedures for Failure Mode and Effects Analysis	Renumbering
Annex 5-3	Ice Accretion Applicable to All Types of Craft	Renumbering
Annex 6-4	Stability of Hydrofoil Craft	Renumbering
Annex 7 5	Stability of Multihull Craft	Renumbering
Annex 8-6	Stability of Monohull Craft	Renumbering
Annex 9-7	Definitions, Requirements and Compliance Criteria related to Operational and Safety Performance	Renumbering
Annex 10 8	Criteria for Testing and Evaluation of Seats	Renumbering
Annex 11 9	Open Reversible Liferafts Craft	Renumbering
Annex 12-10	Factors to be Considered in Determining Craft Operating Limitations <sup>1</sup>	Renumbering

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### 1. General

#### 1.1

**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 73<sup>rd</sup> session, in December 2000, through Resolution MSC. 97(73) including the amendments adopted at:

- its 79<sup>th</sup> session in December 2004, through Resolution MSC.175(79)
- its 82<sup>nd</sup> session in December 2006, through Resolution MSC.222(82)
- its 84<sup>th</sup> session in May 2008, through Resolution MSC.260(84)
- its 85<sup>th</sup> session in December 2008, through Resolution MSC.271(85)
- its 90<sup>th</sup> session in May 2012, through Resolution MSC.326(90)
- its 92<sup>nd</sup> session in June 2013, through Resolution MSC.352(92)
- its 98<sup>th</sup> session in June 2017, through Resolution MSC.424(98)
- its 99<sup>th</sup> session in May 2018, through Resolution MSC.439(99)

Standard construction of the Rules is the same as HSC Code, except for Annexes 1 to 10 are direct comparisons to Annexes 3 to 12 of the HSC Code and are arranged accordingly.

**1.1.2** Classification requirements additional to the provisions of the HSC Code are 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.

**1.1.3** Parts of the HSC Code not applicable for the purpose of Classification are printed on a shaded background as [1.1.3](#).

**1.1.4** Equipment and arrangements dealt with in the parts of the Code mentioned in item [1.1.3](#), such as those concerning life-saving appliances and radio-communications, which are not subject to control by BKI, are intended to be covered by the relevant certification.

**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 “BKI” and “Rules”, respectively.

The Rules for the Construction and Classification of ships are referred to below simply as “BKI Rules”.

## 2. Application

### 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 shaded background placed in the text (see 1.1.3). **The national regulations that are equivalent to HSC Code requirements used for Classification may be accepted if approved by BKI.**

### 2.2 Craft for which both Classification and the IMO Certification are requested or when BKI is authorized by Administration to issue on their behalf the "certificate of high speed craft"

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

## 3. Class Notation

### 3.1 Ship type notation "HSC"

The Craft complying with the Classification requirements of these Rules are assigned the ship type notation **HSC**, following by one of special notations that specifying the category of the craft in accordance with the HSC Code:

- **Passenger A** for a passenger craft which can be defined according to the Code as Category A, see Section 1, 1.4.12
- **Passenger B** for a passenger craft which can be defined according to the Code as Category B, see Section 1, 1.4.13
- **Cargo** for a Cargo Craft, see Section 1, 1.4.10

### 3.2 Additional Notation "HSDE"

**3.2.1** The Craft assigned additional notation "HSDE" to be complying with both Section 3 and 6 requirements of these Rules.

**3.2.2** This additional notation is also to be complying with the following stability and machinery and electrical installations requirements:

- for craft with length  $L > 24$  m or more than 500 GT:
  - Guidelines on Intact Stability (Pt.6, Vol.3) as far as applicable
  - Rules for Machinery Installations (Pt.1, Vol.III)
  - Rules for Electrical Installations (Pt.1, Vol.IV)
- for craft with length  $L \leq 24$  m:
  - Guidelines on Intact Stability (Pt.6, Vol.3) as far as applicable
  - Rules for Small Vessels up to 24 m (Pt.3, Vol.VII) for machinery and electrical installations

**3.2.3** This additional notation applies for:

- passenger craft which do not proceed in the course of their voyage more than four hours at 90 % of maximum speed from a place of refuge, and
- cargo craft which do not proceed in the course of their voyage more than 8 hour at 90 % of maximum speed from a place of refuge when fully laden.

**3.2.4** The additional notation “HSDE” may follow either special notation (**Patrol, Crew Boat, etc.**) or ship type notations (**Pilot, Rescue, Ferry, etc.**) as describe in Guidance for Class Notations (Pt.0, Vol.B)

**3.3** Further information regarding BKI Class notations refers to Guidance for Class Notations (Pt.0, Vol.B).

#### **4. Compliance with other Rules**

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

Classification of a craft with BKI, or more generally any BKI 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.

#### **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 BKI.

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## Preamble

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. The Code takes into account that a high-speed craft is of a light displacement compared with a conventional ship. This displacement aspect is the essential parameter to obtain fast and competitive sea transportation and consequently this Code allows for use of non-conventional shipbuilding materials, provided that a safety standard at least equivalent to conventional ships is achieved.

6. To clearly distinguish 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 Load Line Convention 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.

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 1994 HSC 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 Code to maintain safety equivalence with conventional ships.

9. Accordingly, two differing principles of protection and rescue were embodied in the Code.

10. The first of these recognizes the craft which were originally foreseen at the time of development of the DSC Code. Where rescue assistance is readily available and the total number of passengers is limited, a reduction in passive and active protection may be permitted. Such craft are called "assisted craft" and form the basis for "category A passenger craft" of this Code.

11. The second concept recognizes the further development of high-speed craft into larger craft. Where rescue assistance is not readily available or the number of passengers is unlimited, additional passive and active safety precautions are required. These additional requirements provide for an area of safe refuge on board, redundancy of vital systems, increased watertight and structural integrity and full fire-extinguishing capability. Such craft are called "unassisted craft" and form the basis for "cargo craft" and "category B passenger craft" of this Code.

12. These two concepts of the Code have been developed as a unified document on the basis that an equivalent level of safety to that normally expected on ships complying with the International Convention for the Safety of Life at Sea 1974 as amended is achieved. Where the application of new technology or design indicates an equivalent safety level to the strict application of the Code, the Administration is permitted to formally recognize such equivalence.

13. It is important that an Administration, in considering the suitability of a high-speed craft under this Code, should apply all sections of the Code because non-compliance with any part of the Code could result in an imbalance which would adversely affect the safety of the craft, passengers and crew. For a similar reason, modifications to existing craft, which may have an effect on safety, should be approved by the Administration.

14. In developing the Code, it has been considered desirable to ensure that high-speed craft do not impose unreasonable demands on existing users of the environment or conversely suffer unnecessarily through lack of reasonable accommodation by existing users. Whatever burden of compatibility there is, it should not necessarily be laid wholly on the high-speed craft.

15. Paragraph 1.15.1 of the 1994 HSC Code states that it 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 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

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### 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.<sup>1</sup>

### 1.2 General Requirements

**1.2.1** 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<sup>2</sup>;

.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](#);

<sup>1</sup> Refer to MSC/Circ.652 on Application of the 1966 LL Convention to high-speed craft (subject to final consideration by SLF 43).

<sup>2</sup> Refer to the International Safety Management (ISM) Code adopted by the Organization by resolution A.741(18), as may be amended.

.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.

**C1.2.1.4** Restrictions for the operation of the craft will be specified in the Class Certificate.

**1.2.2** On all craft, new installation of materials containing asbestos used for the structure, machinery, electrical installations and equipment of a craft to which this Code applies shall be prohibited except for:

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

.2 watertight joints and linings used for the circulation of fluids when, at high temperature (in excess of 350 °C) or pressure (in excess of 7 x 106 Pa), there is a risk of fire, corrosion or toxicity; and

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

### 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 BKI Head Office.

These Rules also apply to high speed craft:

.1 the keels of which are laid or which are at a similar stage of construction on or after 1 January 2017; or

.2 the delivery of which is on or after 1 January 2020.

**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 deck-house, 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.

**C1.3.3**   For Fibre-Reinforced Plastic (FRP) Craft, the term "the keels of which are laid or which are at a similar stage of construction" is the date that the first structural reinforced of the complete thickness of the approval hull laminate schedule is laid either in or on the mould.

(IACS UI HSC 9)

**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 90 % of maximum 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 90 % of maximum 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. Upon request, exemptions from some of the requirements of the Rules may be granted in the opinion of the BKI Head Office.

**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.

**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 63<sup>rd</sup> 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.

## **1.4      Definitions**

For the purpose of this Code, unless expressly provided otherwise, the terms used therein have the meanings defined in the following 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 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 (main displays and controls for equipment specified in [13.2](#) to [13.7](#)) 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 2](#), 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 food 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:

$$3,7 \cdot \nabla^{0.1667}$$

where:

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

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

**1.4.33** "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.

**1.4.34** "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.

**C1.4.34** With the reference [1.4.34](#), the weight of mediums on board for the fixed fire-fighting systems (e.g. freshwater, CO<sub>2</sub>, dry chemical powder, foam concentrate, etc.) shall be included in the lightweight and lightship condition.

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

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

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

**1.4.38** "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.

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

**1.4.40** "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>.

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

- .1 to which any passengers carried have access; and
- .2 **which** either:
  - .2.1 are open at both ends; or

.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.

**1.4.42** "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.

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

**1.4.44** "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.

**1.4.45** "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. Such spaces containing no cooking appliances may contain:

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

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

**1.4.54** "Significant wave height" is the average crest-to-trough height of the highest one third of the zero-upcrossing waves in a specified 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 BKI on a particular and clearly identified material, item of equipment or process, shown by design assessment to meet all the stipulations of BKI 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

**C1.5** In respect of Classification the survey requirements in accordance with the [Rules for Classification and Surveys \(Pt.1, Vol.I\)](#) apply.

**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.

**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 wherever 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.

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

**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 an 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, such 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.

**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.

## 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 corresponding to [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 [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 BKI 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. On all craft, all Certificates issued under this Section, or certified copies thereof, shall be carried on the craft. Except where the flag State is a Party to the 1988 SOLAS Protocol, a copy of each of these Certificates shall be posted up in a prominent and accessible place in the craft.

**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

authorize the issue of a Certificate to the craft and, where appropriate, endorse or authorize 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 of the HSC Code . If the language used is not Bahasa, 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 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 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 with 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.

**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.

**1.9.1.1** On all craft, transit voyages may be undertaken without a valid Permit to Operate High-Speed Craft provided the craft is not operating commercially with passengers or cargo onboard. For the purpose of this provision, these transit voyages include delivery voyages, i.e., builder's port to base port, and voyages for repositioning purposes, i.e., change of base port and/or route. Such transit voyages in excess of the limits set out in this Code may be undertaken provided that:

.1 the craft has a valid High-Speed Craft Safety Certificate or similar before the start of such a voyage;

.2 the operator has developed a safety plan for the voyage including any temporary accommodation and all relevant matters listed in 18.1.3 to ensure that the craft is capable of safely completing the transit voyage;

.3 the master of the craft is provided with the materials and information necessary to operate the craft safely during the transit voyage; and

.4 the Administration is satisfied that arrangements have been made for the safe conduct of the voyage.

**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 onboard 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 **of the HSC Code**. If the language used is not English or Bahasa the text shall include a translation into one of these languages.

**1.9.7** In determining the worst intended conditions and the operational limitations on all craft for insertion in the Permit to Operate, the Administration shall give consideration to all the parameters listed in [Annex 10](#). The limitations assigned shall be those that enable compliance with all of these factors.

## 1.10 Control

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.

**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 therefor, which the Organization shall circulate to its Member Governments for their information.

**C1.11** For classification purposes equivalent arrangements may be approved on a case-by-case basis.

## 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.

## 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 six 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

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### Part A General

#### C2.0 Documents to be submitted

**C2.0.1** The following drawings and documents are to be submitted. To facilitate a smooth and efficient approval process they shall be submitted electronically. However, they can also be submitted in paper form in quadruplicate.

- 1) Hull, plotted and numerically;
- 2) Side contour, plotted and numerically;
- 3) Coordinates of non-watertight and non-weathertight 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 BKI.

## 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 3](#) 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, irrespective of size, that would permit passage of water through a water/weathertight structure (e.g., opening windows), but excludes any opening kept closed to an appropriate standard of water/weathertightness at all times other than when required for access or for operation of portable submersible bilge pumps in an emergency (e.g., non-opening windows of similar strength and weathertight integrity to the structure in which they are installed).

.2 "Elsewhere" when applied to sill and coaming heights in [2.2.7](#) and [2.2.8](#) is taken as applying to all weathertight and watertight closures located on or below the datum.

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

.4 "Monohull craft" means any craft which is not a multihull craft.

.5 "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.

.6 "Permeability" of a space means the percentage of the volume of that space which can be occupied by water.

.7 "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 The adequacy of mathematical simulations must first be demonstrated by correlation with full-scale or model tests for the appropriate type of craft. It may be appropriate to use mathematical simulations to help to identify the more critical scenarios for subsequent physical testing.<sup>1</sup>

<sup>1</sup> Some mathematical simulation methods are not well suited to accurate modelling of extreme events. For safety level 3 or 4, it may be appropriate to use model testing as a precursor to, or instead of, full-scale testing

**2.1.6** 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 planning 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.

**2.1.7** Suitable calculations shall be carried out and/or tests conducted to demonstrate that, when operating within approved operational limitations, the craft will, after a disturbance causing roll, pitch, heave or heel due to turning or any combination thereof, return to the original attitude. Where calculations are employed, it shall first be shown that they correctly represent dynamic behaviour within the operational limitations of the craft.

#### C2.1.8 Arrangement of watertight 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 [m] of the collision bulkhead from the forward perpendicular is to be between  $0,05L$  and  $0,05L + 3$  m. 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.
- .3 The collision bulkhead is to extend watertight up to the datum (bulkhead deck). Steps or recesses may be permitted provided C2.1.7.2 are observed.
- .4 The remaining watertight bulkheads are, in general, to extend to the datum. Wherever practicable, they shall be situated in one frame plane, otherwise those portions of decks situated between parts of transverse bulkheads are to be watertight.

## 2.2 Intact Buoyancy and Watertight and Weathertight Integrity

### 2.2.1 Buoyant spaces<sup>2</sup>

**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
- .2 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. Where a buoyant space may be subjected to increased fluid pressure in the equilibrium position after damage, the boundaries and associated openings and penetrations of that space shall be designed and constructed to prevent the passage of fluid under that pressure.

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,

<sup>2</sup> These requirements encompass the need for all hull openings and their closures to be provided with satisfactory integrity

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.

**C2.2.2.9** No doors, manholes, or access openings are generally permitted in the collision bulkhead below the datum. BKI 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 may 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<sup>3</sup> 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

<sup>3</sup> Reference should be made to MSC.1/Circ.1195, which provides guidelines for the conduct of high-speed craft model testing.

in long crested seas of the greatest significant wave height corresponding to the worst intended conditions, either:

- .2.1 the bow loading door is not reached by waves; or
- .2.2 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:

- .4.1  $A \geq 0,3l$

where:

$$\begin{aligned} A &= \text{the total area of freeing ports on each side of the deck in } m^2; \text{ and} \\ l &= \text{the length of the compartment in } m; \end{aligned}$$

- .4.2 the craft shall maintain a residual freeboard to the deck of the ro-ro space of at least 1 m in the worst condition;

- .4.3 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

- .4.4 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 deckhouses located above the datum shall in the outside boundaries have means of closing openings with sufficient strength such as to maintain weathertight integrity in all damage conditions where the space in question is not damaged. Furthermore, the means of closing shall be such as to maintain weathertight integrity in all operational conditions.

## 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.<sup>4</sup>

**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

<sup>4</sup> Refer to ISO 6042 - Ships and Marine Technology – Weather-tight single-leaf steel doors, or a similar standard.

250 mm elsewhere<sup>5</sup>. 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<sup>5</sup>. 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<sup>6</sup>.

**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<sup>5</sup>. 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.

<sup>5</sup> Refer to [2.1.3.2](#)

<sup>6</sup> Conformity with the requirements of organizations recognised by the Administration in accordance with regulation XI-1/1 of the Convention may be considered to possess adequate strength.

**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<sup>5</sup>. 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<sup>5</sup>. 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 0,01L, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions. Where that vertical distance exceeds 0,02L, a single automatic non-return valve without positive means of closing may be accepted. The means for operating the positive action valve shall be readily accessible and provided with an indicator showing whether the valve is open or closed.

**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 inlet and discharge controls in connection with the operation of machinery shall either:

.1 be located at least 50 % of the significant wave height corresponding to the worst intended conditions above the deepest flooded waterline following damage specified in [2.6.6](#) to [2.6.10](#); or

.2 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 0,05L 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 0,02L above any waterline when the intact craft is heeled to an angle of 15° or 0,02L above the highest waterline at all stages of flooding as determined by the damaged stability calculations, whichever is higher.

**2.2.10.4** All air pipes shall be equipped with weathertight 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 (l) in the well is 20 m or less:

$$A = 0,7 + 0,035 l \text{ (m}^2\text{)}; \text{ and}$$

.2 where l exceeds 20 m:

$$A = 0,07 l \text{ (m}^2\text{)},$$

and, in no case, l need be taken as greater than 0,7L.

If the bulwark is more than 1,2 m in average height, the required area shall be increased by 0,004 m<sup>2</sup> per metre of length of well for each 0,1 m difference in height. If the bulwark is less than 0,9 m in average height, the required area shall be decreased by 0,004 m<sup>2</sup> per metre of length of well for each 0,1 m 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:

$$A = 0,3 \cdot b \text{ (m}^2\text{)}$$

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 4](#) 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 5](#) 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 6](#) in all permitted conditions of loading.

**2.3.4** Where the characteristics of multihull craft are inappropriate for application of [Annex 5](#) or the characteristics of monohull craft are inappropriate for application of [Annex 6](#), 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 5](#) and [6](#) may be applied as indicated in the table below.

**Table 2.3.4. Application of Annexes 5 and 6 to monohull and multihull craft<sup>7</sup>**

GM <sub>T</sub>	Angle of maximum GZ	
	≤ 25°	> 25°
≤ 3 m	<a href="#">Annex 5 or Annex 6</a>	<a href="#">Annex 6</a>
> 3 m	<a href="#">Annex 5</a>	<a href="#">Annex 5 or Annex 6</a>

where:

GM<sub>T</sub> = transverse metacentric height in the loading condition corresponding to the design waterline, corrected for free surface effects (m)

GZ = righting lever

## 2.4 Intact Stability in the Non-Displacement Mode

**2.4.1** The requirements of this Section and of [2.12](#) shall be applied on the assumption that any stabilization 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 [Sections 17](#) and [18](#) and [Annex 7](#). 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.

<sup>7</sup> Table 2.3.4 is advisory, and accommodates cases where a monohull has stability characteristics like a multihull, and those of a multihull that are like a monohull.

**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 4](#).

## 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 follows:

Spaces	Permeability
Appropriated to cargo or stores	60
Occupied by accommodation	95
Occupied by machinery	85
Intended for liquids	0 or 95 *
Appropriated for cargo vehicles	90
Void spaces	95

\* 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<sup>8</sup>;
- .2 structurally stable under service conditions;

<sup>8</sup> Reference may be made to Cellular plastics, rigid — Determination of water absorption for assessing water absorption properties (ISO 2896:1987).

The water absorption of low-density material should not exceed 8% by volume after being fully submerged for 8 days according to ISO 2896 and should be considered to be "impervious to water absorption". Material complying with the Revised Recommendation on Testing of Life-Saving Appliances (resolution MSC.81(70)) should also be deemed to satisfy this standard. Refer to Small craft — Stability and buoyancy assessment and categorization (ISO 12217).

.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](#).

.5 void spaces filled with foam or modular buoyancy elements or any space without a venting system are considered to be void spaces for the purposes of this paragraph, provided such foam or elements fully comply with [2.6.4](#).

**2.6.6** Any damage of a lesser extent than that postulated in [2.6.7](#) to [2.6.10](#), as applicable, which would result in a more severe condition shall also be investigated.

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

The following side damage 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:

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

The damage described in this paragraph shall be assumed to have the shape of a parallelepiped.<sup>9</sup> Applying this to [Fig. 2.6.7 a](#), the inboard face at its mid-length shall be tangential to, or otherwise touching in at least 2 places, the surface corresponding to the specified transverse extent of penetration, as illustrated in [Fig. 2.6.7 a](#).

Side damage shall not transversely penetrate a greater distance than the extent of  $0,2\nabla^{1/3}$  at the design waterline, except where a lesser extent is provided for in [2.6.7.2](#). Refer to [Fig. 2.6.7 b](#) and [c](#).

If considering a multihull, the periphery of the craft is considered to only be the surface of the shell encompassed by the outboard surface of the outermost hull at any given section.

<sup>9</sup> A parallelepiped is defined as “a solid contained by parallelograms” and a parallelogram is defined as “a four-sided rectilinear figure whose opposite sides are parallel”.

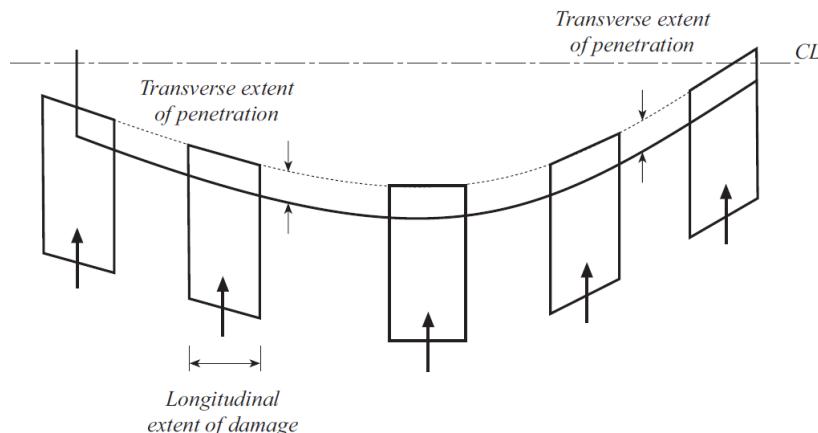


Fig. 2.6.7 a

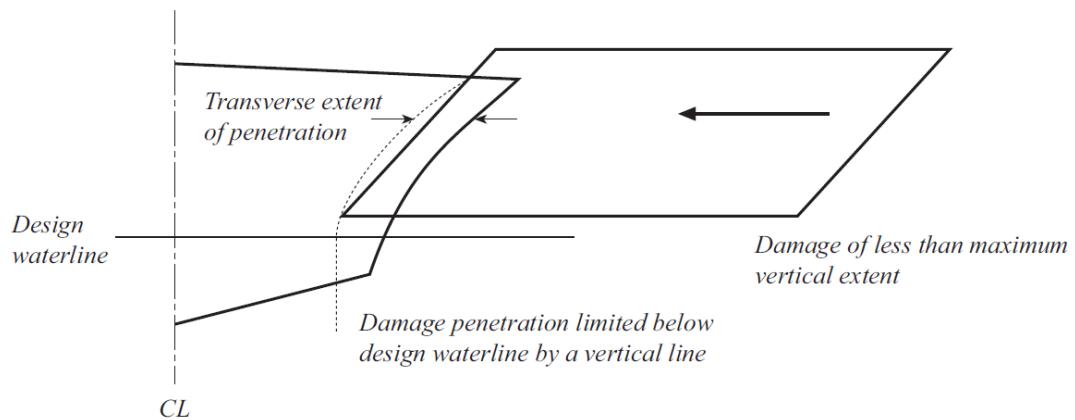


Fig. 2.6.7 b

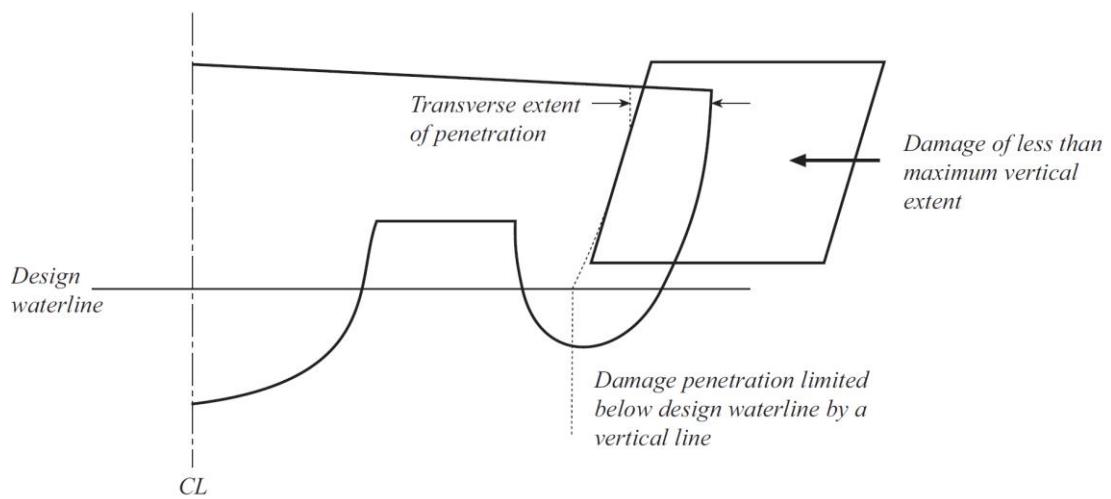


Fig. 2.6.7 c

## 2.6.8 Extent of bow and stern damage

**2.6.8.1** The following extents of damage are to be applied to bow and stern, as illustrated in Fig. 2.6.9:

- .1 at the fore end, damage to the area defined as  $A_{bow}$  in 4.4.1, the aft limit of which being a transverse vertical plane, provided that this area need not extend further aft from the forward extremity of the craft's watertight envelope than the distance defined in 2.6.7.1; and

.2 at the aft end, damage to the area aft of a transverse vertical plane at a distance  $0,2 \nabla^{1/3}$  forward of the aft extremity of the watertight envelope of the hull.

**2.6.8.2** The provisions of [2.6.6](#) in relation to damage of lesser extent remain applicable to such damage.

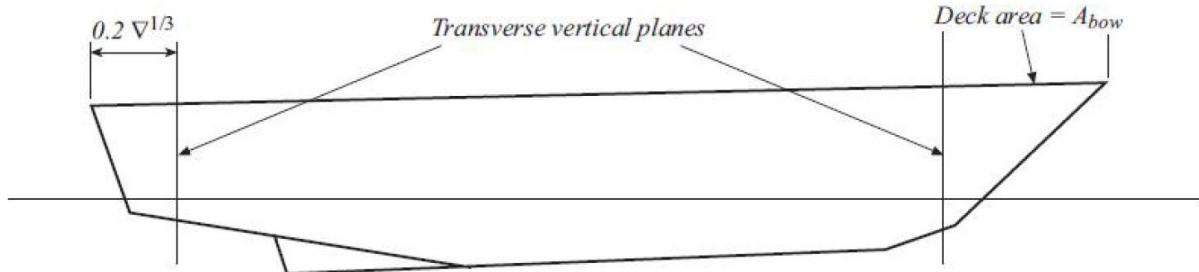


Fig. 2.6.9

**2.6.9 Extent of bottom damage in areas vulnerable to raking damage**

**2.6.9.1 Application**

- .1 Any part of the surface of the hull(s) is considered to be vulnerable to raking damage if:
  - .1.1 it is in contact with the water at 90 % of maximum speed in smooth water, and
  - .1.2 it also lies below two planes which are perpendicular to the craft centreline plane and at heights as shown in [Fig. 2.6.9.1](#). 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 [2.6.10](#).

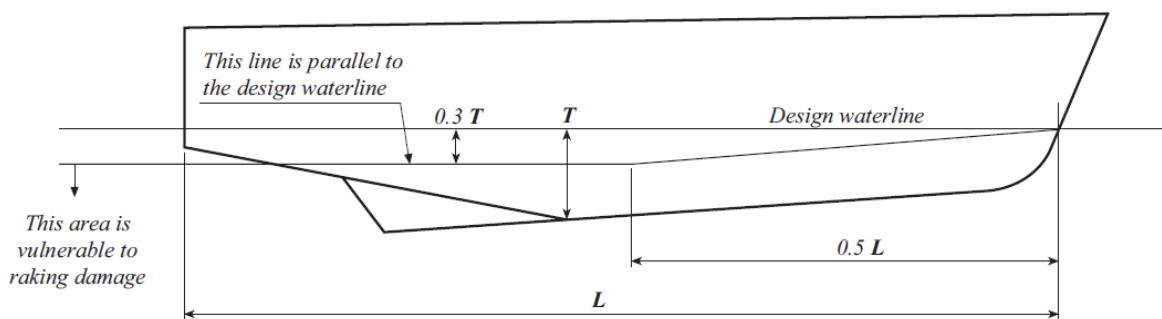


Fig. 2.6.9.1

where:

**T** = maximum draught of the hull (each hull considered individually in the case of multihulls) to the design waterline, excluding any non buoyant structure, provided that structures such as single plate skegs or solid metal appendages shall be considered to be non-buoyant and thus excluded.

**2.6.9.2 Extent**

**2.6.9.2.1** Two different longitudinal extents shall be considered separately:

- .1 55 % of the length  $L$ , measured from the most forward point of the underwater buoyant volume of each hull; and

.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 50 m.

**2.6.9.2.2** Except as provided below, the penetration normal to the shell shall be  $0,04\sqrt[3]{V}$  or 0,5 m, whichever is the lesser, in association with a girth along the shell equal to  $0,1\sqrt[3]{V}$ , where  $V$  is the volume of displacement corresponding to the design waterline ( $m^3$ ). However this penetration or girth shall under no circumstances extend above the vertical extent of the vulnerable area as specified in [2.6.9.1.1](#).

**2.6.9.2.3** The shape of damage shall be assumed to be rectangular in the transverse plane as illustrated in [Fig. 2.6.9.2](#) below. Damage is to be assumed at a series of sections within the defined longitudinal extent in accordance with [Fig. 2.6.9.2](#), the mid-point of the damaged girth being maintained at a constant distance from the centreline throughout that longitudinal extent.

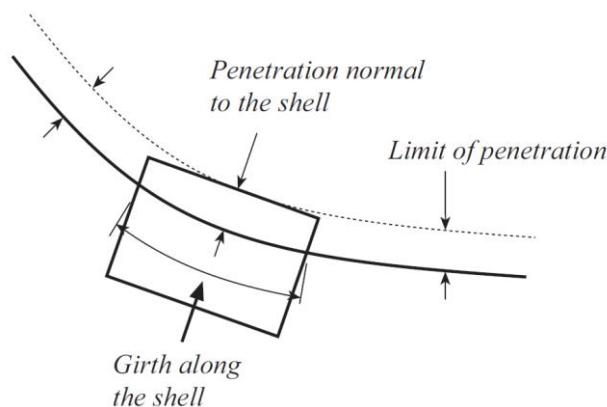


Fig. 2.6.9.2

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

### 2.6.10.1 Application

This applies to all parts of the hull(s) below the design waterline which are not defined as vulnerable to raking damage in [2.6.9.1](#). Damage shall not be applied at the same time as that defined in [2.6.7](#) or [2.6.9](#).

### 2.6.10.2 Extent

The following extent of damage shall be assumed:

.1 the length of damage in the fore-and-aft direction shall be  $0,75\sqrt[3]{V}$ , or  $(3 \text{ m} + 0,225\sqrt[3]{V})$ , or 11 m whichever is the least;

.2 the athwartships girth of damage shall be  $0,2\sqrt[3]{V}$ ; and

.3 the depth of penetration normal to the shell shall be  $0,02\sqrt[3]{V}$ , where:

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

.4 the shape of damage shall be assumed to be rectangular in the plane of the shell of the craft, and rectangular in the transverse plane as illustrated in [Fig. 2.6.9.2](#).

**2.6.11** In applying [2.6.9](#) and [2.6.10](#) to multihull craft, an obstruction at or below the design waterline of 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.

**2.6.12** Following any of the postulated damages detailed in [2.6.6](#) to [2.6.11](#), the craft in still water shall have sufficient buoyancy and positive stability to simultaneously ensure that:

.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 5 and 6](#) according to [Table 2.3.4](#). Within the range of positive stability governed by the criteria of [Annexes 5 or 6](#), no unprotected opening shall be submerged.

**2.6.13** Downflooding openings referred to in [2.6.12.1](#) and [2.6.12.2](#) 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** On all craft, where an accurate inclining experiment is impractical owing to the height of the centre of gravity (VCG or KG) being less than one third of the transverse metacentric height ( $GM_T$ ), the Administration may accept estimation of KG by detailed calculation in place of an inclining experiment. In such cases, a displacement check shall be undertaken to confirm the calculated lightship characteristics, including LCG, which may be accepted if the measured lightship displacement and LCG are respectively within 2 % and 1 %  $L$  relative to the estimate.

**2.7.3** The master 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.

**2.7.4** 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.

**2.7.5** 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.

**2.7.6** 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.

**2.7.7** 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. For amphibious air-cushion vehicles this may be achieved by the use of draught gauges in conjunction with deck datum plates.

**2.7.8** 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.

**2.7.9** 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 crafts 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 displacement 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.
- .7 Passengers assumed to be occupying seats shall be taken as having a vertical centre of gravity corresponding to being seated, with all others standing.
- .8 On the decks where assembly stations are located, the number of passengers on each deck shall be that which generates the maximum heeling moment. Any remaining passengers shall be assumed to occupy decks adjacent to those on which the assembly stations are located, and positioned such that the combination of number on each deck and total heeling moment generate the maximum static heel angle.
- .9 Passengers shall not be assumed to gain access to the weather deck nor be assumed to crowd abnormally towards either end of the craft unless this is a necessary part of the planned evacuation procedure.
- .10 Where there are seats in areas occupied by passengers, one passenger per seat shall be assumed, passengers being assigned to the remaining free areas of the deck (including stairways, if appropriate) at the rate of four per square metre.

## 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<sup>10</sup> 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 4 shall not 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 1.14 of Annex 4 and due to turning shall not exceed 12°.

2.12.3 Demonstrating the effect of the passenger heeling moment calculated as given by 2.10 above, or a defined beam wind pressure when at speed, shall be established by conducting a trial or model test with an equivalent heeling moment applied by test weights. Passenger movement may only be neglected on craft where the safety announcement (refer to 8.4.1 and 18.7) expressly requires passengers to remain seated throughout the voyage.

## 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 2.6.11, in addition to satisfying the requirements of 2.6.12 and 2.6.13, 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<sup>11</sup> 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;

<sup>10</sup> Attention is drawn to the longitudinal centre-of-gravity limitations established in compliance with 17.3.

<sup>11</sup> Refer to the Recommendations on a standard method for establishing compliance with the requirements for cross-flooding arrangements in passenger ships, adopted by the Organization by resolution A.266(VIII), as amended, and the Recommendation on a standard method for evaluating cross-flooding arrangements, adopted by the Maritime Safety Committee by resolution MSC.245(83).

- .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 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<sup>11</sup>, 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.

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## Section 3 Structures

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### 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 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 shall be adequate for the intended use of the craft.

### 3.3 Structural Strength

The structure shall 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 which can occur on the craft, shall not:

- .1 impair the integrity of structure during the anticipated service life of the craft or the service life agreed with the Administration;
- .2 hinder normal functioning of machinery and equipment; and
- .3 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, BKI 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 shall 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 shall require full-scale trials to be undertaken in which loadings are determined. Cognisance shall 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 contains the requirements for structural scantlings of the craft to which these Rules apply, i.e. to craft for which  $V \geq 7,16 \cdot \Delta^{1/6}$ . Craft for which  $V/\sqrt{L} \geq 10$  shall be individually considered by BKI ( $V$  in knots,  $\Delta$  in tonnes,  $L$  in metre).

For what concerns multihull craft, this Section provides the requirements for scantlings of catamarans and trimarans. Other craft will be considered in each separate case by BKI.

.2 The requirements for scantlings of hydrofoils and air-cushion vehicles are contained in [Appendix 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

##### C3.1.2.1 General

.1 BKI may require direct calculations to be carried out, if deemed necessary.

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

.2 In order to increase the flexibility in the structural design of ships BKI also accepts direct calculations with computer programs. The aim of such analyses should be the proof of equivalence of a design with the rule requirements.

.3 Direct calculations may also be used in order to optimize a design; in this case only the final results are to be submitted for review.

### C3.1.2.2 General programs

.1 The choice of computer programs according to "State of the Art" is free. The programs may be checked by BKI through comparative calculations with predefined test examples. A generally valid approval for a computer program is, however, not given by BKI.

.2 Direct calculations may be used in the following fields

- global strength
- longitudinal strength
- beams and grillages
- detailed strength

.3 For such calculation the computer model, the boundary condition and load cases are to be agreed upon with BKI. The calculation documents are to be submitted including input and output. During the examination it may prove necessary that BKI perform independent comparative calculations.

.4 BKI is prepared to carry out the following calculations of this kind within the marine advisory services:

#### .4.1 Strength

Linear and/or non-linear strength calculations with the FE-method:

For an automated performance of these calculations, a number of effective pre- and post processing program is at disposal:

- calculation of seaway loads as per modified strip method or by 3 D-panel method
- calculation of resultant accelerations to ensure quasi-static equilibrium
- calculation of composite structures
- evaluation of deformations, stresses, buckling behaviour, ultimate strength and local stresses, assessment of fatigue strength

#### .4.2 Vibrations

Calculation of free vibrations with the FE-method as well as forced vibrations due to harmonic or shock excitation:

- global vibrations of hull, aft ship, deckhouse, etc.
- vibrations of major local components, such as rudders, radar masts, etc.
- local vibrations of plate fields, stiffeners and panels
- vibrations of simply or double-elastically mounted aggregates

A number of pre- and post processing programs is available here as well for effective analyses:

- calculation of engine excitation forces/moments
- calculation of propeller excitation forces (pressure fluctuations and shaft bearing reactions)
- calculation of hydrodynamic masses
- graphic evaluation of amplitude level as per ISO 6954 recommendations or as per any other standard
- noise predictions

### C3.1.3 Units

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

- thickness of plating [mm]
- section modulus of stiffeners [ $\text{cm}^3$ ]
- shear area of stiffeners [ $\text{cm}^2$ ]
- span and spacing of stiffeners [m]
- stresses [MPa]
- concentrated loads [kN]
- distributed loads [kN/m] or [kPa]

#### **C3.1.4 Documents for Approval**

The following documents are to be submitted. To facilitate a smooth and efficient approval process they shall be submitted electronically to BKI HO.

##### **.1 Midship section**

The cross sectional plans (midship section, other typical sections) shall contain all necessary data on the scantlings of the longitudinal and transverse hull structure as well as details of anchor and mooring equipment.

##### **.2 Longitudinal section**

The plan of longitudinal sections shall contain all necessary details on the scantlings of the longitudinal hull structure and on the location of the watertight bulkheads and the deck supporting structures, the arrangement of superstructures and deck houses.

##### **.3 Decks**

Plans of the decks showing the scantlings of the deck structures, length and breadth of cargo hatches, openings above the engine and boiler room, and other deck openings. On each deck, deck load caused by cargo is to be defined as assumed in determining the scantlings of the decks and their supports.

##### **.4 Shell**

Drawings of shell expansion, containing full details on the location and size of the openings and drawings of the sea chests.

##### **.5 Bulkheads**

Drawings of the transverse, longitudinal and wash bulkheads and of all tank boundaries, with details on densities of liquids, heights of overflow pipes and set pressures of the pressure or vacuum relief valves (if any).

##### **.6 Bottom structure**

Drawings of single and double bottom showing the arrangement of the transverse and longitudinal girders as well as the water and oil tight subdivision of the double bottom.

##### **.7 Engine and boiler seatings**

Drawings of the engine and boiler seatings, the bottom structure under the seatings and of the transverse structures in the engine room, with details on fastening of the engine foundation plate to the seating, as well as type and output of engine.

## .8 Appendages

Drawings of rudder, shaft brackets, stabilizers including supports, bearing materials and propeller details.

## .9 Longitudinal strength

Maximum and minimum still water bending moments, shear forces and, if necessary, torsional moments. This includes the mass distribution for the envisaged loading conditions and the distribution of section moduli and moduli of inertia over the ship's length.

## .10 Materials

The drawings mentioned in .1 – .8 and .13 shall contain details on the hull materials (e.g. hull structural steel grades, standards, material numbers). Where higher tensile steels or materials other than ordinary hull structural steels are used, drawings for possible repairs have to be placed on board.

## .11 Weld joints

The drawings listed in .1 – .8 and .13 shall contain details on the welded joints e.g. weld shapes and dimensions and weld quality. For the relevant data for manufacturing and testing of welded joints see [Rules for Welding \(Pt.1, Vol.VI\)](#).

## .12 Lashing and stowage devices

Drawings containing details on stowage and lashing of cargo (e.g. containers, car decks). In the drawings the location of the connections and the appropriate substructures at the ship shall be shown in detail.

## .13 Substructures

Drawings of substructures below steering gears, windlasses and chain stoppers as well as masts and boat davits, supporting structure of cargo masts, cranes, etc. together with details on loads to be transmitted into structural elements.

## .14 Additional information for fibre reinforced plastic (FRP) craft

For FRP craft, the drawing and documents to be submitted for examination and listed in [C3.1.4](#) are to contain the following additional information:

- arrangement of laminate for the various structural elements: thickness, definition of successive layers of reinforcement, areal weight of reinforcement layers, mass or volume fraction of reinforcement layers, 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

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

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

### C3.1.5 Definitions and symbols

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 deck-houses, 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.
- “Wet deck”: For multihull craft, the wet deck is the bottom structure connecting the hulls which is defined as cross-deck.
- “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.

where :

- $L$  = Rule length [m], equal to LWL which is the waterline measured with the craft at rest in calm water and, for SESs, in the off-cushion condition, for trimarans  $L$  will be defined in each separate case at the discretion of BKI.
- $FP$  = 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 [m], of the craft
- $B_w$  = the greatest moulded breadth [m], measured on the waterline at draught  $T$ ; for catamarans,  $B_w$  is the breadth of each hull; for trimarans,  $B_w$  will be defined in each separate case at the discretion of BKI.
- $H$  = depth [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,  $H$  will be defined in each separate case at the discretion of BKI)

$T$  = draught of the craft [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>) [t]

$C_B$  = total block coefficient, defined as follows:  
 $= \Delta / (1,025 \cdot L \cdot B_w \cdot T)$

For catamarans,  $C_B$  is to be calculated for a single hull, assuming  $\Delta$  equal to one half of the craft's displacement; for trimarans the calculation of  $C_B$  depends on the distribution of displacement of each hull. It will be defined in each separate case at the discretion of BKI.

$V$  = maximum service speed [kn]

$g$  = acceleration of gravity, equal to 9,81 m/s<sup>2</sup>

LCG = longitudinal centre of gravity of the craft.

### C3.1.6 Rounding-Off Tolerances

Where in determining plate thicknesses in accordance with the provisions of this Section the figures differ from full or half mm, they may be rounded off to full or half millimeters up to 0,2 or 0,7; above 0,2 or 0,7 mm they are to be rounded up.

If plate thicknesses are not rounded the calculated required thicknesses shall be shown in the drawings. The section moduli of profiles usual in the trade and including the effective width according to C3.7.4 may be 3 % less than the required values according to the following rules for dimensioning.

### C3.1.7 Workmanship

#### C3.1.7.1 General

##### .1 Requirements to be complied with by the manufacturer

.1.1 The manufacturing plant shall be provided with suitable equipment and facilities to enable proper handling of the materials, manufacturing processes, structural components, etc. BKI reserve the right to inspect the plant accordingly or to restrict the scope of manufacture to the potential available at the plant.

.1.2 The manufacturing plant shall have at its disposal sufficiently qualified personnel. BKI is to be advised of the names and areas of responsibility of all supervisory and control personnel. BKI reserve the right to require proof of qualification.

##### .2 Quality control

.2.1 As far as required and expedient, the manufacturer's personnel has to examine all structural components both during manufacture and on completion, to ensure that they are complete, that the dimensions are correct and that workmanship is satisfactory and meets the standard of good shipbuilding practice.

.2.2 Upon inspection and corrections by the manufacturing plant, the structural components are to be shown to the BKI Surveyor for inspection, in suitable sections, normally in unpainted condition and enabling proper access for inspection.

.2.3 The Surveyor may reject components that have not been adequately checked by the plant and may demand their re-submission upon successful completion of such checks and corrections by the plant.

### C3.1.7.2 Structural details

#### .1 Details in manufacturing documents

.1.1 All significant details concerning quality and functional ability of the component concerned shall be entered in the manufacturing documents (work-shop drawings, etc.). This includes not only scantlings but - where relevant - such items as surface conditions (e.g. finishing of flame cut edges and weld seams), and special methods of manufacture involved as well as inspection and acceptance requirements and where relevant permissible tolerances. So far as for this aim a standard shall be used (works or national standard, etc.) it shall be harmonized with BKI. This standard shall be based on the IACS Recommendation 47 Shipbuilding and Repair Quality Standard for New Construction. For weld joint details, see [Section C.3.2.4.1](#).

.1.2 If, due to missing or insufficient details in the manufacturing documents, the quality or functional ability of the component cannot be guaranteed or is doubtful, BKI may require appropriate improvements. This includes the provision of supplementary or additional parts (for example reinforcements) even if these were not required at the time of plan approval or if - as a result of insufficient detailing - such requirement was not obvious.

#### .2 Cut-outs, plate edges

.2.1 The free edges (cut surfaces) of cut-outs, hatch corners, etc. are to be properly prepared and are to be free from notches. As a general rule, cutting drag lines, etc. shall not be welded out, but are to be smoothly ground. All edges should be broken or in cases of highly stressed parts, should be rounded off.

.2.2 Free edges of flame or machine cut plates or flanges are not to be sharp cornered and are to be finished off as laid down in [2.2.1](#). This also applies to cutting drag lines, etc., in particular to the upper edge of shear strake and analogously to weld joints, changes in sectional areas or similar discontinuities.

#### .3 Cold forming

.3.1 For cold forming (bending, flanging, beading) of plates the minimum average bending radius shall not fall short of  $3 \cdot t$  ( $t$  = plate thickness) and shall be at least  $2 \cdot t$ . Regarding the welding of cold formed areas, see [C3.6.1.2.6](#).

.3.2 In order to prevent cracking, flame cutting flash or sheering burrs shall be removed before cold forming. After cold forming all structural components and, in particular, the ends of bends (plate edges) are to be examined for cracks. Except in cases where edge cracks are negligible, all cracked components are to be rejected. Repair welding is not permissible.

#### .4 Assembly, alignment

.4.1 The use of excessive force is to be avoided during the assembly of individual structural components or during the erection of sections. As far as possible major distortions of individual structural components should be corrected before further assembly.

.4.2 Girders, beams, stiffeners, frames, etc. that are interrupted by bulkheads, decks, etc. shall be accurately aligned. In the case of critical components, control drillings are to be made where necessary, which are then to be welded up again on completion.

.4.3 After completion of welding, straightening and aligning shall be carried out in such a manner that the material properties will not be influenced significantly. In case of doubt, BKI may require a procedure test or a working test to be carried out.

### C3.1.8 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 BKI 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. The [Guidance for Corrosion Protection and Coating Systems \(Pt.1, Vol.G\)](#) are to be observed.

.3 This document shall 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 BKI surveyor at each visit.

## C3.2 Materials and Connections

### C3.2.1 General requirements

All materials to be used for the structural members indicated in the Construction Rules are to be in accordance with the [Rules for Materials \(Pt.1, Vol.V\)](#) or [Rules for Non-Metallic Materials \(Pt.1, Vol.XIV\)](#), as applicable. Materials the properties of which deviate from these Rule requirements may only be used upon special approval.

### C3.2.2 Steel Structures

#### C3.2.2.1 Normal strength hull structural steel

.1 Normal strength hull structural steel is a hull structural steel with a minimum nominal upper yield point  $R_{eH}$  of 235 MPa and a tensile strength  $R_m$  of 400 - 520 MPa.

.2 The material factor k in the formulae of this Section is to be taken 1,0 for normal strength hull structural steel.

.3 Normal strength hull structural steel is grouped into the grades KI-A, KI-B, KI-D, KI-E, which differ from each other in their toughness properties.

.4 If for special structures the use of steels with yield properties less than 235 MPa has been accepted, the material factor k is to be determined by:

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

#### C3.2.2.2 Higher strength hull structural steels

.1 Higher strength hull structural steel is a hull structural steel, the yield and tensile properties of which exceed those of normal strength hull structural steel. According to the [Rules for Materials \(Pt.1, Vol.V\)](#), for three groups of higher strength hull structural steels the nominal upper yield stress  $R_{eH}$  has been fixed at 315, 355 and 390 MPa respectively. Where higher strength hull structural steel is used, for scantling purposes the values in [Table C3.2.1](#) are to be used for the material factor k.

**Table C3.2.1 Material factor k**

R <sub>eH</sub> [MPa]	k
315	0,78
355	0,72
390	0,68

For higher strength hull structural steel with other nominal yield stresses up to 390 MPa, the material factor k may be determined by the following formula:

$$k = (235/R_{eH})^{0,75}$$

**Note:**

*Especially when higher strength hull structural steels are used, limitation of permissible stresses due to buckling and fatigue strength criteria may be required.*

.2 Higher strength hull structural steel is grouped into the following grades, which differ from each other in their toughness properties:

KI-A 32/36/40

KI-D 32/36/40

KI-E 32/36/40

KI-F 32/36/40

.3 Where structural members are completely or partly made from higher strength hull structural steel, a suitable Notation will be entered into the ship's certificate.

.4 Regarding welding of higher strength hull structural steel, see [Rules for Welding \(Pt.1, Vol.VI\)](#).

### C3.2.2.3 Structural members which are stressed in direction of their thickness

In case of high local stresses in the thickness direction, e.g. due to shrinkage stresses in single bevel or double bevel T-joints with a large volume of weld metal, steels with guaranteed material properties in the thickness direction according to the [Rules for Materials \(Pt.1, Vol.V\) Sec. 4, I.](#) are to be used.

### C3.2.2.4 Forged Steel and Cast Steel

Forged steel and cast steel for stem, stern frame, rudder post as well as other structural components, which are subject of this Rule, are to comply with the [Rules for Materials \(Pt.1, Vol.V\)](#). The tensile strength of forged steel and of cast steel is not to be less than 400 MPa. In this respect beside strength properties also toughness requirements and weldability shall be observed.

### C3.2.2.5 Austenitic Steels

Where austenitic steels are applied having a ratio R<sub>p0,2</sub>/R<sub>m</sub> ≤ 0,5, after special approval the 1 % proof stress R<sub>p1,0</sub> may be used for scantling purposes instead of the 0,2 % proof stress R<sub>p0,2</sub>.

Table C3.2.2 Aluminium alloys for welded construction

Guaranteed mechanical characteristics <sup>1</sup>									
Aluminium alloy				Unwelded condition		Welded condition			
Alloy <sup>2</sup>	Products	Temper <sup>2</sup>	Thickness [mm]	R <sub>p0,2</sub> [MPa] <sup>4</sup>	R <sub>m</sub> [MPa] <sup>5</sup>	R <sub>p0,2'</sub> [MPa] <sup>4</sup>	R <sub>m'</sub> [MPa] <sup>5</sup>		
5083	rolled	0 / H111 / H112	t ≤ 50	125	275	125	275		
		H116		215	305				
		H32 / H321							
5083	extruded	0 / H111	t ≤ 50	110	270	110	270		
		H112		125					
5086	rolled	0 / H111 / H112	t ≤ 50	100	240	100	240		
		H116		195	270				
		H32 / H321		185					
5086	extruded	0 / H111 / H112	t ≤ 50	95	240	95	240		
5383	rolled	0 / H111	t ≤ 40	145	290	145	290		
		H116 / H321		220	305				
5383	extruded	0 / H111	t ≤ 50	145	209	145	290		
		H112		190	310				
5059	rolled	0 / H111	t ≤ 50	160	330	155	300		
		H116 / H321	t ≤ 20	270	370				
			20 < t ≤ 40	260	360				
5059	extruded	H112	t ≤ 50	200	330	155	300		
5454	rolled	0 / H111	t ≤ 40	85	215	85	215		
		H32		180	260				
5754	rolled	0 / H111 / H112	t ≤ 50	80	190	80	190		
		H32	t ≤ 40	165	240				
6005A	extruded	T5 / T6	t ≤ 50	215	260	115	165		
6060 <sup>3</sup>	extruded	T5	t ≤ 5	120	160	65	95		
			5 < t ≤ 25	100	140				
6061	extruded	T5 / T6	t ≤ 50	240	260	115	165		
6082	extruded	T5 / T6	t ≤ 50	260	310	115	170		
6106	extruded	T6	t ≤ 10	200	250	65	130		

<sup>1</sup> 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.

<sup>2</sup> Other grades or tempers may be considered, subject to the Society's agreement.

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

<sup>4</sup> R<sub>p0,2</sub> and R<sub>p0,2'</sub> are the minimum guaranteed yield stresses at 0,2 % in unwelded and welded condition respectively.

<sup>5</sup> R<sub>m</sub> and R<sub>m'</sub> are the minimum guaranteed tensile strengths in unwelded and welded condition respectively.

### C3.2.3 Aluminium alloy structures

#### C3.2.3.1 General

All aluminium materials to be used for the structural members indicated in the Construction Rules are to be in accordance with the [Rules for Materials \(Pt.1, Vol.V\) Sec. 10](#). Materials the properties of which deviate from these Rule requirements may only be used upon special approval.

The strength properties for some typical aluminium alloys are given in [Table C3.2.2](#).

### C3.2.3.2 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](#).

### C3.2.3.3 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:

$$k = 100/R_{p0,2'}$$

$R_{p0,2'}$  = minimum guaranteed yield stress of the parent metal in welded condition [MPa], but not to be taken greater than 70 % of the minimum guaranteed tensile strength of the parent metal in welded condition  $R'_m$  [MPa] (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.

### C3.2.3.4 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      BKI 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 BKI surveyor.

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

### C3.2.4 General Welding Requirements

#### *Preface*

*The content of C3.2.4 and C3.6 is to a large extent identical to that of the Rules for Welding (Pt.1, Vol.VI), Sec. 12, G. Because of the re-issues of Rules for Welding (Pt.1, Vol.VI) referred to and this Rules at different times, some temporary divergences may arise and in such circumstances the more recent Rules shall take precedence.*

#### C3.2.4.1 Information contained in manufacturing documents

.1      The shapes and dimensions of welds and, where proof by calculation is supplied, the requirements applicable to welded joints (the weld quality grade, detail category) are to be stated in drawings and other manufacturing documents (parts lists, welding and inspection schedules). In special cases, e.g. where special materials are concerned, the documents shall also state the welding method, the welding consumables used, heat input and control, the weld build-up and any post-weld treatment which may be required.

.2      Symbols and signs used to identify welded joints shall be explained if they depart from the symbols and definitions contained in the relevant standards (e.g. DIN standards). Where the weld preparation (together with approved methods of welding) conforms both to normal shipbuilding practice and to these Rules and recognized standards, where applicable, no special description is needed.

#### C3.2.4.2 Materials, weldability

.1      Only base materials of proven weldability may be used for welded structures. Any approval conditions of the steel or of the procedure qualification tests and the steelmaker's recommendations are to be observed.

.2      For normal strength hull structural steels grades A, B, D and E which have been tested by BKI, weldability normally is considered to have been proven. The suitability of these base materials for high efficiency welding processes with high heat input shall be verified.

.3      Higher strength hull structural steels grade AH/DH/EH/FH which have been approved by BKI in accordance with the relevant requirements of Rules for Materials and Welding normally have had their weldability examined and, provided their handling is in accordance with normal shipbuilding practice, may be considered to be proven. The suitability of these base materials for high efficiency welding processes with high heat input shall be verified.

.4      High strength (quenched and tempered) fine grain structural steels, low temperature steels, stainless and other (alloyed) structural steels require special approval by BKI. Proof of weldability of the respective steel is to be presented in connection with the welding procedure and welding consumables.

.5      Cast steel and forged parts require testing by BKI. For castings intended to be used for welded shipbuilding structures the maximum permissible values of the chemical composition according to the Rules for Materials (Pt.1, Vol.V), Sec. 7, B.4 and Table 7.1 have to be observed.

.6      Aluminium alloys require testing by BKI. Proof of their weldability shall be presented in connection with the welding procedure and welding consumables.

.7 Welding consumables used are to be suitable for the parent metal to be welded and are to be approved by BKI.

#### C3.2.4.3 Manufacture and testing

.1 The manufacture of welded structural components may only be carried out in workshops or plants that have been approved. The requirements that have to be observed in connection with the fabrication of welded joints are laid down in the [Rules for Welding \(Pt.1, Vol.VI\)](#).

.2 The weld quality grade of welded joints without proof by calculation (see [C3.2.4.1](#)) depends on the significance of the welded joint for the total structure and on its location in the structural element (location to the main stress direction) and on its stressing. For details concerning the type, scope and manner of testing, see [Rules for Welding \(Pt.1, Vol.VI\) Sec. 12, I](#). Where proof of fatigue strength is required, in addition the requirements of [C3.7.6](#) apply.

#### C3.2.4.4 Welding processes for aluminium alloys

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 BKI at the time of the approval of welding procedures.

#### 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 BKI.

.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 BKI's agreement.

.4 The use of transition joints made of aluminium/steel-cladded plates or profiles is subject to BKI'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 Materials

###### .1 Constituent materials

Constituent materials contributing to the structural integrity shall be BKI-approved. For a composite structure this will include fibre fabrics, laminating resin (matrix), structural adhesives and core materials.

In individual cases it may be acceptable to provide BKI-approval equivalence by tests.

Production facilities where the vessel and/or major structural components are constructed need to obtain a BKI Shop approval for composite components.

The general requirements for material and production are defined in [Rules for Fiberglass Reinforced Plastics Ship \(Pt.3, Vol.V\)](#).

In addition to this it is strongly recommended to carry out pre-construction baseline testing.

## .2 Baseline testing

This testing of materials is done on pre-fabricated samples, representing typical construction methods and lay-up intended for the particular project. Testing and evaluation should be finished before the vessel's construction starts.

With a variety of tests, cognition shall be attained about:

- Confirming design values, i.e. bending stiffness, bending capacity limited by skins, bending/shear capacity limited by core and/or core bonding. All these issues could be covered with long beam bending tests or shorter beam bending tests.
- Proper building performance.
- Compatibility of materials.

## .3 As-built testing

In order to obtain confirmation about the quality of the finished product, representative test samples need to be taken from the hull and be tested. These test samples can be taken from cut-outs and the scope of testing is depending on the composite design of the vessel and its areas of importance (usually 3 or 4 point bend test on sandwich beams or compressive strength test for solid laminates).

# 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:

$$a_{CG} = c_{HSC} \cdot c_{RW} \cdot \frac{V}{\sqrt{L}} \quad [g]$$

where  $c_{HSC}$  values are indicated in [Table C3.3.1](#).

Table C3.3.1

Type of service	Passenger Ferry, Cargo	Supply	Pilot	Rescue
$c_{HSC}$	0,24	0,36	0,50	0,60

$c_{RW}$  = service range coefficient

= 1,00 for unlimited service range

= 0,90 for P

= 0,75 for L

= 0,60 for T

**Note:**

The provisions in [Section 1, 1.3.4](#) apply irrespective of the above service range restrictions.

.2 For craft with type of service “Passenger, Ferry, Cargo” an acceleration greater than  $a_{CG} = 1,0 \text{ g}$  may not be adopted for the purpose of defining limit operating conditions.

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

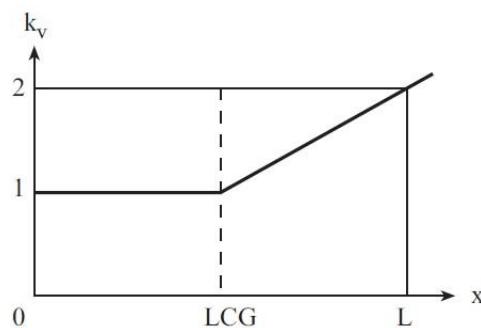
$$a_v = k_v \cdot a_{CG} \quad [\text{g}]$$

$k_v$  = longitudinal distribution factor, not to be less than (see [Fig. C3.3.1](#))

$$= 1 \quad \text{for } x \leq \text{LCG}$$

$$= 2 - \frac{1 - \frac{x}{L}}{1 - \frac{\text{LCG}}{L}} \quad \text{for } x > \text{LCG}$$

$a_{CG}$  = design acceleration at LCG



**Fig. C3.3.1**

.4 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 [g] at the calculation point of the craft may be obtained from:

$$a_t = 2,5 \cdot \frac{H_s}{L} \cdot \left( 1 + 5 \cdot \left( 1 + \frac{V_x}{6\sqrt{L}} \right)^2 \cdot \frac{r}{L} \right) \quad [\text{g}]$$

$H_s$  = permissible significant wave height at actual craft speed  $V_x$  (see [C3.3.3](#)),

$r$  = distance of the point from:

- 0,5 H 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 BKI.

.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 shall 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 [C3.3.1.7](#) below.

.5 The limit operating conditions are defined, at the discretion of BKI, 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 [m], greater than the following:

$$H_{sm} = 5 \cdot \frac{a_{CG}}{V} \cdot \frac{L^{1,5}}{6 + 0,14 \cdot L} \quad [m]$$

where vertical acceleration  $a_{CG}$  is defined in [C3.3.1](#), but need not to be taken less than 1,0 g.

.8 For craft with a particular shape or other characteristics, BKI 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 vertical acceleration at LCG

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

$$H_s = \frac{10,9 \cdot a_{CG} \cdot K_{cat} \cdot K_H}{K_F^2} \quad [m]$$

with

$$\begin{aligned}
 K_{\text{cat}} &= 1 + \frac{B_{\text{cl}} - H_{\text{sm}}}{L} \geq 1,0 \\
 &= 1,0 \quad \text{for monohulls and trimarans} \\
 B_{\text{cl}} &= \text{distance between the center lines of the hulls of catamarans} \\
 K_F &= \frac{3,23}{L} \cdot (2,43 \cdot \sqrt{L} + V_x) \\
 K_H &= K^{0,35} \sqrt{\left(\frac{1}{K^2} - 0,11\right)^2 + 1} \\
 K &= \frac{K_F}{K_T} \\
 K_T &= \sqrt{\frac{4,6 \cdot A_{\text{wp}}}{\Delta} \cdot \sqrt{\frac{x_{\text{CG}}}{L}}}
 \end{aligned}$$

$A_{\text{wp}}$  = area of water line  
 $x_{\text{CG}}$  = distance [m] from aft perpendicular to LCG

.4 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 BKI, on the basis of motion characteristics of the craft.

.5 The reduction of vertical acceleration  $a_{\text{CG}}$  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  $V_{\text{sl}}$  induced by stabilization 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, catamarans and trimarans, 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 apply.

.2 For catamarans and trimarans, the transverse bending moment, the torsional bending moment and the vertical shear force as given in C3.4.2 are depending on vertical acceleration  $a_{\text{CG}}$ . Therefore, the requirements of C3.3.3.2 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 100 m, 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 stabilization 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 BKI 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 In general, the wave induced bending loads and shear forces according to [C3.4.1.2](#) are accepted.

.2 For monohulls of unusual form and design and for ships with extreme bow flare, BKI may require determination of vertical wave-induced bending moments and shear forces as well as their distribution over the ship's length considering various mass distributions. Accepted calculation procedures are to be applied.

.3 Where deemed necessary, stresses due torsion and/or horizontal wave bending are to be considered in a global stress analysis.

**Note:**

*Upon request, such calculations will be performed by BKI.*

#### C3.4.1.2 Bending moment and shear force

##### .1 General

For the envisaged mass distributions for the defined loading condition values of vertical still water bending moment are to be calculated over the ship's length.

The values of the total longitudinal bending moments and shear force are given, in first approximation, by the formula in [C3.4.1.2.3](#) and [C3.4.1.2.4](#). The formula in [C3.4.1.2.2](#) is to be applied when deemed necessary by BKI on the basis of the motion characteristics of the ship.

For ships having  $L < 100$  m, the total bending moments in hogging or in sagging condition respectively, 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](#).

Hull girder loads determined by direct calculation according to [C3.4.1.2.6](#) are accepted.

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

$$M_{blH} = M_{blS} = 0,55 \cdot \Delta \cdot L \cdot (1 + a_{CG}) \quad [\text{kN}\cdot\text{m}]$$

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

$$M_{blH} = M_{sh} + 0,21 \cdot C \cdot L^2 \cdot B \cdot C_B \cdot c_{RW} \quad [\text{kN}\cdot\text{m}]$$

$$M_{blS} = M_{ss} + 0,12 \cdot C \cdot L^2 \cdot B \cdot (C_B + 0,7) \cdot c_{RW} \quad [\text{kN}\cdot\text{m}]$$

$M_{sh}$  = still water hogging bending moment [ $\text{kN}\cdot\text{m}$ ]

$M_{ss}$  = still water sagging bending moment [ $\text{kN}\cdot\text{m}$ ]

$c_{RW}$  = see [C3.3.1.1](#)

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

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

## .4 Total shear force

$$T_{bl} = \frac{3,2 \cdot M_{bl}}{L} \quad [\text{kN}]$$

$M_{bl}$  = 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

$K_M$  = longitudinal distribution factor as shown on [Fig. C3.4.1](#).

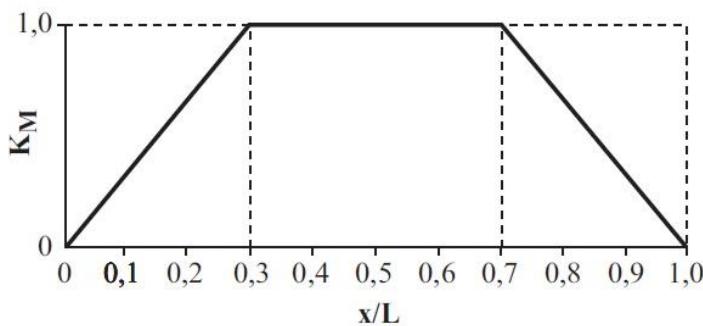


Fig. C3.4.1

## .6 Direct calculation of hull girder design

As a basis for direct calculation of design values, loading conditions corresponding to the actual weight distribution are to be used.

In principle, the estimated representative mass distributions for the defined loading conditions will be the average of the mass distributions that result in the highest and the lowest stillwater vertical bending moment. This representative mass distribution leads to an average displacement and an average vertical stillwater bending moment.

Analysis of the craft in harmonic waves is to be executed by direct computational methods that evaluate response amplitude operators of wave-induced vertical shear forces and bending moments. Using an adequate nonlinear correction procedure that accounts for a realistic wave breaking criterion, the wave contour along the craft's side has to be determined for relevant harmonic waves of selected amplitudes and phase positions. Hydrodynamic pressures are to be extrapolated up to the wave contour.

Hydrodynamic calculations are to be performed for speeds that correspond to the operational profile of the craft.

After completing the nonlinear correction procedure, the forces acting on the craft, including inertial forces, generally are not in balance. Equilibrium can be achieved by resolving the motion equations, resulting in nonlinearly corrected wave amplitude dependent response values of, e.g., bending moments. Repeating this procedure for different wave periods and wave headings yields nonlinearly corrected (pseudo) response amplitude operators that depend on wave height. Depending on the considered phase locations, two separate sets of transfer functions result, one set for the sagging condition and another set for the hogging condition.

Treating these nonlinearly corrected pseudo transfer functions like transfer functions of linear systems, stochastic methods are to be used to evaluate shear forces and bending moments. For stationary seaways, a  $\cos^2$  distribution of wave energy about the principal direction of wave encounter direction is to be assumed. The seaways' main wave headings relative to the craft are to be considered as equally distributed. Wave heights used to obtain the wave amplitude dependent pseudo transfer functions are to be taken as equal to the significant wave height of the corresponding natural seaway.

Calculated long-term values of shear forces and bending moments are to be based on long-term wave statistics relevant for the craft's operating area.

For the sagging condition only, an additional shear force and bending moment caused by slamming loads in the craft's forebody area are to be determined as specified below. For the purpose of this calculation, the hull is considered longitudinally subdivided into a number of intervals. Generally, 20 intervals are to be considered.

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 [kN] is:

$$F_{SL} = \sum q_{SLi} \cdot \Delta x_i \quad [\text{kN}]$$

$\Delta x_i$  = length of interval [m]

$q_{SLi}$  = additional load per unit length [kN/m]

for  $x/L \geq 0,6$  see also Fig. C3.4.2, given by:

$$q_{SLi} = p_0 \cdot B_i \cdot \sin \left[ 2 \cdot \pi \cdot \left( \frac{x_i}{L} - 0,6 \right) \right] \quad [\text{kN/m}]$$

$x_i$  = distance [m] from the aft perpendicular

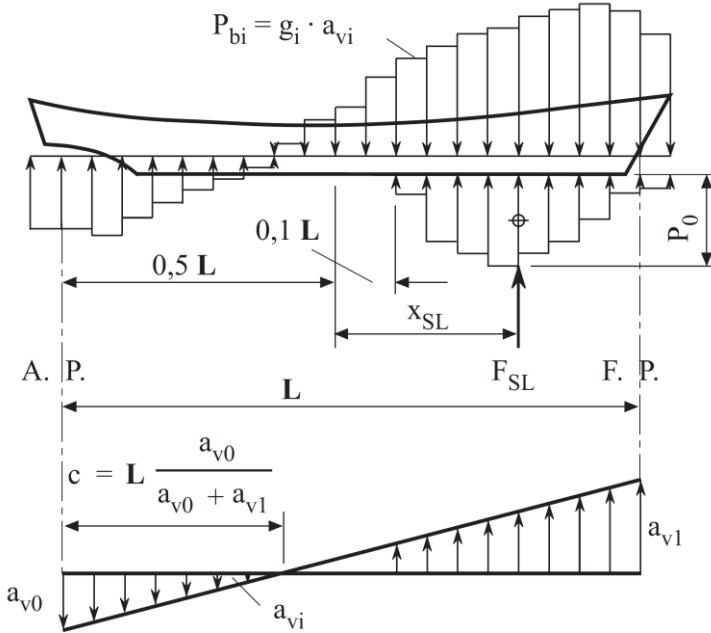


Fig. C3.4.2

- $B_i$  = craft breadth [m] at uppermost deck;  
 ( $x_i$  and  $B_i$  to be measured at the centre of interval  $i$ ),
- $p_0$  = maximum hydrodynamic pressure [kPa] equal to:
- $$= \frac{a_{v1} \cdot G \cdot (r_0^2 - x_w^2)}{f_{SL} \cdot (r_0^2 + 0,5 \cdot L \cdot (x_{SL} - x_w) - x_{SL} \cdot x_w)} \quad [\text{kPa}]$$
- $a_{v1}$  = vertical design acceleration at the forward perpendicular, as defined in C3.3,
- $G$  = weight force [kN] equal to:
- $$= \sum g_i \cdot \Delta x_i \quad [\text{kN}]$$
- $g_i$  = weight per unit length [kN/m] of interval 1;  
 for twin-hull craft,  $g_i$  is to be defined for one hull,
- $x_w$  = distance [m], of LCG from the midship perpendicular:  
 $= \frac{\sum (g_i \cdot \Delta x_i \cdot x_i)}{\sum (g_i \cdot \Delta x_i)} - 0,5 \cdot L \quad [\text{m}]$
- $r_0$  = radius of gyration [m] of weight distribution, equal to:  
 $= \left( \frac{\sum g_i \cdot \Delta x_i \cdot (x_i - 0,5 \cdot L)^2}{\sum g_i \cdot \Delta x_i} \right)^{0,5} \quad [\text{m}]$   
 normally  $0,2 L < r_0 < 0,25 L$  (guidance value)
- $x_{SL}$  = distance [m] of centre of surface  $F_{SL}$  from the midship perpendicular, given by:  
 $= \frac{1}{f_{SL}} \sum \Delta x_i \cdot x_i \cdot B_i \cdot \sin \left( 2\pi \cdot \left( \frac{x_i}{L} - 0,6 \right) \right) - 0,5 \cdot L \quad [\text{m}]$
- $f_{SL}$  = surface [ $\text{m}^2$ ] equal to:

$$= \sum \Delta x_i \cdot B_i \cdot \sin \left( 2\pi \cdot \left( \frac{x_i}{L} - 0,6 \right) \right) \quad [m^2]$$

The resulting load distribution  $q_{si}$  [kN/m] for the calculation of the impact induced sagging bending moment and shear force is:

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

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

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

$$= a_h + a_p \cdot (x_i - 0,5 \cdot L)$$

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

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

$a_p$  = acceleration due to pitching motion [ $m^{-1}$ ]:

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

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

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

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

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 C3.4.1.2.3 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 BKI.

#### 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:

$B_i = \text{maximum breadth of one hull at the considered longitudinal location } x_i [\text{m}]$

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

$B_i = \text{the maximum breadth of one hull at the considered longitudinal location [m] without being greater than } B/2, \text{ multiplied by the coefficient } f_B, \text{ where:}$

$$f_B = 2 \cdot (1 - B_w/B)$$

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

The transverse bending moment  $M_{bt}$  [kNm] and shear force  $T_{bt}$  [kN] are given by:

$$M_{bt} = \frac{\Delta \cdot b \cdot a_{CG} \cdot g}{5} \quad [\text{kNm}]$$

$$T_{bt} = \frac{\Delta \cdot a_{CG} \cdot g}{4} \quad [\text{kN}]$$

$b = \text{transverse distance [m] between the centres of the two hulls,}$

$a_{CG} = \text{vertical acceleration at LCG, defined in C3.3.1.}$

### C3.4.2.4 Transverse torsional connecting moment

The catamaran transverse torsional connecting moment [kNm] about a transverse axis is given by:

$$M_{tt} = 0,125 \cdot \Delta \cdot L \cdot a_{CG} \cdot g \quad [\text{kNm}]$$

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 [kN] (see Fig. C3.4.3) is given by:

$$F_Q = 12,5 \cdot T \cdot \Delta^{2/3} \cdot d \cdot L_s \quad [\text{kN}]$$

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

$$L_s = 2,99 \cdot \tanh \lambda - 0,725$$

$$\lambda = \frac{0,137 \cdot A_{lat}}{(T \cdot \sqrt[3]{\Delta})}$$

$A_{lat}$  = lateral area [ $\text{m}^2$ ] projected on a vertical plane, of one hull with that part of struts or struts below waterline at draught  $T$ .

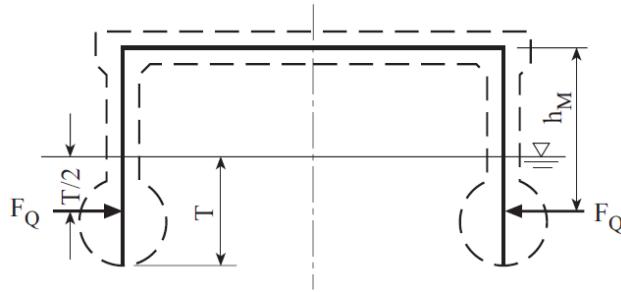


Fig. C3.4.3

.2 The lateral pressure [ $\text{kN/m}^2$ ] acting on one hull is given by:

$$P_Q = \frac{F_Q}{A_{\text{lat}}} \quad [\text{kN/m}^2]$$

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

$$q_Q = \frac{F_Q}{L_e} \quad [\text{kN/m}]$$

### C3.4.3.2 Bending moment

.1 The corresponding design bending moment [ $\text{kNm}$ ] is given by:

$$M_Q = h_M \cdot F_Q \quad [\text{kNm}]$$

$h_M$  = half the draught  $T$  plus the distance from the waterline at draught  $T$  to the midpoint of the wet deck structure (see Fig. C3.4.4) [m]

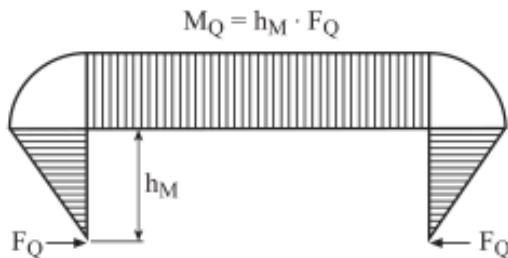


Fig. C3.4.4

### C3.4.4 Trimarans

The transverse design bending moments and shear forces for trimarans, subdivided in two load cases, will be calculated with respect to the structural arrangement. In general, the design loads can be taken as symmetrical to the centre line of the vessel. The sum of deck loads, self weights and buoyancy forces can be evenly distributed in longitudinal direction. Concentrated masses, lifting forces of foils and pillar loads are considered at their effective positions.

#### .1 Upward load case:

Following forces acting at their respective load centres are to be considered:

- maximum upward and outward lifting forces of foils and stabilizers jointed to the outer hulls according to BKI rudder calculation ([C3.10](#)).
- Buoyancy force of the outer hull at 15° heeling angle and max displacement multiplied by 1,1.
- Tank loads and deck load outside the main (centre) hull not to be taken into account.

## .2 Downward load case:

Following design deck loads multiplied by  $(1 + 0,4 \alpha_{CG})$  are to be considered:

- Sheltered deck:  $p = 1,0$  [kPa]
- Passenger deck:  $p = 2,5$  [kPa]
- Car deck (1,0 t axle load):  $p = 2,0$  [kPa]
- Car deck (3,5 t axle load):  $p = 4,0$  [kPa]
- Truck deck: max. truck weights evenly distributed
- tank weights
- maximum downward and inward lifting forces of foils and stabilizers jointed to the outer hulls according to BKI rudder calculation

Sum of static weights and tank loads up to the maximum displacement (half value for a symmetrical model) are to be taken into account in following order:

1. masses in fixed positions (tank loads, etc.)
2. distributed deck loads from upper to lower deck started from outside each with the intention to cover the worst possible transverse weight distribution (concerning the maximum transverse bending moment)

## C3.5 Local Loads and Design Criteria

### C3.5.1 General

This Section provides data regarding design loads for determining the scantlings of the hull structural elements by means of the design formulae given in the following Sections or by means of direct calculations. The dynamic portions of the design loads are design values which can only be applied within the design concept of this **Rules**.

### C3.5.2 Load centre

#### .1 For plates:

- vertical stiffening system:  $0,5 \cdot$  stiffener spacing above the lower support of plate field, or lower edge of plate when the thickness changes within the plate field
- horizontal stiffening system: Midpoint of plate field

#### .2 For stiffeners and girders:

- centre of span

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

- .1 In general, bottom slamming is expected on the whole bottom area. The slamming area may be limited if the conditions for  $\alpha_{CG}$  and  $V_{Fr}$  according to [Table C3.5.1](#) are met.  $V_{Fr}$  is defined as follows:

$$V_{Fr} = \frac{V}{L^{0,5}}$$

Aft of these slamming areas the impact pressure can be reduced to  $p_s$  over a length of  $0,1 L$ .

.2 The impact pressure [kPa] acting on the bottom of hull is not less than:

$$p_{sl} = 100 \cdot T \cdot K_1 \cdot K_2 \cdot K_3 \cdot a_{cg} \quad [\text{kPa}]$$

$K_1$  = longitudinal bottom impact pressure distribution factor (see Fig. C3.5.1):

$$\begin{aligned} &= 0,5 + x/L \quad \text{for } x/L < 0,5 \\ &= 1,0 \quad \text{for } 0,5 \leq x/L \leq 0,8 \\ &= 3,0 - 2,5 \cdot x/L \quad \text{for } x/L > 0,8 \end{aligned}$$

where  $x$  is the distance [m] from the aft perpendicular to the load point

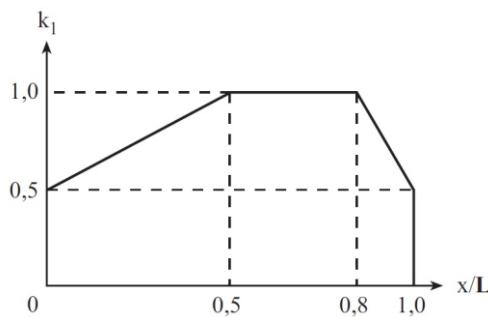


Fig. C3.5.1

$K_2$  = factor accounting for impact area:

$$= 0,455 - 0,35 \cdot \frac{u^{0,75} - 1,7}{u^{0,75} + 1,7}$$

$$\begin{aligned} &\geq 0,50 \quad \text{for plating,} \\ &\geq 0,45 \quad \text{for stiffeners,} \\ &\geq 0,35 \quad \text{for girders and floors.} \end{aligned}$$

$$u = 100 \cdot \frac{s}{S_r}$$

$S_r$  = reference area [ $\text{m}^2$ ]

$$= 0,7 \cdot \frac{\Delta}{T}$$

$\Delta$  = displacement [t] (see C3.1.4). For catamaran,  $\Delta$  in the above formula is to be taken as half of the craft displacement

$s$  = area [ $\text{m}^2$ ] 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:

$$= \frac{70 - \alpha_d}{70 - \alpha_{dCG}}$$

where  $\alpha_{dCG}$  is the deadrise angle [°] measured at LCG and  $\alpha_d$  is the deadrise angle [°] 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° and 30°.

$a_{CG}$  = design vertical acceleration at LCG, defined in [C3.3.1](#).

### .3 Sea intakes and other openings

.3.1 Sea chests are to have scantlings as for bottom structure (see [C3.7.7.3](#) and [C3.7.8.2](#) condition (b)), taking a design pressure  $p_t$ , [kPa], equal to:

$$p_t = p_s + 0,5 \cdot p_{sl} \quad [\text{kPa}]$$

where  $p_s$  and  $p_{sl}$  are as defined in [C3.5.5](#) and **respectively**.

If a safety valve is installed  $p_t$  is not to be less than 100  $p_v$ , where  $p_v$  is the blow out pressure at the safety valve in bar, but not less than 1 bar.

### C3.5.4 Impact pressure on wet deck (including tunnel radius)

.1 In general, wet deck slamming is expected on the whole wet deck area. The slamming area may be limited if the conditions for  $a_{CG}$  and  $V_{Fr}$  according to [Table C3.5.1](#) are met.

Table C3.5.1

$a_{CG}$	$V_{Fr}$	bottom	wet deck
$a_{CG} \leq 1$	$V_{Fr} < 4,5$	fwd of 0,7 L	fwd of 0,8 L
	$4,5 \leq V_{Fr} \leq 5$	fwd of 0,5 L	fwd of 0,7 L
$1 < a_{CG} \leq 1,5$	$V_{Fr} \leq 5$	fwd of 0,5 L	fwd of 0,7 L

The impact pressure [kPa] acting on the wet deck is not less than:

$$P_{sl} = 3 \cdot K_2 \cdot K_3 \cdot K_{WD} \cdot V_{sl} \cdot V_{sl} \cdot \left( 1 - 0,85 \cdot \frac{H_A}{H_s} \right) \quad [\text{kPa}]$$

$V_{sl}$  = relative impact velocity [m/s] equal to:

$$= \frac{4 \cdot H_s}{\sqrt{L}} + 1$$

$H_s$  = significant wave height,

$K_2$  = factor accounting for impact area, as defined in [C3.5.3.1](#) with maximum displacement of the craft

$K_3$  = factor accounting for shape and deadrise of wet deck, as defined in [C3.5.3.2](#) where 10° is taken for  $\alpha_{dCG}$ ,

$K_{WD}$  = longitudinal wet deck impact pressure distribution factor (see [Fig. 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 [m] from the aft perpendicular to the load point

$V_x$  = ship's speed [kn]

$H_A$  = air gap [m] equal to the distance between the waterline at draught  $T$  and the wet deck

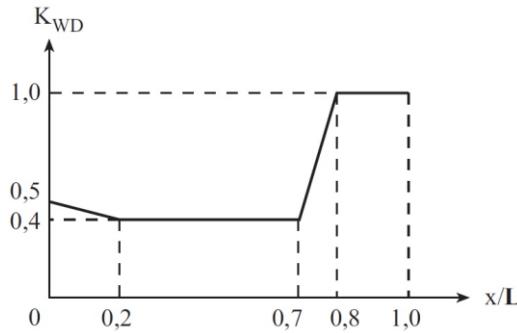


Fig. C3.5.2

### C3.5.5 Sea pressures

#### C3.5.5.1 Sea pressure on bottom and side shell

.1 The sea pressure,  $P_s$  [kPa] considered as acting on the bottom and side shell is not less than  $p_{s\min}$ , defined in [Table C3.5.2](#), nor less than:

– for  $z \leq T$

$$P_s = 10 \cdot \left( T_0 + 0,75 \cdot S - \left( 1 - 0,25 \cdot \frac{S}{T} \right) \cdot z \right) \quad [\text{kPa}]$$

– for  $z > T$

$$P_s = 10 \cdot (T_0 + S - z) \quad [\text{kPa}]$$

$T_0$  =  $T$ , in general

=  $T + 0,09 y$ , for SWATH and outer hulls of trimaran

$z$  = vertical distance [m] from the moulded base line to load point.  $z$  is to be taken positively upwards,

$y$  = transverse distance [m] from the centre line to load point.  $y$  is to be taken positive,

$S$  = as given [m] in [Table C3.5.2](#) with  $C_B$  taken not greater than 0,5.

=  $T$ , for SWATH

Table C3.5.2

	$S$	$P_{\min}$
$x/L \geq 0,9$	$T \leq 0,36 \cdot a_{CG} \cdot \frac{\sqrt{L}}{C_B} \leq 3,5 \cdot T$	$20 \leq \frac{L+75}{5} \leq 35$
$x/L \leq 0,5$	$T \leq 0,60 \cdot a_{CG} \cdot \sqrt{L} \leq 2,5 \cdot T$	$10 \leq \frac{L+75}{10} \leq 20$

.2 Between midship area and fore end ( $0,5 < x/L < 0,9$ ),  $p_s$  varies in a linear way as follows:

$$p_s = P_{sFP} - \left( 2,25 - 2,5 \cdot \frac{x}{L} \right) \cdot (P_{sFP} - P_{sM}) \quad [\text{kPa}]$$

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 [kN] considered for the scantlings of primary members are to be not less than:

- external force:  $F_e = A \cdot p_s \quad [\text{kN}]$
- internal force:  $F_i = F_o + 10 \cdot W \quad [\text{kN}]$

where :

- A = area [ $\text{m}^2$ ] of the door opening
- W = mass of the door [t]
- $F_p$  = total packing force [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 [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 [kN] considered for the scantlings of securing or supporting devices of doors opening outwards are to be not less than:

- external force:  $F_e = A \cdot p_s \quad [\text{kN}]$
- internal force:  $F_i = F_o + 10 \cdot W + F_p \quad [\text{kN}]$

where the parameters are defined in C3.5.5.2.2.

.4 The design forces [kN] considered for the scantlings of securing or supporting devices of doors opening inwards are to be not less than:

- external force:  $F_e = A \cdot p_s + F_p \quad [\text{kN}]$
- internal force:  $F_i = F_o + 10 \cdot W \quad [\text{kN}]$

where the parameters are defined in C3.5.5.2.2.

### C3.5.5.3 Bow doors

The arrangement of bow doors is to comply with the provisions of 2.2.3. Loads according to C3.5.5.2 are to be taken. If an inner bow door is required according to 2.2.3 a design load according to C3.5.5.4 is to be considered. The inner bow door is to be fitted within the limits for the collision bulkhead but not less than 1,2 m aft of the bow door.

#### C3.5.5.4 Sea pressures on front walls of the hull

.1 The pressure,  $P_{sf}$  [kPa], 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:

$$P_{sf} = 6 \cdot \left[ 1 + \frac{x_1}{2 \cdot L \cdot (C_B + 0,1)} \right] \cdot (1 + 0,045 \cdot L - 0,38 \cdot z_1) \quad [\text{kPa}]$$

$x_1$  = distance [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 [m] from load point to waterline at draught T.

$p_{sf}$  is not less than the greater of:

$$3 + (6,5 + 0,06 \cdot L)$$

$$3 + 2,4 \cdot a_{CG}$$

.2 For front walls located at the fore end, the pressure  $p_{sf}$  will be individually considered by BKI, but not less than 1,2 times the value according to C3.5.5.4.1.

#### C3.5.5.5 Sea pressures on deckhouses

.1 The pressure,  $P_{su}$  [kPa] considered as acting on walls of deckhouses is not less than:

$$P_{su} = K_{su} \cdot \left( 1 + \frac{x_1}{2 \cdot L \cdot (C_B + 0,1)} \right) \cdot (1 + 0,045 \cdot L - 0,38 \cdot z_1) \quad [\text{kPa}]$$

$K_{su}$  = coefficient

– 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:

$$K_{su} = 1,5 + 3,5 \cdot b/B \quad (\text{with } 3 \leq K_{su} \leq 5)$$

– for the other walls:

$$K_{su} = 3,0$$

$x_1$  = distance [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 [m] from load point to waterline at draught T.

.2 The minimum values of  $p_{su}$  [kPa] to be considered are:

– for the front wall of the lower tier:

$$p_{su} = 6,5 + 0,06 \cdot L \quad [\text{kPa}]$$

– for the sides and aft walls of the lower tier:

$$p_{su} = 4,0 \quad [\text{kPa}]$$

– for the other walls or sides:

$$p_{su} = 3,0 \quad [\text{kPa}]$$

.3 For unprotected front walls located at the fore end, the pressure  $p_{su}$  will be considered by BKI as given in [C3.5.6.2](#).

### C3.5.6 Bulkheads

#### C3.5.6.1 General

- .1 This section applies to watertight and non-watertight bulkheads.
- .2 Horizontal part of bulkheads are also to comply with the rules for deck beams.
- .3 The special requirements for tanks in the hull are given in [C3.5.7](#).

##### C3.5.6.1.1 Watertight subdivision

- .1 Number and location of transverse bulkheads fitted in addition to those specified in [C2.1.8](#) are to be so selected as to ensure sufficient transverse strength of the hull.
- .2 For ships which require proof of survival capability in damaged conditions, the watertight subdivision will be determined by damage stability calculations.

##### C3.5.6.1.2 Collision bulkhead

- .1 The collision bulkhead shall extend watertight up to the datum (bulkhead deck). Steps or recesses may be permitted provided [Section 2, C2.1.8.2](#) is observed.

##### C3.5.6.1.3 Stern tube bulkhead

- .1 If a stern tube bulkhead is provided, it shall, in general, be so arranged that the stern tube and the rudder trunk are enclosed in a watertight compartment. The stern tube bulkhead should extend to the datum or to a watertight platform situated above the design waterline.
- .2 Where a complete stern tube bulkhead is not practicable, only watertight void spaces enclosing the stern tube entrances, providing the possibility for a second watertight sealing may be arranged. The same arrangement can be applied for the rudder trunk.

##### C3.5.6.1.4 Remaining watertight bulkheads

- .1 The remaining watertight bulkheads are, in general, to extend to the datum. Wherever practicable, they shall be situated in one frame plane, otherwise those portions of decks situated between parts of transverse bulkheads are to be watertight.

##### C3.5.6.1.5 Openings in watertight bulkheads

- .1 The requirements of [Section 2, 2.2.2](#) are to be observed.

#### C3.5.6.2 Pressures on watertight bulkheads

The pressure,  $p_{sb}$  [kPa] considered as acting on subdivision bulkheads is not less than:

$$p_{sb} = 9,81 \cdot h_3 \quad [\text{kPa}]$$

$h_3$  = distance [m] from load point to a point 1 m above the bulkhead deck at the ship's side, for the collision bulkhead to a point 1 m above the upper edge of the collision bulkhead at ship's side.

### C3.5.7 Tank structures

#### C3.5.7.1 General

This section applies to all kinds of tanks with the tank boundaries forming a direct part of the hull structure. In addition the requirements for detached tanks and the procedure of testing for tightness are given.

All tanks are to be suitably subdivided by bulkheads or swash bulkheads in order to avoid excessive liquid sloshing.

Hollow structural elements are not permitted in tanks for flammable liquids.

Oil is not be carried in a forepeak tank.

#### C3.5.7.2 Air, overflow and sounding pipes

Each tank is to be fitted with air pipes, overflow pipes and sounding pipes. The air pipes are to be led to above the exposed deck. The arrangement is to be such as to allow complete filling of the tanks. The height from the deck to the point where the water may have access is to be at least 760 mm on the datum and 450 mm on a superstructure deck.

The sounding pipes are to be led to the bottom of the tanks.

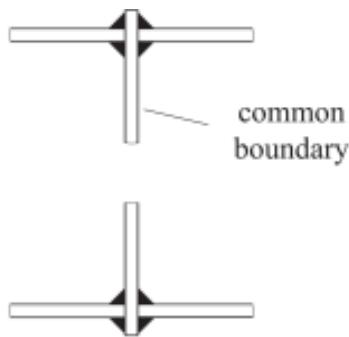
#### C3.5.7.3 Separation of oil fuel tanks from tanks for other liquids

Fuel oil tanks are to be separated from tanks for lubricating oil, hydraulic oil, thermal oil, vegetable oil, feedwater, condensate water and potable water by cofferdams.

For steel and aluminium structures the arrangement of cofferdams between oil fuel and lubricating oil tanks may be dispensed with provided that:

- the common boundary is continuous, i.e. it does not abut at the adjacent tank boundaries, see [Fig. C3.5.3](#)

Where the common boundary cannot be constructed continuously according to [Fig. C3.5.3](#), the fillet welds on both sides of the common boundary are to be welded in two layers and the throat thickness is not to be less than  $0,5 \cdot t$  ( $t$  = plate thickness).



**Fig. C3.5.3 Continuous common boundary replacing a cofferdam**

- Stiffeners or pipes do not penetrate the common boundary.
- The corrosion allowance  $t_k$  for steel plates for the common boundary is not less than 1,0 mm.

#### C3.5.7.4 Potable Water Tanks

Potable water tanks shall be separated from tanks containing liquids other than potable water, ballast water, distillate or feed water.

In no case sanitary arrangement or corresponding piping are to be fitted directly above the potable water tanks.

Manholes arranged in the tank top are to have sills.

If pipes carrying liquids other than potable water are to be led through potable water tanks, they are to be fitted in a pipe tunnel.

Air and overflow pipes of potable water tanks are to be separated from pipes of other tanks.

#### C3.5.7.5 Swash Bulkheads

The total area of perforation shall not be less than 5% and should not exceed 10% of the total bulkhead area.

The plate thickness shall, in general, be equal to the minimum thickness. Strengthenings may be required for load bearing structural parts.

The free lower edge of a swash bulkhead is to be adequately stiffened.

The section modulus of the stiffeners and girders is to be calculated with  $p_{t1}$ , but disregarding  $p_v$ .

#### C3.5.7.6 Independent tanks

Detached tanks are to be adequately secured against forces due to the ship's motions.

Detached tanks in hold spaces are also to be provided with antiflootation devices. It is to be assumed that the hold spaces are flooded to the load water line. The stresses in the antiflootation devices caused by the floatation forces are not to exceed the material's yield stress.

Fittings and pipings on detached tanks are to be protected by battens, and gutter ways are to be fitted on the outside of tanks for draining any leakage oil.

#### C3.5.7.7 Pressures on tank structures

The design pressure,  $p_{t1}$  [kPa], for service condition is:

$$p_{t1} = 9,81 \cdot h_1 \cdot \rho \cdot (1 + 0,4 \cdot a_v) + 100 \cdot p_v \quad [\text{kPa}]$$

$h_1$  = distance [m] from load point to tank top,

$\rho$  = liquid density [ $\text{t/m}^3$ ] ( $1,0 \text{ t/m}^3$  for water),

$p_v$  = setting pressure [bar] of pressure relief valve, when fitted.

The maximum static design pressure [kPa] is:

$$p_{t2} = 9,81 \cdot h_2 \quad [\text{kPa}]$$

$h_2$  = distance [m] from load point to top of overflow or to a point located 1,5 m above the tank top, whichever is greater.

For tanks equipped with pressure relief valves and/or for tanks intended to carry liquids of a density greater than 1,0 t/m<sup>3</sup>, the head  $h_2$  is at least to be measured to a level at the following distance  $h_p$  above tank top:

$$h_p = 2,5 p \quad \text{or} \\ = 10 p_v, \quad \text{where } p_v > 0,25 p$$

Regarding the design pressure of fuel tanks and ballast tanks which are connected to an overflow system, the dynamic pressure increase due to the overflowing is to be taken into account in addition to the static pressure height up to the highest point of the overflow system.

### C3.5.7.8 Testing for Tightness

.1 Testing of fuel oil, ballast, trimming, feed water, fresh water and anti-rolling tanks is to be effected by a combination of a leak test by means of air pressure and an operational test by means of water or the liquid for which the tank is intended to be used. The air pressure is not to exceed 0,2 bar gauge. The increased risk of accident while the tanks are subjected to the air pressure is to be observed.

.2 Where one tank boundary is formed by the ship's shell, the leak test is to be carried out before launching. For all other tanks leak testing may be carried out after launching. Erection welds as well as welds of assembly openings are to be coated<sup>1</sup> after the leak test is carried out. This applies also to manual weld connections of bulkheads with the other tanks boundaries and of collaring arrangements at intersections of tank boundaries and e.g. frames, beams, girders, pipes etc. If it is ensured that in adjacent tanks the same type of liquid is carried, e.g. in adjacent ballast tanks, the above mentioned weld connections may be coated<sup>1</sup> prior to the leak test.

All other welded connections in tank boundaries may be coated prior to the leak test if it is ensured by suitable means (e.g. by visual examination of the welded connections) that the connections are completely welded and the surfaces of the welds do not exhibit cracks or pores.

.3 Where the tanks are not subjected to the leak test as per .2 but are leak tested with water the bulkheads are, in general, to be tested from one side. The testing should be carried out prior to launching or in the dock. Subject to approval by BKI, the test may also be carried out after launching. Water testing may be carried out after application of a coating<sup>1</sup>, provided that during the visual inspection as per .2 above deficiencies are not noted. The test head shall correspond to a head of water of 2,5 m above the top of tank or to the top of overflow or air pipe, whichever is the greater.

.4 The operational test may be carried out when the ship is afloat or during the trial trip. For all tanks the proper functioning of filling and suction lines and of the valves as well as functioning and tightness of the vent, sounding and overflow pipes is to be tested.

### C3.5.8 Deck loads

#### C3.5.8.1 General

.1 The pressure  $p_d$  [kPa], considered as acting on decks is given by the formula:

$$p_d = p \cdot (1 + 0,4 \cdot a_v) \quad [\text{kPa}]$$

$p$  = uniform pressure due to the load carried [kPa]. Minimum values are given in C3.5.8.2 to C3.5.8.6,

$a_v$  = design vertical acceleration, defined in C3.3.

<sup>1</sup> Shopprimers are not regarded as a coating within the scope of these requirements.

.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  $(1 + 0,4 \cdot a_v)$ .

#### C3.5.8.2 Weather decks and exposed areas

.1 For weather decks and exposed areas without deck cargo:

- if  $z_d \leq 2$ :  $p = 6,0$  [kPa]
- if  $2 < z_d < 3$ :  $p = (12 - 3 z_d)$  [kPa]
- if  $z_d \geq 3$ :  $p = 3,0$  [kPa]

where  $z_d$  is the vertical distance [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  $z_d \leq 2$ :  $p = (p_c + 3)$  [kPa]
- if  $2 < z_d < 3$ :  $p = (p_c + 7 - 2 z_d)$  [kPa]
- if  $z_d \geq 3$ :  $p = (p_c + 1)$  [kPa]

$z_d$  = distance defined in C3.5.8.2.1,

$p_c$  = uniform pressure due to deck cargo load [kPa] to be defined by the designer, but taken as not less than 3,0 kPa.

#### C3.5.8.3 Enclosed cargo decks

.1 For enclosed cargo decks other than decks carrying vehicles:

$$p = p_c \quad [\text{kPa}]$$

with  $p_c$  as defined in C3.5.8.2.2.

For enclosed cargo decks carrying vehicles, the loads are defined in C3.5.8.7.

#### C3.5.8.4 Enclosed accommodation decks

.1 For enclosed accommodation decks not carrying goods:

$$p = 3,0 \quad [\text{kPa}]$$

p can be reduced by 20 per cent for primary supporting members and pillars under such decks.

.2 For enclosed accommodation decks carrying goods:

$$p = p_c \quad [\text{kPa}]$$

With  $p_c$  as defined in C3.5.8.2.2.

#### C3.5.8.5 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 decks with care and taking account of the admissible load, which is to be clearly indicated.

The deck load [kPa] for shelter decks is:

$$p_d = 1,3 (1 + 0,4 \cdot a_v) \quad [\text{kPa}]$$

A lower value may be accepted, at the discretion of BKI, 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.

The minimum value to be considered for such areas forward of the bridge is

$$p_d = 3,0 \quad [\text{kPa}]$$

#### C3.5.8.6 Platforms of machinery spaces and mooring decks

.1 The minimum value to be considered for platforms of machinery spaces is

$$p = 8,0 \quad [\text{kPa}]$$

.2 The minimum value to be considered for platforms of mooring decks is

$$p = 6,0 \quad [\text{kPa}]$$

#### C3.5.8.7 Decks carrying vehicles

##### C3.5.8.7.1 General

.1 These Rules apply to movable as well as to removable car decks not forming part of the ship's structure.

.2 The following information should be included in the plans to be submitted for approval:

- scantlings of the car decks
- masses of the car decks
- number and masses of cars intended to be stowed on the decks
- wheel loads and distance of wheels
- connection of the car decks to the hull structure
- moving and lifting gear of the car decks

##### C3.5.8.7.2 Design loads

.1 For determining the deck scantlings, the following loads are to be used:

- uniformly distributed load resulting from the mass of the deck and maximum number of cars to be carried. This load is not to be taken less than 2,5 kPa multiplied by  $(1 + 0,4 a_v)$ .
- wheel load P

Where all wheels of one axle are standing on a deck girder or a deck beam, the axle load is to be evenly distributed on all wheels.

Where not all of the wheels of one axle are standing on a deck girder or a deck beam, the following wheel loads are to be used:

$$P = 0,5 \cdot \text{axle load for 2 wheels per axle}$$

$$= 0,3 \cdot \text{axle load for 4 wheels per axle}$$

$$= 0,2 \cdot \text{axle load for 6 wheels per axle}$$

.2 For determining the scantlings of the suspensions, the increased wheel load in case of four and six wheels per axle as per [C3.5.8.7.2.1](#) need not be considered.

.3 For determining the primary structure of decks under racking effects, the following loads are to be used:

- uniformly distributed load resulting from the mass of the deck and maximum number of cars to be carried. This load is not to be taken less than 2,5 kPa.
- wheel load P.

#### C3.5.8.7.3 Permissible deflection

.1 The deflection of girders subjected to loads stipulated under [C3.5.8.7.2](#) is not to exceed:

$$f = \frac{\ell}{200} \text{ for steel and aluminium structures}$$

$\ell$  = unsupported span of girder

.2 An adequate safety distance should be maintained between the girders of a loaded deck and the top of cars stowed on the deck below.

#### C3.5.8.7.4 Buckling

The buckling strength of girders is to be proved according to [C3.7.5](#), if required.

#### C3.5.9 Handrails

Following design loads can be taken for handrails of

- |  |         |
|--|---------|
| – weather decks and exposed areas                        | 750 N/m |
| – inner decks  | 750 N/m |
| – outer ramps  | 500 N/m |
| – Ro-Ro decks which are only accessible in harbour areas | 200 N/m |
| – sheltered decks  | 200 N/m |

If neither escape routes, life-raft accesses nor heli winch areas etc. are included, reduced requirements can be stipulated.

Following permissible bending stress [MPa] of the stanchions (loaded at upper end) is to be observed:

150/k for steel

70/k for aluminium alloys

The maximum permissible distance between the stanchions is 1,6 m.

#### C3.6 Welded Joints

**Note:**

*The content of C3.6 is to a large extent identical to that of the Rules for Welding (Pt.1, Vol.VI), Sec. 12, G. Because of the re-issues of (Pt.1, Vol.VI) and these Rules at different times, some temporary divergences may*

arise and in such circumstances the more recent Rules shall take precedence. Special questions and problems will be solved in an actual case by using these Rules in addition to the following information.

These requirements and figures arise from welded joints of steel structures. For aluminium alloys deviations or further requirements may be taken into consideration.

### C3.6.1 Design

#### C3.6.1.1 General design principles

.1 During the design stage welded joints are to be planned such as to be accessible during fabrication, to be located in the best possible position for welding and to permit the proper welding sequence to be followed.

.2 Both the welded joints and the sequence of welding involved are to be so planned as to enable residual welding stresses to be kept to a minimum in order that no excessive deformation occurs. Welded joints should not be over dimensioned, see also [C3.6.1.3.3](#).

.3 When planning welded joints, it shall first be established that the type and grade of weld envisaged, such as full root weld penetration in the case of HV or DHV (K) weld seams, can in fact be perfectly executed under the conditions set by the limitations of the manufacturing process involved. If this is not the case, a simpler type of weld seam shall be selected and its possibly lower load bearing capacity taken into account when dimensioning the component.

.4 Highly stressed welded joints -which, therefore, are generally subject to examination- are to be so designed that the most suitable method of testing for faults can be used (radiography, ultrasonic, surface crack testing methods) in order that a reliable examination may be carried out.

.5 Special characteristics peculiar to the material, such as the lower strength values of rolled material in the thickness direction (see [C3.6.1.2.5.1](#)) or the softening of cold worked aluminium alloys as a result of welding, are factors which have to be taken into account when designing welded joints. Clad plates where the efficiency of the bond between the base and the clad material is proved may generally be treated as solid plates (up to medium plate thicknesses where mainly filled weld connections are used).

.6 In cases where different types of material are paired and operate in sea water or any other electrolytic medium, for example welded joints made between unalloyed carbon steels and stainless steels in the wear-resistant cladding in rudder nozzles or in the cladding of rudder shafts, the resulting differences in potential greatly increase the susceptibility to corrosion and shall therefore be given special attention. Where possible, such welds are to be positioned in locations less subject to the risk of corrosion (such as on the outside of tanks) or special protective counter- measures are to be taken (such as the provision of a protective coating or cathodic protection).

#### C3.6.1.2 Design details

##### .1 Stress flow, transitions

.1.1 All welded joints on primary supporting members shall be designed to provide as smooth a stress profile as possible with no major internal or external notches, no discontinuities in rigidity and no obstructions to strains, see [C3.7.1](#).

.1.2 This applies in analogous manner to the welding of subordinate components on to primary supporting members whose exposed plate or flange edges should, as far as possible, be kept free from notch effects due to welded attachments.

.1.3 Butt joints in long or extensive continuous structures such as bilge keels, fenders, crane rails, slop coamings, etc. attached to primary structural members are therefore to be welded over their entire cross-section.

.1.4 Wherever possible, joints (especially site joints) in girders and sections shall not be located in areas of high bending stress. Joints at the knuckle of flanges are to be avoided.

.1.5 The transition between differing component dimensions shall be smooth and gradual. Where the depth of web of girders or sections differs, the flanges or bulbs are to be bevelled and the web slit and expanded or pressed together to equalize the depths of the members. The length of the transition should be at least equal twice the difference in depth.

.1.6 Where the plate thickness differs at joints perpendicularly to the direction of the main stress, differences in thickness greater than 3 mm shall be accommodated by bevelling the proud edge in the manner shown in Fig. C3.6.1 at a ratio of at least 1 : 3 or according to the notch category. Differences in thickness of 3 mm or less may be accommodated within the weld. For aluminium a ratio of 1 : 5 is recommended. Differences in thickness are not allowed.

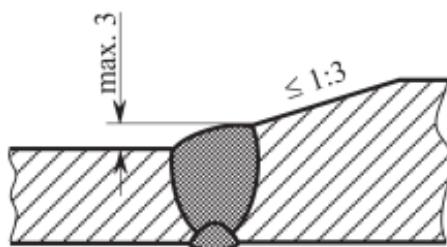


Fig. C3.6.1 Accommodation of differences of thickness

.1.7 For the welding on of plates or other relatively thin-walled elements, forgings and aluminium and steel castings should be appropriately tapered or provided with integrally cast or forged welding flanges in accordance with Fig. C3.6.2.



Fig. C3.6.2 Welding flanges on steel castings or forgings

.1.8 For the connection of shaft brackets to the boss and shell plating, see C3.6.1.4.3 and C3.9.1.

## .2 Local clustering of welds, minimum spacing

.2.1 The local clustering of welds and short distances between welds are to be avoided. Adjacent butt welds should be separated from each other by a distance of at least

$$50 \text{ mm} + 4 \times \text{plate thickness}$$

Fillet welds should be separated from each other and from butt welds by a distance of at least

$$30 \text{ mm} + 2 \times \text{plate thickness}$$

The width of replaced or inserted plates (strips) should, however, be at least 300 mm or ten times the plate thickness, whichever is the greater.

**.2.2** Reinforcing plates, welding flanges, mountings and similar components socket-welded into plating should be of the following minimum size:

$$D_{\min} = 170 + 3(t - 10) \geq 170 \text{ [mm]}$$

D = diameter of round or length of side of angular weldments [mm]

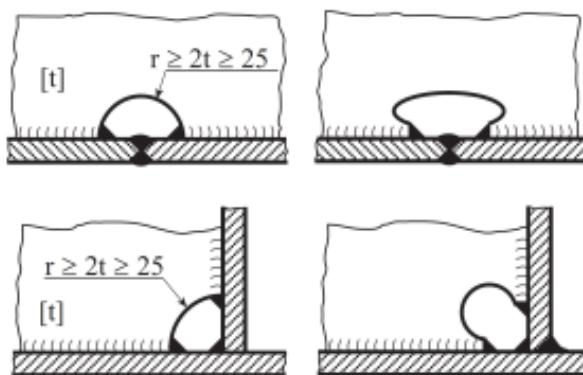
t = plating thickness [mm]

The corner radii of angular socket weldments should be  $5 \cdot t$  [mm] but at least 50 mm. Alternatively, the "longitudinal seams" are to extend beyond the "transverse seams". Socket weldments are to be fully welded to the surrounding plating.

Regarding the increase of stress due to different thickness of plates see also [C3.7.6](#).

### **.3 Welding cut-outs**

**.3.1** Welding cut-outs for the (later) execution of butt or fillet welds following the positioning of transverse members should be rounded (minimum radius 25 mm or twice the plate thickness, whichever is the greater) and should be shaped to provide a smooth transition on the adjoining surface as shown in [Fig. C3.6.3](#) (especially necessary where the loading is mainly dynamic).



**Fig. C3.6.3 Welding cut-outs**

**.3.2** Where the welds are completed prior to the positioning of the crossing members, no welding cut-outs are needed. Any weld reinforcements present are to be machined off prior to the location of the crossing members or these members are to have suitable cut-outs.

### **.4 Local reinforcements, doubling plates**

**.4.1** Where platings (including girder plates and tube walls) are subjected locally to increased stresses, thicker plates should be used wherever possible in preference to doubling plates. Bearing bushes, hubs etc. shall invariably take the form of thicker sections welded into the plating, see [C3.6.1.2.2.2](#).

**.4.2** Where doublings cannot be avoided, the thickness of the doubling plates should not exceed twice the plating thickness. Doubling plates whose width is greater than approximately 30 times their thickness shall be plug welded to the underlying plating in accordance with [C3.6.1.3.3.3.11](#) at intervals not exceeding 30 times the thickness of the doubling plate.

**.4.3** Along their (longitudinal) edges, doubling plates shall be continuously fillet welded with a throat thickness "a" of  $0,3 \times$  the doubling plate thickness. At the ends of doubling plates, the throat thickness "a"

at the end faces shall be increased to  $0,5 \times$  the doubling plate thickness but shall not exceed the plating thickness, see Fig. C3.6.4.

The welded transition at the end faces of the doubling plates to the plating should form with the latter an angle of 45° or less.

**.4.4** Where proof of fatigue strength is required (see C3.7.6), the configuration of the end of the doubling plate shall conform to the selected detail category.

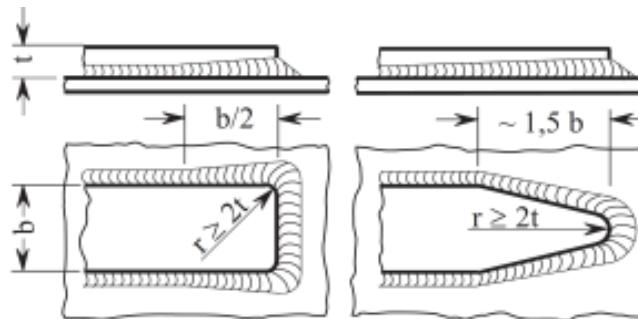


Fig. C3.6.4 Welding at the ends of doubling plates

**.4.5** Doubling plates are not permitted in tanks for flammable liquids.

#### **.5** Intersecting members, stress in the thickness direction.

**.5.1** Where, in the case of intersecting members, plates or other rolled products are stressed in the thickness direction by shrinking stresses due to the welding and/or applied loads, suitable measures shall be taken in the design and fabrication of the structures to prevent lamellar tearing (stratified fractures) due to the anisotropy of the rolled products.

**.5.2** Such measures include the use of suitable weld shapes with a minimum weld volume and a welding sequence designed to reduce transverse shrinkage. Other measures are the distribution of the stresses over a larger area of the plate surface by using a build-up weld or the joining together of several "fibres" of members stressed in the thickness direction as exemplified by the deck stringer/sheer strake joint shown in Fig. C3.6.12.

**.5.3** In case of very severe stresses in the thickness direction due, for example, to the aggregate effect of the shrinkage stresses of bulky single or double-bevel butt welds plus high applied loads, plates with guaranteed through thickness properties (extra high-purity material and guaranteed minimum reductions in area of tensile test specimens taken in thickness direction)<sup>2</sup> are to be used.

#### **.6** Welding of cold formed sections, bending radii

**.6.1** Wherever possible, welding should be avoided at the cold formed sections with more than 5% permanent elongation<sup>3</sup> and in the adjacent areas of structural steels with a tendency towards strain ageing.

<sup>2</sup> See Rules for Materials (Pt.1, Vol.V), Sec. 4, I.

<sup>3</sup> Elongation ε in the outer tensile-stressed zone

$$\epsilon = \frac{100}{1 + 2 \cdot r/t} [\%]$$

r = inner bending radius [mm]

**.6.2** Welding may be performed at the cold formed sections and adjacent areas of hull structural steels and comparable structural steels (e.g. those in quality groups S...J... and S...K... to DIN EN 10025) provided that the minimum bending radii are not less than those specified in [Table C3.6.1](#).

**Table C3.6.1 Minimum inner bending radius r**

Plate thickness t	Minimum inner bending radius r
to 4 mm	$1,0 \times t$
to 8 mm	$1,5 \times t$
to 12 mm	$2,0 \times t$
to 24 mm	$3,0 \times t$
over 24 mm	$5,0 \times t$

**Note:**

*The bending capacity of the material may necessitate a larger bending radius.*

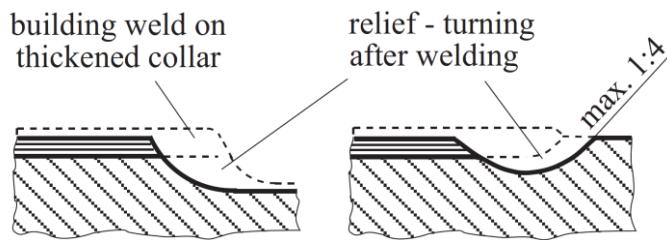
**.6.3** For other steels and other materials, where applicable, the necessary minimum bending radius shall, in case of doubt, be established by test. Proof of adequate toughness after welding may be stipulated for steels with minimum nominal upper yield point of more than 355 N/mm<sup>2</sup> and plate thicknesses of 30 mm and above which have undergone cold forming resulting in 2 % or more permanent elongation.

## **.7 Build-up welds on rudderstocks and pintles**

**.7.1** Wear resistance and/or corrosion resistant build-up welds on the bearing surfaces of rudder stocks, pintles etc. shall be applied to a thickened collar exceeding by at least 20 mm the diameter of the adjoining part of the shaft.

**.7.2** Where a thickened collar is impossible for design reasons, the build-up weld may be applied to the smooth shaft provided that relief-turning in accordance with [C3.6.1.2.7.3](#) is possible (leaving an adequate residual diameter).

**.7.3** After welding, the transition areas between the welded and non-welded portions of the shaft shall be relief-turned with large radii, as shown in [Fig. C3.6.5](#), to remove any base material whose structure close to the concave groove has been altered by the welding operation and in order to effect the physical separation of geometrical and metallurgical "notches".



**Fig. C3.6.5 Build-up welds applied to rudderstocks and pintles**

### **C3.6.1.3 Weld shapes and dimensions**

#### **.1 Butt joints**

**.1.1** Depending on the plate thickness, the welding method and the welding position, butt joints shall be of the square, V or double-V shape conforming to the relevant standards (e.g. EN 22553/ISO 2533, ISO

t = plate thickness [mm]

9692 -1, -2, -3 or -4). Where other weld shapes are applied, these are to be specially described in the drawings. Weld shapes for special welding processes such as single-side or electrogas welding shall have been tested and approved in the context of a welding procedure test.

**.1.2** As a matter of principle, the rear sides of butt joints shall be grooved and welded with at least one capping pass. Exceptions to this rule, as in the case of submerged-arc welding or the welding processes mentioned in C3.6.1.3.1.1, require to be tested and approved in connection with a welding procedure test. The effective weld thickness shall be deemed to be the plate thickness, or, where the plate thicknesses differ, the lesser plate thickness. Where proof of fatigue strength is required (see C3.7.6), the detail category depends on the execution (quality) of the weld

**.1.3** Where the aforementioned conditions cannot be met, e.g. where the welds are accessible from one side only, the joints shall be executed as lesser bevelled welds with an open root and an attached or an integrally machined or cast, permanent weld pool support (backing) as shown in Fig. C3.6.6.

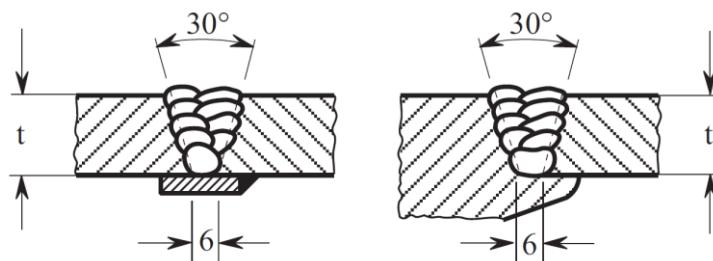
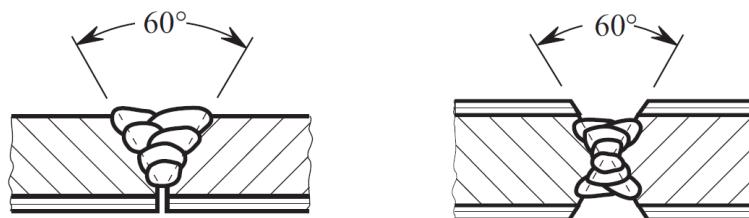


Fig. C3.6.6 Single-side welds with permanent weld pool supports (backings)

**.1.4** The weld shapes illustrated in Fig. C3.6.7 shall be used for clad plates. These weld shapes shall be used in analogous manner for joining clad plates to (unalloyed and low alloyed) hull structural steels.



Welding the support material at an adequate distance  
(min. 2 mm) from the cladding material



Grooving out the clad side of the plate



Welding the clad side of the plate in at least two passes,  
using special interpass electrocodes where necessary

Fig. C3.6.7 Weld shapes for welding of clad plates

## .2 Corner, T and double-T (cruciform) joints

**.2.1** Corner, T and double-T (cruciform) joints with complete union of the abutting plates shall be made as single or double-bevel welds with a minimum root face and adequate air gap, as shown in Fig. C3.6.8, and with grooving of the root and capping from the opposite side.

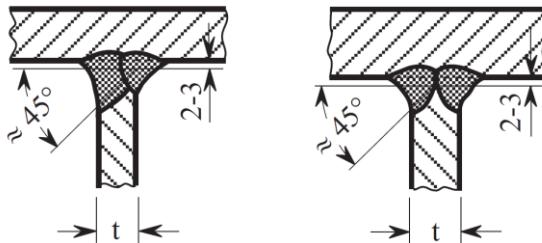


Fig. C3.6.8 Single and double-bevel welds with full root penetration

The effective weld thickness shall be assumed as the thickness of the abutting plate. Where proof of fatigue strength is required (see C3.7.6), the detail category depends on the execution (quality) of the weld.

**.2.2** Corner, T and double-T (cruciform) joints with a defined incomplete root penetration, as shown in Fig. C3.6.9, shall be made as single or double-bevel welds, as described in C3.6.1.3.2.1, with a back-up weld but without grooving of the root.

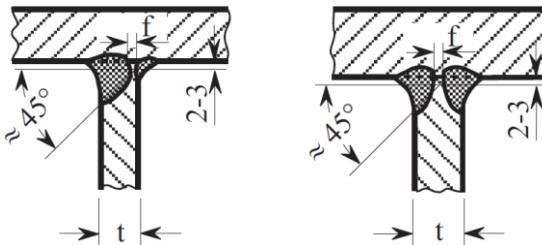


Fig. C3.6.9 Single and double-bevel welds with defined incomplete root penetration

The effective weld thickness may be assumed as the thickness of the abutting plate  $t$ , where  $f$  is the incomplete root penetration of  $0,2 \cdot t$  with a maximum of 3 mm, which is to be balanced by equally sized double fillet welds on each side. Where proof of fatigue strength is required (see C3.7.6), these welds are to be assigned to type D1.

**.2.3** Corner, T and double-T (cruciform) joints with both an unwelded root face  $c$  and a defined incomplete root penetration  $f$  shall be made in accordance with Fig. C3.6.10

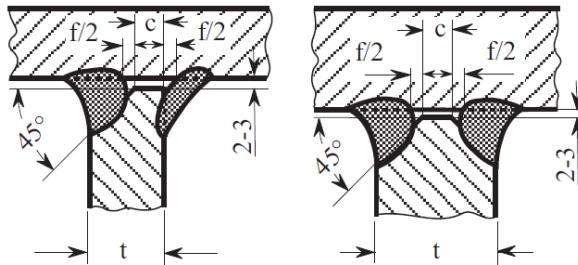


Fig. C3.6.10 Single and double-bevel welds with unwelded root face and defined incomplete root penetration

The effective weld thickness shall be assumed as the thickness of the abutting plate  $t$  minus  $(c + f)$ , where  $f$  is to be assigned a value of  $0,2 \cdot t$  subject to a maximum of 3 mm. Where proof of fatigue strength is required (see C3.7.6), these welds are to be assigned to types D2 or D3.

.2.4 Corner, T and double-T (cruciform) joints which are accessible from one side only may be made in accordance with Fig. C3.6.11 in a manner analogous to the butt joints referred to in C3.6.1.3.1.3 using a weld pool support (backing), or as single-side, single bevel welds in a manner similar to those prescribed in C3.6.1.3.2.2.

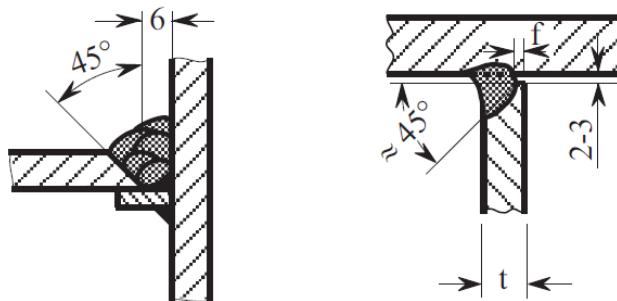


Fig. C3.6.11 Single-side welded T joints

The effective weld thickness shall be determined by analogy with C3.6.1.3.1.3 or C3.6.1.3.2.2, as appropriate. Wherever possible, these joints should not be used where proof of fatigue strength is required (see C3.7.6).

.2.5 Where corner joints are flush, the weld shapes shall be as shown in Fig. C3.6.12 with bevelling of at least 30° of the vertically drawn plates to avoid the danger of lamellar tearing. A similar procedure is to be followed in the case of fitted T joints (uniting three plates) where the abutting plate is to be socketed between the aligned plates.

.2.6 Where, in the case of T joints, the direction of the main stress lies in the plane of the horizontal plates (e.g. the plating) shown in Fig. C3.6.13 and where the connection of the perpendicular (web) plates is of secondary importance, welds uniting three plates may be made in accordance with Fig. C3.6.13 (with the exception of those subjected mainly to dynamic loads). For the root passes of the three plate weld sufficient penetration shall be achieved. Sufficient penetration has to be verified in way of the welding procedure test.

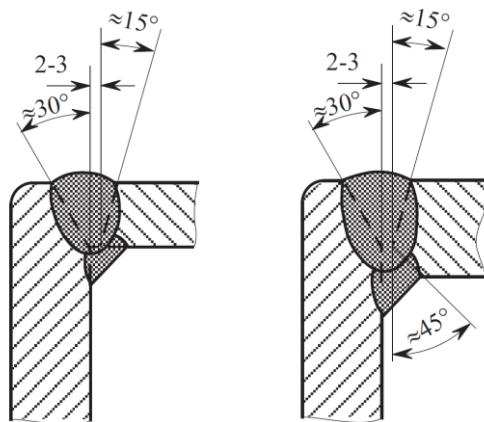


Fig. C3.6.12 Flush fitted corner joints

The effective thickness of the weld connecting the horizontal plates shall be determined in accordance with C3.6.1.3.2.2. The requisite "a" dimension is determined by the joint uniting the vertical (web) plates and shall, where necessary, be determined in accordance with Table C3.6.3 or by calculation as for fillet welds.

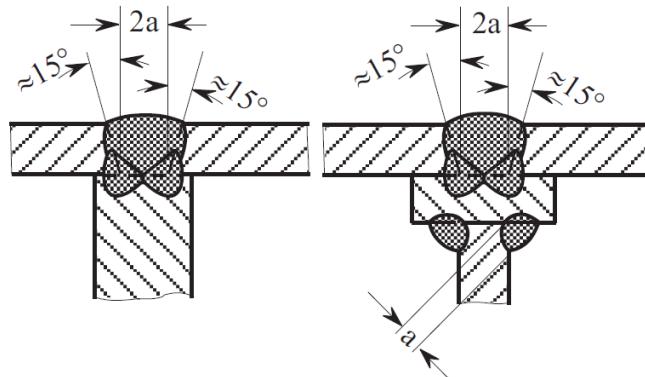


Fig. C3.6.13 Welding together three plates

### .3 Fillet weld connections

**.3.1** In principle fillet welds are to be of the double fillet weld type. Exceptions to this rule (as in the case of closed box girders and mainly shear stresses parallel to the weld) are subject to approval in each individual case. The throat thickness "a" of the weld (the height of the inscribed isosceles triangle) shall be determined in accordance with [Table C3.6.3](#) or by calculation according to [C3.6.2](#). The leg length of a fillet weld is to be not less than 1,4 times the throat thickness "a". For fillet welds at doubling plates, see [C3.6.1.2.4.3](#) and for bracket joints, see [C3.6.2.2.7](#).

**.3.2** The relative fillet weld throat thicknesses specified in [Table C3.6.3](#) relate to normal strength and higher strength hull structural steels and comparable structural steels. They may also be generally applied to high-strength structural steels and non-ferrous metals provided that the "tensile shear strength" of the weld metal used is at least equal to the tensile strength of the base material. Failing this, the "a" dimension shall be increased accordingly and the necessary increment shall be established during the welding procedure test (see [Rules for Welding \(Pt.1, Vol. VI\), Sec. 12, F.](#)). Alternatively proof by calculation taking account of the properties of the weld metal may be presented.

**Note:**

*In the case of higher-strength aluminium alloys, such an increment may be necessary for cruciform joints subject to tensile stresses, as experience shows that in the welding procedure tests the tensile-shear strength of fillet welds (made with matching filler metal) often fails to attain the tensile strength of the base material. See also [Rules for Welding \(Pt.1, Vol. VI\), Sec. 12, F.](#)*

**.3.3** The throat thickness of fillet welds shall not exceed 0,7 times the lesser thickness of the parts to be connected (generally the web thickness). The minimum throat thickness is defined by the expression:

$$a_{\min} = \sqrt{\frac{t_1 + t_2}{3}} \quad [\text{mm}], \quad \text{but not less than } 2,5 \text{ mm}$$

$t_1$  = lesser (e.g. the web) plate thickness [mm]

$t_2$  = greater (e.g. the flange) plate thickness [mm]

**.3.4** It is desirable that the fillet weld section shall be flat faced with smooth transitions to the base material. Where proof of fatigue strength is required (see [C3.7.6](#)), machining of the weld (grinding to remove notches) may be required depending on the notch category. The weld should penetrate at least close to the theoretical root point.

**.3.5** Where mechanical welding processes are used which ensure deeper penetration extending well beyond the theoretical root point and where such penetration is uniformly and dependably maintained

under production conditions, approval may be given for this deeper penetration to be allowed for in determining the throat thickness. The effective dimension:

$$a_{\text{deep}} = a + \frac{2 \cdot e_{\min}}{3} \quad [\text{mm}]$$

shall be ascertained in accordance with Fig. C3.6.14 and by applying the term "e<sub>min</sub>" to be established for each welding process by a welding procedure test. The throat thickness shall not be less than the minimum throat thickness related to the theoretical root point.

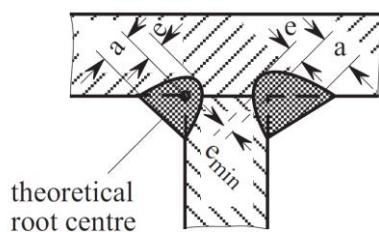


Fig. C3.6.14 Fillet welds with increased penetration

.3.6 When welding on top of shop primers which are particularly liable to cause porosity, an increase of the "a" dimension by up to 1 mm may be stipulated depending on the welding process used. This is specially applicable where minimum fillet weld throat thicknesses are employed. The size of the increase shall be decided on a case by case basis considering the nature and severity of the stressing following the test results of the shop primer in accordance with the [Rules for Welding \(Pt.1, Vol. VI\)](#), Sec. 12, F. This applies in analogous manner to welding processes where provision has to be made for inadequate root penetration.

.3.7 Strengthened filled welds continuous on both sides are to be used in areas subjected to severe dynamic loads (e.g. for connecting the longitudinal and transverse girders of the engine base to top plates close to foundation bolts, see [Table C3.6.3](#)), unless single or double-bevel welds are stipulated in these locations. In these areas the "a" dimension shall equal 0,7 times the lesser thickness of the parts to be welded.

.3.8 Intermittent fillet welds in accordance with [Table C3.6.3](#) may be located opposite one another (chain intermittent welds, possibly with scallops) or may be staggered, see [Fig. C3.6.15](#). In case of small sections other types of scallops may be accepted.

In water and cargo tanks, in the bottom area of fuel oil tanks and of spaces where condensed or sprayed water may accumulate and in hollow components (e.g. rudders) threatened by corrosion, only continuous or intermittent fillet welds with scallops shall be used. This applies accordingly also to areas, structures or spaces exposed to extreme environmental conditions or which are exposed to corrosive cargo.

There shall be no scallops in areas where the plating is subjected to severe local stresses (e.g. in the bottom section of the fore ship) and continuous welds are to be preferred where the loading is mainly dynamic.

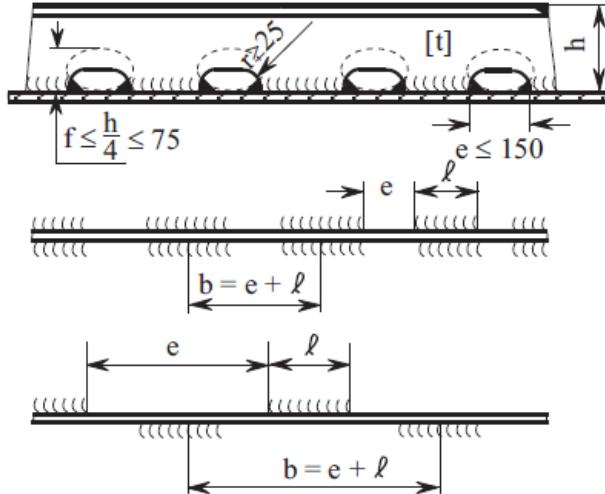


Fig. C3.6.15 Scallop, chain and staggered welds

**.3.9** The throat thickness  $a_u$  of intermittent fillet welds is to be determined according to the selected pitch ratio  $b/\ell$  by applying the formula:

$$a_u = 1,1 \cdot a \left( \frac{b}{\ell} \right) \text{ [mm]}$$

$a$  = required fillet weld throat thickness [mm] for a continuous weld according to [Table C3.6.3](#) or determined by calculation

$b$  = pitch =  $e + \ell$  [mm]

$e$  = interval between the welds [mm]

$\ell$  = length of fillet weld [mm]

The pitch ratio  $b/\ell$  should not exceed 5. The maximum unwelded length ( $b - \ell$  with scallop and chain welds, or  $b/2 - \ell$  with staggered welds) should not exceed 25 times the lesser thickness of the parts to be welded. The length of scallops should, however, not exceed 150 mm.

**.3.10** Lap joints should be avoided wherever possible and are not to be used for heavily loaded components. In the case of components subject to low loads lap joints may be accepted provided that, wherever possible, they are orientated parallel to the direction of the main stress. The width of the lap shall be  $1,5 t + 15$  mm ( $t$  = thickness of the thinner plate). Except where another value is determined by calculation, the fillet weld throat thickness "a" shall equal 0,4 times the lesser plate thickness, subject to the requirement that it shall not be less than the minimum throat thickness required by [C3.6.1.3.3.3](#). The fillet weld shall be continuous on both sides and shall meet at the ends.

**.3.11** In the case of plug welding, the plugs should, wherever possible, take the form of elongated holes lying in the direction of the main stress. The distance between the holes and the length of the holes may be determined by analogy with the pitch "b" and the fillet weld length " $\ell$ " in the intermittent welds covered by [C3.6.1.3.3.8](#). The fillet weld throat thickness " $a_u$ " may be established in accordance with [C3.6.1.3.3.9](#). The width of the holes shall be equal to at least twice the thickness of the plate and shall not be less than 15 mm. The ends of the holes shall be semi-circular. Plates or sections placed underneath should at least equal the perforated plate in thickness and should project on both sides to a distance of  $1,5 \times$  the plate thickness subject to a maximum of 20 mm. Wherever possible only the necessary fillet welds shall be welded, while the remaining void is packed with a suitable filler. Lug joint welding is not allowed.

### C3.6.1.4 Welded joints of particular components

#### .1 Welds at the ends of girders and stiffeners

.1.1 As shown in Fig. C3.6.16, the web at the end of intermittently welded girders or stiffeners is to be continuously welded to the plating or the flange plate, as applicable, over a distance at least equal to the depth "h" of the girder or stiffener subject to a maximum of 300 mm. Regarding the strengthening of the welds at the ends, extending normally over 0,15 of the span, see Table C3.6.3.

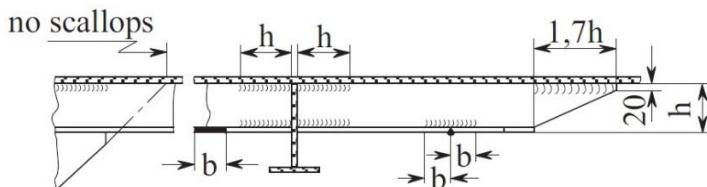


Fig. C3.6.16 Welds at the ends of girders and stiffeners

.1.2 The areas of bracket plates should be continuously welded over a distance at least equal to the length of the bracket plate. Scallops are to be located only beyond a line imagined as an extension of the free edge of the bracket plate.

.1.3 Wherever possible, the free ends of stiffeners shall abut against the transverse plating or the webs of sections and girders so as to avoid stress concentrations in the plating. Failing this, the ends of the stiffeners are to be sniped and continuously welded over a distance of at least 1,7 h subject to a maximum of 300 mm.

.1.4 Where butt joints occur in flange plates, the flange shall be continuously welded to the web on both sides of the joint over a distance at least equal to the width of the flange.

#### .2 Joints between section ends and plates

.2.1 Welded joints connecting section ends and plates may be made in the same plane or lapped.

Where no design calculations have been carried out or stipulated for the welded connections, the joints may be made analogously to those shown in Fig. C3.6.17.

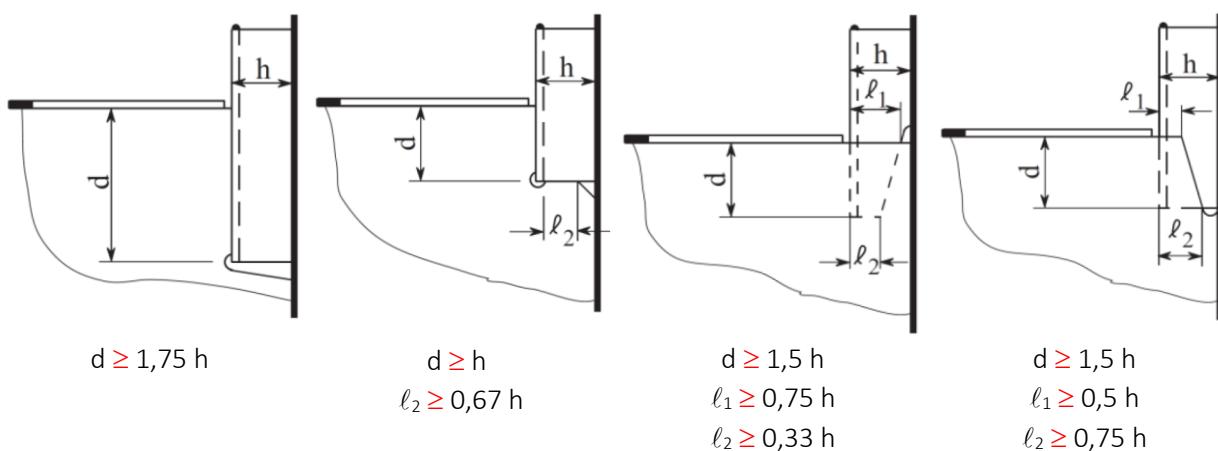


Fig. C3.6.17 Joints uniting section ends and plates

.2.2 Where the joint lies in the plane of the plate, it may conveniently take the form of a single-bevel butt weld with fillet. Where the joint between the plate and the section end overlaps, the fillet weld shall be continuous on both sides and shall meet at the ends. The necessary "a" dimension is to be calculated in

accordance with C3.6.2.2.6. The fillet weld throat thickness is not to be less than the minimum specified in C3.6.1.3.3.3.

### .3 Welded shaft bracket joints

.3.1 Unless cast in one piece or provided with integrally cast welding flanges analogous to those prescribed in C3.6.1.2.1.7 (see Fig. C3.6.18), strut barrel and struts are to be connected to each other and to the shell plating in the manner shown in Fig. C3.6.19.

.3.2 In the case of single-strut shaft brackets no welding is to be performed on the arm at or close to the position of constraint. Such components shall be provided with integrally forged or cast welding flanges.

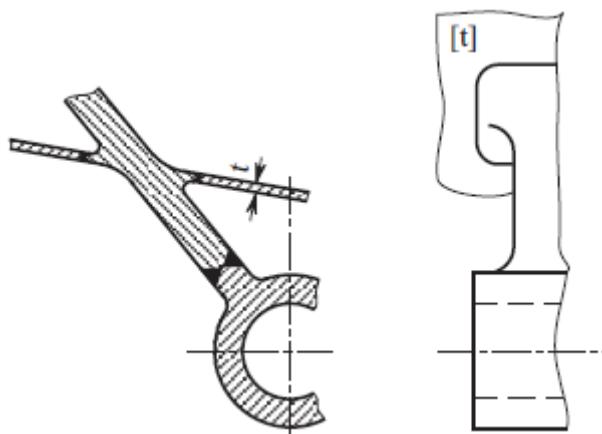
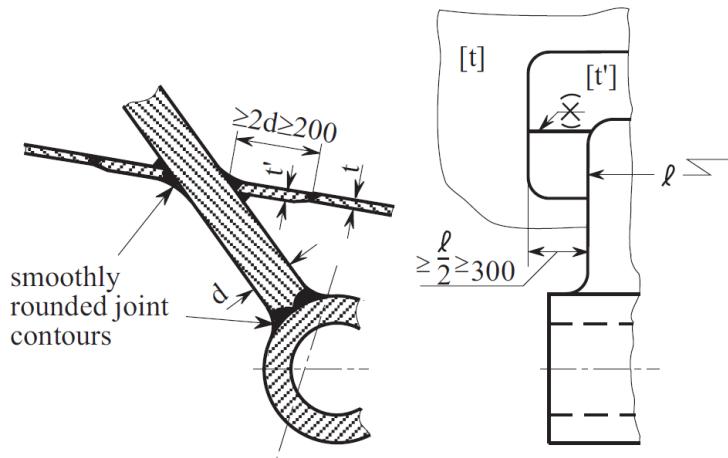


Fig. C3.6.18 Shaft bracket with integrally cast welding flanges



$t$  = required plate thickness [mm]

$$t' = \frac{d}{3} + 5 \quad [\text{mm}] \text{ where } d < 50 \text{ mm}$$

$$t' = 3 \cdot \sqrt{d} \quad [\text{mm}] \text{ where } d > 50 \text{ mm}$$

For shaft brackets of elliptically shaped cross section  $d$  may be substituted by  $2/3 d$  in the above formulae.

Fig. C3.6.19 Shaft bracket without integrally cast welding flanges

### C3.6.2 Stress Analysis

#### C3.6.2.1 General analysis of fillet weld stresses

##### .1 Definition of stresses

For calculation purposes, the following stresses in a fillet weld are defined (see also Fig. C3.6.20):

- $\sigma_{\perp}$  = normal stresses acting vertically to the direction of the weld seam
- $\tau_{\perp}$  = shear stress acting vertically to the direction of the weld seam
- $\tau_{\parallel}$  = Shear stress acting in the direction of the weld seam

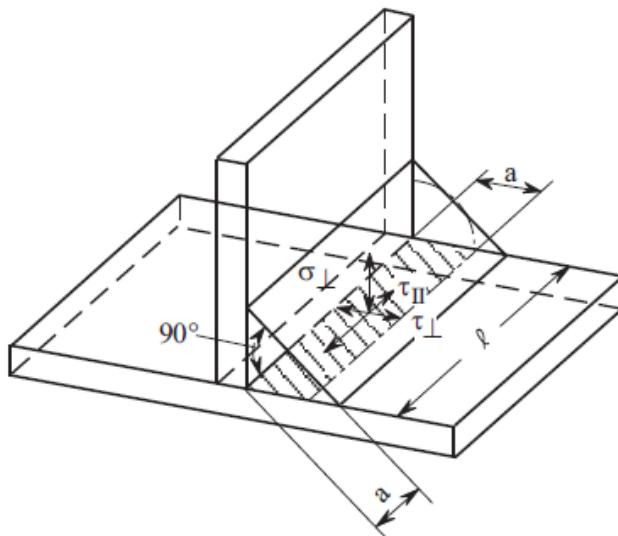


Fig. C3.6.20 Stresses in a fillet weld

Normal stresses acting in the direction of the weld seam need not be considered.

For calculation purposes the weld seam area is  $a \cdot l$ .

Due to equilibrium conditions the following applies to the flank area vertical to the shaded weld seam area:  
 $\tau_{\perp} = \sigma_{\perp}$ .

The equivalent stress is to be calculated by the following formula:

$$\sigma_v = \sqrt{\sigma_{\perp}^2 + \tau_{\perp}^2 + \tau_{\parallel}^2}$$

##### .2 Definitions

- $a$  = throat thickness [mm]
- $l$  = length of fillet weld [mm]
- $P$  = single force [N]
- $M$  = bending moment at the position considered [Nm]
- $Q$  = shear force at the point considered [N]
- $S$  = first moment of the cross sectional area of the flange connected by the weld to the web in relation to the neutral beam axis [ $\text{cm}^3$ ]

- I = moment of inertia of the girder section [cm<sup>4</sup>]  
 W = section modulus of the connected section [cm<sup>2</sup>]

### C3.6.2.2 Determination of stresses

#### .1 Fillet welds stressed by normal and shear forces

Flank and frontal welds are regarded as being equal for the purposes of stress analysis. In view of this, normal and shear stresses are calculated as follows:

$$\sigma = \tau = \frac{P}{\sum a \cdot \ell} \quad [\text{N/mm}^2]$$

Joint as shown in Fig. C3.6.21:

- Stresses in frontal fillet welds:

$$\tau_{\perp} = \frac{P_1}{2 \cdot a(\ell_1 + \ell_2)} \quad [\text{N/mm}^2]$$

$$\tau_{\parallel} = \frac{P_2}{2 \cdot a(\ell_1 + \ell_2)} \pm \frac{P_2 \cdot e}{2 \cdot a \cdot F_t} \quad [\text{N/mm}^2]$$

$$F_t = (\ell_1 + a)(\ell_2 + a) \quad [\text{mm}^2]$$

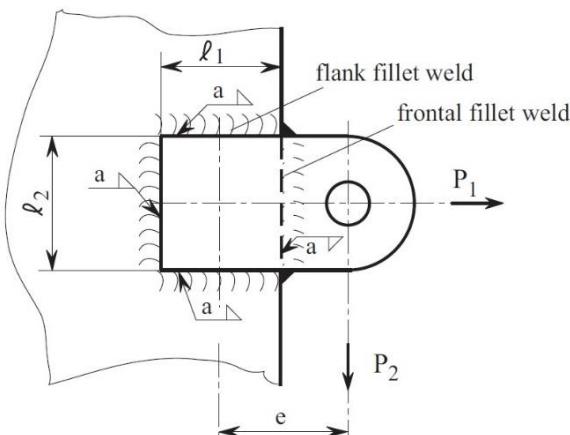


Fig. C3.6.21 Weld joint of an overlapped lifting eye

- Stresses in flank fillet welds:

$$\tau_{\perp} = \frac{P_2}{2 \cdot a(\ell_1 + \ell_2)} \quad [\text{N/mm}^2]$$

$$\tau_{\parallel} = \frac{P_1}{2 \cdot a(\ell_1 + \ell_2)} \pm \frac{P_2 \cdot e}{2 \cdot a \cdot F_t} \quad [\text{N/mm}^2]$$

$$\ell_1, \ell_2, e \quad [\text{mm}]$$

- Equivalent stress for frontal and flank fillet welds:

$$\sigma_v = \sqrt{\tau_{\perp}^2 + \tau_{\parallel}^2}$$

Joint as shown in Fig. C3.6.22:

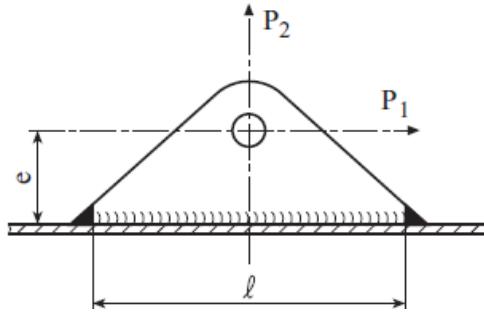


Fig. C3.6.22 Weld joint of a vertically mounted lifting eye

$$\tau_{\perp} = \frac{P_2}{2 \cdot l \cdot a} + \frac{3 \cdot P_1 \cdot e}{l^2 \cdot a} \quad [\text{N/mm}^2]$$

$$\tau_{\parallel} = \frac{P_1}{2 \cdot l \cdot a} \quad [\text{N/mm}^2]$$

Equivalent stress:

$$\sigma_v = \sqrt{\tau_{\perp}^2 + \tau_{\parallel}^2}$$

## .2 Fillet weld joints stressed by bending moments and shear forces

The stresses at the fixing point of a girder are calculated as follows (in Fig. C3.6.23 a cantilever beam is given as an example):

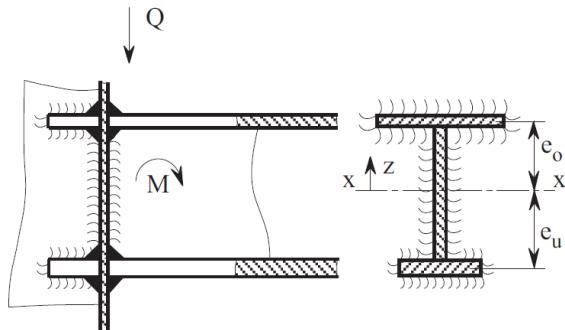


Fig. C3.6.23 Fixing point of a cantilever beam

- Normal stress due to bending moment:

$$\sigma_{\perp} = \frac{M}{I_s} z \quad [\text{N/mm}^2]$$

$$\sigma_{\perp \max} = \frac{M}{I_s} e_u \quad [\text{N/mm}^2], \quad \text{if } e_u > e_0$$

$$= \frac{M}{I_s} e_0 \quad [\text{N/mm}^2], \quad \text{if } e_u < e_0$$

- Shear stress due to shear force:

$$\tau_{\parallel}(z) = \frac{Q \cdot S_s(z)}{10 \cdot I_s \cdot \sum a} \quad [\text{N/mm}^2]$$

$$\tau_{\parallel\max} = \frac{Q \cdot S_{s\max}}{20 \cdot I_s \cdot a} \quad [\text{N/mm}^2]$$

$I_s$  = moment of inertia of the welded joint related to the x-axis [cm<sup>4</sup>]

$S_s(z)$  = the first moment of the connected weld section at the point under consideration [cm<sup>3</sup>]

$z$  = distance from the neutral axis [cm]

- Equivalent stress:

It has to be proved that neither  $\sigma_{\perp\max}$  in the region of the flange nor  $\tau_{\parallel\max}$  in the region of the neutral axis nor the equivalent stress  $\sigma_v = \sqrt{\sigma_{\perp}^2 + \tau_{\parallel}^2}$  exceed the permitted limits given in C3.6.2.2.8 at any given point. The equivalent stress  $\sigma_v$  should always be calculated at the web-flange connection

### .3 Fillet weld joints stressed by bending and torsional moments and shear forces

Regarding the normal and shear stresses resulting from bending, see C3.6.2.2.2. Torsional stresses resulting from the torsional moment  $M_T$  are to be calculated:

$$\tau_T = \frac{M_T \cdot 10^3}{2 \cdot a \cdot A_m} \quad [\text{N/mm}^2]$$

$M_T$  = torsional moment [Nm]

$A_m$  = sectional area [mm<sup>2</sup>] enclosed by the weld seam

The equivalent stress composed of all three components (bending, shear and torsion) is calculated by means of the following formulae:

$$\sigma_v = \sqrt{\sigma_{\perp}^2 + \tau_{\parallel}^2 + \tau_T^2} \quad [\text{N/mm}^2]$$

where  $\tau_{\parallel}$  and  $\tau_T$  have not the same direction

$$\sigma_v = \sqrt{\sigma_{\perp}^2 + (\tau_{\parallel} + \tau_T)^2} \quad [\text{N/mm}^2]$$

where  $\tau_{\parallel}$  and  $\tau_T$  have the same direction

### .4 Continuous fillet weld joints between web and flange of bending girders

The stresses are to be calculated in way of maximum shear forces. Stresses in the weld's longitudinal direction need not be considered.

In the case of continuous double fillet weld connections the shear stress is to be calculated as follows:

$$\tau_{\parallel} = \frac{Q \cdot S}{20 \cdot I \cdot a} \quad [\text{N/mm}^2]$$

The fillet weld thickness required is:

$$a_{req} = \frac{Q \cdot S}{20 \cdot I \cdot \tau_{zul}} \quad [\text{mm}]$$

## .5 Intermittent fillet weld joints between web and flange of bending girders

Shear stress:

$$\tau_{\parallel} = \frac{Q \cdot S \cdot \alpha}{20 \cdot I \cdot a} \left( \frac{b}{\ell} \right) \quad [\text{N/mm}^2]$$

b = pitch

$\alpha$  = 1,1 stress concentration factor which takes into account increases in shear stress at the ends of the fillet weld seam " $\ell$ "

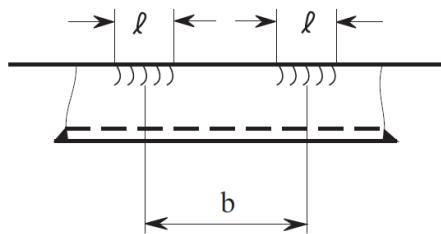


Fig. C3.6.24 Intermittent fillet weld joint

The fillet weld thickness required is:

$$a_{\text{req}} = \frac{Q \cdot S \cdot 1,1}{20 \cdot I \cdot \tau_{\text{zul}}} \left( \frac{b}{\ell} \right) \quad [\text{mm}]$$

## .6 Fillet weld connections on overlapped profile joints

### .6.1 Profiles joined by means of two flank fillet welds (see Fig. C3.6.25):

$$\tau_{\perp} = \frac{Q}{2 \cdot a \cdot d} \quad [\text{N/mm}^2]$$

$$\tau_{\parallel} = \frac{M \cdot 10^3}{2 \cdot a \cdot c \cdot d} \quad [\text{N/mm}^2]$$

The equivalent stress is:

$$\sigma_v = \sqrt{\tau_{\perp}^2 + \tau_{\parallel}^2} \quad [\text{N/mm}^2]$$

c, d,  $\ell_1$ ,  $\ell_2$ , r [mm] see Fig. C3.6.25

$$c = r + \frac{3 \cdot \ell_1 - \ell_2}{4} \quad [\text{mm}]$$

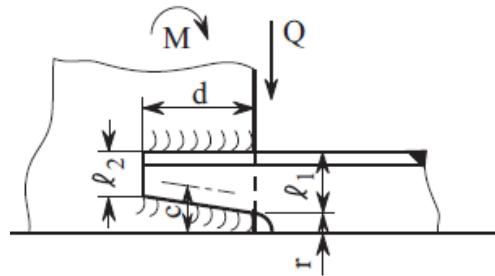


Fig. C3.6.25 Profile joined by means of two flank fillet joints

As the influence of the shear force can generally be neglected, the required fillet weld thickness may be determined by the following formula:

$$a_{req} = \frac{W \cdot 10^3}{15 \cdot c \cdot d} \quad [\text{mm}]$$

.6.2 Profile joined by mean of two flank and two frontal fillet welds (all round welding as shown in Fig. C3.6.26):

$$\tau_{\perp} = \frac{Q}{a \cdot (2 \cdot d + \ell_1 + \ell_2)} \quad [\text{N/mm}^2]$$

$$\tau_{\parallel} = \frac{M \cdot 10^3}{a \cdot c \cdot (2 \cdot d + \ell_1 + \ell_2)} \quad [\text{N/mm}^2]$$

The equivalent stress is:

$$\sigma_v = \sqrt{\tau_{\perp}^2 + \tau_{\parallel}^2} \quad [\text{N/mm}^2]$$

$$a_{req} = \frac{W \cdot 10^3}{1,5 \cdot c \cdot d \cdot \left(1 + \frac{\ell_1 + \ell_2}{2 \cdot d}\right)} \quad [\text{mm}]$$

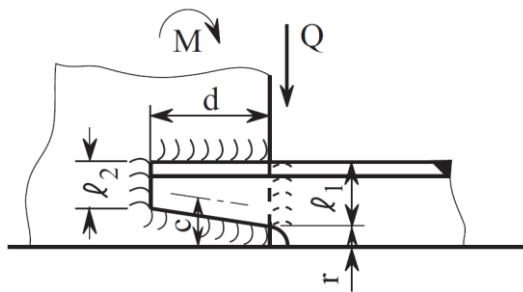


Fig. C3.6.26 Profile joined by means of two flank and two frontal fillet welds (all round welding)

## .7 Bracket joints

Where profiles are joined to brackets as shown in Fig. C3.6.27, the average shear stress is:

$$\tau = \frac{3 \cdot M \cdot 10^3}{4 \cdot a \cdot d^2} + \frac{Q}{2 \cdot a \cdot d} \quad [\text{N/mm}^2]$$

$d$  = length of overlap [mm]

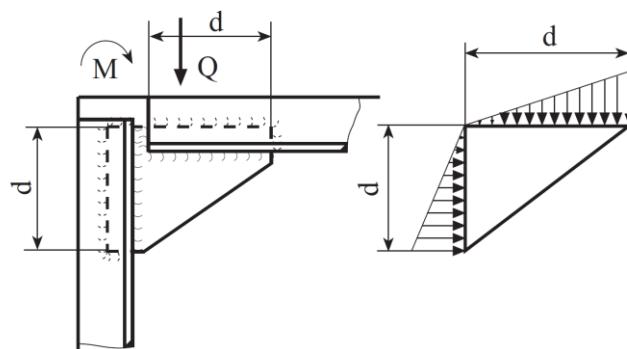


Fig. C3.6.27 Bracket joint with idealized stress distribution resulting from moment M and shear force Q

The required fillet weld thickness is to be calculated from the section modulus of the profile as follows:

$$a_{req} = \frac{1000 \cdot W}{d^2} \quad [\text{mm}]$$

(The shear force Q has been neglected.)

#### .8 Permissible stresses

The permissible stresses for various materials under mainly static loading conditions are given in [Table C3.6.2](#). The values listed for high strength steels, austenitic stainless steels and aluminium alloys are based on the assumption that the strength values of the weld metal used are at least as high as those of the parent metal. If this is not the case, the "a"-value calculated shall be increased accordingly (see also [C3.6.1.3.2](#)).

**Table C3.6.2 Permissible stresses in fillet weld seams**

Material	R <sub>eh</sub> or R <sub>p0,2</sub> [N/mm <sup>2</sup> ]	Permissible stresses [N/mm <sup>2</sup> ] equivalent stress, shear stress σ <sub>vp</sub> , τ <sub>p</sub>
normal strength hull structural steel	235	115
higher strength structural steel	KI-A/D/E/F 32	315
	KI-A/D/E/F 36	355
	KI-A/D/E/F 40	390
austenitic and austenitic ferritic stainless steels	1.4306/304 L	180
	1.4404/316 L	190
	1.4435/316 L	190
	1.4438/317 L	195
	1.4541/321	205
	1.4571/316 Ti	215
	1.4406/316 LN	280
	1.4429/316 LN	295
	1.4439/317 LN	285
aluminium alloys	1.4462/318 LN	480
	AlMg3/5754	80 <sup>1</sup>
	AlMg4,5Mn0,7/5083	125 <sup>1</sup>
	AlMgSi/6060	65 <sup>2</sup>
	AlSi1MgMn/6082	115 <sup>2</sup>

<sup>1</sup> Plates, soft condition

<sup>2</sup> Sections, cold hardened

Table C3.6.3 Fillet weld connections

Structural parts to be connected	Basic thickness of fillet welds $a/t_0^1$ for double continuous fillet welds <sup>2</sup>	Intermittent fillet welds permissible <sup>3</sup>
<b>Bottom structures</b>		
transverse and longitudinal girders to each other	0,35	×
– to shell and inner bottom	0,20	×
centre girder to flat keel and inner bottom	0,40	
transverse and longitudinal girders and stiffeners including shell plating in way of bottom strengthening forward	0,30	
machinery space		
transverse and longitudinal girders to each other	0,35	
– to shell and inner bottom	0,30	
inner bottom to shell	0,40	
sea chests, water side	0,50	
inside	0,30	
<b>Machinery foundation</b>		
longitudinal and transverse girders to each other and to the shell	0,40	
– to inner bottom and face plates	0,40	
– to top plates	0,50 <sup>4</sup>	
– in way of foundation bolts	0,70 <sup>4</sup>	
– to brackets and stiffeners	0,30	
longitudinal girders of thrust bearing to inner bottom	0,40	
<b>Decks</b>		
– to shell (general)	0,40	
deckstringer to sheerstrake	0,50	
<b>Frames, stiffeners, beams etc.</b>		
general	0,15	×
in peak tanks	0,30	×
bilge keel to shell	0,15	
<b>Transverses, longitudinal and transverse girders</b>		
general	0,15	×
within 0,15 of span from supports	0,25	
cantilevers	0,40	
pillars to decks	0,40	
<b>Bulkheads, tank boundaries, walls of superstructures and deckhouses</b>		
– to decks, shell and walls	0,40	
<b>Hatch coamings</b>		
– to deck	0,40	
– to longitudinal stiffeners	0,30	
<b>Hatch covers</b>		
general	0,15	<sup>5</sup>
watertight or oiltight fillet welds	0,30	
<b>Rudder</b>		
plating to webs	0,25	×
<b>Stem</b>		
plating to webs	0,25	×

<sup>1</sup>  $t_0$  = thickness of the thinner plate.

<sup>2</sup> In way of large shear forces larger throat thicknesses may be required on the bases of calculations according to C3.6.2.

<sup>3</sup> For intermittent welding in spaces liable to corrosion C3.6.1.3.3.8 is to be observed.

<sup>4</sup> For plate thicknesses exceeding 15 mm single or double bevel butt joints with, full penetration or with defined incomplete root penetration according to Fig. C3.6.9 to be applied.

<sup>5</sup> excepting hatch covers above holds provided for ballast water.

## C3.7 Steel and Aluminium Alloy Craft

### C3.7.1 Structural Details

#### C3.7.1.1 Longitudinal members

.1 All longitudinal members taken into account for calculating the midship section modulus are to extend over the required length within 0,4 L amidships and are to be tapered gradually to the required end scantlings.

.2 Abrupt discontinuities of strength of longitudinal members are to be avoided as far as practicable. Where longitudinal members having different scantlings are connected with each other, smooth transitions are to be provided.

.3 At the ends of longitudinal bulkheads or continuous longitudinal walls suitable scarping brackets are to be provided.

#### C3.7.1.2 Transverses and girders

.1 Where transverses and girders fitted in the same plane are connected to each other, major discontinuities of strength shall be avoided. The web depth of the smaller girder shall, in general, not be less than 60 % of the web depth of the greater one.

.2 The taper between face plates with different dimensions is to be gradual. In general the taper shall not exceed 1:3. At intersections the forces acting in the face plates are to be properly transmitted.

.3 For transmitting the acting forces the face plates and webs are to be supported at their knuckles.

.4 For preventing the face plates from tripping adequately spaced stiffeners or tripping brackets are to be provided. The spacing of these tripping elements shall not exceed  $12 \cdot b_f$

.5 The webs are to be stiffened to prevent buckling (see also [C3.7.5](#)).

.6 The location of lightening holes shall be such that the distance from hole edge to face plate is not less than  $0,25 \cdot$  web depth.

.7 In way of high shear stresses lightening holes in the webs are to be avoided as far as possible.

In the following requirements for the scantlings of hull structures (plating, stiffeners, primary supporting members) are given. The loads acting on such structures are to be calculated in accordance with the provisions of [C3.5](#).

### C3.7.2 Definitions and symbols

The definitions and symbols used are the following ones:

- t = thickness [mm] of plating and deck panels,  
z = required section modulus [ $\text{cm}^3$ ] of stiffeners and primary supporting members,  
s = spacing of stiffeners [m] measured along the plating,  
 $\ell$  = overall span of stiffeners [m] i.e. the distance between the supporting elements at the ends of the stiffeners (see [Fig. C3.7.1](#)),  
S = scantling span of primary supporting members [m], which can be reduced by one third of sum of bracket length, if any,  
b = actual spacing of primary supporting members,

- p = design pressure [kPa] calculated as defined in C3.5,  
 $\sigma_{am}$  = permissible normal stress [MPa],  
 $\tau_{am}$  = permissible shear stress [MPa],  
 k = material factor defined in C3.2,  
 e = ratio between permissible and actual hull girder longitudinal bending stresses,  
 =  $\sigma_p/\sigma_{bl}$   
 $\sigma_p$  = maximum permissible stress [MPa] as defined in C3.7.3.1,  
 $\sigma_{bl}$  = longitudinal bending stress [MPa] as defined in C3.7.3.1,  
 $\mu$  = defined as follows:  
 =  $\sqrt{1,1 - 0,5 \cdot \left(\frac{s}{\ell}\right)^2}$ , which needs not be taken greater than 1,0

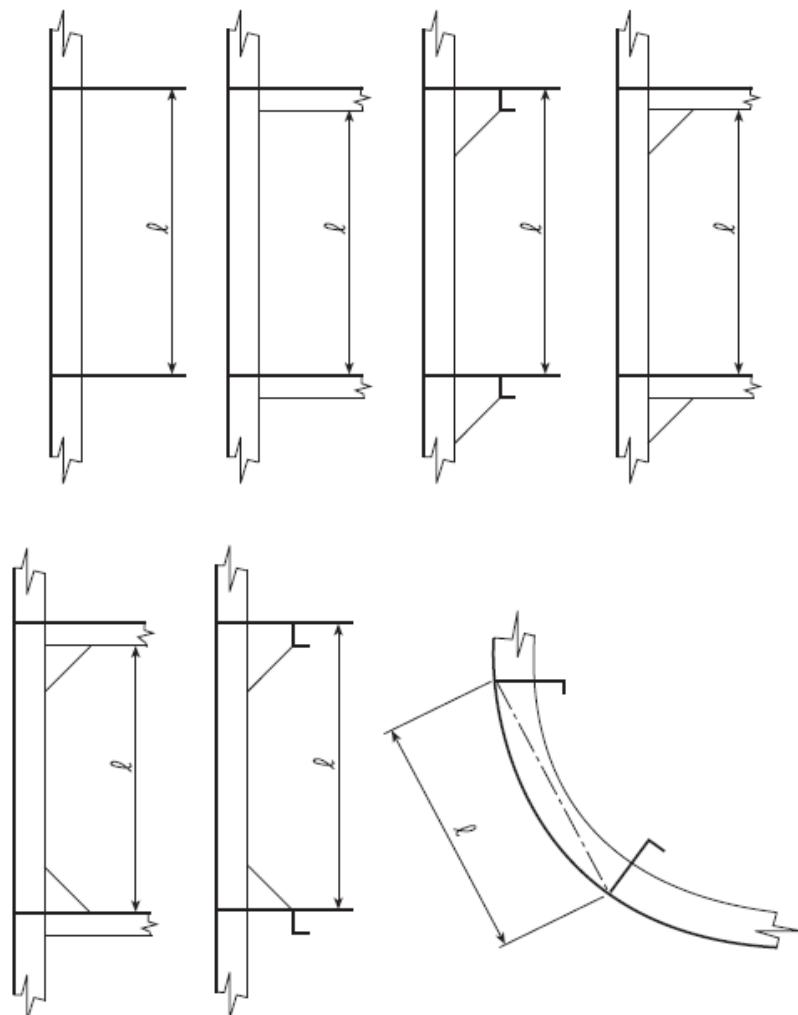


Fig. C3.7.1 Examples of spans of ordinary stiffeners

### C3.7.3 Overall strength

#### C3.7.3.1 Longitudinal strength

.1 In general, the scantlings resulting from local strength calculations in the following 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 Longitudinal stress [MPa] at height  $z$  above the base line contributing to the craft longitudinal strength is obtained from the following equation:

$$\sigma_{bl} = \left| \frac{M_{bl}}{I_y} \cdot (z - z_0) \cdot 10^{-3} \right| \quad [\text{MPa}]$$

$M_{bl}$  = total bending moment [kNm] defined in [C3.4.1](#) or [C3.4.2](#),

$z_0$  = height of neutral axis above base line [m],

$I_y$  = moment of inertia [ $\text{m}^4$ ] related to the transverse axis,

The values of stress  $\sigma_{bl}$  are not to exceed  $\sigma_p$ , with:

- steel structures:

$$\sigma_p = 150/k \quad [\text{MPa}]$$

- aluminium alloy structures:

$$\sigma_p = 70/k \quad [\text{MPa}]$$

.4 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:

$$\sigma_p = 175/k \quad [\text{MPa}]$$

- aluminium alloy structures:

$$\sigma_p = 75/k \quad [\text{MPa}]$$

.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 wet deck is to be constituted by continuous plating for its entire longitudinal and transverse extension. Alternative solutions may, however, be examined by BKI on the basis of considerations pertaining to the height of the wet 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  $L > 65$  m or speed  $V > 45$  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 C3.1.2.

### 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 Fig. C3.7.2, G is the centre of the stiffnesses  $r_i$  of the n beams. Its position is defined by:

$$a = \frac{\sum r_i \cdot x_i}{\sum r_i}$$

$a$  = abscissa [m] of the centre G with respect to an arbitrarily chosen origin 0,

$r_i$  = stiffness [N/m] of the beam i:

$$= \frac{12 \cdot E_i \cdot I_i}{S_i^3} \cdot 10^6 \quad [\text{N/m}]$$

$E_i$  = Young's modulus [MPa] of the beam i,

$I_i$  = bending inertia [ $\text{m}^4$ ] of the beam i,

$S_i$  = span [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 0,

If  $F_i$  [N] is the force taken over by the beam i, the deflection  $y_i$  [m] of the hull in way of the beam i, is:

$$y_i = \frac{F_i \cdot S_i^3 \cdot 10^{-6}}{12 \cdot E_i \cdot I_i} = \frac{F_i}{r_i} = d_i \cdot \omega \quad [\text{m}]$$

$d_i$  = abscissa [m] of the beam i in relation to G:

$$= x_i - a$$

$\omega$  = rotation angle [rad] of one hull in relation to the other around a transverse axis passing through G

.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:

$$\omega = \frac{M_{tt}}{\sum r_i \cdot d_i^2} \cdot 10^3 \quad [\text{rad}]$$

.3 As  $M_{tt}$ ,  $r_i$  and  $d_i$  are known,  $\omega$  is thus deduced, then the force  $F_i$  [N] the bending moment  $M_i$  [Nm] and the corresponding normal and shear stresses can be evaluated in each beam:

$$F_i = \omega \cdot r_i \cdot d_i \quad [\text{N}]$$

$$M_i = F_i \cdot S_i / 2 \quad [\text{Nm}]$$

**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.

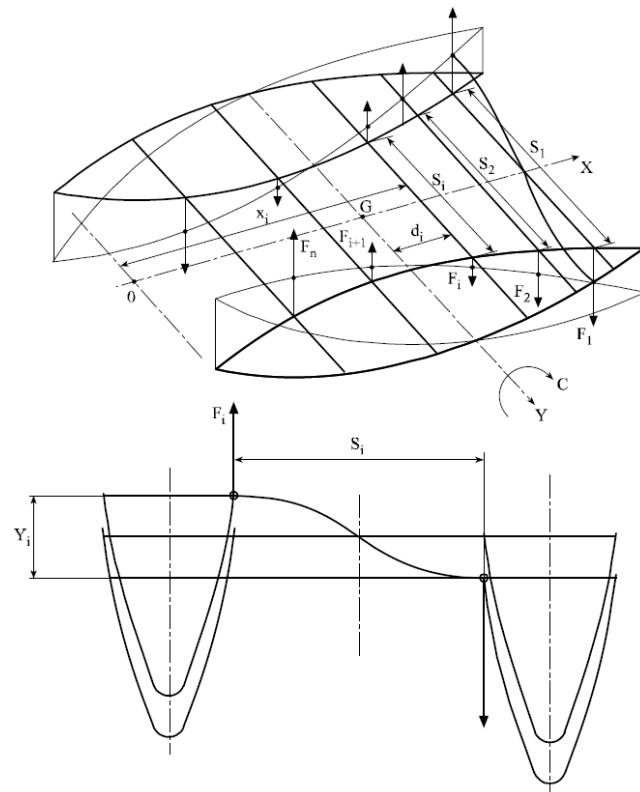


Fig. C3.7.2

#### C3.7.4 Effective width of plating

##### C3.7.4.1 Stiffeners

.1 Generally, the spacing of stiffeners (secondary members) may be taken as effective width of plating.

.2 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.

##### C3.7.4.2 Girders

.1 The effective width of plating  $e_m$  of frames and girders may be determined according to [Table 3.7.1](#) considering the type of loading.

**Table C3.7.1 Effective width  $e_m$  of frames and girders**

P/e	0	1	2	3	4	5	6	7	8
$e_{m1}/e$	0	0,36	0,64	0,82	0,91	0,96	0,98	1,00	1,0
$e_{m2}/e$	0	0,20	0,37	0,52	0,65	0,75	0,84	0,89	0,9

$e_{m1}$  is to be applied where girders are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads.  
 $e_{m2}$  is to be applied where girders are loaded by 3 or less single loads.  
 Intermediate values may be obtained by direct interpolation.  
 P = length between zero-points of bending moment curve, i.e. unsupported span in case of simply supported girders and 0,6 x unsupported span in case of constraint of both ends of girders  
 e = width of plating supported, measured from centre to centre of the adjacent unsupported fields

Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

.2      The effective cross sectional area of plates is not to be less than the cross sectional area of the face plate.

.3      The effective width of stiffeners and girders subjected to compressive stresses may be determined according to [C3.7.5](#), but is in no case to be taken greater than the effective breadth determined by [C3.7.4.2.1](#).

### C3.7.4.3 Cantilevers

Where cantilevers are fitted at every frame, the effective width of plating may be taken as the frame spacing. Where cantilevers are fitted at a greater spacing the effective width of plating at the respective cross section may approximately be taken as the distance of the cross section from the point on which the load is acting, however, not greater than the spacing of the cantilevers.

### C3.7.5 Proof of buckling strength

The buckling strength is to be proved according to the [Rules for Hull \(Pt.1, Vol.II\)](#), Sec. 3, F.

### C3.7.6 Fatigue

The fatigue strength is to be proved according to the [Rules for Hull \(Pt.1, Vol.II\)](#), Sec. 20.

### C3.7.7 Plating

#### C3.7.7.1 Formula

.1      The thickness [mm] required for the purposes of resistance to design pressure, is given by the formula:

$$t = 22,4 \cdot \mu \cdot s \cdot \sqrt{\frac{p}{\sigma_{am}}} \quad [\text{mm}]$$

Pressure  $p$  [kPa] and permissible stress  $\sigma_{am}$  [MPa] are defined in requirements stipulated in [C3.7.7.3](#) to [C3.7.7.8](#) for the various parts of the hull.

.2      Adequate provision is also to be made to limit corrosion. In general, a corrosion allowance of 0,5 mm has been considered in the following formulas. Steel plating of tanks, sea chests and chain lockers are to be increased by an additional 0,5 mm.

.3      In addition, the thicknesses of plating are to be not less than the minimum values given in [Table C3.7.2](#), in general.

.4      Lesser thicknesses than 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 BKI.

Table C3.7.2

Element	Minimum thickness [mm]
Shell plating: – Bottom shell plating – Side shell plating and wet deck plating	$1,35 \cdot L^{1/3} \geq 2,5$ $1,15 \cdot L^{1/3} \geq 2,5$
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 BKI.

### 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)  $p = \text{impact pressure } p_{sl}$  if occurring on the bottom as defined in C3.5.3;

$$\sigma_{am} = 235/k \text{ [MPa]} \quad \text{for steel structures}$$

$$= 95/k \text{ [MPa]} \quad \text{for aluminium alloy structures}$$

- b)  $p = \text{sea pressure } p_s$  as defined in C3.5.5;

$$\sigma_{am} = 185/k \text{ [MPa]} \quad \text{for steel structures}$$

$$= 85/k \text{ [MPa]} \quad \text{for aluminium alloy structures}$$

.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 BKI.

.5 Sea intakes and other openings are to be well rounded at the corners and located, as far as practicable, well clear of sharp edges.

### C3.7.7.4 Plating of side shell and front walls

- .1 The minimum required thickness is given by the formula in C3.7.7.1, assuming:

$p = \text{sea pressure } p_s$  as defined in C3.5.5, for side shell plating

$p = \text{sea pressure } p_{sf}$  as defined in C3.5.5.4, for front wall plating

$$\sigma_{am} = 185/k \text{ [MPa]} \quad \text{for steel structures}$$

$$\sigma_{am} = 85/k \text{ [MPa]} \quad \text{for aluminium alloy structures}$$

.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.

### C3.7.7.5 Plating of wet deck 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)  $p = \text{impact pressure } p_{sl}$  as defined in C3.5.4;

$$\sigma_{am} = 235/k \text{ [MPa]} \quad \text{for steel structures}$$

$$\sigma_{am} = 95/k \text{ [MPa]} \quad \text{for aluminium alloy structures}$$

b)  $p = \text{sea pressure } p_s$  as defined in C3.5.5;

$$\sigma_{am} = 185/k \text{ [MPa]} \quad \text{for steel structures}$$

$$\sigma_{am} = 85/k \text{ [MPa]} \quad \text{for aluminium alloy structures}$$

.2 Moreover, the thickness of internal sides, may be intermediate between that of the bottom of hulls and the bottom of the wet deck. In any case, it is to be no less than that required in C3.7.7.4 for external sides.

### C3.7.7.6 Deck plating

.1 The minimum required thickness is given by the formula in C3.7.7.1, assuming:

$p = \text{deck pressure } p_d$  as defined in C3.5.8;

$$\sigma_{am} = 185/k \text{ [MPa]} \quad \text{for steel structures}$$

$$\sigma_{am} = 85/k \text{ [MPa]} \quad \text{for aluminium alloy structures}$$

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 and C3.7.12.

### .2 Thickness of decks for wheel loading

.2.1 The thickness of deck plating for wheel loading is to be determined by the following formula:

$$t = c \cdot f_M (P \cdot k)^{0,5} \text{ [mm]}$$

$P$  = static load [kN] of one wheel or group of wheels on a plate panel  $s \cdot b$  considering the acceleration factor  $(1 + 0,4 a_v)$

$a_v$  = design vertical acceleration defined in Section C3.3

$f_M$  = 1,0 for steel

= 1,46 for aluminium

$c$  = factor according to the following formulae:

– for the aspect ratio  $b/s = 1$ :

– for the range  $0 < f/F < 0,3$ :

$$c = 1,87 \cdot \sqrt{\frac{f}{F} \left( 3,4 - 4,4 \frac{f}{F} \right)}$$

– for the range  $0,3 \leq f/F \leq 1,0$ :

$$c = 1,20 - 0,40 f/F$$

– for the aspect ratio  $b/s \geq 2,5$ :

– for the range  $0 < f/F < 0,3$ :

$$c = 2,0 \cdot \sqrt{\frac{f}{F} \left( 5,2 - 7,2 \frac{f}{F} \right)}$$

– for the range  $0,3 \leq f/F \leq 1,0$ :

$$c = 1,20 - 0,517 f/F$$

For intermediate values of  $b/s$  the factor  $c$  is to be obtained by direct interpolation.

$f$  = print area of wheel or group of wheels

$F$  = area of plate panel  $s \cdot b$  according to Fig. C3.7.3

$s$  = width of smaller side of plate panel (in general beam spacing)

$b$  = width of larger side of plate panel

$F$  need not be taken greater than  $2,5 s^2$

In case of narrowly spaced wheels these may be grouped together to one wheel print area.

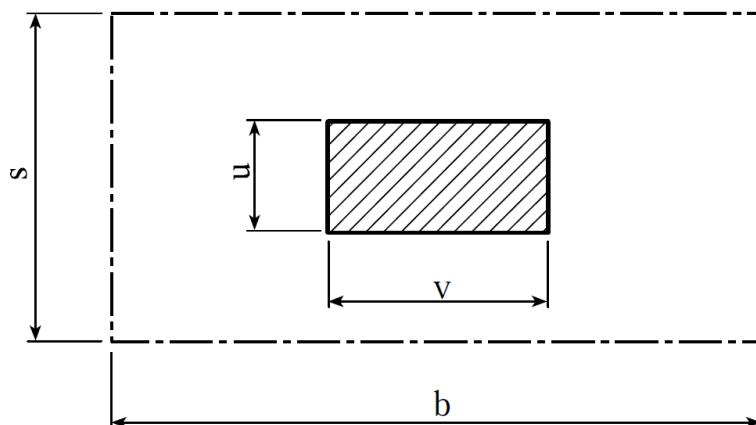


Fig. C3.7.3

.2.2 Where the wheel print area is not known, it may approximately be determined as follows:

$$f = 100 \cdot P/p [\text{cm}^2]$$

$p$  = specific wheel pressure according

.2.3 In deck beams and girders, the stress is not to exceed  $165/k$  [MPa] for steel structures or  $75/k$  [MPa] for aluminium structures respectively.

#### C3.7.7.7 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 C3.5.5.5;

$\sigma_{am} = 185/k$  [MPa] for steel structures

$= 85/k$  [MPa] for aluminium alloy structures

.2 Openings (doors, windows) are to be well rounded at the corners.

.3 Where there is no access from inside deck houses 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 BKI.

### C3.7.8 Ordinary stiffeners

#### C3.7.8.1 General

.1 In the following the requirements are given to be complied with for ordinary stiffeners of the bottom, sides, decks and, for catamaran, the wet deck and internal sides.

.2 The section modulus  $Z$  [ $\text{cm}^3$ ] and the shear area  $A_t$  [ $\text{cm}^2$ ] required for the purpose of supporting the design pressure transmitted by the plating, are given by the following formulae:

$$Z = 1000 \cdot \frac{\ell^2 \cdot s \cdot p}{m \cdot \sigma_{am}} \quad [\text{cm}^3]$$

$$A_t = 5 \cdot \frac{\ell \cdot s \cdot p}{\tau_{am}} \quad [\text{cm}^2]$$

where  $m$  is a coefficient depending on the type of stiffener. The values of  $m$  are indicated in [Table C3.7.4](#).

The pressure  $p$  [ $\text{kPa}$ ] and allowable stresses  $\sigma_{am}$  and  $\tau_{am}$  [ $\text{MPa}$ ] 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 stiffeners	12
Non-continuous stiffeners and without brackets at the end 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 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.

.5 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.

.6 In general, the resistant weld section  $A_w$  [ $\text{cm}^2$ ] connecting the ordinary stiffeners to the web of primary members, is not to be less than:

$$A_w = \phi \cdot p \cdot s \cdot \ell \cdot k \cdot 10^{-3} \quad [\text{cm}^2]$$

- $\phi$  = coefficient as indicated in [Table C3.7.5](#)  
 p = design pressure [kPa] acting on the secondary stiffeners, defined below for various hull regions  
 s = spacing of ordinary stiffeners [m]  
 $\ell$  = span of ordinary stiffeners [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

.7 For aluminium alloys, when calculating the resistant connecting weld section, the fillet weld length  $d_e$  [mm] is determined as follows (see cases 1 and 2 in [Table C3.7.5](#)):

case 1 :  $d_e = d - 10$ ,

where d is the length of the weld [mm]

case 2 : for extruded T stiffeners, the lesser of:

$d_e = b - 10$  and  $d_e = 4 t$ ,

where b [mm] is the flange width of the ordinary stiffener and t [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  $p_{sl}$  if occurring on the bottom as defined in [C3.5.3](#);

For steel structures:  $\sigma_{am} = 150/k$  [MPa]

$\tau_{am} = 90/k$  [MPa]

For aluminium alloy structures:  $\sigma_{am} = 70/k$  [MPa]

$\tau_{am} = 45/k$  [MPa]

b)  $p$  = sea pressure  $p_s$  as defined in [C3.5.5](#);

For stiffeners contributing to the longitudinal strength:

- steel structures:  $\sigma_{am} = 150 C_s/k$  [MPa]

$\tau_{am} = 90/k$  [MPa]

- aluminium alloy structures:  $\sigma_{am} = 70 C_A/k$  [MPa]

$\tau_{am} = 45/k$  [MPa]

For stiffeners not contributing to the longitudinal strength:

- steel structures:  $\sigma_{am} = 150/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

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
- $p =$  sea pressure  $p_{sf}$  as defined in [C3.5.5.4](#), for front wall stiffeners

For side stiffeners contributing to the longitudinal strength:

- steel structures:  $\sigma_{am} = 150 C_S/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70 C_A/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

For side stiffeners not contributing to the longitudinal strength and front wall stiffeners:

- steel structures:  $\sigma_{am} = 150/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

where  $C_S$  and  $C_A$  are given by [Table C3.7.6](#).

#### C3.7.8.4 Stiffeners of wet deck and internal sides of catamaran

.1 The section modulus, shear area and welding section required for bottom stiffeners of the wet deck are given by the formulae in [C3.7.8.1](#), assuming:

- a)  $p =$  impact pressure  $p_{sl}$  if occurring on the bottom as defined in [C3.5.4](#);

- For steel structures:  $\sigma_{am} = 180/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- For aluminium alloy structures:  $\sigma_{am} = 85/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

- b)  $p =$  sea pressure  $p_s$  as defined in [C3.5.5](#);

For stiffeners contributing to the longitudinal strength:

- steel structures:  $\sigma_{am} = 150 C_S/k$  [MPa]

- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70 C_A/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

For stiffeners not contributing to the longitudinal strength:

- steel structures:  $\sigma_{am} = 150/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

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 wet 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](#)

For stiffeners contributing to the longitudinal strength:

- steel structures:  $\sigma_{am} = 150 C_S/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70 C_A/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

For side stiffeners not contributing to the longitudinal strength:

- steel structures:  $\sigma_{am} = 150/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

where  $C_S$  and  $C_A$  are given by [Table C3.7.6](#).

.2 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. BKI may allow double brackets welded to the transverse element, provided that special provision is made for the alignment of longitudinals.

Table C3.7.6 Coefficient CS and CA

L	x/L	Steel structures C <sub>S</sub> <sup>1</sup>	Aluminium alloy structure C <sub>A</sub> <sup>1</sup>
L ≤ 24 m	0 ≤ x/L ≤ 1	1	1
L > 24 m <sup>2</sup>	0 ≤ x/L ≤ 1	1,4 - $\frac{1}{e}$	1,3 - $\frac{1}{e}$
Alternative method for 24 m < L ≤ 65 m <sup>3</sup>	x/L < 1	1	1
	0,1 < x/L ≤ 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 < x/L ≤ 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 ≤ 1	1	1

<sup>1</sup> In these formulae, the values of C<sub>S</sub> and C<sub>A</sub> are to be taken less than or equal to 1.

<sup>2</sup> The ratio e is to be calculated at the location x, on basis of bending moments dist. defined in C3.4.1 & C3.4.2.

<sup>3</sup> The ratio e is to be calculated at the section comprised between 0,3·L and 0,7·L at which e takes the highest value.

### 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<sub>su</sub> as defined in C3.5.5.5.

- steel structures:	$\sigma_{am}$	$= 150/k$	[MPa]
	$\tau_{am}$	$= 90/k$	[MPa]
- aluminium alloy structures:	$\sigma_{am}$	$= 70/k$	[MPa]
	$\tau_{am}$	$= 45/k$	[MPa]

.2 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.

.3 In general, reinforced stiffeners are to be fitted on the edges of large openings in the plating. They are to be scarphed into the area outside of openings. The openings for doors are, in general, to be stiffened all the way round.

### C3.7.9 Primary supporting members

#### C3.7.9.1 General

.1 In the following the requirements are given to be complied with for primary supporting members of the bottom, sides, decks and, for catamaran, the wet deck.

.2 The primary supporting members (floors, frames, beams) are to form continuous transverse frames. In general, the stiffened frame spacing [mm] is not to exceed:

$$1200 + 10 \cdot L$$

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  $Z$  [ $\text{cm}^3$ ] and shear area  $A_t$  [ $\text{cm}^2$ ] required to support the design pressure transmitted by the ordinary stiffeners are given by the following formulae:

$$Z = 1000 \cdot \frac{S^2 \cdot b \cdot p}{m \cdot \sigma_{am}} \quad [\text{cm}^3]$$

$$A_t = 5 \cdot \frac{S \cdot b \cdot p}{\tau_{am}} \quad [\text{cm}^2]$$

$m$  = coefficient which depends on support conditions at the ends of the girder span, generally assumed to be:

= 10, in general

= 8, if one end condition is to be regarded as simply supported, at least

= 12, if the bending stiffness of both supporting structures are considerably higher than for this girder

The pressure  $p$  [ $\text{kPa}$ ] and allowable stresses  $\sigma_{am}$  and  $\tau_{am}$  [ $\text{MPa}$ ] 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 BKI.

.5 The section modulus of primary supporting members is to be calculated in association with an attached plating, according to criteria according to C3.7.4 to C3.7.6.

.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.

### 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  $p_{sl}$  if occurring on the bottom as defined in C3.5.3;

For steel structures:  $\sigma_{am} = 150/k$  [ $\text{MPa}$ ]

$$\tau_{am} = 90/k \quad [\text{MPa}]$$

$$\text{For aluminium alloy structures: } \sigma_{am} = 70/k \quad [\text{MPa}]$$

$$\tau_{am} = 45/k \quad [\text{MPa}]$$

b)  $p = \text{sea pressure } p_s$  as defined in C3.5.5;

$$\begin{aligned} \text{- steel floors: } \sigma_{am} &= 150/k \quad [\text{MPa}] \\ \tau_{am} &= 90/k \quad [\text{MPa}] \end{aligned}$$

$$\begin{aligned} \text{- aluminium alloy floors: } \sigma_{am} &= 70/k \quad [\text{MPa}] \\ \tau_{am} &= 45/k \quad [\text{MPa}] \end{aligned}$$

$$\begin{aligned} \text{- steel girders: } \sigma_{am} &= 150 C_S/k \quad [\text{MPa}] \\ \tau_{am} &= 90/k \quad [\text{MPa}] \end{aligned}$$

$$\begin{aligned} \text{- aluminium alloy girders: } \sigma_{am} &= 70 C_A/k \quad [\text{MPa}] \\ \tau_{am} &= 45/k \quad [\text{MPa}] \end{aligned}$$

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  $t$  [mm] obtained from the formula:

$$t = (0,05 \cdot L + 2) \cdot k^{0,5} \quad \text{for steel}$$

$$= (0,07 \cdot L + 2,5) \cdot k^{0,5} \quad \text{for aluminium alloys}$$

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 BKI.

### 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:

$p = \text{sea pressure } p_{sf}$  as defined in C3.5.5, for primary members of side

$p = \text{sea pressure } p_{sf}$  as defined in C3.5.5.4, for primary members of front walls

- steel structures:  $\sigma_{am} = 150/k - \sigma_a$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70/k - \sigma_a$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

$\sigma_a$  being the stress induced by the normal force in side transverses due to deck loads transmitted by deck beams.

#### C3.7.9.4 Primary supporting members of the wet deck and internal sides of catamaran

.1 The required section modulus and shear area are given by the formulae in C3.7.9.1 for the following two conditions:

a)  $p =$  impact pressure  $p_{sl}$  as defined in C3.5.4:

- steel structures:  $\sigma_{am} = 180/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 85/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

Additional intermediate frames are to be provided forward of 0,8 L. The required section modulus and shear area is not to be less than 70 % of the required values according to the slamming pressure considering the main frame spacing.

b)  $p =$  sea pressure  $p_d$  as defined in C3.5.8

- steel structures:  $\sigma_{am} = 150/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy structures:  $\sigma_{am} = 70/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

#### C3.7.9.5 Primary supporting members of decks

.1 The required section modulus and shear area are given by the formulae in C3.7.9.1 for the following two conditions:

$p =$  deck pressure  $p_d$  as defined in C3.5.8

- steel deck transverses:  $\sigma_{am} = 150/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy deck transverses:  $\sigma_{am} = 70/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]
- steel deck girders:  $\sigma_{am} = 150 C_s/k$  [MPa]
- $\tau_{am} = 90/k$  [MPa]
- aluminium alloy deck girders:  $\sigma_{am} = 70 C_A/k$  [MPa]
- $\tau_{am} = 45/k$  [MPa]

where  $C_s$  and  $C_A$  are given by Table C3.7.6.

.2 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.

#### 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 C3.5.5.5

$$\begin{aligned} \text{- steel structures: } \sigma_{am} &= 150/k \quad [\text{MPa}] \\ &\tau_{am} = 90/k \quad [\text{MPa}] \\ \text{- aluminium alloy structures: } \sigma_{am} &= 70/k \quad [\text{MPa}] \\ &\tau_{am} = 45/k \quad [\text{MPa}] \end{aligned}$$

#### C3.7.10 Pillars

##### .1 General

.1.1 Structural members at heads and heels of pillars as well as substructures are to be constructed according to the forces they are subjected to.

Where pillars are affected by tension loads doublings are not permitted.

.1.2 Pillars in tanks are to be checked for tension. Tubular pillars are not permitted in tanks for flammable liquids.

.1.3 For structural elements of the pillars' transverse section, sufficient buckling strength according to C3.7.5 has to be verified. The wall thickness of tubular pillars which may be expected to be damaged during loading and unloading operations is not to be less than:

$$\begin{aligned} t_w &= 4, 5 + 0, 015 d_a \quad [\text{mm}] \quad \text{for } d_a \leq 300 \text{ mm} \\ &= 0, 03 d_a \quad [\text{mm}] \quad \text{for } d_a > 300 \text{ mm} \end{aligned}$$

.1.4 Pillars also loaded by bending moments have to be specially considered.

##### .2 Scantlings

The sectional area of pillars is not to be less than:

$$A_{s\text{req}} = 10 \cdot \frac{P_s}{\sigma_p} \quad [\text{cm}^2]$$

$\sigma_p$  = permissible compressive stress [MPa]

$$= \frac{\kappa}{S'} \cdot R_{eH}$$

$S'$  = safety factor

= 2,00 in general

= 1,66 in accommodation area, for steel pillar, only

$\kappa$  = reduction factor

$$= \frac{1}{\phi + \sqrt{\phi^2 - \lambda_s^2}}$$

$$\phi = 0,5 \cdot [1 + n_p \cdot (\lambda_s - \lambda_0) + \lambda_s^2]$$

for steel:

$$\lambda_0 = 0,2$$

$n_p = 0,34$  for tubular and rectangular pillars

$= 0,49$  for open sections

for aluminium without heat treatment (i.e. 5000 series):

$$\lambda_0 = 0,0$$

$$n_p = 0,32$$

for aluminium with heat treatment (i.e. 6000 series):

$$\lambda_0 = 0,1$$

$$n_p = 0,20$$

$\lambda_s$  = degree of slenderness of the pillar

$$= \frac{l_s}{i_s \cdot \pi} \sqrt{\frac{R_{eH}}{E}} \geq \lambda_0$$

$l_s$  = length of the pillar [cm]

$R_{eH}$  = nominal yield point or  $R_{p0,2}$  for aluminium alloy [MPa]

$E$  = Young's modulus [MPa]

$i_s$  = minimum radius of gyration [cm] of the pillar cross section

$$= \sqrt{\frac{l}{A}} \quad [\text{cm}]$$

$= 0,25 d_s$  for solid pillars of circular cross section

$= 0,25 (d_a^2 + d_i^2)^{0,5}$  for tubular pillars

$I_s$  = minimum moment of inertia [ $\text{cm}^4$ ] of the pillar cross section

$A$  = sectional area of the pillar [ $\text{cm}^2$ ]

$d_s$  = pillar diameter [cm]

$d_a$  = outside diameter of pillar [cm]

$d_i$  = inside diameter of pillar [cm]

### C3.7.11 Bulkhead Structures

.1 Proof of buckling strength of longitudinal and transverse bulkhead structures is to be carried out according to C3.7.5. For longitudinal bulkheads the global design stresses and the stresses due to local loads are to be considered.

#### C3.7.11.1 Plating

.1 The thickness of the bulkhead plating [mm] is not to be less than:

$$t = 22,4 \cdot f_m \cdot \mu \cdot s \cdot \sqrt{\frac{p_{sb}}{\sigma_{am}}} \quad [\text{mm}]$$

- $f_m$  = coefficient depending on the material
- = 0,75 for steel structures
- = 0,70 for aluminium alloy structures
- $p_{sb}$  = design pressure [kPa] as defined in C3.5.6.2
- $\sigma_{am}$  = 235/k [MPa] for steel structures
- = 95/k [MPa] for aluminium alloy structures

.2 The stern tube bulkhead is to be provided with a strengthened plate in way of the stern tube.

.3 In areas where concentrated loads due to ship manoeuvres at terminals may be expected, the buckling strength of bulkhead plate fields directly attached to the side shell, is to be examined.

#### C3.7.11.2 Stiffeners and girders

.1 The required scantlings of stiffeners and girders are determined according to strength calculations, by applying the following permissible stress values:

- for steel structures:  $\sigma_{am} = 200/k$  [MPa]
- $\tau_{am} = 120/k$  [MPa]
- $\sigma_{vM} = 220/k$  [MPa]
- for aluminium alloy structures:  $\sigma_{am} = 90/k$  [MPa]
- $\tau_{am} = 55/k$  [MPa]
- $\sigma_{vM} = 95/k$  [MPa]

.2 The buckling strength of the webs is to be checked according to C3.7.5

.3 Bulkhead stiffeners cut in way of watertight doors are to be supported by carlings or stiffeners.

.4 In areas with cut-outs secondary bending of the plate strips beneath the cut-out shall be taken into account for girders.

#### C3.7.11.3 Corrugated Bulkheads

.1 The plate thickness of corrugated bulkheads is not to be less than required according to C3.7.11.1

For the spacing  $s$  [m] the greater one of the values  $b$  or  $c$  according to C3.7.11.3.3 is to be taken.

.2 The section modulus of a corrugated bulkhead element is to be determined according to C3.7.11.3.3.

.3 The actual section modulus [ $\text{cm}^3$ ] of a corrugated bulkhead element is to be assessed according to the following formula:

$$W_c = d \cdot t \cdot (3 \cdot b + c) / 6000 \quad [\text{cm}^3]$$

where the symbols are as shown in Fig. C3.7.6 and are expressed in mm. In no case is the angle  $\phi$  to be less than 45°.

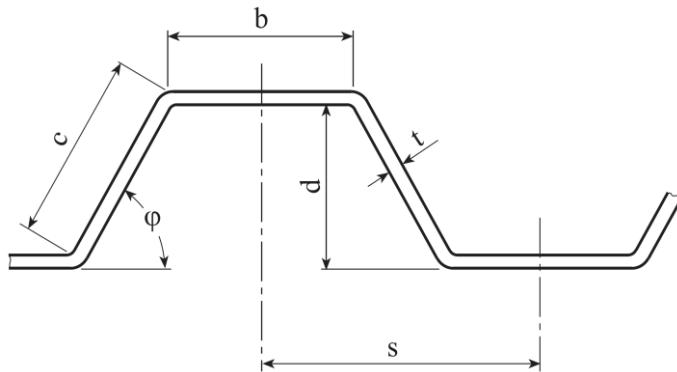


Fig. C3.7.6

### C3.7.12 Tank Structures

#### .1 General

If the boundaries of tanks are formed by integrated structural elements of the ship, their dimensioning has to follow the definitions in the sections for the relevant parts. The requirements of this section have to be observed additionally.

For independent tanks the minimum thickness is 2,5 mm in general.

#### .2 Plating

The plate thickness, in mm, is not to be less than:

$$t = 22,4 \cdot f_m \cdot \mu \cdot s \cdot \sqrt{\frac{p_t}{\sigma_{am}}} + t_k \quad [\text{mm}]$$

$f_m$  = coefficient depending on the material

= 0,80 for steel structures

= 0,75 for aluminium alloy structures

$p_t$  = design pressure [kPa] as taken the maximum value of  $p_{t1}$  and  $p_{t2}$ , as defined in [C3.5.7.7](#)

$\sigma_{am}$  = 185/k [MPa] for steel structures

$\sigma_{am}$  = 85/k [MPa] for aluminium alloy structures

The corrosion allowance  $t_k$  for steel plates is not less than 0,5 mm, for aluminium plates  $t_k = 0$  mm.

#### .3 Stiffeners and girders

The required scantlings of stiffeners and girders are determined according to strength calculations, by applying the following permissible stress values:

- if subjected to load  $p_{t1}$ :
- steel structures

$\sigma_{am}$  = 150/k [MPa]

$\tau_{am}$  = 90/k [MPa]

$\sigma_{vm}$  = 180/k [MPa]

- aluminium alloy structures:

$$\sigma_{am} = 70/k \quad [\text{MPa}]$$

$$\tau_{am} = 45/k \quad [\text{MPa}]$$

$$\sigma_{vm} = 85/k \quad [\text{MPa}]$$

- if subjected to load  $p_{t2}$ :

- steel structures

$$\sigma_{am} = 180/k \quad [\text{MPa}]$$

$$\tau_{am} = 115/k \quad [\text{MPa}]$$

$$\sigma_{vm} = 200/k \quad [\text{MPa}]$$

- aluminium alloy structures:

$$\sigma_{am} = 80/k \quad [\text{MPa}]$$

$$\tau_{am} = 50/k \quad [\text{MPa}]$$

$$\sigma_{vm} = 90/k \quad [\text{MPa}]$$

The buckling strength of the webs is to be checked according to [C3.7.5](#)

### C3.7.13 Bow, Shell Side and Stern Doors

#### C3.7.13.1 Plating

- .1 The required thickness, in mm, is given by the following formula:

$$t = 22,4 \cdot \mu \cdot s \cdot \sqrt{\frac{p_s}{\sigma_{am}}} \quad [\text{mm}]$$

$p_s$  = design pressure [kPa] as defined in [C3.5.5.2.1](#),

$\sigma_{am}$  = 185/k [MPa] for steel structures

= 85/k [MPa] for aluminium alloy structures

#### C3.7.13.2 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](#),

- steel structures:  $\sigma_{am} = 150/k \quad [\text{MPa}]$

$$\tau_{am} = 90/k \quad [\text{MPa}]$$

- aluminium alloy structures:  $\sigma_{am} = 70/k \quad [\text{MPa}]$

$$\tau_{am} = 45/k \quad [\text{MPa}]$$

### C3.7.13.3 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 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 for steel (not to be taken less than 0,72) or in C3.2.3.3 for aluminium alloys:

$\sigma_{am}$	=	bending stress
	=	120/k [MPa] for steel structures
	=	55/k [MPa] for aluminium alloy structures
$\tau_{am}$	=	shear stress
	=	80/k [MPa] for steel structures
	=	35/k [MPa] for aluminium alloy structures
$\sigma_{vm}$	=	150/k [MPa] for steel structures
	=	70/k [MPa] for aluminium alloy structures

## C3.8 Fibre-reinforced Plastic Craft

### C3.8.1 General

The subsequent requirements are applicable under the following conditions, which are subject to update/amendment:

- Loads and design pressures are of “maximum service loads” character, as defined in relevant BKI Rules. Possible reductions on particularly “rare loading” scenarios such as pressure loading on watertight bulkheads have not been implemented and yet should be handled case by case.
- The following methodology typically applies to orthogonal structured components with a clear hierarchy of structural members. Where this condition is not fulfilled, more comprehensive investigations will have to apply, e.g. grillage analysis.
- The orthogonal structured components are assumed to have constant structural and material properties along their length, respectively. If this is not the case, the locations of highest bending moment and shear force can vary from the general assumptions within this section and thus need to be treated specifically (e.g. stiffener or girder with varying height or laminate).

### C3.8.2 Elasto-mechanical properties of laminated structures

#### C3.8.2.1 Nomenclature:

$\psi$	=	mass content of reinforcing material in a laminate
$\phi$	=	volume content of reinforcement material in a laminate
$E_{11}$	=	Young's modulus of a single ply with unidirectional fibres, parallel to fibres
$E_{22}$	=	Young's modulus of a single ply with unidirectional fibres, perpendicular to fibres
$v_{12}, v_{21}$	=	Poisson's ratios of a single ply
$G_{12}$	=	shear modulus of a single ply
$\rho_f$	=	specific gravity of fibre material
$\rho_m$	=	specific gravity of matrix material

- $E_{fL}$  = Young's modulus of fibre in fibre direction  
 $E_{fT}$  = Young's modulus of fibre transverse to fibre direction  
 $E_m$  = Young's modulus of matrix  
 $\nu_{f12}$  = Poisson's ratio of fibre  
 $\nu_m$  = Poisson's ratio of resin  
 $G_m$  = shear modulus of the matrix  
 $G_f$  = shear modulus of the fibre  
 $E_x$  = Young's modulus of a ply, multiply or laminate in x-direction of global laminate coordinate system  
 $E_y$  = Young's modulus of a ply, multiply or laminate in y-direction of global laminate coordinate system  
 $G_{xy}$  = shear modulus of a ply, multiply or laminate in xy-direction of global laminate coordinate system  
 $\Theta$  = angle of inclination/transformation from local ply coordinate system (1, 2 coordinates) to global laminate coordinate system (x, y coordinates), see Fig. 3.8.1

laminate = is a general expression for a structural unity, a composition of structural fibres, laid down in a polymer matrix. A laminate may contain a sandwich core or other constituents for achieving certain mechanical purposes.

layer types:

ply = In the definition of these Rules, a ply is one laminated layer containing fibre reinforcements aligned in one direction only (unidirectional) or one layer of isotropic or quasi-isotropic material (CSM)

multiply = A multiply is consisting of a limited number of plies of different alignments (e.g. laminated fabrics, such as bi-axial, tri-axial, quad-axial, in woven or stiched arrangement, or as pre-preg).

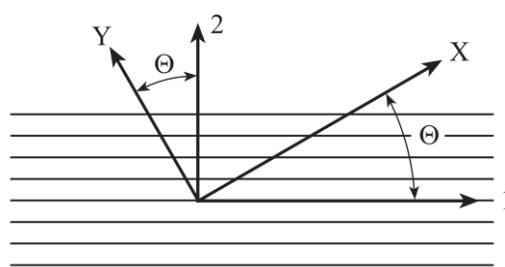


Fig. C3.8.1 Local single ply and global laminate coordinate systems

### C3.8.2.2 Basic single ply analysis

#### .1 Fibre content by volume

The fibre volume fraction of a laminate is determined by the formula:

$$\phi = \frac{\psi}{\psi + (1-\psi) \cdot \frac{\rho_f}{\rho_m}}$$

The thickness  $t_{i,ply}$  of a single ply is then derived as:

$$t_{i,ply} = m_{fi} \cdot \left( \frac{1}{\rho_f} + \frac{1 - \psi_i}{\psi_i \cdot \rho_m} \right)$$

$m_{fi}$  = single ply areal weight of fibre reinforcements

$\psi_i$  = fibre mass fraction of single ply

## .2 Basic ply stiffness properties

A single unidirectional laminated ply consists of long fibres, oriented in one direction, embedded in a polymeric matrix. Typical fibre materials are E-glass, aramid or carbon. Representative material properties of fibre and matrix materials can be found in [Table C3.8.1](#).

**Table C3.8.1 Constituent materials properties**

		Fibres				Matrices	
		E-Glass	Aramid	HS Carbon	HM Carbon	Polyester	Epoxy
Specific gravity	[g/cm³]	2,54	1,44	1,74	1,81	1,2	1,2
Young's Modulus	parallel to fibres	[MPa]	73000	124000	230000	392000	3000
	perpendicular to fibres	[MPa]	73000	6900	28000	15000	
Shear Modulus	[MPa]	30000	2800	50000	28600	1140	1330
Poisson's ratio	-	0,18	0,36	0,23	0,20	0,316	0,35

The following values are derived for plies containing unidirectional fibres. From those, the properties of multiaxially aligned laminated plies may be derived, see [C3.8.2.3](#) and [C3.8.2.4](#). Chopped strand mats are considered separately in [C3.8.2.2.3](#).

a) Longitudinal Young's modulus:

$$E_{11} = \phi \cdot E_{fL} + (1 - \phi) \cdot E_m$$

b) Transverse Young's modulus:

$$E_{22} = \frac{E_m}{1 - v_m^2} \cdot \frac{1 + 0,85 \cdot \phi^2}{(1 - \phi)^{1,25} + \phi \cdot \frac{E_m}{E_{fT} \cdot (1 - v_m^2)}}$$

c) Poisson's ratios:

$$v_{12} = \phi \cdot v_{f12} + (1 - \phi) \cdot v_m$$

$$v_{21} = v_{12} \cdot \frac{E_{22}}{E_{11}}$$

d) Shear modulus:

$$G_{12} = \frac{G_m \cdot \frac{1 + 0,8 \cdot \phi^{0,8}}{(1 - \phi)^{1,25} + \frac{G_m}{G_{f12}} \cdot \phi}}{G_{f12}}$$

$$G_m = \frac{E_m}{2 \cdot (1 + v_m)}$$

### .3 Stiffness properties of chopped strand mat

The Young's modulus of a chopped strand mat (CSM) laminate can be calculated as:

$$E_{\text{CSM}} = \frac{3}{8} \cdot E_{11} + \frac{5}{8} \cdot E_{22}$$

$$G_{\text{CSM}} = \frac{E_{\text{CSM}}}{2 \cdot (1 + v_{\text{CSM}})}$$

with  $E_{11}$  and  $E_{22}$  determined like for a basic single unidirectional layer with fibre volume content appropriate for CSM.

#### C3.8.2.3 Single ply stiffness

The representative stiffness values for a single ply that is part of a multiply fabric or a laminate is derived in three steps. Firstly the stiffness matrix Q is computed for each ply from its engineering constants in the local coordinate system (ref. [C3.8.2.3.1](#)). In a second step, the stiffness matrix Q is transformed to the global coordinate system, resulting in the transformed stiffness matrix  $Q'$  (ref. [C3.8.2.3.2](#)). From this, the engineering constants of each ply in the global laminate coordinate system are determined in a third step (see [C3.8.2.4](#)).

##### .1 Stiffness matrix of single ply in local coordinate system

The components of the stiffness matrix are determined for an orthotropic ply, which is part of a nonwoven or woven fabric and are calculated as follows:

$$Q_{11} = \frac{E_{11}}{(1 - v_{12} \cdot v_{21})}$$

$$Q_{12} = \frac{v_{21} \cdot E_{11}}{(1 - v_{12} \cdot v_{21})}$$

$$Q_{22} = \frac{E_{22}}{(1 - v_{12} \cdot v_{21})}$$

$$Q_{33} = G_{12} \cdot a$$

$$Q_{21} = Q_{12}$$

Q = Stiffness matrix of orthotropic layer in local ply coordinate system

a = 1,0 for a non-woven fabric

= 1,2 for satin (1x8 or 1x6) weave style fabrics

= 1,5 for twill (2x2, 3x1, 4x4) weave style fabrics

= 2,0 for plain (1x1) weave style fabrics

Stiffness matrix components Q for chopped strand mat (CSM) are to be derived using the above equations, too, where:

$$E_{11} = E_{22} = E_{\text{CSM}}$$

$$v_{12} = v_{21} = 0,28$$

$$G_{12} = G_{CSM}$$

## .2 Angle transformation for single unidirectional ply stiffnesses to global coordinate system

The following formulae are used to transform elastomechanical properties found in C3.8.2.3.1 for a unidirectional laminated ply in the local 1, 2 coordinate system to the global x, y coordinate system by an inplane polar transformation of angle “ $\Theta$ ”.

$$Q_{11}' = Q_{11} \cdot \cos^4 \Theta + 2 \cdot (Q_{12} + 2 \cdot Q_{33}) \cdot \sin^2 \Theta \cdot \cos^2 \Theta + Q_{22} \cdot \sin^4 \Theta$$

$$Q_{22}' = Q_{11} \cdot \sin^4 \Theta + 2 \cdot (Q_{12} + 2 \cdot Q_{33}) \cdot \sin^2 \Theta \cdot \cos^2 \Theta + Q_{22} \cdot \cos^4 \Theta$$

$$Q_{23}' = Q_{32}' = (Q_{22} - Q_{12} - 2 \cdot Q_{33}) \cdot \cos^3 \Theta \cdot \sin \Theta - (Q_{11} - Q_{12} - 2 \cdot Q_{33}) \cos \Theta \cdot \sin^3 \Theta$$

$$Q_{13}' = Q_{31}' = (Q_{22} - Q_{12} - 2 \cdot Q_{33}) \cdot \cos \Theta \cdot \sin^3 \Theta - (Q_{11} - Q_{12} - 2 \cdot Q_{33}) \cos^3 \Theta \cdot \sin \Theta$$

$$Q_{12}' = (Q_{11} + Q_{22} - 4 \cdot Q_{33}) \cdot \sin^2 \Theta \cdot \cos^2 \Theta + Q_{12} (\sin^4 \Theta + \cos^4 \Theta)$$

$$Q_{33}' = (Q_{11} + Q_{22} - 2 \cdot Q_{12} - 2 \cdot Q_{33}) \cdot \sin^2 \Theta \cdot \cos^2 \Theta + Q_{33} (\sin^4 \Theta + \cos^4 \Theta)$$

$$Q_{21}' = Q_{12}'$$

$\Theta$  = Angle of transformation

$Q'$  = Transformed stiffness matrix of orthotropic layer in global coordinate system

### C3.8.2.4 Stiffness properties of a single or multiply layer

The multiply is a layer, which is treated as laminate with a distinct number of plies (e.g. woven, stitched or pre-pregged; bi-axial, tri-axial or quad-axial arrangement) and is considered to be one layer of fabric used to build up a laminate.

The stiffness properties of this single or multiply layer will be determined by Classical Laminate Theory with the exception that coupling effects causing out-of plane deformations are restrained.

Thus, the bending extension coupling effects of the single or multiply will be neglected here by forcing the coupling matrix “B” to be zero. This simulates the multiply to be symmetrical.

Following the classical laminate theory the  $ABD_L$  matrix is the stiffness matrix of the multiply (Index “L” for “layer”) and will lead to the engineering constants of the multiply.

The individual matrices are calculated as follows:

Extension matrix  $A_L$ :

$$A_{11L} = \sum_{i=1}^n Q_{11}'_i \cdot t_i$$

$$A_{12L} = A_{21} = \sum_{i=1}^n Q_{12}'_i \cdot t_i$$

$$A_{13L} = A_{31} = \sum_{i=1}^n Q_{13}'_i \cdot t_i$$

$$A22_L = \sum_{i=1}^n Q22'_i \cdot t_i$$

$$A23_L = A32 = \sum_{i=1}^n Q23'_i \cdot t_i$$

$$A33_L = \sum_{i=1}^n Q33'_i \cdot t_i$$

Bending extension matrix  $B_L$ :

All forced to be zero:

$$B11_L = B12_L = B13_L = B21_L = B22_L = B23_L = B31_L = B32_L = B33_L = 0$$

Bending matrix D:

$$D11_L = \frac{1}{3} \sum_{i=1}^n Q11'_i \cdot (z_i^3 - z_{i-1}^3)$$

$$D12_L = D21 = \frac{1}{3} \sum_{i=1}^n Q12'_i \cdot (z_i^3 - z_{i-1}^3)$$

$$D13_L = D31 = \frac{1}{3} \sum_{i=1}^n Q13'_i \cdot (z_i^3 - z_{i-1}^3)$$

$$D22_L = \frac{1}{3} \sum_{i=1}^n Q22'_i \cdot (z_i^3 - z_{i-1}^3)$$

$$D23_L = D32 = \frac{1}{3} \sum_{i=1}^n Q23'_i \cdot (z_i^3 - z_{i-1}^3)$$

$$D33_L = \frac{1}{3} \sum_{i=1}^n Q33'_i \cdot (z_i^3 - z_{i-1}^3)$$

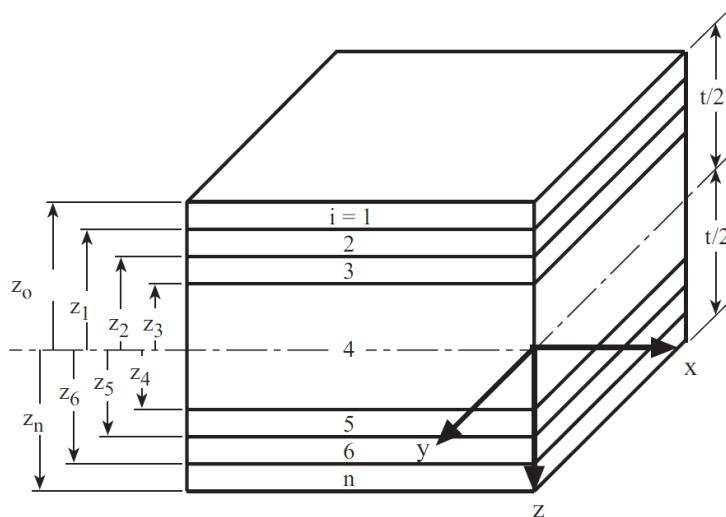


Fig. C3.8.2 Ply definitions

Resulting in the  $ABD_L$  matrix:

$$\begin{bmatrix} A_{11_L} & A_{12_L} & A_{12_L} & 0 & 0 & 0 \\ A_{21_L} & A_{22_L} & A_{23_L} & 0 & 0 & 0 \\ A_{31_L} & A_{32_L} & A_{33_L} & 0 & 0 & 0 \\ 0 & 0 & 0 & D_{11_L} & D_{12_L} & D_{13_L} \\ 0 & 0 & 0 & D_{21_L} & D_{22_L} & D_{23_L} \\ 0 & 0 & 0 & D_{31_L} & D_{32_L} & D_{33_L} \end{bmatrix} = \begin{bmatrix} A & B \\ B & D \end{bmatrix}_L$$

and the inverse  $ABD_L$  matrix

$$\begin{bmatrix} a_{11_L} & a_{12_L} & a_{12_L} & 0 & 0 & 0 \\ a_{21_L} & a_{22_L} & a_{23_L} & 0 & 0 & 0 \\ a_{31_L} & a_{32_L} & a_{33_L} & 0 & 0 & 0 \\ 0 & 0 & 0 & d_{11_L} & d_{12_L} & d_{13_L} \\ 0 & 0 & 0 & d_{21_L} & d_{22_L} & d_{23_L} \\ 0 & 0 & 0 & d_{31_L} & d_{32_L} & d_{33_L} \end{bmatrix} = \begin{bmatrix} a & b \\ b & d \end{bmatrix}_L = \begin{bmatrix} A & B \\ B & D \end{bmatrix}_L^{-1}$$

The engineering constants for the multiply layer are:

$$E_x = \frac{1}{t \cdot a_{11_L}} ;$$

$$E_y = \frac{1}{t \cdot a_{22_L}} ;$$

$$G_{xy} = \frac{1}{t \cdot a_{33_L}} ;$$

$$v_{xy} = -\frac{a_{12_L}}{\underline{a_{11_L}}} ;$$

The following layer stiffness values will be used for buckling analysis in [C3.8.6.2](#):

$$Q_{11'}_L = \frac{A_{11_L}}{t_L}$$

$$Q_{12'}_L = \frac{A_{12_L}}{t_L}$$

$$Q_{22'}_L = \frac{A_{22_L}}{t_L}$$

$$Q_{33'}_L = \frac{A_{33_L}}{t_L}$$

$$Q_{21'}_L = Q_{12'}_L$$

$t_L$  = thickness of single or multiply layer

### C3.8.2.5 Laminate stiffness

#### .1 Single skin laminates

A single skin laminate is consisting of a total of n laminated layers, where the index i stands for a particular layer i of this compound. The following is also valid for determining the properties of sandwich skins each:

- a) The mean laminate engineering constants and the thickness of a laminate are:

$$E_{x,\text{laminate}} = \frac{\sum E_{xi} \cdot t_i}{\sum t_i}; \quad E_{y,\text{laminate}} = \frac{\sum E_{yi} \cdot t_i}{\sum t_i}$$

$$G_{xy,\text{laminate}} = \frac{\sum G_{xyi} \cdot t_i}{\sum t_i} \quad t_{\text{laminate}} = \sum t_i$$

$E_{xi,yi}; G_{xy,i}$  = engineering constants of layer

$t_i$  = thickness of layer i

These mean values should only be used for in-plane assessments or for very homogeneous layups:

- b) Neutral axis z of an unsymmetrical laminate, measured vs. a reference axis:

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

$E_i$  = Young's modulus layer in relevant direction

$z_i$  = distance of layer centroid from reference axis

Note that the neutral axes of a laminate can be dissimilar in different directions.

- c) Flexural stiffness EI of a single skin laminate per unit width:

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

$e_i$  = distance of layer centroid from neutral axis of laminate

Note that the flexural stiffness of a laminate can be dissimilar in different directions.

- d) The in-plane shear stiffness GA<sub>u</sub> of a single skin laminate per unit width:

$$GA_u = \sum G_i \cdot t_i$$

If the shear stiffness per unit width is not applicable but the shear stiffness of a whole plate, the relevant plate width needs to be accounted for additionally.

$$GA = \sum G_i \cdot t_i \cdot w$$

w = plate width

## .2 Sandwich laminates

In the sense of this methodology, "sandwich" is considered to be an effective structural arrangement of materials with significantly different stiffness characteristics, where however the sandwich core shall have a sufficient amount of shear stiffness to allow for simplifications made in elemental beam theory.

Thus, the flexural and in-plane shear stiffness of a sandwich laminate is calculated like for single skin laminates, taking into account the core as an elementary layer with its particular thickness and modulus.

### C3.8.2.6 Beam analysis

Beams are structural elements that are mainly subjected to bending moments and also to shear forces when loaded laterally. In general, the associated plating contributes to stiffness and strength. Stiffeners, frames and girders can be considered as beams in this sense.

The following assumptions imply that the beams perform "plane bending", i.e. that the neutral axis of the beam with associated plating is parallel to the axis about which the assembly bends; the beam assembly is symmetrical about the axis which is perpendicular to the plating.

#### .1 Effective width of plating

The following approach provides an indication about the effective width of plating. This is based on the assumption that the associated plating has near-quasi-isotropic in-plane properties. It may be adopted for reasonably balanced in-plane stiffness laminates.

The effective width of plating  $w_{eff}$  is taken as being dependant on the ratio  $L_1/w$  solely. The width of plating to account for when determining the beams stiffness can be taken from Fig. C3.8.3 as a fraction of  $w$ .

$L_1$  is the length between zero bending moments of a beam between supports and is determined as follows:

- $L_1$  = unsupported span for beams with hinged end supports
- = 0,4 – times the unsupported span for beam with ends fixed
- $w$  = width of plating supported, measured from centre to centre of the adjacent unsupported fields

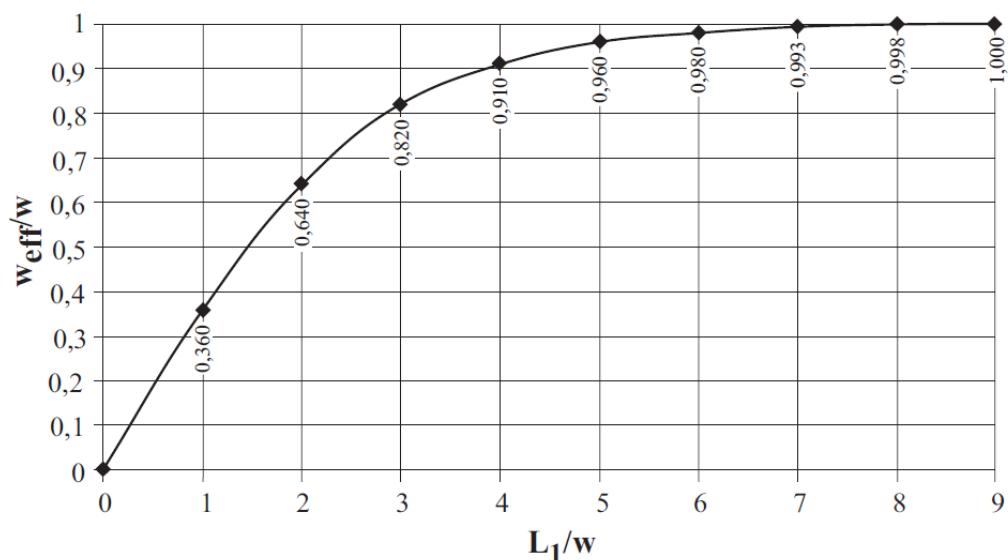


Fig. C3.8.3 Effective width of plating

Additionally the beams foot width "w<sub>f</sub>" can be added to w<sub>eff</sub>, see Fig. C3.8.4.

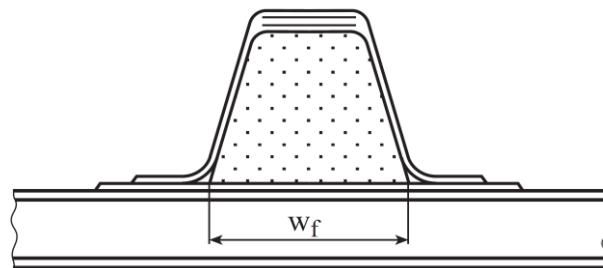


Fig. C3.8.4 Typical top hat stiffener

The calculated effective width shall not be taken greater than the load width.

## .2 Flexural stiffness

$$EI = \sum E_i \cdot (I_i + S_i \cdot e_i^2)$$

E<sub>i</sub> = tensile modulus of element

I<sub>i</sub> = specific moment of inertia of element

e<sub>i</sub> = distance of element's centroid from neutral axis of assembly

S<sub>i</sub> = cross sectional area of element

## .3 Shear stiffness

For determining the shear stiffness of a beam assembly, usually only the shear webs are accounted for.

$$GA = \sum G_i \cdot t_i \cdot h_i$$

t<sub>i</sub> = web thickness

h<sub>i</sub> = height of web measured perpendicular to associated plating

G = in-plane shear modulus of element

### C3.8.3 Laterally loaded plates

#### C3.8.3.1 Applicability

In the following the structural design requirements for laterally loaded shells and plates are given. Lateral loading is usually caused by static or dynamic sea or water pressure (slamming) of hull shells, decks, superstructure, watertight bulkheads, tank walls etc.

The methodology presented in the following is covering flat or slightly curved panels of generally square or rectangular geometry with different boundary conditions. Other geometries (e.g. triangular or trapezoid styled) require an equivalent approach.

Plates considered here are generally laminated as single skin or sandwich panels. It is recommended that elasto-mechanical properties of inner and outer sandwich skin do not differ significantly. This is to avoid secondary effects, such as superimposed twist or bending in plates.

The following approaches are featuring the ideas and the background of the “plate theory”. Membrane effects occurring due to curved shells are treated with a linear reduction coefficient. Further contribution, like calculated using other methods or FEA, will generally not be accepted.

The objective is to determine plate stresses and strains from bending moments and shear forces caused by lateral pressure. The problem of an all-side supported panel will effectively be reduced to a unit beam strip, by using appropriate coefficients. The evaluation of stresses/strains is focussing on the spot where the maximum bending stress/strain occurs and a spot where the maximum through-thickness shear stress/strain occurs. Further to that, a correction is incorporated to allow the use of orthotropic material and plate properties and the application to sandwich construction.

If not explicitly mentioned, unit consistent variables are to be used.

### C3.8.3.2 Parameters

Laminated plates are to be characterised by the following parameters:

#### .1 Structural parameters

- $EI_x$  = panel bending stiffness in panels global x-direction (about panels global y-direction)
- $EI_y$  = panel bending stiffness in panels global y-direction (about panels global x-direction)
- $t_c$  = thickness of sandwich core
- $z_i$  = distance from a certain location of the neutral axis in bending

These values are calculated in C3.8.2.2 or C3.8.2.3.

#### .2 Geometrical parameters

- $s_x$  = unsupported span in global x-direction
- $s_y$  = unsupported span in global y-direction

Boundary conditions: all edges fixed or all edges simply supported

#### .3 Load details and design pressures

Lateral design pressures acc. to relevant BKI Rules and Guidelines.

#### .4 Geometric aspect ratio $ar_g$

$$ar_g = \frac{s_x}{s_y}$$

#### .5 Effective aspect ratio

For orthotropic panel properties with  $EI_x$  not equal  $EI_y$ , the geometrical aspect ratio  $ar_g$  needs to be corrected:

$$ar_{corr} = ar_g \cdot \sqrt[4]{\frac{EI_y}{EI_x}}$$

For the purpose of further calculations, the corrected aspect ratio  $ar_{corr}$  has to be related to the span of the panel that is considered to be effective to take up the major bending and shear loads (see [C3.8.3.1](#)) and will be called "effective span  $s_{eff}$ ":

If  $ar_{corr}$  is  $> 1$ , then  $ar_{eff} = ar_{corr}$ .

Thus, the panel effective span  $s_{eff}$  (direction of main load take-up) runs in y-direction.

If  $ar_{corr}$  is  $< 1$ , then  $ar_{eff} = 1/ar_{corr}$

Thus, the panel effective span  $s_{eff}$  (direction of main load take-up) runs in x-direction.

## .6 Edge support boundary conditions and corrections

Generally, panels which are continuous over their supporting structure can be assumed providing a fixed edge boundary condition, whereas panels e.g. butting against a sandwich panel will be considered with edge condition "simply supported". Similar considerations should be carried out for great variations in neighboring panel sizes.

In specific cases, hull chines or other sudden changes in geometry may be considered being a boundary as well. Should a chine be considered presenting one edge of a panel, the angle of the chine  $\omega$  shall be close to  $90^\circ$  to allow for such assumption, see [Fig. C3.8.5](#). Should the angle be greater than  $90^\circ$ , the panel span taken for panel calculations needs to be increased virtually, using the characteristic correction factors described below.

The panel span which is delimited by a chine has to be multiplied by the correction factor  $c_s$ :

$s_{x/y}$  = corrected panel span

=  $c_s \cdot s_c$

$c_s$  = correction factor

$s_c$  = panel span

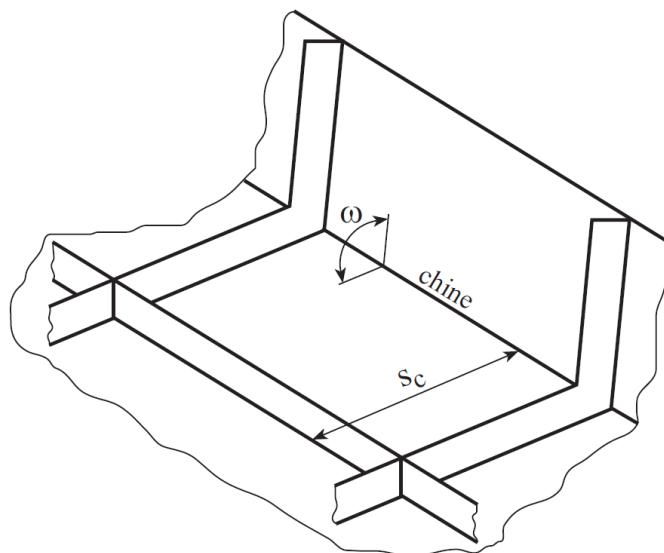


Fig. C3.8.5 Panel span

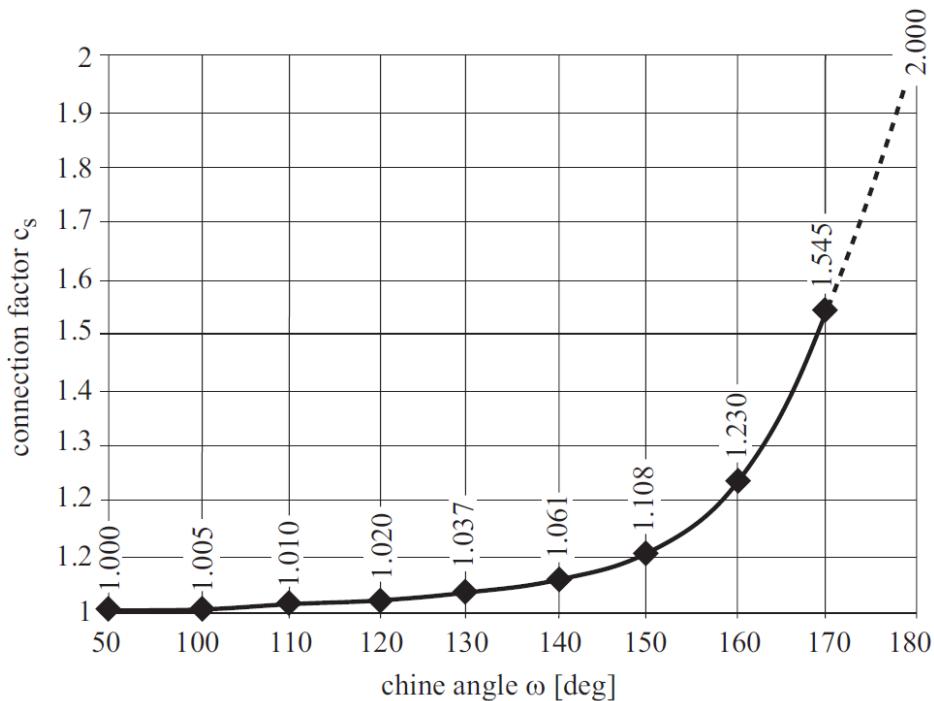


Fig. C3.8.6 Panel span correction factor  $c_s$  dependant on chine angle

This correction is particularly applicable for equidistant spacings of panels, i.e. for panels on both sides of vessel's chined centreline without the existence of a centreline girder, e.g. where the panels are delimited by off-centre longitudinals. For determination of  $c_s$  see Fig. C3.8.6

## .7 Plate curvature

Curvature will only be considered if the plate is curved in the direction of the effective span  $s_{\text{eff}}$ , see Fig. C3.8.7.

Curvature correction coefficient:

$$r_c = 1,15 - 5 \cdot \frac{h}{s_{\text{eff}}}$$

for  $0,03 < \frac{h}{s} < 0,1$

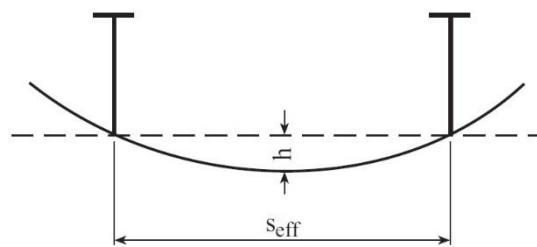


Fig. C3.8.7 Plate curvature

### C3.8.3.3 Maximum bending moment, shear

As mentioned in C3.8.3.1, the calculation is being reduced to the assessment of a panel strip of one unit width (e.g. 1 mm).

## .1 Maximum bending moment

$$M_{b\text{-max}} = \frac{\beta \cdot P_d \cdot s_{\text{eff}}^2}{6} \cdot r_c$$

$\beta$  = see [Table C3.8.2](#)

$P_d$  = lateral design pressure on associated plating acc. to [C3.8.3.2.3](#)

$s_{\text{eff}}$  = effective panel span

$r_c$  = curvature correction coefficient

## .2 Maximum reaction shear force

$$F_{Q\text{-max}} = \gamma \cdot P_d \cdot s_{\text{eff}}$$

$\gamma$  = see [Table C3.8.2](#)

$P_d$  = lateral design pressure on associated plating acc. to [C3.8.3.2.3](#)

$s_{\text{eff}}$  = effective panel span

## .3 Maximum lateral deflection

$$z_{\text{max}} = \frac{\alpha \cdot P_d \cdot s_{\text{eff}}^4}{12 \cdot EI_{\text{eff}}}$$

$\alpha$  = see [Table C3.8.2](#)

$P_d$  = lateral design pressure on associated plating acc. to [C3.8.3.2.3](#)

$s_{\text{eff}}$  = effective panel span

$EI_{\text{eff}}$  = plate bending stiffness relevant for the direction of the effective panel span

For allowable deflections see [C3.8.8](#)

**Table C3.8.2 Values  $\beta$ ,  $\alpha$ ,  $\gamma$**

For all edges simply supported										
$ar_{\text{eff}}$	1	1,2	1,4	1,6	1,8	2	3	4	5	$\infty$
$\beta$	0,2874	0,3762	0,453	0,5172	0,5688	0,6102	0,7134	0,741	0,7476	0,75
$\alpha$	0,0444	0,0616	0,077	0,0906	0,1017	0,111	0,1335	0,14	0,1417	0,1421
$\gamma$	0,42	0,455	0,478	0,491	0,499	0,503	0,505	0,502	0,501	0,5
For all edges fixed										
$ar_{\text{eff}}$	1	1,2	1,4	1,6	1,8	2	$\infty$			
$\beta$	0,3078	0,3834	0,4356	0,468	0,4872	0,4974	0,5			
$\alpha$	0,0138	0,0188	0,0226	0,0251	0,0267	0,0277	0,0284			
$\gamma$	0,42	0,455	0,478	0,491	0,499	0,503	0,5			

## C3.8.3.4 Determination of laminate strains and stresses

### .1 Laminate strains

The structural performance of a laterally loaded plate is characterized by the occurring strains in the laminate using the following approach.

Resulting strains at a distance  $z_i$  from the plate's neutral axis:

$$\varepsilon_i = \frac{M_{b-\max} \cdot z_i}{EI_{\text{eff}}}$$

The maximum strains through bending moments usually emerge at the outer surfaces of a composite. Hence, for evaluating the maximum strains, use the maximum distances from the neutral axis at each side of the plate.

The calculated strains may not exceed the allowables defined in [C3.8.8](#). Apart from the pure bending strains, stability issues such as skin wrinkling need to be considered, relate to [C3.8.6](#).

## .2 Determination of core shear stresses in sandwich laminates

Whereas with solid coreless laminates, the through-thickness interlaminar stress is rarely a design criterion, it is so for most of the lower density/strength cores of a typical sandwich. The core has to transmit the through-thickness shear forces. A certain contribution by the skins is assumed.

Core shear stress is calculated as being:

$$\tau_c = \frac{F_{q-\max}}{t_c + \frac{t_{s1}}{2} + \frac{t_{s2}}{2}}$$

$F_{q-\max}$  = see [C3.8.3.3.2](#)

$t_c$  = core thickness

$t_{s1}, t_{s2}$  = skin thickness of skins

The calculated stresses may not exceed the allowables defined in [C3.8.8](#).

## C3.8.4 Laterally loaded beams

### C3.8.4.1 Applicability

The following approach can be used for laterally loaded beams, stiffeners, frames and girders, with or without associated plating attached. These structural members are usually part of an orthogonal structural system of a vessel. In well found cases, curvature effects may be taken into account in a similar way as shown for panels, see [Fig. C3.8.8](#).

Typically, the beams consist of a web designed to carry the shear force and two flanges to carry the bending load, both generated by lateral pressure.

The web may be attached vertically or inclined to the attached shell (only the structural height times the thickness as effective shear area is to be considered). One flange is usually presented by a certain amount of attached plating (see effective width) and possible additional pads beneath the web. The other flange is presented by the "capping" of the beam.

Beams should be designed in a way that the transfer of loads is fibre dominant. In general this will require shear webs to consist of +/-45° layers of laminate, whereas the flanges consist of a certain number of 0° plies. However, it shall be taken into account that shear loads are transferred from the web into the flange.

The following approaches are featuring the partly simplified "Classical Laminate Theory" and the simple "Beam Theory".

The objective is to determine beam stresses and strains from bending moments and shear forces caused by lateral pressure on the associated plating. The computational model is presented by a simple beam with appropriate support conditions.

In case the scantlings are constant over the full length of the beam, it is sufficient to evaluate stresses and strains, respectively, through

- bending moment and shear force at the end of the beam for a support condition “ends fixed”
- bending moment at the centre of the beam and shear effects at the end of the beam for a support condition “ends simply supported”

Laminated beams may have a great variety of section shapes. Generally it is recommended to use symmetrical or near-symmetrical section shapes, as unsymmetrical shapes are subjected to superimposed secondary effects such as transverse bending or a twisting of the beam (flange). This makes a more refined analysis necessary than offered below.

**Note:**

*Due to the resulting transverse bending moment occurring in the flange, L-section beams with common width to height ratio show up to 2-times the calculated strains/stresses compared to calculated using the below approach. Measures shall be taken to reduce the strains by increasing the flange scantlings, or mounting tripping brackets along the beam.*

If not explicitly mentioned, use consistent unit variables.

Laminated beams including their associated plating are to be characterized by the following parameters:

#### C3.8.4.2 Parameters

##### .1 Structural parameters

The following parameters have been determined in C3.8.2.6:

- EI = beam bending stiffness including associated plating
- GA = shear stiffness of webs
- $z_i$  = distance from a certain location within the beam to the neutral axis in bending
- $w_{eff}$  = effective width of plating

##### .2 Geometrical parameters

- $\ell$  = unsupported length of the beam
- w = load width

Boundary condition (all edges fixed or all edges simply supported)

##### .3 Load details

For panel design pressures see C3.8.3.2.3

##### .4 Beam curvature correction

Curvature correction coefficient:

$$r_{cb} = 1,15 - 5 \cdot \frac{h}{\ell} \quad \text{for} \quad 0,03 < \frac{h}{\ell} < 0,1$$

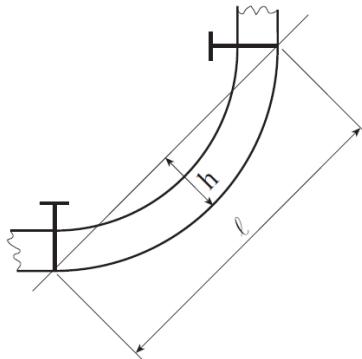


Fig. C3.8.8 Beam curvature definitions

#### C3.8.4.3 Maximum bending moment, shear force and lateral deflection of beam

##### .1 Maximum bending moment

$$M_{b\text{-max}} = \frac{P_d \cdot w \cdot l^2 \cdot r_{cb}}{c_b}$$

$P_d$  = lateral design pressure on associated plating acc. to [C3.8.3.2.3](#)

$w$  = load width

$l$  = length of beam between supports

$r_{cb}$  = beam curvature reduction factor see [3.8.4.2.4](#)

$c_b$  = boundary condition coefficient

= 12 for fixed end supports

= 8 for simply supported

##### .2 Maximum reaction shear force

The maximum shear force typically occurs at the boundaries:

$$F_{q\text{-max}} = \frac{P_d \cdot l \cdot w}{2}$$

$P_d$  = see [C3.8.3.2.3](#)

$l$  = see [C3.8.4.3.1](#)

$w$  = see [C3.8.4.3.1](#)

##### .3 Maximum lateral deflection

The maximum lateral deflection of a beam is typically observed half way along the beam, considering that both ends have similar end support conditions and the beam has constant structural section and material properties along its length:

$$z_{\max} = \frac{P_d \cdot w \cdot l^4 \cdot c_d}{384 \cdot EI}$$

$P_d$  = see [C3.8.3.2.3](#)

- $\ell$  = see C3.8.4.3.1  
 $w$  = see C3.8.4.3.1  
 $c_d$  = boundary condition coefficient  
= 1 for fixed end supports  
= 5 for simply supported

For allowable deflections see C3.8.8.

#### C3.8.4.4 Beam construction notes

.1 In general, the bonding laminate (if not integral with the shear web) of a shear web needs to have the same shear stiffness/strength as the web. The lap of the bonding has to be large enough to transmit in-plane shear forces. It is important to place the bonding tapes using the specified fibre orientations throughout see Fig. C3.8.9.

This is not only applicable to the bond between the beam and the associated plate but also to the bond between the beam and the next higher hierarchical member in structure, which it is supported by.

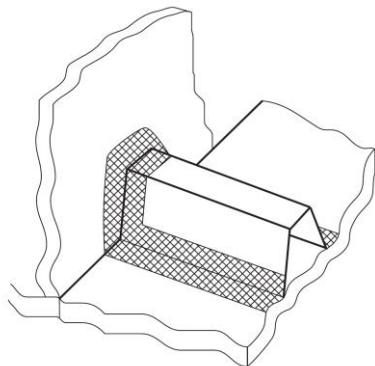


Fig. C3.8.9 Bonding of a beam to adjacent structure

.2 The requirement for a sufficient amount of shear buckling stiffness of web laminates may lead to the inclusion of stabilizing measures for webs (e.g. sandwich web or foam filled). If webs are of single skin style, the web height may not exceed 30-times the web thickness to prevent shear buckling.

.3 In special cases it may be required to replace the core of the associated plate with a higher strength/ stiffness shear tie.

.4 Web laminates necessary to carry the shear loads should in general continue across the capping laminate and be interspersed with the capping laminate.

#### C3.8.5 Determination of laminate strains and stresses

##### C3.8.5.1 General

The structural performance of a laterally loaded beam is characterized by the occurring strains in the laminate. The maximum bending strains usually emerge at the most external areas of the composite. The most critical shear loading can usually be found in the shear webs.

### C3.8.5.2 Strains and stresses

#### .1 In-plane uniaxial strains

Resulting bending strains at a distance of  $e_i$  from the beam's neutral axis:

$$\varepsilon_i = \frac{M_{b-\max} \cdot e_i}{EI}$$

For evaluating the maximum strains, the maximum distances  $e_i$  from the neutral axis at each side of the beam are to be used. Due to special configurations, materials or geometries it might be necessary to calculate the strains at other characteristic locations along the beam.

The calculated strains may not exceed the allowables defined in C3.8.8.

#### .2 In-plane shear strains in webs

$$\gamma_s = \frac{F_{q-\max}}{GA}$$

The calculated strains shall not exceed the allowables defined in C3.8.8.

### C3.8.6 Stability considerations

Sandwich structures need to undergo special stability evaluations to prove that pertinent buckling in different forms will not occur. For marine structures typically the most critical buckling modes are the global buckling of a panel and face wrinkling of the skins. To cope for the latter, analytical approaches are offered in the following. Buckling modes like shear crimping and face dimpling are less likely to occur but need to be evaluated in addition should facings or cores be of uncommon type or configuration.

#### C3.8.6.1 Skin wrinkling of sandwich skins

Skin wrinkling of sandwich skins may be critical especially in cases where a sandwich panel is subjected to loadings so that at least one skin is in compression. Depending on the stiffness of the laminate in the relevant direction and on the supporting properties of the core, the following approach is used to assess strains above which skin wrinkling is expected:

Critical wrinkling strain for sandwich with "solid, isotropic" cores like foam:

$$\varepsilon_{sw-crit} = k_1 \cdot \frac{(E_{bf} \cdot E_c \cdot G_c)^{1/3}}{E_f}$$

Critical wrinkling strain for sandwich cored with honeycomb:

$$\varepsilon_{sw-crit} = k_2 \cdot \frac{(E_{bf} \cdot E_c \cdot t_f/t_c)^{1/2}}{E_f}$$

$E_{bf}$  = skin laminate flexural modulus relevant to direction of compression. Thus, care shall be taken for laminate stacks of only few layers of alternating fibre direction. For skins made of many layers providing balanced through thickness elastic properties, a mean compressive young's modulus may be adopted instead

$E_f$  = skin laminate tensile (compressive) modulus

$E_c$	=	core's Young's modulus in compression
$G_c$	=	core's shear modulus
$t_f$	=	thickness of skin
$t_c$	=	thickness of core
$k_1$	=	0,5
$k_2$	=	0,6

### C3.8.6.2 Buckling of orthotropic plates under uniaxial membrane loads

#### .1 Considerations and limitations

The buckling of sandwich panels needs to be considered for global in-plane compression and in-plane shear.

The following methodology is based on simplified classical laminate theory, i.e. only valid for laminate plates (sandwich or single skin) which are well balanced through thickness. Only sandwich laminates with skin in-plane tensile stiffness ( $E \cdot t$ ) difference of no more than 20 % in each direction x or y may be considered this way:

$$0,8 \leq \frac{E_{x-os} \cdot t_{os}}{E_{x-is} \cdot t_{is}} \leq 1,2$$

and

$$0,8 \leq \frac{E_{y-os} \cdot t_{os}}{E_y \cdot t_{is}} \leq 1,2$$

where "os" and "is" are indices for "outer skin" and "inner skin".

Also, all edges need to be supported. There is no implementation for the possibility to calculate plates with one free edge.

This condition presumes that there will be no or only minor coupling between in-plane and out-of-plane effects.

#### .2 Critical buckling strain

For arbitrary boundary conditions the critical membrane strain of an orthotropic plate that leads to buckling is:

$$\varepsilon_{B-crit} = \frac{1}{E_{a-mean} \cdot t_{tot}} \cdot k_x \cdot \left( \frac{\pi}{b} \right)^2 \cdot \sqrt{D11 \cdot D22}$$

$E_{a-mean}$	=	mean Young's modulus in load direction (a) of full laminate (incl. core)
$t_{tot}$	=	total thickness of full laminate (incl. core)
$b$	=	plate width perpendicular to load direction
$a$	=	plate width parallel to load direction
$k_x$	=	buckling coefficient:  $= h(\bar{\alpha}) + q \cdot \beta$

- q = boundary condition adjustment factor  
 = 2 for unloaded edges simply supported  
 = 2,36 for unloaded edges clamped  
 $h(\bar{\alpha})$  = see Fig. C3.8.10  
 $\bar{\alpha}$  = modified aspect ratio:  
 =  $\frac{a}{b} \cdot \sqrt[4]{\frac{D_{22}}{D_{11}}}$   
 $\beta$  = "Seydel" orthotropic parameter  
 =  $\frac{D_{12} + 2 \cdot D_{33}}{\sqrt{D_{11} \cdot D_{22}}}$

Coefficients from the laminate's bending matrix D:

$$D_{11} = \sum_{i=1}^n Q_{11}'_{Li} \cdot \frac{1}{3} (z_i^3 - z_{i-1}^3)$$

$$D_{12} = \sum_{i=1}^n Q_{12}'_{Li} \cdot \frac{1}{3} (z_i^3 - z_{i-1}^3)$$

$$D_{22} = \sum_{i=1}^n Q_{22}'_{Li} \cdot \frac{1}{3} (z_i^3 - z_{i-1}^3)$$

$$D_{33} = \sum_{i=1}^n Q_{33}'_{Li} \cdot \frac{1}{3} (z_i^3 - z_{i-1}^3)$$

Index "i" stands for each particular layer of a total of "n" layers of a laminate.

$Q_{11}'_{Li}$ ,  $Q_{12}'_{Li}$ ,  $Q_{22}'_{Li}$  and  $Q_{33}'_{Li}$  are coefficients determined in C3.8.2.4.

$z_i$  are distances from ply surfaces to the laminate midplane as depicted in Fig. C3.8.2.

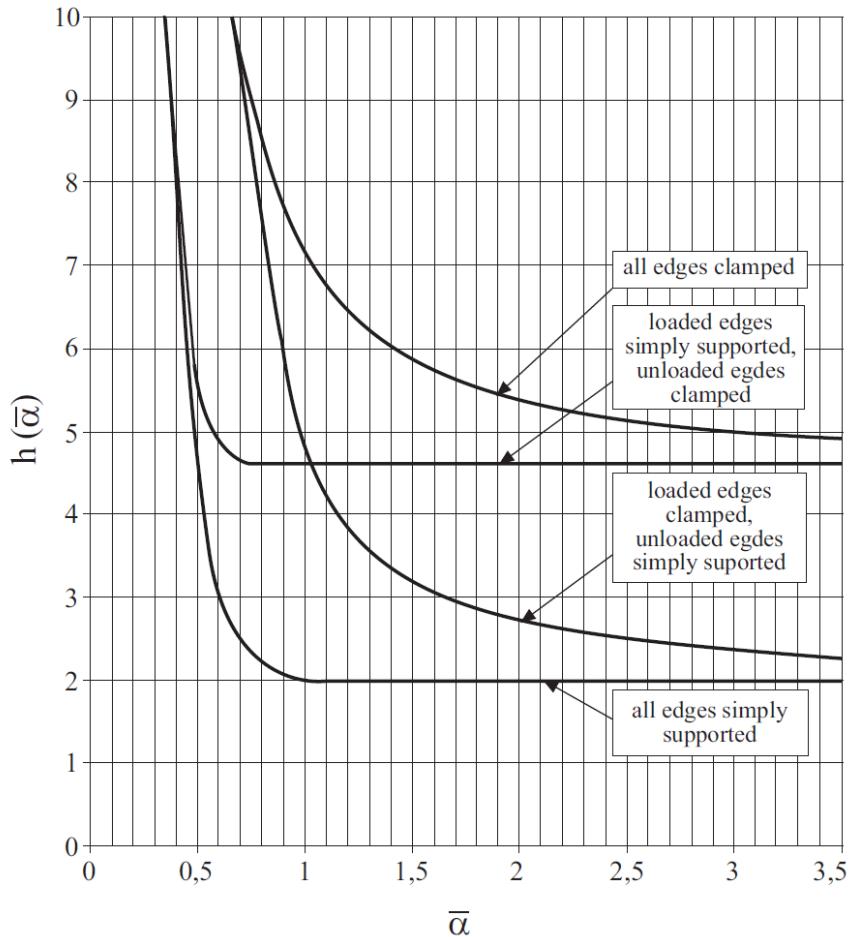


Fig. C3.8.10 Simplified  $h(\bar{\alpha})$  curves

### C3.8.6.3 Buckling of orthotropic plates under in-plane shear loads

The general provisions [C3.8.6.2.1](#) apply.

#### .1 Critical buckling strain

For an all-sided simply supported orthotropic plate, the critical in-plane shear strain that leads to buckling is:

$$\gamma_{B\text{-crit}} = \frac{1}{G_{a\text{-mean}} \cdot t_{\text{tot}}} \cdot k_s \cdot \left( \frac{\pi}{w} \right)^2 \cdot \sqrt[4]{D_a \cdot D_b^3}$$

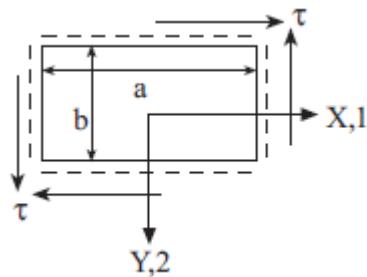


Fig. C3.8.11 Nomenclature

$G_{a\text{-mean}} =$  mean in-plane shear modulus of full laminate

- $t_{\text{tot}}$  = total thickness of full laminate  
 $w$  = plate width a or b, see below  
 $k_s$  = buckling coefficient, as per Fig. C3.8.12  
 $\beta$  = "Seydel" orthotropic parameter:  
 $= \frac{D_{12} + 2 \cdot D_{33}}{\sqrt{D_{11} \cdot D_{22}}}$   
 $\alpha$  = modified inverse aspect ratio  
 $= \frac{1}{\alpha} = \frac{b}{a} \cdot \sqrt[4]{\frac{D_{11}}{D_{22}}}$

If  $\alpha \leq 1$ , then

- $w$  = b  
 $D_a$  = D11  
 $D_b$  = D22

If  $\alpha > 1$ , then

- $\alpha$  =  $\bar{\alpha}$   
 $w$  = a  
 $D_a$  = D22  
 $D_b$  = D11  
 $b$  = plate width in X,1 direction  
 $a$  = plate width in Y,2 direction

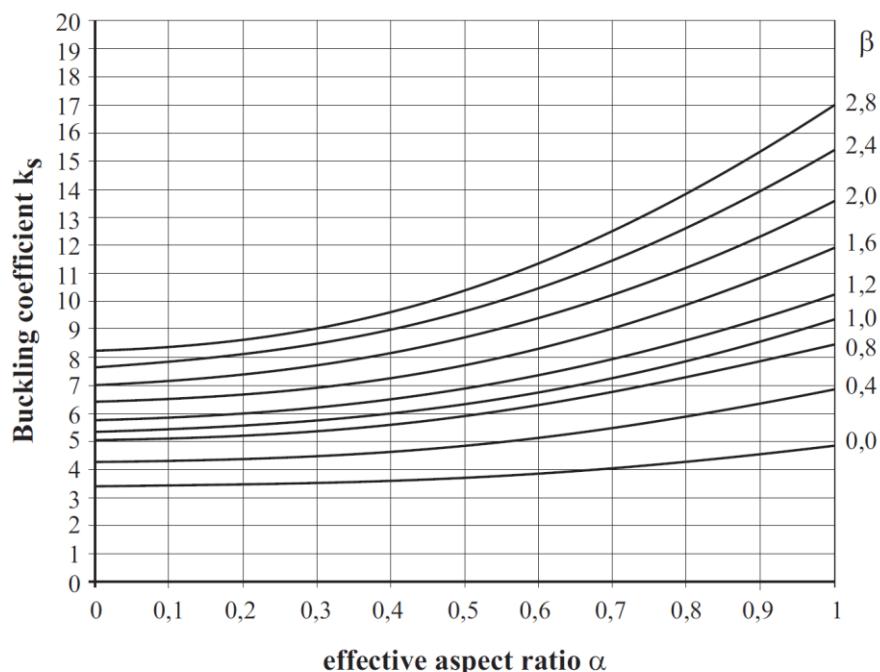


Fig. C3.8.12 Buckling coefficient  $k_s$

### C3.8.7 Further considerations

#### C3.8.7.1 Through-thickness effects

In general it is preferred to have a fibre-dominant load absorption in a composite structure, but in some cases it will be unavoidable that through thickness effects occur. Those structural details will be treated individually and case by case.

#### C3.8.7.2 Minimum shell thickness

No particular algorithm has been implemented to determine a minimum shell or skin thickness for hull laminates. As global strength and stiffness criteria have been set, a remaining issue is that of a shell laminate being prone to local forces or impact when docking, dry docking or from collision with floating or submerged debris. This subject will be handled individually.

### C3.8.8 Allowable strains, safety factors and maximum deflections

For fibre reinforced composite components, the “maximum strain criteria” is mainly used to assess the structural integrity. This criterion may solely be used in association with the provisions described and defined so far.

This criterion is providing an appropriate limit for fibre reinforced composites under the condition that the composite shows a fibre-dominant load transfer.

These limits provide a sufficient margin over interlaminar micro cracking and fibre failure in all in-plane directions.

For adhesive bonds, the structural evaluation of sandwich cores and evaluation of stability criteria, safety factors are serving to achieve sufficient integrity. Further to that, a deflection criterion has to be fulfilled:

- Maximum strain for carbon laminates in axial tension/compression is to be the smaller value of:
  - 0,25% (typical for standard modulus, intermediate modulus or high strength carbon fibre) or
  - Ultimate compressive strain/3
- BKI reserves the right to inquire test certificates for tests on ultimate compressive strain, using ASTM D-695. Tests need to be carried out at accredited, independent laboratories.
- Maximum allowable strain of 0,35% for E-Glass laminates in axial tension/compression
- Maximum allowable in-plane shear strain for carbon laminates is to be smaller value of
  - 0,45% (typical for standard modulus, intermediate modulus or high strength carbon fibres) or
  - Ultimate compressive strain · 0,6
- Maximum allowable in-plane shear strain for E- Glass laminates of 0,7%
- Safety factor of 2,5 vs. core shear failure (linear shear stress distribution over the core and each half of the skins). Basis are the BKI approved values or the “msmv”(manufacturer specified minimum values) values for structural cores.
- Appropriate safety of skin/core bond
- Factor of 2,5 vs. panel buckling and 2,0 for skin wrinkling on the strains determined according to C3.8.6.
- Factor of 2,5 vs. shear strength in an adhesive bond using adhesives approved by BKI.
- Maximum permissible lateral deflections under lateral load:
  - 1,5% of effective panel span for single skin laminate panels
  - 1,0% of effective panel span for sandwich panels

- 0,5% of unsupported span of a stiffener or girder
- 0,3% of unsupported span of engine foundation

### C3.8.9 Construction and design details

#### C3.8.9.1 Consequences of elasticity

Unlike metals, fibre reinforced composites used for marine applications exhibit almost linear elastic behaviour to failure. This is as long as the structural response is fibre-dominated, which is preferred over a matrix dominant behaviour. Respecting this, composites show little or no yielding until failure. This aspect requires particular attention. Especially in structural details with occurring stress concentrations, consideration shall already be given in static strength analysis. In cases in which these concentrations are compensated appropriately, fatigue will not be as critical. This is valid for in-plane loads with fibre dominated load absorption. However, through-thickness loading (especially shear and tension) can not always be avoided and yet needs to be handled in an appropriately conservative way. "Intercracking" or delamination caused by overloading, impact or deficient structural design is considered to be the cause for subsequent failure of components and thus can be deemed as cause for fatigue with composites.

#### C3.8.9.2 Recommendations

The following recommendations do not claim to be all-inclusive and are subject to up-date/change/amendment:

- In general, the basic laminate stacking sequence shall be homogeneous; preferably symmetrical and balanced, if not particular attention has to be paid to possible arising secondary effects.
- A laminate should consist of plies aligned in at least 4 distinct directions (e.g. 0°, +/-45°, 90°), with not less than 10% in each direction. Ply angles should be aligned appropriately for major load direction(s). Exemptions are the following components/items:
  - mainly in-plane shear loaded webs of girders, stiffeners, frames
  - local tape reinforcements
- Grouping of plies with the same fibre direction should be avoided, but total thickness of these plies may not exceed 1,5 mm (typically for carbon laminates).
- Not all parts are suitable for composites. Complex 3-dimensional stress states may make suitable isotropic materials a preferred choice (e.g. local fittings).
- Inaccessibility of composite components needs to be considered in design in terms of inspectability during production, in-service and after damage.

#### C3.8.9.3 Details

All structural details are subject to examination by BKI. In general the following provisions shall be observed.

- .1 The occurrence of peeling effects, such as abrupt stiffness changes is to be minimized. Secondary bonding is always to be backfilled with suitably coved filler bed.
- .2 For mechanical fastenings, a domination of fibre orientation in one direction of more than 40 % is not advisable.
- .3 Core chamfers of sandwich laminates should not be steeper than 1:3 thickness/taper ratio.
- .4 Exposed fibres and sandwich cores shall be sealed or clashed with laminate.

## C3.9 Hull Appendages

### C3.9.1 Shaft brackets

.1 The strut axes should intersect in the axis of the propeller shaft as far as practicable. The angle between two struts shall be in range from  $50^\circ$  to  $120^\circ$  which differs from the angle included between propeller blades. Where 3- or 5-bladed propellers are fitted, an approximately  $90^\circ$  angle is recommended. Where 4-bladed propellers are fitted, the angle should be approximately  $70^\circ$  or  $110^\circ$ . The axes of the arms should intersect in the axis of the propeller shaft. Exceptions to this will be considered by BKI on a case-by-case basis.

The struts are to be extended through the shell plating and are to be attached in an efficient manner to the frames and plate floors respectively. The construction in way of the shell is to be carried out with special care. For strengthening of the shell in way of struts and shaft bossings, see [C3.7.7.3.3](#).

In case of welded connection, the struts are to have a weld flange or a thickened part or are to be connected with the shell plating in another suitable manner. The requirements of [C3.6.1.4.3](#) are to be observed.

.2 In general, the scantlings of solid struts can be determined as outlined below depending on shaft diameter d:

- strut thickness :  $0,44 d$
  - cross-sectional area :  $0,44 d^2$  in propeller bracket
  - length of boss :  $2,5 d_a$
  - wall thickness of boss :  $0,25 d$
- $d_a$  = as-built diameter  
 $d$  =  $95 (P_w \cdot C_w / n)^{(1/3)}$   
 $C_w$  =  $560/(160 + R_m)$   
 $R_m$  = tensile strength of the strut material  
 $P_w$  = single engine output in kW  
 $n$  = shaft revolutions per minute

Based on further details other scantling calculations can be accepted as agreed by BKI.

.3 Propeller brackets and shaft bossings of welded construction are to have the same strength as solid ones according to [.2](#). The thickness of plating shall not be less than  $0,1 d$ .

.4 The shaft brackets are to be checked of cracks during each drydocking.

.5 For one strut propeller brackets a strength, vibration and fatigue analysis is to be carried out.

### 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.

.6 The stress criteria for static analysis may be taken as the following one, in MPa:

- 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:

$$\sigma_{eq,am} = \frac{190}{k \cdot f'_m}$$

$k$  = material factor defined in C3.2

$f'_m$  = coefficient depending on the material

= 1,00 for steel structures

= 2,15 for aluminium alloy structures

Table C3.9.1

Component	LDC1	LDC2	LDC3	LDC4
Built-in nozzle:				
- plating	X <sup>1</sup>	X <sup>2</sup>		
- bending behaviour				X <sup>3</sup>
Ship stern		X <sup>2</sup>	X	X <sup>4</sup>
Bolting on stern			X <sup>5</sup>	X <sup>5</sup>

<sup>1</sup> to be checked under lateral pressure and against fatigue behaviour  
<sup>2</sup> buckling to be checked (100 % of  $F_x$  transferred by built-in nozzle in case of thrust bearing aft of the stern)  
<sup>3</sup> ratio of  $M_y$  directly sustained by the built-in nozzle to be estimated on basis of relative stiffnesses  
<sup>4</sup> ratio of  $M_y$  directly sustained by the transom structure to be estimated on basis of relative stiffnesses  
<sup>5</sup> bolting calculation taking account of the actual pre-tension in bolts

.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 here after:

- 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 fulfil 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 Rudder

### C3.10.1 General

.1 Rudder stock, cone coupling, rudder bearings and the rudder body of spade rudders are dealt with in the following. For rudders supported by sole piece and semi-spade rudders and other types of couplings the [Rules for Hull \(Pt.1, Vol.II\), Sec. 14](#) are to be observed.

.2 The steering gear compartment shall be readily accessible and, as far as practicable, separated from the machinery space.

**Note:**

*Concerning the use of non-magnetisable material in the wheel house in way of a magnetic compass, the requirements of the national Administration concerned are to be observed.*

### C3.10.2 Structural details

.1 Effective means are to be provided for supporting the weight of the rudder body without excessive bearing pressure, e.g. by 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 provided to prevent the rudder from lifting.

Connections of rudder blade structure with solid parts in forged or cast steel, which are used as rudder stock housing, are to be suitably designed to avoid any excessive stress concentration at these areas.

.3 The rudder stock is to be carried through the hull either enclosed in a watertight trunk, or glands are to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of the rudder trunk is below the deepest waterline two separate stuffing boxes are to be provided.

**Note:**

*The following measures are recommended for preventive measures to avoid or minimize rudder cavitation:*

*Profile selection:*

- Use the appropriate profile shape and thickness.
- Use profiles with a sufficiently small absolute value of pressure coefficient for moderate angles of attack (below 5°). The pressure distribution around the profile should be possibly smooth. The maximum thickness of such profiles is usually located at more than 35 % behind the leading edge.
- Use a large profile nose radius for rudders operating in propeller slips.
- Computational Fluid Dynamic (CFD) analysis for rudder considering the propeller and ship wake can be used.

*Rudder sole cavitation:*

*Round out the leading edge curve at rudder sole.*

*Propeller hub cavitation:*

*Fit a nacelle (body of revolution) to the rudder at the level of the propeller hub. This nacelle functions as an extension of the propeller hub.*

*Cavitation at surface irregularities:*

- Grind and polish all welds.
- Avoid changes of profile shape. Often rudders are built with local thickenings (bubbles) and dents to ease fitting of the rudder shaft. Maximum changes in profile shape should be kept to less than two percent of profile thickness.

*Gap cavitation:*

- Round out all edges of the part around the gap.
- Gap size should be as small as possible.
- Place gaps outside of the propeller slipstream.

### C3.10.3 Materials

.1 For materials for rudder stock, pintles, coupling bolts etc. see [Rules for Materials \(Pt.1, Vol.V\)](#).

.2 In general materials having a minimum nominal upper yield point  $R_{eH}$  of less than 200 MPa and a minimum tensile strength of less than 400 MPa or more than 900 MPa shall not be used for rudder stocks, pintles, keys and bolts.

The requirements of this Section are based on a material's minimum nominal upper yield point  $R_{eH}$  of 235 MPa. If material is used having a  $R_{eH}$  differing from 235 MPa, the material factor  $k_r$  is to be determined as follows:

$$k_r = \begin{cases} \left(\frac{235}{R_{eH}}\right)^{0,75} & \text{for } R_{eH} > 235 \text{ [N/mm}^2\text{]} \\ \frac{235}{R_{eH}} & \text{for } R_{eH} \leq 235 \text{ [N/mm}^2\text{]} \end{cases}$$

$R_{eH}$  = minimum nominal upper yield point of material used [MPa]

$R_{eH}$  is not to be taken greater than  $0,7 \cdot R_m$  or 450 MPa, whichever is less.  $R_m$  = tensile strength of the material used.

.3 Before significant reductions in rudder stock diameter due to the application of steels with  $R_{eH}$  exceeding 235 MPa are accepted, BKI may require the evaluation of the elastic rudder stock deflections. Large deflections should be avoided in order to avoid excessive edge pressures in way of bearings.

.4 The permissible stresses given in C3.10.8 are applicable for normal strength hull structural steel. When higher tensile steels are used, higher values may be used which will be fixed in each individual case.

#### C3.10.4 Definitions

$C_R$  = rudder force [N]

$Q_R$  = rudder torque [Nm]

$A$  = total movable area of the rudder [ $m^2$ ], measured at the mid-plane of the rudder

$A_t$  =  $A +$  area of a rudder horn, if any [ $m^2$ ]

$A_f$  = portion of rudder area located ahead of the rudder stock axis [ $m^2$ ]

$b$  = mean height of the rudder area [m]. Mean breadth and mean height of rudder are calculated according to the coordinate system in Fig. C3.10.1

$c$  = mean breadth of rudder area [m], see Fig. C3.10.1

$\Lambda$  = aspect ratio of rudder area  $A_t$

$$= \frac{b^2}{A_t}$$

$v_a$  = astern speed of ship [kn]; if the astern speed  $v_a$  is less than  $0,4 \cdot v_0$  or 6 kn, whichever is less, determination of rudder force and torque for astern condition is not required. For greater astern speeds special evaluation of rudder force and torque as a function of the rudder angle may be required. If no limitations for the rudder angle at astern condition is stipulated, the factor  $\kappa_2$  is not to be taken less than given in Table C3.10.1 for astern condition.

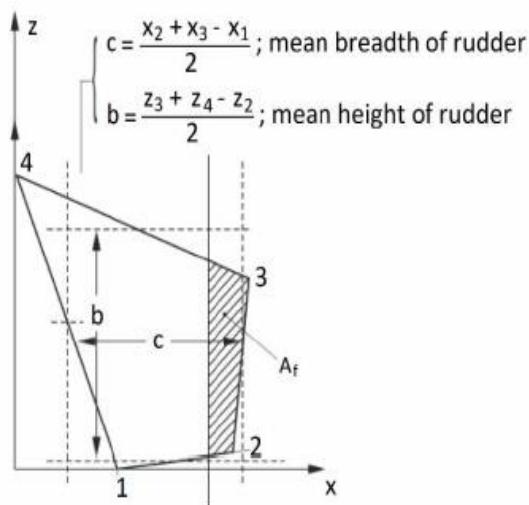


Fig. C3.10.1 Rudder area geometry

### C3.10.5 Rudder Force and Torque

.1 The rudder force is to be determined according to the following formula:

$$C_R = 132 \cdot A \cdot V_0^2 \cdot k_1 \cdot k_2 \cdot k_3$$

$$V_0 = \min [V, 2/3 \cdot (V + 2 \cdot L^{0.5})]$$

=  $v_a$  for astern condition

$k_1$  = coefficient, depending on the aspect ratio  $\Lambda$

=  $(\Lambda + 2)/3$ , where  $\Lambda$  need not be taken greater than 2

$k_2$  = coefficient, depending on the type of the rudder and the rudder profile according to [Table C3.10.1](#)

$k_3$  = coefficient, depending on the location of the rudder

= 0,8 for rudders outside the propeller jet

= 1,0 elsewhere, including also rudders within the propeller jet

= 1,15 for rudders aft of the propeller nozzle

**Table C3.10.1 Coefficient  $k_2$**

Profile / type of rudder	$k_2$	
	ahead	astern
NACA-00 series Göttingen profiles	1,1	1,4
flat side profiles	1,1	1,4
mixed profiles (e. g. HSVA)	1,21	1,4
hollow profiles	1,35	1,4
high lift rudders	1,7	to be specially considered; if not known: 1,7

.2 The rudder torque is to be determined by the following formula:

$$Q_R = C_R \cdot r \text{ [Nm]}$$

$$r = c (\alpha - k_b) \text{ [m]}$$

$\alpha$  = 0,33 for ahead condition

= 0,66 for astern condition (general)

$k_b$  = balance factor as follows:

$$= \frac{A_f}{A}$$

= 0,08 for unbalanced rudders

$r_{min}$  =  $0,1 \cdot c$  [m] for ahead condition

.3 Effects of the provided type of rudder/profile on choice and operation of the steering gear are to be observed.

### C3.10.6 Scantlings of the Rudder Stock

#### C3.10.6.1 Rudder stock diameter

.1 The diameter of the rudder stock for transmitting the rudder torque is not to be less than:

$$D_t = 4,2 \cdot \sqrt[3]{Q_R \cdot k_r} \quad [\text{mm}]$$

$$Q_R = \text{see C3.10.5.1.2}$$

The related torsional stress is:

$$\tau_t = \frac{68}{k_r} \quad [\text{N/mm}^2]$$

$$k_r = \text{see C3.10.3.2}$$

.2 The steering gear is to be determined for the rudder torque  $Q_R$  as required in [C3.10.5.1.2](#) and under consideration of the frictional losses at the rudder bearings.

.3 In case of mechanical steering gear the diameter of the rudder stock in its upper part which is only intended for transmission of the torsional moment from the auxiliary steering gear may be  $0,9 D_t$ . The length of the edge of the quadrangle for the auxiliary tiller shall not be less than  $0,77 D_t$  and the height not less than  $0,8 D_t$ .

.4 The rudder stock is to be secured against axial sliding. The degree of the permissible axial clearance depends on the construction of the steering engine and on the bearing.

#### C3.10.6.2 Strengthening of rudder stock

.1 If the rudder is so arranged that additional bending stresses occur in the rudder stock, the stock diameter has to be suitably increased. The increased diameter is, where applicable, decisive for the scantlings of the coupling.

For the increased rudder stock diameter the equivalent stress of bending and torsion is not to exceed the following value:

$$\sigma_v = \sqrt{\sigma_b^2 + 3\tau^2} \leq \frac{118}{k_r} \quad [\text{N/mm}^2]$$

Bending stress:

$$\sigma_b = \frac{10,2 \cdot M_b}{D_1^3} \quad [\text{N/mm}^2]$$

$$M_b = \text{bending moment at the neck bearing [Nm]}$$

Torsional stress:

$$\tau = \frac{5,1 \cdot Q_R}{D_1^3} \quad [\text{N/mm}^2]$$

$$D_1 = \text{increased rudder stock diameter [cm]}$$

The increased rudder stock diameter may be determined by the following formula:

$$D_1 = 0,1 \cdot D_t \cdot \sqrt{1 + \frac{4}{3} \left( \frac{M_b}{Q_R} \right)^2}$$

$Q_R$  = see [C3.10.5.1.2](#)

$D_t$  = see [C3.10.6.1.1](#)

**Note:**

Where a double-piston steering gear is fitted, additional bending moments may be transmitted from the steering gear into the rudder stock. These additional bending moments are to be taken into account for determining the rudder stock diameter.

### C3.10.6.3 Analysis

#### .1 General

The evaluation of bending moments, shear forces and support forces for the system rudder - rudder stock may be carried out for some basic rudder type as shown in [Fig. C3.10.1](#) as outlined in .2 to .3.

#### .2 Data for the analysis

$P_{10} - P_{30}$  = lengths of the individual girders of the system [m]

Load on rudder body (general):

$$p_R = \frac{C_R}{\ell_{10} \cdot 10^3}$$

$C_R$ , see [C3.10.5.1.1](#)

#### .3 Moments and forces to be evaluated

.3.1 The bending moment  $M_R$  and the shear force  $Q_1$  in the rudder body, the bending moment  $M_b$  in the neck bearing and the support forces  $B_2, B_3$  are to be evaluated.

The so evaluated moments and forces are to be used for the stress analyses required by [C3.10.6.2](#) and [C3.10.8.1](#).

.3.2 The moments and forces may be determined by the following formulae:

$$M_b = C_R \cdot \left( \ell_{20} + \frac{\ell_{10}(2 \cdot x_1 + x_2)}{3 \cdot (x_1 + x_2)} \right) \quad [\text{Nm}]$$

$$B_3 = \frac{M_b}{\ell_{30}} \quad [\text{N}]$$

$$B_2 = C_R + B_3 \quad [\text{N}]$$

### C3.10.7 Rudder Couplings

#### C3.10.7.1 General

.1      The couplings are to be designed in such a way as to enable them to transmit the full torque of the rudder stock.

.2      For spade rudders only cone couplings are permitted, in general.

#### C3.10.7.2 Cone couplings

##### C3.10.7.2.1 Cone couplings with key

.1      Cone couplings shall have a taper  $c$  on diameter of  $1 : 8 - 1 : 12$ .  $c = (d_0 - d_u)/\ell$  according to Fig. C3.10.3.

The cone shapes should fit very exact. The nut is to be carefully secured, e.g. by a securing plate as shown in Fig. C3.10.3.

.2      The coupling length  $\ell$  shall, in general, not be less than  $1,5 \cdot d_0$ .

.3      For couplings between stock and rudder a key is to be provided, the shear area of which is not to be less than:

$$a_s = \frac{16 \cdot Q_F}{d_k \cdot R_{eH1}} \quad [\text{cm}^2]$$

$Q_F$     =    design yield moment of rudder stock [Nm] according to C3.10.9

$d_k$     =    diameter of the conical part of the rudder stock [mm] at the key

$R_{eH1}$     =    minimum nominal upper yield point of the key material [MPa]

.4      The effective surface area of the key (with-out rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_k = \frac{5 \cdot Q_F}{d_k \cdot R_{eH2}} \quad [\text{cm}^2]$$

$R_{eH2}$     =    minimum nominal upper yield point of the key, stock or coupling material [MPa], whichever is less.

.5      The dimensions of the slugging nut are to be as follows, see Fig. C3.10.3:

– height:

$$h_n = 0,6 \cdot d_g$$

– outer diameter (the greater value to be taken):

$$d_n = 1,2 \cdot d_u \quad \text{or}$$

$$d_n = 1,5 \cdot d_g$$

– external thread diameter:

$$d_g = 0,65 \cdot d_0$$

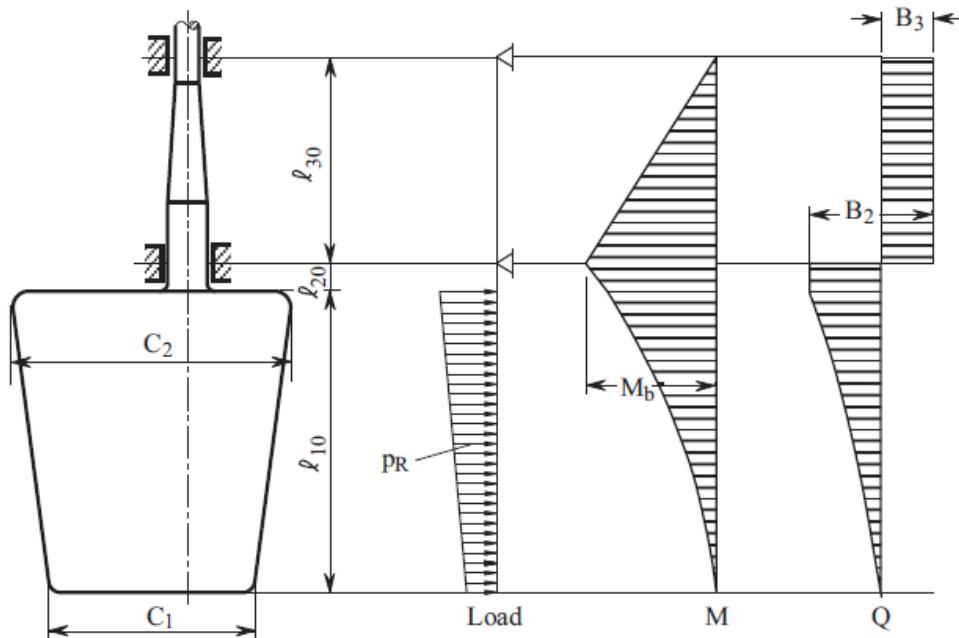


Fig. C3.10.2 Spade rudder

.6 It is to be proved that 50 % of the design yield moment will be solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure and push-up length according to [C3.10.7.3](#) for a torsional moment  $Q'F = 0,5 \cdot QF$ .

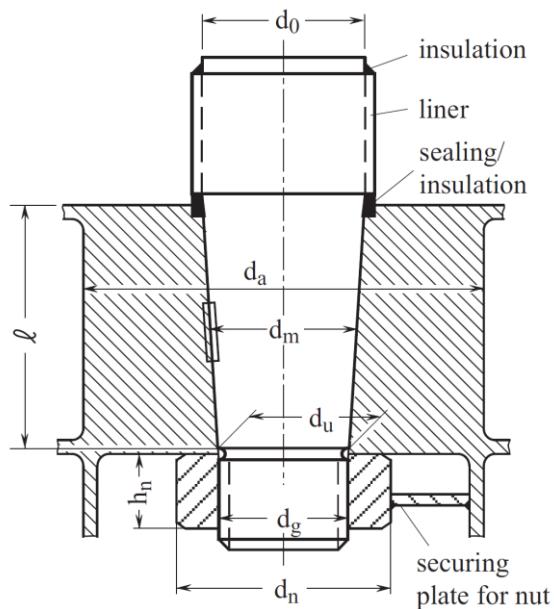


Fig. C3.10.3 Cone coupling with key and securing plate

#### C3.10.7.3 Cone couplings with special arrangements for mounting and dismounting the couplings

.1 Where the stock diameter exceeds 200 mm the press fit is recommended to be effected by a hydraulic pressure connection. In such cases the cone shall be more slender,  $c \approx 1 : 12$  to  $\approx 1 : 20$ .

.2 In case of hydraulic pressure connections the nut is to be effectively secured against the rudder stock or the pintle. A securing plate for securing the nut against the rudder body is not to be provided, see [Fig. C3.10.4](#).

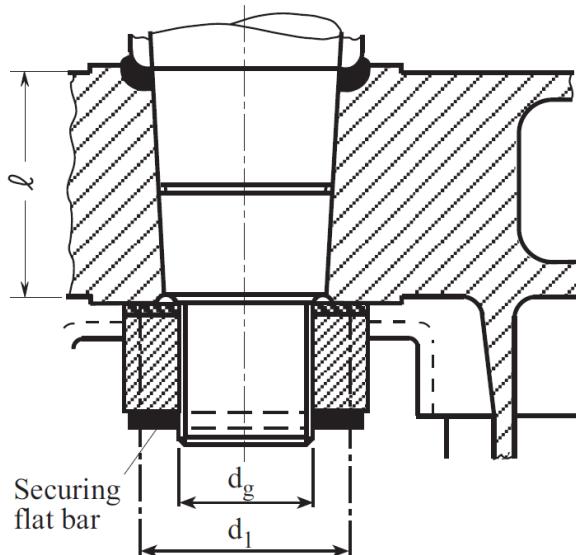


Fig. C3.10.4 Cone coupling without key and with securing flat bar

**Note:**

A securing flat bar will be regarded as an effective securing device of the nut, if its shear area is not less than:

$$A_s = \frac{P_s \cdot \sqrt{3}}{R_{eH}} \quad [\text{mm}^2]$$

$P_s$  = shear force as follows

$$= \frac{P_e}{2} \cdot \mu_1 \cdot \left( \frac{d_1}{d_g} - 0,6 \right) \quad [\text{N}]$$

$P_e$  = push-up force according to C3.10.7.3.3.2 [N]

$\mu_1$  = frictional coefficient between nut and rudder body, normally  $\mu_1 = 0,3$

$d_1$  = mean diameter of the frictional area between nut and rudder body, see Fig.C3.10.4

$d_g$  = thread diameter of the nut

$R_{eH}$  = yield point [MPa] of the securing flat bar material

.3 For the safe transmission of the torsional moment by the coupling between rudder stock and rudder body the push-up length and the push-up pressure are to be determined by the following formulae.

### .3.1 Push-up pressure

The push-up pressure is not to be less than the greater of the two following values:

$$p_{req1} = \frac{2 \cdot Q_F \cdot 10^3}{d_m^2 \cdot \ell \cdot \pi \cdot \mu_0} \quad [\text{MPa}]$$

$$p_{req2} = \frac{6 \cdot M_b \cdot 10^3}{\ell^2 \cdot d_m} \quad [\text{MPa}]$$

$Q_F$  = design yield moment of rudder stock according to C3.10.9 [Nm]

$d_m$  = mean cone diameter [mm]

$\ell$  = cone length [mm]

$\mu_0$  = 0,15 (frictional coefficient)

$M_b$  = bending moment in the cone coupling (e.g. in case of spade rudders) [Nm]

It has to be proved that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure is to be determined by the following formula:

$$p_{\text{perm}} = \frac{0,8 \cdot R_{\text{eH}} \cdot (1 - \alpha^2)}{\sqrt{3 + \alpha^4}}$$

$R_{\text{eH}}$  = yield point [MPa] of the material of the gudgeon

$\alpha$  =  $\frac{d_m}{d_a}$  (see Fig. C3.10.3)

The outer diameter of the gudgeon shall not be less than:

$$d_a = 1,5 \cdot d_m \quad [\text{mm}]$$

### .3.2 Push-up length

The push-up length is not to be less than:

$$\Delta P_1 = \frac{p_{\text{req}} \cdot d_m}{E \left( \frac{1 - \alpha^2}{2} \right) c} + \frac{0,8 \cdot R_{\text{tm}}}{c} \quad [\text{mm}]$$

$R_{\text{tm}}$  = mean roughness [mm]

$\approx$  0,01 mm

$c$  = taper on diameter according to C3.10.7.3.1

$E$  = Young's modulus ( $2,06 \cdot 10^5$  MPa)

The push-up length is, however, not to be taken greater than:

$$\Delta P_2 = \frac{1,6 \cdot R_{\text{eH}} \cdot d_m}{\sqrt{3 + \alpha^4} \cdot E \cdot c} + \frac{0,8 \cdot R_{\text{tm}}}{c} \quad [\text{mm}]$$

#### Note:

In case of hydraulic pressure connections the required push-up force  $P_e$  for the cone may be determined by the following formula:

$$P_e = p_{\text{req}} \cdot d_m \cdot \pi \cdot \ell \left( \frac{c}{2} + 0,02 \right) \quad [\text{N}]$$

The value 0,02 is a reference for the friction coefficient using oil pressure. It varies and depends on the mechanical treatment and roughness of the details to be fixed.

Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subject to approval by BKI.

### C3.10.8 Rudder Body, Rudder Bearings

#### C3.10.8.1 Strength of rudder body

.1 The rudder body is to be stiffened by horizontal and vertical webs in such a manner that the rudder body will be effective as a beam. The rudder shall be additionally stiffened at the aft edge.

.2 The strength of the rudder body is to be proved by direct calculation according to [C3.10.6.3](#)

.3 For rudder bodies without cut-outs the permissible stress are limited to:

bending stress due to  $M_R$ :

$$\sigma_b = 110 \text{ [MPa]}$$

shear stress due to  $Q_1$ :

$$\tau = 50 \text{ [MPa]}$$

equivalent stress due to bending and shear:

$$\sigma_v = \sqrt{\sigma_b^2 + 3\tau^2} = 120 \text{ [MPa]}$$

$M_R, Q_1$  see [C3.10.6.3.3](#).

In case of openings in the rudder plating for access to cone coupling the permissible stresses according to [1.4](#) apply. Smaller permissible stress values may be required if the corner radii are less than  $0,15 \cdot h_o$ , where  $h_o$  = height of opening.

.4 In rudder bodies with cut-outs the following stress values are not to be exceeded:

bending stress due to  $M_R$ :

$$\sigma_b = 90 \text{ [MPa]}$$

shear stress due to  $Q_1$ :

$$\tau = 50 \text{ [MPa]}$$

torsional stress due to  $M_t$ :

$$\tau_t = 50 \text{ [MPa]}$$

The distance  $\ell$  between the vertical webs shall not exceed  $1,2 \cdot h$ .

The radii in the rudder plating are not to be less than 4 – 5 times the plate thickness, but in no case less than 50 mm.

#### C3.10.8.2 Rudder plating

.1 The thickness of the rudder plating is to be determined according to the following formula:

$$t = 1,74 \cdot a \sqrt{p_R \cdot k} + t_k \quad [\text{mm}]$$

$$t_k = 2 \text{ mm for steel},$$

- = 0 mm for aluminium
- $$p_R = 10 \cdot T + \frac{C_R}{10^3 \cdot A} \quad [\text{kPa}]$$
- a = the smaller unsupported width of a plate panel [m]

The thickness shall, however, not be less than the thickness  $t_{\min}$  of hull bottom plating.

Regarding dimensions and welding [Rules for Hull \(Pt.1, Vol.II\), Sec. 19, B.4.4.1](#) have to be observed in addition.

.2 For connecting the side plating of the rudder to the webs tenon welding is not to be used. Where application of fillet welding is not practicable, the side plating is to be connected by means of slot welding to flat bars which are welded to the webs (on one side of the rudder only).

.3 The thickness of the webs is not to be less than 70 % of the thickness of the rudder plating according to .1. Webs exposed to seawater shall be dimensioned according to .1.

#### C3.10.8.3 Transmitting of the rudder torque

.1 For transmitting the rudder torque, the rudder plating according to [C3.10.8.2.1](#) is to be increased by 25 % in way of the coupling. A sufficient number of vertical webs is to be fitted in way of the coupling.

.2 If the torque is transmitted by a prolonged shaft extended into the rudder, the latter shall have the diameter  $D_t$  or  $D_1$ , whichever is greater, at the upper 10 % of the intersection length. Downwards it may be tapered to 0,6  $D_t$ , in spade rudders to 0,4 **times the strengthened diameter, if sufficient support is provided for.**

#### C3.10.8.4 Rudder bearings

.1 In way of bearings liners and bushes are to be fitted. Their minimum thickness is

$$t_{\min} = 8 \quad [\text{mm}] \text{ for metallic materials and synthetic material}$$

$$= 22 \quad [\text{mm}] \text{ for lignum material}$$

Where in case of small ships bushes are not fitted, the rudder stock is to be suitably increased in diameter in way of bearings enabling the stock to be re-machined later.

.2 An adequate lubrication is to be provided.

.3 The projected bearing surface  $A_b$  (bearing height  $\times$  external diameter of liner) is not to be less than

$$A_b = \frac{B}{q} \quad [\text{mm}^2]$$

- B = support force [N]  
 q = permissible surface pressure acc. to [Table C3.10.2](#)

Table C3.10.2 Permissible surface pressure q

Bearing material	q [N/mm <sup>2</sup> ]
lignum vitae	2,5
white metal, oil lubricated	4,5
synthetic material <sup>1</sup>	5,5
steel <sup>2</sup> , bronze and hot-pressed bronze-graphite materials	7,0

<sup>1</sup> Synthetic materials to be of approved type.  
 Surface pressures exceeding 5,5 N/mm<sup>2</sup> may be accepted in accordance with bearing manufacturer's specification and tests, but in no case more than 10 N/mm<sup>2</sup>.

<sup>2</sup> Stainless and wear resistant steel in an approved combination with stock liner. Higher surface pressures than 7 N/mm<sup>2</sup> may be accepted if verified by tests.

.4 Stainless and wear resistant steels, bronze and hot-pressed bronze-graphite materials have a considerable difference in potential to non-alloyed steel. Respective preventive measures are required.

.5 The bearing height shall be equal to the bearing diameter, however, is not to exceed 1,2 times the bearing diameter. Where the bearing depth is less than the bearing diameter, higher specific surface pressures may be allowed.

#### C3.10.8.5 Guidance values for bearing clearances

.1 For metallic bearing material the bearing clearance shall generally not be less than:

$$\frac{d_b}{1000} + 1,0 \text{ [mm]}$$

$d_b$  = inner diameter of bush

.2 If non-metallic bearing material is applied, the bearing clearance is to be specially determined considering the material's swelling and thermal expansion properties.

.3 The clearance is not to be taken less than 1,5 mm on diameter. In case of self lubricating bushes going down below this value can be agreed to on the basis of the manufacturer's specification.

#### C3.10.9 Design Yield Moment of Rudder Stock

The design yield moment of the rudder stock is to be determined by the following formula:

$$Q_F = 0,02664 \frac{D_t^3}{k_r} \text{ [Nm]}$$

$D_t$  = stock diameter [mm] according to C3.10.6.1

Where the actual diameter  $D_{ta}$  is greater than the calculated diameter  $D_t$ , the diameter  $D_{ta}$  is to be used. However,  $D_{ta}$  need not be taken greater than  $1,145 \cdot D_t$ .

#### C3.10.10 Stopper, Locking Device

##### .1 Stopper

The motions of quadrants or tillers are to be limited on either side by stoppers. Except where the steering gear is provided with its own rudder stopping devices, the stoppers and their foundations connected to the ship's hull are to be of strong construction so that the yield point of the applied materials is not exceeded at the design yield moment of the rudder stock.

## .2 Locking device

Each steering gear is to be provided with a locking device in order to keep the rudder fixed at any position. This device as well as the foundation in the ship's hull are to be of strong construction so that the yield point of the applied materials is not exceeded at the design yield moment of the rudder stock as specified in [C3.10.9](#).

Where the ship's speed exceeds 12 kn, the design yield moment need only be calculated for a stock diameter based on a speed  $v_0 = 12$  kn.

# C3.11 Stabilizers

## C3.11.1 General

Two different situations are to be considered for the purpose of [Section 3](#), depending on the main function of the stabilization system.

- In general, the stabilization system (foils, trim tabs or interceptors) is only a motion reduction or a ride control system. The hydrodynamic effects of fin stabilizers on the rolling or pitching behaviour of the ship are not part of the classification procedure. The classification however includes the integration of the system into the hull structure.
- The second situation is that the stabilization system is associated with the safe operation of the craft as described in [16.1.1](#). In that case, the system has to comply to the present Rules.

## C3.11.2 Classification process

.1 The complete bearing system and the drive unit directly mounted at the fin stock are to be situated within an own watertight compartment of moderate size at the ship's side or bottom. For installation purposes, inspection and maintenance watertight closable openings (with safeguards that they can be opened only during docking) have to be provided in suitable number and size.

For retractable fins a recess of sufficient size to harbour the complete fin has to be provided in addition at the ship's shell.

.2 At the penetration of the fin stock and at the slot of retractable fins, the shell has to be strengthened in a sufficient way.

.3 The watertight boundaries of the fin recess, if applicable, and of the drive compartment have to be dimensioned according to bottom and side shell requirements. Special attention has to be given to the transmission of the fin support forces from the stock bearings into the ship's structure. The local reinforcements and the overall transmission of the forces by girders, web frames, etc. have to be defined by direct calculations considering fatigue strength and have to be included in the hull drawings submitted.

.4 If the fin body extends over the maximum breadth of the ship, the location of non-retractable fins should be marked on the shell.

.5 Possible interferences between hydraulic installation and the safety of the craft are of concern, only. 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.

.6 For the second situation the structure of the stabilization devices, hydraulic system used for activation of stabilization system and associated electrical devices has additionally comply to the present rule.

## Appendix C3A1 Special Requirements for Scantlings of Hydrofoil Hull Structure

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C3A1.7	Foils .....	App1-8

### 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, BKI 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<sub>a</sub> = longitudinal distance, in m, between mid bow foil and mid after foil, measured parallel to L,  
L<sub>ft</sub> = overall length, in m,  
B = moulded breadth, in m (see [C3.1](#)),  
B<sub>a</sub> = greatest foil breadth, in m,  
H = depth, in m (see [C3.1](#)),  
H<sub>a</sub> = 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<sub>a</sub> = greatest draught, in m, of the more deeply submerged foil, measured vertically with craft at rest  
T'<sub>a</sub> = greatest draught, in m, of the more deeply submerged foil, measured vertically with full load craft on sailing trim on foils,  
f<sub>m</sub> = coefficient depending on the material:  
= 1,00 for steel structures  
= 1,45 for aluminium alloy structures  
f'<sub>m</sub> = coefficient depending on the material:  
= 1,00 for steel structures  
= 2,15 for aluminium alloy structures  
k = material factor defined in [Section 3, C3.2](#)

### C3A1.4 Documents to be submitted

.1 In addition to the plans and information listed in [C3.1.4](#), the following calculations, specifications and plans are to be submitted **in electronic format** to BKI for approval, together with the following information:

- 1) outer shell expansion, including stiffeners in way of foils, rudder, stern tubes and propeller shaft brackets;
- 2) 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;
- 3) calculations and diagrams relevant to the longitudinal strength of the hull;
- 4) 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 BKI 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.

1) Floating hydrofoil

Hydrofoil floating in still water,

2) Emerging hydrofoil on foils

A) 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,

B) Hydrofoil in the conditions specified in A) 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> ]
<a href="#">C3A1.5.1.1.1</a> <a href="#">C3A1.5.1.1.2) A)</a>	45 / (k·f'm)	45 / (k·f'm)	40 / (k·f'm)
<a href="#">C3A1.5.1.1.2) B)</a>	85 / (k·f'm)	85 / (k·f'm)	70 / (k·f'm)

In general, maximum  $\sigma$  stresses occur at about  $0,5L_a$ , 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  $L \leq 35m$ , the Rule midship section moduli at bottom  $Z_b$  and at deck  $Z_d$ , in cm<sup>3</sup>, are given by the formula:

$$Z_b = Z_d = (6,3 \cdot L_a \cdot 60) \cdot 10^3$$

.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 takeoff 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  $0,2 \cdot H$  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  $\text{cm}^3$ :

$$4 \cdot f_m \cdot \sqrt{k}$$

.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, continuous 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, BKI 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 BKI 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 BKI, 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, BKI reserves the right to require thermal stress-relieving in the furnace after welding.

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## Appendix C3A2 Requirements for Scantlings of Air-cushion Vehicle Hull Structures

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C3A2.2	General .....	App3–1
C3A2.3	Documents to be submitted .....	App3–1
C3A2.4	Overall Loads .....	App3–2
C3A2.5	Local Loads .....	App3–7
C3A2.6	Load Factors .....	App3–9
C3A2.7	Allowable Stresses .....	App3–10

### C3A2.1 Foreword

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.

Unless otherwise specified, the symbols used here are those already defined in [C3.1](#).

### C3A2.2 General

#### C3A2.2.1 Definitions and symbols

$W_{\max}$  = maximum operational weight: the weight up to which operation in the intended mode is permitted [kg]

$W_{\min}$  = minimum operational weight: is the minimum overall weight at which the craft is permitted to operate under normal conditions [kg]

The  $W_{\min}$  is the sum of the weights of:

- basic weight: weight of the craft with its basic equipment, including a declared quantity of oil and unusable fuel, without any passengers and payload [kg]
- weight of a minimum crew to ensure a save manoeuvring and navigation of the craft [kg]

L = maximum length of the rigid structure [m]

LCG = longitudinal centre of gravity, measured from stern [m]

Section = longitudinal fragmentation of craft into parts of equal length

Station = centre of one section

### C3A2.3 Documents to be submitted

#### C3A2.3.1 Documents submitted for approval

In addition to the information stipulated in [C3.1.4](#), the following information and drawings are requested:

- general arrangement drawing showing the general structural layout, intended use of different spaces and tanks, and location of propelling, lifting and operating installations.
- structural members of the hull shown in side view, plan view and cross sections, which includes hull, deck, superstructures, bulkheads, frames, floors, bottom plating, side plating, etc.

- hull to deck joint drawing
- fuel tanks, holding tanks (material, dimensions, connections, pressure head, fastening details)
- bonding of structural components to the hull and to each other (for example laminate angles or welding (procedure, throat thickness))
- engine foundation
- structural design of the propelling mountings and integration of propelling foundation to the hull structure with designation of maximum occurring thrust/lifting loads in all relevant directions
- skirt and its structural integration and the occurring loads at its mounting parts
- seating, foundations, supporting brackets and air pipes of lifting plant
- landing, ground supporting and mooring arrangements, if any, including handling equipment
- hoisting and handling equipment, if any, used on board
- longitudinal weight distribution for following loading cases:
  - minimum operational weight
  - maximum operational weight
- a design performance curve showing the speed in kn vs. the significant wave height in m has to be provided for minimum operational weight and maximum operational weight.

This is not an exhaustive list; other drawings and information may be required.

### 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.
3. Justifications 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.

## C3A2.4 Overall Loads

The overall loads addressed in this Section are considered to subject global structural characteristics of the vessel, i.e. global sections.

### C3A2.4.1 Loads due to water impact while flying

#### .1 General

This Section addresses load scenarios in which air-cushion vehicles are subjected to wave impacts while operating in the flying mode.

Impact by waves is causing a global response of the vessel. The resulting inertia effects are acting on the hull's global structure and are causing a global longitudinal bending and global shear loading, varying over the craft's length.

The amount of this inertia load is depending on following parameters:

- Loading case
- Speed of air cushion vehicle
- Corresponding wave
- Location of wave impact

and has to be determined for the most severe combination which can arise within the design environmental conditions and the craft limitations for which certification is sought.

The results of these calculations are to be submitted to BKI.

## .2 Principle of procedure

The craft will be divided into equally spaced longitudinal sections. Weights, accelerations and the corresponding inertia loads will be calculated for each section station to result in a global force balance.

These individual forces of each section are resulting in a characteristic bending moment and shear force distribution.

For this procedure a detailed weight distribution has to be provided to determine:

- Masses per section
- Craft's centre of gravity, LCG
- Craft's gyration radius

## .3 Determination of weight distribution, LCG and radius of gyration

The following defines the mass moment of inertia characteristics:

The overall weight of each weight scenario has to be distributed over the longitudinal stations likewise the existing mass distribution.

$$W = \sum_{i=1}^m M_i$$

W = overall weight [kg]

m = total number of sections

M<sub>i</sub> = mass of section i [kg]

Determination of longitudinal centre of gravity:

$$\text{LCG} = \frac{\sum_{i=1}^m (M_i \cdot x_i)}{\sum_{i=1}^m M_i}$$

x<sub>i</sub> = x – location of station i [m]

Determination of mass moment of inertia J [kg · m<sup>2</sup>]:

$$\underline{J = \sum_{i=1}^m (M_i \cdot x_i'^2)}$$

$$x'_i = LCG - x_i [m]$$

Determination of radius of gyration k [m]:

$$k = \sqrt{\frac{J}{W}}$$

As described in [C3A2.4.1.1](#), the wave's impact leads to inertia loads, acting on the whole structure of the craft. The loads consist mainly of two components, which are the overall vertical acceleration and the angular acceleration. Both depend amongst others on the location of the impact. Does the wave impact the craft at its LCG, the crafts reaction will result in vertical acceleration only, whereas an impact off the LCG will result in an overall vertical acceleration and angular acceleration. Both types of acceleration will be determined separately and will be superimposed afterwards.

#### .4 Vertical acceleration

The overall vertical acceleration is depending on the maximum speed of the craft, the craft's overall weight, the vertical speed of impact and location of impact. It can be expressed by the formula:

$$n_w = \frac{K_x \cdot V_v \cdot V}{W^{1/3} \cdot (1 + r_G^2)^{2/3}}$$

$n_w$  = impact load of the craft at position  $x_i$  of spot of the impact [g]

$n_{w\min}$  = 0,5

$K_x$  = coefficient depending on position  $x_i$  of spot of the impact, determined according to [Fig. C3A2.1](#)

$V_v$  = relative vertical speed of impact [m/s]

$V$  = the maximum speed of air-cushion vehicle [m/s]. It correlates to a significant wave height  $H_w$ . The relation between  $V$  and  $H_w$  is to be provided by the designer as the design performance curve.

$r_G$  = ratio of distance measured parallel to the hull reference axis from spot of impact to LCG, to the radius of gyration:

$$r_G = \frac{x'_i}{k}$$

Determination of relative vertical speed of impact  $V_v$  [m]:

$$V_v = 0,6 + H_w \cdot \sqrt{\frac{\pi \cdot g}{2 \cdot A}}$$

$H_w$  = wave height [m]

$A$  = wave length [m]

Values of  $A$  and  $H_w$  are defined in [C3A2.4.2](#)

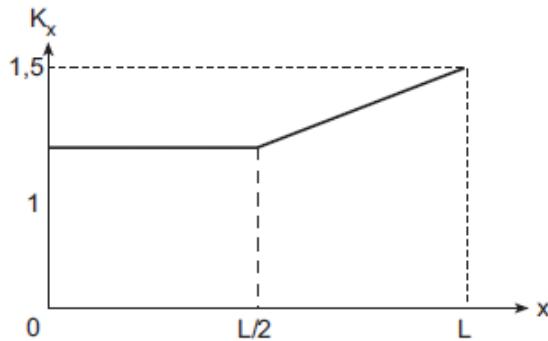


Fig. C3A2.1 Coefficient K<sub>x</sub>

## .5 Angular acceleration

The angular acceleration results from a wave impact at the rigid bottom of the air-cushion vehicle at a longitudinal location, which differs from the location of the craft's LCG. The impact induces a rotation about the LCG and yields to a linear distribution of tangential acceleration.

Equation of overall angular acceleration, n<sub>a</sub>:

$$n_a = \frac{T}{J} = \frac{n_{wi} \cdot W \cdot x_{i,impact}}{J}$$

n<sub>a</sub> = overall angular acceleration [rad/s<sup>2</sup>], applies for all stations

T = applied torque [N.m]

n<sub>wi</sub> = impact load at station of wave impact [g] (see [C3A2.4.1.4](#))

x<sub>i, impact</sub> = distance of station of wave impact to LCG [m]

## .6 Superimposing of accelerations

The superimposing of both, the vertical (see [C3A2.4.1.4](#)) and the tangential acceleration gives the occurring (vertical) acceleration for each station.

Equation of superimposed vertical acceleration at the rearmost station, n<sub>v,aft</sub>:

$$n_{v,aft} = n_{w,i} - n_a \cdot x_{aft}$$

n<sub>v,aft</sub> = vertical acceleration at rearmost station

x<sub>aft</sub> = distance of the rearmost station to LCG [m]

Equation of superimposed vertical acceleration at the foremost station, n<sub>v,fore</sub>:

$$n_{v,fore} = n_{w,i} + n_a \cdot x_{fore}$$

n<sub>v,fore</sub> = acceleration at foremost station [g]

x<sub>fore</sub> = distance of the foremost station to LCG [mm]

n<sub>w,i</sub> = acceleration at station i [g]

Linear interpolation between the rearmost and foremost acceleration gives the individual acceleration n<sub>vi</sub> of each station.

## .7 Forces acting on each section

As described in [C3A2.4.1](#), the bending moment and shear force distribution will be derived by the summation of vertical forces acting on each station.

This force is the product of the section mass and the stations acceleration (derived in [C3A2.4.1.5](#)). In addition to that, if applicable for the specific station, the direct load of the wave impact also has to be added to the respective section load.

The forces acting on each section are finally described in following equation:

$$F_i = M_i \cdot n_{v,i} \cdot g + F_{i,\text{wave}}$$

The amount of the total wave impact force is equal to the sum of all station forces. It is recommended to distribute the direct wave load onto two adjacent stations, and apply it depending on the location of impact at the bow, stern or LCG.

$$\underline{F_{i,\text{wave}} = \sum_{i=1}^m (M_i \cdot g \cdot n_{v,i})}$$

**Note:**

Hence the wave impact load  $F_{i,\text{wave}}$  is acting in the opposite direction to the section mass, it is negative.

- $M_i$  = mass of section i [kg]
- $n_{v,i}$  = acceleration for station i [rad/s<sup>2</sup>]
- $g$  = acceleration due to gravity [9,81 m/s<sup>2</sup>]

To analyse the most critical load case, it is required to investigate wave impacts at bow, stern and LCG.

**Note:**

Steady state 1g is not included and is assumed to be supported by cushion with negligible effect on global loads.

## C3A2.4.2 Air-cushion vehicle afloat

The wave considered for scantling calculations of flexible skirt craft afloat is a sinusoidal wave of height  $H_w$  and length A [m] and confirming the following equations:

- for  $A \leq 41,50$  m:

$$H_w = A/10$$

- for  $A > 41,50$  m:

$$H_w = 6,51 - 0,57 \cdot \left( \frac{300 - A^{3/2}}{100} \right)$$

The value  $H_w$  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.

## C3A2.5 Local Loads

### C3A2.5.1 Water impact loads

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 local and distributed pressures have to be determined for the maximum loads which can arise from the most severe combination of loading scenarios, speed of air cushion vehicle and corresponding relative vertical velocity.

#### .1 Local pressure

The local pressure due to water impact is considered to be the peak slamming load. It will be applied to evaluate scantlings of secondary stiffeners and shell elements on a frame space. It can be expressed by the formula:

$$P_{loc} = 1,2 \cdot K'_x \cdot V_v \cdot V \quad [\text{kN/m}^2]$$

$K'_x$  = coefficient depending on position  $x$  of spot of the impact and determined according to Fig. C3A2.2

$V_v$  &  $V$  = values defined in C3A2.4.1.4 above.

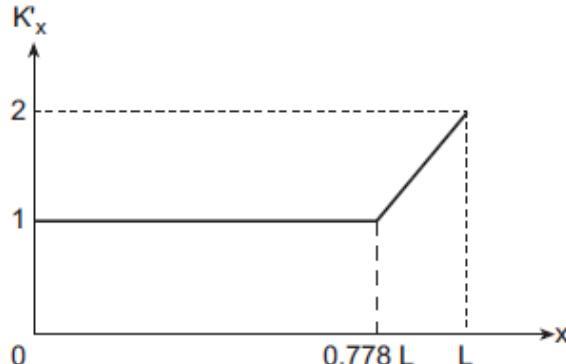


Fig. C3A2.2 Coefficient  $K'_x$

#### .2 Distributed bottom pressure

The average pressure is 44% of the local pressure. It will be applied to evaluate scantlings of main frames and is given by the formula:

$$P_{distr} = 0,53 \cdot K'_x \cdot V_v \cdot V \quad [\text{kN/m}^2]$$

#### .3 Increased pressures in bow section

Hence the bow area of the craft is exposed to slamming loads, pressures in this area will be determined regardless of the values provided by the design performance curve. A high velocity in combination with a high wave height yields to the increased local and distributed pressure:

$$P_{loc,bow} = 1,2 \cdot K'_x \cdot V_v \cdot V_{bow}$$

$$P_{distr,bow} = 0,53 \cdot K'_x \cdot V_v \cdot V_{bow}$$

The bow area is defined as:  $\frac{X}{L} \geq 0,8$

$$V_{bow} = V_{max} \cdot 0,8$$

$$H_{bow} = H_w \cdot (0,8 \cdot V_{max}) \cdot 3$$

**Note:**

$V_{max}$  and  $H_w$  to be taken from design performance curve  $V_V$ , see [C3A2.4.1.4](#)

### C3A2.5.2 Loads arising from propelling and steering installation

These loads are applied to the structure through the connections of foundations, seating, gantries, etc. supporting the propelling engine, the lifting installation, their auxiliaries as well as steering gear such as rudders and skegs.

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).

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

See also [C3A2.7.8](#).

### C3A2.5.3 Deck loads

#### .1 General

.1.1 The pressure [ $\text{kN/m}^2$ ] considered as acting on deck is given by the formula:

$$p_d = p (1 + n_{vi})$$

$p$  = uniform pressure due to the load carried [ $\text{kN/m}^2$ ]. Minimum values are given in [C3.5.8.2](#) to [C3.5.8.6](#)

$n_{vi}$  = design vertical acceleration, see [C3A2.4.1.5](#)

.1.2 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  $(1+n_{vi})$

#### .2 Decks loads in particular

For determination of:

- weather decks and exposed areas
- sheltered decks
- enclosed accommodation decks
- enclosed cargo decks

- platforms in machinery spaces
- decks carrying vehicles
- pressures on tank structures
- pressures on subdivision bulkheads

see: [C3.5.8.2](#) to [C3.5.8.10](#)

### .3 Sea pressures on deckhouses

For determination see [C3.5.7](#)

### C3A2.5.4 Landing load

- .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.

### C3A2.5.5 Hoisting Load

- .1 This case affects the scantlings of hoisting points and their connections to the structure (distribution of concentrated forces).
- .2 It also has to be checked that this case does not generate general bending or torsion 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.

### C3A2.5.6 Anchoring – Mooring – Towage

- .1 These situations determine the concentrated forces applied to points of ground or quay anchoring and mooring, together with towage.
- .2 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.

## C3A2.6 Load Factors

### C3A2.6.1 Acceleration under 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](#)).

### C3A2.6.2 Acceleration in event of collision

See [C4.3](#)

## C3A2.7 Allowable Stresses

All Loads defined in [C3A2.4](#) and [C3A2.5](#) are maximum design loads. These loads are maximum loads anticipated in the conditions for which the certification is sought.

Requirements for the scantlings of hull structures (plating, stiffeners, primary supporting members) and corresponding limiting values for materials are defined for

- steel and aluminium alloy structures in [C3.7](#)
- for reinforced fibre structures in [C3.8](#)

## Section 4 Accommodation and Escape Measures

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### C4.0 Documents to be submitted

The following plans and documents are to be submitted. To facilitate a smooth and efficient approval process they shall be submitted electronically to BKI Head Office.

- .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 BKI.

### 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 mal operation 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<sup>1</sup>

**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 A3.1](#) 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](#).

<sup>1</sup> 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(18)).

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

where:

$g_{coll}$  = the collision design acceleration expressed as a multiple of the acceleration due to gravity ( $9,806 \text{ m/s}^2$ )

**4.3.4** Collision design acceleration  $g_{coll}$  (for craft other than amphibious ACVs where  $g_{coll} = 6$ ) shall be calculated as follows:

$$g_{coll} = 1,2 \cdot \left( \frac{P}{g \times \Delta} \right), \text{ but not to be taken greater than 12}$$

where the load P shall be taken as the lesser of  $P_1$  and  $P_2$ , where:

$$P_1 = 460(M \cdot C_L)^{2/3} (E \cdot C_H)^{1/3}$$

$$P_2 = 9000 \cdot M \cdot C_L (C_H \cdot H)^{1/2}$$

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:

$$\underline{C_L = \frac{(165+L)}{245} \left( \frac{L}{80} \right)^{0,4}}$$

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:

$$E = 0,5 \cdot \Delta \cdot V_{imp}^2$$

where the main particulars of the craft are:

L = craft length as defined in [Section 1](#) [m]

H = 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 lightweight and maximum operational weight [t]  
 $V_{imp}$  = estimated impact speed [m/s] = 60 % of maximum 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 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 7](#).

**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 90 % of maximum speed and at reduced speed as necessary.

## 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 [Fig. 4.4.1](#)) such that:

$$A_{bow} = 0,0035 \cdot A \cdot m \cdot f \cdot V, \text{ but never less than } 0,04 \cdot A,$$

where:

- $A_{bow}$  = the plan projected area of craft energy absorbing structure forward of the transverse plane (m<sup>2</sup>)  
 $A$  = total plan projected area of craft (m<sup>2</sup>)  
 $m$  = material factor =  $\frac{0,95}{M}$   
 $M$  = 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  $A_{bow}$ .  
 $f$  = framing factor as follows:  
 – longitudinal deck and shell stiffening = 0,8  
 – mixed longitudinal and transverse = 0,9  
 – transverse deck and shell stiffening = 1,0

$V = 90\% \text{ of maximum speed [m/s].}$

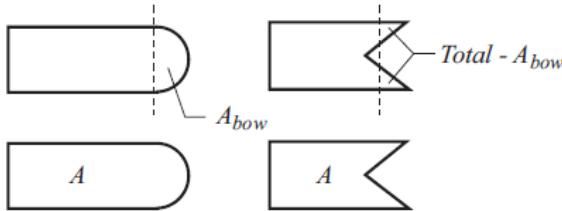


Fig. 4.4.1 Plan view of two different craft styles

**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.

Table 4.4.2 Overview general design guideline<sup>2</sup>

Design level 1: $g_{coll}$ 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: $g_{coll} = 3 \text{ to } 12$	
1	Seat/seat belts
1.1	Seatbacks 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 unless satisfactorily tested without belts in that orientation and arrangement
2	Tables with protective feature allowed. Dynamic testing
3	Padding of protective 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

**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.

<sup>2</sup> Other arrangements may be employed if an equivalent level of safety is achieved

**4.4.5** There shall be adequate handholds on both sides of any passage to enable passengers to steady themselves while moving about. The armrests and backrests of seats in public spaces may serve as hand holds.

## 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 8](#).

## 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 3, 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, lifejacket 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. Clear markings, including the location of the fire control plan, shall 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. Doors providing escape from a space shall, where possible, be situated at opposite ends of the space. Where the doors providing escape from a space are situated in the same end of the space, the distance between those doors shall be greater than the maximum length of the space.

**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. Requirements of this paragraph do not apply to aisles (fore-aft passageways separating seating areas) or to spaces between adjacent rows of seats. However, the width of aisles and the seat pitch shall be such as to allow the craft to comply with the provisions of 4.8.

**4.7.14** Special category spaces used for stowage of motor vehicles shall be provided with walkways having a width of at least 600 mm leading to a safe means of escape

**4.7.15** Adequate notices shall be provided to direct passengers to exits.

**4.7.16** 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.

**4.7.17** 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. At least one means of escape from a machinery space shall consist of either a ladder leading to a door or hatch (not being a horizontal flush-hatch) or a door located in the lower part of that space and giving access to an adjacent compartment from which a safe means of escape is provided.

**4.7.18** Spaces that are only entered occasionally by crew members may have only one means of escape provided that it is independent of watertight doors.

## 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 (SFT) provided in [7.4.1](#) for areas of major fire hazard areas after subtracting a period of 7 min for initial detection and extinguishing action.

$$\text{Evacuation time} = \frac{(SFT - 7)}{3} \text{ (min)}$$

where:

SFT = structural fire protection time (min)

In determining the evacuation time, all means of escape are to be considered serviceable and they need not be dimensioned to take into account any additional number of persons that might be diverted from other means of escape if one or more of those other means of escape are lost or rendered unserviceable.

**4.8.2** An evacuation procedure, including an evacuation analysis carried out taking into account the guidelines developed by the Organization<sup>3</sup> 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](#). 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;

<sup>3</sup> Refer to the Guidelines for a simplified evacuation analysis of high-speed passenger craft (MSC/Circ.1166).

- .6 the order to evacuate;
- .7 the deployment of survival craft and marine escape systems and rescue boats;
- .8 the bowsing 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.

**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** Where the Administration is satisfied that the evacuation time determined in accordance with [4.8.1](#) to [4.8.9](#) can thereby be accurately estimated, the Administration may accept an evacuation demonstration in which persons are not required to descend through MES or equivalent means of evacuation, provided the time required to embark into the survival craft can be determined using:

.1 data obtained from the type-approval tests of the equipment, increased by a factor based on the guidelines developed by the Organization<sup>4</sup> or

.2 time extrapolated from trials using a limited number of participants.

**4.8.11** 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.

**4.8.12** 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).

<sup>4</sup> Refer to the Guidelines for a simplified evacuation analysis of high-speed passenger craft (MSC/Circ.1166), in particular paragraph 3.5.1 thereof.

**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 radio communications.

## 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.

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## Section 5 Direction Control Systems

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### C5.0 Documents to be submitted

**C5.0.1** The following drawings and documents are to be submitted. To facilitate a smooth and efficient approval process they shall be submitted in electronically.

- .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 BKI.

### 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 7](#).

**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 BKI, 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 BKI, 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 [Rules for Materials \(Pt.1, Vol.V\)](#).

## **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 1](#).

**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](#).

**C5.2.7** 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 BKI, 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 BKI, 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 7](#).

**5.3.2** Demonstration in accordance with [Annex 7](#) 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 BKI. During the test, no over-heating, 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.

**C5.3.5** Sea trials have to be carried out in conformity with [Rules for Machinery Installations \(Pt.1, Vol.III\) Sec.14](#). (See also the [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#)). Notwithstanding from the before mentioned Rules and Guidelines, the average turning rates have to be in compliance with [C5.2.8](#) and [C5.2.9](#).

## 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

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### 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 bitts, 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.

**6.1.4** Under any operating load up to the breaking strength of the anchor cable or mooring lines, the loads on the bitts, bollards, etc., shall not result in damage to the hull structure that will impair its watertight integrity. A strength margin of at least 20 % above the resultant load based on the minimum specified breaking strength of the relevant cable or warp shall be required.

**C6.1.5** The SWL for the intended use for each shipboard fitting is to be noted in the towing and mooring arrangements plan available on board for the guidance of the Master.

### 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.

**C6.2.1** The equipment of anchors, chain cables, wires and ropes is to be determined from [Table C6.5.1](#) in accordance with the equipment numeral Z.

Ships built under survey of BKI and which are to have the mark ① stated in their Certificate and in the Register Book shall be equipped with anchors and chain cables complying with the [Rules for Materials \(Pt.1, Vol.V\)](#) and having been tested on approved machines in the presence of a Surveyor.

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.

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.

**Note:**

*The anchoring equipment required by this Section is intended of temporary mooring of a vessel within a harbour or sheltered area when the vessel is awaiting berth, tide, etc.*

*The equipment is, therefore, not designed to hold a ship 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.*

*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.*

*The anchoring equipment required by this Section 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.*

*The equipment numeral formula for anchoring equipment required under this Section is based on an assumed current speed of 2,5 m/sec, wind speed of 25 m/sec and a scope of chain cable between 6 and 10, the scope being the ratio between length of chain paid out and water depth.*

*It is assumed that under normal circumstances a ship will use only one bow anchor and chain cable at a time.*

**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 equipment 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, bitts 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 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 Z number.

The anchoring equipment to be fitted on the concerned craft is to be specified.

### C6.5.2 Equipment number

#### .1 Monohull craft

The equipment number is to be calculated as follows:

$$Z = \Delta^{2/3} + 2 \cdot \left[ a \cdot B + \sum_i (b_i \cdot h_i \cdot \sin \Theta_i) \right] + 0,1 \cdot A$$

Where:

- $\Delta$  = maximum displacement [t]
- $a$  = distance [m] from summer load waterline amidships to the upper deck at side
- $h_i$  = height [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 [m] as defined in C3.1.4 of Section 3
- $\Theta_i$  = angle of inclination aft of each front bulkhead, as shown on Fig. C6.5.1
- $A$  = area [ $m^2$ ] in profile view of the hull, superstructures and houses, having a breadth greater than  $B/4$ , above the summer load waterline within the length  $L$  of the craft defined in C3.1.4.

In the measurement of  $h_i$ , sheer and trim are to be ignored.

If a deckhouse having a breadth greater than  $B/4$  is located above of a deck house equal to or less than  $B/4$  in breadth, the wider house is to be considered and the narrow house may be ignored.

Only the parts of windscreens or bulwarks more than 1,5 m in height above the deck are to be included when determining  $h_i$  and  $A$ .

#### .2 Multihull craft

The equipment number is to be calculated as follows:

$$Z = K_m \cdot \Delta^{2/3} + 2 \cdot \left[ a \cdot B + \sum_i (b_i \cdot h_i \cdot \sin \Theta_i) - S_t \right] + 0,1 \cdot A$$

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 ( $N = 2 \cdot n + 1$ ):

$$K_m = \frac{(B_0 \cdot T_0)^{2/3} + 2 \cdot \sum_{i=1}^n (B_i \cdot T_i)^{2/3}}{\left( B_0 \cdot T_0 + 2 \cdot \sum_{i=1}^n (B_i \cdot T_i) \right)} \quad (N \text{ odd})$$

- 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

$B_0, T_0$  = breadth and draught [m] of the mid full hull (if any), measured amidship (see [Fig. C6.5.2](#))

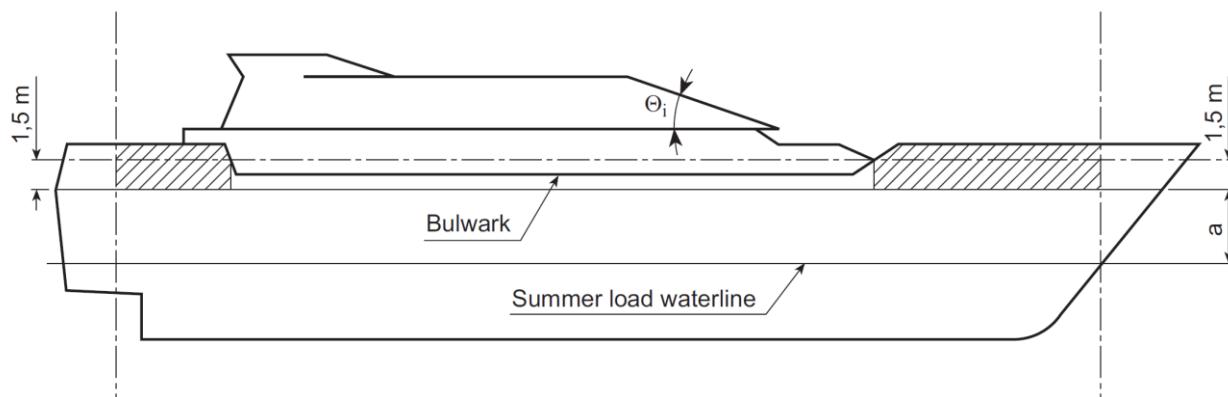
$B_i, T_i$  = breadth and draught [m] of the lateral hulls, measured amidship (see [Fig. C6.5.2](#))

$N$  = 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 [t]

Other symbols are defined in [C6.5.2.1](#).



**Fig. C6.5.1**

### C6.5.3 Anchors

.1 For craft with an equipment number greater than 600, two anchors and two relevant chain cables are required. 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 [Table C6.5.1](#).

The bow anchors are to be connected to their chain cables and positioned on board ready for use. It is to be ensured that each anchor can be stowed in the hawse and hawse pipe in such a way that it remains firmly secured in seagoing conditions. Details have to be coordinated with the owner.

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.

.2 Anchors shall be of an approved design. Normally "high holding power anchors" (HHP) or "very high holding power anchors" (VHHP) are to be used. Possible use of ordinary anchors will be specially considered by BKI.

.3 For HHP anchors, the mass of the anchor shall comply with the values in [Table C6.5.1](#). The actual mass of each anchor may vary within (+7, -3) percent of the required individual mass provided that the total mass of all bower anchors is not less than the sum of the required individual masses.

.4 The mass of a VHHP anchor is to be not less than 2/3 of the required mass as per [Table C6.5.1](#).

.5 A HHP or VHHP anchor is to be suitable for use on board without any prior adjustment or special placement on the sea bed.

For approval as a HHP or VHHP anchor satisfactory tests are to be made on various types of bottom and the anchor is to have a holding power at least, twice or four times, respectively, that of an ordinary stockless anchor ("Admiralty Standard Stockless") of the same mass. The mass of anchors to be tested should be representative of the full range of sizes intended to be manufactured. The tests are to be carried out on at least two sizes of anchors in association with the chain cables appropriate to the weight. The anchors to be tested and the standard stockless anchors should be of approx. the same mass.

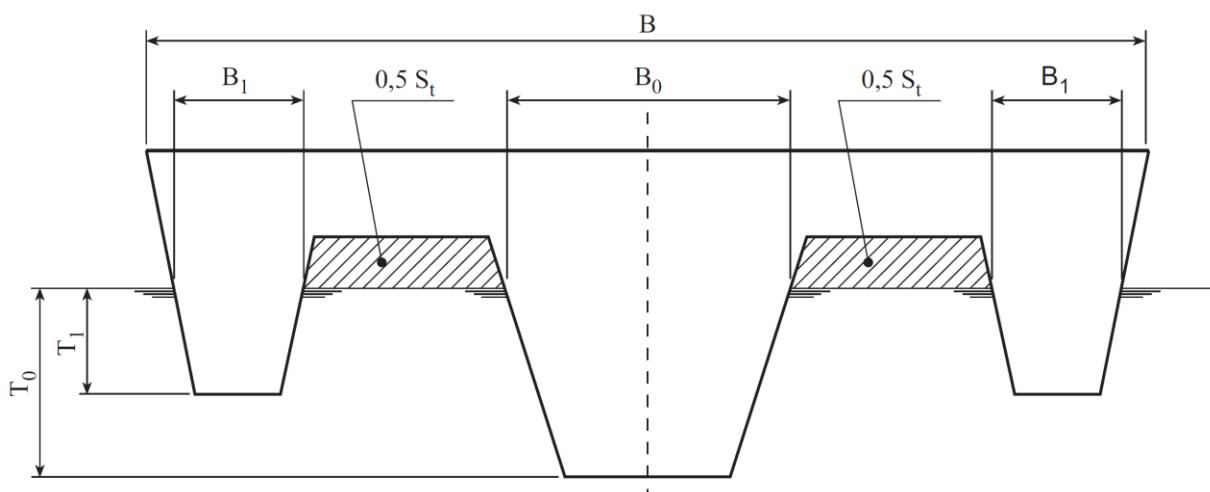
The chain length used in the tests should be approx. 6 to 10 times the depth of water.

The tests are normally to be carried out from a tug, however, alternative shore based tests (e.g. with suitable winches) may be accepted.

Three tests are to be carried out for each anchor and type of bottom. The pull shall be measured by means of a dynamometer or recorded by a recording instrument. Measurements of pull based on rpm/bollard pull curve of the tug may be accepted.

Testing by comparison with a previously approved HHP anchor may be accepted as a basis for approval. The maximum mass of an anchor thus approved may be 10 times the mass of the largest size of anchor tested.

The dimensioning of the chain cable and of the windlass is to be based on the undiminished anchor mass according to the Tables.



In the example: N=3 and n=1. In cases where N is even:  $B_0 = T_0 = 0$

**Fig. C6.5.2**

#### C6.5.4 Chain cables

.1 The diameters for stud link chain cables given in the Tables apply to chain cables made of chain cable materials specified in the [Rules for Materials \(Pt.1, Vol.V\)](#), for the following grades:

- Grade K2 (special quality)
- Grade K3 (extra special quality)

Normally grade K2 or K3 stud link chain cables are to be used with HHP anchors. In case of VHHP anchors, grade K3 chain cables are to be used.

Proposal for use of grade K1 chain cables connected to ordinary anchors will be specially considered by BKI.

.2 The total length of chain given in [Table C6.5.1](#) is to be divided in approximately equal parts between the required numbers of bower anchors

.3 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 K2 chain cables:

$$BL = 13,73 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

- for grade K3 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 K2 and grade K3 chain cables.

.4 For craft with an equipment number  $Z \leq 205$ , studless short link chain cables may be used, provided that:

- a) steel grade of the studless chain cable meets the requirement of [C6.5.4.1](#)
- b) equivalence in strength is to be based on proof load (not on breaking load)
- c) the studless chain cable meets the requirements of BKI.

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 K2 and grade K3 stud chain cables taken from [Table C6.5.1](#):

- grade K2:

$$PL_2 = 9,807 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

$$BL_2 = 2 \cdot PL_2$$

- grade K3:

$$PL_3 = 13,73 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

$$BL_3 = 2 \cdot PL_3$$

.5 For connection of the anchor with the chain cable approved Kenter-type anchor shackles may be chosen in lieu of the common Dee-shackles. A forerunner with swivel is to be fitted between anchor and chain cable. In lieu of a forerunner with swivel an approved swivel shackle may be used. However, swivel shackles are not to be connected to the anchor shank unless specially approved. A sufficient number of

suitable spare shackles are to be kept on board to facilitate fitting of the spare anchor at any time. On owner's request the swivel shackle may be dispensed with.

.6 The attachment of the inboard ends of the chain cables to the ship's structure is to be provided with means suitable to permit, in case of emergency, an easy slipping of the chain cables to sea operable from an accessible position outside the chain locker.

The inboard ends of the chain cables are to be secured to the structures by a fastening able to withstand a force neither less than 15 % nor more than 30 % of the rated breaking load of the chain cable.

#### 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](#) 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  $Z \leq 130$ :

$$L_{swr} = L_{ch}$$

- when  $130 < Z \leq 500$ :

$$L_{swr} = L_{ch} \cdot (Z + 850) / 900$$

- when  $Z > 500$ :

$$L_{swr} = 1,5 \cdot L_{ch}$$

where  $L_{ch}$  is the required length of stud link chain cable as per [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 Between anchor and steel wire rope a shot of 12,5 m in length or of the distance between stowed anchor and windlass shall be provided. The smaller length of this chain part is to be taken.

#### 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  $Z \leq 130$ , 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  $Z \leq 60$ :

$$L_{sfr} = L_{ch}$$

- when  $60 < Z \leq 130$

$$L_{sfr} = L_{ch} \cdot (Z + 80) / 140$$

where  $L_{ch}$  is the required length of stud link chain cable as per [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:

$$P_s = 2,2 \cdot BL^{8/9}$$

where  $BL$ , in kN, is the required breaking load of stud link chain cable as per [Table C6.5.1](#).

.5 Between anchor and synthetic fibre rope a short length of chain cable shall be provided.

#### C6.5.7 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 K2 chain cables:

$$P_c = 42,5 \cdot d^2$$

- for grade K3 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 windlass, its frame and the brake are to be efficiently anchored to the deck. Corresponding drawings including joining details are to be submitted for approval.

#### C6.5.8 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.

#### C6.5.9 Chain locker

.1 The chain locker is to be of capacity and depth 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 minimum required stowage capacity ( $S$ ) without mud box for each bow anchor chain is as follows:

$$S = 1,1 \cdot d^2 \cdot \ell / 200000 \text{ [m}^3\text{]}$$

$d$  = chain diameter [mm] according to [Table C6.5.1](#)

$\ell$  = total length of stud link chain cable according to [Table C6.5.1](#)

The shape of the base areas shall as far as possible be quadratic with a maximum edge length of 33  $d$ . As an alternative, circular base areas may be selected, the diameter of which shall not exceed 30 – 35  $d$ .

Above the stowage of each chain locker a free depth of at least

$$h = 750 \text{ [mm]} \quad \text{for } L = 25 \text{ m}$$

$$h = 1500 \text{ [mm]} \quad \text{for } L \geq 50 \text{ m}$$

is to be additionally provided. For intermediate lengths  $L$  linear interpolation is to be applied for the depth  $h$ .

.4 The chain locker boundaries and their access openings are to be watertight to prevent flooding of adjacent spaces, where essential installations or equipment are arranged, in order to not affect the proper operation of the ship after accidental flooding of the chain locker.

#### C6.5.10 Special requirements to minimize the ingress of water

.1 Spurling pipes and cable lockers are to be watertight up to the weather deck.

.2 Where means of access is provided, it is to be closed by a substantial cover and secured by closely spaced bolts.

.3 Spurling pipes through which anchor cables are led are to be provided with permanently attached closing appliances to minimize water ingress.

.4 Adequate drainage facilities of the chain locker are to be provided.

.5 Where the chain locker boundaries are also tank boundaries their scantlings of stiffeners and plating are to be determined as for tanks in accordance with [C3.7.12](#).

Where this is not the case the plate thickness and the section modulus are to be determined according to [C3.7.12](#). The distance from the load centre to the top of the chain locker pipe is to be taken for calculating the load.

#### C6.5.11 Allowable stresses

The allowable stresses for the windlass, chain stopper and the corresponding substructures etc. are not to exceed

- Normal : 85 %
- Shear : 55 %
- Von Mises : 95 %

of the specific minimum yield point  $R_{eH}$  or  $R_{p0,2}$  of the used material, respectively.

#### C6.5.12 Anchoring sea trials

.1 The anchoring sea trials are to be carried out on board in the presence of a BKI surveyor.

.2 The test is to demonstrate that the windlass complies with the requirements given in [C6.5.9.5](#). (See also [Rules for Machinery Installations \(Pt.1, Vol.III\) Sec. 14](#) and [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#)).

.3 The brake is to be tested during lowering operations.

### C6.6 Shipboard fittings for towing

#### C6.6.1 Arrangement and strength

Shipboard fittings for towing are to be located on longitudinals, beams and/or girders, which are part of the deck construction so as to facilitate efficient distribution of the towing load. Other arrangements may be accepted provided the strength is confirmed adequate for the intended service.

The strength of shipboard fittings used for ordinary towing operations (not emergency towing) at bow, sides and stern and their supporting hull structures are to be determined on the basis of [1.1.1](#) and [1.1.2](#).

#### .1 Load considerations

Unless greater safe working load (SWL) of shipboard fittings is specified by the applicant, the minimum design load to be used is the following value of [1](#)) or [2](#)), whichever is applicable:

- 1) for normal towing operations (e.g. harbour/ manoeuvring), 1,25 times the intended maximum towing load (e.g. static bollard pull) as indicated on the towing and mooring arrangements plan.
- 2) for other towing service (e.g. escort), the nominal breaking strength of the tow line according to [Table C6.4.1](#).

**Note:**

*Side projected area including maximum stacks of deck cargoes is to be taken into account for selection of towing lines.*

- 3) The design load is to be applied through the tow line according to the arrangement shown on the towing and mooring arrangements plan, see [Fig. C6.4.1](#).
- 4) When a specific SWL is applied for a shipboard fitting at the request of the applicant, by which the design load will be greater than the above minimum values, the strength of the fitting is to be designed using this specific design load.

## .2 Allowable stresses

Normal stress: 100% of the specified minimum yield point of the material

Shearing stress: 60% of the specified minimum yield point of the material

### C6.6.2 Safe working load (SWL)

- 1) The SWL used for normal towing operations (e.g. harbour / manoeuvring) is not to exceed 80% of the design load per [1.1.1.1](#)) and the SWL used for other towing operations (e.g. escort) is not to exceed the design load per [1.1.1.2](#)). For fittings used for both normal and other towing operations, the greater of the design loads of [1.1.1.1](#)) and [1.1.1.2](#)) is to be used.
- 2) The SWL of each shipboard fitting is to be marked (by weld bead or equivalent) on the deck fittings used for towing.
- 3) The above requirements on SWL apply for a single post basis (no more than one turn of one cable).
- 4) The towing and mooring arrangements plan mentioned in [Rules for Hull \(Pt.1, Vol.II\) Sec.18,H.](#) is to define the method of use of towing lines.

## C6.7 Mooring Equipment

### C6.7.1 Ropes

.1 The following requirements and the [Tables C6.7.1](#) and [C6.5.1](#) for tow lines and mooring ropes are recommendations only, a compliance with which is not a condition of Class.

.2 For tow lines and mooring lines, steel wire ropes as well as fibre ropes made of natural or synthetic fibres or wire ropes consisting of steel wire and fibre cores may be used. The breaking loads <sup>1</sup> specified in [Table C6.7.1](#) are valid for wire ropes and ropes of natural fibre (manila) only. Where ropes of synthetic fibre are used, the breaking load is to be increased above the table values. The extent of increase depends on the material quality.

The required diameters of synthetic fibre ropes used in lieu of steel wire ropes may be taken from [Table C6.7.1](#).

<sup>1</sup> The term "breaking load" used throughout this section means the "nominal breaking load".

Table C6.7.1. Wire/fiber ropes diameter

Steel wire ropes <sup>1</sup>	Synthetic wire ropes polyamide <sup>2</sup>	Fibre ropes		
		polyamide	polyester	polypropylene
diam. [mm]	diam. [mm]	diam. [mm]	diam. [mm]	diam. [mm]
12	30	30	30	30
13	30	32	32	32
14	32	36	36	36
16	32	40	40	40
18	36	44	44	44
20	40	48	48	48
22	44	48	48	52
24	48	52	52	56
26	56	60	60	64
28	60	64	64	72
32	68	72	72	80
36	72	80	80	88
40	72	88	88	96

1 according to DIN 3068 or similar.

2 Regular laid ropes of refined polyamide monofilaments and filament fibres.

.3 Wire ropes shall be of the following type:

- 6 × 24 wires with 7 fibre cores for breaking loads of up to 500 kN  
type: Standard
- 6 × 36 wires with 1 fibre core for breaking loads of more than 500 kN  
type: Standard

Where wire ropes are stored on mooring winch drums, steel cored wire ropes may be used e.g.:

- 6 × 19 wires with 1 steel core  
type: Seale
- 6 × 36 wires with 1 steel core  
type: Warrington-Seale

.4 Regardless of the breaking load, recommended in C6.5.1, the diameter of fibre ropes should not be less than 20 mm.

.5 The length of the individual mooring ropes may be up to 7 percent less than that given in the table provided that the total length of all the wires and ropes is not less than the sum of the required individual lengths.

Where mooring winches on large ships are located on one side of the ship, the lengths of mooring ropes should be increased accordingly.

### C6.7.2 Shipboard fittings (mooring bollards and bitts, fairleads, stand rollers, chocks)

The selection of shipboard fittings is to be made by the shipyard in accordance with an industry standard (e.g. ISO 3913 Shipbuilding Welded Steel Bollards) accepted by BKI. When the shipboard fitting is not selected from an accepted industry standard, the design load used to assess its strength and its attachment to the ship is to be in accordance with C6.7.3.

## .1 Arrangement

Shipboard fittings for mooring are to be located on longitudinals, beams and/or girders, which are part of the deck construction so as to facilitate efficient distribution of the mooring load. Other arrangements may be accepted provided the strength is confirmed adequate for the service.

## .2 Safe working load (SWL)

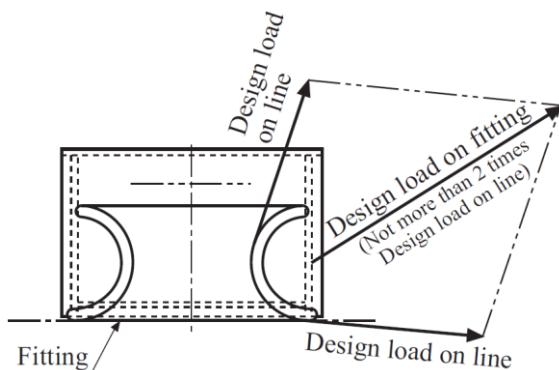
- 1) The SWL is not to exceed 80% of the design load per [C6.7.3.1](#).
- 2) The SWL of each shipboard fitting is to be marked (by weld bead or equivalent) on the deck fittings used for mooring.
- 3) The above requirements on SWL apply for a single post basis (no more than one turn of one cable).
- 4) The towing and mooring arrangements plan mentioned in [C6.1.5](#) is to define the method of use of mooring lines

## C6.7.3 Supporting hull structure for mooring equipment

Arrangement of the reinforced members (carling) beneath shipboard fittings is to consider any variation of direction (horizontally and vertically) of the mooring forces (which is to be not less than the design load as per [.1](#)) acting through the arrangement of connection to the shipboard fittings.

### .1 Load considerations

- 1) Unless greater safe working load (SWL) of shipboard fittings is specified by the applicant, the design load applied to shipboard fittings and supporting hull structures is to be 1,25 times the breaking strength of the mooring line according to [Table C6.7.1](#).
- 2) The design load applied to supporting hull structures for winches, etc. is to be 1,25 times the intended maximum brake holding load and, for capstans, 1,25 times the maximum hauling-in force.
- 3) The design load is to be applied through the mooring line according to the arrangement shown on the towing and mooring arrangements plan, see [Fig. C6.7.1](#).



**Fig. C6.7.1. Application of design loads**

- 4) When a specific SWL is applied for a shipboard fitting at the request of the applicant, by which the design load will be greater than the above minimum values, the strength of the fitting is to be designed using this specific design load.
- 5) The acting point of the mooring force on shipboard fittings is to be taken at the attachment point of a mooring line or at a change in its direction.

## .2 Allowable stresses

Normal stress: 100 % of the specified minimum yield point of the material

Shearing stress: 60 % of the specified minimum yield point of the material

Table C6.5.1 Equipment

No. for Reg.	Equipment Number Z		HHP bow anchor		Stud link chain cable for bow anchor		Recommended ropes					
	A < Z ≤ B		Mass of each anchor	Num- ber of anchors	Total length [m]	Diameter <sup>1</sup>		Towline		Mooring ropes		
	A	B				grade K2 steel [mm]	grade K3 steel [mm]	Length <sup>2</sup> [m]	Break. Load [kN]	Num- ber	Length <sup>3</sup> [m]	Break. Load [kN]
51	19	22	16	1	65	(6)	(5,5)	180	100	3	80	35
52	22	25	20	1	70	(6,5)	(6)	180	100	3	80	35
53	25	30	24	1	70	(7)	(6,5)	180	100	3	80	35
54	30	35	28	1	75	(7,5)	(7)	180	100	3	80	35
55	35	40	32	1	75	(8)	(7,5)	180	100	3	80	35
56	40	45	40	1	80	(8,5)	(7,5)	180	100	3	80	35
57	45	50	48	1	82,5	(9)	(8)	180	100	3	80	35
58	50	60	60	1	82,5	(10)	(8,5)	180	100	3	80	35
59	60	70	67	1	82,5	11	(9,5)	180	100	3	80	35
60	70	80	75	1	110	11	(10)	180	100	3	100	40
61	80	90	90	1	110	12,5	11	180	100	3	100	40
62	90	100	105	1	110	12,5	11	180	100	3	110	40
63	100	110	120	1	110	14	12,5	180	100	3	110	40
64	110	120	135	1	110	14	12,5	180	100	3	110	45
65	120	130	150	1	110	14	12,5	180	100	3	110	45
66	130	140	180	1	110	16	14	190	100	3	120	50
67	140	150	195	1	137,5	16	14	180	100	3	120	50
68	150	175	225	1	137,5	17,5	16	180	100	3	120	55
69	175	205	270	1	137,5	17,5	16	180	110	3	120	60
70	205	240	315	1	137,5	19	17,5	180	130	4	120	65
71	240	280	360	1	137,5	20,5	19	180	150	4	120	70
72	280	320	430	1	165	22	20,5	180	175	4	140	80
73	320	360	495	1	165	24	22	180	200	4	140	85
74	360	400	525	1	165	26	22	180	225	4	140	95
75	400	450	585	1	165	26	24	180	250	4	140	100
76	450	500	675	1	192,5	28	26	190	275	4	140	110
77	500	550	765	1	192,5	30	26	190	305	4	160	120
78	550	600	855	1	192,5	32	28	190	340	4	160	130
79	600	660	900	2	385	32	30	190	370	4	160	145
80	660	720	970	2	385	34	30	190	405	4	160	160
81	720	780	1080	2	440	36	32	190	440	4	170	170
82	780	840	1125	2	440	36	32	190	480	4	170	185
83	840	910	1195	2	440	38	34	190	520	4	170	200
84	910	980	1305	2	440	40	36	200	560	4	170	215
85	980	1060	1440	2	440	42	36	200	600	4	180	230
86	1060	1140	1575	2	440	42	38	200	645	4	180	250
87	1140	1220	1710	2	467,5	44	38	200	690	4	180	270
88	1220	1300	1845	2	467,5	46	40	200	740	4	180	285

<sup>1</sup> Values of chain cable diameters shown in brackets are given only to allow determination of the corresponding studless chain cable.

<sup>2</sup> Length of towline needs not to be taken greater than 5 L

<sup>3</sup> Length of mooring ropes needs not to be taken greater than 2 L

## Section 7 Fire and Safety

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### Part A General

#### C7.0 Documents to be submitted

**C7.0.1** The following drawings and documents are to be submitted. To facilitate a smooth and efficient approval process they shall be submitted electronically.

- .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 BKI.

## 7.1 General Requirement

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.

.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 authorized 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.

**C.7.2.1** 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 [1.4.5](#)
- 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 [1.4.6](#)
- 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. 16](#)

.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 an 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 relation to the classification of spaces in [7.3.1](#), the following additional criteria shall be applied:

.1 if a space is divided by partial bulkheads into two (or more) smaller areas such that they form enclosed spaces, then the enclosed spaces shall be surrounded by bulkheads and decks in accordance with [Tables 7.4-1](#) and [7.4-2](#), as applicable. However, if the separating bulkheads of such spaces are at least 30% open, then the spaces may be considered as the same space.

.2 Cabinets having a deck area of less than 2 m<sup>2</sup> may be accepted as part of the space they serve, provided they have open ventilation to the space and do not contain any material or equipment that could be a fire risk.

.3 Where a space has the special characteristics of two or more space groupings, the structural fire protection time of the divisions shall be the highest for the space groupings concerned. For example, the structural fire protection time of the divisions of emergency generator rooms shall be of the highest value for the space when the space is considered as being a control station (D) and a machinery space (A).

**7.3.3** 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.

**7.3.4** To prevent heat transmission at intersections and terminal points, the insulation of the deck or bulkhead shall be carried past the intersection or terminal point for a distance of at least 450 mm in the case of steel or aluminium structures (refer to [Fig. 7.3.4a](#) and [7.3.4b](#)).

**7.3.5** If a space is divided by a deck or bulkhead and the fire insulation required for each space is different, the insulation with the higher structural fire protection time shall continue on the deck or bulkhead with the insulation of the lesser structural fire protection time for a distance of at least 450 mm beyond the boundary between the spaces.

**7.3.6** Where the lower part of the fire insulation has to be cut for drainage, the construction shall be in accordance with the structural details shown in [Fig. 7.3.6](#).

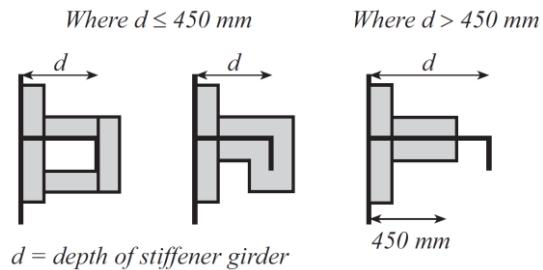


Fig. 7.3.4a

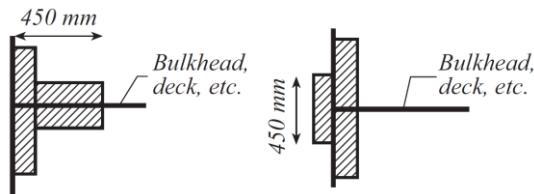


Fig. 7.3.4b

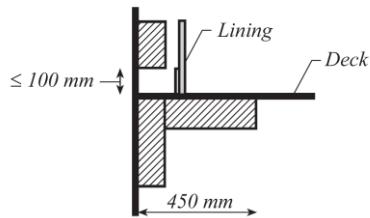


Fig. 7.3.6

## 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.

**7.4.1.4** Paragraph 7.4.1.3 does not apply to appendages such as air propellers, air ducts to propellers, transmission shafts, rudders and other control surfaces, struts, spars, flexible skirts, etc., which do not comprise part of the main structure of the craft.

**Table 7.4-1 Structural fire protection times for separating bulkheads and decks of passenger craft**

	A	B	C	D	E	F
A Area of major fire hazard	60 (1,2) 60 (1,2)	30 60 (1)	(3) 60 (1,8)	(3,4) 60 (1)	(3) 60 (1)	- 60 (1,7,9)
B Area of moderate fire hazard		30(2) 30(2)	(3) 30(8)	(3,4) 60	(3) 30	- (3)
C Area of minor fire hazard			(3) (3)	(3,4) 30(8,10)	(3) (3)	- (3)
D Control stations				(3,4) (3,4)	(3) (3,4)	- (3)
E Evacuation stations and escape routes					(3) (3)	- (3)
F Open space						-

**Table 7.4-2 Structural fire protection times for separating bulkheads and decks of cargo craft**

	A	B	C	D	E	F
A Area of major fire hazard	60 (1,2) 60 (1,2)	30 60 (1)	(3) 60 (1,8)	(3,4) 60 (1)	(3) 60 (1)	- 60 (1,7,9)
B Area of moderate fire hazard		(2,6) (2,6)	(3) (6)	(3,4) 60	(3) (6)	- (3)
C Area of minor fire hazard			(3) (3)	(3,4) 30(8)	(3) (3)	- (3)
D Control stations				(3,4) (3,4)	(3) (3,4)	- (3)
E Evacuation stations and escape routes					(3) (3)	- (3)
F Open space						-

**Notes:**

*The figures on either side of the diagonal line represent the required structural fire protection time for the protection system on the relevant side of the division. When steel construction is used 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 decks within spaces protected by fixed fire-extinguishing systems need not be insulated.*
- .2 *Where adjacent spaces are in the same alphabetical category and a note 2 appears, a bulkhead or deck between such spaces need not be fitted if deemed unnecessary by the Administration. For example, a bulkhead need not be required between two 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 tables.*
- .6 *The fire protection time is 0 min and the time for prevention of passage of smoke and flame is 30 min as determined by the first 30 min of the standard fire test.*
- .7 *Fire resisting divisions need not comply with 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 the crew need not have access to them during any emergency.*
- .10 *On category A craft, this value may be reduced to 0 min where the craft is provided with only a single public space (excluding lavatories) protected by a sprinkler system and adjacent to the operating compartment.*

#### **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 least 300 mm below the craft's waterline in the lightweight condition in displacement mode, 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 min for areas of major fire hazards 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. Where machinery shafts penetrate fire-resisting watertight divisions, arrangements shall be made to ensure that the required watertight and fire-resisting integrity of the division is not impaired.

**7.4.2.7** Ventilation openings may be accepted in entrance doors to public toilets, provided they are positioned in the lower portion of the door and fitted with closable grilles made of non-combustible or fire-restricting material and operable from outside the space.

#### **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. The fire insulation in such spaces may be covered by metal sheets (not perforated) or by vapour proof glass cloth sealed at joints.

**7.4.3.3** Furniture and furnishings in public spaces and crew accommodation shall comply with the following standards:<sup>1</sup>

.1 all case furniture e.g., desks, wardrobes, dressing tables, bureaux and dressers is constructed entirely of approved non-combustible or fire-restricting materials, except that a combustible veneer with a calorific value not exceeding 45 MJ/m<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

<sup>1</sup> Fire test procedures referenced in the FTP Code (resolution MSC.61(67), as amended, and MSC/Circ.916, 964, 1004, 1008, 1036 and 1120 should be applied to items and materials covered by this paragraph as follows:

- 1) case furniture (FTP Code, annex 1, parts 1 and 10);
- 2) frames of all other furniture (FTP Code, annex 1, parts 1 and 10);
- 3) draperies, textiles and other suspended textile materials (FTP Code, annex 1, part 7);
- 4) upholstered furniture, e.g. passenger seating (FTP Code, annex 1, part 8);
- 5) bedding components (FTP Code, annex 1, part 9); and
- 6) deck finish materials (FTP Code, annex 1, parts 2 and 6).

.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** Subject to [7.4.3.5](#) 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** Paragraph [7.4.3.4](#) does not apply to partitions, windows and sidescuttles made of glass which are deemed to be non-combustible and to comply with the requirements for low-flame spread surfaces or to items and materials referred to in [7.4.3.3.<sup>2</sup>](#).

**7.4.3.6** 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.

**7.4.3.7** 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.

**7.4.3.8** 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.

**7.4.3.9** 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.

**7.4.3.10** 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.

**7.4.3.11** 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.

**7.4.4.2** Open stairways may be fitted in public spaces consisting of only two decks, provided the stairways lie wholly within such public spaces and the following conditions are met:

<sup>2</sup> Refer to [7.9.3.4](#) and the FTP Code, annex 2, paragraphs 1 and 5.1.

- .1 all levels are used for the same purpose;
- .2 the area of the opening between the lower and upper parts of the space is at least 10% of the deck area between the upper and lower parts of the space;
- .3 the design is such that persons within the space should be generally aware, or could easily be made aware of, a developing fire or other hazardous situation located within that space;
- .4 sufficient means of escape are provided from both levels of the space directly leading to an adjacent safe area or compartment; and
- .5 the whole space is served by one section of the sprinkler system.

**7.4.4.3** 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.

**7.4.4.4** 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. Draught stops are not required in public spaces of category A craft having only one public space and on other craft in spaces with open ceilings (perforated ceilings) where the opening is 40 % or more and the ceiling is arranged in such a way that a fire behind the ceiling can be easily seen and extinguished.

## 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. The use of aluminium in lubricating oil sump tanks for engines, or in lubricating oil filter housings fitted integral with the engines, is accepted.

**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<sup>3</sup>, in respect of strength and fire integrity having regard to the service pressure and the spaces in which they are installed. Wherever practicable, the use of flexible pipes shall be avoided.

**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.

<sup>3</sup> Refer to the Guidelines for the application of plastic pipes on ships, adopted by the Organization by resolution A.753(18).

**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 be discharged to a position which, in the opinion of the Administration is '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<sup>4</sup> electrical equipment be used in all spaces where fuel leakage could occur, including the ventilation system. Only electrical equipment and fittings essential for operational purposes shall be fitted in such spaces;

.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 paragraphs 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 50 l/m for not less than 10 min;

<sup>4</sup> Refer to Recommendations published by the International Electrotechnical Commission and, in particular, publication 60092–Electrical Installations in Ships

.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 BKI's 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. The controls shall be easily accessible as well as prominently and permanently marked and shall indicate whether the shut-off is open or closed. 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 (the junction between the duct and the galley range hood) which is automatically and remotely operated, and in addition a remotely operated fire damper located in the upper end of the duct;

.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, a remote means located with the above controls 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. At minimum, one hatch shall be provided close to the exhaust fan and others located in areas of high grease accumulation such as the lower end of the duct as referred to in [7.6.3.2](#).

**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. Fire and smoke dampers shall be arranged so as to be readily accessible. Where placed behind

ceilings or linings, they shall be provided with an inspection door marked to identify the damper. Such identification shall also be placed on any required remote controls.

**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 spaces not normally manned such as stores and toilets that may be manually operated only from outside the served spaces. Manual closing may be achieved by mechanical means of release or by remote operation of the fire or smoke damper by means of a fail-safe electrical switch or pneumatic release (i.e. spring-loaded, etc.). 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 System**

### **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. Control stations not normally occupied (e.g., emergency generator rooms) need not be provided with manually operated call points. 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, each of which shall comprise a group of fire detectors and manually operated call points as displayed at the indicating unit(s) required by this paragraph. The activation of any detector or manually operated call point 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. Notwithstanding the preceding requirements of this paragraph, the Administration may accept that the same section of detectors can serve spaces on more than one deck if such spaces are located in the fore or aft end of the craft or they are so arranged that they constitute common spaces on different decks (e.g., fan rooms, galleys, public spaces, etc.).

.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. In the case of a fire detection system with remotely and individually identifiable fire detectors, this requirement is met if no machinery spaces of a major fire hazard are included in a loop (electrical circuit linking detectors of various sections in a sequence and connected (input and output) to the indicating unit(s)) covering accommodation spaces, service spaces and control stations.

.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 the control panel may be used to activate one or more of the following:

.14.1 paging system;

.14.2 fan stops;

.14.3 closure of fire doors;

.14.4 closure of fire and smoke dampers; and

.14.5 sprinkler system.

.15 Fire detection systems in which all fire detectors are individually identifiable (i.e. having zone address identification capability) shall be so arranged that:

.1 a loop cannot be damaged at more than one point by a fire and no loop shall pass through a space twice. When this is not practical (e.g., for large public spaces), the part of the loop which by necessity passes through the space for a second time shall be installed at the maximum possible distance from the other parts of the loop;

.2 means are provided to ensure that any fault (e.g., power break; short circuit; earth) occurring in the loop shall not 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.

.16 The fire detection system in vehicle deck spaces, excluding manual call points, may be switched off with a timer during loading/unloading of vehicles.

#### 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 [7.7.1.11](#) 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. Detectors which are located in the overhead shall be a minimum distance of 0,5 m away from bulkheads, except in corridors, lockers and stairways.

.4 The maximum spacing of detectors shall be in accordance with the table below:

Type of detector	Maximum floor area per detector	Maximum distance apart between centres	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

The Administration may require or permit other spacings based upon test data which demonstrate the characteristics of the detectors.

.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 of 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 deck head temperature in drying rooms and similar spaces of a normal high ambient temperature.

.5 Flame detectors corresponding to 7.7.1.11 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, insufficient 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 operating compartment and, where provided, from a 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<sup>5</sup> and be capable of local manual control and remote control from the continuously manned control stations.

**7.7.3.2** Additional fixed fire-extinguishing systems not required by the Code, but fitted to the craft are to meet the design requirements of this Code, except for the second discharge required for fixed gas fire-extinguishing systems.

#### 7.7.3.3 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<sup>6</sup>, 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.

.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. Pipelines may pass through accommodation spaces, provided they are of substantial thickness and their tightness is verified with a pressure test, after their installation, at a pressure head not less than 5 N/mm<sup>2</sup>. In addition, pipelines passing through accommodation areas shall only be joined by welding and shall not be fitted with drains or other openings within such spaces. Pipelines shall not pass through refrigerated spaces. 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. Openings that may admit air to, or allow gas to escape from, a protected space shall be capable of being closed from outside the 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 corresponding to the gross volume of the machinery space being increased

<sup>5</sup> 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.

<sup>6</sup> Refer to the Guidelines for the approval of fixed water-based local application fire-fighting systems for the use in category A machinery spaces (MSC/Circ.913), and the associated interpretations of MSC/Circ.1082.

by the volume of air receivers converted to free air volume. Alternatively, a discharge pipe connected to a safety valve may be fitted to each air receiver, provided it leads directly to the open air.

.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 which personnel can be expected to enter (e.g., ro-ro spaces) and where their access is facilitated by doors or hatches or to which they have access. The alarm shall automatically operate (e.g., by opening of the release cabinet door) 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 <sup>7</sup>.

.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. Spaces are considered as separated where divisions comply with [Tables 7.4-1](#) and [7.4-2](#), as appropriate, or the divisions are gastight and of steel or equivalent materials.

.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 without moving the containers completely from their fixing position.

.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 location. For the purpose of the application of [Tables 7.4-1](#) and [7.4-2](#), such storage rooms shall be treated as control stations. For the storage rooms for fire-extinguishing media of fixed gas fire-extinguishing systems, the following apply:

.14.1 the storage room shall not be used for any other purposes;

.14.2 if the storage space is located below deck, it shall be located no more than one deck below the open deck and shall be directly accessible by a stairway or ladder from the open deck;

.14.3 spaces shall be effectively ventilated. Spaces which are located below deck or spaces where access from the open deck is not provided, shall be fitted with a mechanical ventilation system designed to take exhaust air from the bottom of the space and shall be sized to provide at least 6 air changes per hour; and

.14.4 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 adjacent enclosed spaces shall be gastight.

.15 Spare parts for the system shall be stored on board or at a base port.

<sup>7</sup> Refer to the Code on Alarms and Indicators, 1995 (resolution A.830(19))

.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 BKI Rules 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 6 air changes per hour; if such rooms have a direct door access to open deck, natural ventilation may be sufficient.

#### 7.7.3.4 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 2000 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 0,56m<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<sup>8</sup>

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.

Each portable fire extinguisher shall:

<sup>8</sup> Refer to the Improved guidelines for marine portable fire extinguishers (resolution A.951(23)), and Fire protection equipment—Portable fire extinguishers—Performance and construction (ISO 7165:1999).

- .1 not exceed 23 kg in total mass;
- .2 have a capacity of at least 5 kg if of powder or carbon dioxide type;
- .3 have a capacity of at least 9 l if of foam type;
- .4 be examined annually;
- .5 be provided with a sign indicating the date when was last examined;
- .6 be hydraulic-pressure tested (cylinders and propellant bottles) every 10 years;
- .7 not be placed in accommodation spaces if of carbon dioxide type;
- .8 if located in control stations and other spaces containing electrical or electronic equipment or appliances necessary for the safety of the craft, be provided with extinguishing media which are neither electrically conductive nor harmful to the equipment and appliances;
- .9 be ready for use and located in easily visible places such that it can be reached quickly and easily at any time in the event of a fire;
- .10 be located such that its serviceability is not impaired by the weather, vibration or other external factors; and
- .11 be provided with a device to identify whether it has been used.

**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 pumps powered by independent sources of power 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 .4.
- .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 fire main shall be capable of being drained and shall be fitted with valves arranged so that fire main branches can be isolated when the main is used for purposes other than fire-fighting. 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 within the space can be reached by two water jets from two different hydrants, each jet being supplied from a single length of hose. One hydrant shall be located in the vicinity of and outside each entrance to a machinery space.
- .5 Each fire hose shall be of non-perishable material. Fire hoses shall have a length of:

- .5.1. at least 10 m;
  - .5.2. or more than 15 m in machinery spaces; and
  - .5.3. or more than 20 m for other spaces and open decks.
- .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 passenger craft of less than 4000 tons GT,
- 0,4 N/mm<sup>2</sup> for passenger craft of 4000 tons GT and above.
- 0,25 N/mm<sup>2</sup> for cargo craft of less than 6000 tons GT,
- 0,27 N/mm<sup>2</sup> for cargo craft of 6000 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 <sup>9</sup>;
- .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 Subject to [7.8.1.2](#) boundaries of special category spaces shall be insulated in accordance with Tables [7.4-1](#) and [7.4-2](#).

7.8.1.2 The vehicle deck of a special category space or a ro-ro space, including an open ro-ro space, need only be insulated on the underside if required. Vehicle decks located totally within ro-ro spaces may be accepted without structural fire protection, provided these decks are not part of, or do not provide support to, the craft's main load-carrying structure and provided satisfactory measures are taken to ensure that the safety of the craft, including fire-fighting abilities, integrity of fire resisting divisions and means of evacuation, is not affected by a partial or total collapse of these internal decks.

<sup>9</sup> Refer to ISO 15371 – Ships and marine technology – Fire-extinguishing systems for protection of galley deep-fat cooking equipment – Fire tests.

**7.8.1.3** 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.

**7.8.1.4** 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**

**7.8.2.1** Each special category space and ro-ro space shall be fitted with an approved fixed pressure water-spraying system<sup>10</sup> 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.

**7.8.2.2** The pumps of the system shall be capable of maintaining:

.1 half the total required application rate with any one pump unit out of function, for category A craft; and

.2 the total required application rate with any one pump unit out of function, for category B craft.

**7.8.2.3** Fixed fire-extinguishing systems shall fulfil the following requirements:

.1 the valve manifold shall be provided with a pressure gauge, and each of the valves shall be marked to identify the protected areas;

.2 instructions for maintenance and operation of the installation shall be set up in the room where the valves are located; and

.3 the piping system shall be provided with a sufficient number of drainage valves.

## **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.

**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, which shall consist of a metal L-shaped pipe, the long limb being approximately 2 m in length and capable of being fitted to a fire hose, and the short limb being approximately 250 mm in length and fitted with a fixed water fog nozzle or capable of being fitted with a water spray nozzle;

.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 20 l of foam-

<sup>10</sup> Refer to Recommendation on fixed fire-extinguishing systems for special category spaces (resolution A.123(V)).

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. In addition to complying with 7.7.4, fire extinguishers shall be suitable for A and B class fires and have a capacity of 12 kg dry powder or equivalent.

### 7.8.5 Ventilation system

7.8.5.1 There shall be provided an effective power ventilation system <sup>11</sup> for the special category spaces and ro-ro spaces sufficient to give at least 10 air changes per hour while navigating and 20 air changes per hour at the quayside during vehicle loading and unloading operations. The system for such spaces 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, pumping and drainage arrangements shall be such as to prevent such accumulation. Scuppers fitted for this purpose shall be arranged 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 weather tight 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.

7.8.6.2 In respect of scuppers and drainage pumps fitted in accordance with 7.8.6.1:

.1 the amount of water for which drainage is provided shall take into account the capacity of both the water spraying system pumps and required number of fire hose nozzles;

.2 the drainage system shall have a capacity of not less than 125 % of the capacity specified in .1 above; and

.3 bilge wells shall be of sufficient holding capacity and shall be arranged at the side shell of the ship at a distance from each other of not more than 40 m in each watertight compartment.

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<sup>11</sup> Refer to the Design guidelines and operational recommendations for ventilation systems in ro-ro cargo spaces (MSC/Circ.729)

### 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 more than 450 mm above the deck or platform shall be of a type enclosed and protected by an enclosure having an ingress protection based on an international standard acceptable to the Organization<sup>12</sup>. However, if the installation electrical equipment and wiring 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 the equipment is certified "safe type" based on an international standard acceptable to the Organization.<sup>13</sup>

**7.8.7.2** If installed in an exhaust ventilation duct, electrical equipment shall be certified "safe type"<sup>14</sup>. The equipment and wiring, if fitted, shall be suitable for use based on standards acceptable to the Organization<sup>15</sup> 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<sup>16</sup> shall be in the

<sup>12</sup> Refer to publication IEC 60529 – Degrees of protection provided by enclosures (IP Code), in particular, refer to the standards for an ingress protection of at least IP 55 or refer to the publication IEC 60079 series – Electrical apparatus for explosive gas atmospheres, in particular, refer to the standards for protection by an apparatus for use in zone 2 areas.

<sup>13</sup> Refer to the publication IEC 60079 series – Electrical apparatus for explosive gas atmospheres (in particular, refer to the standards for equipment and wiring to be suitable for use in zone 1 areas).

<sup>14</sup> Refer to publication IEC 60092

<sup>15</sup> Refer to zone 1 areas as defined in the publication IEC 60079 series

<sup>16</sup> Refer to Graphical symbols for fire control plans, adopted by the Organization by resolution A.654(16) and Graphical symbols for shipboard fire control plans adopted by the Organization by resolution A.952(23).

official language of the flag state. However, if the language is neither English nor French, a translation into one of those languages shall be included.

**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 re-opened 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:

.10.1 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;

.10.2 the power supply for all other doors not subject to fire shall not impaired; and

.10.3 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<sup>17</sup> 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 complying with the requirements of 7.8.4.1, 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 and sets of personal equipment shall be stored in permanently and clearly marked locations arranged so 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:

<sup>17</sup> Refer to the definition in 7.3.1.6

.1.1 protective clothing<sup>18</sup> 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 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 explosion-proof type certified to a standard acceptable to the Organization<sup>19</sup> with a minimum burning period of 3 h; and

.1.5 an axe having handle provided with high-voltage insulation.

.2 a self-contained compressed-air-operated breathing apparatus of an approved type, the volume of air contained in the cylinders of which shall be at least 1200 l, or other self-contained breathing apparatus, which shall be capable of functioning for at least 30 min. Two spare charges suitable for use with the apparatus shall be provided for each required apparatus.

.3 For each breathing apparatus a fireproof lifeline of approximately 30 m in length and sufficient strength shall be provided capable of being attached by means of a snap hook to the harness of the apparatus or to a separate belt in order to prevent the breathing apparatus becoming detached when the lifeline is operated. The lifeline shall be subjected to a test by static load of 3,5 kN for 5 min.

## 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 within the structural fire protection time for areas of major fire hazard.

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.

<sup>18</sup> Refer to Protective clothing – Protection against heat and fire – Evaluation of materials and material assemblies when exposed to source of radiant heat (ISO 6942:2002).

<sup>19</sup> Refer to Electrical apparatus for explosive gas atmospheres (IEC publication 60079).

## 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<sup>20</sup>. A stairway open at one deck shall be considered part of the space to which it is open and consequently shall be protected by any sprinkler system provided for that space. 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. In category B craft, no section of the system shall serve more than one of the zones required in 7.11.

**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 90 % of maximum speed from departure port to destination when fully laden does not exceed 2 hours.

## 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 7.7.3.3 operable from the control station.

<sup>20</sup> 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, and the associated interpretations of MSC/Circ.912.

## 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<sup>20</sup>.

**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<sup>21</sup>

### 7.17 General

**7.17.1** In addition to complying with the requirements of 7.15 for cargo craft and with the requirements of 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<sup>22</sup> and excepted quantities<sup>23</sup>, unless such requirements have already been met by compliance with the requirements elsewhere in this Section. 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.

Craft constructed on or after 1 July 2002 but before 1 January 2011, with cargo spaces intended for the carriage of packaged dangerous goods, shall comply with 7.13.3, except when carrying dangerous goods specified as classes 6.2 and 7 and dangerous goods in limited quantities<sup>22</sup> and excepted quantities<sup>23</sup> in accordance with Tables 7.17-1 and 7.17-3, not later than the date of the first renewal survey on or after 1 January 2011.

#### 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. In this regard, a purpose-built container space is a cargo space fitted with cell guides for stowage and securing containers;

.3 craft and ro-ro spaces, including special category spaces, intended for the carriage of dangerous goods; and

<sup>21</sup> Refer to chapter 3.4 of the International Maritime Dangerous Goods Code (IMDG Code) for the provisions on the carriage of "limited quantities".

<sup>22</sup> Refer to chapter 3.4 of the IMDG Code.

<sup>23</sup> Refer to chapter 3.5 of the IMO G Code.

.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. For the purpose of this Section, "on deck" shall be taken to mean spaces on the weather deck.

**Table 7.17-1 Application of the requirements of [7.17.3](#) to different modes of carriage**

Sub-section <a href="#">7.17.2</a>	Weather decks <a href="#">7.17.2.1</a> to <a href="#">7.17.2.4</a> inclusive	<a href="#">7.17.2.1</a>	<a href="#">7.17.2.2</a>	<a href="#">7.17.2.3</a>		<a href="#">7.17.2.4</a>
		Not specifically designed	Container cargo spaces	Ro-ro spaces	Open ro-ro spaces	Solid dangerous goods in bulk (includes cargoes of group B of the International Maritime Solid Bulk Cargoes Code, except for cargoes denoted Materials Hazardous in Bulk)
<a href="#">7.17.3.1.1</a>	x	x	x	x	x	For application of requirements of <a href="#">Part D</a> to different classes of dangerous goods, see <a href="#">Table 7.17-2</a>
<a href="#">7.17.3.1.2</a>	x	x	x	x	x	
<a href="#">7.17.3.1.3</a>	-	x	x	x	x	
<a href="#">7.17.3.1.4</a>	-	x	x	x	x	
<a href="#">7.17.3.2</a>	-	x	x	x	x	
<a href="#">7.17.3.3</a>	-	x	x	x	-	
<a href="#">7.17.3.4.1</a>	-	x	x <sup>1</sup>	x	-	
<a href="#">7.17.3.4.2</a>	-	x	x <sup>1</sup>	x	-	
<a href="#">7.17.3.5</a>	-	x	x	x	-	
<a href="#">7.17.3.6.1</a>	x	x	x	x	x	
<a href="#">7.17.3.6.2</a>	x	x	x	x	x	
<a href="#">7.17.3.7</a>	x	x	-	-	x	
<a href="#">7.17.3.8.1</a>	-	x	x	x	-	
<a href="#">7.17.3.8.2</a>	-	-	-	x <sup>2</sup>	x	
<a href="#">7.17.3.9</a>	-	-	-	x	x	
<a href="#">7.17.3.10</a>	x	-	-	x	x	

**Notes :**

<sup>1</sup> For classes 4 and 5.1 solids not applicable to closed freight containers. For classes 2, 3, 6.1 and 8 when carried in closed freight containers, the ventilation rate may be reduced to not less than two air changes per hour. For classes 4 and 5.1 liquids when carried in closed freight containers, the ventilation rate may be reduced to not than two air changes per hour. For the purpose of this requirement a portable tank is a closed freight container.

<sup>2</sup> Applies only to ro-ro spaces, not capable of being sealed.

x Wherever "x" appears in the table it means that this requirement is applicable to all classes of dangerous goods as given in the appropriate line of [Table 7.17-3](#), except as indicated by the notes

**Table 7.17-2 Application of the requirements of 7.17.3 to different classes of dangerous goods for craft and cargo spaces carrying solid dangerous goods in bulk**

Class Sub- section	4.1	4.2	4.3 <sup>3</sup>	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 <sup>4</sup>	X	X <sup>5</sup>	-	-	X <sup>5</sup>
7.17.3.4.1	-	X <sup>4</sup>	X	-	-	-	-
7.17.3.4.2	X <sup>6</sup>	X <sup>7</sup>	X <sup>7</sup>	X <sup>4,6</sup>	-	-	X <sup>4,6</sup>
7.17.3.4.4	X	X	X	X	X	X	X
7.17.3.6	X	X	X	X	X	X	X

**Notes :**

- <sup>3</sup> 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.
- <sup>4</sup> Only applicable to seedcake containing residues of solvent extractions, to ammonium nitrate and to ammonium nitrate fertilizers.
- <sup>5</sup> Only applicable 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 Atmosphere", is sufficient.
- <sup>6</sup> Only suitable wire mesh guards are required.
- <sup>7</sup> For seedcake containing residues of solvent extraction and cargoes of IMSBC Code Class 4.3, two separate fans shall be permanently fitted unless portable type fans have been adapted for being securely fitted (e.g., fixed) prior to loading and during the voyage. The ventilation system shall comply with the provisions of 7.17.3.4.1 and 7.17.3.4.2. Ventilation shall be such that any escaping gases cannot reach public spaces or crew accommodation on or under deck.

### 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.

**C7.17.3.1.1** Immediate supply of water from the fire main shall be provided by remote starting arrangement for all main fire pumps from the navigation bridge or by permanent pressurization of the fire main and by automatic start-up of the main fire pumps.

**7.17.3.1.2** The quantity of water delivered shall be capable of simultaneously supplying the arrangements required by 7.17.3.1.3 for the largest designated cargo space and the 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 requirement shall be met by the total capacity of the main fire pump(s) not including the capacity of the emergency fire pump, if fitted. This amount of water may be applied by equivalent means to the satisfaction of the Administration.

**7.17.3.1.3** Means shall be provided of effectively cooling the designated under deck cargo space with water at not less than 5 l/min/m<sup>2</sup> of the horizontal area of cargo spaces, either by a fixed arrangement of spraying nozzles, or flooding the space with water<sup>10</sup>. 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 meet the requirements of 7.8.6 and be such as to prevent the build-up of free surfaces. If this is not possible the adverse effect upon stability of the added weight and free surface of water 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. Substitution by a high expansion foam system complying with regulation II-2/**10**.4.1.1.2 of the **SOLAS** Convention is also acceptable.

**7.17.3.1.5** The requirements of [7.17.3.1.1](#) to [7.17.3.1.4](#) may be fulfilled by a water spray system approved by the Administration based on the standards developed by the Organization<sup>24</sup>, provided that the amount of water required for fire-fighting purposes in the largest cargo space allows simultaneous use of the water spray system plus four jets of water from hose nozzles in accordance with [7.17.3.1.2](#).

**7.17.3.1.6** Craft carrying dangerous goods shall be provided with three fire hoses and nozzles complying with [7.7.5.6](#) in addition to those required by [7.7.5.5](#).

### 7.17.3.2 Sources of ignition

Electrical equipment and wiring shall not be fitted in enclosed cargo spaces or vehicle decks, unless it is essential for operational purposes. However, if electrical equipment is fitted in such spaces, it shall be of a certified safe type<sup>25</sup> for use in the dangerous environments to which it may be exposed unless it is possible to completely isolate the electrical system (by removal of links in the system, other than fuses). Cable penetrations of the decks and bulkheads 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.

**C7.17.3.2** For the design and explosion protection of the electrical equipment and classification of the dangerous areas, see [Rules for Electrical Installations \(Pt 1, Vol. IV\) Sec. 17](#).

### 17.7.3.3 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.

### 17.7.3.4 Ventilation

**17.7.3.4.1** 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. Exhaust fans shall be of non-sparking type<sup>26</sup>. Suitable wire mesh guards having a mesh size not exceeding 13mm x 13mm shall be fitted over inlet and outlet ventilation openings to prevent foreign objects from entering into the casing.

**7.17.3.4.3** If adjacent spaces are not separated from cargo spaces by gastight bulkheads or decks, ventilation requirements shall apply to the adjacent spaces as for the cargo space itself.

**7.17.3.4.4** 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.

<sup>24</sup> Refer to paragraphs 9.2, 9.3 and 9.4 of the Interim guidelines for open-top containerships (MSC/Circ.608/Rev.1).

<sup>25</sup> Refer to [Electrical installations in ships — Part 506: Special features - Ships carrying specific dangerous goods and materials hazardous only in bulk \(IEC Publication 60092-506\)](#) and [Electrical apparatus for explosive gas atmospheres \(IEC Publication 79\)](#).

<sup>26</sup> Refer to [IACS Unified Requirement F 29](#), as revised.

**7.17.3.4.5** For open-top container craft, power ventilation is required only for the lower part of the cargo hold for which purpose-built ducting is required. The ventilation rate shall be at least two air changes per hour based on the empty hold volume below the weather deck.

**C7.17.3.4** The ducting is to be arranged for removal of gases and vapours from the upper and lower part of the cargo hold. This requirement is considered to be met if the ducting is arranged such that approximately 1/3 of the air volume is removed from the upper part and 2/3 from the lower part. The position of air inlets and air outlets shall be such as to prevent short circuiting of the air. Inter-connection of the hold atmosphere with other is not permitted.

#### 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 as follows:

.1 if the bilge drainage system for cargo spaces is additional to the system served by pumps in the machinery space, the capacity of the system shall be not less than  $10 \text{ m}^3/\text{h}$  per cargo space served. If the additional system is a common system, the capacity need not exceed  $25 \text{ m}^3/\text{h}$ . The additional bilge system need not be arranged with redundancy. Whenever flammable or toxic liquids are carried, the bilge line into the machinery space shall be isolated either by fitting a blank flange or by a closed lockable valve;

.2 if bilge drainage of cargo spaces is arranged by gravity drainage, the drainage shall be either lead directly overboard or to a closed drain tank located outside the machinery spaces. The tank shall be provided with vent pipe to a safe location on the open deck;

.3 enclosed spaces outside machinery spaces containing bilge pumps serving cargo spaces intended for carriage of flammable or toxic liquids shall be fitted with separate mechanical ventilation giving at least six air changes per hour. Electrical equipment in the space shall be of certified safe type<sup>27</sup>. If the space has access from another enclosed space, the door shall be self-closing; and

.4 drainage from a cargo space into bilge wells in a lower space is only permitted if that space satisfies the same requirements as the cargo space above.

#### 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 firefighter's outfits required by 7.10 and shall be selected taking into account the hazards associated with the chemicals being transported and the standards developed by the Organization according to the class and physical state. 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. In addition to the requirements of 7.10.3.2.2, two spare charges suitable for use with the breathing apparatus shall be provided for each required apparatus.

#### 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.

<sup>27</sup> Refer to publication IEC 60092-506: Special features – Ships carrying dangerous goods and materials hazardous only in bulk

#### 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<sup>28</sup>.

**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<sup>10</sup> 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 meet the requirements of [7.8.6](#), have valves operable from outside the space at a position in the vicinity of the extinguishing system controls and shall be such as to prevent the build-up of free surfaces<sup>29</sup>. 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](#)<sup>30</sup>.

<sup>28</sup> For cargoes for which a fixed gas fire extinguishing system is ineffective, refer to the List of cargoes in table 2 of MSC.1/Circ.1395.

<sup>29</sup> Refer to relevant provisions of regulation II-2/20.6.1.4 of the SOLAS Convention

<sup>30</sup> Refer to MSC.1/Circular.1266 — Issuing and renewal of Documentation of Compliance with the special requirements applicable to ships carrying dangerous goods.

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## Section 8 Life-Saving Appliances and Arrangements

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### 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.

**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<sup>1</sup>; or

.2 have successfully undergone, to the satisfaction of the Administration, tests which are substantially equivalent to those specified in those recommendations.

**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<sup>2</sup>; or

.2 have successfully undergone, to the satisfaction of the Administration, evaluation and tests which are substantially equivalent to those recommendations.

**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.

<sup>1</sup> Refer to the Revised Recommendation on Testing of Life-Saving Appliances, adopted by the Organization by resolution MSC.81(70).

<sup>2</sup> 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).

**8.1.7** 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<sup>3</sup>.

.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.

<sup>3</sup> This definition does not include an appliance or device fitted to the craft (e.g. mini-slide fitted as an alternative to survival craft embarkation arrangements accepted under 8.7.5) the deployment of which is not taken into account in determining the evacuation time in accordance with 4.8.

.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<sup>4</sup>;

.2 at least one search and rescue locating device shall be carried on each side of every passenger high-speed craft and every cargo high-speed craft of 500 gross tonnage and upwards. Such search and rescue locating device shall conform to the applicable performance standards not inferior to those adopted by the Organization<sup>5</sup>. The search and rescue locating device shall be stowed in such locations that they can be rapidly placed in any one of the liferafts. Alternatively, one search and rescue locating device shall be stowed in each survival craft.

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

<sup>4</sup> 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).

<sup>5</sup> 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 MSC.247(83) (A.802(19), as amended) and the Recommendation on performance standards for survival craft AIS search and res- cue transmitter (AIS SART), adopted by the Organization by resolution MSC.246(83).

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 activated 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.<sup>6</sup>

**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<sup>6</sup>.

**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:

<sup>6</sup> Refer to the Guidelines for passenger safety instructions on roro passenger ships (MSC/Circ.681).

- .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 mess room 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; and
- .3 use symbols in accordance with the recommendations of the Organization<sup>7</sup>.

## **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](#).

<sup>7</sup> 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).

**8.6.5** 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 free-board 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** Where an MES is provided for embarkation into survival craft on a category B craft, an alternative means of evacuating passengers and crew into survival craft on the same side of the craft in conditions up to and including the worst intended conditions is to be provided for use if the MES is lost or rendered unserviceable in the event of damage of longitudinal extent specified in [2.6.7.1](#).

**8.7.7** 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.

**8.7.8** 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.

**8.7.9** 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  $HL_4$ .

**8.7.10** 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](#).

**8.7.11** 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

**8.9.2.1** 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.

**8.9.2.2** The Administration may accept, in lieu of the instructions required by [8.9.2.1](#), 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 paragraph [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 handbook.; 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<sup>8</sup>.

#### **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, 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:

.1 The new and novel liferaft arrangement shall maintain the same standard, as required by testing procedure, throughout the extended service intervals.

.2 The liferaft system shall be checked on board by certified personnel according to paragraph 8.9.7.

.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 manufacturers 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 paragraph 8.9.9 shall notify the Organization of such action in accordance with regulation I/5(b) of the SOLAS 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.**

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 SOLAS Convention;

.2 shall be subject to a thorough examination at the annual surveys required by paragraph 1.5.1.3; and

<sup>8</sup> 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).

.3 shall upon completion of the examination in .2 be subjected to a dynamic test of the winch brake at maximum lowering speed. The load to be applied shall be the mass of the survival craft or rescue boat without persons on board, except that, at intervals not exceeding five years, the test shall be carried out with a proof load equal to 1,1 times the weight of the survival craft or rescue boat and its full complement of persons and equipment.

## 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 centerline 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 notwithstanding the provisions of .4 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:

.5.1 not more than nine of the liferafts provided in accordance with 8.10.1.1 are marshalled by each rescue boat; or

.5.2 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

.5.3 the craft can be evacuated within the time specified in 4.8.

.6 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:

.6.1 the craft is arranged to allow a helpless person to be recovered from the water in a horizontal or near-horizontal body position;

.6.2 recovery of the helpless person can be observed from the navigating bridge; and

.6.3 the craft is sufficiently manoeuvrable to close in and recover persons in the worst intended conditions.

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

Craft operating on voyages having a duration of 2 hours 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<sup>9</sup>.

<sup>9</sup> Refer to the International Aeronautical and Maritime Search and Rescue Manual (IAMSAR), adopted by the Organization by resolution A.894(21), as amended.

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## Section 9 Machinery

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### 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<sup>1</sup> 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-pressure 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 BKI 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 BKI 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.

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<sup>1</sup> Refer to the Unified interpretation to the 2000 HSC Code (MSC/Circ.1177)

### 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 BKI 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 BKI'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, BKI 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 BKI may permit deviations from the Rules where these are specially warranted.

**C9.1.15.4** National rules or regulations outside BKI 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](#).

**Table C9.1 Inclinations (see note)**

Installations, Components	Angle of inclinations [°] <sup>2</sup>			
	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 <sup>1</sup> and remote-control systems				

<sup>1</sup> Up to an angle of inclination of 45° no undesired switching operations or functional changes may occur.

<sup>2</sup> Athwartships and fore-and-aft inclinations may occur simultaneously.

**Note:**

BKI may 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:**

BKI may approve other conditions for craft operating only in special agreed geographical areas.

### 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.

#### 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 BKI Rules.

.2 The fabrication of welded components, approval of companies and testing of welders are subject to BKI 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 BKI.

.4 In the case of parts produced in series, other methods of testing may be agreed with BKI instead of the tests prescribed, provided that the former are recognized as equivalent by BKI.

.5 BKI 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 BKI 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 and sea trials

Sea trials are to be performed in compliance with the [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#), unless stipulated otherwise in these Rules.

#### C9.1.18.2 Sea trials with propulsion engines driving fixed pitch propellers:

.1 Sea trials with internal combustion engines driving fixed pitch propellers are to be performed in conformity with the [Rules for Machinery Installations \(Pt.1, Vol.III\), Sec. 2, E.5](#) (See also [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#)).

.2 Sea trials with gas turbines driving fixed pitch propellers have to be carried out at rated turbine speed  $n_0$  for at least 2 hours. Other tests such as starting tests, minimum on load speed, astern trial and final testing of monitoring and safety system have to be carried out in conformity with the [Rules for Machinery Installations \(Pt.1, Vol.III\), Sec. 2, E.5](#) (See also [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#)).

#### C9.1.18.3 Sea trials with propulsion engines driving controllable pitch propellers, reversing gears or water jets:

.1 Sea trials with internal combustion engines driving controllable pitch propeller, reversing gears or water jets are to be performed in conformity with the [Rules for Machinery Installations \(Pt.1, Vol.III\)](#),

**Sec.2, E.5** (See also [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#)). Manoeuvring trials are to be conducted with various propeller pitches. Where provision is made for combinator operation, the combinator curves are to be plotted and verified by measurements.

.2 Sea trials with gas turbines driving controllable pitch propellers, reversing gears or water jets have to be carried out at 100% power at turbine speed  $n_0$  for at least 2 hours. Other tests such as starting tests, minimum on load speed, astern trial and final testing of monitoring and safety system have to be carried out in conformity with the [Rules for Machinery Installations \(Pt.1, Vol.III\)](#), Sec. 2, E.5 (See also [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#)). Manoeuvring trials are to be conducted with various propeller pitches. Where provision is made for combinator operation, the combinator curves are to be plotted and verified by measurements.

**C9.1.18.4** Sea trials for main engines driving generators for propulsion:

Sea trials for main engines driving generators for propulsion are to be performed in conformity with the [Rules for Machinery Installations \(Pt.1, Vol.III\)](#), Sec. 2, E.5 (See also [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#)).

**C9.1.18.5** Sea trials for engines driving auxiliaries and electrical generators:

Sea trials for engines driving auxiliaries and electrical generators are to be performed in conformity with the [Rules for Machinery Installations \(Pt.1, Vol.III\)](#), Sec. 2, E.5 (See also [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol.B\)](#)).

**C9.1.18.6** 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<sup>2</sup>, including automatic fire detection system, bilge alarm system, remote machinery instrumentation and alarm system. Where the space is continuously manned, this requirement may be varied in accordance with the requirements of the Administration.

**9.2.2** The engines shall be protected against over-speed, 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 minimize the risk of fire or explosion and to enable compliance with the fire precaution requirements of [Section 7](#).

<sup>2</sup> Refer to part E of chapter II-I of the [SOLAS](#) Convention.

**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 BKI's Rules are to be submitted for approval by the turbine manufacturer. To facilitate a smooth and efficient approval process they shall be submitted electronically.

**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 BKI 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 BKI Rules are to be submitted for approval by the engine manufacturer. To facilitate a smooth and efficient approval process they shall be submitted electronically.

**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 BKI 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 BKI. For this purpose, a type-approval test in accordance with BKI's 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 minimize 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 minimize 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 the [Rules for Machinery Installations \(Pt.1, Vol.III\)](#).

Sea Trials have to be carried out according to [C9.1.18](#).

#### **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 the [Rules for Machinery Installations \(Pt.1, Vol.III\), Sec. 2, H.](#) (See also [Guidelines for Sea Trials of Motor Vessels \(Pt.1, Vol B\)](#)).

**C9.4.9.3** Starting air compressors are to be approved according to BKI's 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 turbocharger 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 BKI's 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 BKI's Rules.
- .2 Shaft dimensions are to comply with BKI'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 BKI'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 BKI 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 BKI.
- .4 If fire protection requirements are relevant for the composites shafting, specific arrangements are to be provided at the satisfaction of BKI.

### C9.5.0.5 Protection of Propeller Shafts

The requirement related protection of propeller shaft see Guidance for Code and Convention Interpretations (Pt.1, Vol.Y), Sec.6 HSC 6

**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 BKI 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 BKI Rules.

Torsional vibration measurements may be required by BKI. 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 BKI.

#### **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 BKI.

#### **C9.5.2.3 Whirling vibrations**

Calculations of natural frequencies for whirling may be required by BKI. 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 BKI.

#### **C9.5.2.4 Lateral vibrations**

Vibration calculations for resiliently mounted reciprocating main engines are to be submitted to BKI 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 BKI's 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 BKI, 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 minimized;
- .2 the possibility of injury to personnel from shafting or rotating parts is minimized; 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.

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## Section 10 Auxiliary Systems

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### 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. To facilitate a smooth and efficient approval process they shall be submitted electronically.

- .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 anti-heeling 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 element
- .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 BKI.

## 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 <sup>1</sup>.

#### 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](#).

BKI's [Rules for Materials \(Pt.1, Vol. V\)](#) 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 BKI. In general, carbon and carbon manganese steel pipes, valves and fittings are not to be used for temperatures above 400 °C.

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<sup>1</sup> Refer to the Guidelines for the Application of Plastic Pipes on Ships, adopted by the Organization by resolution A.753(18).

Table C10.1 Classification of pipes into pipe classes

Medium/type of pipeline	Design pressure PR [bar] Design temperature t [°C]		
	I	II	III
Pipe class			
Toxic media	all		
Corrosive media			
Inflammable media with service temperature above the flash point	all	1)	—
Inflammable media with a flash point of 60 °C or less			
Steam	PR > 16 or t > 300	PR ≤ 16 and t ≤ 300	PR ≤ 7 and t ≤ 170
Air, gas Non-flammable hydraulic fluid Boiler feedwater, condensate Seawater and fresh water for cooling Brine in refrigerating plant	PR > 40 or t > 300	PR ≤ 40 and t ≤ 300	PR ≤ 16 and t ≤ 200
Liquid fuels, lubricating oil, flammable hydraulic fluid	PR > 16 or t > 150	PR ≤ 16 and t ≤ 150	PR ≤ 7 and t ≤ 60
Refrigerants	—	all	—
Open-ended pipelines (without shutoff), e.g. drains, venting pipes, overflow lines and boiler blowdown lines	—	—	all

<sup>1)</sup> Classification in Pipe 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

Type of component	Approved materials	Design temperature	Pipe class	Nominal diameter DN	Type of Certificate <sup>2</sup>		
					A	B	C
Pipes <sup>1</sup> , Pipe elbows, Fittings	Steel, Copper, Copper alloys, Aluminium, Aluminium alloys Plastics	—	I + II	> 50 ≤ 50	x —	— x	— —
			III	All	—	—	x
Valves <sup>1</sup> , Flanges,	Steel, Cast steel, Nodular cast iron	300 °C	I, II	DN > 100 DN ≤ 100	x —	— x	— —
	Copper, Copper alloys	> 225 °C		PB x DN > 2500 or DN > 250	x	—	—
	Steel, Cast steel, Nodular cast iron	≤ 300 °C	I, II	PB x DN ≤ 2500 or DN ≤ 250	—	x	—
	Steel, Cast steel, Nodular cast iron, Grey cast iron	—		All	—	—	x
	Copper, Copper alloys	≤ 225 °C	I, II	PB x DN > 1500	x	—	—
	Aluminium, Aluminium alloys	≤ 200 °C		PB x DN ≤ 1500	—	x	—
	Plastics	Acc. to Type Approval Certificate	III	All	—	—	x
Semi-finished products, Screws and other components	According to Table C10.3	—	I, II	—	—	x	—
			III	—	—	—	x

<sup>1)</sup> Casings of valves and pipes fitted on ship's side and bottom and bodies of valves fitted on collision bulkhead are to be included in pipe class II

<sup>2)</sup> Test Certificates acc. to [Rules for Materials \(Pt.1, Vol.V\) Sec. 1, H.](#) with the following abbreviations:  
 A: BKI Material Certificate, B: Manufacturer Inspection Certificate, C: Manufacturer Test Report

#### C10.1.6.2 Pipes, valves and fittings of aluminium and aluminium alloy

Aluminium and aluminium alloys are to comply with BKI's [Rules for Materials \(Pt.1, Vol.V\)](#) 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 BKI.

#### 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 BKI.

**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 BKI. 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.

#### C10.1.6.5 Pipes, valves and fittings of nodular ferritic cast iron

Pipes, valves and fittings of nodular ferritic cast iron according to BKI's Rules may be used for bilge and ballast pipes within double-bottom tanks, and tanks for other purposes approved by BKI. In special cases (applications corresponding in principle to Classes II and III) and at BKI's discretion, valves and fittings made of ferritic nodular cast iron may be accepted for temperatures up to 350 °C.

Table C10.3 Approved materials

Material or application		Pipe class		
		I	II	III
Steels	Pipes	Pipes for general applications: - above 300 °C: high-temperature steel pipes - below -10 °C: pipes made of steel with high low-temperature toughness, stainless steel pipes for chemicals	Pipes for general applications	Steel not subject to any special quality specification, weldability in accordance with <a href="#">Rules for Welding (Pt.1, Vol.VI)</a>
	Forgings, Plates, Fanges	Steel suitable for the corresponding loading and process conditions, for temperatures > 300 °C, high temperature steels, for temperatures below -10 °C, steel with high low-temperature toughness		
	Bolts, Nuts	Bolts for general machinery constructions: - above 30 °C: high-temperature steels - below -10 °C: steel with high low temperature toughness	Bolts for general machinery construction	
Castings (valves, fittings, pipes)	Cast steel	Cast steel for general applications: - above 30 °C: high-temperature cast steel - below -10 °C: cast steel with high low-temperature toughness - for aggressive media: stainless castings	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 bulkhead 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 BKI	See <a href="#">C10.1.6.2</a>
Non-metallic materials	Non-metallic	—	—	See <a href="#">C10.1.6.3</a>

#### C10.1.6.6 Pipes, valves and fittings of lamella 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 BKI's [Rules for Materials \(Pt.1, Vol.V\)](#) under BKI'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.

.2 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 BKI.

.3 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](#).

.4 Pressure testing of pipes with nominal diameters less than 15 mm may be omitted, at BKI'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 BKI, 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	N	X	X	N	N	X	M	N	
Ballast lines												
Seawater lines												
Fuel lines												
Lubricating lines												
Hydraulic lines												
Drinking water lines												
Fresh cooling water lines												

M, N Refer to [Table C10.10](#)  
 X Pipelines are not to be installed.  
 (–) Pipelines may be installed by special agreement with BKI.

Table C10.5 Choice of minimum wall thickness for air, overflow, sounding

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 freeboard deck	above open deck	below open deck			
without shut-off on ship's side	with shut-off on ship's side									
Air, overflow and sounding pipes	M	C	–	–	–	C	M	M	M	
Scupper pipes from open deck					A					
Discharge and scupper pipe leading directly overboard	A	B	B	A	–	–	–	B	A	
Discharge of pumps of sanitary systems			–		A					

A, B, C : Refer to [Table C10.10](#) M : Refer to [Table C10.6](#)

Table C10.6 Minimum wall thickness of steel pipes

Group N						Group M			
$d_a^1$ [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 43,5	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 117,8	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

<sup>1</sup>  $d_a$  = outside diameter

Table C10.7 Minimum wall thickness for austenitic steel pipes

Pipe outside diameter $d_a$ [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

Table C10.8 Minimum wall thickness for copper and copper alloy pipes

Pipe outside diameter $d_a$ [mm]	Minimum wall thickness s [mm]	
	Copper	Copper alloy
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 s [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 not to be less than 5,0 mm.*

Table C10.10 Minimum wall thickness for copper and copper alloy pipes

Pipe outside diameter [mm]	Minimum wall thickness s [mm]		
	A	B <sup>1</sup>	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

<sup>1</sup> The pipe thickness may not be greater than the thickness of the shell plates.

### 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 BKI
- 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.

#### 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 BKI, 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 equal to that of the shell plating, but need not to exceed 8 mm.

##### 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 BKI 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 BKI's 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 BKI 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 BKI 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.<sup>2</sup>

#### 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.
- b) Pumps are to be provided with shutoff valves.

<sup>2</sup> Refer to the Guidelines to Minimize Leakages from Flammable Liquid Systems for Improving Reliability and Reducing Risk of Fire (MSC/Circ.647).

- 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.

**C10.2.3.1** 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 [10.6](#) and [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 [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.  
b) Valves subject to static head are to be made of ductile material.

- 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 Administration 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 Administration 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 BKI 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 over-pressure in any oil tank or in any part of the fuel system, including bunkering pipes and any filling pipes served by on-board pumps. Any relief valves and air or overflow pipes shall discharge to a safe position where there is no risk of fire and explosion from the emergence of oils and vapours, shall not lead into crew spaces, passenger spaces, special category spaces, ro-ro spaces (other than open ro-ro spaces), machinery spaces or similar spaces. For fuel of flashpoint less than 43 °C such valves and pipes shall terminate with flame arresters in accordance with the standards developed by the Organization<sup>3</sup>.

**C10.2.4.8** Lines of relief/safety valves and overflow-lines are to discharge into leakage, drain or overflow tanks.

<sup>3</sup> Refer to the Revised Standards for the Design, Testing and Locating of Devices to Prevent the Passage into Cargo Tanks in Tankers (MSC/Circ.677).

**10.2.4.9** Oil fuel pipes and their valves and fittings shall be of steel or other approved material<sup>4</sup>, except that restricted use of flexible pipes shall be permissible in positions where the Administration is satisfied that they are necessary<sup>5</sup>. Such flexible pipes and end attachments shall be approved fire-resisting materials of adequate strength and shall be constructed to the satisfaction of the Administration.

#### 10.2.5 Lubricating oil arrangements

The arrangements for the storage, distribution and utilization 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; and
- .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 BKI 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 BKI.
  - b) Lubricating oil systems are to be constructed to ensure reliable lubrication over the whole range of speed and during rundown of the engines, and are to ensure adequate heat transfer.
  - 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.
  - 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.

<sup>4</sup> For values fitted to oil fuel tanks and which are under static pressure-head, steel or nodular cast iron may be accepted. However, ordinary cast iron valves may be used in piping systems where the design pressure is lower than 0.7 N/mm<sup>2</sup> and the design temperature is below 60°C.

<sup>5</sup> Refer to recommendations published by the International Organization for Standardization, in particular, Publications ISO 15540:1999 - Ships and marine technology - Fire resistance of hose assemblies - Test methods and ISO 15541:1999 - Ships and marine technology - Fire resistance of hose assemblies - Requirements for the test bench.

#### 10.2.6 Arrangements for other flammable oils

The arrangements for storage, distribution and utilization of other flammable oil 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 Arrangement 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:

.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.

.2 Other equipment which treats flammable liquids automatically, such as oil fuel purifiers, which, whenever practicable, should 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 BKI's Rules.

.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 suctions are to be suitably arranged and fitted with mud boxes.
- b) Every machinery space is normally to be provided with at least two bilge suctions, one at each side. Additional suctions may be required for craft having long machinery spaces.

c) Bilge suctions 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 to 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 suctions 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.
- 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 suctions, one screw-down non-return valve is sufficient.
- 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 BKI.
- 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.
- 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/s.

**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:

$$d = 25 + 1,68 (L(B + H))^{0.5}$$

where :

- d = the internal diameter of the bilge main [mm];
- L = the length of the craft [m] as defined in [Section 1](#);
- B = for monohull craft, the breadth of the craft [m] as defined in [Section 1](#) and, for multi-hull craft, the breadth of a hull at or below the design waterline [m]; and
- H = the moulded depth of the craft to the datum [m].

**10.3.7** Internal diameters of suction branches shall meet the requirements of the Administration 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:

$$d_B = 25 + 2,15 (L_B \cdot (B_1 + H))^{0,5}$$

where:

- $d_B$  = internal diameter [mm] of the branch pipes  
 $L_B$  = length [m] of the watertight compartment  
 $B_1$  = average breadth [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 or oil pump. Emergency bilge suctions 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**

- Emergency bilge suctions 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.
- 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:

$$Q_n = Q/(N-1) \quad [\text{tonnes/h}] \quad \text{with a minimum of 8 tonnes/h}$$

where :

- $N$  = number of submersible pumps  
 $Q$  = total capacity as defined in [10.3.13](#).

**10.3.15** Nonreturn 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 shutoff 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**

**10.5.1** 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 BKI.

**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 [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 [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 to comply with [2.2.8.4](#) of [Section 2](#).

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 water-line shall be fitted with erosion-/corrosion-resistant shut-off 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 over-flow 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.
- b) The use of flexible hoses in wet exhaust systems may be accepted at the discretion of the BKI, if the hoses are suitable for this purpose (media, pressure and temperature).
- 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 nonreturn 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 BKI at a height not lower than 760 mm above deck.

**Note:**

*Refer to International Convention on Load Lines, 1966 Reg. 20 (ICLL66) 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 BKI, 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 [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 BKI's 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 BKI's Rules ( $D_i$  being the inside diameter [mm]).

Testing of materials by BKI 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 BKI's 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 BKI.

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 un-damaged compartment will be available.

**C10.9.2** The “emergency source” is to be located above the datum.

**10.9.3** On multihull 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 multihull 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](#).

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## Section 11 Remote Control, Alarm and Safety Systems

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### C11.0 Documents to be submitted

**C11.0.1** The following drawings and documents are to be submitted. To facilitate a smooth and efficient approval process they shall be submitted in electronically.

- .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 2](#) 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 BKI.

### 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 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 BKI 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 BKI.

**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 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 power 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 at one or more stations outside the operating compartment. Such stations shall have direct communication with the operating compartment which shall be a continuously manned control station.

## 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, malfunctions 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 detection of bilge water in each watertight compartment below the design waterline;
- .5 failure of compass system;
- .6 low level of a fuel tank contents;
- .7 fuel oil tank overflow;
- .8 extinction of side, masthead or stern navigation lights;
- .9 low level of contents of any fluid reservoir the contents of which are essential for normal craft operation;
- .10 failure of any connected electrical power source;
- .11 failure of any ventilation fan installed for ventilating spaces in which inflammable vapours may accumulate; and
- .12 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](#).

**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.<sup>1</sup>

**11.4.3** Equipment monitoring the passenger, cargo and machinery spaces for fire and flooding shall, so far as is practicable, form an integrated sub-centre incorporating monitoring and activation control for all emergency situations. This sub-centre may require feedback instrumentation to indicate that actions initiated have been fully implemented.

**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 cylinder 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	
Stern tube temperature	high	

<sup>1</sup> Refer to the Code on Alarms and Indicators, 1995, adopted by the Organization by resolution A.830(19).

**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

Where arrangements are fitted for overriding any automatic shutdown system for the main propulsion machinery in accordance with 9.2.2, they shall be such as to preclude inadvertent operation. When a shutdown system is activated, an audible and visual alarm shall be given at the control station and means shall be provided to override the automatic shutdown 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 shutdown, 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.

**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 11.4.1.2.6 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	

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## Section 12 Electrical Installations

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### Part A General

#### C12.0 Documents to be submitted

**C12.0.1** The following drawings and documents are to be submitted. To facilitate a smooth and efficient approval process they shall be submitted in electronically.

- .1 Arrangement of essential electric equipment
- .2 Single line general electric diagram of the installation (including emergency installation)
- .3 Diagram of power supplies or converters
- .4 Electrical load analysis
- .5 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
- .6 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
- .7 Single line and functional diagram of the main switchboard
- .8 Single line and functional diagram of the emergency switchboard
- .9 Diagram of the most important section boards
- .10 Diagram of the supply, monitoring and control systems of the steering gear
- .11 Diagram of the supply, monitoring and control systems of the propulsion plant
- .12 Diagram of the general 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 firedoor 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 BKI.

## 12.1 General

**12.1.1** Electrical installations <sup>1</sup> 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.

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.

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<sup>1</sup> Refer to the recommendations published by the International Electrotechnical Commission and, in particular, Publication 60092 - Electrical Installations in Ships

**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 minimise risk of supplies to essential and emergency services being interrupted by the inadvertent or accidental opening of switches or circuit-breakers.

**C12.1.6** Ambient conditions for electrical equipment see [Section 9, C9.1.16](#)

## 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.

**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, and sanitary and fresh water.

### 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

**12.2.3** 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.

### 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.

**12.2.4** 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 12.8.2.1 to 12.8.2.4.1, 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 is stated in 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 Fig. 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 normally accessible to and used by passengers and crew shall be supplied from the main source of electrical power.

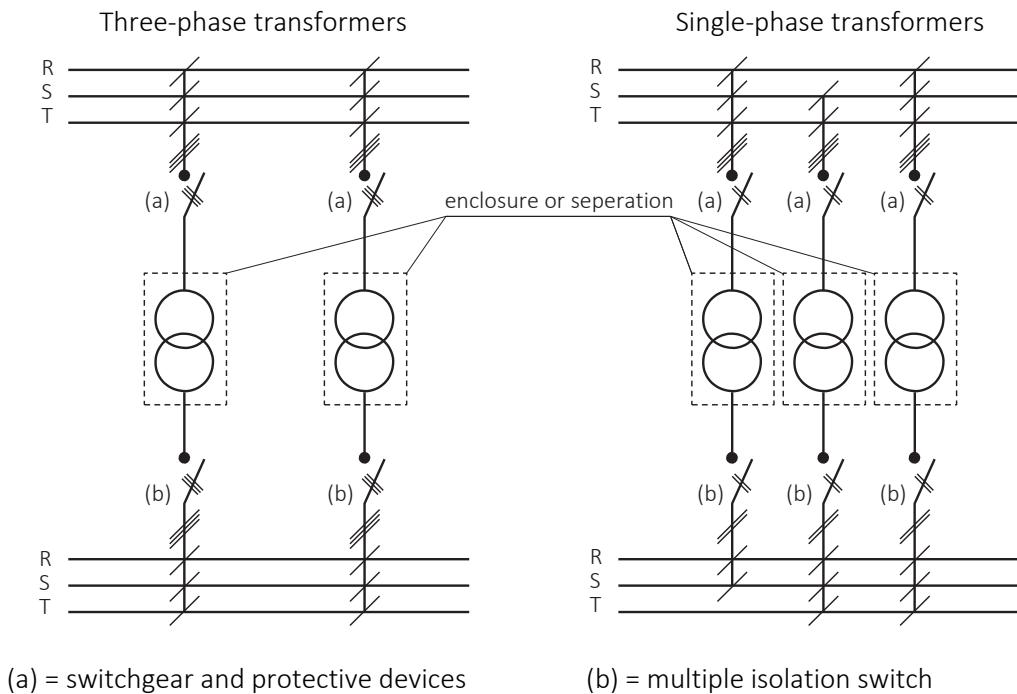
**12.2.7** The arrangement of the main electric lighting system shall be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render inoperative the main electric lighting systems 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 electrical 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 the 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, BKI 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".



**Fig. 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 is 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 non-return 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, then 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 50V direct current or 50V, 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 250V 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 BKI 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 BKI, on the basis of IEC standards, 92.3. series. Use of other cables is subject to special consideration by BKI 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 BKI.

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 BKI 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 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 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, 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 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, 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 5000 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 generating 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 5000 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 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 paragraph [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 paragraph [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 System and Equipment and Voyage Date Recorders

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### 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 navigation 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**

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 paragraph 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 Navigational 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** High-speed craft shall be fitted with an ECDIS as follows:

- .1 craft constructed on or after 1 July 2008;
- .2 craft constructed before 1 July 2008, not later than 1 July 2010.

**13.8.3** 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 ship 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 The 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 ships;

.3 monitor and track ships; and

.4 exchange data with shore-based facilities.

13.15.3 The requirements of paragraph 13.15.2 shall not be applied to cases 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 3000 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 facilities stating the data 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 the 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 the 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 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.<sup>1</sup>

## 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.

<sup>1</sup> 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 indicatespeed 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 "Auto Tracking"( resolution MSC.64(67), annex 4, appendix 1);  
Recommendation on performance standards for shipborne Decca navigator receivers (resolution A.816(19));  
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 GLONASS 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 equipmentfor 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)).

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## Section 14 Radiocommunications

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### 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 <sup>1</sup>.

**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).

<sup>1</sup> 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

.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, **recognized mobile satellite service** 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 coordinated broadcast and automatic reception on 518 kHz of maritime safety information by means of narrow-band direct-printing telegraphy using the English language.<sup>2</sup>

.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 radio-telephone 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.<sup>3</sup>

.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.<sup>3</sup>

.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.

.17 **Recognized mobile satellite service means any service which operates through a satellite system and is recognized by the Organization, for use in the global maritime distress and safety system (GMDSS).**

**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.**

<sup>2</sup> Refer to the NAVTEX Manual approved by the Organization

<sup>3</sup> Refer to resolution A.801(19) concerning provision of radio services for the global maritime distress and safety system (GMDSS), adopted by the Organization

## 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 Coordination 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 coordinating communications;
- .5 of transmitting and receiving on-scene communications;
- .6 of transmitting and, as required by [13.5](#), receiving signals for locating <sup>4</sup>;
- .7 of transmitting and receiving <sup>5</sup> maritime safety information;

<sup>4</sup> Refer to resolution A.614(15) on carriage of radar operating in the frequency band 9,300 - 9,500 MHz, adopted by the Organization

<sup>5</sup> 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 radiocommunications 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 onboard 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 search and rescue locating device, 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 of maritime safety information by **a recognized mobile satellite service enhanced** group calling system if the craft is engaged on voyages in **sea area A1, or A2 or A3** 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.<sup>6</sup>

.6 subject to the provisions of [14.8.3](#), a satellite emergency position indicating radio beacon (satellite EPIRB)<sup>7</sup> which shall be:

.6.1 capable of transmitting a distress alert either through the polar orbiting satellite service operating in the 406 MHz 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:

<sup>6</sup>- Refer to the Recommendation on Promulgation of Maritime Safety Information, adopted by the Organization by resolution A.705(17).

<sup>7</sup> Refer to resolution A.616(15) concerning search and rescue homing capability, adopted by the Organization.

.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 a **recognized mobile satellite service**; this requirement may be fulfilled by:

.5.1 an ship earth station <sup>8</sup>; 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.

**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 2187,5 kHz using DSC; and

.1.2 2182 kHz using radiotelephony;

.2 a radio installation capable of maintaining a continuous DSC watch on the frequency 2187,5 kHz which may be separate from, or combined with, that required by 14.9.1.1.1; and

<sup>8</sup> This requirement can be met by **recognized mobile satellite service** ship earth stations capable of two-way communications, such as **Fleet-77** (resolution A.808(19)) and **MSC 130(75)** or Inmarsat-C (resolution A.807(19) as amended) ship earth stations. Unless otherwise specified, this footnote applies to all requirements for a **recognized mobile satellite service** ship earth station prescribed by this chapter.

.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 a **recognized mobile satellite service by a ship earth station**; 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 1605 kHz and 4000 kHz or between 4000 kHz and 27500 kHz; this requirement may be fulfilled by the addition of this capability in the equipment required by [14.9.1.1](#); or

.2 a **recognized mobile satellite service** 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 a **recognized mobile satellite service** 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 2187,5 kHz using DSC; and

.2.1 2182 kHz using radiotelephony;

.3 a radio installation capable of maintaining a continuous DSC watch on the frequency 2187,5 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 a recognized mobile satellite service by an additional ship earth station.

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 1605 kHz and 4000 kHz and between 4000 kHz and 27500 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 2187,5 kHz, 8414,5 kHz and on at least one of the distress and safety DSC frequencies 4207,5 kHz, 6312 kHz, 12577 kHz or 16804,5 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 a recognized mobile satellite service by a ship earth station, 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 1605 kHz and 4000 kHz and between 4000 kHz and 27500 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

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 2187,5 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 2187,5 kHz and 8414,5 kHz and also on at least one of the distress and safety DSC frequencies 4207,5 kHz, 6312 kHz, 12577 kHz or 16804,5 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 a **recognized mobile satellite service** 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 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 <sup>9</sup>, at intervals not exceeding 12 months, when the craft is not 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 <sup>10</sup>.

<sup>9</sup> 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.

<sup>10</sup> Refer to the following resolutions adopted by the Assembly of the Organization:  
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.

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.

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.

## 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.<sup>11</sup>

**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.<sup>12</sup>

**14.15.8** However, for craft operating solely between ports where adequate facilities for shore-based 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.

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.

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.

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.

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).

Resolution A.802(19): Performance Standards for Survival Craft Radar Transponders for Use in Search and Rescue Operations.

Resolution A.805(19): Performance Standards for Float-Free VHF Emergency Position-Indicating Radio Beacons.

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.

Resolution A.664(16): Performance Standards for Enhanced Group Call Equipment.

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.

Resolution A.662(16): Performance Standards for Float-Free Release and Activation Arrangements for Emergency Radio Equipment.

Resolution A.699(17): System Performance Standard for the Promulgation and Co-ordination of Maritime Safety Information Using High-Frequency Narrow-Band Direct Printing.

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.

Resolution MSC.80(70): Recommendation on Performance Standards for on-scene (Aeronautical) Portable Two-Way VHF Radiotelephone Apparatus.

<sup>11</sup> 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).

<sup>12</sup> 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).

**14.15.9** 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 on all craft shall be:

.1 annually tested for all aspects of operational efficiency, with special emphasis on checking the emission on operational frequencies, coding and registration, at intervals within 3 months before the expiry date, or 3 months before or after the anniversary date, of the High-Speed Craft Safety Certificate;

The test may be conducted on board the craft or at an approved testing station; and

.1 on passenger craft, within 3 months before the expiry date of the High-Speed Craft Safety Certificate; and

.2 on cargo craft, within 3 months before the expiry date, or 3 months before or after the anniversary date, of the High-Speed Craft Safety Certificate;

The test may be conducted on board the craft or at an approved testing station; and

.2 subject to maintenance at intervals not exceeding five years, to be performed at an approved shore-based maintenance facility.

## 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 14.16.1 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

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### 15.1 Definitions

**15.1.1** Operating area<sup>1</sup> 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.

<sup>1</sup> Refer to Ship's Bridge Layout and Associated Equipment — Requirements and guidelines (ISO 8468:1990); and the Guidelines on ergonomic criteria for bridge equipment and layout (MSC/Circ.982)

**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.

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## Section 16 Stabilization Systems

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### 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 1](#) 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 stabilization control system devices shall be based on demonstrations and a verification process in accordance with [Annex 7](#).

**16.4.2** Demonstration in accordance with [Annex 7](#) 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

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### 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 7.

**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.

## 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 2 shall be verified in accordance with Annex 7.

## 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.

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## Section 18 Operational Requirements

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### Part A General

#### 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.

**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.

**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 having functions and facilities in accordance with the requirements of this Code;

.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 coordination 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.<sup>1</sup>

**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;

<sup>1</sup> 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).

- .16 procedure for dry-docking or lifting, including limitations;
- .17 in particular, the manual shall provide information, in clearly defined chapters, 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.

#### **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 or 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.

#### 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 revalidated 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 [.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, shall be acceptable as evidence of satisfactory training and experience 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** Crew members with enclosed space entry or rescue responsibilities shall participate in an enclosed space entry and rescue drill, to be held on board the craft, at least once every two months.

**18.5.5** 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.

**18.5.6** 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.

**18.5.7** 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.

### 18.5.8 Records

**18.5.8.1** The date when musters are held, details of abandon craft drills and fire drills, drills of other life-saving appliances, enclosed space entry and rescue drills, and onboard 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.

**18.5.8.2** 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.

### 18.5.9 Evacuation drills

**18.5.9.1** Evacuation drill scenarios shall vary each week so that different emergency conditions are simulated.

**18.5.9.2** 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.

### 18.5.9.3 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<sup>2</sup>.

**18.5.9.4** 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.

**18.5.9.5** 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.

<sup>2</sup> Refer to resolution A.624(15) concerning guidelines on training for the purpose of launching lifeboats and rescue boats from ships making headway through the water.

#### **18.5.10 Fire drills**

**18.5.10.1** Fire drill scenarios shall vary each week so that emergency conditions are simulated for different craft compartments.

**18.5.10.2** 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.

#### **18.5.11 Damage control drills**

**18.5.11.1** Damage control drill scenarios shall vary each week so that emergency conditions are simulated for different damage conditions.

**18.5.11.2** 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 water-tight 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.

#### **18.5.12 Enclosed space entry and rescue drill**

**18.5.12.1** Enclosed space entry and rescue drills should be planned and conducted in a safe manner, taking into account, as appropriate, the guidance provided in the recommendations developed by the Organization<sup>3</sup>.

**18.5.12.2** Each enclosed space entry and rescue drill shall include:

- .1 checking and use of personal protective equipment required for entry;
- .2 checking and use of communication equipment and procedures;
- .3 checking and use of instruments for measuring the atmosphere in enclosed spaces;

<sup>3</sup> Refer to the Revised Recommendations for entering enclosed spaces aboard ships, adopted by the Organization by resolution A.1050(27).

- .4 checking and use of rescue equipment and procedures; and
- .5 instructions in first aid and resuscitation techniques

**18.5.12.3** The risks associated with enclosed spaces and onboard procedures for safe entry into such spaces which should take into account, as appropriate, the guidance provided in recommendations developed by the Organization<sup>3</sup>.

## 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.

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## 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.

**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.

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## Annex 1 Use of Probability Concept

1.	General .....	A1-1
2.	Terms associated with Probabilities .....	A1-1
3	Numerical Values.....	A1-3

### 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<sup>1</sup> 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).

<sup>1</sup> 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 A1.1](#).

### **3 Numerical Values**

Where numerical probabilities are used in assessing compliance with requirements using the terms similar to those given above, the following approximate values may be used as guidelines to assist in providing a common point of reference. The probabilities quoted shall be on an hourly or per-journey basis, depending on which is more appropriate to the assessment in question.

Frequent	More than $10^{-3}$
Reasonably probable	$10^{-3}$ to $10^{-5}$
Remote	$10^{-5}$ to $10^{-7}$
Extremely remote	$10^{-7}$ to $10^{-9}$
Extremely improbable	Whilst no approximate numerical probability is given for this, the figures used shall be substantially less than $10^{-9}$

**Note:**  
*Different occurrences may have different acceptable probabilities, according to the severity of their consequences (see [Table A1.2](#)).*

**Table A1.1**

EFFECT	CRITERIA NOT TO BE EXCEEDED		COMMENTS
	Type of load	Value <sup>2</sup>	
LEVEL 1 MINOR EFFECT Moderate degradation of safety	Maximum acceleration measured horizontally <sup>1</sup>	0,2 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 <sup>1</sup>	0,35 g	0,25 g: Maximum load for mean person keeping balance when holding. 0,45 g: Mean person fall out of seat when not wearing seat belt.
LEVEL 3 HAZARDOUS EFFECT Major degradation of safety	Collision design condition calculated  Maximum structural design load, based on vertical acceleration at center of gravity	Ref. 4.3.3  Ref. 4.3.1	Risk of injury to passenger; safe emergency operation after collision.  1,0 g: Degradation of passenger safety.
LEVEL 4 CATASTROPHIC EFFECT			Loss of craft or/and fatalities

<sup>1</sup> The accelerometer used shall have an accuracy of at least 5 % full scale and shall not have a frequency response of less than 20 Hz. The sampling frequency should not be less than 5 times the maximum frequency response. Anti-alias filter, if used, should have a pass band equal to frequency response

<sup>2</sup> g = gravity acceleration (9,81 m/s<sup>2</sup>)

Table A1.2

SAFETY LEVEL	1	1	2	3	4
EFFECT ON CRAFT AND OCCUPANTS	Normal Nuisance	Operating limitations	Large reduction in safety margins; crew over-burden because of work-load or environmental conditions; serious injury to small number of occupants.	Deaths, with usually 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	
	10 <sup>-0</sup>	10 <sup>-1</sup>	10 <sup>-2</sup>	10 <sup>-3</sup>	10 <sup>-4</sup>
CATEGORY OF EFFECT		MINOR	MAJOR	HAZARDOUS	CATASTROPHIC

<sup>1</sup> United States Federal Aviation Regulations.

<sup>2</sup> European Joint Airworthiness Regulations.

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## **Annex 2 Procedures for Failure Mode and Effects Analysis**

C0.	Document to be submitted.....	A2-1
1.	Introduction .....	A2-1
2.	Objectives .....	A2-2
3.	Scope of Application .....	A2-2
4.	System Failure Mode and Effects Analysis.....	A2-2
5.	Equipment Failure Mode and Effects Analysis.....	A2-3
6.	Procedures.....	A2-3
7.	System Definition.....	A2-4
8.	Development of System Block Diagrams .....	A2-4
9.	Identification of Failure Modes, Causes and Effects .....	A2-4
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### **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 programs 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 program 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 program;
- .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 A2.1](#). The failure modes listed in [Table A2.1](#) can describe the failure of any system element in sufficiently specific terms. When used in conjunction with performance specifications governing the inputs and outputs on the system block diagram, all potential failure modes can be thus identified and described. Thus, for example, a power supply may have a failure mode described as "loss of output" (29), and a failure cause "open (electrical)" (31).

**Table 2.1. Example of a set of failure modes<sup>1</sup>**

1	Structural failure (rupture)
2	Physical binding or jamming
3	Vibration
4	Fails to remain (in position)
5	Fails to open
6	Fails to close
7	Fails open
8	Fails closed
9	Internal leakage
10	External leakage
11	Fails out of tolerance (high)
12	Fails out to tolerance (low)
13	Inadvertent operation
14	Intermittent operation
15	Erratic operation
16	Erroneous indication
17	Restricted flow
18	False actuation
19	Fails to stop
20	Fails to start
21	Fails to switch
22	Premature operation
23	Delayed operation
24	Erroneous input (increased)
25	Erroneous input (decreased)
26	Erroneous output (increased)
27	Erroneous output (increased)
28	Loss of input
29	Loss of output
30	Shorted (electrical)
31	Open (electrical)
32	Leakage (electrical)
33	Other unique failure conditions as applicable to the system characteristics, requirements and operational constraints

<sup>1</sup> Refer to IEC Publication: IEC 812 (1985), Analysis techniques for system reliability — procedure for failure mode and effects analysis (FMEA)

**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 1](#) 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 1](#) 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**

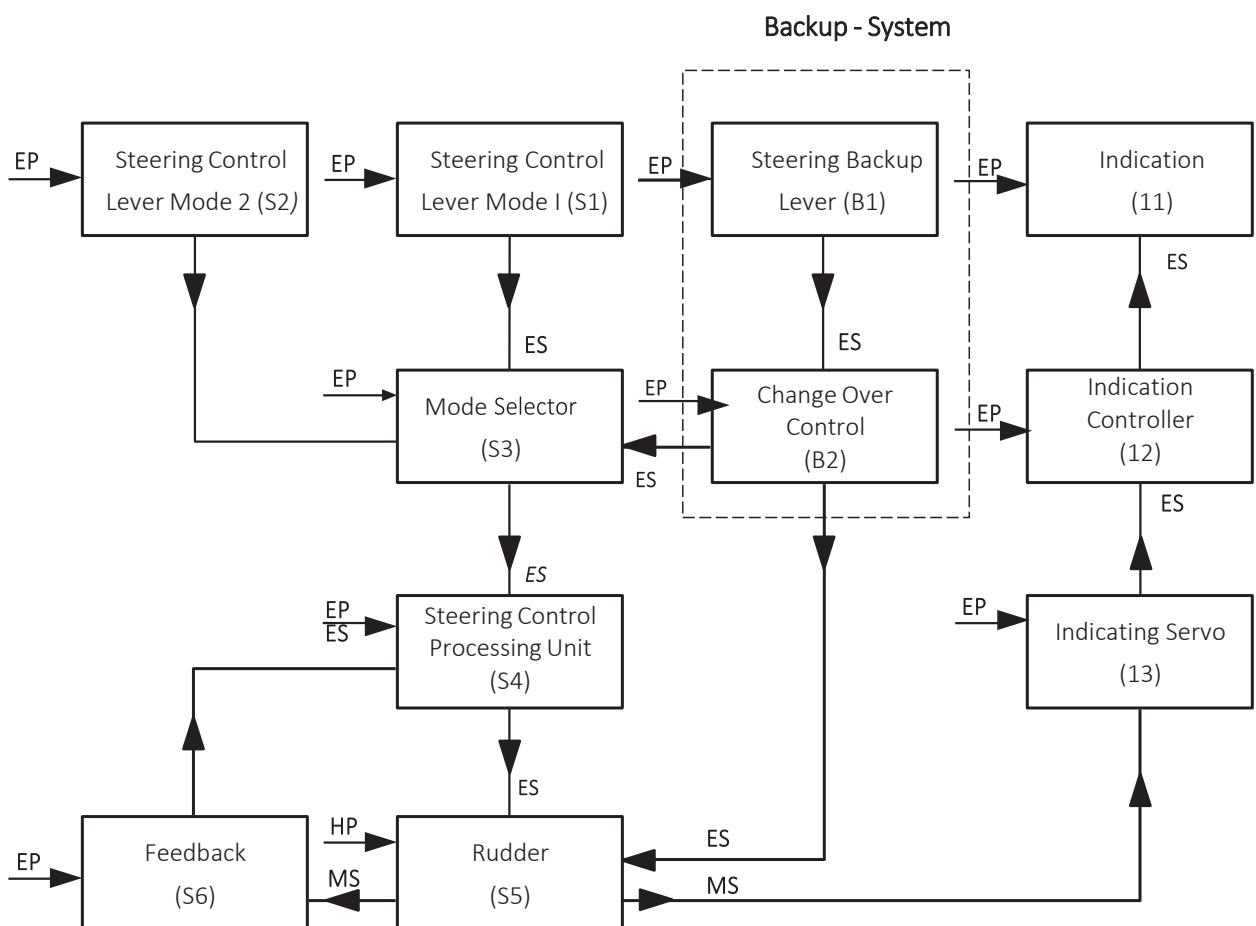
The FMEA report shall be a self-contained document with a full description of the craft, its systems and their functions and the proposed operation and environmental conditions for the failure modes, causes and effects to be understood without any need to refer to other plans and documents not in the 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.

## Appendix 1 Example of a system block diagram

Steering control system

Date .....

Analyst .....



where:

EP	-	electric power
HP	-	hydraulic power
ES	-	electrical signal
MS	-	mechanical signal

## Appendix 2 FMEA Worksheet

Name of system ..... References .....

Mode of operation ..... System block diagram .....

Sheet No. .... .....

Date ..... .....

Name of analyst..... Drawings .....

Equip- ment name or number	Function	Ident. No.	Failure mode	Failure cause	Failure mode		Failure detection	Correc- tive action	Severity of failure effect	Probabi- lity of failure (if appli- cable)	Remark
					Local mode	End mode					

## **Annex 3      Ice Accretion Applicable to All Types of Craft**

1.	Icing Allowances.....	A3-1
2.	Areas of Icing Conditions .....	A3-1
3.	Special Requirements .....	A3-2

### **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° 0' 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° to latitude 73° 0' N, longitude 15° E, north of latitude 73° 0' 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.

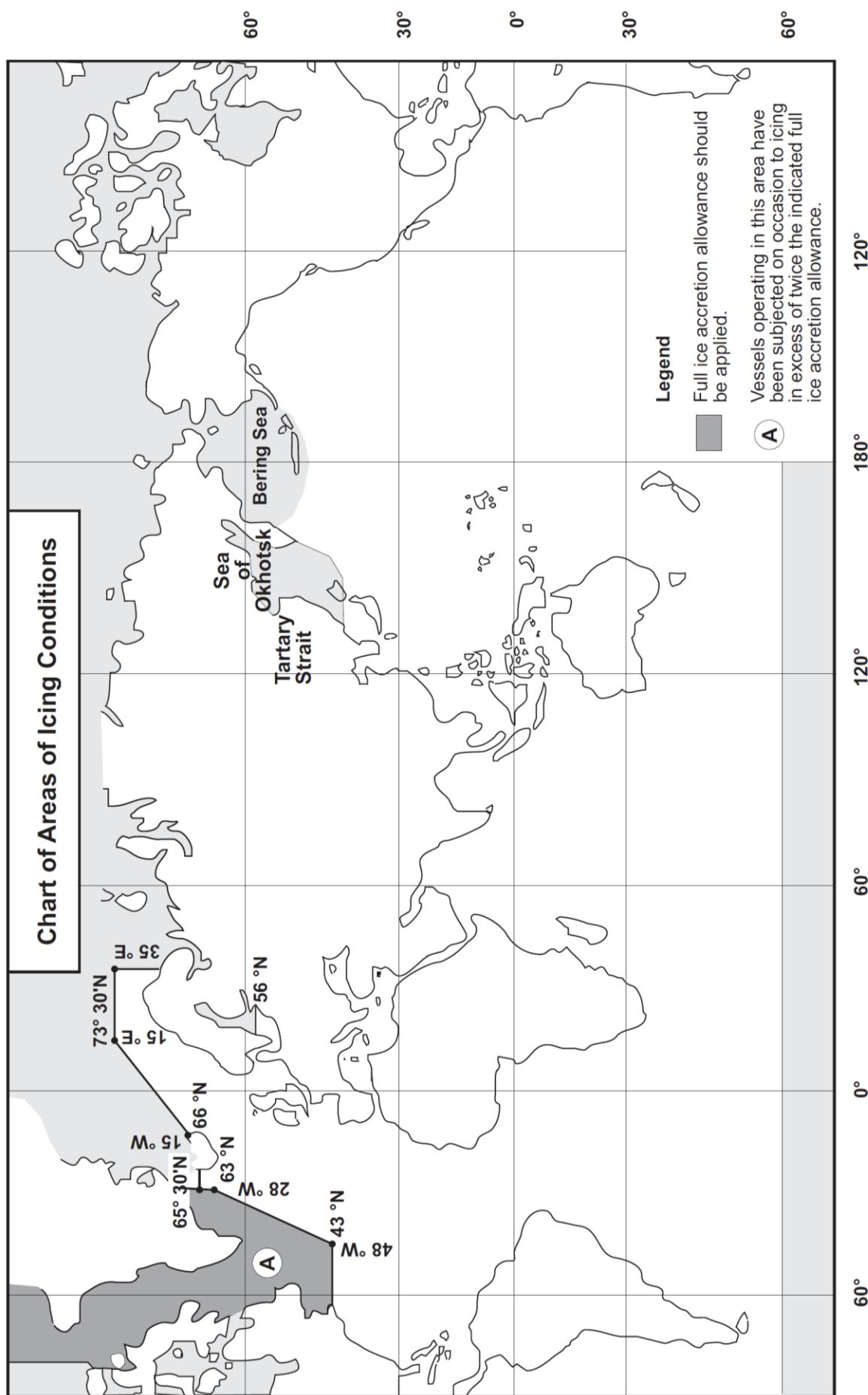
- .4 The Bering and Okhotsk Seas and the Tartary Strait during the icing season.
- .5 South of latitude 60°.

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.



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## Annex 4 Stability of Hydrofoil Craft

1. Surface piercing hydrofoils ..... A4-1
2. Fully submerged hydrofoils..... A4-4

The stability of these craft shall be considered in the hull-borne, transitional and foil-borne modes. The stability investigation shall also take into account the effects of external forces. The following procedures are outlined for guidance in dealing with stability.

As required by 2.3.1, the stability of hydrofoil craft shall be assessed under all permitted conditions of loading.

The term "hull-borne mode" has the same meaning as "displacement mode" defined in 1.4.22 of the code.

The term "foil-borne mode" has the same meaning as "non-displacement mode" defined in 1.4.38 of the code.

### 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 the 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:

$$M_R = 0,196 \cdot \frac{V_0^2}{L} \cdot \Delta \cdot KG \quad [kN.m]$$

Where:

$M_R$  = moment of heeling

$V_0$  = 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 crafts is 2 to 4.

#### 1.1.3 Relationship between the capsizing moment and heeling moment to satisfy the weather criterion

The stability of a hydrofoil boat in the displacement mode can be checked for compliance with the weather criterion K as follows:

$$K = \frac{M_C}{M_V} \geq 1$$

where:

- $M_c$  = minimum capsizing moment as determined when account is taken of rolling  
 $M_v$  = dynamically applied heeling moment due to the wind pressure

#### 1.1.4 Heeling moment due to wind pressure

The heeling moment  $M_v$  shall be taken as constant during the whole range of heel angles and calculated by the following expression:

$$M_v = 0,001 \cdot P_v \cdot A_v \cdot Z \quad [\text{kN.m}]$$

where :

- $P_v$  = wind pressure =  $750 (V_w/26)^2 (\text{N/m}^2)$   
 $A_v$  = windage area including the projections of the lateral surfaces of the hull, superstructure and various structures above the waterline ( $\text{m}^2$ )  
 $Z$  = 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 When the static stability curve is used,  $M_c$  is determined by equating the areas under the curves of the capsizing and righting moments (or levers) taking rolling into account, as indicated by Fig. A4.1, 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.

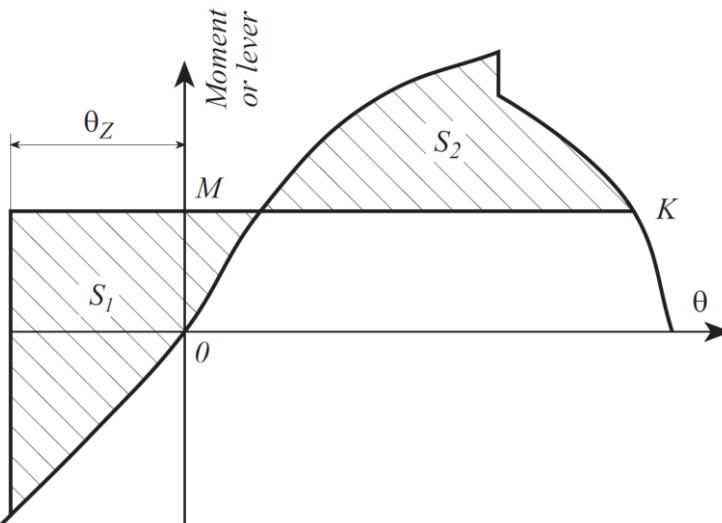


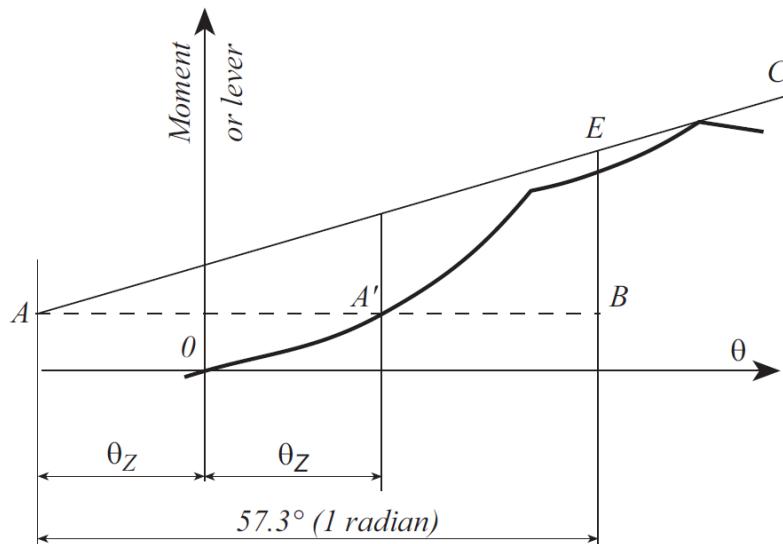
Fig. A4.1 Static stability curve

- $M_c$  = OM, if the scale of ordinates represents moments,  
 $M_c$  = OM · displacement, if the scale of ordinates represents levers.

- .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 Fig. A4.2). 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 BE is equal to the capsizing moment if measured along the ordinate axis of the dynamic stability curve. If, however, the dynamic stability levers are plotted along this axis, BE is then the capsizing lever, and in this case the capsizing moment  $M_c$  is determined by multiplication of ordinate BE (in metres) by the corresponding displacement in tonnes

$$M_c = 9.81 BE \text{ (kNm)}$$



**Fig. A4.2 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 models

1.2.1 The stability shall satisfy the provisions of 2.4 and 2.5 of this Code.

1.2.1.1 The stability in the transitional and foil-borne modes shall be checked for all cases of loading for the intended service of the craft.

1.2.1.2 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 settling to hull-borne modes, these results will provide an indication of the values of the stability in the various situations of the craft during the transitional condition.

1.2.1.3 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 5 to this Code.

**1.2.2** One of the possible methods of assessing foil-borne metacentric height (GM) in the design stage for a particular foil configuration is given in Fig. A4.3.

$$GM = n_B \cdot \left( \frac{L_B}{2 \cdot \tan l_B} - S \right) + n_H \cdot \left( \frac{L_H}{2 \cdot \tan l_H} - S \right)$$

where:

- $n_B$  = percentage of hydrofoil load borne by front foil
- $n_H$  = percentage of hydrofoil load borne by aft foil
- $L_B$  = clearance width of front foil
- $L_H$  = clearance width of aft foil
- $a$  = clearance between bottom of keel and water
- $g$  = height of centre of gravity above bottom of keel
- $l_B$  = angle at which front foil is inclined to horizontal
- $l_H$  = angle at which aft foil is inclined to horizontal
- $S$  = height of centre of gravity above water

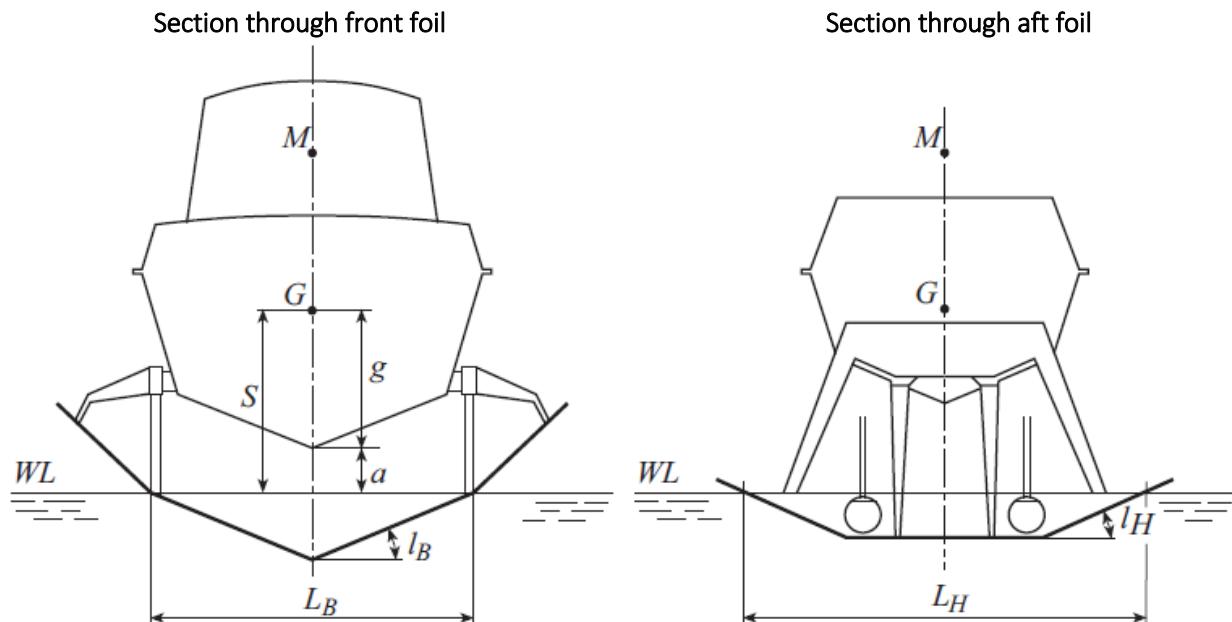


Fig. A4.3

## 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.

## 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.

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## Annex 5 Stability of Multihull Craft

- |    |  |      |
|----|--|------|
| 1. | Stability criteria in the intact condition .....   | A5-1 |
| 2  | Criteria for Residual stability after damage ..... | A5-3 |
| 3. | Application of heeling levers.....                 | A5-4 |

### 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:

$$A_1 = 0,055 \times 30^\circ / \theta \quad [\text{m.rad}]$$

Where:

- $\theta$  = 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:

$$HL_1 = \frac{P_i \cdot A \cdot Z}{9800 \cdot \Delta} \quad [\text{m}]$$

$$HL_2 = 1,5 \cdot HL_1 \quad [\text{m}] \quad (\text{see Fig. A5.1})$$

where:

$$P_i = 500 (V_w/26)^2 \quad [\text{N/m}^2]$$

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:

$$TL = \frac{1}{g} \frac{V_0^2}{R} \left( KG - \frac{d}{2} \right) \quad [m]$$

where:

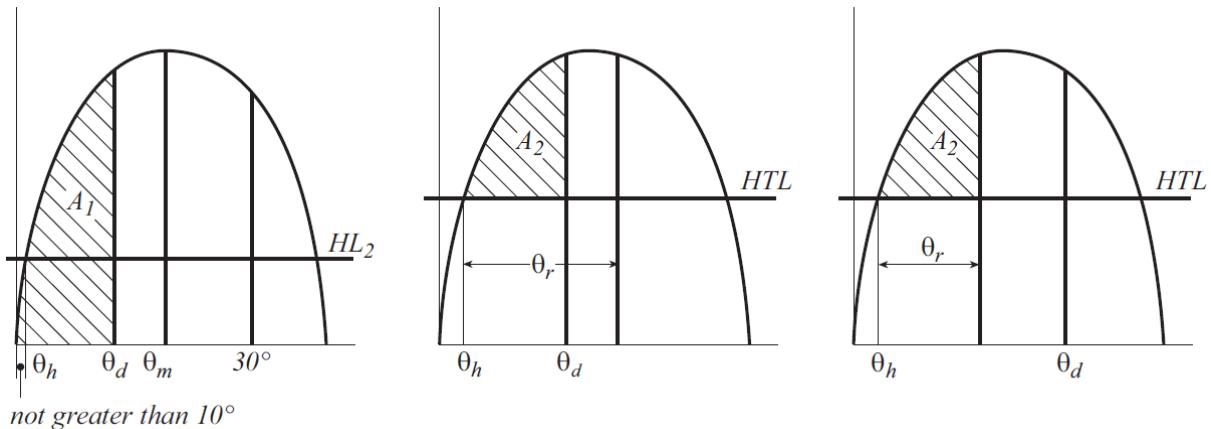
- TL = turning lever [m]  
V<sub>0</sub> = speed of craft in the turn [m/s]  
R = turning radius [m]  
KG = height of vertical centre of gravity above keel [m]  
d = mean draught [m]  
g = acceleration due to gravity

Alternatively, another method of assessment may be employed, as provided for in [2.1.4](#) of this Code.

## **1.5 Rolling in waves (Fig. A5.1)**

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 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° or an angle of ( $\theta_d - \theta_h$ ), whichever is less.

The determination of  $\theta_r$  using model test or other data shall be made using the method for determining  $\theta_z$  in [1.1.5.3](#) of [Annex 4](#).



**Fig. A5.1 Intact Stability**

Abbreviations used in Fig. A5.1 & Fig. A5.2

HL <sub>2</sub>	=	Heeling lever due to wind + gusting
HTL	=	Heeling lever due to wind + gusting + (passenger crowding or turning)
HL <sub>3</sub>	=	Heeling lever due to wind
HL <sub>4</sub>	=	Heeling lever due to wind + passenger crowding
θ <sub>m</sub>	=	Angle of maximum GZ
θ <sub>d</sub>	=	Angle of downflooding
θ <sub>r</sub>	=	Angle of roll
θ <sub>e</sub>	=	Angle of equilibrium, assuming no wind, passenger crowding or turning effects
θ <sub>h</sub>	=	Angle of heel due to heeling lever HL <sub>2</sub> , HTL, HL <sub>3</sub> or HL <sub>4</sub>
A <sub>1</sub>	≥	Area required by 1.1
A <sub>2</sub>	≥	0,028 m.rad

## 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<sub>2</sub> shall be not less than 0,028 m.rad (Fig. A5.2 refers); and
- .2 there is no requirement regarding the angle at which the maximum GZ value shall occur.

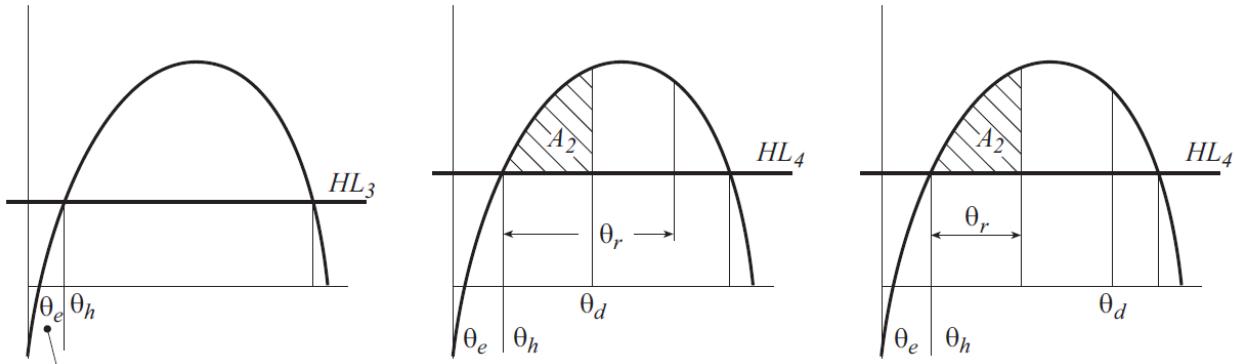
**2.2** The wind heeling lever for application on the residual stability curve shall be assumed constant at all angles of inclination and shall be calculated as follows:

$$HL_3 = \frac{P_d \cdot A \cdot Z}{9800 \cdot \Delta}$$

Where:

$$P_d = 120 (V_w / 26)^2 \quad [N/m^2]$$

- $V_w$  = 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 ( $m^2$ )  
 $Z$  = vertical distance from the centre of A to a point one half of the lightest service draught (m)  
 $\Delta$  = displacement (t)



*not greater than 15° for passenger craft and 20° for cargo craft*

**Fig. A5.2 Damage Stability**

**2.3** The same values of roll angle shall be used as for the intact stability, as determined in [1.5](#) of this Annex.

**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:

**.1** for intact condition:

**.1.1** wind heeling lever (including gusting effect) ( $HL_2$ ); and

**.1.2** wind heeling lever (including gusting effect) plus either the passenger crowding or speed turning levers whichever is the greater ( $HTL$ ).

**.2** for damage condition:

**.2.1** wind heeling lever - steady wind ( $HL_3$ ); and

**.2.2** 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  $10^\circ$  and

**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  $15^\circ$  for passenger craft and  $20^\circ$  for cargo craft.

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## Annex 6 Stability of Monohull Craft

1. Stability criteria in the intact condition ..... A6-1
2. Criteria for residual stability after damage..... A6-2

### 1. Stability criteria in the intact condition

**1.1** The weather criterion contained in paragraph 3.2 of the Intact Stability Code<sup>1</sup> shall apply. In applying the weather criterion, the value of wind pressure P (N/m<sup>2</sup>) shall be taken as:

$$P = 500 \cdot \left( \frac{V_w}{26} \right)^2 \quad [\text{N/m}^2]$$

Where:

$V_w$  = wind speed (m/s) corresponding to the worst intended condition.

The angle of heel due to wind, in applying paragraph 3.2.2.1.2 of the Intact Stability Code, shall not exceed 16° or 80% of the angle of deck-edge immersion (whichever is less). Where the angle of heel due to wind exceeds 10°, efficient non-slip deck surfaces and suitable holding points shall be provided, in accordance with paragraph 2.13.1.1 of this Code. 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 using the method for determining  $\theta_z$  in 1.1.5.3 of Annex 6. Hulls with features which greatly increase damping, such as immersed sidehulls, substantial arrays of foils, or flexible skirts or seals, are likely to experience significantly smaller magnitudes of roll angle. For such craft, therefore, the roll angle shall be derived from model or full scale tests or, in the absence of such data, shall be taken as 15°.

**1.2** The area under the righting lever curve (GZ curve) shall not be less than 0,07 m.rad 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:

$$A = 0,055 + 0,001 (30^\circ - \theta_{\max}) \quad [\text{m.rad}]$$

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  $\theta_F$ ,<sup>2</sup> if this angle is less than 40° shall not be less than 0,03 m.rad.

**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 GMT shall not be less than 0,15 m.

<sup>1</sup> 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).

<sup>2</sup> In applying this criterion, small openings through which progressive flooding cannot take place need not be considered open.

## 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:

$$\frac{15}{\text{range}}$$

where the range is expressed in degrees. The range shall be taken as the difference between the equilibrium heel angle and the heel angle at which the residual righting lever subsequently becomes negatives or the angle at which progressive flooding occurs, whichever less.

**2.1.2** The area under 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, calculated by the formula:

$$GZ = \frac{\text{heeling moment}}{\text{displacement}} + 0,04 \quad [\text{m}]$$

However, in no case, the 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 at 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  $\left(120 \left\{ \frac{V_w}{26} \right\}^2 \right) [\text{N/m}^2]$ , 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 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 0,05m 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.

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## Annex 7 Definitions, Requirements and Compliance Criteria related to Operational and Safety Performance

1.	Performance.....	A7-1
2.	Stopping .....	A7-2
3.	Cruise Performance .....	A7-2
4.	Effects of Failures or Malfunction.....	A7-3

This Annex applies to all types of craft. Tests to evaluate operational safety shall be conducted on the first 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.

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 90 % of maximum speed;
- .2 emergency stop for 90 % of maximum speed; and
- .3 crash stop from 90 % of maximum 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 1](#) 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 1](#) 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 1](#). 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 1](#) and of vertical accelerations close to the craft longitudinal centre of gravity.

RMS values could be used for extrapolation of peak values. To obtain the expected peak values related to structural design load and safety levels (one per 5-min exceedance), multiply the RMS values by 3,0 or

$$C = \sqrt{2 \ln N}$$

where:

N is the number of successive amplitudes within the relevant period.

If not otherwise verified by model tests or by mathematical calculations, it might be assumed a linear relation between wave height and accelerations based on measurements in the two sea conditions. The worst intended conditions shall not exceed 150% of the more severe of the two measured sea conditions. Limits for worst intended condition shall be documented both related to passenger safety in accordance with 2.4 of Annex 1 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 90 % of maximum speed the accelerations shall not exceed safety level 1 in Annex 1 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 the worst intended conditions, with reduced speed as necessary, the accelerations shall not exceed safety level 2 in Annex 1 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 1 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 8 Criteria for Testing and Evaluation of Seats**

1.	Purpose and Scope.....	A8-1
2.	Static Seat Tests .....	A8-1
3.	Dynamic Seat Tests .....	A8-2

### **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 3g.

### 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 3g 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 Fig. A8.1 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 equivalent 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.

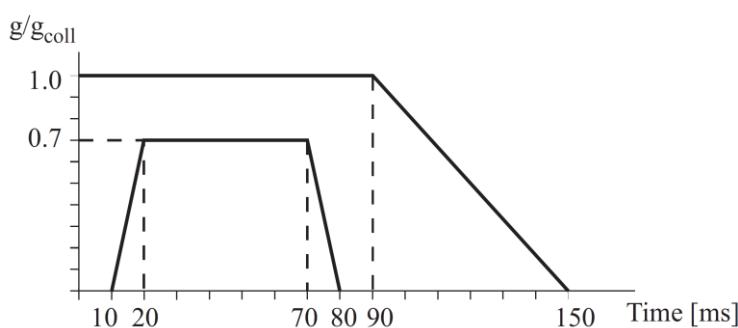


Fig. A8.1 Acceleration time-history envelope

- 3.5 During the dynamic seat test, a fiftieth percentile anthropomorphic test dummy, suitable for the test being conducted<sup>1</sup>, shall be placed in the seat in an upright seating position. If a typical seating unit is

<sup>1</sup> Refer to the Hybrid III human surrogate (unless a more advanced test dummy is available).

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<sup>2</sup> 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.

**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 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<sup>3</sup>.

**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

$$HIC = (t_2 - t_1) \left[ \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t) dt \right]^2$$

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 30g except for periods totalling less than 3 ms

$$TTI = \frac{g_R + g_{LS}}{2} \text{ or acceleration at the centre of gravity}$$

where:

$g_R$  is the acceleration in g of either the upper or lower rib;

<sup>2</sup> Refer to ECE 80 with addendum 79. Other national standards may be acceptable.

<sup>3</sup> Refer to the specifications of International Standard ISO 6487 - Technique of measurement in impact tests (1987) or SAE J211 -Instrumentation.

$g_{LS}$  is the acceleration in g of the lower spine; and

.3.3 neck flexion does not exceed 88 Nm;

.3.4 neck extension does not exceed 48 Nm;

.3.5 in lieu of the requirements of subparagraphs .3.3 and .3.4 above, a seatback or headrest of at least 850 mm above the seat cushion is acceptable; and

.3.6 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 9 Open Reversible Liferafts

1.	General .....	A9-1
2.	Construction .....	A9-1
3.	Open Reversible Liferaft Fittings .....	A9-2
4.	Containers for Open Reversible Inflatable Liferafts .....	A9-4
5.	Markings on Open Reversible Inflatable Liferafts .....	A9-4
6.	Instructions and Information .....	A9-5
7.	Testing of Open Reversible Inflatable Liferafts .....	A9-5

### 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 °C to +65 °C;
  - .3 be capable of operating throughout an air temperature range of -18 °C to +65 °C and a seawater temperature range of -1 °C to +30°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.<sup>1</sup>

### 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

<sup>1</sup> 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 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 °C and 20 °C and within a period of three minutes at an ambient temperature of -18 °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 bowsing-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 x 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.

Omittances and substitution, as described above, shall be reflected in the type approval certificate.

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## Annex 10 Factors to be Considered in Determining Craft Operating Limitations<sup>1</sup>

1.	Purpose and Scope.....	A10-1
2.	Factors to be considered .....	A10-1

### 1. Purpose and Scope

The purpose of this annex is to identify the parameters to which consideration should be given when determining the worst intended conditions (defined in [1.4.61](#)) and other operational limitations (defined in [1.4.41](#)) for insertion into the Permit to Operate, in order to facilitate consistent application of the Code.

### 2. Factors to be considered

As a minimum, the following factors shall be considered:

- .1 The maximum distance from refuge implied by [1.3.4](#).
- .2 The availability of rescue resources to comply with [1.4.12.1](#) (category A craft only).
- .3 Minimum air temperature (susceptibility to icing), visibility and depth of water for safe operation as addressed by [1.4.61](#).
- .4 The significant wave height and maximum mean wind speed used when applying the requirements for stability and buoyancy in [Section 2](#) and associated annexes.
- .5 The safe seakeeping limitations (especially significant wave height) considering the known stability hazards listed in [2.1.5](#), the operating conditions on the intended route (see [18.1.3.2](#)) and the motions experienced during operation defined in [3.3](#) of [Annex 7](#).
- .6 The structural safety of the craft in critical design conditions according to [Section 3](#).
- .7 The safe deployment and operation of evacuation systems and survival craft as required by [8.6.5](#).
- .8 The safe handling limitations determined in accordance with the sea trials required by [Section 17](#) and [Annexes 1 and 7](#), identifying any limitations on weight and centre of gravity position according to [17.3](#), and the effects of failures and malfunctions according to [17.4](#).

<sup>1</sup> Refer to the guidelines to be developed by the Organization.

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