

RUSSIAN MARITIME REGISTER OF SHIPPING

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# RULES

## FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

VOLUME

1



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**LIST OF CIRCULAR LETTERS AMENDING/SUPPLEMENTING NORMATIVE DOCUMENT**

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Item No.	Circular letter No., date of approval	List of amended and supplemented paras

Rules for the Classification and Construction of Sea-Going Ships of Russian Maritime Register of Shipping have been approved in accordance with the established approval procedure. The date of coming into force of the present Rules is 1 October 2008.

The Rules are based on the eleventh edition (2007) taking into account amendments developed immediately before publication.

The unified requirements, interpretations and recommendations of the International Association of Classification Societies (IACS) and the relevant resolutions of the International Maritime Organization (IMO) have been taken into consideration in the Rules.

The Rules are published in five volumes.

General Regulations for the Classification and Other Activity, Part I "Classification", Part II "Hull", Part III "Equipment, Arrangements and Outfit", Part IV "Stability", Part V "Subdivision", Part VI "Fire Protection" are included in Volume 1.

Part VII "Machinery Installations", Part VIII "Systems and Piping", Part IX "Machinery", Part X "Boilers, Heat Exchangers and Pressure Vessels", Part XI "Electrical Equipment", Part XII "Refrigerating Plants", Part XIII "Materials", Part XIV "Welding", Part XV "Automation", Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats" are included in Volume 2.

The text of the Rules in the Russian language published in 2008 shall be considered as the original.

Part XVII "Common Structural Rules for Double Hull Oil Tankers" is included in Volume 3.

In case of contradictions in the texts the English text shall be considered as the original.

Part XVIII "Common Structural Rules for Bulk Carriers" is included in Volume 4.

In case of contradictions in the texts the English text shall be considered as the original.

Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" is included in Volume 5.

The text of the Rules in the Russian language published in 2008 shall be considered as the original.

*As compared to the previous edition (2007), the twelfth edition contains the following amendments.*

## **GENERAL REQUIREMENTS FOR THE CLASSIFICATION AND OTHER ACTIVITY**

Chapter 1.3: Rules for the Prevention of Pollution from Ships (invalid since 1 January 2007) have been deleted from the list of rules applied by the Register.

## **RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS**

### **PART I. CLASSIFICATION**

1. Chapter 1.1: the definition of "Ro-ro passenger ship" has been specified as regards ferries classed among passenger ro-ro ships as well;

the definition of "Berth-connected ship" has been specified as regards floating docks and berth-connected ships in operation when bottomed;

new definitions of "Barge" and "Barge-carrier (lighter carrier)" have been introduced;

the term "Shipborne barge" has been amended to read "Shipborne barge (lighter)", and the words "barge carriers" have been amended to read "barge carriers, lighter carriers";

the text of explanation "Date of contract for construction of a ship (series of ships)" has been amended in compliance with IACS PR No.29 (Rev. 4, June 2007) according to the Register circular letter No. 007-2.1-260 of 20.07.2007.

2. Chapter 2.2: para 2.2.3: the paragraph heading has been amended to read "Ice category marks and polar class marks";

para 2.2.3.1: reference has been made to the new Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships", which takes into consideration the IACS UR I1, I2 and I3 for polar class ships;

para 2.2.3.7: in the column "Rules, edition 1995" of Table 2.2.3.7 ice category marks for ice class ships and icebreakers have been amended according to the Register circular letter No. 007-264 of 16.08.2007;

new distinguishing marks have been introduced:

the Chapter has been supplemented with a new para 2.2.12 "Distinguishing mark for ships fitted with equipment for icing protection";

the Chapter has been supplemented with a new para 2.2.13 "Distinguishing mark for a ship intended for carriage of packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes (INF cargo)";

the Chapter has been supplemented with a new para 2.2.14 "Distinguishing mark for ships fitted with a loading instrument";

the Chapter has been supplemented with a new para 2.2.15 "Distinguishing mark for ships fitted with a cargo vapour discharge system";

the Chapter has been supplemented with a new para 2.2.16 "Distinguishing mark for ships fitted with an inert gas system";

the Chapter has been supplemented with a new para 2.2.17 "Distinguishing mark for ships fitted with a crude oil washing system";

the Chapter has been supplemented with a new para 2.2.18 "Distinguishing mark for ships fitted with a centralized cargo control system";

the Chapter has been supplemented with a new para 2.2.19 "Distinguishing marks for ships of high ecological safety";

the Chapter has been supplemented with a new para 2.2.20 "Distinguishing mark for ships complying with ballast water management requirements";

the Chapter has been supplemented with a new paragraph 2.2.21 "Distinguishing marks for ships fitted with a diving system permanently installed on the ship";

the Chapter has been supplemented with a new para 2.2.22 "Distinguishing mark for ships fitted with a manned submersible";

the numbering of subsequent paragraphs has been amended accordingly.

3. Chapters 3.2 and 3.3 specifying the scope of ship documentation to be submitted for the Register consideration have been supplemented by necessary documents, as stipulated by the Register Rules.

## **PART II. HULL**

1. Chapters 1.1 and 1.2: have been amended as regards protective coatings of ballast tanks inner surfaces basing on IMO resolutions MSC.215(82) and MSC.216(82).

2. Chapter 1.2: has been amended as regards requirements for clad steel base metal.

3. Para 3.10.1.1.1: has been supplemented with a reference to Section 1, Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships", which takes into consideration the IACS UR I1, I2 and I3 for polar class ships.

## **PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT**

1. Chapters 4.3 and 5.3: have been amended considering IACS URA2 (Rev.3 July 2007).

2. Chapter 8.6: has been amended considering IACS UI LL47.

3. Editorial amendments have been made.

## **PART IV. STABILITY**

1. Para 1.4.7: has been amended considering requirements of IMO resolution A.749(18) and IACS UI LL61.

2. Para 1.4.11.2 and Chapter 1.5: has been amended considering requirements of IMO MSC1/Circ.1158.

3. Chapter 2.1: has been amended considering requirements of IMO MSC1/Circ.1200 and MSC1/Circ.1227.

4. Chapter 3.2: has been supplemented with para 3.2.6 considering requirements of Regulation XII/11.3 of SOLAS-74.

5. Paras 1.1.1, 1.5.10, 1.5.11.3, 2.1.2.1, 2.2.4, 3.3.9, 4.1.8.1.6: editorial amendments have been made.

6. Appendix 1: paras 4.1.5, 4.1.6 and 4.1.8: have been amended considering requirements of Regulation II-1/5.1 of SOLAS-74 (IMO resolution MSC.194(80));

para 3.1.1.4: has been amended considering provisions of IMO MSC1/Circ.1228;

paras 2.1.14, 5.1.3: editorial amendments have been made.

## **PART V. SUBDIVISION**

1. Chapters 1.1, 3.4: have been amended considering requirements of IMO resolution MSC.194(80).

2. Chapters 1.5, 3.3 and 3.4, paras 6.1.1, 6.1.5, 6.3.3 and 6.3.4: have been amended as regards requirements for the damage trim and stability of supply vessels, and clarifications have been introduced on implementation of subdivision mark in the class notation in accordance with the "Guidelines for the Design and Construction of Offshore Supply Vessels" (IMO resolution MSC.235(82)).

## **PART VI. FIRE PROTECTION**

1. Chapter 1.2: a new definition "Cabin balcony" has been introduced in accordance with Regulation II-2/3.53 of SOLAS-74.

2. Chapter 2.1: has been amended considering provisions of IMO resolution MSC.216(82) concerning requirements for primary deck coverings and finishes for cabin balconies on passenger ships as regards the potential of releasing smoke and toxic products at elevated temperatures.

3. Chapter 2.2: has been amended considering provisions of IMO resolution MSC.216(82) as regards the requirements for fire growth potential of furniture, linings, ceilings, partial bulkheads and decks of cabin balconies on passenger ships.

4. Chapter 2.4: para 2.4.5 has been amended as regards restriction on boundary openings in accordance with IMO resolution MSC.216(82).

5. Chapter 3.4: the requirement of IMO resolution MSC.216(82) as regards fixed fire-extinguishing system which shall be installed on cabin balconies of passenger ships has been introduced;

the provisions of IMO resolution MSC.217(82) as regards the approval by Administrations of fixed pressure water-spraying fire-extinguishing systems for cabin balconies and water-mist fire-extinguishing systems for machinery spaces and cargo pump-rooms have been introduced.

6. Chapter 3.7: para 3.7.2.1 has been supplemented with the requirement of IMO resolution MSC.217(82) as regards the time limit for discharging by the foam fire-extinguishing system a quantity of foam sufficient to produce an effective foam blanket.

7. Chapter 4.2: the requirement of IMO resolution MSC.216(82) as regards fixed fire detection and fire alarm system to be installed on cabin balconies of passenger ships has been introduced;

the provisions of IMO resolution MSC.217(82) as regards the approval by Administrations of the fixed fire detection and fire alarm systems for cabin balconies have been introduced.

8. Chapter 5.1: has been amended considering the requirement of IMO Resolution MSC.217(82) as regards design and performance of portable foam applicators.

9. Editorial amendments have been made.

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# GENERAL REGULATIONS FOR THE CLASSIFICATION AND OTHER ACTIVITY

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## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The present General Regulations for the Classification and Other Activity cover the activity of Russian Maritime Register of Shipping<sup>1</sup> during:

consideration and agreement of technical documentation for the construction, repair, conversion and modernization of ships and fixed offshore platforms<sup>2</sup>, for the manufacture of materials and products for ships and FOP;

technical supervision of the construction, repair, conversion and modernization of ships and FOP;  
survey of ships and FOP in service.

The classification activity of the Register is based on Regulations Concerning the Classification of Ships and Fixed Offshore Platforms.

The Register activity in other spheres is regulated by relevant documents.

### 1.2 CLASSIFICATION AND OTHER ACTIVITY

**1.2.1** The Register is a state institution which carries out surveys of and assigns class to civil ships. The Register is a member to International Association of Classification Societies (IACS) and uses IACS resolutions and the provisions of IACS Code of Ethics in its activity.

The Register maintains a quality system complying with the requirements of IACS and with the applicable requirements of ISO 9001 which is confirmed by the relevant IACS Certificate issued on the basis of appropriate audits.

Besides, being authorized by the government of the Russian Federation<sup>3</sup> and by the governments of other countries to act on their behalf, the Register carries out surveys within its terms of reference for compliance with the requirements of international conventions and agreements to which the above governments are parties.

**1.2.2** The Register establishes technical requirements ensuring safe operation of ships and FOP in accordance with their purpose, safety of life at sea and safe carriage of goods by sea and inland waterways as well as pollution prevention from ships; it

carries out surveys for compliance with the above requirements, assigns class to ships and FOP, determines the net and gross tonnage of sea-going ships and FOP and the tonnage measurement characteristics of inland navigation ships in its registry.

**1.2.3** The Register activity is based on the rules published by that body and is aimed at determining whether ships and FOP in its registry as well as materials and products intended for the construction and repair of ships and FOP and their equipment comply with the rules and with additional requirements. The application and fulfillment of the rules and additional requirements are the obligation of design bureaus, shipowners, shipyards and manufacturers of materials and products to which the requirements of the rules apply.

The interpretation of the requirements of the Register rules and other normative documents is within the competence of the Register only.

The Register activity does not substitute for the state surveillance of merchant shipping carried out by both the federal body of executive power responsible for transport and the federal body of executive power responsible for fisheries, nor does it interfere with shipowners, shipyards or manufacturers technical control.

**1.2.4** Classification activity of the Register covers the following:

.1 development and publication of rules and other normative documents;

.2 consideration and approval of technical documentation;

.3 construction, conversion, modernization and repair surveys of ships and FOP, manufacture and repair surveys of products as well as manufacture surveys of materials for shipbuilding;

.4 surveys of ships and FOP in service;

.5 assignment, renewal and reinstatement of class;

.6 drawing up and issue of the Register certificates.

**1.2.5** Other activity of the Register covers:

.1 construction, conversion, modernization and repair surveys of ships and FOP as well as manufacture and repair surveys of products and manufacture surveys of materials for shipbuilding for compliance with the provisions of international conventions and agreements;

.2 ship and FOP registry;

.3 investigation and registry of accidents aboard ships;

.4 initiative surveys of ships;

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<sup>1</sup> Hereinafter referred to as "the Register".

<sup>2</sup> Hereinafter referred to as "FOP".

<sup>3</sup> Hereinafter referred to as "RF".

.5 judgement in technical matters;

.6 other activity not connected with classification of ships and FOP.

**1.2.6** The Register carries out classification of the following types of sea-going ships, ships of inland navigation and fixed offshore platforms both under construction and in service:

.1 passenger ships and tankers, tugs, ships designed for the carriage of dangerous goods, sea-going pleasure boats with passenger capacity above 12, all these irrespective of their main engine power and gross tonnage;

.2 self-propelled ships not mentioned under 1.2.6.1 with main engine power of 55 kW and above;

.3 ships not mentioned under 1.2.6.1 and 1.2.6.2 with a gross tonnage of 80 and above or with the total power of prime movers of 100 kW and above;

.4 fixed offshore platforms of different purposes.

**1.2.7** The Register carries out surveys of ship refrigerating plants from the point of view of ship's safety, safe carriage of goods, absence of the ozone-destructive effect of refrigerants upon the environment, as well as the classification of ship refrigerating plants.

**1.2.8** The Register carries out surveys of ship cargo-handling gear of 1 t lifting capacity and upwards.

**1.2.9** On special agreement, the Register may carry out surveys of ships, installations or arrangements not specified in 1.2.6 to 1.2.8.

**1.2.10** The technological and special arrangements of fishing vessels, cable layers, vessels of dredging fleet and special purpose ships are not subject to the Register survey except the equipment specified in the relevant parts of the rules.

**1.2.11** Draft standards and other normative documents related to the Register activity are considered and approved by the Register.

**1.2.12** The Register may initiate examinations of technical issues related to its activity or participate therein.

**1.2.13** The Register of Ships is published by the Register, containing the particulars of self-propelled sea-going ships of 100 gross tonnage and upwards classed with the Register.

**1.2.14** For services rendered by the Register fees are charged according to the scales of fees of the Register. If the commitments to the Register including those on payment for its services fail to be performed or are improperly performed, the Register is entitled not to assign a class or, where a class has already been assigned, to suspend or withdraw it from the ship in connection with which the commitments to the Register, including those on payment for its services failed to be performed or were improperly performed, and to withdraw (make an entry indicating cessation of validity) the certificates issued by the Register.

### 1.3 RULES

#### 1.3.1 Rules to be applied.

**1.3.1.1** The following rules are developed, published and used by the Register:

.1 Rules for the Classification and Construction of Sea-Going Ships;

.2 Rules for the Equipment of Sea-Going Ships;

.3 Load Line Rules for Sea-Going Ships;

.4 Rules for the Cargo-Handling Gear of Sea-Going Ships;

.5 Rules for the Classification Surveys of Ships in Service;

.6 Rules for the Classification and Construction of Inland Navigation Ships (for the Danube);

.7 Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units (MODU) and Fixed Offshore Platforms (FOP);

.8 Rules for the Classification and Construction of Chemical Tankers;

.9 Rules for the Classification and Construction of Nuclear Ships and Floating Facilities;

.10 Rules for the Classification and Construction of Nuclear Support Vessels;

.11 Rules for the Classification and Construction of Gas Carriers;

.12 Rules for the Classification and Construction of Manned Submersibles, Ship's Diving Systems and Passenger Submersibles;

.13 Rules for the Classification and Technical Supervision of Sea-Going Pleasure Boats;

.14 Rules for the Classification and Construction of High-Speed Craft;

.15 Rules for the Classification and Construction of Type A WIG Craft;

.16 Rules for the Carriage of Grain.

.17 Rules for the Construction of Hulls of Sea-Going Ships and Floating Facilities Using Reinforced Concrete;

.18 Rules for the Tonnage Measurement of Sea-Going Ships;

.19 Rules for the Tonnage Measurement of Inland Navigation Ships;

.20 Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

.21 Rules for the Survey of Ship Propulsion Plants for Compliance with Technical Standards of Noxious Substance Emission into the Air;

.22 Rules for the Classification and Construction of Small Sea Fishing Vessels.

**1.3.1.2** Besides the rules mentioned under 1.3.1.1, the following rules are applied in the Register activity:

.1 Rules for the Measurement of Vessels for the Panama Canal;

**.2** Rules for the Tonnage Measurement for the Suez Canal;

**.3** Rules of the RF River Register;

**.4** other external normative documents approved by the Register.

**1.3.1.3** The Register also develops, publishes and uses guidelines on the survey of ships, FOP, materials and products for shipbuilding as well as other guidelines and technical requirements regulating the Register activity in other spheres.

**1.3.2 Application of the rules to ships and FOP under construction, materials and products.**

**1.3.2.1** Newly published rules and amendments thereto come into force on the date stated in the annotation on the back of the title page. Before that date, they shall be considered recommendations.

**1.3.2.2** For newly built ships and FOP the rules or amendments thereto as in effect on the date of signing the contract for construction of a ship (series of sister ships) or the FOP respectively are generally applied.

If the ship/FOP design is submitted to the Register for approval before the date of signing the contract for construction, the Rules or amendments thereto as in effect on the date of the customer's request for the design review are applied. In this case, if the new rules or amendments thereto, according to which the ship/FOP design was approved become effective on the date of signing the contract for construction of a ship/FOP, the design shall be revised for compliance with the above rules or amendments.

**1.3.2.3** Materials and products, technical documentation on which is submitted to the Register for approval after the enforcement of the rules or amendments thereto, shall comply with the requirements of the above rules and amendments.

**1.3.3 Application of rules to ships and FOP in service.**

**1.3.3.1** For ships and FOP in service the requirements of the edition of the rules, according to which the ships and FOP were built, are applied, unless otherwise specified in the subsequent editions of the rules and notices of amendments thereto issued after publication of the above rules.

**1.3.3.2** For ships and FOP in service, classified by the Register for the first time, the requirements of the rules effective for the period of construction of the given ship/FOP considering the requirements of subsequent editions of the rules, which apply to ships and FOP in service.

**1.3.3.3** The scope of application of the newly published rules to ships and FOP in service, repair after an accident or other similar cases, as well as at conversion, shall be specified by the Register con-

sidering practicability and technical feasibility in each particular case.

**1.3.4 Deviations from the Rules.**

**1.3.4.1** The Register may allow to use materials and products, ship structures, FOP or their separate arrangements, other than those required by the rules, provided they are as effective as those specified by the rules. Where ships and FOP covered by international conventions and agreements are concerned, deviations from the requirements of the rules may only be allowed by the Register if they are accepted by the relevant conventions or agreements.

In the above cases, data shall be submitted to the Register enabling to ascertain that the materials, structures and products in question meet the requirements ensuring the ship/FOP safety, safety of life at sea, safe carriage of goods by sea and by inland waterways as well as ecological safety of the environment.

**1.3.4.2** Where the structure of a ship, FOP, machinery, arrangements, installations, equipment and outfit or the materials used cannot be recognized as being adequately verified in service, the Register may require special tests to be held during construction and, in case of a ship in service, may reduce intervals between periodical surveys or extend the scope of these surveys.

If the Register considers it necessary, appropriate restrictive entries may be made in the classification or other certificates issued by the Register and in the Register of Ships. The restrictions are withdrawn subsequent to satisfactory results obtained in service.

**1.4 DOCUMENTS**

**1.4.1** As a result of its activity, the Register issues relevant certificates:

**.1** certificates confirming compliance with the requirements of Rules for the Classification and Construction of Sea-Going Ships and rules for the classification and construction of particular types of ships;

**.2** seaworthiness certificates stipulated by the Merchant Shipping Code;

**.3** certificates stipulated by international conventions and codes;

**.4** survey reports serving as the basis for issuing relevant certificates;

**.5** certificates for materials and products confirming their compliance with the requirements of the Register rules.

## **1.5 THE REGISTER RESPONSIBILITIES**

**1.5.1** The Register entrusts carrying out inspections to experts adequately skilled and performing their duties with proper diligence.

The Register is responsible for failure to perform or for improper performance of its commitments only when found guilty (by intent or carelessness).

The Register covers the losses to persons entering with it into contractual relations, as stipulated by the Rules, and whose losses result from its failure to perform or improper performance of its contractual commitments due to carelessness, to the amount not exceeding the contract fees determined on the basis of the Register scales of fees and provided solely the causal relationship

has been proved between such failure to perform or improper performance of contractual commitments by the Register and the suffered losses.

## **1.6 CONFIDENTIALITY**

**1.6.1** The Register considers as confidential any information obtained in the course of rendering services and does not provide its contents or copies without prior agreement with the customer to outside organizations except for the following: in cases specified in the Register rules, upon the requirements of the current legislations, upon a decision of the court, on trials and at the request of flag states.

## 2 SURVEYS

### 2.1 GENERAL

**2.1.1** For the surveys to be carried out, the shipowners, administrations of shipyards, manufacturers and other enterprises shall ensure that the Register representatives have the opportunity to carry out ship surveys, as well as free access to all places where materials and products are manufactured and tested, and shall provide all conditions for the surveys to be carried out.

Where necessary, the Register may require to provide the access to surveyed items as well as the conditions for performing the work by Surveyors to the Register together with IACS auditors when the latter carry out audits of the Register quality system.

**2.1.2** Shipowners, shipyards, design bureaus and manufacturers shall fulfil the requirements of the Register or Surveyors to the Register when they are in the course of their duty.

**2.1.3** Any alterations on the part of shipowners, shipyards, design bureaus and manufacturers in respect of ship and FOP materials and structures, as well as products, to which the requirements of the Rules apply shall be approved by the Register before they are put into service.

**2.1.4** Controversial issues arising in connection with the Register activity may be transferred by shipowners, shipyards, manufacturers and other enterprises to the higher Register Branch Office. The judgement of the Register Head Office is final.

**2.1.5** The Register may refuse from a survey in case a shipyard or manufacturer systematically violates the Rules or if the other party to a contract violates it.

**2.1.6** When a material or product proves defective under a valid certificate, the Register may require additional tests or relevant repair to be carried out, and where the defects cannot be repaired, may cancel the certificate.

### 2.2 SURVEYS DURING THE MANUFACTURE OF MATERIALS AND PRODUCTS

**2.2.1** The relevant parts of the Rules contain lists of materials and products the manufacture of which shall be surveyed by the Register, as well as technological processes specified by the Register.

By special agreement, the Register may carry out the surveys of materials and products not mentioned in the above lists.

**2.2.2** Materials and products within the Register terms of reference shall be manufactured in accordance with technical documentation approved by the Register.

**2.2.3** During surveys, the Register may check compliance with structural, technological and production standards and processes which are not regulated by the Rules, but which may influence the fulfillment of the Rules requirements.

**2.2.4** During ship and FOP construction or repair, manufacture of materials and products, the Register shall approve the application of new materials, products and processes, or those submitted to it for the first time, that are within its terms of reference. For this purpose, specimens of the material, product or the new process shall be tested in the scope agreed with the Register subsequent to their technical documentation being approved by the Register.

**2.2.5** The Register surveys during the manufacture of materials and products are carried out by Surveyors to the Register, or may be entrusted by the Register to another classification body in accordance with Agreement on Mutual Substitution.

**2.2.6** In cases specified by the Register, the manufacturing works will be surveyed by the Register to inspect the facilities for manufacturing materials and products complying with the Register requirements.

**2.2.7** In the process of surveys during manufacture materials and products shall undergo the surveys and tests according to the procedures and within the scope prescribed by the Register.

**2.2.8** Materials and products manufactured in accordance with the Register requirements shall be provided with the documents specified by the Register and, where necessary, the brands and marking enabling to determine their compliance with the above documents.

**2.2.9** In sound cases, the Register may establish special conditions for the application of particular products.

### 2.3 SURVEYS OF SHIPS AND FOP UNDER CONSTRUCTION, RECONSTRUCTION AND CONVERSION

**2.3.1** Surveys of ships and FOP under construction, reconstruction and conversion are carried out by Surveyors to the Register on the basis of technical documentation approved by the Register. The scope of examinations, measurements and tests during surveys is determined by the Register on the basis of current instructions and proceeding from the situation.

## 2.4 SURVEYS OF SHIPS AND FOP IN SERVICE

**2.4.1** Surveys of ships and FOP in service is carried out according to Rules for the Classification Surveys of Ships in Service and other normative documents of the Register.

## 2.5 SURVEYS IN COMPLIANCE WITH THE REQUIREMENTS OF INTERNATIONAL CONVENTIONS AND AGREEMENTS

**2.5.1** The requirements of the following international conventions and agreements, as well as amendments thereto, are taken into account in the relevant Rules:

International Convention for the Safety of Life at Sea, 1974, Protocols, 1978, 1988 thereto;

International Convention for the Prevention of Pollution from Ships, 1973 and Protocol, 1978 thereto;

International Convention on Load Lines, 1966 and Protocol of 1988 Relating thereto (revised in 2003);

International Convention on Tonnage Measurement, 1969;

International Convention on Occupation Safety and Health (Dock Work), 1979 (ILO 152 );

Shipping Regulations for the Danube, 1975;

Convention on Tonnage Measurement of Ships of Inland Navigation, 1966;

International Regulations for Preventing Collisions at Sea, 1972;

Final Acts of the World Administrative Radio Conference, 1997;

IMO Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk;

IMO Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk;

IMO Code of Safety for High-Speed Craft;

IMO Code for the Construction and Equipment of Mobile Offshore Drilling Units;

IMO Code of Safety for Special Purpose Ships;

IMO Code of Safety for Diving Systems;

inter-governmental agreements on load lines in force;

other normative documents used in international sea-going practice.

The provisions of the above conventions and agreements apply to ships engaged on international voyages.

**2.5.2** Surveys of items falling under the requirements of international conventions and agreements are carried out in conformity with approved technical documentation and the normative documents of the Register considering the requirements of the above conventions and agreements.



# RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

## PART I. CLASSIFICATION

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### 1 GENERAL

#### 1.1 DEFINITIONS AND EXPLANATIONS

Definitions and explanations pertinent to the general terminology used in the normative documents of the Register are given in Part I "General Regulations for Technical Supervision" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

For the purpose of Rules for the Classification and Construction of Sea-Going Ships<sup>1</sup> the following definitions and explanations have been adopted (unless expressly provided otherwise in particular parts of the Rules).

##### 1.1.1 Definitions.

A barge is a non-self propelled cargo ship designed to be towed or pushed.

A barge carrier (lighter carrier) is a dry cargo ship carrying cargo in ship barges (lighters).

A tug is a ship specially intended for the towage and pushing of other ships and floating facilities.

Displacement of a light ship means the displacement of a ship without cargo, fuel oil, lubricating oil, ballast, fresh and boiler feed water in its tanks, provisions, consumable stores, and also without passengers, crew and their effects.

A cargo ship is any ship which is not a passenger ship (dry cargo ship, tanker, refrigerating transport ship, icebreaker, tug, pusher, salvage ship, vessel of dredging fleet, cable layer, special purpose ship and other non-passenger ship).

A hopper barge is a self-propelled or non-self-propelled ship intended for the carriage of spoil.

Reid vapour pressure is the pressure of liquid vapour established by standard procedure in the Reid tester at the temperature of 37,8 °C and at the gas to liquid volume ratio of 4:1.

Deadweight means the difference between the displacement of a ship at the load waterline corresponding to the summer freeboard assigned for the water with a density of 1,025 t/m<sup>3</sup> and the displacement of a light ship.

A vessel of dredging fleet is a self-propelled or non-self-propelled vessel intended for extraction and carriage of spoil.

A dredger is a self-propelled or non-self-propelled ship intended for extraction of spoil using dredging gear (buckets, suction pipes, grabs, etc.) and having no holds for the storage or carriage of spoil.

A combination carrier is a ship intended for the carriage of crude oil and petroleum products in bulk, as well as bulk cargoes (by these ships are meant ore/oil carriers, oil/bulk dry cargo carriers and similar ships).

A container ship is a ship intended for the carriage of goods in containers of the international standard and provided with the cellular guides in the holds.

A crane ship is a construction similar to the floating crane, but on a floating hull with ship lines or lines of a similar shape.

An icebreaker is a self-propelled ship intended for various types of icebreaking operations to maintain navigation in the freezing seas (for details refer to 2.2.3.1.1).

A timber carrier is a dry cargo ship intended for the carriage of deck timber cargo.

Place of refuge is any naturally or artificially sheltered aquatorium which may be used as a shelter by a ship under conditions likely to endanger the safety of the ship.

A bulk carrier is a one deck ship with top-side and hopper-side tanks in cargo spaces which is primarily intended for the carriage of bulk cargoes.

A roll-on/roll-off ship is a ship specially designed for transportation of various wheeled vehicles (cars, rolling stock, tracked vehicles, trailers with and without cargo), in which the cargo loading operations are performed preferably in a horizontal direction – by a roll-on/roll-off.

A docklift ship is a dry cargo ship adapted to carry out cargo handling operations using the docking principle in ports and protected water areas.

A tanker is a ship intended for the carriage of liquid cargoes in bulk, including:

a special tanker is a ship intended for the bulk carriage of liquid cargoes other than oil and oil products. The precise purpose of the special tanker is stated by the descriptive notation in the class notation in accordance with 2.2.12;

an oil tanker is a ship intended for the carriage in bulk of crude oil and petroleum products having a flash point 60 °C and below for sea-going ships, 55 °C and below for ships of inland navigation, Reid vapour pressure being below atmospheric pressure;

an oil tanker (> 60 °C) is a sea-going ship intended for the carriage of petroleum products having a flash point over 60 °C in bulk;

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<sup>1</sup> Hereinafter referred to as "the Rules".

an oil tanker ( $> 55^{\circ}\text{C}$ ) is a ship of inland navigation intended for the carriage of petroleum products having a flash point over  $55^{\circ}\text{C}$  in bulk;

an oil recovery vessel is a ship intended for recovery of crude oil and petroleum products having a flash point of  $60^{\circ}\text{C}$  or below from the sea surface;

an oil recovery vessel ( $> 60^{\circ}\text{C}$ ) is a ship intended for recovery of crude oil and petroleum products having a flash point above  $60^{\circ}\text{C}$  from the sea surface;

a bilge water removing ship is a ship designed to remove the bilge water from the machinery spaces of ships.

A passenger is every person other than the master and the members of the crew or other persons employed or engaged in any capacity on board a ship (special personnel) on the business of that ship, and a child under one year of age.

A passenger ship is a ship intended for or carrying more than 12 passengers.

A roll-on/roll-off passenger ship (ro-ro passenger ship) is a passenger ship with enclosed or open cargo spaces which is loaded/unloaded in the horizontal direction, or with special category spaces defined in 1.5.4.3 and 1.5.9, Part VI "Fire Protection".

Classed among passenger ro-ro ships are also ferries, i.e. ships loaded/unloaded in the horizontal direction which regularly carry passengers and which carry vehicles with fuel in their tanks and/or railway carriages on open and/or enclosed decks at ferry crossings.

A floating crane is a crane structure on a floating hull of pontoon or similar type, which is intended for cargo handling or other working operations (mounting, undersea, hydraulic engineering, salvage, pipe laying, etc.) and may be also used for the carriage of cargoes on deck and/or in the hold.

A lightship is a non-self-propelled ship having special equipment (light appliances, fog signaling arrangements, radar beacons, etc.) intended for bounding navigational hazards and ships orientation to ensure safety of navigation

A fishing vessel is a vessel used directly for catching or for catching and processing the catch (fish, whales, seals, walrus or other living resources of the sea).

A salvage ship is a self-propelled ship intended for rendering assistance to ships in distress at sea.

Special personnel means all persons who are not passengers or members of the crew and who are carried on board in connection with the special purpose of that ship or because of special work being carried out aboard that ship.

A berth-connected ship is a non-self propelled floating structure, having the pontoon-type

or ship-type hull, which is in operation either when lying at anchor or bottomed or when moored at quay. These ships include floating docks, floating hotels and hostels, floating workshops, floating power plants, floating warehouses, floating oil storages, etc.

A ship of river-sea navigation is a self-propelled cargo ship intended for the carriage of cargoes by sea and by inland waterways.

A shipborne barge (lighter) is a non-self-propelled cargo ship unmanned and appropriated for transportation in specially equipped ships (barge and lighter carriers) and for towing (pushing) within the specified restricted area of navigation.

A supply vessel is a vessel designed basically for the carriage of supplies and cargoes to the mobile and fixed offshore units intended for the different purposes, and fitted generally with a forward superstructure and an after weather cargo deck for processing of the cargo at sea. The ship may be used for towing operations provided the appropriate requirements of the Register rules are complied with.

A special purpose ship is a mechanically self-propelled ship which by reason of its function carries on board more than 12 persons of special personnel including passengers (by these ships are meant research, expeditionary, hydrographic, training ships; whale and fish factory ships and other ships engaged in processing of living resources of the sea and not engaged in catching, and the like ships).

A dry cargo ship is a ship intended for the carriage of different cargoes (general cargoes, containers, timber, bulk cargoes, etc.), except for the liquid bulk cargoes.

A pontoon is a non-self-propelled unmanned ship intended for the carriage of deck cargo and having no hatches on deck, except for small manholes for access into the hull, which are closed by covers with seal gaskets.

A hopper dredger is a self-propelled or non-self-propelled ship intended for the extraction of spoil using dredging gear (buckets, suction pipes, grabs, etc.) and having holds for the storage or carriage of spoil.

Crew of a fishing vessel means persons engaged in any business on board a ship connected with its purpose.

Definitions of particular types of ships (nuclear ships and floating facilities, nuclear support vessels, high-speed craft, dynamically supported craft, WIG craft, gas carriers, chemical tankers, pleasure boats, drilling ships, mobile offshore drilling units and fixed offshore platforms, manned submersibles and diving systems) are given in relevant rules for the classification and construction of such types of ships.

The Register rules are listed in 1.3, General Regulations for the Classification and Other Activity.

### 1.1.2 Explanations.

For the purpose of the present Rules classification means development, publication and application of the Rules continuous compliance with which will, along with the proper maintenance of the ship by the owner or by the operator, ensure:

structural strength and integrity of the hull and its elements including structural fire protection;

seaworthiness (stability) of the ship under all specified loading conditions and under particular sea-and-wind conditions;

safe and reliable operation of its propulsion plant, systems and devices for ship control, other systems, auxiliary machinery and equipment including fire-fighting equipment,

and thereby permit safe operation of the ship in accordance with its purpose.

**Date of contract for construction of a ship (series of ships).**

**.1** The date of "contract for construction" of a ship is the date on which the contract to build the ship is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the ships included in the contract shall be declared to the Register by the party applying for the assignment of class to a newbuilding.

**.2** The date of "contract for construction" of a series of ships, including specified optional ships for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.

Ships built under a single contract for construction are considered a "series of ships" if they are built to the same approved plans for classification purposes. However, ships within a series may have design alterations from the original design provided:

**.2.1** such alterations do not affect matters related to classification; or

**.2.2** if the alterations are subject to classification requirements, these alterations shall comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Register for approval.

The optional ships will be considered part of the same series of ships if the option is exercised not later than 1 year after the contract to build the series was signed.

**.3** If a contract for construction is later amended to include additional ships or additional options, the date of "contract for construction" for such ships is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract shall

be considered as a "new contract" to which the above explanations apply.

**.4** If a contract for construction is amended to change the ship type, the date of "contract for construction" of this modified ship or ships is the date on which revised contract or new contract is signed between the shipowner, or shipowners and the shipbuilder.

**Notes:** 1. By optional ships, ships are meant, which are included in the contract with the condition of the additional confirmation of their construction (order) by a prospective owner.

2. This explanation became effective on 21 June 2007.

**Additional requirements** are the requirements caused by the object features or its operational conditions, which are not provided for by the rules imposed by the Register in writing to ensure the safety of objects under technical supervision.

The Register class (class) is a combination of conventional characters and descriptive notations assigned to the ships, other floating facilities, as well as to fixed offshore platforms, which define their structural features, purpose and operational conditions stipulated by the Rules.

An operator is a physical person or legal entity operating a ship on the basis of a contract concluded with a proprietor or shipowner.

Rules (the Register Rules) are the set of the regulating and technical requirements for objects under technical supervision.

The Register Rules are listed in 1.3, General Regulations for the Classification and Other Activity.

A proprietor is a physical person or legal entity having proprietary rights to a ship irrespective of the fact whether he (she) or it operates the ship on his (her) or its own, or has placed it in the operation of another person or entity whether on the fiduciary or some other legal basis.

Special consideration is the determination of the extent, to which an object under technical supervision meets the additional requirements.

Standards, as applied to the Rules, means all kinds of standards and other regulating and technical documents of all countries approved or recognized by the Register.

A ship under construction is a ship during a period from the date of laying the keel till the date of issuing the documents for a ship. The date of laying the keel means the beginning of construction identifiable with a specific ship when the mass of the assembled part of a hull comprises not less than 50 tons or 1 per cent of the estimated mass of all structural material, whichever is less.

A ship in service is a ship which is not under construction.

A shipowner is a physical person or legal entity operating a ship on his (her) or its own behalf irrespective of the fact whether he (she) or it is the proprietor or is operating the ship on some other legal basis.

## 1.2 APPLICATION

**1.2.1** Rules for the Classification and Construction of Sea-Going Ships apply to:

**.1** passenger ships, tankers, ships intended for the carriage of dangerous goods as well as tugs, irrespective of the power of main engines and gross tonnage;

**.2** self-propelled ships not specified in 1.2.1.1, with the main engines of power output 55 kW and upwards;

**.3** ships not specified in 1.2.1.1 and 1.2.1.2 of 80 gross tonnage and upwards or ships fitted out with machinery and equipment of total prime movers power output 100 kW and upwards;

**.4** materials and equipment that shall be installed on the above ships (lists of relevant materials and equipment are given in the appropriate parts of the Rules).

**1.2.2** The present Rules also apply to the following types of ships to the extent specified in the relevant rules for the classification and construction of such ships:

**.1** nuclear ships and floating facilities (refer to Rules for the Classification and Construction of Nuclear Ships and Floating Facilities);

**.2** nuclear support vessels (refer to Rules for the Classification and Construction of Nuclear Support Vessels);

**.3** gas carriers (refer to Rules for the Classification and Construction of Gas Carriers);

**.4** chemical tankers (refer to Rules for the Classification and Construction of Chemical Tankers);

**.5** mobile offshore drilling units and fixed offshore platforms (refer to Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms);

**.6** high-speed craft (refer to Rules for the Classification and Construction of High-Speed Craft);

**.7** type A WIG craft (refer to Rules for the Classification and Construction of Type A WIG Craft);

**.8** manned submersibles, ship's diving systems and passenger submersibles (refer to the Rules for the Classification and Construction of Manned Submersibles, Ship's Diving Systems and Passenger Submersibles);

**.9** sea-going pleasure boats (refer to Rules for the Classification and Technical Supervision of Sea-Going Pleasure Boats);

**.10** small sea fishing vessels (refer to the Rules for the Classification and Construction of Small Sea Fishing Vessels).

**1.2.3** With the Register consent, the Rules may be applied for the classification of ships not specified in 1.2.1 and 1.2.2.

**1.2.4** For special purpose ships of less than 500 gross tonnage, the applicable scope of the present Rules requirements is determined by the Register on the case-to-case basis.

**1.2.5** The Rules set down the requirements regulating the assignment of class to a ship or a shipboard refrigerating plant.

**1.2.6** Confirmation of compliance with the requirements of the Register rules is the Register prerogative and is carried out in accordance with the procedure established by it.

Any statements to the effect a supervised item complies with the rules requirements, which are made or documentally supported by a body other than the Register and which are not confirmed by the latter in accordance with the established procedure, cannot be considered as evidence of such a compliance.

## 2 CLASS OF A SHIP

### 2.1 GENERAL

**2.1.1** Assignment of the Register class to a ship means confirmation by the Register that the ship construction complies with the applicable requirements of the Register rules and its technical condition complies with the conditions of the ship operation; the ship is registered with the Register for a specified period with performing the surveys stipulated by Rules for the Classification Surveys of Ships for this period.

**2.1.2** The Register may assign a class to a ship proceeding from the results of survey during its construction, as well as assign or renew a class to a ship in service.

**2.1.3** Renewal of a ship's class means confirmation by the Register that the construction and technical condition of the ship comply with the provisions based on which a class has been assigned as well as extension of validity of the Register documents for a definite period as required by the Rules.

**2.1.4** Class of a ship is, generally, assigned or renewed by the Register for 5 years, however, in sound cases the Register may assign or renew a class for a lesser period.

**2.1.5** If a ship has the valid Register class this means that the ship's technical condition in full measure or to a degree considered adequate by the Register complies with the requirements of the Rules which apply to it according to its purpose, service conditions and class notation. If a class of a ship is

valid it is certified by the valid Classification Certificate on board.

**2.1.6** Classification Certificate becomes invalid and classification is automatically suspended in the following cases:

if the ship as whole or her separate elements have not been subjected to scheduled periodical or occasional surveys in specified terms (if the special survey has not been completed or the ship is not under attendance for completion prior to resuming trading, by the due date; if the annual survey has not been completed within three (3) months of the due date of the annual survey; if the intermediate survey has not been completed within three (3) months of the due date of the third annual survey in each periodic survey cycle);

unless the ship is under attendance for completion of the relevant survey or if in RS Rules it is not required otherwise;

after an accident (the ship shall be submitted for occasional survey at port where the accident took place or at the first port of call, if the accident took place at sea);

if alterations not agreed with the Register have taken place in the construction and/or if any change has been made in the equipment which may result in reducing the standards required by the Rules;

when repair of ship's items has been performed without the agreement and/or survey by the Register;

when a ship navigates with a draught exceeding that specified by the Register for specific conditions as well as in case of operation of a ship in conditions which do not comply with the requirements for assigned class of a ship or the restrictions specified by the Register;

if the prescribed specific requirements which during previous survey of the ship were the conditions for assignment or retainment of the Register class have not been fulfilled within the specified period;

if the process of surveying the ship by the Register has been suspended on the shipowner's initiative or through his fault;

when the ship has been taken out of service for a long period (more than 3 months) for fulfillment of the Register requirements (except the case when a ship is under repair for these purposes).

The Register shall specially notify the shipowner of suspension of a ship's class and Classification Certificate.

**2.1.7** Suspended (as stated in 2.1.6) class of a ship may be reinstated on the basis of satisfactory results of the appropriate periodical or occasional survey carried out by the Register in the case of ship to be submitted for survey. In so doing when the ship is taken out of service for a long period (more than 3 months), the scope of survey for reinstatement of a

ship's class shall be specially established by the Register taking into account the age and condition of the ship as well as the period for which she is taken out of service.

During the period from suspension of a class to its reinstatement or renewal the ship is considered to have been lost the Register class.

The class may be suspended for a period of no more than six months.

**2.1.8** The class of a ship is withdrawn by the Register in the following cases:

**.1** upon expiration of the maximum term of class suspension;

**.2** when the Register and/or shipowner consider reinstatement of the class suspended as stated in 2.1.6 to be impossible;

**.3** upon transfer of the ship to the class of another classification body;

**.4** at the request of the shipowner.

Withdrawal of the ship's class means cessation of the Classification Certificate validity.

**2.1.9** The class of a ship shall be cancelled due to her loss or scrapping.

**2.1.10** After assigning the class the Register introduces the sea-going self-propelled ships and self-propelled mobile offshore drilling units of 100 gross tonnage and upwards into the Register of Ships and excludes them in case of withdrawal or cancellation of a class.

## 2.2 CLASS NOTATION OF A SHIP

The class notation assigned by the Register to a ship or floating facility consists of the character of classification and distinguishing marks and descriptive notations defining structure and purpose of a ship or floating facility.

The sequence of distinguishing marks and descriptive notations (if any) being added to the character of classification of a ship is set down by the provisions of this Chapter as well as by relevant provisions concerning the class notation included in rules for the classification and construction of ships of special types, as listed under 1.2.2.

**2.2.1** The character of classification assigned by the Register to a ship or floating facility consists of distinguishing marks:

**KM⊙, KM★, (KM)★** — for self-propelled ships and floating facilities;

**KE⊙, KE★, (KE)★** — for non-self-propelled ships and floating facilities with total power output of prime movers 100 kW and upwards;

**K⊙, K★, (K)★** — for other non-self-propelled ships and floating facilities.

**2.2.2** Depending on the Rules on the basis of which a ship or a floating facility was surveyed, and the classification body which carried out the survey, the character of classification is established as follows:

**.1** ships and floating facilities built according to the Rules of and surveyed by the Register are assigned a class notation with the character of classification: **KM**★ or **KE**★ or **K**★ (refer to 2.2.1);

**.2** ships and floating facilities which were as a whole (or their hull or machinery installation, machinery and equipment) built and/or manufactured according to the Rules of another classification body recognized by the Register and surveyed by that body during their construction and manufacture, when classed with the Register are assigned a class notation with the character of classification: **KM**★, **KE**★ or **K**★ (refer to 2.2.1);

**.3** ships and floating facilities which were as a whole (or their hull or machinery installation, machinery and equipment) built and/or manufactured without being surveyed by a classification body recognized by the Register or without any survey of a classification body at all, when classed with the Register, are assigned a class notation with the character of classification: **(KM)**★ or **(KE)**★ or **(K)**★ (refer to 2.2.1);

**.4** ships and floating facilities for which their design does not permit the main class notation out of those listed in 2.2.2.2 to be assigned a class with the character of classification: **KM**★ or **KE**★ or **K**★.

This also applies when a ship or floating facility changes a class to the Register from one of the IACS Member Societies. The possibility of such a change is considered in each case by the Register Head Office.

### **2.2.3 Ice category marks and polar class marks.**

**2.2.3.1** Ice category marks are assigned to icebreakers and ice class ships in compliance with the requirements of 2.2.3.1 to 2.2.3.7.

Polar class marks are assigned to polar class ships in accordance with the requirements of Section 1, Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships".

**2.2.3.1.1** Icebreakers are specialized ships intended for all kinds of icebreaking operations: escort of ships in ice, surmount of ice ridges, breaking of a navigable channel, towing, breaking of ice and rescue operations. There are two main regimes of ice navigation while performing icebreaking operations: continuous motion and ramming.

**2.2.3.1.2** Ice class ships are ships intended for independent ice navigation including motion in fractures between floes, surmounting of ice isthmuses and portions of relatively thin compact ice, or navigation in ice with icebreaker escort.

**2.2.3.1.3** The following definitions are used for the description of ice navigation conditions:

ice concentration is a measure of ice continuity, which is characterized by the ratio of the area covered by ice to the total water area using 10 number scale;

open floating ice is ice of concentration 4 to 6, where most of the floes do not touch each other;

close floating ice is ice of concentration 7 to 8 where most of the floes touch each other forming ice isthmuses;

very close floating ice is ice of concentration 9 or over, but less than 10;

compact ice is ice of concentration 10.

**2.2.3.2** If an icebreaker complies with the requirements of the Rules, one of the following ice category marks is added to the class notation: **Icebreaker6**; **Icebreaker7**; **Icebreaker8**; **Icebreaker9**.

Icebreakers of the above categories have the following tentative service characteristics:

**Icebreaker6** — intended for ice breaking operations in harbour and roadstead water areas as well as in non-arctic freezing seas where the ice is up to 1,5 m thick. Continuous motion capability in unbroken ice up to 1 m thick;

**Icebreaker7** — intended for ice breaking operations in the arctic seas on coastal routes during winter/spring navigation in ice up to 2,0 m thick and summer/autumn navigation in ice up to 2,5 m thick; in non-arctic freezing seas and mouths of rivers flowing into arctic seas in ice up to 2,0 m thick. Continuous motion capability in unbroken ice up to 1,5 m thick. The total shaft power not less than 11 MW;

**Icebreaker8** — intended for ice breaking operations in the arctic seas on coastal routes during winter/spring navigation in ice up to 3,0 m thick and summer/autumn navigation without restrictions. Continuous motion capability in unbroken ice up to 2,0 m thick. The total shaft power not less than 22 MW;

**Icebreaker9** — intended for ice breaking operations on coastal routes in arctic seas during winter/spring navigation in ice up to 4,0 m thick and summer/autumn navigation without restrictions. Continuous motion capability in unbroken ice over 2,0 m thick. The total shaft power not less than 48 MW.

### **2.2.3.3 Categories of ice class ships.**

**2.2.3.3.1** If a self-propelled ship complies with the relevant requirements of the Rules, one of the following ice category marks shall be added to its class notation: **Ice1**, **Ice2**, **Ice3**, **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9**. Ice category marks need not be added to the class notation of non-self-propelled ships.

**2.2.3.3.2** Categories **Ice1**, **Ice2**, **Ice3** which form the group of non-arctic categories refer to ships intended for navigation in freezing non-arctic seas (non-arctic ships).

**2.2.3.3.3** Categories **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** which form the group of arctic categories refer to ships intended for navigation in arctic seas (arctic ships).

**2.2.3.3.4** For tugs, depending on the compliance with the appropriate ice category requirements, one of the following marks is added to the class notation: **Ice2**, **Ice3**, **Arc4**, **Arc5**.

**2.2.3.4** Averaged quantitative data on permitted service areas and ice service conditions presented in Tables 2.2.3.4-1 to 2.2.3.4-3 shall be used when choosing the ice category of arctic ships. It is not permitted to use these data for regulating the allowable navigation conditions of ships in service. It is assumed that during service the owner will follow the requirements of the Ice Certificate or another document specifying the conditions of safe operation of the ship in ice depending on the ice category mark, the ship's specific features, ice conditions and ice-breaker escort.

Table 2.2.3.4-1 shows service areas for ships in the Russian arctic seas (the Barents Sea, the Kara Sea, the Laptev Sea, the East-Siberian Sea, the

Chukchee Sea) in relation to the season, tactics of ice navigation and type of navigation.

Table 2.2.3.4-2 shows, for arctic category ships, limiting type and thickness of ice enabling a ship to navigate in a channel following an icebreaker at a low speed (3 to 5 knots) without running a heightened risk of damage through contact of hull with ice.

Table 2.2.3.4-3 shows, for arctic category ships operating independently, permissible speeds which a ship under the ice conditions set out in the table may reach when navigating in fractures between floes or surmounting ice isthmuses without running a heightened risk of damage through contact of hull with ice.

**2.2.3.5** When choosing the category of ice strengthening for non-arctic ships, it is recommended to use mean values of permitted conditions of ice navigation set forth in Table 2.2.3.5.

**2.2.3.6** Arctic ships may navigate in non-arctic freezing seas in ice conditions corresponding to those stated in 2.2.3.4-2 and 2.2.3.4-3.

**2.2.3.7** In Table 2.2.3.7 an attempt has been made to correspond the ice category marks of the present Rules to those of the Rules, edition 1995. The

Table 2.2.3.4-1

Service areas and conditions for ships of arctic categories

Category of ice strengthening	Type of ice navigation	Winter/spring navigation					Summer/autumn navigation				
		The Barents Sea	The Kara Sea <sup>1</sup>	The Laptev Sea	The East Siberian Sea	The Chuckchee Sea	The Barents Sea	The Kara Sea	The Laptev Sea	The East Siberian Sea	The Chuckchee Sea
		ENHME	ENHME	ENHME	ENHME	ENHME	ENHME	ENHME	ENHME	ENHME	ENHME
<b>Arc4</b>	IN	— — — +	— — — —	— — — —	— — — —	— — — —	++ ++	— — ++	— — — +	— — — +	— — ++
	IEN	— * ++	— — — +	— — — —	— — — —	— — — *	++ ++	* ++ +	— — ++	— — ++	— * ++
<b>Arc5</b>	IN	— — ++	— — — +	— — — —	— — — —	— — — —	++ ++	— ++ +	— — ++	— — ++	— — ++
	IEN	* ++ +	— — * +	— — — +	— — — +	— — * +	++ ++	* ++ +	* ++ +	* ++ +	* ++ +
<b>Arc6</b>	IN	* ++ +	— — — +	— — — +	— — — +	— — — +	++ ++	++ ++	— ++ +	— ++ +	— ++ +
	IEN	++ ++	** ++	— ** +	— ** +	— * ++	++ ++	++ ++	++ ++	++ ++	++ ++
<b>Arc7</b>	IN	++ ++	— — ++	— — — +	— — — +	— — ++	++ ++	++ ++	++ ++	++ ++	++ ++
	IEN	++ ++	++ ++	* ++ +	* ++ +	* ++ +	++ ++	++ ++	++ ++	++ ++	++ ++
<b>Arc8</b>	IN	++ ++	++ ++	— * ++	— * ++	* ++ +	++ ++	++ ++	++ ++	++ ++	++ ++
	IEN	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++
<b>Arc9</b>	IN	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++
	IEN	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++	++ ++

**Symbols:**  
IN — independent navigation  
IEN — icebreaker escorted navigation  
+ — operation allowed  
— — operation not allowed  
\* — operation connected with the increased risk of damage  
EN — extreme navigation (average periodicity once in ten years)  
H, M, E — hard, medium, easy navigation (average periodicity once in three years)

**Note:**  
<sup>1</sup>For ships with ice category mark **Arc7** an independent (IN) year-round navigation in the southwestern part of the Kara Sea, at EN, H, M and E types of navigation.

Table 2.2.3.4-2

Ship category	Permitted type and thickness of ice	
	Winter/spring navigation	Summer/autumn navigation
Arc4	Thin first-year	Medium first-year up to 0,9 m
Arc5	Medium first-year up to 0,8 m thick	Medium first-year
Arc6	Medium first-year	Thick first-year up to 1,5 m
Arc7	Thick first-year up to 1,8 m	Second-year
Arc8	Multi-year up to 3,4 m	Multi-year
Arc9	Multi-year	Multi-year
N o t e . The classification of ice adopted according to the "Sea Ice Nomenclature" of the World Meteorological Organization (WMO):		
Ice type	Ice thickness	
Multi-year	> 3,0 m	
Second-year	> 2,0 m	
Thick first-year	> 1,2 m	
Medium first-year	0,7 — 1,2 m	
Thin first-year	< 0,7 m	

Table 2.2.3.4-3

Ship category	Permitted speed, in knots	Ice concentration and type	Ice thickness, in m		Methods of surmounting ice ridges
			Winter/spring navigation	Summer/autumn navigation	
<b>Arc4</b>	6 — 8	open floating first-year ice	0,6	0,8	Continuous motion
<b>Arc5</b>		open floating first-year ice	0,8	1,0	
<b>Arc6</b>		open floating first-year ice	1,1	1,3	
<b>Arc7</b>		close floating first-year ice	1,4	1,7	
<b>Arc8</b>	10	close floating second-year ice	2,1	3,0	Regular ramming
<b>Arc9</b>	12	very close floating and compact multi-year ice	3,5	4,0	Surmount of ice ridges and episodic ramming of compact ice fields

Table 2.2.3.5

Ship category	Permitted thickness of ice, in m		Type of operation
	Independent navigation in open pack ice at a speed of 5 knots	Navigation in channel following an icebreaker in compact ice at a speed of 3 knots	
<b>Ice1</b>	0,40	0,35	Episodically Regularly Regularly
<b>Ice2</b>	0,55	0,50	
<b>Ice3</b>	0,70	0,65	

provisions of 2.2.3.4 to 2.2.3.6 do not apply to the ships built according to the Rules, edition 1995 and earlier.

In accordance with the requirements of the present Rules, ice category marks may only be applied to such ships on the shipowner's discretion and after their hull examination for compliance with the requirements of 3.10, Part II "Hull".

#### 2.2.4 Subdivision distinguishing marks.

Ships complying with the applicable requirements of Part V "Subdivision" and fully complying with the requirements of Section 3 of the above Part in the case of flooding of any one compartment or

any two or three adjacent compartments over complete length of the ship in the case of design side damage specified in 3.2 are assigned subdivision distinguishing mark **1**, **2** or **3** added to the character of classification, respectively.

#### 2.2.5 Distinguishing marks for restricted areas of navigation.

**2.2.5.1** Ships complying with the Rules requirements provided for ships operating only in restricted areas of navigation are assigned one of the following marks: **R1**, **R2**, **R2-RSN**, **R3-RSN** or **R3** added to the character of classification to clarify restrictions of the ship navigation as follows:



Table 2.2.3.7

Present Rules	Rules, edition 1995	Present Rules	Rules, edition 1995
Ice ships		Icebreakers	
Ice1	JI4 (L4)	Icebreaker6	JJI4 (LL4)
Ice2	JI3 (L3)	Icebreaker7	JJI3 (LL3)
Ice3	JI2 (L2)	Icebreaker8	JJI2 (LL2)
Arc4	JI1 (L1)	Icebreaker9	JJI1 (LL1)
Arc5	YJI (UL)		
Arc6			
Arc7	YJIA (ULA)		
Arc8			
Arc9			

**.1 R1** — navigation in sea areas at seas with a wave height of 8,5 m with 3 per cent probability and with the ships proceeding not more than 200 miles away from the place of refuge and with an allowable distance between the places of refuge not more than 400 miles;

**.2 R2** — navigation in sea areas at seas with a wave height of 7,0 m with 3 per cent probability with ships proceeding from the place of refuge not more than 100 miles and with an allowable distance between the places of refuge not more than 200 miles;

**.3 R2-RSN** — river-sea navigation at seas with a wave height of 6,0 m with 3 per cent probability with ships proceeding from the place of refuge:

in open seas up to 50 miles and with an allowable distance between the places of refuge not more than 100 miles;

in enclosed seas up to 100 miles and with an allowable distance between the places of refuge not more than 200 miles;

**.4 R3-RSN** — river-sea navigation at seas with a wave height of 3,5 m with 3 per cent probability with due regard for particular restrictions on the area and conditions of navigation resulting from the wind and wave conditions of the basins with determination of a maximum allowable distance from the place of refuge which in no case shall be more than 50 miles;

**.5 R3** — harbour, roadstead and coastal navigation within limits established by the Register in each case.

**.6 Berth-connected ship** (with indication of the positions of stay and geographical service area according to Fig. 4.3.3.6, Part IV "Stability").

Restrictions for particular floating crane operations (cargo-handling operations or navigation with eventual carriage of cargoes on deck and/or in the hold) shall be imposed by the Register in each particular case.

**2.2.5.2** The restrictions provided for by 2.2.5.1 define the allowable conditions of ship's navigation resulting from ship's stability and strength which are

indicated in the Seaworthiness Certificate and in the Classification Certificate.

**2.2.5.3** Particular restrictions on the area and conditions of navigation for ships of river-sea navigation **R3-RSN** are determined as the geographical place-names of basins or their parts with the indication, where necessary, of the geographical boundary of the navigation area within the basin, the restrictions on proceeding from the place of refuge and the restrictions of ship navigation by calendar periods, or an indication of voyage between the terminal ports. In this case, the restrictions with due regard to the wind and wave conditions of the basins shall be determined by using the data of Table 2.2.5.3 or the data from the submitted to the Register justifications of possibility of ship's navigation in the certain area or passage, made in accordance with the procedure approved by the Register.

**2.2.5.4** Whatever the area of navigation of ships whose stability does not comply with the requirements of Part IV "Stability" of the Rules imposed upon the ships navigating in winter seasonal zones to the North of parallel 66°30' N and to the South of parallel 66°00' S as well as in winter in the Bering Sea, the Sea of Okhotsk and in the Tatar Strait, the Register specifies the appropriate restrictions by introducing the entry into the Classification Certificate that the ship is not allowed to navigate in the above winter seasonal zones and areas.

#### 2.2.6 Distinguishing automation marks.

Ships and floating facilities fitted with automation equipment complying with the requirements of Part XV "Automation" are assigned one of the following distinguishing marks added to the character of classification, namely:

**.1 AUT1** — where the automation extent is sufficient for the machinery installation operation with unattended machinery spaces and the main machinery control room;

**.2 AUT2** — where the automation extent is sufficient for the machinery installation operation by one operator at the main machinery control room with unattended machinery spaces;

**.3 AUT3** — where the automation extent is sufficient for the machinery installation operation of a ship with the main machinery power output not more than 2250 kW with unattended machinery spaces and the main machinery control room;

**.4 AUT1-C, AUT2-C or AUT3-C** — where automation is based on computers or programmable logic controllers (PLC) meeting the requirements of Section 7, Part XV "Automation";

**.5 AUT1-ICS, AUT2-ICS or AUT3-ICS** — where automation is made with the use of a computerized integrated monitoring and control system meeting the requirements of Section 7, Part XV "Automation".

Table 2.2.5.3

Basin	Geographical restrictions	Season
The Sea of Azov	No restrictions	Throughout the year
The Adriatic Sea	South of 42°N, 20-mile coastal area along the East and West coast, crossing the sea in Otranto Strait in the area of p. Brindizi (p. Bari) — p. Bar and in the area of the Cape Franchesco — the Lastovo Island. North of 42°N, 40-mile coastal area with calling at ports of the West coast	Throughout the year
The Baltic Sea	No restrictions, including the Gulfs of Bothnia, Finland, Riga, the Zund, Great and Small Belt, Kattegat Straits to the South of 57°45'N.	Throughout the year
The Baltic Sea and the North Sea	Exit to the Skagerrak Straits in the waters to the East of the line the Cape Skagen — Oslo- Fjord and South of 59°N and also along the coast of Sweden in Sekken and Single-Fjord Straits	March to September
The White Sea	The Onezhsky, Dvinsky and Kandalakshsky Gulfs, as well as 20-mile coastal area to the South of 66°45'N	May to October
The Ionian Sea	20-mile coastal area along the East coast from Kathira to Otronto Straits 20-mile coastal area along the East coast from the Gulf of Patraikos to the Strait of Otranto	March to November Throughout the year
The Kara Sea	20-mile coastal area from p. Dikson to r. Pyasing 20-mile coastal area along the North and West coast of the Yamal Peninsula from Obskaya Guba to p. Kharasavey via the Malygin Straits	July to September August to 15 October
The Caspian Sea	To the North of 44°30'N as well as to the South of 44°30'N within 20-mile coastal area along the East coast up to p. Krasnovodsk, along the West coast to p. Makhachkala and from p. Baku to p. Anzali; passage at the area of p. Beckdash (p. Krasnovodsk) — p. Baku	March to November
The Laptev Sea and the East-Siberian Sea	20-mile coastal area from the mouth of r. Yana to the mouth of r. Kolyma Coastal area within 6 to 15 m isobath from the mouth of r. Kolyma to p. Pevek	20 July to September August to September during years of low to medium ice formation determined by the position of the Ayon ice mass
The Sea of Marmora	No restrictions from Bosphorus to Dardanelles Straits	Throughout the year
The Persian Gulf (the Arabian Sea)	East part — from Ormus Strait to 54°E; central part — coastal area along the West coast in the area restricted by 54°E, parallel 28°59'N and line connecting islands Abu-Musa, Khalul, Al-Kharkus, Falaika; north part — from parallel 28°59'N	Throughout the year
The North Sea	Helgoland Bay to the South of 54°02'N and to the East of 7°58'E Coastal area in the zone of traffic separation along the East-Frisian Islands and farther on with possible calls at the ports of South coast to p. Antwerp inclusive	Throughout the year March to October
The Mediterranean Sea	From Rhodes Strait in 20-mile coastal area to the ports of Israel inclusive with calls at the port of Cyprus Island	March to November
The Black Sea	20-mile coastal area along the North, West and East coast from p. Batumi to Bosphorus	Throughout the year
The Aegean Sea	From the Dardanelles to Karpathos and Kithira Straits to the North of 36°N Passage to the Ionian Sea through the Gulf of Saronikos, Corinth Canal, Gulf of Corinth, Gulf of Patraikos	Throughout the year Throughout the year
The Sea of Japan and the Sea of Okhotsk	20-mile coastal area along the West coast from p. Vladivostok to the Preobrazhenia Bay The Tatar Strait and the Amur Firth from the line of p. Sovetskaya Gavan — p. Uglegorsk to the line of the Cape Menshikov — the Cape Tam-lavo	Throughout the year June to October

### 2.2.7 Distinguishing mark of one man bridge operated ship.

If the navigational equipment of self-propelled ship installed on the navigating bridge complies with the requirements for self-propelled one man bridge

operated ships specified in Part V "Navigational Equipment" of Rules for the Equipment of Sea-Going Ships, a distinguishing mark **OMBO** is added to the character of classification.

### 2.2.8 Distinguishing mark for ships carrying equipment for fire fighting aboard other ships.

If a ship carries supplementary systems, equipment and outfit for fire fighting aboard other ships, offshore drilling units, floating and shore facilities and if the ship is in full compliance with the relevant requirements of the Rules in respect to those appliances, marks **FF1WS**, **FF1**, **FF2WS**, **FF2** or **FF3WS** are added to the character of classification proceeding from the degree of the ship equipment with these appliances.

The degree of the ship equipment for fire fighting in other structures is determined on the basis of the list of fire fighting equipment and systems prescribed by 6.6, Part VI "Fire Protection".

### 2.2.9 Distinguishing mark for ships fitted with a dynamic positioning system.

If a ship is fitted with a dynamic positioning system complying with the requirements of Section 8, Part XV "Automation", one of the following marks: **DYNPOS-1**, **DYNPOS-2** or **DYNPOS-3** is added to the ship's character of classification, depending on the redundancy of the dynamic positioning system.

### 2.2.10 Distinguishing mark for a ship intended for carriage of refrigerated cargo.

Ships intended for carriage or storage of refrigerated cargo or catch in ship's cargo spaces and/or in thermal containers with the use of a refrigerating plant available on board and classed in compliance with Section 4 of the present Part of the Rules and meeting the requirements of Part XII "Refrigerating Plants" are assigned the distinguishing mark **REF** added to the character of classification.

Ships intended for carriage or storage of refrigerated cargo or catch in ship's cargo spaces and/or in thermal containers and using non-classed refrigerating plant for maintaining the required temperature, complying with the relevant requirements of Part XII "Refrigerating Plants", are assigned the distinguishing mark (**REF**) added to the character of classification.

### 2.2.11 Distinguishing mark for ships fitted with the main electric propulsion plant.

If a ship is fitted with the main electric propulsion plant complying with the requirements of Section 17, Part XI "Electrical Equipment", the distinguishing mark **EPP** is added to the character of classification.

### 2.2.12 Distinguishing mark for ships fitted with equipment for icing protection.

If a ship is fitted with equipment providing effective icing protection in compliance with the requirements of Section 4, Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships", the distinguishing mark **ANTI-ICE** is added to the character of classification.

### 2.2.13 Distinguishing mark for a ship intended for carriage of packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes (INF cargo).

Ships intended for carriage of packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes, which comply with the requirements of 7.3, Part VI "Fire Protection", are assigned one of the following distinguishing marks added to the character of classification:

**INF1** for Class **INF1** ships;

**INF2** for Class **INF2** ships;

**INF3** for Class **INF3** ships.

### 2.2.14 Distinguishing mark for ships fitted with a loading instrument.

If a ship is fitted with a loading instrument complying with the requirements of 1.4.9.4 and Appendix 2, Part II "Hull", the distinguishing mark **LI** is added to the character of classification.

### 2.2.15 Distinguishing mark for ships fitted with a cargo vapour discharge system.

If a ship is fitted with a cargo vapour discharge system complying with the requirements of 9.9, Part VIII "Systems and Piping", the distinguishing mark **VCS** is added to the character of classification.

### 2.2.16 Distinguishing mark for ships fitted with an inert gas system.

If a ship is fitted with an inert gas system complying with the requirements of 9.16, Part VIII "Systems and Piping", one of the following distinguishing marks is added to the character of classification:

**1 IGS-IG** if a system uses an oil-burning inert gas generator as the inert gas source and the requirements of 9.16.9, Part VIII "Systems and Piping" are complied with;

**2 IGS-NG** if a system uses a nitrogen generator as the inert gas source and the requirements of 9.16.12, Part VIII "Systems and Piping" are complied with;

**3 IGS-Pad** if an inert gas system is only intended for forming an insulating pad in cargo tanks and the requirements of 9.16.11, Part VIII "Systems and Piping" are complied with. This distinguishing mark may be used where systems with inert gas supplied from cylinders are installed as well as for systems using inert gas and nitrogen generators whose capacity is insufficient for assigning the distinguishing marks **IGS-IG** or **IGS-NG**.

### 2.2.17 Distinguishing mark for ships fitted with a crude oil washing system.

If a ship is fitted with a crude oil washing system complying with the requirements of 9.12, Part VIII "Systems and Piping", the distinguishing mark **COW** is added to the character of classification.

### 2.2.18 Distinguishing mark for ships fitted with a centralized cargo control system.

If a ship is fitted with a cargo control room complying with the requirements of 3.2.11, Part VII

"Machinery Installations", the distinguishing mark **CCO** is added to the character of classification.

#### 2.2.19 Distinguishing marks for ships of high ecological safety.

Ships complying with the requirements of Section 3, Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" are assigned with one of the following distinguishing marks added to the character of classification:

**.1 ECO** — if a ship meets the requirements for controlling and limiting operational emissions and discharges, as well as requirements for prevention of environmental pollution in case of emergency, as specified in 3.4, Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships";

**.2 ECO-S** — if a ship meets more stringent requirements than those for assignment of the distinguishing mark **ECO** in the class notation, as specified in 3.5, Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships".

#### 2.2.20 Distinguishing mark for ships complying with ballast water management requirements.

If a ship carries approved Ballast Water Management Plan according to 1.4.13, Part IV "Stability" and its ballast systems comply with the requirements of 8.7, Part VIII "Systems and Piping", the distinguishing mark **BWM** is added to the character of classification.

#### 2.2.21 Distinguishing marks for ships fitted with a diving system permanently installed on the ship.

If a ship is fitted with a diving system permanently installed on the ship, which comply with the relevant requirements of Rules for the Classification and Construction of Manned Submersibles, Ship's Diving Systems and Passenger Submersibles, one of the following distinguishing marks is added to the character of classification:

**.1 SDS < 12** for ships fitted with a diving system designed for diving operations at depths less than 12 m;

**.2 SDS < 60** for ships fitted with a diving system designed for diving operations at depths less than 60 m;

**.3 SDS ≥ 60** for ships fitted with a diving system designed for diving operations at depths of 60 m and over.

#### 2.2.22 Distinguishing mark for ships fitted with a manned submersible.

If a ship is fitted with a manned submersible complying with the relevant requirements of Rules for the Classification and Construction of Manned Submersibles, Ship's Diving Systems and Passenger Submersibles, the distinguishing mark **MS** is added to the character of classification.

#### 2.2.23 Descriptive notation in the class notation.

Ships complying with a definite scope of requirements of the Rules taking account of their structural

particulars and service conditions are assigned the appropriate descriptive notation added to the character of classification of a ship.

The current Register rules cover certain requirements the fulfilment of which makes possible introducing of the following descriptive notations in the class notation:

**Bilge water removing ship**

**Bulk carrier**

**Catamaran**

**Container ship**

**Crane vessel**

**Dock lift ship**

**Dredger**

**Fishing vessel**

**Floating crane**

**Floating dock**

**Hopper**

**Oil recovery ship**

**Oil tanker**

**Oil/bulk carrier**

**Oil/bulk/ore carrier**

**Ore carrier**

**Passenger ship**

**Pontoon**

**Ro-ro passenger ship**

**Ro-ro ship**

**Salvage ship**

**Shipborne barge**

**Special purpose ship**

**Supply vessel**

**Tanker**

**Tanker (water)**

**Tanker (wine)**

**Timber carrier**

**Tug, etc.**

*Note.* Descriptive notation in the class notation is written in English. At the discretion of the shipowner it may be written in two languages, English and Russian, for example: **Oil tanker** (нефтеналивное) (ESP).

To the class notations of nuclear ships and floating facilities, nuclear support vessels, gas carriers, chemical tankers, high-speed craft, type A WIG craft, mobile offshore drilling units, manned submersibles and diving systems, sea-going pleasure boats, the distinguishing marks and descriptive notations shall be inserted in conformity with the provisions of rules for the classification and construction of the relevant types of ships (refer to 1.2.2).

The descriptive notation **Tanker** shall be accompanied by a cargo carried specification in brackets such as **Tanker (water)**, **Tanker (wine)**.

For ships of restricted area of navigation with the descriptive notation **Berth-connected ship** (refer to 2.2.5.1.6), the descriptive notation shall be supplemented by the statement of ship purpose out of those

listed in the definition of the berth-connected ship (refer to 1.1.1.1).

If the scope of the Rules requirements which a ship complies with allows, two and more descriptive notations may be stated in the class notation of a ship (e.g. **Passenger hydrofoil craft**, **Supply vessel**, **Salvage ships Tug**) or the descriptive notation may be written as compounds (e.g. **Oil/bulk carrier**, **Oil/bulk/ore carrier**).

If an oil tanker or oil recovery vessel complies with the requirements for the ships, which carry petroleum products or recover them from the sea surface and carry them having flash point above 60 °C, this temperature shall be indicated in the descriptive notation. For example: **Oil tanker (>60 °C)**, **Oil/ore carrier (>60 °C)**, **Oil recovery ship (>60 °C)**.

For oil tankers fully complying with the requirements of Part XVII "Common Structural Rules for Double Hull Oil Tankers" a distinguishing mark **CSR** shall mandatory be added to the character of classification.

For bulk carriers fully complying with the requirements of Part XVIII "Common Structural Rules for Bulk Carriers" a distinguishing mark **CSR** shall mandatory be added to the character of classification.

When adding the descriptive notation **Bulk carrier** to the character of classification for ships 150 m long and over with the relevant requirements in Part XVIII "Common Structural Rules for Bulk Carriers" met, one of the following marks is added to the descriptive notation:

**.1 BC-A** – for ships designed to carry the bulk cargoes having density 1 t/m<sup>3</sup> and above with specified holds empty at the maximum draught;

**.2 BC-B** – for ships designed to carry the bulk cargoes having density 1 t/m<sup>3</sup> and above with all holds loaded;

**.3 BC-C** – for ships designed to carry the bulk cargoes having density less than 1 t/m<sup>3</sup>.

For bulk carriers having distinguishing mark **BC-A** or **BC-B** in their class notation, and cargo holds of which are designed for loading/unloading using grabs with a mass of 20 t and over each in compliance with the requirements of Section 1, Chapter 12, Part XVIII "Common Structural Rules for Bulk Carriers", after the above mark the distinguishing mark **GRAB(X)**, where grab mass in tons shall be indicated instead of **X**, for example, **GRAB(30t)**, shall mandatory be added.

For all other bulk carriers addition of mark **GRAB(X)** shall be voluntary.

In case when the ship has not been designed for loading and unloading in several ports, the notation (**no MP**) is added after all the above marks.

When adding descriptive notation to the character of classification of self-propelled ships such as **Chemical tanker**, **Oil tanker**, **Bulk carrier**, **Ore carrier** or the

word combinations: **Oil/bulk carrier**, **Oil/ore carrier** etc. after descriptive notation it shall be added (**ESP**). This means the necessity to survey these ships based on the Enhanced Survey Programme.

For example: **Oil/ore carrier (>60 °C) (ESP)**.

#### 2.2.24 Limitations on validity of some distinguishing marks.

When the particular scope of requirements of the Rules on the basis of which the appropriate distinguishing marks are introduced in the class notation are met only under limitations specified by the Register, these distinguishing marks and limitations, on exceeding of which these marks become invalid, are added (in parentheses) to the class notation, e.g.: **KM⊗Arc7⊡AUT2Ro-ro ship (Arc7⊡ at d≤8,4 m)**.

### 2.3 ADDITIONAL CHARACTERISTICS

**2.3.1** When complying with definite requirements of the Rules stipulated by the structural features or operational characteristics of the ship the fulfilment of which is not reflected by distinguishing marks and descriptive notation in the class notation, the confirmation of compliance of the ship with such requirements is certified by the entry in column "Other characteristics" of the Classification Certificate stating for example that the ship is fit for the carriage of dangerous goods as it is indicated in the Certificate...; the ship is equipped for the carriage of cargo in international standard containers on deck and/or in appropriate holds, that the ship is suitable for operation in waters covered with oil, etc. (refer also to 1.1.4.8, 1.1.5.1, 1.1.5.2 and 3.3.1.5, Part II "Hull").

**2.3.2** For bulk carriers with distinguishing marks **BC-A**, **BC-B** or **BC-C** (refer to 2.2.11) in the class notation, the restrictions to be observed during operation due to loading conditions assumed in design (refer to 3.1.3, Section 1, Chapter 1, Part XVIII "Common Structural Rules for Bulk Carriers") shall be entered in column "Other characteristics" of the Classification Certificate in the following cases:

for marks **BC-A** and **BC-B** – entry "**maximum cargo density .... t/m<sup>3</sup>**" is made if the maximum density of cargo is less than 3 t/m<sup>3</sup>;

for mark **BC-A** the acceptable combination of particular empty cargo tanks is additionally entered, for example: "**cargo tanks Nos. 2, 4, ... may be empty**".

### 2.4 ALTERATION OF MARKS IN CLASS NOTATION

**2.4.1** The Register may delete or alter any mark in the class notation in the case of any alteration of, or non-compliance with the requirements defining the insertion of this mark in the class notation.

### 3 TECHNICAL DOCUMENTATION

#### 3.1 GENERAL

**3.1.1** General provisions pertinent to the consideration and approval (agreement) of technical documentation of ships, materials and equipment are given in Part II "Technical Documentation" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**3.1.2** This Part of the Rules contains lists of documentation of the technical and technical working design, as well as of the working documentation of ship under construction, to be submitted to the Register for consideration and approval.

**3.1.3** Requirements for the scope of technical documentation of a ship under conversion, repair or renovation, transfer of class, as well as during the initial survey of ship not built under the technical supervision of the Register or any other classification body, are given in Part I "General Provisions" of Rules for the Classification Surveys of Ships in Service.

**3.1.4** Requirements for the scope of technical documentation of materials and products for ships are given in the relevant Parts of the Rules.

#### 3.2 TECHNICAL DESIGN DOCUMENTATION AND DETAIL DESIGN DOCUMENTATION OF A SHIP UNDER CONSTRUCTION

##### 3.2.1 General provisions.

Before the beginning of the construction of a ship technical design documentation proving that the requirements of the Register rules applicable to the ship concerned are complied with shall be submitted to the Register for consideration. The documentation for consideration shall be submitted to the Register as a rule in three copies completed in accordance with the lists given in 3.2.2 to 3.2.11 taking into account the peculiarities and type of a ship.

##### 3.2.2 General:

**.1** general ship's specification (no stamp of approval is needed);

**.2** general arrangement plans with indication of escape routes;

**.3** list of associated equipment and materials with indication of the basic technical data, manufacturer and availability of the approval of the Register or other competent body (no stamp of approval is needed);

**.4** drawing of explosion-dangerous zones and spaces;

**.5** list of regime measures carried out by the shipowner when preparing the oil recovery ship for performing operations on elimination of oil spillage;

**.6** list of measures and engineering solutions to ensure electrostatic and galvanic sparking safety including descriptions and arrangement plans of relevant structures and equipment;

**.7** plan showing the position of the IMO number on board the ship in accordance with the requirements of regulation XI-1/3 of SOLAS-74/2004 (for all passenger ships of 100 gross tonnage and above and for all cargo ships of 300 gross tonnage and above).

##### 3.2.3 Hull documentation.

**3.2.3.1** In the case of subsequent approval of working documentation the following documentation shall be submitted<sup>1</sup>:

**.1** hull members scantlings determination, as well as analysis of the overall longitudinal strength and stability of members for all specified loading conditions of the ship including the loading and carriage of bulk cargoes other than grain (no stamp of approval is needed);

**.2** midship section plan with the most typical transverse sections with indication of spacing between main longitudinal and transverse members, main particulars of the ship and their ratios, class notation of a ship;

**.3** constructional profile with indication of frame spacings, boundaries of the portions of the ship's length, position of the watertight bulkheads, pillars, arrangement of superstructures and deckhouses;

**.4** deck and platform plans with indication of design loads (including the loads induced by lift trucks and containers), positions and dimensions of openings, their strengthening, end structures of the side coamings;

**.5** double bottom (single bottom) plan together with sea chest section and with indication of pressure in the blowing system. For bulk carriers and ore carriers an allowable load on inner bottom plating shall be indicated;

**.6** shell expansion with indication of the boundaries of the ship's hull sections, positions and dimensions of openings in shell plating, and for ships strengthened for navigation in ice also the upper and lower edges of the ice belt and corresponding forward and aft draughts (with due regard for trim), arrangement of intermediate frames. Shell expansion for

<sup>1</sup> All drawings mentioned below shall indicate the scantlings of the hull members, their material (with indication of grades according to Part XIII "Materials"), as well as typical sections and details, types and dimensions of fillet welds.

glass reinforced ships shall be submitted if the outer shell plating has different thickness;

.7 drawings of longitudinal and transverse bulkheads including tank wash bulkheads (for tanks the heights of overflow and air pipes shall be indicated);

.8 drawing of the after end framing and sternframe;

.9 drawing of the fore end framing and stem;

.10 drawings of propeller brackets and bossings, as well as fixed nozzles;

.11 drawings of seatings of main machinery and boiler bearers with bottom construction in that area with indication of the type and power of machinery as well as with indication that seatings and bearers comply with the requirements of the supplier's technical documentation on main machinery and boilers or that no special requirements are placed by the supplier on the seatings and bearers;

.12 drawing of superstructures and deckhouses;

.13 basic parameters of the hull protection by damping from damages when mooring (for ships to be moored at sea to other ships).

**3.2.3.2** With no subsequent approval of working documentation, documentation as stated in 3.2.3.1 shall be submitted with indication of tables of pressure heads, compartments, dimensions and position of manholes and other openings on the double bottom plan (refer to 3.2.3.1.5).

The following documentation shall be submitted additionally:

.1 scheme of welding quality control and table of hull welding containing the following information:

.1.1 name and thickness of structural components to be joined;

.1.2 shape or symbol of edge preparation;

.1.3 marks and grades of base metal;

.1.4 marks and grades of welding consumables;

.1.5 method of welding and position of joint in space.

If the information indicated in 3.2.3.2.1.1.1 to 3.2.3.2.1.1.5 is stated to the full in the drawings of the ship hull, then submission of the table of welding is not required;

.2 subdivision of hull into sections, including brief description of prefabricating and welding methods (no stamp of approval is needed);

.3 description of the basic technological process of joining hull parts afloat based on the methods of carrying out such operations acceptable for the Register;

.4 detailed description of the technological hull constructing process, containing the information on materials, methods of forming the structural items, necessary conditions required during hull construction, as well as analysis of the structural strength both local and general (only for ships constructed of glass-reinforced plastic);

.5 scheme of tightness test of hull structures;

.6 drawings of penetrations of piping, ventilation ducts, cable ducts, etc. through bulkheads, decks, inner bottom, watertight floors and web members;

.7 hull painting list;

.8 programme of mooring tests and sea trials;

.9 Loading Manual for ships of 65 m and over in length (refer to 1.4.9, Part II "Hull").

**3.2.4 Documentation on arrangements, equipment and outfit.**

**3.2.4.1** In the case of subsequent approval of working documentation, the following shall be submitted:

.1 arrangement plan of openings in hull, superstructures and deckhouses with indication of coaming heights and type of closing appliances;

.2 strength calculation of closing appliances (no stamp of approval is needed);

.3 general arrangement plans of steering gear, active means of ship's steering, anchor, mooring and towing arrangements;

.4 calculations of strength and efficiency of the rudder, calculations of means of ship's active steering, anchor, mooring and towing arrangements, as well as diagram of tractive force for tugs (no stamp of approval is needed);

.5 drawings of signal masts and rigging;

.6 calculation of signal masts and rigging (no stamp of approval is needed);

.7 general arrangement plan of guide members for containers in holds;

.8 calculation of guide members for containers in holds (no stamp of approval is needed);

.9 drawings of openings in subdivision bulkheads and their closing appliances.

**3.2.4.2** With no subsequent approval of working drawings the documentation as stated in 3.2.4.1 shall be submitted, as well as:

.1 list of emergency outfit and its arrangement;

.2 programme of mooring tests and sea trials;

.3 documentation stated in 1.3.4, Part III "Arrangements, Equipment and Outfit".

**3.2.5 Documentation on stability (no stamp of approval is needed) and manoeuvrability:**

.1 lines drawing, coordinate tables of lines drawing;

.2 hydrostatic curves;

.3 curves of areas and static moments of hull cross sections;

.4 calculations and curves of arms of form stability (cross-curves) with schemes of hull volumes taken into account;

.5 summary table of displacements, positions of centre of gravity, trim and initial stability for various loading conditions;

.6 calculation materials relating to verification of ship's stability according to the Rules; mass tables for

various loading conditions with indication of distribution of cargoes, fuel oil, fresh water and liquid ballast in tanks; calculations of roll amplitude and weather criterion; diagrams of windage area of a ship and calculations of heeling moments; calculations of heel caused by crowding of passengers and by turning; calculations of icing, angles of flooding, corrections for free surface effect of liquid cargoes and stores; arrangement plans of openings in hull, superstructures and deckhouses, etc.;

.7 summary table of the results of stability verification according to the Rules and curves of static or dynamic stability;

.8 stability calculations for the case of loading and stowage of bulk cargoes other than grain;

.9 program of full-scale and maneuverability trials in compliance with the Guidelines on Determining the Maneuvering Qualities of Ships.

#### **3.2.6 Documentation on subdivision:**

.1 calculation on probability estimation of subdivision (if required) and curves of floodable length of compartments (no stamp of approval is needed);

.2 calculations of damage stability and trim including static stability curves (no stamp of approval is needed);

.3 plan of subdivision showing all watertight structures and openings with indication of types of closing appliances, as well as arrangements used for equalizing heel and trim of the damaged ship;

.4 cross-curves of stability (for damaged ship) if necessary for the adopted method of damage stability calculation (no stamp of approval is needed);

.5 calculations of sectional areas of cross-flooding fittings and of uprighting time of ship (no stamp of approval is needed);

.6 corner point coordinate table for compartments and tanks;

.7 arrangement plan of the alarm system on water presence in bulk carriers compartments sensors, including technical description of the alarm system equipment; type approval certificate for the alarm system; arrangement of the alarm system with indication of the equipment location at the ship general arrangement plan; documents with indication of the fastening, protection and test methods of the alarm system equipment; list of cargoes, the 50 per cent mixture of which with sea water does not affect operational capabilities of sensors covered with protective casing; description of procedures necessary to be performed if the alarm system fails; requirements on maintenance of the alarm system equipment.

#### **3.2.7 Documentation on fire protection.**

**3.2.7.1** In the case of subsequent approval of working documentation, the following shall be submitted:

.1 documents on structural fire protection:

.1.1 arrangement plan of fire-protective divisions including doors and penetrations (cutouts) in these structures with indication of categories of these spaces in compliance with 2.2.1.3, 2.2.1.5, 2.3.3 or 2.4.2, Part VI "Fire Protection", as well as numbers of type approval certificates for structures, doors and penetrations (cutouts);

.1.2 schemes or description of insulation, lining, finishing, deck covering and other finishing materials with indication of numbers of type approval certificates for materials issued in compliance with the Fire Test Procedures Code (refer to 1.6 and 2.1.1.5 to 2.1.1.9, Part VI "Fire Protection");

.1.3 calculations required by 2.1.1.4 and 2.1.1.10, Part VI "Fire Protection";

.2 elementary diagrams of fire extinguishing systems and smoke detection system by air sampling with associated calculations and other data, which confirm the fulfillment of the requirements of Part VI "Fire Protection";

.3 list of fire-fighting outfit with indication of numbers of type approval certificates for outfit items.

**3.2.7.2** With no subsequent approval of working documentation the documentation specified in 3.2.7.1 shall be submitted, and additionally:

.1 structural drawings of assemblies and parts of fire-protective divisions;

.2 structural drawings of insulation, lining and deck covering;

.3 arrangement plan of fire-fighting outfit;

.4 list of spare parts and tools;

.5 fire extinction systems tests programs;

.6 preliminary fire plan (refer to 3.3.6.8).

#### **3.2.8 Documentation on machinery and boiler installations.**

**3.2.8.1** In the case of subsequent approval of working drawings the following shall be submitted:

.1 general arrangement plans of machinery and equipment in the machinery spaces of category A (refer to 1.2, Part VII "Machinery Installations") with indication of escape routes also in emergency diesel generator spaces;

.2 diagram and description of the remote control for main machinery complete with information on equipment of remote control stations with control devices, indication and alarm signalling devices, means of communication and other arrangements;

.3 documentation on shafting;

.3.1 general view of shafting;

.3.2 drawings of sterntube and parts of sterntube arrangement;

.3.3 drawings of shafts (propeller, intermediate and thrust);

.3.4 drawings of shaft connections and couplings;



**.3.5** drawings of journal and thrust bearings of shafting and their fastening to seatings;

**.3.6** strength calculation of shafts and their fastening parts (no stamp of approval is needed);

**.3.7** calculation of the number of shaft bearings, their position and experienced loads (no stamp of approval is needed);

**.3.8** calculation of fitting of propeller and shafting couplings (no stamp of approval is needed);

**.3.9** torsional vibration calculations in conformity with Section 8, Part VII "Machinery Installations" (no stamp of approval is needed). In some cases, an axial vibration calculation may be required;

**.3.10** sterntube bearing and sterntube seal lubrication and cooling diagrams;

**.3.11** calculation of bending vibration of shaft in accordance with the requirements of Section 5, Part VII "Machinery Installations" (no stamp of approval is needed);

**.4** documentation on propeller:

**.4.1** general view of propeller;

**.4.2** drawings of blade, boss and items for their securing (for detachable blade propeller and controllable pitch propeller);

**.4.3** diagrams of actuating mechanism of CP-propeller and its description (no stamp of approval is needed on descriptions);

**.4.4** drawings of the main parts of the pitch control gear of CP-propeller, including hydrocylinders, push-pull rods, pistons, slides, lubricating oil supply tube to hydrocylinder in hub;

**.4.5** strength calculation of propeller blade and for detachable blade propellers and CP-propellers — also calculation of fastening of blades to the boss (no stamp of approval is needed);

**.5** documentation on active means of the ship's steering (AMSS):

**.5.1** general arrangement plans with necessary sections and sealing details;

**.5.2** drawings and calculations of propeller, shafts, couplings, pinions, gear wheels of steerable propellers, waterjets and thrusters (no stamp of approval is needed on calculations);

**.5.3** drawings of shafts, gearing, rotors, blades and blade turning mechanism of vertical-axis propellers as well as strength calculations of the driving shaft of rotor, blade, gearing (no stamp of approval is needed on calculations);

**.5.4** drawings of bearings and seals;

**.5.5** hull member drawings and analyses of connections, propeller nozzles and tunnel drawings (no stamp of approval is needed on calculations);

**.5.6** diagrams of cooling, lubricating, hydraulic turning systems for steerable propellers (blades of CP-propellers) as well as particulars of pipings of the above systems;

**.5.7** calculations and diagrams of electric drives for electrically driven AMSS (no stamp of approval is needed on calculations);

**.5.8** documentation on monitoring, control, and protection systems;

**.5.9** torsional vibration calculations (for main AMSS and dynamic positioning systems) and service life calculation of rolling bearings (no stamp of approval is needed on calculations).

Moreover, the Register may require presentation of rotational and pendular vibration calculations for steerable propellers if used as main AMSS;

**.5.10** material specifications for principal components;

**.5.11** prototype and pilot specimen test programme;

**.5.12** description, service and maintenance manual (no stamp of approval is needed);

**.6** documentation on refrigerating plants (refer to 4.3).

**3.2.8.2** With no subsequent approval of working drawings, documentation as stated in 3.2.8.1 shall be submitted, including information on treatment and geometry of working surfaces, heat treatment, tolerances on mating parts, hydraulic tests, non-destructive test and additionally:

**.1** calculation of parameters of shafting alignment (no stamp of approval is needed);

**.2** drawings of seating and attachment fittings of main machinery, shafting bearings and boilers;

**.3** list of spare parts;

**.4** programme of mooring tests and sea trials.

**3.2.9 Documentation on automation equipment.**

**3.2.9.1** In the case of subsequent approval of working drawings, the following shall be submitted:

**.1** list of systems, devices and elements used in automation systems, their technical description with indication of the purpose, principle of operation, data on reliability and Register approval;

**.2** circuit schemes and block diagrams of alarm and warning systems, including diagrams of power supply;

**.3** list of controlled parameters with indication of types of devices, manufacturers, data on reliability and Register approval for devices;

**.4** technical documentation on remote automated control for main engines and CP-propellers: circuit schemes and block diagrams, front panels of the remote automated control deck with indication of all devices, diagram of power supply to remote automated control, diagrams of protection, alarm and indication of parameters of main engines and CP-propellers;

**.5** circuit schemes and block diagrams of automation systems for main engines (cooling, lubricating oil, fuel oil preparation systems, etc.);

.6 technical documentation on automation of auxiliary engines and electric generating plant: circuit schemes and block diagrams, front panels of control desks for electric generating plant with indication of all devices, diagram of power supply, protection, signalling and indication of parameters of auxiliary engines and electric generators;

.7 technical documentation on automation of boiler installation: circuit schemes and block diagrams, front panels of control desks with indication of all devices, diagrams of power supply, protection, signalling and indication of parameters;

.8 circuit schemes and block diagrams of automation of starting air compressors, including diagrams of protection, alarm and indication;

.9 circuit schemes and block diagrams of automation and remote control of bilge and ballast systems, diagrams of power supply, signalling and indication;

.10 circuit schemes and block diagrams of remote level sounding in tanks;

.11 drawings of front panels of desks and boards of control and alarm signalling systems at the main control station and on the bridge with indication of all devices;

.12 general arrangement plans of automation equipment at the main control station and on the bridge.

**3.2.9.2** With no subsequent approval of working plans documentation as stated in 3.2.9.1 shall be submitted and additionally:

.1 circuit schemes and block diagrams of automation systems supervised by the Register and stated in the appropriate parts of the Rules which are not indicated in 3.2.9.1;

.2 programme of mooring tests and sea trials;

.3 list of spare parts for particular automation systems.

#### **3.2.10 Documentation on systems and piping.**

**3.2.10.1** In the case of subsequent approval of working plans the following documentation shall be submitted:

.1 documentation on ship's systems:

.1.1 bilge system diagram;

.1.2 ballast system diagram;

.1.3 heeling and trimming system diagrams, as well as diagrams of devices (automatic or manually controlled) for ship trimming by crossflooding;

.1.4 air, overflow and sounding pipes diagrams;

.1.5 diagrams of ventilation and air conditioning systems of accommodation, service, cargo, machinery and working spaces with indication of watertight bulkheads and fire-proof divisions, arrangement of fire dampers, as well as indication of closures of ventilation ducts and openings;

.1.6 diagrams of sewage and other waste water systems, as well as scuppers with indication of watertight bulkheads, freeboard deck and distances

from waterline or freeboard deck to appropriate openings, as stated in 4.3.2.4 and 4.3.2.6, Part VIII "Systems and Piping";

.1.7 diagrams of blowing and heating systems of sea chests, heating system of side fittings, heating system for liquids in tanks, steaming system for tanks;

.1.8 diagram of the compressed air system for tyfons, for blowing the sea chests;

.1.9 diagrams of hydraulic systems for drives of mechanisms and arrangements;

.1.10 diagrams of systems: cargo, stripping, vapour emission control and gas vent systems (for oil tankers and combination carriers);

.1.11 calculations of the systems: bilge, ballast, vapour emission control; ventilation of accumulator rooms, cargo pump rooms, enclosed spaces and holds intended for the carriage of motor vehicles (no stamp of approval is needed);

.1.12 diagram of thermal liquid system;

.2 documentation on machinery installation systems:

.2.1 diagrams of live and exhaust steam systems;

.2.2 diagrams of blowing-off systems for boilers, machinery and steam piping;

.2.3 diagram of condensate and feed water system;

.2.4 diagram of fuel oil system;

.2.5 diagram of lubricating oil system;

.2.6 diagrams of fresh and sea water cooling systems;

.2.7 diagram of starting air system;

.2.8 diagram of exhaust gas pipes and uptakes;

.2.9 drawing of sea chests and ice chests equipment;

.2.10 calculation of starting air system (no stamp of approval is needed);

.2.11 calculation of fuel oil service tank capacity of emergency diesel-generator (no stamp of approval is needed).

**3.2.10.2** With no subsequent approval of working plans the documentation as stated in 3.2.10.1 shall be submitted including the information on materials, insulation, manufacture, assembling, arrangement, hydraulic tests, etc. and additionally:

.1 drawings of silencers and spark arresters of exhaust gas pipes and uptakes;

.2 programme of mooring tests and sea trials.

#### **3.2.11 Documentation on electrical equipment.**

**3.2.11.1** In the case of subsequent approval of working plans, the following shall be submitted:

.1 circuit diagrams of power generation and distribution from the main and emergency sources of electrical power: ship's mains, lighting (up to section switchboards) and navigation lights;

.2 circuit diagrams and general arrangement plans of main and emergency switchboards, control desks and other switchboards of non-standard design;

**.3** calculation results of necessary output of ship's electric power plant providing for the operating conditions specified in 3.1.5, Part XI "Electrical Equipment", substantiation of the choice of the number and output of generators, as well as calculation of output of emergency sources of electrical power (no stamp of approval is needed);

**.4** calculation results of cross-sections of cables with indication of their types, currents and protection (no stamp of approval is needed);

**.5** circuit or detailed diagrams of the main current, excitation, control, pilot, signalling, protection and interlocking of the electric propulsion plant;

**.6** calculation results of necessary output of the propulsion generators to ensure normal operation under all operating conditions of ship's service (no stamp of approval is needed);

**.7** calculation results of short-circuit currents and analysis of selective properties of protection equipment for rated current generators or for generators working in parallel in excess of 1000 A (no stamp of approval is needed);

**.8** calculation results of illumination intensity for spaces (no stamp of approval is needed);

**.9** circuit diagrams of electric engine telegraph, telephone communication, general alarm system, fire detection and fire alarm systems, alarms to warn that fire smothering system is put into action, signalling systems of closing of watertight and fireproof doors, alarms in the engineers' accommodation spaces;

**.10** circuit diagrams of essential electric drives;

**.11** diagrams of lubrication systems for electric machines and air cooling systems for main electric machines;

**.12** diagrams of earthing of the protection system and, if necessary, calculations of lightning conductors for tankers, gas carriers, drilling units and non-metal ships;

**.13** circuit diagram of cable runs with indication of spaces which they pierce;

**.14** capacity calculation results for accumulator batteries of emergency lighting, navigation lights, general alarm system, fire alarm system and fire smothering appliances starting devices of the emergency diesel-generator set (no stamp of approval is needed);

**.15** results of preliminary calculations of factors accounting for voltage anharmonicity in different parts of ship's mains when using power semiconductor units (no stamp of approval is needed);

**.16** information on electrical equipment installed in explosion dangerous zones, areas and spaces with indication of its version for each space;

**.17** calculation of expected efficiency of overload protection of generator sets by means of disconnection of the part of consumers with explanations of the number of disconnection steps and the list of

disconnected consumers in every step (no stamp of approval is needed);

**.18** diagram and drawing of disconnection and blocking system of electrical equipment which is not used in operations on elimination of oil spillage;

**.19** instruction on preparation and application of electrical equipment for elimination of oil spillage determining procedure of compulsory disconnection and blocking of electrical consumers without Certificates on Safe Type Electrical Equipment (no stamp of approval is needed);

**.20** drawings of equipment layout and cable laying in dangerous areas and spaces. Documentation (certificates issued by competent bodies), confirming the possibility of using the electrical equipment in dangerous areas and spaces;

**.21** documentation on fixed and portable devices for measuring and signalling of explosive concentrations of gases;

**.22** calculation of voltage dip when a consumer with maximum starting power is switched on (no stamp of approval is needed);

**.23** list of all essential electrical equipment installed on board the ship with indication of technical characteristics and data on approval of this equipment by the Register or another competent body;

**.24** list of measures to be taken to ensure the electromagnetic compatibility of ship equipment;

**.25** list of spare parts.

**3.2.11.2** With no subsequent approval of working plans, documentation as stated in 3.2.11.1 shall be submitted, as well as the following:

**.1** drawings of cable runs and their penetrations through watertight, gastight and fire-fighting bulkheads, decks and platforms with indication of measures taken to suppress radio interferences;

**.2** diagrams of main and emergency lighting in the spaces and places of arrangement of essential appliances, evacuation routes, survival craft embarkation stations at the deck and outboard (supplying from section switchboards);

**.3** programme of mooring tests and sea trials;

**.4** drawings of arrangement and installation of electrical equipment in all spaces and zones of the ship;

**.5** assembly drawings (only for non-standard articles) of main switchboards, emergency switchboards, electric propulsion plant boards, control stations and desks, special boards, power and lighting switchboards;

**.6** diagrams and installation drawings of devices for measuring non-electric values (level, pressure, temperature indicators, etc.).

**3.2.11.3** Where refrigerating plants are to be classified, documentation as stated in 3.2.11.1 and 3.2.11.2 shall contain data concerning electrical equipment of refrigerating plant.

### 3.3 WORKING DOCUMENTATION FOR A SHIP UNDER CONSTRUCTION

#### 3.3.1 General:

.1 lists of emergency, fire extinguishing and other outfit with indication of main technical characteristics and its position in a ship; lists of spare parts and special tools. These lists shall be submitted for all sections where it is specified by the Rules;

.2 programmes of mooring tests and sea trials;

.3 plan showing the position of the IMO number on board the ship in accordance with the requirements of regulation XI-1/3 of SOLAS-74/2004 (for all passenger ships of 100 gross tonnage and above and for all cargo ships of 300 gross tonnage and above).

#### 3.3.2 Hull documentation:

.1 stem and sternframe drawings;

.2 drawings of sections and details of the main hull, including decks, transverse and longitudinal bulkheads, sides, bottom, double bottom (with indication of the position of manholes and openings), tanks outside the double bottom being a structural part of the hull, etc.;

.3 drawings of sections and details of superstructures and deckhouses;

.4 drawings of engine and boiler casings, coamings and sills, companions and other guards of openings in the ship's hull;

.5 drawings of propeller shaft tunnel, recesses and escape trunks;

.6 drawings of propeller brackets and bossings;

.7 drawings of seatings for main machinery, boilers and bearings of shafting, seatings of auxiliaries, equipment and arrangements included in the nomenclature;

.8 bulwark drawings;

.9 plan of testing the hull for watertightness;

.10 plan of weld control of hull and superstructures and table of hull welding, containing the information given in 3.2.3.2.1;

.11 plan of subdivision of hull into sections;

.12 description of the basic technological process of joining hull parts afloat, based on the methods of carrying out such operations acceptable for the Register;

.13 hull painting list;

.14 Loading Manual for ships of 65 m and over in length (refer to 1.4.9, Part II "Hull");

.15 Information (booklet) on Stability and Strength during Loading, Unloading and Stowage of Bulk Cargoes Other than Grain (refer to 1.4.9.7, Part II "Hull").

#### 3.3.3 Documentation on arrangements, equipment and outfit:

.1 general arrangement plans of assemblies and parts of closing appliances in hull, superstructures and deckhouses, in the subdivision bulkheads;

.2 general arrangement plans of assemblies and parts of steering gear, active means of ship's steering, anchor, mooring and towing arrangements, as well as spar and rigging, and guard rails;

.3 general arrangement plans of assemblies and parts of bulk cargo separation fittings.

#### 3.3.4 Documentation on stability and manoeuvrability:

preliminary Information on Stability and calculations provided that these are not included in the documentation submitted according to 3.2.5.1 to 3.2.5.9.

#### 3.3.5 Documentation on subdivision:

preliminary Information on Emergency Trim and Stability and calculations on which it is based (provided that these are not included in the documentation submitted according to 3.2.6).

#### 3.3.6 Documentation on fire protection:

.1 structural drawings of assemblies and parts of fire-protection divisions;

.2 structural drawings of insulation, lining and deck covering;

.3 structural drawings of assemblies and equipment of fire extinction systems with required calculations;

.4 arrangement plans of fire-fighting outfit;

.5 list of spare parts and tools;

.6 fire extinction systems tests programs;

.7 operational diagrams and fire extinction systems operational manuals, which shall be available on board a ship in compliance with Part VI "Fire Protection";

.8 fire plan according to 1.4, Part VI "Fire Protection" (stamp of approval shall be placed upon a completion of the ship's construction).

#### 3.3.7 Documentation on systems and piping:

.1 ship's system drawings:

.1.1 bilge;

.1.2 ballast;

.1.3 heeling and trimming, diagram and construction of arrangements (automatic and manual-controlled) used for equalizing the damaged ship by means of counterflooding;

.1.4 air, overflow, sounding pipes, liquid level indicators, systems of remote level sounding in fuel tanks, cargo and slop tanks of the tankers;

.1.5 ventilation of accommodation, service, cargo, machinery and working spaces, construction of dampers and shut-off fittings of ventilation and other openings necessary for fire safety of the ship;

.1.6 gas vent pipes and gas vent equipment (design of flame arresters, flame-arresting gauzes, breathing valves and high-velocity devices);

.1.7 sewage, drainage and scuppers;

.1.8 cargo and stripping;

.1.9 liquid cargo heating;

- .1.10 fuel oil loading and transfer system;
- .1.11 thermal liquid;
- .2 drawings of propulsion plant piping:
  - .2.1 live and waste steam and blow-off pipes;
  - .2.2 feed water, condensate and evaporator;
  - .2.3 fuel oil;
  - .2.4 lubricating oil;
  - .2.5 cooling;
  - .2.6 exhaust manifold and uptakes;
  - .2.7 compressed air;
  - .2.8 heating system of fuel oil, water and lubricating oil; structural drawings of details and connections of heating elements;
  - .2.9 position and details of attachment of bottom and side fittings;
- .3 structural drawings of leading the pipes and vent ducts through the watertight bulkheads, fire-proof divisions, decks and platforms.

### **3.3.8 Documentation on machinery and boiler installations:**

- .1 drawings of installation and attachment of main machinery and steam boilers;
- .2 drawings of fittings of fuel oil and lubricating oil tanks;
- .3 drawings of silencers and spark arresters in exhaust gas pipes and uptakes;
- .4 drawings of shafting and stern tube:
  - .4.1 thrust, intermediate and propeller shafts;
  - .4.2 main and thrust bearings and their attachment;
  - .4.3 couplings;
  - .4.4 stern tube and details of stern tube arrangement (bushes, bearings, sealings);
- .5 fixed-pitch propeller (together with details of fastening of blades, if detachable blade propeller is fitted);
- .6 controllable pitch propeller (CPP):
  - .6.1 hub complete;
  - .6.2 blades;
  - .6.3 propeller shaft and fastening thereof to the hub;
  - .6.4 oil transfer block in assembly;
  - .6.5 pitch actuating mechanism complete (PAM);
  - .6.6 shaft of pitch actuating mechanism (PAM);
- .7 drawings of installation and attachment of AMSS:

.7.1 drawings of propellers and impellers (when CPP are used, refer to 3.3.8.6);

.7.2 drawings of bearings and seals;

.7.3 drawings of shafts, couplings, gear wheels, pinions.

*Note.* For propellers not covered by the requirements of the Rules, the list of the working plans shall be agreed with the Register in each individual case.

### **3.3.9 Documentation on automation systems and devices:**

mounting and structural drawings of blocks of automation systems and devices, sensors, alarm devices, instruments, as well as of switchboards and desks of control and monitoring.

### **3.3.10 Documentation on electrical equipment:**

- .1 diagrams of main and emergency lighting circuits in the spaces and places of arrangement of essential appliances, evacuation routes, survival craft embarkation stations at the deck and outboard (supplying from the section switchboards);
  - .2 cable installation drawings with indication of cable penetrations through the watertight, gastight and fire-fighting bulkheads, decks and platforms;
  - .3 structural assembly drawings (for non-standard articles only) including:
    - .3.1 main switchboards;
    - .3.2 electric propulsion plant boards;
    - .3.3 emergency switchboards;
    - .3.4 control stations and desks;
    - .3.5 special boards;
    - .3.6 power and lighting switchboards;
  - .4 arrangement and installation drawings and diagrams of devices intended for measuring non-electric values (level, pressure, temperature indicators, etc.);
  - .5 drawings and diagrams of devices for suppression of radio interference;
  - .6 arrangement and installation drawings of electrical equipment in all ship's rooms and spaces;
  - .7 corrected drawings and diagrams specified in 3.2.11.1.
- 3.3.11** Documentation on refrigerating plants is specified in 4.3.3.

## **4 CLASSIFICATION OF REFRIGERATING PLANTS**

### **4.1 GENERAL**

**4.1.1** For ensuring safety of a ship and preventing ozone-destructive effect of refrigerants on environment the refrigerating plants installed in ships classed

with the Register are subject to surveys in the following cases:

- .1 refrigerating plants working with Group II refrigerants in accordance with Table 2.2.1, Part XII "Refrigerating Plants";

**.2** refrigerating plants working with Group I refrigerants and comprising the compressors with theoretical suction capacity 125 m<sup>3</sup>/h and above;

**.3** refrigerating plant ensures the functioning of systems affecting the ship safety.

**4.1.2** From the number of the refrigerating plants stated in 4.1.1 the Register assigns a class to:

**.1** refrigerating plants intended for developing and maintaining the required temperatures in refrigerated cargo spaces of transport ships, as well as in thermal containers to provide proper carriage of goods;

**.2** refrigerating plants intended for developing and maintaining the required temperatures in refrigerated cargo spaces, for cold-treatment of sea products (cooling, freezing) and supplying the cold necessary for operation of process plants in fishing ships and other ships used for processing of the biological resources of sea;

**.3** refrigerating plants intended to maintain the required conditions for transportation of liquefied gas in bulk in gas carriers.

Other refrigerating plants from the number of those stated in 4.1.1 subject to the Register supervision are considered unclassified.

## 4.2 CLASS OF A REFRIGERATING PLANT

### 4.2.1 General.

**4.2.1.1** The Register may assign a class to a refrigerating plant after the ship's construction, as well as assign, or renew a class of a refrigerating plant installed in a ship in service.

**4.2.1.2** Assignment or renewal of a class means that the refrigerating plant fully or to a degree considered acceptable by the Register complies with the requirements of the relevant Rules. The fact of a class being assigned or renewed indicates that the refrigerating plant complies either fully or to a degree deemed acceptable by the Register, with the requirements of the relevant Rules and is taken under the Register supervision, and that the technical condition of the plant is in accordance with the provisions of design specifications included in the Classification Certificate for the Refrigerating Plant.

**4.2.1.3** Assignment or renewal of a class granted to a refrigerating plant shall be confirmed by the issue of a Classification Certificate after the survey carried out.

### 4.2.2 Class notation of a refrigerating plant.

**4.2.2.1** The character of classification of a refrigerating plant consists of the following marks:

**REF**★ — for a refrigerating plant built according to the Rules and surveyed by the Register;

**REF**★ — for a refrigerating plant built according to the Rules of a classification body recognized by the Register, surveyed by that classification body and then classed by the Register;

**(REF)**★ — for a refrigerating plant built without being surveyed by a classification body recognized by the Register or without being surveyed by a classification body at all, but subsequently classed with the Register;

**REF**★ — for a refrigerating plant built according to the Rules of an IACS Member Society, surveyed by that Society during construction and subsequently classed by the Register, if the refrigerating plant does not fully comply with the requirements of Part XII "Refrigerating Plants".

### 4.2.2.2 Mark of a capability to cargo refrigeration.

If the refrigerating plant has a capacity sufficient to refrigeration of a non-precooled cargo on shipboard during a period of time that provides preservation of that cargo, a distinguishing mark **PRECOOLING** shall be added in the character of classification.

In such a case a note specifying the conditions of cargo cooling on shipboard shall be entered into the Classification Certificate for the refrigerating plant and in the Register Book.

**4.2.2.3** Mark of capability for cooling or freezing sea products.

An additional mark **QUICK FREEZING** is added to the character of classification if the plant is intended for cooling or freezing sea products and is in accordance with the relevant requirements specified in Part XII "Refrigerating Plants".

**4.2.2.4** Additional character letters of refrigerating plants.

**4.2.2.4.1** If a refrigerating plant is intended for cooling of cargo transported in thermal containers and complies with applicable requirements of Part XII "Refrigerating Plants" a character letter **CONTAINERS** is added to the character of classification of the plant.

**4.2.2.4.2** If, in addition to a refrigerating plant, a ship is equipped with atmosphere control system in refrigerated spaces and/or thermal containers which complies with applicable requirements of Part XII "Refrigerating Plants" a character letter **CA** is added to the character of classification of the plant.

**4.2.2.4.3** If a refrigerating plant is intended to maintain the required conditions for transportation of liquefied gas in bulk in a gas carrier and complies with applicable requirements of Part XII "Refrigerating Plants" a character letter **LG** is added to the character of classification of the plant.

### 4.2.3 Additional characteristics.

**4.2.3.1** Additional details of conditions for cooling cargoes on board, specified temperature condi-

tions for transportation of cargoes and other details are indicated in the Classification Certificate and in the Register of Ships if it is found necessary by the Register to specify the purpose or structural features of the refrigerating plant.

**4.2.3.2** Number of thermal containers served by the refrigerating plant is indicated in the Classification Certificate for refrigerating plant and in the Register of Ships.

**4.2.4 Alteration of marks in class notation.**

The Register may delete or alter a mark shown in the class notation in case of any modification or non-compliance with the requirements which served as the basis for the insertion of that mark into the class notation.

**4.3 TECHNICAL DOCUMENTATION  
OF A REFRIGERATING PLANT**

**4.3.1 Technical design documentation and detail design documentation of a classed refrigerating plant.**

**4.3.1.1 General.**

Before commencement of ship's construction technical design documentation with a sufficient scope of information to prove that the requirements of the Rules of the Register for a refrigerating plant are complied with, shall be submitted for consideration to the Register. Approximate lists of technical documents to the Register are given in 4.3.1.2 and 4.3.1.3.

**4.3.1.2** In the case of subsequent approval of working documentation, the following information shall be submitted:

**.1** technical description of a refrigerating plant (no stamp of approval is needed);

**.2** cooling capacity calculations with indication of thermal load from each refrigerated cargo space and cold consumers (no stamp of approval is needed);

**.3** general arrangement plans of a refrigerating plant on board the ship;

**.4** circuit schemes of working and emergency ventilation systems in the refrigerating machinery spaces with indication of the watertight bulkheads and fire-proof divisions, as well as the number of air changes per hour;

**.5** circuit schemes of refrigerant, cooling medium, cooling water systems with indication of places for installation of instruments and automatic devices;

**.6** air cooling diagram with indication of watertight bulkheads and fire-proof divisions;

**.7** arrangement plans of equipment in refrigerating machinery spaces with indication of escape routes;

**.8** arrangement plans of equipment in refrigerated spaces with indication of places for installation of temperature control devices;

**.9** construction plans of insulation of refrigerated spaces with specification of insulating materials;

**.10** elementary diagram of water screen system of refrigerating machinery spaces (for refrigerants of Group II);

**.11** general arrangement plans of freezing and cooling arrangements and other refrigerating processing equipment;

**.12** circuit schemes of automatic control, protection and alarm systems;

**.13** list of machinery, vessels and apparatus of refrigerating plant with indication of technical characteristics, type (trade-mark), manufacturer and information on approval by the Register (no stamp of approval is needed);

**.14** list of control devices and measuring instruments, protection and alarm systems with indication of technical characteristics, type (trade-mark), manufacturer and information on approval by the Register (no stamp of approval is needed);

**.15** tables of the values of the bounding surface areas of the refrigerated cargo spaces and holds with data on calculated heat transfer coefficient for each surface (no stamps of approval is needed);

**.16** drawings of cargo cooling air ducts in thermoinsulated containers with an indication of the layout on board;

**.17** drawings of air duct insulation with technical data of insulation materials;

**.18** drawings of sealing and flexible joints with indication of details on materials;

**.19** general arrangement plans of atmosphere control installation;

**.20** list of equipment of the atmosphere control system including control and automatic devices and data on their approval by the Register.

**4.3.1.3** The documentation specified in 4.3.1.2 shall be submitted without subsequent approval of working documentation, which is also true for the following documentation to be submitted additionally:

**.1** drawings of installation and fastening of machinery, vessels and apparatus;

**.2** arrangement plans of piping of refrigerant, cooling medium and cooling water system with indication of places of their penetration through the bulkheads, decks and platforms;

**.3** arrangement plan of emergency discharge system of refrigerant outboard;

**.4** list of spare parts;

**.5** test program with indication of the method of design thermal load generation (including a calculation of the power of additional heaters to be used) and the method of determining the actual averaged heat-transfer coefficient for the insulating structure of refrigerated cargo spaces.

**4.3.2 Technical design documentation and detail design documentation of an unclassified refrigerating plant.**

**4.3.2.1** In the case of subsequent approval of working documentation, the documentation stated in 4.3.1.2.3 to 4.3.1.2.5 (for refrigerant only), 4.3.1.2.7, 4.3.1.2.10, 4.3.1.2.11 (only for arrangements operating under the pressure of refrigerant), 4.3.1.2.12 (only for protection and alarm system), 4.3.1.2.13, 4.3.1.2.14 (only for protection and alarm devices).

**4.3.2.2** The documentation specified in 4.3.2.1, as well as the documentation stated in 4.3.1.3.1, 4.3.1.3.2 (for refrigerant only), 4.3.1.3.3 shall be submitted without subsequent approval of working documentation.

**4.3.3 Working documentation on refrigerating plants:**

**.1** drawings of installation and fastening of machinery, vessels and apparatus;

**.2** arrangement plan of refrigerant piping;

**.3** arrangement plan of cooling medium and cooling water piping;

**.4** drawing of cooling air system;

**.5** drawing of water screen and water spraying systems for the refrigerating machinery spaces;

**.6** arrangement plan of emergency discharge system of refrigerant outboard;

**.7** instructions on maintenance and operation of refrigerating plant (no approval stamps are needed);

**.8** list of spare parts;

**.9** test programme.

For unclassified refrigerating plants the documentation specified in 4.3.3.1, 4.3.3.2, 4.3.3.5 and 4.3.3.6, shall be submitted.



## PART II. HULL

### 1 DESIGN PRINCIPLES

#### 1.1 GENERAL

##### 1.1.1 Application.

**1.1.1.1** Unless provided otherwise, requirements of the present Part of the Rules apply to steel ships of welded construction, from 12 to 350 m in length whose proportions are taken within the limits given in Table 1.1.1.1.

Table 1.1.1.1

Proportion of ship	Area of navigation					
	Unrestricted	R1	R2	R2-RSN	R3-RSN	R3
$L/D$	18	19	20	21	22	23
$B/D$	2,5	2,5 <sup>1</sup>	3 <sup>2</sup>	3	3	4 <sup>3</sup>
<sup>1</sup> For vessels of dredging fleet, not more than 3. <sup>2</sup> For vessels of dredging fleet, not more than 4. <sup>3</sup> For floating cranes, not less than 4,5.						

The requirements of the present Part of the Rules do not apply to oil tankers of 150 m and over in length and to bulk carriers of 90 m and over in length.

The scantlings of hull members, essential to the strength of hull and the construction of the said ships are regulated by Part XVII "Common Structural Rules for Double Hull Oil Tankers" and Part XVIII "Common Structural Rules for Bulk Carriers".

**1.1.1.2** The scantlings of hull members, essential to the strength of ships whose construction and main dimensions are not regulated by the present Rules are subject to special consideration by the Register.

##### 1.1.2 General.

**1.1.2.1** All hull structures regulated by the present Part of the Rules are subject to the Register survey. For this purpose an access shall be provided for their survey.

**1.1.2.2** The structures regulated by the present Part of the Rules shall comply with the requirements of Part XIII "Materials" and Part XIV "Welding" and with the approved technical documentation listed in Part I "Classification".

**1.1.2.3** Tightness test of ship's hull shall be carried out according to the provisions of Appendix 1.

##### 1.1.3 Definitions and explanations.

The definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification".

For the purpose of the present Part of the Rules the following definitions and explanations have been adopted.

**Upper deck** is the uppermost continuous deck extending the full length of the ship.

**Moulded depth  $D$**  is the vertical distance measured amidships from the top of the plate keel or from the point where the inner surface of shell plating abuts upon the bar keel, to the top of the upper deck beam at side. In ships having a rounded gunwale, the depth is measured to the point of intersection of the moulded lines of upper deck and side, the lines extending so as if the gunwale were of angular design.

**Length  $L$**  is the distance, in m, on the summer load waterline from the forward side of the stem to the after side of the rudder post or to the centre of the rudder stock if there is no rudder post, or the distance equal to 96 per cent of the length on the summer load waterline from the forward side of the stem to the after side of after end of the ship, whichever is the greater.

However,  $L$  need not be greater than 97 per cent of the ship's length on the summer load waterline.

Where the fore or after end is of an unusual form, length  $L$  is subject to special consideration by the Register.

**After perpendicular** is a vertical line run through the ship centre plane, which limits the ship length  $L$  at the aft end.

**Block coefficient  $C_b$**  is the block coefficient at draught  $d$  corresponding to summer load waterline, based on length  $L$  and breadth  $B$ , determined by the formula

$$C_b = \frac{\text{Moulded displacement (m}^3\text{)}}{LBd}$$

**Summer load waterline** is the waterline on the level of the centre of the load line ring for the ship's position without heel and trim.

**Engine room aft** corresponds to the position of the mid-length of the engine room beyond  $0,3L$  aft of amidships.

**Midship section** is the hull section at the middle of ship's length  $L$ .

**Superstructure** is a decked structure on the upper deck extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4 per cent of the breadth of the ship.

**Tight structure** is a structure impervious to water and other liquids.

**Lower decks** are the decks located below the upper deck.

Where the ship has several lower decks, they are called: second deck, third deck, etc., counting from the upper deck.

**Forward perpendicular** is a vertical line run through the ship centre plane at a point where the summer loadline and the fore side of stem intersect.

**Ship's ends** are portions of the ship's length beyond the midship region.

**Draught  $d$**  is the vertical distance measured amidships from the top of the plate keel, or the point where the inner surface of the shell plating abuts upon the bar keel, to the summer load waterline. In ships with timber freeboard the draught shall be measured at side to the summer timber load waterline.

**Main frames** are vertical side framing members fitted in the plane of floors or bilge brackets within a spacing of each other.

**Freeboard deck** is the deck from which the freeboard is calculated.

**Superstructure deck** is a deck forming the top of a tier of superstructure. Where the superstructure has several tiers, the superstructure decks are called as follows: first tier superstructure deck, second tier superstructure deck, etc., counting from the upper deck.

**Bulkhead deck** is the deck to which the main transverse watertight bulkheads are carried.

**Deck house top** is a deck forming the top of a tier of a deckhouse.

Where the deckhouse has several tiers, the deckhouse tops are called as follows: first tier deckhouse top, second tier deckhouse top, etc., counting from the upper deck. If a deckhouse is fitted on a superstructure deck of first tier, second tier, etc., the deckhouse top is called accordingly the top of second tier deckhouse, third tier deckhouse, etc.

**Platform** is a lower deck extending over portions of the ship's length or breadth.

**Intermediate frames** are additional frames fitted between main frames.

**Strength deck** is the deck forming the upper flange of hull girder. The uppermost continuous deck, long bridge deck, long forecastle or long poop deck outside end regions, or quarter deck outside the transition area may be considered as the strength deck (refer to 2.12.1.2).

**Deck house** is a decked structure on the upper deck or superstructure deck with its side plating, on one side at least, being inboard of the shell plating by more than 4 per cent of the breadth of the ship.

**Specified speed of ship  $v_0$**  is the maximum speed of the ship, in knots, at the summer load waterline in still water at rated engine speed of propulsion plant.

$g = 9,81 \text{ m/s}^2$  — acceleration due to gravity;

$\rho = 1,025 \text{ t/m}^3$  — density of sea water.

**Midship region** is the part of the ship's length equal to  $0,4L$  ( $0,2L$  forward and aft of amidships), unless expressly provided otherwise.

**Moulded breadth  $B$**  is the greatest moulded breadth, in m, measured amidships from outside of frame to outside of frame.

**Spacing** is the distance between primary members, determined on the basis of the value of standard spacing  $a_0$ , in m, determined by the formula  $a_0 = 0,002L + 0,48$ .

Deviation from normal spacing may be permitted within the following limits:

$0,75a_0$  to  $1,25a_0$  for ships of unrestricted area of navigation and restricted area of navigation **R1**;

$0,7a_0$  to  $1,25a_0$  for ships of restricted areas of navigation **R2** and **R2-RSN**;

$0,65a_0$  to  $1,25a_0$  for ships of restricted areas of navigation **R3** and **R3-RSN**.

In the fore and after peaks the spacing of primary members shall not exceed 0,6 m; between the fore peak bulkhead and  $0,2L$  aft of the forward perpendicular — not more than 0,7 m. Variations from these values are subject to special consideration by the Register.

In all cases the spacing of primary members shall not exceed 1 m.

#### 1.1.4 Basic provisions for determining the scantlings of hull members.

**1.1.4.1** The scantlings of hull members are regulated based on the Rule design loads, calculation methods and safety factors with due regard to corrosion allowance (refer to 1.1.5).

**1.1.4.2** Derivation of the scantlings of hull members in the Rules is based on structural idealization using beam models subject to bending, shear, longitudinal loading and torsion having regard to the effect of adjacent structures.

**1.1.4.3** For the purpose of the present Part of the Rules, the design characteristics of the material used for hull structures shall be as follows:

$R_{eH}$  = upper yield stress, in MPa;

$\sigma_n$  = design specified yield stress for normal stresses, in MPa, determined by the formula

$$\sigma_n = \frac{235}{\eta} \quad (1.1.4.3-1)$$

where  $\eta$  = application factor of mechanical properties of steel, determined from Table 1.1.4.3;

$\tau_n$  = design specified yield stress for shear stresses, in MPa, determined by the formula

$$\tau_n = 0,57\sigma_n. \quad (1.1.4.3-2)$$

Table 1.1.4.3

$R_{eH}$	235	315	355	390
$\eta$	1,0	0,78	0,72	0,68

**1.1.4.4** The requirements for strength of structural members and structures as a whole aiming at determining their scantlings and strength characteristics are set forth in the Rules by assigning the specified values of permissible stresses for design normal  $\sigma_p = k_\sigma \sigma_n$  and shear  $\tau_p = k_\tau \tau_n$  stresses (where  $k_\sigma$  and  $k_\tau$  = factors of permissible normal and shear stresses respectively).

The values of  $k_\sigma$  and  $k_\tau$  are given in the relevant chapters of this Part of the Rules.

**1.1.4.5** The buckling strength requirements are imposed upon the structural members subject to considerable compressive normal and/or shear stresses (refer to 1.6.5).

**1.1.4.6** The thickness of hull structural members determined according to the requirements of the present Part of the Rules shall be the minimum thickness specified for particular structures in the relevant chapters of the present Part of the Rules.

For ships of restricted areas of navigation **R2**, **R2-RSN**, **R3** and **R3-RSN**, a reduction in the thickness of hull members is permitted, but not in excess of the values given in Table 1.1.4.6.

Table 1.1.4.6

Permissible reduction of minimum hull member thickness

Hull members	Service area	
	<b>R2 and R2-RSN</b>	<b>R3 and R3-RSN</b>
Web frames in way of ballast tanks	Other hull members	15 per cent 10 per cent

In all cases, unless expressly provided otherwise, the hull member thickness shall not be less than 4 mm.

**1.1.4.7** In the present Part of the Rules, the requirements for determining the hull member scantlings are based on the assumption that during the construction and service of a ship measures are taken for the corrosion prevention of the hull in accordance with current standards and other current normative documents.

**1.1.4.8** On agreement with the shipowner, a reduction in the scantlings of certain hull members may be permitted within the limits agreed with the Register.

The reduced scantlings as well as scantlings determined in accordance with the requirements of the present Rules for the 24-years service life of the ship shall be expressly indicated in the hull structural drawings submitted to the Register for review. A special entry shall be made in the Classification Certificate of such ships (refer to 2.3.1, Part I "Classification").

#### 1.1.5 Corrosion allowance.

**1.1.5.1** Corrosion allowance  $\Delta s$ , in mm, is set for the structures whose planned service life exceeds 12 years and is determined by the formula

$$\Delta s = u(T - 12) \quad (1.1.5.1)$$

where  $u$  = average annual reduction in thickness of the member, in mm per annum, due to corrosion wear or tear according to 1.1.5.2;

$T$  = planned service life of structure, in years; if service life is not specially prescribed,  $T$  shall be taken equal to 24.

For the structures whose planned service life is less than 12 years,  $\Delta s = 0$ .

In the drawings of hull structures, which planned service life has been taken to be less than 24 years, scantlings determined at  $T = 24$  shall be additionally indicated. A special entry shall be made in the Classification Certificate of such ships (refer to 2.3.1, Part I "Classification").

**1.1.5.2** When there are no special requirements for service conditions and means of corrosion prevention of the hull for determining the scantlings of hull members according to the Rules one shall be guided by the data on the average annual reduction in thickness  $u$  of structural member given in Table 1.1.5.2 depending on the group of ships and the designation of the space.

Table 1.1.5.2 provides for division of all ships into two groups depending on corrosion wear conditions:

Group I: dry cargo ships and similar ships as regards the service conditions;

Group II: tankers, bulk carriers, combination carriers and similar ships as regards the service conditions.

For the webs separating the different purpose compartments,  $u$  is determined as the average value for adjacent compartments.

For ships of restricted service intended to operate only in fresh water basins, the value of  $u$  may be reduced 2,5 times for group I and 1,2 times for group II; for ships intended to operate in fresh water basins only for a part of time,  $u$  shall be determined by linear interpolation in proportion to that part of time.

In the drawings of hull structures, which scantlings have been adopted with regard to the reduced value of  $u$ , the reduced scantlings determined at  $u$  according to Table 1.1.5.2 shall be additionally indicated. A special entry shall be made in the Classification Certificate of such ships (refer to 2.3.1, Part I "Classification").

**1.1.5.3** The factor  $\omega_c$  taking into account corrosion allowance with regard to the cross-sectional area of the web and to the section modulus of members of rolled section is determined by the formula

$$\omega_c = 1 + \alpha_c \Delta s \quad (1.1.5.3)$$

where  $\alpha_c = 0,07 + \frac{6}{W'} \leq 0,25$  for  $W' < 200 \text{ cm}^3$ ;

$$\alpha_c = \frac{1}{0,15} \left( 0,01 + \frac{1}{W'} \right) \text{ for } W' \geq 200 \text{ cm}^3$$

where  $W'$  = section modulus of the member under consideration in accordance with 1.6.4.2; for  $\Delta s$ , refer to 1.1.5.1.

Table 1.1.5.2

## Average annual reduction in thickness of structural members

Nos	Structural member	u, in mm per annum	
		Group I	Group II
<b>1</b>	<b>Plating of decks and platforms</b>		
1.1	Upper deck	0,1	0,2 <sup>1, 2</sup>
1.2	Lower deck	0,11	—
1.3	Deck in accommodation and working spaces	0,14	0,14
<b>2</b>	<b>Side plating</b>		
2.1	Side (no inner skin is provided):		
2.1.1	freeboard	0,1	0,13 <sup>2</sup>
2.1.2	in the region of alternating waterlines	0,17	0,19 <sup>2</sup>
2.1.3	below the region of alternating waterlines	0,14	0,16
2.2	Side (inner skin is provided) (compartments of double skin side are not designed to be filled):		
2.2.1	freeboard	0,1	0,1
2.2.2	in the region of alternating waterlines	0,17	0,17
2.2.3	below the region of alternating waterlines	0,14	0,14
2.3	Side (inner skin is provided) (compartments of double skin side are designed for the of carriage cargo, fuel oil or water ballast):		
2.3.1	freeboard:		
	.1 tanks filled with fuel oil	0,19	0,19
	.2 tank for reception of water ballast	0,21	0,21
2.3.2	in the region of alternating waterlines:		
	.1 tank filled with fuel oil	0,18	0,18
	.2 tank for reception of water ballast	0,21	0,21
2.3.3	below the region of alternating waterlines:		
	.1 tank filled with fuel oil	0,17	0,17
	.2 tank for reception of water ballast	0,18	0,18
<b>3</b>	<b>Bottom plating</b>		
3.1	Bottom (inner bottom is not provided):		
3.1.1	including bilge	0,14	—
3.1.2	in way of cargo tanks	—	0,17
3.1.3	in way of fuel oil tanks	0,17	0,17
3.1.4	in way of ballast compartments	0,2	0,2
3.2	Bottom (inner bottom is provided):		
3.2.1	including bilge	0,14	0,14
3.2.2	in way of fuel oil tanks	0,15	0,15
3.2.3	in way of ballast compartments	0,2	0,2
<b>4</b>	<b>Plating of inner bottom, hopper tank and trapezoidal stools under transverse bulkheads</b>		
4.1	Inner bottom in the area of cargo holds (tanks):		
4.1.1	in way of fuel oil tanks	0,12	0,17
4.1.2	in way of ballast compartments	0,15	0,2
4.1.3	in way of boiler room	0,3	0,3
4.1.4	in way of engine room	0,2	0,2
4.1.5	with no wood sheathing in holds if cargo is expected to be discharged by grabs	0,3	0,3
4.2	Hopper tanks, trapezoidal stools under transverse bulkheads, margin plate:		
4.2.1	plating of hopper tanks and trapezoidal stools:		
	bottom strake	0,25	0,3
	other strakes	0,12	0,17
4.2.2	margin plate (inclined and horizontal)	0,2	0,22
4.2.3	margin plate in boiler room:		
	inclined	0,28	0,3
	horizontal	0,23	0,28
<b>5</b>	<b>Plating of longitudinal and transverse bulkheads of inner skin</b>		
5.1	Watertight bulkheads:		
5.1.1	top strake (0,1D from the upper deck)	0,1	—
5.1.2	middle strake	0,12	—
5.1.3	bottom strake	0,13	—
5.2	Bulkheads between holds loaded with bulk cargoes:		
5.2.1	top strake (0,1D from the upper deck)	—	0,13
5.2.2	other strakes	—	0,18
5.3	Bulkheads between holds loaded with oil cargo or bulk cargo:		
5.3.1	top strake (0,1D from the upper deck)	—	0,16
5.3.2	other strakes	—	0,18
5.4	Bulkheads between cargo tanks:		
5.4.1	top strake (0,1D from the upper deck)	—	0,2 <sup>2</sup>

Table 1.1.5.2 — continued

Nos	Structural member	<i>u</i> , mm per annum	
		Group I	Group II
5.4.2	middle strake	—	0,13 <sup>2</sup>
5.4.3	bottom strake	—	0,18
5.5	Bulkheads between cargo and ballast compartments:		
5.5.1	top strake (0,1 <i>D</i> from the upper deck)	0,13	0,3
5.5.2	middle strake	0,15	0,25
5.5.3	bottom strake	0,16	0,2
5.6	Topside tanks	0,12	0,2
6	<b>Framing of decks and platforms</b>		
6.1	Deck longitudinals and beams of decks and platforms forming boundaries of:		
6.1.1	holds loaded with general cargoes	0,12	—
6.1.2	holds loaded with bulk cargoes	—	0,15
6.1.3	holds loaded with crude oil and petroleum products or bulk cargoes	—	0,18
6.1.4	cargo tanks	—	0,25 <sup>2</sup>
6.1.5	fuel oil tanks	0,15	0,17
6.1.6	ballast compartments	0,18	0,2
6.2	Deck girders, transverses of decks and platforms forming boundaries of:		
6.2.1	holds loaded with general cargoes	0,12	—
6.2.2	holds loaded with bulk cargoes	—	0,13
6.2.3	holds loaded with crude oil and petroleum products or bulk cargoes	—	0,15
6.2.4	cargo tanks	—	0,2 <sup>2</sup>
6.2.5	fuel oil tanks	0,19	0,19
6.2.6	ballast compartments	0,21	0,21
6.3	Cargo hatch coamings	0,1	0,12
7	<b>Framing of sides and bulkheads</b>		
7.1	Longitudinals, main and web frames, cross ties, vertical stiffeners and horizontal girders of sides and bulkheads forming boundaries of:		
7.1.1	holds loaded with general cargoes	0,1	—
7.1.2	holds loaded with bulk cargoes	—	0,13
7.1.3	holds loaded with crude oil and petroleum products or bulk cargoes	—	0,15
7.1.4	cargo tanks	—	0,2 <sup>2, 3</sup>
7.1.5	fuel oil tanks	0,18 <sup>3</sup>	0,18 <sup>3</sup>
7.1.6	ballast compartments	0,21	0,21
8	<b>Framing of bottom and inner bottom</b>		
8.1	Bottom centre girder, side girders, floors and bottom longitudinal girders (inner bottom is omitted):		
8.1.1	in general cargo compartments	0,14	—
8.1.2	in cargo tanks	—	0,2
8.1.3	in ballast compartments	0,2	0,2
8.1.4	under the boilers	0,3	0,3
8.2	Bottom centre girder, side girders, floors, bottom and inner bottom longitudinals in double bottom compartments:		
8.2.1	not intended to be filled	0,14	0,14
8.2.2	in oil fuel tanks	0,15	0,15
8.2.3	in water ballast tanks	0,2	0,2
8.2.4	under the boilers	0,25	0,25
9	<b>Superstructures, deckhouses and bulwarks</b>		
9.1	Shell plating	0,1	0,1
9.2	Framing	0,1	0,1

<sup>1</sup> For combination carriers and ships for the carriage of bulk cargoes, *u* = 0,15 mm per annum.  
<sup>2</sup> With a compartment filled with inert gas, *u* is increased by 10 per cent.  
<sup>3</sup> For horizontal stiffeners arranged in the upper portion having a width of 0,1 times the compartment height, *u* = 0,25 mm per annum.

### 1.1.6 Requirements of international conventions to be taken into account.

1.1.6.1 In passenger ships, the peak and machinery space bulkheads, shaft tunnels, etc. shall comply with the following requirements<sup>1</sup>:

.1 a fore peak or collision bulkhead shall be fitted which shall be watertight up to the bulkhead deck. This bulkhead shall be located at a distance from the forward perpendicular of not less than 5 per cent of the length of the ship *L<sub>s</sub>* and not more

<sup>1</sup> For the purpose of this paragraph, "length of ship" is the length measured between perpendiculars from the extreme points of the ship on the level of the deepest subdivision load line. For the definitions of the deepest subdivision load line refer to 1.2, Part V "Subdivision".

than 3 m plus 5 per cent of the length of the ship  $L_s$  (Fig. 1.1.6.1).

Where the stem forms the external contour of the hull from the forward end with no protruding parts except the bulbous bow, the forward perpendicular shall coincide with the forward edge of the stem on the level of the deepest subdivision load line;

**.2** where any part of the ship below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distances stipulated in 1.1.6.1.1 shall be measured from a point either at the midlength of such extension, or at a distance 1,5 per cent of the length of the ship forward of the forward perpendicular, or at a distance 3 m forward of the forward perpendicular, whichever gives the smallest measurement;

**.3** where a long forward superstructure is fitted, the fore peak or collision bulkhead on all passenger ships shall be extended weathertight to the next full deck above the bulkhead deck. The extension shall be so arranged as to preclude the possibility of the bow door causing damage to it in the case of damage to, or detachment of, the bow door;

**.4** the extension required in 1.1.6.1.3 need not be fitted directly above the bulkhead below, provided that all parts of the extension are not located forward of the forward limit specified in 1.1.6.1.1 or 1.1.6.1.2.

However, in ships constructed before 1 July 1997:

**.4.1** where a sloping ramp forms part of the extension, the part of the extension which is more than 2,3 m above the bulkhead deck may extend no more than 1 m forward of the forward limits specified in 1.1.6.1.1 or 1.1.6.1.2;

**.4.2** where the existing ramp does not comply with the requirements for acceptance as an extension to the collision bulkhead and the position of the ramp prevents the siting of such extension within the limits specified in 1.1.6.1.1 or 1.1.6.1.2, the extension may be sited within a limited distance aft of the aft limit specified in 1.1.6.1.1 or 1.1.6.1.2. The limited distance aft shall be no more than is necessary to ensure non-interference with the ramp.

The extension to the collision bulkhead shall open forward. The extension shall comply with the requirements of 1.1.6.1.3 and shall be so arranged as to preclude the possibility of the ramp causing damage to it in the case of damage to, or detachment of, the ramp;

**.5** ramps that do not comply with the above requirements shall be disregarded as an extension of the collision bulkhead;

**.6** in ships constructed before 1 July 1997, the requirements of 1.1.6.1.3 and 1.1.6.1.4 shall apply not later than the date of the first periodical survey after 1 July 1997;

**.7** an after peak bulkhead dividing the engine room from the cargo and passenger spaces forward and aft, shall also be fitted and made watertight up to the bulkhead deck.

The after peak bulkhead may, however, be stepped below the bulkhead deck, provided the degree of safety of the ship as regards subdivision is not thereby diminished;

**.8** in all cases sterntubes shall be enclosed in watertight spaces of moderate volume. The stern gland shall be situated in a watertight shaft tunnel or other watertight space separate from the sterntube compartment and of such volume that, if flooded by leakage through the stern gland, the margin line will not be submerged.

**1.1.6.2** In cargo ships, the peak and machinery space bulkheads, stern tubes shall comply with the following requirements<sup>1</sup>:

**.1** a collision bulkhead shall be fitted which shall be watertight up to the freeboard deck. This bulkhead shall be located at a distance from the forward perpendicular of not less than 5 per cent of the length of the ship or 10 m, whichever is the less, in separate cases other value may be permitted, but not more than 8 per cent of the length of the ship;

**.2** where any part of the ship below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distances stipulated in 1.1.6.2.1 shall be measured from a point either at the mid-length of such extension, or at a distance 1,5 per cent of the length of the ship forward of the forward perpendicular, or at a distance 3 m forward of the forward perpendicular, whichever gives the smallest measurement;

**.3** the bulkhead may have steps or recesses provided they are within the limits prescribed in 1.1.6.2.1 or 1.1.6.2.2;

**.4** where a long forward superstructure is fitted, the collision bulkhead shall be extended weathertight to the deck next above the freeboard deck. The extension need not be fitted directly above the bulkhead below provided it is located within the limits prescribed in 1.1.6.2.1 or 1.1.6.2.2 with the exemption permitted by 1.1.6.2.5 and the part of the deck which forms the step is made effectively weathertight;

**.5** where bow doors are fitted and a sloping loading ramp forms part of the extension of the fore peak bulkhead above the freeboard deck, the part of the ramp which is more than 2,3 m above the freeboard deck may extend forward of the limit specified in 1.1.6.2.1 or 1.1.6.2.2. The ramp shall be weathertight over its complete length;

**.6** the number of openings in the extension of the fore peak bulkhead above the freeboard deck shall be

<sup>1</sup>For the purpose of the present paragraph "freeboard deck", "length of ship" and "forward perpendicular" have the meanings as defined in 1.2 of Load Line Rules for Sea-Going Ships.

restricted to the minimum compatible with the design and normal operation of the ship;

**.7** bulkheads shall be fitted separating the engine room from cargo and passenger spaces forward and aft and made watertight up to the freeboard deck;

**.8** sterntubes shall be enclosed in a watertight space (or spaces) of moderate volume. Other measures may be taken to minimize the danger of water penetrating into the ship in case of damage to sterntube arrangements.

**1.1.6.3** In passenger ships, the double bottom shall comply with the following requirements:

**.1** a double bottom shall be fitted extending from the fore peak bulkhead to the after peak bulkhead as far as this is practicable and compatible with the design and proper working of the ship.

In ships of 50 m and upwards but less than 61 m in length a double bottom shall be fitted at least from the engine room to the fore peak bulkhead, or as near thereto as practicable.

In ships of 61 m and upwards but less than 76 m in length a double bottom shall be fitted at least outside the engine room, and shall extend to the fore and after peak bulkheads, or as near thereto as practicable.

In ships of 76 m in length and upwards, a double bottom shall be fitted amidships, and shall extend to the fore and after peak bulkheads, or as near thereto as practicable;

**.2** where a double bottom is required to be fitted, its depth shall be in accordance with the requirements of 2.4.4.1 and the inner bottom shall be continued out to the ship's sides in such a manner as to protect the bottom to the turn of the bilge. Such protection will be deemed satisfactory if the line of intersection of the outer edge of the margin plate with the bilge plating is not lower at any part than a horizontal plane passing through the point *A* at midship section, as shown in Fig. 1.1.6.3;

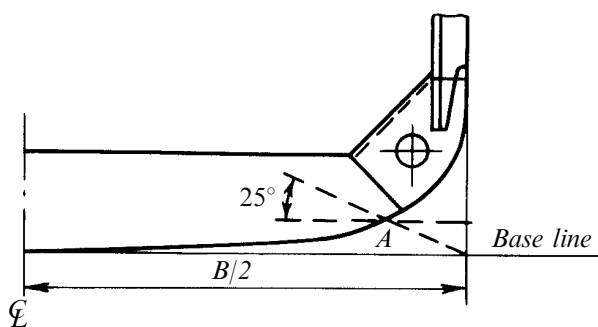


Fig. 1.1.6.3

**.3** small wells constructed in the double bottom in connection with drainage arrangements of holds, etc. shall not extend downwards more than necessary. The depth of the well shall in no case be more than

the depth less 460 mm of the double bottom at the centreline, nor shall the well extend below the horizontal plane referred to in 1.1.6.3.2. A well extending to the outer bottom is, however, permitted at the after end of the shaft tunnel. Other wells (e.g., for lubricating oil under main engines) may be permitted if the arrangements give protection equivalent to that afforded by a double bottom complying with the requirements of present paragraph;

**.4** a double bottom need not be fitted in way of watertight compartments of moderate size used exclusively for the carriage of liquids, provided the safety of the ship, in the event of bottom or side damage, is not thereby impaired.

**1.1.6.4** In cargo ships other than tankers, the double bottom shall comply with the following requirements:

**.1** a double bottom shall be fitted extending from the collision bulkhead to the after peak bulkhead, as far as this is practicable and compatible with the design and proper working of the ship;

**.2** the double bottom depth shall be in conformity with 2.4.4.1, and the inner bottom shall be continued out to the ship's side in such a manner as to protect the bottom to the turn of the bilge;

**.3** small wells constructed in the double bottom, in connection with the drainage arrangements of holds, shall not extend in depth more than necessary. A well extending to the outer bottom may, however, be permitted at the after end of the shaft tunnel of the ship. Other wells may be permitted if the arrangements give protection equivalent to that afforded by a double bottom complying with the present paragraph;

**.4** a double bottom need not be fitted in way of watertight compartments used exclusively for the carriage of liquids, provided the safety of the ship in the event of bottom damage is not thereby impaired.

**1.1.6.5** The freeing ports in bulwarks shall be assigned proceeding from 3.2.13 of Load Line Rules for Sea-Going Ships.

The lower edges of freeing ports shall be arranged as near to the deck as practicable, but they shall not bear upon the sheerstrake.

In ships of 65 m in length and upwards a continuous slot shall generally be provided between the freeboard and sheerstrake edge instead of freeing ports.

**1.1.6.6** In passenger ships and cargo ships, the design of watertight decks, trunks, etc. shall comply with the following requirements:

**.1** watertight decks, trunks, tunnels, duct keels and ventilation ducts shall have a strength equal to that of watertight bulkheads fitted on the same level. Watertight ventilation ducts and trunks shall be carried at least to the bulkhead deck in passenger ships and at least to the freeboard deck in cargo ships;

**.2** where a ventilation trunk passing through a structure penetrates the bulkhead deck, the trunk

shall be capable of withstanding the water pressure that may be present within the trunk, after having taken into account the maximum heel angle allowable during intermediate stages of flooding, in accordance with 3.5.1.8, Part V "Subdivision";

**.3** where all or part of the penetration of bulkhead deck is on the main ro-ro deck, the trunk shall be capable of withstanding impact pressure due to internal water motions of the trapped water on the vehicle deck;

**.4** in ships constructed before 1 July 1997, the requirements of 1.1.6.6.2 shall apply not later than the date of the first periodical survey after 1 July 1997.

## 1.2 MATERIALS

### 1.2.1 General.

The materials used for hull structures regulated by this Part of the Rules shall comply with the requirements of Part XIII "Materials".

### 1.2.2 Steel for hull structures.

**1.2.2.1** Hull elements shall be fabricated of ordinary structural steel of grades A,B,D and E with the upper yield stress  $R_{eH} = 235\text{MPa}$  and of AH,DH, EH and FH higher tensile steel of grades A32, D32, E32 and F32 with the upper yield stress  $R_{eH} = 315\text{ MPa}$ , A36, D36, E36 and F36 steel grades with the upper yield stress  $R_{eH} = 355\text{ MPa}$ , and A40, D40, E40 and F40 steel grades with the upper yield stress  $R_{eH} = 390\text{ MPa}$ . The application of high strength steel grades D,E,F with the upper yield stress of 420 MPa and above is subject to special consideration by the Register in each case.

The application of high strength steel grades D, E, F with the upper yield stress of 420 MPa and above is subject to special consideration by the Register in each case.

**1.2.2.2** In case of high local stresses in the thickness direction, Z-steel (refer to 3.14, Part XIII "Materials") shall be used for the fabrication of structural members having a thickness in excess of 18 mm unless no measures are taken to structurally prevent lamellar tearing.

**1.2.2.3** Where clad steel is used, the mechanical properties of the base material shall not be lower than those required for the steel grade specified in 1.2.3.1.

Hull structural steel stated in 3.17, Part XIII "Materials" shall be used as the base material.

### 1.2.3 Selection of steel grades for hull structures.

**1.2.3.1** Steel grades for structural members, including those intended for prolonged exposure to low service temperatures, shall be selected according to

Figs 1.2.3.1-1, 1.2.3.1-2 and 1.2.3.1-3 for various categories of structural members based on the adopted design thickness of the member concerned and the design temperature of the structure determined by a method approved by the Register.

**1.2.3.2** The design temperature of the structures which come constantly or periodically in contact with ambient air are expressed in terms of minimum design temperature of ambient air  $T_A$ . In the absence of any other provisions, for the value of  $T_A$  the minimum average daily air temperature is adopted which can take place during a five-year period of operation on the routes passing in the most unfavourable waters as regards cooling conditions.

**1.2.3.3** In all cases the value of  $T_A$  shall not exceed:

- 40 °C<sup>1</sup> for icebreakers of categories **Icebreaker9**, **Icebreaker8**, **Icebreaker7** and ships with ice strengthening of categories **Arc9**, **Arc8**, **Arc7**, **Arc6**, **Arc5**;
- 30 °C for icebreakers of category **Icebreaker6** and ships with ice strengthening of category **Arc4**;
- 10 °C for ships with ice strengthening of categories **Ice3**, **Ice2**;

0 °C for ships with ice strengthening of category **Ice1**, as well as without ice strengthening.

**1.2.3.4** An approximate determination of temperatures of structures is permitted based on the values of  $T_A$  obtained by this method in accordance with the recommendations given in Table 1.2.3.4.

**1.2.3.5** At the design tensile stresses in the upper deck and side longitudinals (of sheerstrake) due to the still water hogging moment ( $\sigma_{sw}$ ), exceeding the value  $65/\eta$ , the design temperature of longitudinals may be corrected by the value of  $\Delta T_d = -10(\sigma_{sw}/65 - 1)^\circ\text{C}$ .

**1.2.3.6** The design temperature of hull structures located within the refrigerated cargo spaces shall be assumed equal to the temperature in the refrigerated cargo space.

The design temperature of the structures forming boundaries of the refrigerated cargo spaces shall be assumed as follows:

with no insulation fitted on the side of the refrigerated cargo space, the temperature in this space;

with insulation fitted on the side of the refrigerated cargo space and with no insulation on the other side, the temperature on the uninsulated side of the boundary in the space;

with insulation fitted on both sides, arithmetical mean of the temperatures in the adjacent spaces.

**1.2.3.7** Depending on the level and type of applied stress, presence of stress concentrations, complexity of structural design of the assemblies and the workmanship, the assumed damage consequences for safety of the ship as a whole, the structural members are grouped into three application categories according to Table 1.2.3.7-1.

<sup>1</sup>If operation involves sailing into the mouths of northern rivers, the value of  $T_A$  shall not exceed  $-50^\circ\text{C}$ .



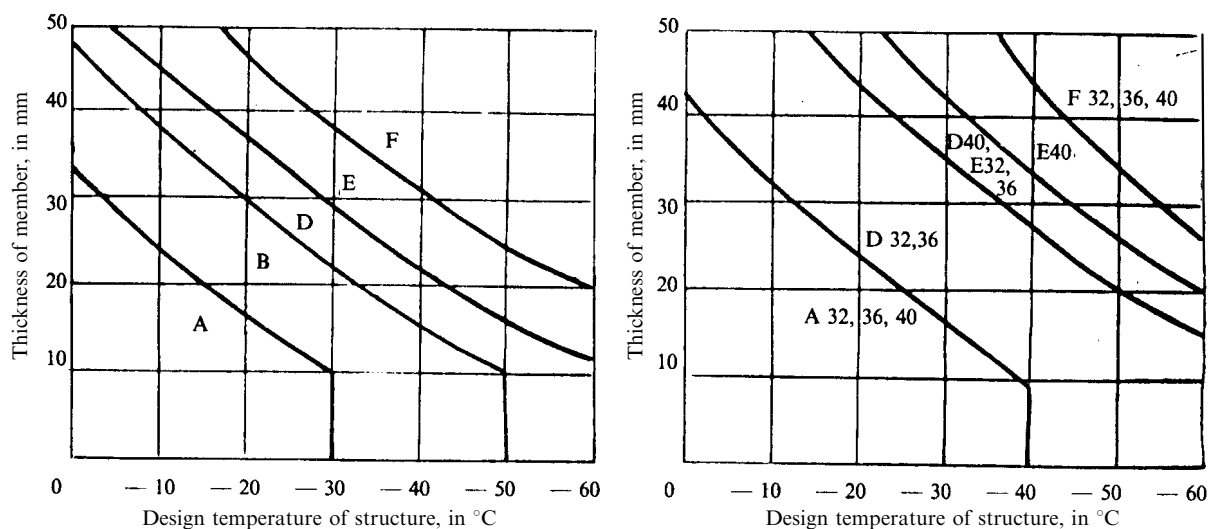


Fig. 1.2.3.1-1 Structural members of category I

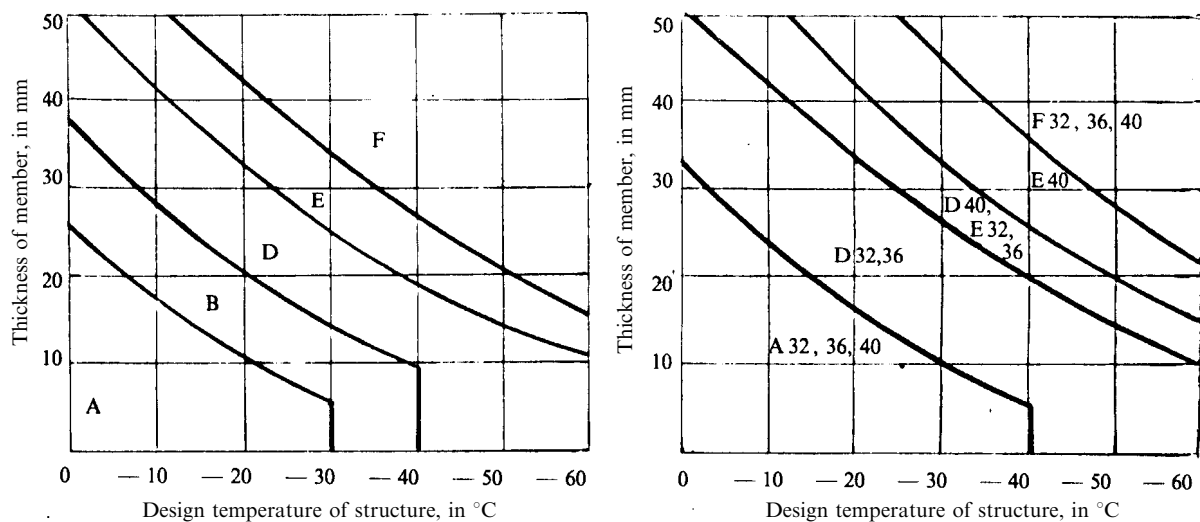


Fig. 1.2.3.1-2 Structural members of category II

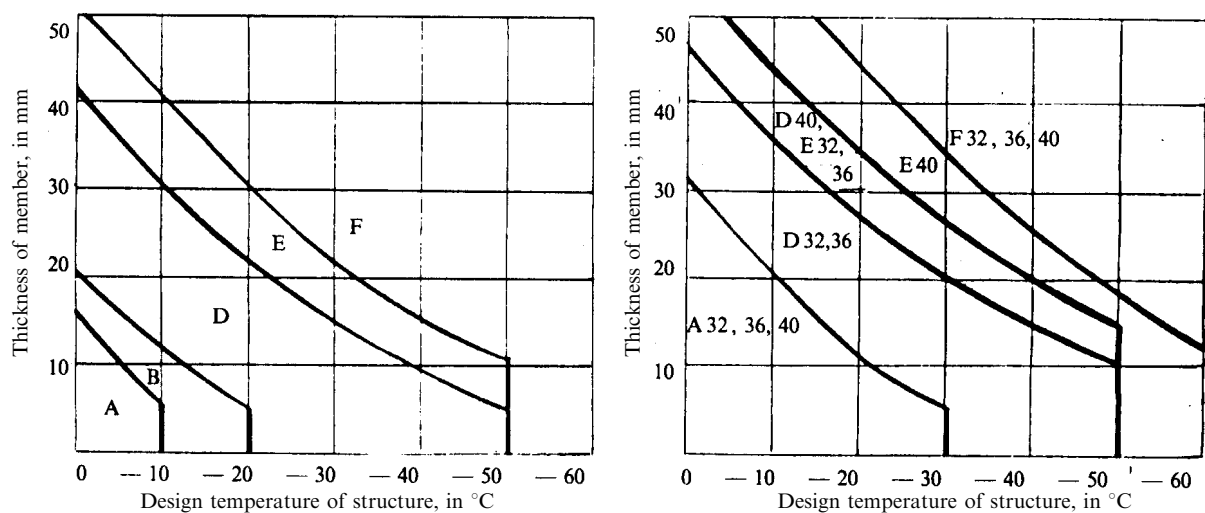


Fig. 1.2.3.1-3 Structural members of category III

Table 1.2.3.4

Hull structure	Insulation	Heating	Design temperature $T_d$		
			Cargo space region		Region of spaces other than cargo spaces
			tanks	holds	
Exposed part of strength deck, side plating portion above summer load waterline (for ships intended to operate in ice — above ice belt) as well as adjacent framing and portions up to 1,0 m wide of bulkhead structures, decks, platforms, topside tanks, etc.	Fitted	Not provided	$T_A$		
	Not relevant	Provided	$0,50T_A$		
	Not fitted	Not provided	$0,70T_A$	$T_A + 5\text{ }^{\circ}\text{C}$	$0,60T_A$
Strength deck portion under unheated superstructures	Not relevant	Not provided	$-10\text{ }^{\circ}\text{C}$		
External structures of superstructures and deckhouses	Fitted	Provided	$0,50T_A$		
		Not provided	$0,70T_A$		
Structures cooled on both sides with ambient air	Not fitted	Not provided	$T_A$		
Side plating portion in the region of alternating waterline. Ice belt of ships intended to operate in ice	Fitted	Not provided	$0,55T_A$		
	Not relevant	Provided	$0,35T_A$		
	Not fitted	Not provided	$0,40T_A$		
Note. For external structures of underwater portion of the hull $T_d = 0\text{ }^{\circ}\text{C}$ .					

Table 1.2.3.7-1

Nos.	Structural members	Member category	
		Midship region	Outside midship region
1 2 3 4 5	Sheerstrake and strength deck stringer plate <sup>1,9</sup> Bilge strake <sup>2,3,9</sup> Strength deck strakes adjacent to longitudinal bulkheads <sup>4,9</sup> , strength deck strakes at cargo hatchway corners <sup>5,6</sup> including those of lower decks in refrigerated spaces <sup>7</sup> Longitudinal coamings over $0,15L$ in length including end brackets <sup>8</sup> Transition sections of superstructure sides (refer to Fig. 2.12.5.3) <sup>8</sup>	III	II (I outside $0,6L$ )
6 7 8 9 10 11	Other strength deck strakes except those between transverse edges of hatch openings Strength deck longitudinals including those of upper strakes in longitudinal bulkheads, sheerstrake, sides of top-side tanks Strakes of bottom shell plating including plate keel and inner bottom plating Upper strakes of longitudinal bulkheads and topside tanks Longitudinal coamings of hatchways under $0,15L$ in length External longitudinal members, plating and framing of long superstructures and plating of sides of short superstructures and deckhouses (first tier)	II	I
12	Side plating at cargo port corners	II	II
13	Plating and framing (welded members) in ice-strengthening region I (refer to Figs. 3.10.1.3.2 and 3.10.1.3.3); welded plate stems and stern frames of: .1 ships of ice categories <b>Arc4</b> , <b>Ice3</b> , <b>Ice2</b> and <b>Ice1</b> ; .2 ships of ice categories <b>Arc9</b> , <b>Arc8</b> , <b>Arc7</b> , <b>Arc6</b> and <b>Arc5</b> and icebreakers irrespective of category	I II	I II
14	Rolled section framing of: .1 ships irrespective of ice category and icebreakers of ice category <b>Icebreaker6</b> .2 icebreakers of ice categories <b>Icebreaker9</b> , <b>Icebreaker8</b> and <b>Icebreaker7</b>	I II	I II
<sup>1</sup> In the midship region of ships over 250 m in length, steel grades not lower than E or EH shall be used. <sup>2</sup> Category II members shall be fitted throughout the length of ships 150 m in length and less if double-bottomed from side to side. <sup>3</sup> In midship region of ships over 250 m in length, steel grades not lower than D or DH shall be used. <sup>4</sup> Excepting deck plating strakes adjacent to the inner skin plating of double skin side ships. <sup>5</sup> For ships with large deck openings, shall be classified as category III members within the cargo area. <sup>6</sup> For bulk carriers and oil/bulk dry cargo carriers, ore carriers and ore/oil carriers, shall be classified as category III members within $0,6L$ and as category II members within the remaining part of the cargo area. <sup>7</sup> The boundaries of areas for members related to this category correspond to Fig. 1.2.3.7. <sup>8</sup> A steel grade not lower than D or DH shall be used. <sup>9</sup> Within amidships, a strake of member category III or E/EH grade shall have a breadth not less than $800 + 5L$ , but it may be adopted not greater than 1800 mm so far as this is compatible with the hull structure.			

The steel grade depending on the hull element thickness is determined in accordance with Table 1.2.3.7-2.

**1.2.3.8** Structural members not mentioned in Table 1.2.3.7-1, whose scantlings are regulated by this Part of the Rules, shall be referred to category I.

**1.2.3.9** For structures with high level of stress concentration, subject to dynamic loads (e.g. when mooring at sea) or being in combined stress state, the use of Grade D or Grade E steel may be required. Steel of Grade A is not permitted.

**1.2.3.10** In the midship region, the breadth of strakes referred to category III or made of grade E or EH steel shall not be less than  $800 + 5L$  mm, but it may not exceed 1800 mm.

**1.2.3.11** For ships less than 40 m in length, steel specified for the categories of structural members outside the midship region according to Table 1.2.3.7-1 may be used throughout the length of the ship.

**1.2.3.12** Plating materials for sternframes, rudders, rudder horns and shaft brackets shall in general not be of lower grades than corresponding to member category II. For rudder and rudder body plates subjected to stress concentrations (e.g. in way of lower support of semi-spade rudders or at upper part of spade rudders), member category III shall be applied.

*B-B*

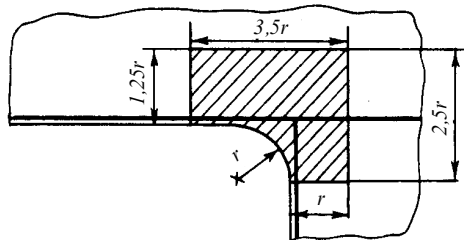


Fig. 1.2.3.7  
Areas of cargo hatch corners (lined) belonging to members referred to category III

#### 1.2.4 Aluminium alloys.

**1.2.4.1** This Part of the Rules admits the following applications of aluminium alloys:

hull, superstructures and deckhouses, if  $12 < L \leq 40$  m;

superstructures and deckhouses, if  $L > 40$  m.

#### 1.2.5 Protective coatings.

**1.2.5.1** Epoxy-based coatings or equivalent shall be applied to the inner surfaces of ballast tanks in accordance with the manufacture's recommendations. Light colours of the coatings are the most preferable. For ships of 500 gross tonnage and over, the coating shall be applied according to the Performance Standard for Protective Coatings (refer to IMO resolutions MSC.215(82) and MSC.216(82)). Where necessary, anodic protection may be used in addition to the coatings.

### 1.3 DESIGN LOADING

#### 1.3.1 General.

**1.3.1.1** This Chapter contains the basic formulae for determining the design weather loading on hull, ship acceleration at motions as well as loading from dry and liquid cargoes.

**1.3.1.2** Wave impacts loading on the forward portion of the bottom and flare, loading from vehicles and deck heavy cargo as well as emergency loading are given in the chapters of the Rules pertaining to the appropriate structures.

**1.3.1.3** Rules of determining the value and the load point of the design loading are specified in the appropriate chapters pertaining to particular structures. In the absence of such provisions the loading is assumed to be on the lower edge of the plate, at the middle of design span of the member or at the centre of the area taking up distributed load.

**1.3.1.4** The basic parameter of design loading and accelerations on ship's hull exposed to weather is the wave factor  $c_w$ , determined by the formulae:

Table 1.2.3.7-2

Thickness of ship hull element $S$ , mm	Member category, to which the ship hull element is related							
	I		II		III			
	Mild strength steel	Higher tensile steel	Mild strength steel	Higher tensile steel	Mild strength steel	Higher tensile steel		
$S \leq 15,0$	A	AH	A	AH	A	AH		
$15 < S \leq 20$			B		B			
$20 < S \leq 25$			B	D	DH			
$25 < S \leq 30$			D			DH		
$30 < S \leq 35$	B		D	DH	E	EH		
$35 < S \leq 40$								
$40 < S \leq 50$	D	DH					E	EH

Table 1.3.1.5

Area of navigation	$\varphi_r$
<b>R1</b>	1
<b>R2</b>	$1,25 - 0,25L \cdot 10^{-2} \leq 1$
<b>R2-RSN</b>	$1,0 - 0,20L \cdot 10^{-2}$
<b>R3-RSN</b>	$0,86 - 0,18L \cdot 10^{-2}$
<b>R3</b>	$0,75 - 0,18L \cdot 10^{-2}$

$$c_w = 0,0856L \text{ for } L \leq 90 \text{ m};$$

$$c_w = 10,75 - \frac{(300 - L)^{3/2}}{100} \text{ for } 90 < L < 300 \text{ m};$$

$$c_w = 10,75 \text{ for } 300 \leq L \leq 350 \text{ m}. \quad (1.3.1.4)$$

**1.3.1.5** For ships of restricted area of navigation the wave factor  $c_w$  shall be multiplied by the reduction factor  $\varphi_r$  obtained from Table 1.3.1.5.

**1.3.2 External loading on ship's hull exposed to weather.**

**1.3.2.1** The design pressure  $p$ , in kPa, acting on the ship's hull exposed to weather is determined by the following formulae:

for the points of application of the loads below the summer load waterline

$$p = p_{st} + p_w; \quad (1.3.2.1-1)$$

for the points of application of the loads above the summer load waterline

$$p = p_w \quad (1.3.2.1-2)$$

where  $p_{st}$  = static pressure, in kPa, determined by the formula

$$p_{st} = 10z_i;$$

$z_i$  = distance from the point of application of the load to the summer load waterline, in m;

$p_w$  = as defined in 1.3.2.2.

**1.3.2.2** The design pressure  $p_w$ , in kPa, due to ship's hull motion about the wave contour is determined by the following formulae:

for the points of application of the loads below the summer load waterline

$$p_w = p_{w_0} - 1,5c_w \frac{z_i}{d}; \quad (1.3.2.2-1)$$

for the points of application of the loads above the summer load waterline

$$p_w = p_{w_0} - 7,5a_x z_i \quad (1.3.2.2-2)$$

where  $p_{w_0} = 5c_w a_y a_x$ ;

for  $c_w$ , refer to 1.3.1.4 and 1.3.1.5;

$$a_y = 0,8 \frac{v_a}{\sqrt{L}} \left( \frac{L}{10^3} + 0,4 \right) + 1,5;$$

$$a_x = k_x \left( 1 - \frac{2x_1}{L} \right) \geq 0,267;$$

$k_x$  = factor equal to 0,8 and 0,5 for hull sections forward and aft of the midship section respectively;

$x_1$  = distance of the considered section from the nearest fore or after perpendicular, in m;

for  $z_i$ , refer to 1.3.2.1-2.

In any case, the product  $a_y a_x$  shall not be taken as less than 0,6.

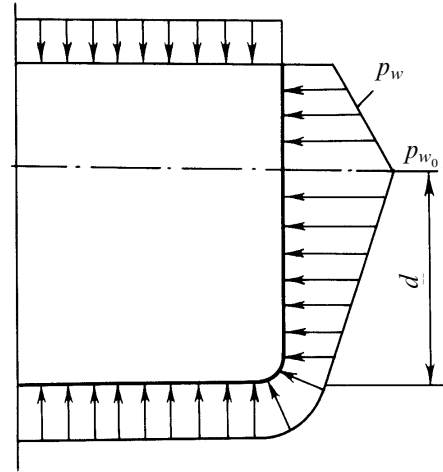


Fig. 1.3.2.2

Distribution of load  $p_w$  over the hull section contour is shown in Fig. 1.3.2.2.

**1.3.3 Ship's acceleration at motions.**

**1.3.3.1** Design acceleration  $a$ , in  $\text{m/s}^2$ , at motions in waves is determined by the formula

$$a = \sqrt{a_c^2 + a_p^2 + 0,4a_r^2} \quad (1.3.3.1-1)$$

where  $a_c$  = projection of ship's centre of gravity acceleration on the appropriate direction;

$a_p$ ,  $a_r$  = projections of pitching and rolling acceleration on the appropriate directions at the point under consideration.

Acceleration projections for the considered member on the vertical (index  $z$ ), horizontal-transverse (index  $y$ ) and horizontal-longitudinal (index  $x$ ) directions are determined by the following formulae:

$$\begin{aligned} a_{cx} &= 0,1(100/L)^{1/3} g \varphi_r; \\ a_{cy} &= 0,2(100/L)^{1/3} g \varphi_r; \\ a_{cz} &= 0,2(100/L)^{1/3} g \varphi_r; \\ a_{px} &= (2\pi/T_p)^2 \psi z_0; \\ a_{py} &= 0; \\ a_{pz} &= (2\pi/T_p)^2 \psi x_0; \\ a_{rx} &= 0; \\ a_{ry} &= (2\pi/T_r)^2 \theta z_0; \\ a_{rz} &= (2\pi/T_r)^2 \theta y_0 \end{aligned} \quad (1.3.3.1-2)$$

where  $\varphi_r$  is given in Table 1.3.1.5 ( $\varphi_r = 1$  for ships of unrestricted service);

$T_p$  and  $T_r$  = pitching and rolling periods, in s, determined by the formulae:

$$T_p = \frac{0,8\sqrt{L}}{1 + 0,4 \frac{v_a}{\sqrt{L}} \left( \frac{L}{10^3} + 0,4 \right)}; \quad (1.3.3.1-3)$$

$$T_r = cB/\sqrt{h}$$

where  $c$  = numerical factor determined on the basis of the data for the ship of similar type. As a first approximation,  $c = 0,8$ ;

$h$  = metacentric height for the most unfavourable conditions of operation; for a ship in fully loaded condition,  $h \approx 0,07B$  unless more detailed data are available.

For a tanker in ballast condition,  $T_r$ , as a first approximation, can be determined by the formula

$$T_r \approx 3\sqrt[3]{B};$$

$\psi$  = design angle of trim, in rad, determined by the formula

$$\psi = \varphi \frac{0,23}{1 + L \cdot 10^{-2}} \quad (1.3.3.1-4)$$

where for  $\varphi$ , refer to Table 1.4.4.3 ( $\varphi = 1$  for ships of unrestricted service);

$\theta$  = design angle of heel, in rad, determined by the formula

$$\theta = \varphi_r \frac{0,6}{1 + 0,5L \cdot 10^{-2}}; \quad (1.3.3.1-5)$$

$x_0$  = distance of the considered point from the transverse plane passing through the ship's centre of gravity, in m;

$y_0, z_0$  = distance of the considered point from the centreline and the horizontal plane passing through the ship's centre of gravity respectively, in m.

If  $L \leq 40$  m in the Formulae (1.3.3.1-4) and (1.3.3.1-5)  $L$  shall be taken equal to 40 m.

At all types of motions, the total acceleration in the vertical direction  $a_z$ , in  $\text{m/s}^2$ , can be determined by the formula

$$a_z = g \frac{0,9}{\sqrt[3]{L}} (1 + k_a) \quad (1.3.3.1-6)$$

where  $k_a = 1,6(1 - 2,5 x_1/L) \geq 0$  in the forward region;

$k_a = 0,5(1 - 3,33x_1/L) \geq 0$  in the aft region;

for  $x_1$ , refer to 1.3.2.2.

If  $L < 80$  m in the Formula (1.3.3.1-6),  $L$  shall be taken equal to 80 m.

### 1.3.4 Cargo, fuel and ballast loading.

**1.3.4.1** Design pressure  $p_c$ , in kPa, on the grillages of cargo decks, platforms and double bottom from package cargo is determined having regard to inertia forces by the formula

$$p_c = h \rho_c g (1 + a_z/g) \quad (1.3.4.1)$$

where  $h$  = design stowage height, in m;

$\rho_c$  = density of the cargo carried, in  $\text{t/m}^3$ ;

$a_z$  = design acceleration in the vertical direction determined in accordance with 1.3.3.1,

but not less than 20 kPa.

**1.3.4.2** The design pressure on the structures forming boundaries of the compartments intended for the carriage of liquid cargoes and ballast in tankers, the ballast tanks in dry cargo ships as well as the tanks for ballast and fuel oil is determined depending on their dimensions, the extent of filling and the height of air pipe. By compartment is meant a tank or a part of a tank confined between the effective bulkheads. Both watertight and wash bulkheads with the total area of openings not over 10 per cent of the bulkhead area are considered as effective bulkheads.

**1.3.4.2.1** The design pressure  $p_c$ , in kPa, on the structures of fully loaded compartments is determined by the following formulae:

$$p_c = \rho_c g (1 + a_z/g) z_i; \quad (1.3.4.2.1-1)$$

$$p_c = \rho_c g (z_i + b\theta); \quad (1.3.4.2.1-2)$$

$$p_c = \rho_c g (z_i + h\psi); \quad (1.3.4.2.1-3)$$

$$p_c = 0,75 \rho_c g (z_i + \Delta z); \quad (1.3.4.2.1-4)$$

$$p_c = \rho_c g z_i + p_v \quad (1.3.4.2.1-5)$$

where  $\rho_c$  = cargo, ballast or fuel density, in  $\text{t/m}^3$ , whichever is appropriate;

$a_z$  = design acceleration in the vertical direction according to 1.3.3.1;

$z_i$  = distance, in m, from the member concerned to the deck level (tank top) as measured at the centreline;

$\theta$  and  $\psi$  = as determined by the Formulae (1.3.3.1-4) and (1.3.3.1-5);

$\Delta z$  = height, in m, of air pipe above deck (tank top), but shall not be less than: 1,5 m for the ballast tanks of dry cargo ships and for fresh water tanks, 2,5 m for the tanks of tankers and for fuel oil and lubricating oil tanks; for small expansion tanks and for lubricating oil tanks of less than 3  $\text{m}^3$  capacity, the minimum values of  $\Delta z$  are not stipulated;

$p_v$  = pressure, in kPa, for which the safety valve is set, if fitted, but shall not be less than: 15 kPa for the ballast tanks of dry cargo ships and for fresh water tanks, 25 kPa for the tanks of tankers and for fuel oil and lubricating oil tanks; for small expansion tanks and for lubricating oil tanks of less than 3  $\text{m}^3$  capacity, the minimum values of  $p_v$  are not stipulated;

$l$  and  $b$  = length and breadth, in m, of a compartment as measured at mid-height; if the values of  $l$  and/or  $b$  change abruptly over the compartment height,  $l$  and/or  $b$  are measured at mid-height of each compartment section where their variation is not appreciable; the Formulae (1.3.4.2.1-2) and (1.3.4.2.1-3) are used for each measured value of  $l$  and  $b$  accordingly,

whichever is the greater.

**1.3.4.2.2** Where a compartment shall be partially filled proceeding from service conditions, with the compartment length  $l \leq 0,13L$  and compartment breadth  $b \leq 0,6B$ , the design pressure  $p_c$ , in kPa, for the structures mentioned below shall not be less than:

for the side, longitudinal bulkheads and adjoining compartment top within 0,25 $b$  of the line of compartment top and side intersection, or of the longitudinal bulkhead

$$p_c = \rho_c (5 - B/100)b; \quad (1.3.4.2.2-1)$$

for transverse bulkheads and adjoining compartment top within 0,25 $l$  of the line of compartment top and transverse bulkhead intersection

$$p_c = \rho_c (4 - L/200)l. \quad (1.3.4.2.2-2)$$

$l$  and  $b$  shall be measured on the level of the free surface of liquid.

For compartments where  $l > 0,13L$  and/or  $b > 0,6B$ , the design pressure for the case of partial flooding is determined in accordance with a special procedure approved by the Register.

**1.3.4.3** The design pressure  $p_c$ , in kPa, on structures bounding the bulk cargo hold is determined by the formula

$$p_c = \rho_c g k_c (1 + a_z/g) z_i \quad (1.3.4.3)$$

where for  $\rho_c$ , refer to 1.3.4.1;

$$k_c = \sin^2 \alpha \operatorname{tg}^2(45^\circ - \varphi_{a,p}/2) + \cos^2 \alpha,$$

or

$$k_c = \cos \alpha,$$

whichever is the greater;

$\alpha$  = angle of web inclination to the base line, in deg.;

$\varphi_{i,f}$  = internal friction angle of bulk cargo, in deg.;

$a_z$  = design acceleration in the vertical direction according to 1.3.3.1;

$z_i$  = vertical distance from the load application point to the free surface level of cargo, in m,

but not less than 20 kPa.

The pressure on the inner bottom is determined by the Formula (1.3.4.3) where  $k_c = 1$ .

**1.3.4.4** The design pressure from package cargo acting upon the structures in horizontal plane is determined with regard for inertia forces. In the Formula (1.3.3.1-1) the acceleration in the horizontal-transverse direction is determined by the formula

$$a_y = \sqrt{a_{cy}^2 + (a_{ry} + g \sin \theta)^2}; \quad (1.3.4.4-1)$$

and in the horizontal-longitudinal direction

$$a_x = \sqrt{a_{cx}^2 + (a_{px} + g \sin \psi)^2} \quad (1.3.4.4-2)$$

where  $\theta$  and  $\psi$  are determined by the Formulae (1.3.3.1-4) and (1.3.3.1-5).

## 1.4 LONGITUDINAL STRENGTH

### 1.4.1 General and definitions.

**1.4.1.1** The requirements of this Chapter apply to ships of unrestricted service and of restricted areas of navigation **R1** and **R2**, 65 m in length and upwards, as well as to ships of restricted areas of navigation **R2-RSN**, **R3-RSN** and **R3**, 60 m in length and upwards, whose proportions are stated in 1.1.1.1.

Ships with large deck openings and vessels of dredging fleet shall comply additionally with the requirements of 3.1 and 3.6 respectively.

**1.4.1.2** Special consideration shall be given to ships having the following characteristics:

**.1** proportion

$$L/B \leq 5;$$

$B/D \geq 2,5$  (for ships of restricted areas of navigation **R2**, **R2-RSN**, **R3-RSN** and **R3** the ratio  $B/D$  is obtained from Table 1.1.1.1);

**.2** block coefficient  $C_b < 0,6$ ;

**.3** specified speed  $v_0$  exceeding the value of  $v$ , in knots, determined by the formula

$$v = k\sqrt{L} \quad (1.4.1.2.3)$$

where  $k = 2,2$  if  $L \leq 100$  m;

$$k = 2,2 - 0,25(L - 100)/100 \text{ if } L > 100 \text{ m.}$$

Special consideration will also be given to ships carrying heated cargoes and ships of unusual design and/or type.

**1.4.1.3** For longitudinal strength calculation, design loads shall include still water bending moments and shear forces, wave bending moments and shear forces, and for ships with large flare, bending moments due to wave impacts on the flare as well.

Design wave and impact loads may be calculated both from formulae given in the Rules and according to the approved procedure taking into consideration

the rolling in waves, long-term distribution of wave conditions and area of navigation.

**1.4.1.4** Downward shear forces are assumed to be taken as positive values and upward shear forces — as negative values. The hogging bending moments are assumed to be taken as positive values and sagging bending moments — as negative values.

For the calculation of still water bending moment and shear force, transverse loads shall be integrated in the forward direction from the aft end of  $L$ ; in this case, downward loads are assumed to be taken as positive values.

The sign conventions of still water bending moment and shear force are as shown in Fig. 1.4.1.4.

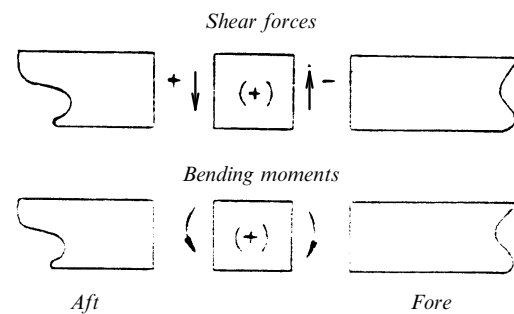


Fig. 1.4.1.4

### 1.4.2 Symbols.

For the purpose of this Chapter the following symbols have been adopted:

$L_1$  = length of the compartment considered, in m;

$B_1$  = breadth of the compartment considered, in m;

$A_F$  = difference between the area of horizontal upper deck projection (including forecastle deck) and summer load waterline on a length up to  $0,2L$  aft from the forward perpendicular, in  $m^2$ ;

$z_F$  = vertical distance from the summer load waterline to the upper deck (forecastle deck included), as measured on the forward perpendicular, in m;

$I$  = actual inertia moment of the hull about the horizontal neutral axis of the hull section under consideration, in  $cm^4$ ;

$S$  = actual statical moment, about the neutral axis, of the portion of the considered hull section, located above or below the level at which the thickness of the web is determined, in  $cm^3$ ;

$x$  = distance of the considered hull section from the after perpendicular, in m.

### 1.4.3 Still water bending moments and shear forces.

**1.4.3.1** The still water bending moments and shear forces shall be calculated for all actually possible cases of weight distribution over the length of the ship including full-load and ballast conditions for departure and arrival of the ship.

The bending moments and shear forces in the course of consuming the contents of each tank with ship's stores (fuel oil, water, lubricating oil) during voyage shall be also calculated if the above moments and forces exceed those for departure or arrival of the ship. The same applies to ship's ballasting/deballasting at sea. In so doing, partially filled ballast tanks, including peak tanks, shall be ignored in the consideration excepting the following cases:

calculated bending moments and shear forces do not exceed the maximum design values at all levels of ballast tanks filling from an empty condition to full filling;

for bulk carriers, all intermediate conditions of ballast tanks filling from an empty condition to full filling with each cargo hold flooded are considered (refer to 3.3.5).

As a rule, when determining the scantlings of framing members, consideration shall be given to the following loading conditions:

.1 for dry cargo ships, ships with large deck opening, roll on-roll off ships, refrigerated cargo ships, bulk carriers and ore carriers:

homogeneous loading conditions at maximum draught;

ballast condition;

special loading conditions, e.g. container or light load conditions at less than the maximum draught, heavy cargo, empty holds or non-homogeneous cargo conditions, deck cargo conditions, etc., where applicable;

short voyage, where applicable;

loading and unloading transitory conditions;

docking condition afloat;

.2 for oil tankers:

homogeneous loading conditions (excluding dry and clean ballast tanks);

partly loaded and ballast conditions for both departure and arrival;

any specified non-uniform distribution of loading;

mid-voyage conditions relating to tank cleaning or other operations where these differ significantly from the ballast conditions;

loading and unloading transitory conditions;

docking condition afloat;

.3 for combination carriers:

loading conditions as specified for dry cargo ships and oil tankers;

.4 ballast loading conditions where forepeak, afterpeak and/or other ballast tanks are partly filled at the departure, arrival or mid-voyage, shall not be considered as the design loading conditions. The exception shall be the cases where any partial filling of the tank does not exceed the permissible strength limitations. A notion "any partial filling" in the present paragraph assumes loading condition, which corresponds to an empty tank, fully loaded tank and a tank filled up to the prescribed level.

Where there are several partly loaded tanks, then all the combinations comprising empty, full and partly filled tanks shall be considered.

For ore carriers with large side ballast tanks in cargo area for the case where empty or full loading of one or maximum two pairs of these ballast tanks causes a trim exceeding at least one of the values mentioned below, then it shall be sufficient to demonstrate compliance with maximum, minimum and assigned partial filling levels of these one or maximum two pairs of side tanks, so that actual trim does not exceed any of these trim values. Fill up levels for the rest side ballast tanks shall be considered between full and empty. The above-mentioned trim values are as follows:

trim by the stern for 3 per cent of ship length;

trim by the bow for 1,5 per cent of ship length;

any trim, at which propeller depth axis constitutes 25 per cent of its diameter.

Maximum and minimum filling levels of the above-mentioned one or maximum two pairs of side ballast tanks shall be included to the Loading Manual.

If a ship is cargo loaded, then the requirements of the present paragraph shall apply to the peak tanks only and shall not apply to the cases of ballast replacement at sea by a method of successive substitution.

**1.4.3.2** The maximum absolute values of sagging and hogging bending moments  $M_{sw}$  and shear force  $N_{sw}$  shall be determined for any section along the ship's length for all the still water loading conditions, which are possible in service.

The values  $M_{sw}$  and  $N_{sw}$  are regarded further as design values for the section under consideration.

**1.4.3.3** For ships without effective longitudinal bulkheads, with non-uniform distribution of loading, i.e. alternation of loaded and empty holds, the still water shear force curve may be corrected by reducing its ordinates on transverse bulkheads by a value equal to the total of bottom longitudinal responses in way of those bulkheads in the event of bottom bending (Fig. 1.4.3.3).

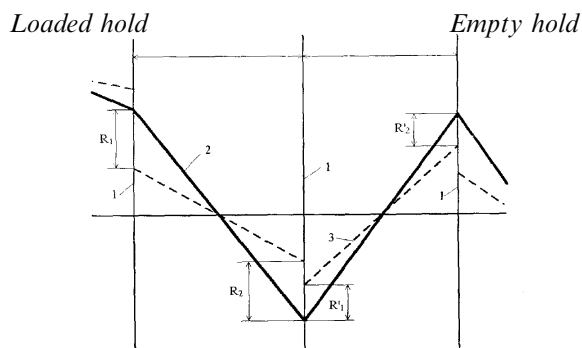


Fig. 1.4.3.3

Shear force curve correction diagram:

1 — transverse bulkhead; 2 — uncorrected curve;

3 — corrected curve;  $R_1$  and  $R_2$  — total of bottom longitudinal responses for a loaded hold in way of aft bulkhead and forward bulkhead accordingly;  $R'_1$  and  $R'_2$  = same for an empty hold

The bottom longitudinal responses in way of transverse bulkheads shall be determined on the basis of the bottom grillage calculation in accordance with 3.3.4.1. The design loads to be considered shall not include the wave loads mentioned under 1.3.2.2, the angles of heel, trim and accelerations at motions determined in accordance with 1.3.3.1.

**1.4.3.4** Where provision is made in ship's design for loading conditions resulting in regular change of a sign of the still water bending moment (in fully loaded and ballast conditions on direct and return voyages), its components at the section with the maximum range of bending moment (Fig. 1.4.3.4) shall be determined for use in the calculation under 1.4.6.3.

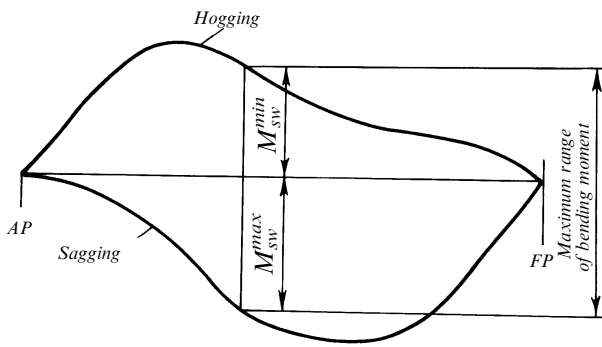


Fig. 1.4.3.4

#### 1.4.4 Wave bending moments and shear forces.

**1.4.4.1** The wave bending moment  $M_w$ , in kN·m, acting in the vertical plane at the section under consideration shall be determined by the formulae:

hogging bending moment

$$M_w = 190c_w BL^2 C_b \alpha \cdot 10^{-3}; \quad (1.4.4.1-1)$$

sagging bending moment

$$M_w = -110c_w BL^2 (C_b + 0,7) \alpha \cdot 10^{-3} \quad (1.4.4.1-2)$$

where  $c_w$  = as determined from 1.3.1.4;

$\alpha$  = coefficient determined from Table 1.4.4.1 and Fig. 1.4.4.1;

$C_b$  = as defined in 1.1.3, but not less than 0,6.

Table 1.4.4.1

Position of section along the ship's length	$\alpha$
$\frac{x}{L} < 0,4$	$2,5 \frac{x}{L}$
$0,4 \leq \frac{x}{L} \leq 0,65$	1
$\frac{x}{L} > 0,65$	$\frac{(1-x/L)}{0,35}$

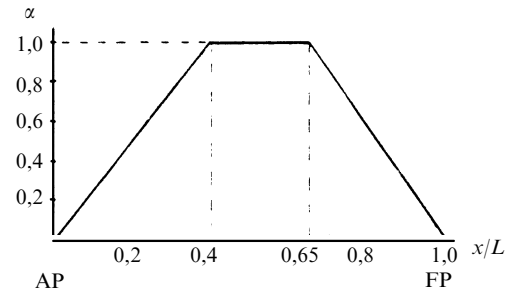


Fig. 1.4.4.1

**1.4.4.2** The wave shear force  $N_w$ , in kN, at the section concerned shall be determined by the formulae:

positive

$$N_w = 30c_w BL(C_b + 0,7)f_1 \cdot 10^{-2}; \quad (1.4.4.2-1)$$

negative

$$N_w = -30c_w BL(C_b + 0,7)f_2 \cdot 10^{-2} \quad (1.4.4.2-2)$$

where  $c_w$  = as determined from 1.3.1.4;

$C_b$  = as defined in 1.1.3, but not less than 0,6;

$f_1$  and  $f_2$  = coefficients determined from Table 1.4.4.2, Figs 1.4.4.2-1 and 1.4.4.2-2.

Table 1.4.4.2

Position of section along the ship's length	$f_1$	$f_2$
$0 \leq x/L < 0,2$	$7,945 f_0 x/L$	$4,6x/L$
$0,2 \leq x/L \leq 0,3$	$1,59f_0$	$0,92$
$0,3 < x/L < 0,4$	$1,59f_0 - (15,9f_0 - 7) \times (x/L - 0,3)$	$0,92 - 2,2(x/L - 0,3)$
$0,4 \leq x/L \leq 0,6$	$0,7$	$0,7$
$0,6 < x/L < 0,7$	$0,7 + 3(x/L - 0,6)$	$0,7 + (17,3f_0 - 7) \times (x/L - 0,6)$
$0,7 \leq x/L \leq 0,85$	$1,0$	$1,73f_0$
$0,85 < x/L \leq 1,0$	$1 - 6,67(x/L - 0,85)$	$f_0[1,73 - 11,53(x/L - 0,85)]$
$f_0 = \frac{C_b}{C_b + 0,7}$		

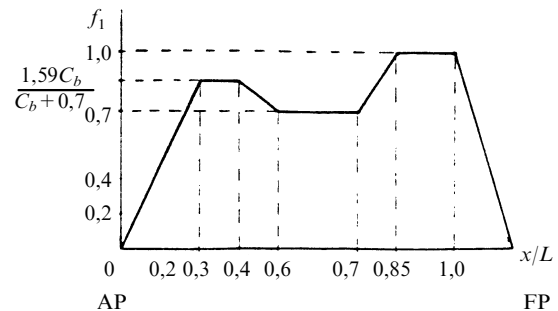


Fig. 1.4.4.2-1



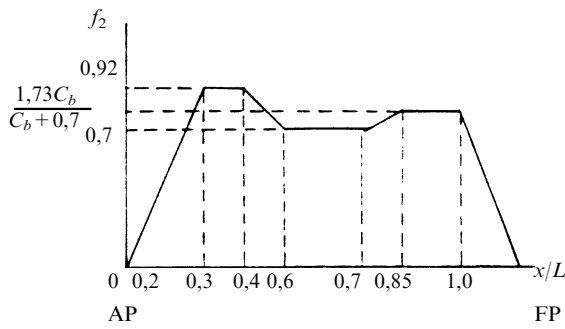


Fig. 1.4.4.2-2

**1.4.4.3** For ships of restricted area of navigation, the wave bending moments and shear forces determined in accordance with 1.4.4.1 and 1.4.4.2 shall be multiplied by the reduction factor  $\phi$  obtained from Table 1.4.4.3 as well as by the factors  $\phi$  and  $\nu$  determined by the following formulae:

$$\phi = 0,95(1 + \rho_n f \cdot 10^{-2}); \quad (1.4.4.3-1)$$

$$\nu = \frac{1}{1 + \Delta} \quad (1.4.4.3-2)$$

where  $\rho_n = \alpha^2(0,5 + 2,5\sin\beta_0) \geq \alpha$  for conventional bow shape (no bulb);

$\rho_n = \alpha^2(1 + \alpha^2) \geq 1$  for a bulbous bow;

$\alpha$  = waterplane area coefficient for summer load waterline;

$\beta_0$  = angle, in deg., between a frame tangential and a vertical at the level of summer load waterline at the section within  $0,4(1 - C_b)L \leq 0,1L$  from the fore perpendicular;

$$f = \left\{ \frac{Lv_0}{430D_1\eta\phi} \left[ \frac{2,5}{\phi^{0,3}} + 1,5 \left( \frac{L}{100} \right)^{2/3} \right] \right\}^{1,5} \left( \frac{L}{100} \right)^{0,75};$$

$D_1 = D + h_c$ ;

$h_c$  = height of continuous hatch side coamings, in m (where these are not fitted,  $h_c = 0$ );

$$\Delta = 0,045(\alpha - 0,25)^2 \frac{L}{20D_1\eta\phi} \cdot \frac{L}{100}.$$

The above requirements apply to ships of restricted area of navigation, from 60 to 150 m in length. Application of the requirements to ships of a different length is subject to special consideration by the Register.

Table 1.4.4.3

Area of navigation	$\phi$
<b>R1</b>	$1,1 - 0,23L \cdot 10^{-2} \leq 1$
<b>R2</b>	$1,0 - 0,25L \cdot 10^{-2}$
<b>R2-RSN</b>	$0,94 - 0,26L \cdot 10^{-2}$
<b>R3-RSN</b>	$0,71 - 0,22L \cdot 10^{-2}$
<b>R3</b>	$0,60 - 0,20L \cdot 10^{-2}$

### 1.4.5 Bending moment due to wave impacts on the flare.

**1.4.5.1** The bending moment due to wave impacts on the flare shall be calculated only for ships of

length from 100 to 200 m where the relationship  $A_F/Lz_F \geq 0,1$  is satisfied.

**1.4.5.2** The sagging bending moment due to wave impacts on the flare  $M_F$  shall be calculated as follows:

$$M_F = -k_F c_w B L^2 (C_b + 0,7) \alpha_F 10^{-3} \quad (1.4.5.2)$$

where  $k_F = 7(1 + 1,25v_0/\sqrt{L})c_1c_2$ , but not more than 23;

$c_1 = (L - 100)/30$  for  $100 \leq L < 130$  m;

$c_1 = 1$  for  $130 \leq L \leq 170$  m;

$c_1 = 1 - (L - 170)/30$  for  $170 < L \leq 200$  m;

$c_2 = 5A_F/Lz_F - 0,5$  at  $0,1 \leq A_F/Lz_F \leq 0,3$ ;

$c_2 = A_F/Lz_F + 0,7$  at  $0,3 < A_F/Lz_F < 0,4$ ;

$c_2 = 1,1$  at  $A_F/Lz_F \geq 0,4$ ;

for  $c_w$ , refer to 1.3.1.4;

$\alpha_F$  is obtained from Table 1.4.5.2 and Fig. 1.4.5.2.

Table 1.4.5.2

Position of section along the ship's length	$\alpha_F$
$x/L \leq 0,15$	$0,667x/L$
$0,15 < x/L < 0,45$	$0,1 + 3(x/L - 0,15)$
$0,45 \leq x/L \leq 0,75$	1
$x/L > 0,75$	$1 - 4(x/L - 0,75)$

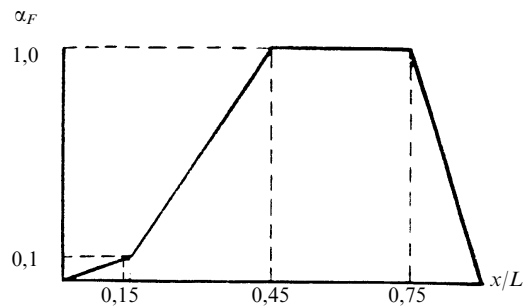


Fig. 1.4.5.2

**1.4.5.3** For ships of restricted area of navigation, the bending moment due to wave impacts on the flare  $M_F$  calculated in accordance with 1.4.5.2 shall be multiplied by the reduction factor  $\phi$  determined from Table 1.4.4.3. For ships of restricted areas of navigation **R3-RSN** and **R3**  $M_F = 0$ .

### 1.4.6 Hull section modulus and moment of inertia.

**1.4.6.1** The requirements of this paragraph regulate the hull section modulus and moment of inertia about the horizontal neutral axis.

**1.4.6.2** The hull section modulus (for deck and bottom)  $W$ , in  $\text{cm}^3$ , at the section concerned shall not be less than:

$$W = \frac{M_T}{\sigma} \cdot 10^3 \quad (1.4.6.2)$$

where  $M_T = |M_{sw} + M_w|$  — design bending moment, in  $\text{kN}\cdot\text{m}$ , at the section concerned equal to the maximum absolute value of algebraic sum of  $M_{sw}$  and  $M_w$  components at this section;

for  $M_{sw}$ , refer to 1.4.3, in kN·m;  
for  $M_w$ , refer to 1.4.4;

$$\sigma = \frac{175}{\eta} \text{ MPa.}$$

**1.4.6.3** In cases specified by 1.4.3.4 the section modulus  $W$  determined in accordance with 1.4.6.2 shall be multiplied by the factor  $m$  determined by the formula

$$m = 1 + \frac{M_{sw}^{\min}}{10M_{sw}^{\max}} \left( \frac{M_{sw}^{\min} + M_{sw}^{\max}}{0,076c_w BL^2(C_b + 0,7)} - 1 \right) \quad (1.4.6.3)$$

where  $M_{sw}^{\min}$ ,  $M_{sw}^{\max}$  = absolute values of hogging and sagging bending moments at the maximum range section, in kN·m (refer to Fig. 1.4.3.4),

but not less than 1.

**1.4.6.4** For ships for which the bending moment due to wave impacts on the flare (refer to 1.4.5) shall be considered the section modulus  $W$ , in cm<sup>3</sup>, at the section concerned shall not be less than:

$$W = \frac{M_T}{\sigma} \cdot 10^3 \quad (1.4.6.4)$$

where  $M_T = |M_{sw} + M_w + M_F|$  — design bending moment, in kN·m, at the section concerned equal to the maximum absolute value of algebraic sum of  $M_{sw}$ ,  $M_w$  and  $M_F$  components at this section;

$M_{sw}$  = maximum still water sagging bending moment or minimum hogging bending moment if solely the hogging bending moments occur at this hull section, in kN·m;

$M_w$  = wave sagging bending moment (refer to 1.4.4);

$M_F$  = as determined from 1.4.5;

for  $\sigma$ , refer to 1.4.6.2.

**1.4.6.5** The hull section modulus determined from 1.4.6.2 to 1.4.6.4 for maximum value of design bending moment shall be maintained within 0,4L amidships. However, if the maximum design bending moment occurs outside 0,4L amidships, the steady section modulus requirement is applicable over the ship's length up to the section where maximum design bending moment acts.

The section modulus shall be gradually reduced towards the ship's ends outside the region in which it is being maintained.

**1.4.6.6** For sharp-lined ships without middle-body, deviation from the requirements of 1.4.6.5 may be permitted on agreement with the Register.

**1.4.6.7** In any case, the hull section modulus, in cm<sup>3</sup>, within the midship region (for deck and bottom) shall not be less than:

$$W_{\min} = c_w BL^2(C_b + 0,7)\eta \quad (1.4.6.7-1)$$

where for  $c_w$ , refer to 1.3.1.4.

For ships of restricted area of navigation, the minimum hull section modulus, in cm<sup>3</sup>, within the midship region (for deck and bottom) shall not be less than  $W_{\min_1}$  or  $W_{\min_2}$ , whichever is the greater, determined by the following formulae:

$$W_{\min_1} = \varphi W_{\min}; \quad (1.4.6.7-2)$$

$$W_{\min_2} = 0,95\varphi\nu\varphi W_{\min} \quad (1.4.6.7-3)$$

where for  $\varphi$ , refer to Table 1.4.4.3;

for  $\phi$ , refer to the Formula (1.4.4.3-1);

for  $\nu$ , refer to the Formula (1.4.4.3-2).

**1.4.6.8** Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement in 1.4.6.7 shall be maintained within 0,4L amidships. However, in special cases, based on consideration of type of ship, hull form and loading conditions, the scantlings may be gradually reduced towards the ends of the 0,4L part, bearing in mind the desire not to inhibit the vessel's loading flexibility.

**1.4.6.9** The moment of inertia of hull section  $I$ , in cm<sup>4</sup>, within the midship region shall not be less than:

$$I_{\min} = 3c_w BL^3(C_b + 0,7) \quad (1.4.6.9-1)$$

where  $c_w$  = as determined from 1.3.1.4.

For ships of restricted area of navigation,  $I_{\min}$  shall be multiplied by the reduction factor  $\varphi_0$  determined by the formula

$$\varphi_0 = \varphi\eta \frac{18}{(L/D)_{\max}} \quad (1.4.6.9-2)$$

where for  $\varphi$ , refer to Table 1.4.4.3;

for  $\eta$ , refer to 1.4.4.3;

$(L/D)_{\max}$  = maximum permissible value of  $L/D$  for the area of navigation under consideration, obtained from Table 1.1.1.1.

**1.4.7 Thickness of side shell plating and continuous longitudinal bulkhead plating.**

**1.4.7.1** The thickness of side shell plating  $s$ , in mm, at the considered section over the length and depth of the ship where longitudinal bulkheads are not fitted shall not be less than:

$$s = \frac{0,5(N_{sw} + N_w)}{\tau} \frac{S}{I} \cdot 10^2 \quad (1.4.7.1)$$

where  $N_{sw}$  = as defined in 1.4.3.2, in kN;

for  $N_w$ , refer to 1.4.4.2 and 1.4.4.3;

$\tau = 110/\eta$  MPa.

**1.4.7.2** The thickness of side shell plating  $s_s$  and thickness of longitudinal bulkhead plating  $s_l$ , in mm, at the section under consideration for ships with two plane longitudinal bulkheads shall not be less than:

$$s_s = \frac{N_{sw} + N_w}{\tau} \frac{S}{I} \alpha_s \cdot 10^2; \quad (1.4.7.2-1)$$

$$s_l = \frac{N_{sw} + N_w}{\tau} \frac{S}{I} \alpha_l \cdot 10^2 \quad (1.4.7.2-2)$$

where for  $N_{sw}$ ,  $N_w$ , refer to 1.4.7.1;

$\alpha_s = 0,27$ ;

$\alpha_l = 0,23$ .

**1.4.7.3** For ships having one or more than two continuous plane longitudinal bulkheads as well as longitudinal bulkheads with horizontal corrugations

the required thickness of side plating and members in question shall be calculated according to the procedure approved by the Register.

Appropriate calculation may also be required for ships with two continuous longitudinal bulkheads if the transverse distribution of load is substantially different from uniform distribution.

#### 1.4.8 Calculation of actual hull section modulus.

##### 1.4.8.1 The hull section modulus is determined:

for strength deck  $W_d$ , at moulded deck line at side (lower edge of deck stringer);

for bottom  $W_b$ , at moulded base line (top of plate keel).

For ships with continuous longitudinal strength members above strength deck including trunk and continuous hatch side coamings,  $W_d$  is calculated by dividing the moment of inertia of hull section about the horizontal neutral axis by the value of  $z_t$  determined by the formula

$$z_t = z(0,9 + 0,2y/B) \quad (1.4.8.1)$$

where  $z$  = distance from neutral axis to the top of continuous strength member above deck included in the calculation of  $W_d$ , in m;

$y$  = horizontal distance from the centreline of the ship to the top of continuous strength member above deck included in the calculation of  $W_d$ , in m.

$z$  and  $y$  shall be measured to the point giving the largest value of  $z_t$ .

**1.4.8.2** When calculating the hull section modulus, all continuous longitudinal strength members shall be taken into account, including continuous

hatch side coamings, and, where the ship's design provides for multiple hatchways — the longitudinal deck strips between them on condition the deck strips are effectively supported by longitudinal bulkheads, including the topside tank bulkheads (inner skins).

The sectional area of long bridges or deckhouses shall be included with the reduction coefficient which similarly to stresses in the ship's hull and superstructure (deckhouse) is determined according to the procedure approved by the Register.

Continuous hatch side coamings in ships with single hatches not above the mentioned structures may be included in the calculation of the hull section modulus only if the calculation has been specially approved to this effect.

The sectional area of longitudinal deck strips, each being of a uniform width throughout the length, including deck plating with longitudinal framing and hatch side coamings not supported by longitudinal bulkheads, is included with the reduction coefficient  $\xi$  determined by the formula

$$\xi = m + \frac{0,65 + C_b}{3} \frac{L}{\Sigma l_H + \Delta l_1 + \Delta l_2} \quad (1.4.8.2)$$

where  $m = \begin{cases} -0,10 & \text{at } n = 1; \\ -0,12 & \text{at } n = 2; \end{cases}$

$n$  = number of longitudinal strips over ship's breadth;

$\Sigma l_H$  = total length of longitudinal deck strips, in m;

$\Delta l_1, \Delta l_2$  = length of end attachments of longitudinal deck strips aft and forward, in m.

If the end of the longitudinal deck strip is effectively attached to continuous deck and/or longitudinal bulkhead (Fig. 1.4.8.2),

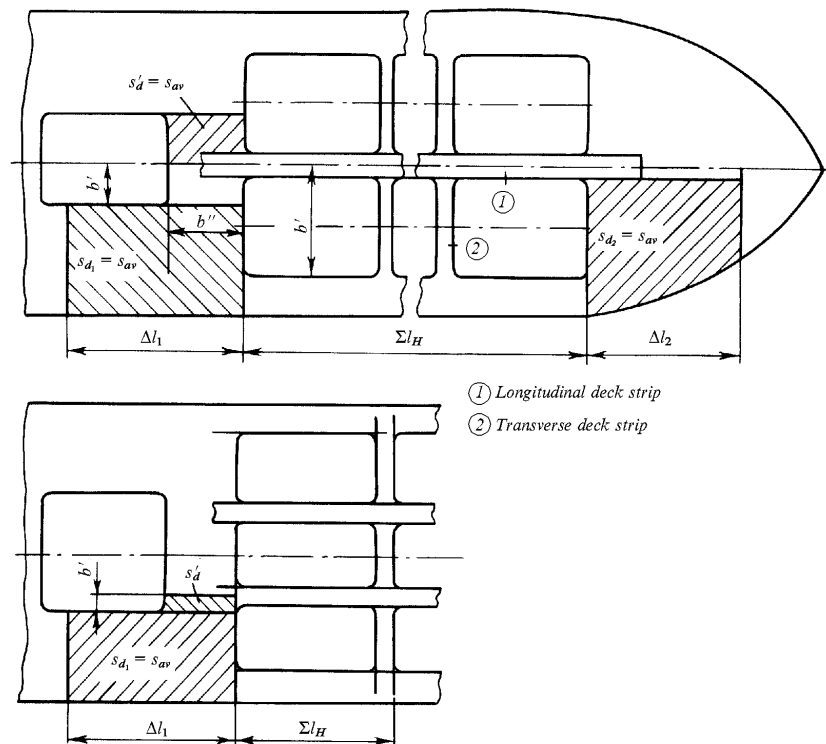


Fig. 1.4.8.2

Longitudinal deck strips to be included in the calculation of hull section modulus

$$\Delta I_{1,2} = 4f/B_{1,2} s_{d_{1,2}}$$

where  $f$  = sectional area of one longitudinal deck strip, in  $\text{cm}^2$ ;

$B_{1,2}$  = breadth of ship in way of longitudinal deck strip termination, in m;

$s_{d_{1,2}}$  = average thickness of the portion of deck plating between the extension of longitudinal deck strip and ship's side along the effective attachment, in mm.

Where a longitudinal deck strip terminates at the transverse deck strip, provided  $10b's_d \geq nf$  and  $b'' > b'$

$$\Delta I_{1,2} = 1,3\eta \frac{f}{10s_d} (b'/b'' + 1)$$

where  $s_d$  = average plate thickness of the transverse deck strip, in mm;

$b'$  = distance between longitudinal edge of the hatch opening and symmetry plane of the longitudinal deck strip, in m;

$b''$  = length of transverse deck strip, in m.

**1.4.8.3 Large openings, i.e. openings exceeding 2,5 m in length and/or 1,2 m in breadth, and scallops, where scallop-welding is applied, shall be deducted from the sectional areas used in the section modulus calculation.**

Smaller openings (manholes, lightening holes, single scallops in way of welds, etc.) need not be deducted, if the following conditions are met:

the sum of their breadths and shadow area breadths (Fig. 1.4.8.3) in one transverse section of the hull does not exceed  $0,06 (B - \Sigma b)$  (where  $\Sigma b$  is the total breadth of openings) or does not reduce the section modulus at deck or bottom by more than 3 per cent;

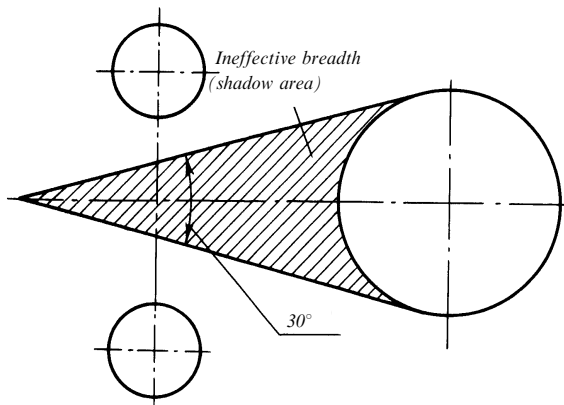


Fig. 1.4.8.3  
Design section

the height of lightening holes, drain holes and single scallops in longitudinal members does not exceed 25 per cent of the web depth, and the height of scallops in way of welds is not over 75 mm.

**1.4.8.4** Where continuous longitudinal members are built of higher tensile steel, they shall extend so far beyond amidships towards the ends as to provide a hull section modulus in way where the yield stress changes not less than required for an identical hull of ordinary steel.

**1.4.8.5** The continuous longitudinal members at a distance from horizontal neutral axis of hull section greater than:

$$\frac{z}{\eta} \frac{W_a}{W_{\eta=1}} \quad (1.4.8.5)$$

where  $z$  = distance of strength deck (upper face plate of continuous hatch side coaming) or bottom from neutral axis, in m;

$\eta$  = factor given in Table 1.1.4.3 for the members of the remainder of hull section;

$W_a, W_{\eta=1}$  = actual section modulus and Rule section modulus with  $\eta = 1$  for the deck (continuous hatch coaming) or bottom respectively,

shall be made of steel with the same yield stress as the strength deck (continuous hatch coaming) or bottom.

#### 1.4.9 Loading control facilities.

**1.4.9.1** By loading control facilities are meant Loading Manual and loading instrument by means of which it can be ascertained that the still water bending moments, shear forces, and the still water torsional and lateral loads, where applicable, in any load or ballast condition will not exceed the specified permissible values.

**1.4.9.2** Ships to be provided with loading control facilities are categorized as follows.

Category I:

ships with large deck opening, for which combined stresses due to vertical and horizontal hull girder bending, as well as torsional and lateral loads, shall be considered;

ships for which uneven loading, i.e. uneven distribution of cargo and/or ballast, is possible.

chemical tankers and gas carriers.

Category II:

ships with arrangement giving small possibilities for variation in cargo and ballast distribution;

ships on regular and fixed trading pattern where the Loading Manual gives sufficient guidance;

ships not falling under category I including ships of less than 120 m in length, which design takes uneven distribution of cargo or ballast into account.

**1.4.9.3** A Loading Manual is a document approved by the Register which describes:

the loading conditions on which the design of the ship has been based;

permissible limits of still water bending moment and shear force and, where applicable, limitations due to torsional and lateral loads;

the results of the calculations of still water bending moments, shear forces for loading conditions stated in 1.4.3.1;

the allowable local loadings for the structure (hatch covers, decks, double bottom, etc.).

**1.4.9.4** A loading instrument is an instrument approved by the Register, which is either analog or digital by means of which the still water bending moments, shear forces and torsional and lateral loads, where required, in any load or ballast condition can be easily and quickly checked at specified readout points.

The number and position of sections and permissible still water bending moments and shear forces as well as the limitations due to torsional and lateral loads shall be approved by the Register.

Single point loading instruments are not acceptable.

An approved Operational Manual shall be provided for the loading instrument.

**1.4.9.5** All ships other than category II ships of less 90 m in length, which deadweight is not greater than 30 per cent of summer load line displacement, shall be provided with the Loading Manual approved by the Register. In addition to the Loading Manual, all ships of category I shall carry a loading instrument approved by the Register (requirements for loading instruments are given in Appendix 4).

**1.4.9.6** For ore carriers, ore-oil carriers and oil-bulk carriers having a length of 150 m and more, additional requirements for strength control during loading are given in 3.3.6.

**1.4.9.7** Information (booklet) on Stability and Strength during Loading, Unloading and Stowage of Bulk Cargoes Other than Grain.

To prevent excessive hull stresses, provision shall be made for Information (booklet) on Stability and strength during Loading, Unloading and Stowage of Bulk Cargoes other than Grain to be carried on board, including the following as a minimum:

**.1** stability data required in 1.4.11, Part IV "Stability";

**.2** data on the capacity of ballast tanks and of equipment for their filling and emptying;

**.3** maximum permissible load upon a unit of double-bottom plating surface;

**.4** maximum permissible cargo hold load;

**.5** general instructions concerning loading and unloading and pertinent to hull strength, including any limitations due to the worst operating conditions during loading, unloading, handling of water ballast, and during the voyage;

**.6** any special limitations, for instance, those due to the worst operating conditions, where applicable;

**.7** where necessary — strength calculations: maximum permissible forces and moments affecting the hull during loading, unloading and the voyage.

The Information (booklet) shall be drawn up in the language familiar to the ship officers, and in English.

**1.4.9.8** When developing the Loading Manual and Information (booklet) on Ship Stability and Strength During Loading, Unloading and Stowage of Bulk Cargoes Other Than Grain, one shall be guided by the recommendations contained in Collection of Regulating Documents of the Register, Book 9.

## **1.5 VIBRATION OF HULL STRUCTURES. VIBRATION STANDARDS**

### **1.5.1 General.**

**1.5.1.1** The present Chapter shall establish the highest permissible vibration levels (hereinafter, vibration standards) of hull structures in sea-going displacement ships.

**1.5.1.2** The vibration standards are set down proceeding from the condition of ensuring the strength of hull structures and the dependability of machinery, instruments and equipment installed on board the ship.

**1.5.1.3** The application of standards stipulated in this Chapter does not release one from compliance with sanitary norms and other requirements for permissible vibration parameters at work places in the accommodation, service and other spaces of ships.

**1.5.1.4** Vibration standards for ship machinery and equipment are specified in Section 9, Part VII "Machinery Installations".

**1.5.1.5** Where vibration parameters are determined at the design stage, they may be calculated using the procedures given in the Collection of Regulating Documents of the Register, Book 14.

**1.5.1.6** Vibrations shall be measured in the first ship of a series and in single buildings. The procedure, scope and sequence of vibration measurement shall be approved by the Register.

**1.5.1.7** On special agreement with the Register, departure from the present standards may be permitted in well-grounded cases.

### **1.5.2 Technical documentation.**

After mooring tests and sea trials, a report on vibration measurement shall be submitted to the Register, which shall be approved by the management of the firm having carried out the evaluation of the vibration characteristics of the ship. Where additional measures are taken to reduce vibration, the report shall contain those measures as well as the results of a second measurement of vibrations to confirm the efficiency of measures taken.

### **1.5.3 Measured vibration parameters.**

**1.5.3.1** For the purpose of the present Chapter, the following vibration parameters have been adopted as main ones:

root mean square value of vibration velocity measured in one-third octave bands and, where necessary, in octave bands;

root mean square value of vibration acceleration and, in well-grounded cases, the root mean square or peak value of vibratory displacement.

**1.5.3.2** Vibration parameters shall be measured in absolute units or in logarithmic units (decibels) with regard to standard threshold values of vibration velocity or acceleration equal to  $5 \times 10^{-5}$  mm/s and  $3 \times 10^{-4}$  m/s<sup>2</sup>, accordingly.

**1.5.3.3** Measurements shall be carried out in the following directions:

in each of the inter-perpendicular directions with regard to the ship: vertical, horizontal-transverse and horizontal-longitudinal direction, when measuring the main hull vibration;

in the direction normal to the plane of ship structures (deck, side, bulkheads, etc.) or in the lowest-rigidity direction of the hull girder, when measuring local vibration.

**1.5.3.4** The permissible root mean square values of vibration velocity and vibration acceleration of the hull and superstructures as well as hull structures are mentioned in Table 1.5.3.4 and in Fig. 1.5.3.4.

**1.5.3.5** When measuring the parameters in octave bands, the permissible values stated in Table 1.5.3.4 for mean geometric frequencies of 2, 4, 8, 16, 31.5 and 63 Hz may be increased  $1,41(\sqrt{2})$  times or by 3 dB as compared to tabulated values.

**1.5.3.6** Permissible values given in Table 1.5.3.4 and in Fig. 1.5.3.4 shall not be exceeded at specified ship speeds and at zero speed, if specified.

## 1.6 REQUIREMENTS FOR SCANTLINGS OF HULL STRUCTURAL MEMBERS

### 1.6.1 General.

**1.6.1.1** This Chapter contains general requirements for plating and framing.

**1.6.1.2** Plate structure means a portion of plating bounded by stiffening members. By plate structures are meant portions of the deck, platform and inner bottom plating and portions of the bottom, side, bulkhead plating as well as webs of deep members.

**1.6.1.3** In the present Part of the Rules the term "framing" includes primary members and deep members strengthening the plate structures. Deep members also serve as supporting structures for primary members. Primary members are deck longitudinals, side longitudinals, bulkhead longitudinals, inner bottom plating and bottom longitudinals, as well as vertical and horizontal stiffeners of bulkheads, frames, beams, reverse and bottom frames of bracket floors, etc. Deep members are deck transverses, deck girders, web frames, side stringers, floors, side girders, centre girder, vertical webs and horizontal girders of bulkheads, etc.

**1.6.1.4** The scantlings of primary and deep members are based on the required section modulus, moment of inertia, web sectional area, thicknesses of web and face plate, as well as width of the face plate.

Table 1.5.3.4

Mean geometric values of octave ranges, in Hz	Hull and superstructure, rigid members <sup>1</sup>				Hull structures							
					frames <sup>2</sup>				plates			
	Permissible root mean square values											
	vibration velocity		vibration acceleration		vibration velocity		vibration acceleration		vibration velocity		vibration acceleration	
	mm/s	dB	m/s <sup>2</sup>	dB	mm/s	dB	m/s <sup>2</sup>	dB	mm/s	dB	m/s <sup>2</sup>	dB
1,6	5,6	101	0,054	45	5,6	101	0,054	45	5,6	101	0,054	45
2	5,6	101	0,067	47	5,6	101	0,067	47	5,6	101	0,067	47
2,5	5,6	101	0,084	49	5,6	101	0,084	49	5,6	101	0,084	49
3,15	5,6	101	0,106	51	7,1	103	0,135	53	7,1	103	0,135	53
4	5,6	101	0,135	53	8,9	105	0,21	57	8,9	105	0,21	57
5	5,6	101	0,17	55	11	107	0,34	61	11	107	0,34	61
6,3	5,6	101	0,21	57	11	107	0,43	63	14	109	0,54	65
8	5,6	101	0,27	59	11	107	0,54	65	16	110	0,75	68
10	5,6	101	0,34	61	11	107	0,65	67	16	110	0,94	70
12,5	5,6	101	0,43	63	11	107	0,84	69	16	110	1,2	72
16	5,6	101	0,54	65	11	107	1,06	71	16	110	1,5	74
20	5,6	101	0,67	67	11	107	1,35	73	16	110	1,9	76
25	5,6	101	0,84	69	11	107	1,7	75	16	110	2,4	78
31,5	5,6	101	1,06	71	11	107	2,1	77	16	110	3,0	80
40	5,6	101	1,35	73	11	107	2,7	79	16	110	3,8	82
50	5,6	101	1,7	75	8,9	105	2,7	79	12,5	108	3,8	82
63	5,6	101	2,1	77	7,1	103	2,7	79	10	106	3,8	82
80	5,6	101	2,7	79	5,6	101	2,7	79	8	104	3,8	82

<sup>1</sup> Hull and superstructures, rigid members are the intersections of decks with main transverse and longitudinal bulkheads, sides, transom, superstructure walls, etc.

<sup>2</sup> Girders supporting the foundations of ship machinery and equipment are included.

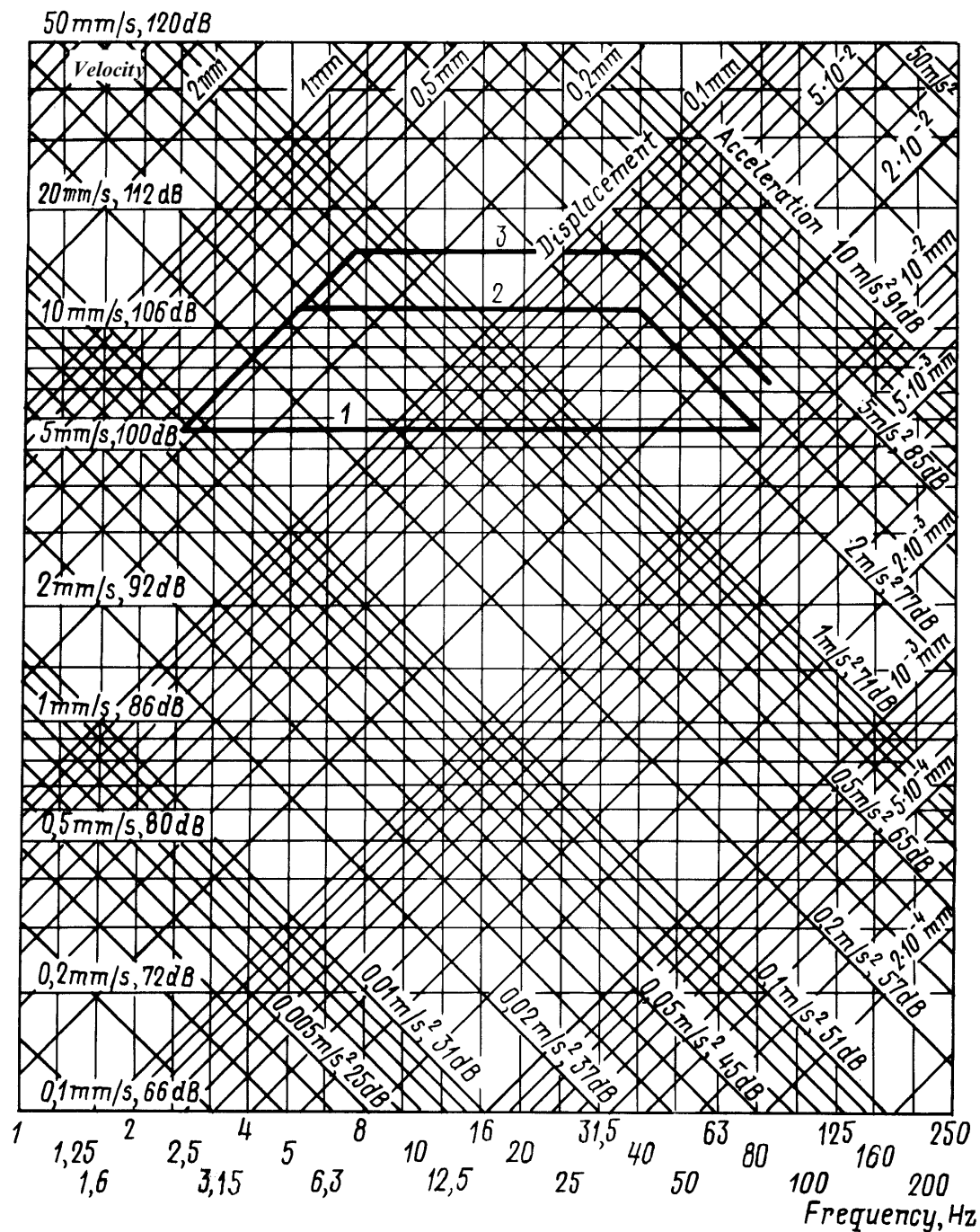


Fig. 1.5.3.4

Permissible mean root values of vibration velocity and vibrational acceleration:

- 1 – hull, superstructures and rigid members;
- 2 – framing members including the girders by which the foundations of ship machinery and equipment are supported;
- 3 – plates

Geometric properties of the member section, unless stated otherwise, are determined taking into account the effective flange.

If the member is so arranged that it is not normal to the effective flange, the section modulus shall be increased in proportion to  $1/\cos \alpha$  (where  $\alpha$  is the angle, in degrees, between the member web and the

perpendicular to the effective flange at the section considered. If  $\alpha \leq 15^\circ$ , no increase of section modulus is required.

**1.6.1.5** Rounding off the required scantlings of structural members generally shall be made in the direction of increase. Plate thickness shall be rounded off to the nearest 0,5 or integer of millimetres.

The values of negative rolling tolerances for plates shall comply with the requirements of 3.2.7, Part XIII "Materials".

### 1.6.2 Symbols.

For the purpose of this Chapter, the following symbols have been adopted:

$l$  = span of concerned member, determined from 1.6.3.1, in m;

$p$  = design pressure at the point of load application, determined in the relevant chapters of the present Part of the Rules, in kPa;

$a$  = spacing, in m, of concerned primary or deep members of longitudinal or transverse framing system; where this varies,  $a$  is a half-sum of distances of adjacent members from the member concerned;

$h$  = depth of the member web, in cm;

$I$  = actual moment of inertia of the hull about the horizontal neutral axis, in cm<sup>4</sup>;

$z_i$  = vertical distance from horizontal neutral axis of ship to the centre of section area of the longitudinal considered, in m;

$\sigma_n$  = design specified yield stress for normal stresses, in MPa, determined from 1.1.4.3;

$\tau_n$  = design specified yield stress for shear stresses, in MPa, determined from 1.1.4.3;

$\Delta s$  = corrosion allowance, in mm, determined from 1.1.5.1.

### 1.6.3 Span and effective flange of member.

**1.6.3.1** The span of primary and deep member  $l$  is measured along the member face plate as the distance between its span points. Unless provided otherwise, where the end brackets are fitted, the span points shall be taken at the mid-length of the bracket. In this case, the span point position shall be such that the height of the end bracket in it does not exceed the web depth of the member considered (Fig. 1.6.3.1).

For curvilinear members the span shall be taken equal to the chord connecting the span point centres.

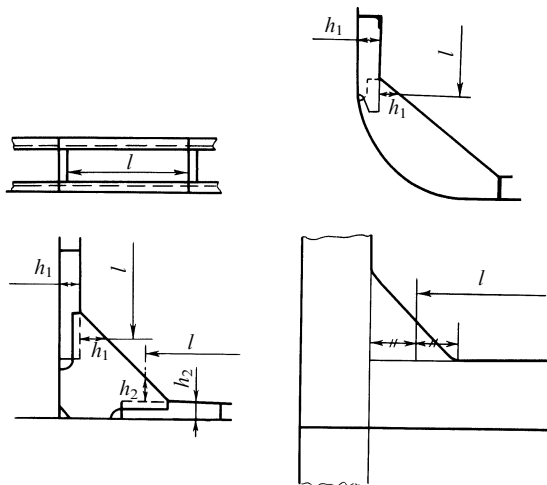


Fig. 1.6.3.1

**1.6.3.2** The thickness of the effective flange is taken equal to its mean thickness in the considered section of the member.

**1.6.3.3** The width of the effective flange  $a_f$  in m, of primary members shall be determined by the formulae:

$$a_f = l/6; \quad (1.6.3.3-1)$$

$$a_f = 0,5(a_1 + a_2) \quad (1.6.3.3-2)$$

where  $a_1, a_2$  = distance of the considered member from the nearest members of the same direction located on both sides of the considered member, in m,

whichever is the smaller.

**1.6.3.4** The width of the effective flange of deep members  $c_f$  in m, is determined by the formula

$$c_f = kc \quad (1.6.3.4)$$

where  $c = 0,5(c_1 + c_2)$ ;

$c_1, c_2$  = distance of the considered deep member from the nearest deep members of the same direction located on both sides of the considered member, in m;

$k$  = factor obtained from Table 1.6.3.4 depending on  $c$ , given span  $l_{sp}$  and number  $n$  of members supported by considered deep members.

Table 1.6.3.4

Number of members $n$	$k$ values at $l_{sp}/c$ equal to:						
	1	2	3	4	5	6	7 and more
$\geq 6$	0,38	0,62	0,79	0,88	0,94	0,98	1
$\leq 3$	0,21	0,4	0,53	0,64	0,72	0,78	0,8

Note. For intermediate values of  $l_{sp}/c$  and  $n$ , the factor  $k$  is determined by linear interpolation.

For simply supported deep members the given span  $l_{sp} = l$ , and for fixed deep members  $l_{sp} = 0,6l$ . The way in which the framing members shall be supported (simple supporting or fixing) is determined proceeding from the general engineering principles with regard for the actual structure (presence of brackets, welding of webs, face plates, etc.) and is characterized by the presence or absence of bending moment effects in the span point of the member.

**1.6.3.5** The width of the hatch coaming effective flange shall be equal to one-twelfth of their span but not more than half the distance between the cargo hatch and the ship's side for the side coaming and, accordingly, half the distance between a cargo hatch and a transverse bulkhead (or the beam nearest to the cargo hatch) for the hatch end coaming.

**1.6.3.6** The width of the effective flange of deep members located normal to the direction of corrugations shall be taken equal to  $15s$  and  $20s$  for trapezoidal and wave-shaped corrugations respectively ( $s$  = thickness of corrugated plates, in mm) or  $0,1c$  (for  $c$ , refer to 1.6.3.4), in mm, whichever is less.



**1.6.3.7** Where primary members parallel to deep members are fitted over the width of the effective flange of the latter, full cross-sectional areas of the above primary members shall be adopted for calculation when determining the inertia moment and section modulus of the deep members.

**1.6.3.8** In case the area of the effective flange is less than that of the face plate, the determination of section modulus and moment of inertia of the deep members is subject to special consideration by the Register. This requirement applies to deep members of corrugated structures.

**1.6.4 Scantlings of structural members.**

**1.6.4.1** The section modulus  $W$ , in  $\text{cm}^3$ , of primary members of rolled section shall not be less than:

$$W = W' \omega_c \quad (1.6.4.1)$$

where  $W'$  = section modulus of member considered, in  $\text{cm}^3$ , determined from 1.6.4.2;

$\omega_c$  = multiplier taking into account corrosion allowance, determined in accordance with 1.1.5.3;

The section modulus of built-up welded members shall satisfy the requirements of 1.6.4.2. In this case the thickness of section elements shall be increased by corrosion allowance  $\Delta s$ .

**1.6.4.2** The section modulus of member considered, in  $\text{cm}^3$ , without taking into account corrosion allowance is determined by the formula

$$W' = \frac{Ql \cdot 10^3}{m k_\sigma \sigma_n} \quad (1.6.4.2)$$

where  $Q$  = *pal* — transverse load on member considered, in kN;  
 $m, k_\sigma$  = factors of bending moment and permissible stresses to be found in the relevant chapters of the present Part of the Rules.

**1.6.4.3** The net sectional area (excluding openings)  $f_w$ , in  $\text{cm}^2$ , of primary and deep member webs shall not be less than:

for members of rolled section

$$f_w = f'_w \omega_c \quad (1.6.4.3-1)$$

$$\text{where } f'_w = \frac{10N_{\max}}{k_\tau \tau_n} \quad (1.6.4.3-2)$$

$N_{\max}, k_\tau$  = maximum shear force value and permissible shear stress factor as defined in the relevant chapters of the Rules;  
 for  $\omega_c$ , refer to 1.1.5.3;

for built-up welded members, the required web cross-sectional area shall be determined by the Formula (1.6.4.3-2) with a subsequent increase in thickness by the value of  $\Delta s$ .

**1.6.4.4** The thickness  $s$ , in mm, of the plates under transverse loading shall not be less than:

$$s = mak \sqrt{\frac{P}{k_\sigma \sigma_n}} + \Delta s \quad (1.6.4.4)$$

where  $m, k_\sigma$  = bending moment and permissible stress factors as defined in the relevant chapters of the Rules;

$k = 1,2 - 0,5a/b$ , but not greater than 1;

$a$  and  $b$  = smaller and greater sizes, in m, of supporting contour sides of plate structure.

**1.6.4.5** The scantlings of the corrugated structures shall comply with the following requirements:

**.1** the thickness of the trapezoidal corrugations shall be determined by the Formula (1.6.4.4) taking  $a$  equal to  $b$  or  $c$ , whichever is the greater (Fig. 1.6.4.5).

The following relationship shall be satisfied:

$$b/s \leq 0,06 \sqrt{\eta} \quad (1.6.4.5.1)$$

where  $b$  = width of the panel parallel to the bulkhead plane, in m (refer to Fig. 1.6.4.5).

Angle  $\varphi$  (refer to Fig. 1.6.4.5 *a*) shall be assumed not less than  $40^\circ$ ;

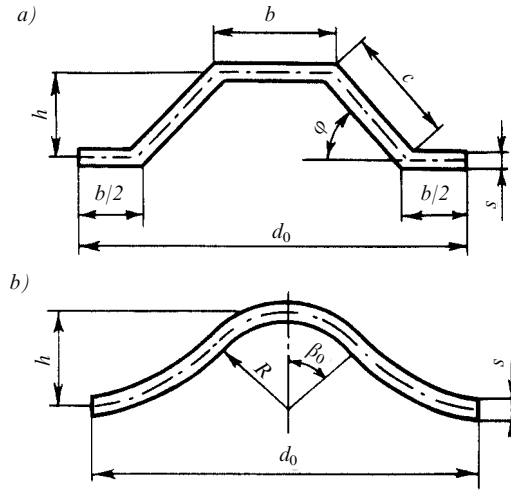


Fig. 1.6.4.5  
Trapezoidal (a)  
and wave-shaped (b) corrugations

**.2** the thickness of the wave-shaped corrugations,  $s$ , in mm, shall not be less than:

$$s = 22\beta_0 R \sqrt{\frac{P}{k_\sigma \sigma_n}} + \Delta s \quad (1.6.4.5.2-1)$$

where  $\beta_0$  = half-angle of spread of corrugation (refer to Fig. 1.6.4.5, b) in rad.;

$R$  = radius of corrugation, in m;

$k_\sigma$  = factor of permissible stresses determined in the relevant chapters of the present Part of the Rules.

In this case, the following relationship shall be satisfied:

$$R/s \leq 17/R_{eH}; \quad (1.6.4.5.2-2)$$

**.3** the section modulus of the corrugation is determined according to 1.6.4.1 and 1.6.4.2 taking  $Q = pd_0l$  (for  $d_0$ , refer to Fig. 1.6.4.5).

The spacing and section modulus of corrugations can be determined by the formulae given in Table 1.6.4.5. (Linear dimensions are expressed in cm,  $\varphi$  and  $\beta_0$  — in deg.).

Table 1.6.4.5

Type of corrugation	Spacing of corrugations	Section modulus
Trapezoidal	$d_0 = 2(b + c \cos \varphi)$	$W = hs(b + c/3)$
Wave-shaped	$d_0 = 4R \sin \beta_0$	$W = \gamma s R^2$

Factor  $\gamma$  is determined by the formula

$$\gamma = 2 \frac{\beta_0 + 2\beta_0 \cos^2 \beta_0 - 1,5 \sin 2\beta_0}{1 - \cos \beta_0}. \quad (1.6.4.5.3)$$

In calculating the factor  $\gamma$ , the angle  $\beta_0$  shall be taken in radians.

**1.6.4.6** Permissible stress factors  $k_\sigma$  and  $k_\tau$  defined in the relevant chapters of the Rules may be increased by 5 per cent for ships of restricted areas of navigation **R2** and **R2-RSN** and by 10 per cent for **R3-RSN** and **R3** unless dependent upon the factors  $k_B$  and  $k_D$  determined by the Formula (2.2.4.1).

#### 1.6.5 Buckling strength of hull structural members.

**1.6.5.1** The buckling strength of longitudinals, shell plates and hull structure plating shall be ensured within the midship region of ships of unrestricted service and ships of restricted areas of navigation **R1** and **R2**, 65 m and greater in length, of restricted areas of navigation **R2-RSN**, **R3-RSN** and **R3**, 60 m and greater in length subject to compressive stresses due to longitudinal bending of the hull girder.

Effective compressive stresses  $\sigma_c$ , in MPa, shall be determined by the following formula:

$$\sigma_c = \frac{M_T}{I} z_i \cdot 10^5 \geq 30/\eta \quad (1.6.5.1-1)$$

where  $M_T$  = design bending moment, in kN·m, at the section under consideration equal to the maximum absolute value of algebraic sum of the moment components;

$M_T = |M_{sw} + M_w|$  — for longitudinal members arranged below the neutral axis;

$M_T = |M_{sw} + M_w + M_F|$  — for longitudinal members arranged above the neutral axis;

$M_{sw}$  = as defined in 1.4.3, in kN·m;

$M_w$  = as determined from 1.4.4;

for  $M_F$ , refer to 1.4.5.

The maximum hogging bending moment shall be assumed as design value  $M_T$  for longitudinal members arranged below the neutral axis, and the maximum sagging bending moment — for longitudinal members arranged above the neutral axis.

The buckling strength of side shell and longitudinal bulkheads at the section considered shall be ensured under shear stresses  $\tau_c$ , in MPa, calculated by the following formulae:

for side shell plating in ships without effective longitudinal bulkheads

$$\tau_c = \frac{N_{sw} + N_w}{2s} \frac{S}{I} \cdot 10^2; \quad (1.6.5.1-2)$$

for side shell plating in ships with two effective longitudinal bulkheads

$$\tau_c = \frac{N_{sw} + N_w}{s_s} \frac{S}{I} \alpha_s \cdot 10^2; \quad (1.6.5.1-3)$$

for longitudinal bulkhead plating in ships with two effective longitudinal bulkheads

$$\tau_c = \frac{N_{sw} + N_w}{s_l} \frac{S}{I} \alpha_l \cdot 10^2 \quad (1.6.5.1-4)$$

where  $N_{sw}$  = still water shear force at the section considered, defined in 1.4.3, in kN;

$N_w$  = wave vertical shear force determined from 1.4.4.2;

$s$  = actual thickness of side shell plating in ships without longitudinal bulkheads, in mm;

$s_s, s_l$  = actual thicknesses of side shell plating and longitudinal bulkhead plating at the section considered in ships with two longitudinal bulkheads, in mm;

$S, I$  = as defined in 1.4.2;

for  $\alpha_s, \alpha_l$ , refer to 1.4.7.2.

Where one or more than two continuous longitudinal plane bulkheads or longitudinal bulkheads with horizontal corrugations are fitted, the shear stresses are determined by a procedure approved by the Register.

**1.6.5.2** The buckling strength of longitudinal members is considered sufficient if the following conditions are met:

$$k\sigma_c \leq \sigma_{cr}; \quad (1.6.5.2-1)$$

$$\tau_c \leq \tau_{cr}$$

where  $k = 1$  for plating and for web plating of stiffeners;

$k = 1,1$  for stiffeners;

for  $\sigma_c, \tau_c$ , refer to 1.6.5.1;

for  $\sigma_{cr}, \tau_{cr}$ , refer to 1.6.5.3.

For plate panels, the factor  $k$  may be reduced in respect of ships of restricted navigation areas: **R1** — by 10 per cent, **R2** and **R2-RSN** — by 15 per cent, **R3-RSN** and **R3** — by 20 per cent. In this case, when determining the actual section modulus of hull in accordance with 1.4.8, the strength reduction of compressed plate shall be considered, i.e. where  $\sigma_{cr} < \sigma_c$  the plates shall be included in the hull girder section, except for the areas adjoining the longitudinals and having a breadth equal to 0,25 of the shorter side of supporting contour, with the reduced factor  $\psi_n$  to be determined by the formula

$$\psi_n = \sigma_{cr}/\sigma_c. \quad (1.6.5.2-2)$$

**1.6.5.3** Critical stresses  $\sigma_{cr}$  and  $\tau_{cr}$ , in MPa, shall be determined by the formulae:

$$\begin{aligned}\sigma_{cr} &= \sigma_e \text{ when } \sigma_e \leq 0,5R_{eH}; \\ \sigma_{cr} &= R_{eH}(1 - R_{eH}/4\sigma_e) \text{ when } \sigma_e > 0,5R_{eH}; \\ \tau_{cr} &= \tau_e \text{ when } \tau_e \leq 0,29R_{eH}; \\ \tau_{cr} &= R_{eH}(0,58 - 0,08R_{eH}/\tau_e) \text{ when } \tau_e > 0,29R_{eH}\end{aligned}\quad (1.6.5.3)$$

where  $\sigma_e$ ,  $\tau_e$  = Euler normal and shear stresses to be determined in accordance with 1.6.5.4 and 1.6.5.5.

**1.6.5.4** When checking the buckling strength, the Euler stresses  $\sigma_e$ , in MPa, for primary and deep longitudinal members shall be determined by the following formulae:

**.1** for column buckling of primary longitudinal members without rotation of the cross section

$$\sigma_e = 206i/f^2 \quad (1.6.5.4.1)$$

where  $i$  = moment of inertia, in  $\text{cm}^4$ , of longitudinal, including plate flange and calculated with thickness reduced by the value of  $\Delta s$  (for  $\Delta s$ , refer to Table 1.6.5.5-2);

$f$  = cross-sectional area, in  $\text{cm}^2$ , of longitudinal, including plate flange and calculated with a thickness reduced by the value of  $\Delta s$  (for  $\Delta s$ , refer to Table 1.6.5.5-2); a plate flange equal to the frame spacing may be included;

**.2** for torsional buckling of primary longitudinal members

$$\sigma_e = (203/\bar{I}^2)(i_w/i_p)(m^2 + k/m^2) + 79310i_i/i_p \quad (1.6.5.4.2)$$

where  $k = 0,05c^4/i_w$ ;

$m$  = number of half waves, given by Table 1.6.5.4;

Table 1.6.5.4

$k$	$0 < k < 4$	$4 < k < 36$	$36 < k < 144$	$(m-1)^2m^2 < k < m^2(m+1)^2$
$m$	1	2	3	$m$

$i_t$  = moment of inertia, in  $\text{cm}^4$ , of profile under simple torsion (without plate flange), determined as follows:

$$i_t = \frac{h_w s_w^3}{3} \cdot 10^{-4} \text{ for flat bars};$$

$$i_t = \frac{1}{3} [h_w s_w^3 + b_f s_f^3 (1 - 0,63s_f/b_f)] \cdot 10^{-4} \text{ for angles, bulb, symmetrical bulb and T-profiles};$$

$i_p$  = polar moment of inertia, in  $\text{cm}^4$ , of profile about connection of stiffener to plate, determined as follows:

$$i_p = \frac{h_w^3 s_w^3}{3} \cdot 10^{-4} \text{ for flat bars};$$

$$i_p = \left( \frac{h_w s_w^3}{3} + h_w^2 b_f s_f \right) \cdot 10^{-4} \text{ for angles, bulb, symmetrical bulb and T-profiles};$$

$i_w$  = sectional moment of inertia, in  $\text{cm}^6$ , of profile about connection of stiffener to plate, determined as follows:

$$i_w = \frac{h_w^3 s_w^3}{36} \cdot 10^{-6} \text{ for flat bars};$$

$$i_w = \frac{s_f b_f^3 h_w^2}{12} \cdot 10^{-6} \text{ for T- and symmetrical bulb profiles};$$

$$i_w = \frac{b_f^3 h_w^2}{12(b_f + h_w)^2} [s_f(b_f^2 + 2b_f h_w + 4h_w^2) + 3s_w b_f h_w] \cdot 10^{-6} \text{ for}$$

angles and bulb profiles;

$h_w$  = web height, in mm;

$s_w$  = web thickness, in mm, reduced by the value of  $\Delta s$  (for  $\Delta s$ , refer to Table 1.6.5.5-2);

$b_f$  = flange width, in mm, for angles and T-profiles or bulb width, in mm, for bulb and symmetrical bulb profiles;

$s_f$  = flange thickness or bulb thickness, in mm, reduced by the value of  $\Delta s$  (for  $\Delta s$ , refer to Table 1.6.5.5-2). For bulb and symmetrical bulb profiles,  $s_f$  may be adopted equal to the mean thickness of the bulb;

$c$  = spring stiffness exerted by supporting plate panel, determined by the formula

$$c = \frac{68,7k_p s^3}{(1 + \frac{1,33k_p h_w s^3}{a s_w^3} \cdot 10^{-3})a}$$

$k_p = 1 - \sigma_e/\sigma_e \geq 0$  (to be taken not less than 0,1 for angles, bulb, symmetrical bulb and T-profiles);

$\sigma_e$  = compressive stress according to 1.6.5.1;

$\sigma_e$  = Euler stress of supporting plate according to 1.6.5.5;

$s$  = supporting plate thickness, in mm, reduced by the value of  $\Delta s$  (for  $\Delta s$ , refer to Table 1.6.5.5-2);

$a$  = distance between longitudinals;

**.3** for web and flange buckling

$$\sigma_e = 7,83(s_w/h_w)^2 \cdot 10^5 \text{ for web plates of longitudinal deep members}; \quad (1.6.5.4.3)$$

for flanges of deep longitudinal members buckling is taken care by the following requirement:

$$b_f/s_f \geq 15$$

where  $b_f$  = flange width, in mm, for angles, half the flange width for T-sections;

$s_f$  = flange thickness, in mm.

**1.6.5.5** Euler normal  $\sigma_e$  and shear  $\tau_e$  stresses, in MPa, for plate structures shall be determined as for rectangular plates by the formulae:

$$\sigma_e = 0,1854n(s'/b)^2; \quad (1.6.5.5-1)$$

$$\tau_e = 0,1854n(s'/b)^2 \quad (1.6.5.5-2)$$

where  $n$  = factor depending on the load type of the plate and the ratio of sides (Table 1.6.5.5-1);

$s'$  = actual thickness of the plate reduced by the value of  $\Delta s$  obtained from Table 1.6.5.5-2;

$b$  = plate side located normal to the direction of normal compressive stresses; when the plate is exposed to shear stresses,  $b$  is the smaller side of the plate, in m.

**1.6.5.6** The moment of inertia  $i$ , in  $\text{cm}^4$ , of the stiffeners on deep girder webs (refer to 1.7.3.2) shall not be less than determined by the formulae:

for the stiffeners fitted normal to the girder face plate

$$i = \gamma a s^3 \cdot 10^{-3}; \quad (1.6.5.6-1)$$

for the stiffeners parallel to the girder face plate

$$i = 2,35 \frac{(f + 0,1as)l^2}{\eta} \quad (1.6.5.6-2)$$

where  $\gamma$  = coefficient obtained from Table 1.6.5.6 depending on the ratio of the girder web depth  $h$  to the spacing of stiffeners  $a_1$ ;

Table 1.6.5.5-1

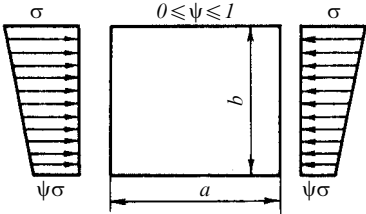
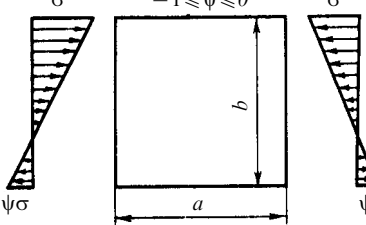
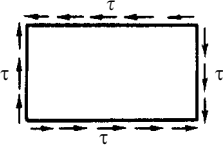
Type of load	$\gamma = a/b$	$n$
	$\gamma > 1$  $\gamma < 1$	$\frac{8,4}{\psi + 1,1}$  $\varepsilon \left( \gamma + \frac{1}{\gamma} \right)^2 \frac{2,1}{\psi + 1,1}$
	$\gamma > 1$  $\gamma < 1$	$10\psi^2 - 6,4\psi + 7,6$  $\varepsilon[10\psi^2 - 14\psi + 1,9(1 + \psi)(\gamma + 1/\gamma)^2]$
	$\gamma > 1$	$5,34 + 4/\gamma^2$
<p>Notes: 1. <math>\psi</math> = ratio between smallest and largest compressive stress when linear variation across panel.  2. <math>\varepsilon = 1,3</math> when plating is stiffened by floors or deep girders;  <math>\varepsilon = 1,21</math> when stiffeners are angles, symmetrical bulbs or T-sections;  <math>\varepsilon = 1,1</math> when stiffeners are bulb flats;  <math>\varepsilon = 1,05</math> when stiffeners are flat bars.</p>		

Table 1.6.5.5-2

Structure	$\Delta s$ , mm
Compartments carrying dry bulk cargoes. Vertical surfaces and surfaces sloped at an angle greater than $25^\circ$ to the horizontal line. One side exposure to ballast and/or liquid cargo	$0,05s$ ( $0,5 \leq \Delta s \leq 1$ )
Horizontal surfaces and surfaces sloped at an angle less than $25^\circ$ to the horizontal line. One side exposure to ballast and/or liquid cargo Vertical surfaces and surfaces sloped at an angle greater than $25^\circ$ to the horizontal line. Two side exposure to ballast and/or liquid cargo	$0,10s$ ( $2 \leq \Delta s \leq 3$ )
Horizontal surfaces and surfaces sloped at an angle less than $25^\circ$ to the horizontal line. Two side exposure to ballast and/or liquid cargo	$0,15s$ ( $2 \leq \Delta s \leq 4$ )
$s$ = actual thickness, in mm, of the structural member under consideration.	
Note. $\Delta s = 0$ otherwise.	

$a$  = spacing of stiffeners, in cm;  
 $s$  = actual thickness of the web, in mm;  
 $f$  = actual cross-sectional area of the stiffener, in cm<sup>2</sup>;  
 $l$  = span of the stiffener, in m.  
 $\eta$  = as determined according to 1.1.4.3.

Table 1.6.5.6

$H/a$	1 and less	1,2	1,4	1,6	1,8	2,0	2,5	3,0	3,5	4,0
$\gamma$	0,3	0,6	1,3	2,0	2,9	4,1	8,0	12,4	16,8	21,2
Note. The intermediate values of $\gamma$ are determined by linear interpolation.										

### 1.6.6 Aluminium alloy structures.

**1.6.6.1** The scantlings of aluminium alloy structures shall be determined by conversion of the scantlings relating to the corresponding steel structures. The conversion shall be made using the formulae of Table 1.6.6.1 without considering the limits by minimum scantlings of steel structures.

**1.6.6.2** The sectional area of sternframe, stem, bar keel and propeller shaft brackets shall be 1,3 times that required for steel application.

**1.6.6.3** Where continuous welds (fillets, butt welds) are located in most stressed positions, account shall be taken of the reduction in strength at the welded joint location depending on the given aluminium alloy and the process of welding.

Table 1.6.6.1

Parameter	Requirement
Thickness of plating for the shell, decks (without covering), bulkheads, enclosures and other details made of plates	for superstructures $s_1 = s\sqrt{R_{eH}/R_{p0.2}}$ for main hull $s_1 = 0,9s\sqrt{R_{eH}/R_{p0.2}}$
Section modulus of framing members	$W_1 = WR_{eH}/R_{p0.2}$
Cross-sectional area of pillars	$f_1 = fR_{eH}/R_{p0.2}$
Moment of inertia of pillars and framing members	$I_1 = 3I$
Notes: 1. $R_{p0.2}$ = proof stress of aluminium alloy, in MPa. 2. The values of $s$ , $W$ , $f$ , $I$ as stipulated by the Rules may be adopted without corrosion allowance.	

**1.6.6.4** On agreement with the Register, the bi-metallic (steel — aluminium) pressed elements for connection of steel and aluminium alloy structures may be used.

## 1.7 WELDED STRUCTURES AND JOINTS

### 1.7.1 General.

**1.7.1.1** Any change in the shape or section of the members of welded hull structure shall take place gradually. All openings shall have rounded corners and smooth edges.

**1.7.1.2** The scantlings of sections and the thicknesses of plates used for longitudinal members shall change gradually throughout the ship's length.

Any change of framing system and plating thicknesses used for the strength deck, bottom, side shell and longitudinal bulkheads shall not be permitted in areas where mechanical properties of steel change.

**1.7.1.3** Continuity shall be ensured for as many of main longitudinal members as possible, and a gradual change of their sections is required in way of the ends together with other arrangements, contributing to the reduction of stress concentration.

**1.7.1.4** In tight structures, as well as in non-tight structures subject to intense vibration, stiffeners and similar details shall be fitted to prevent hard spots in the plating at the toes of brackets and in way of face plates of the members passing through, or terminating at the above-mentioned structures.

**1.7.1.5** The length of unsupported plating between the end of a longitudinal and the nearest web

normal to direction member shall be as short as possible, however, not more than  $4s$  or  $60$  mm, whichever is less ( $s$  = plate thickness, in mm).

**1.7.1.6** For the purpose of this Part of the Rules, the hull structures subject to intense vibration are those situated in way of machinery and equipment which constitute a source of vibration.

Considered as regions with high level of vibration in all ships are the regions situated below the lower platform continuous within the engine room and bounded:

at aft end, by a section forward of the edge of propeller boss at twice the propeller diameter, but not less than to the after peak bulkhead;

in the engine room, by the bulkheads of this space.

The bulkheads forming boundaries of engine room, the after peak bulkhead and the lower continuous platform in the above regions throughout the length of the ship are considered to be structures subject to intense vibration.

**1.7.1.7** In way of the ends of bulwark, bilge keels, and other details welded to the hull, as well as generally of gutterway bars, their height shall decrease on a length of at least 1,5 times the height of these members. The ends of bulwarks shall be tapered. This is also recommended for the portions of the ends of the gutter bars.

**1.7.1.8** Welded joints, welding consumables and procedures, testing and inspection methods of welded joints shall comply with requirements of Part XIV "Welding".

### 1.7.2 Connections of framing members.

**1.7.2.1** In general, the framing members shall have butt-welded joints. Overlapping joints may be allowed on agreement with the Register, except in regions with high level of vibration, deep member connections and in way of heavy concentrated loads.

In general, brackets shall be made of steel having the same yield stress as the steel of the members connected.

#### 1.7.2.2 Connections of primary members.

**1.7.2.2.1** Unless provided otherwise, the size of brackets  $c$ , in cm, measured in accordance with Fig. 1.7.2.2.1 shall be determined by the formula

$$c = 5\sqrt{W/s} \quad (1.7.2.2.1)$$

where  $W$  = Rule section modulus of the member attached, in cm<sup>3</sup>;  
 $s$  = thickness of bracket, in mm.

The thickness of bracket is taken equal to that of the member web. Where the web thickness is more than 7 mm the bracket thickness may be reduced by 1 mm; where the web thickness is more than 12 mm, the bracket thickness may be reduced by 2 mm.

Where a bracket connects two members of different profile, the characteristics of the smaller profile shall be used for determining the bracket size.

The bracket height  $h$  (refer to Fig. 1.7.2.2.1) shall be not less than 0,7 times the required size  $c$ .

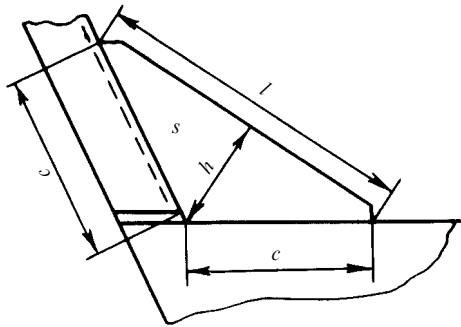


Fig. 1.7.2.2.1

The size of brackets determined as indicated above, refers to the case when the members to be interconnected are not welded to each other or the member butts are not welded to the plating. The allowable gap shall not exceed 40 mm or 25 per cent of size  $c$ , whichever is less. Otherwise,  $c$  may be required to be increased.

**1.7.2.2.2** If the free edge  $l$ , in mm, of a bracket (refer to Fig. 1.7.2.2.1) is longer than  $45s$  ( $s$  = thickness of the bracket, in mm), the bracket shall have a flange (face plate). The width of the flange shall be not less than 50 mm, the width of the face plate, not less than 75 mm. The thickness of the face plate shall not be less than that of the bracket. The width of the flange (face plate) shall be in accordance with the requirements of 1.7.3.1.

**1.7.2.2.3** The size of brackets may be reduced:

by 10 per cent, where the framing members are welded to each other or to the plating;

by 15 per cent, where a face plate or flange is provided;

by 25 per cent, where the framing members are welded to each other and the brackets are provided with a face plate or flange.

**1.7.2.2.4** In regions with high level of vibration the butt ends of framing members shall generally be connected, with the minimum dimensions of the plating portions unsupported by the framing (Fig. 1.7.2.2.4).

**1.7.2.2.5** Where there is a gap between the butt of beam and the frame in way of side strengthening of ships mooring at sea, in region I of ice strengthening in categories **Arc9**, **Arc8**, **Arc7**, **Arc6**, **Arc5** ships and in region AI of category **Ice3** ships, the beam bracket shall have a face plate or flange.

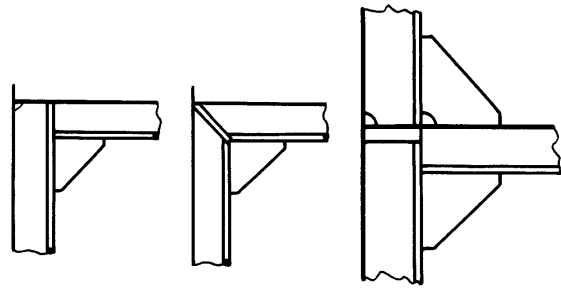


Fig. 1.7.2.2.4

**1.7.2.3** Deep members are recommended to be connected by rounded brackets with smooth change of web depth and face plate size.

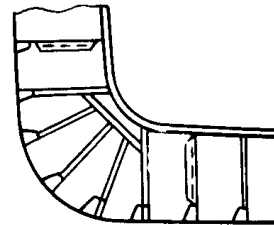


Fig. 1.7.2.3

**1.7.2.3.1** The height and width of brackets interconnecting the members, or attaching them to bulkheads are, unless provided otherwise, to be not less than the members web depth (or the lesser web depth of the members connected). The bracket thickness is assumed equal to the lesser of the member web thicknesses. In member connections no gaps are permissible.

**1.7.2.3.2** The brackets connecting the members shall have a face plate or flange along the free edge. In places of transition from the face plates of brackets to those of members, the width and thickness of the face plate along the free edge at different sizes of the member face plates shall change smoothly. The area of face plate (or flange) of tripping bracket shall be taken not less than 0,8 times the area of lesser face plate of the members connected.

If the distance, in mm, between bracket ends exceeds  $160s\sqrt{\eta}$  ( $s$  = thickness of bracket, in mm), a stiffener shall be fitted parallel to the line connecting bracket ends at the distance  $a$  equal to  $1/4$  of the bracket height or 35 times its thickness (whichever is less). The inertia moment of the stiffener shall be determined by the Formula (1.6.5.6-2).

Brackets shall be additionally stiffened depending on their size and configuration (refer to 1.7.3.2.2).

**1.7.2.3.3** The radius of rounding shall not be less than the depth of the smaller members connected.

The webs and face plates shall be supported by stiffeners and tripping brackets in way of rounding (Fig. 1.7.2.3).

**1.7.2.4** The constructions used for the attachment of primary members to supporting members shall comply with existing standards.

### 1.7.3 Construction of deep members.

**1.7.3.1** The depth  $h$  and thickness  $s_w$  of member webs (as well as of built-up primary members) and their sectional area are regulated by the relevant chapters of this Part of the Rules. The width of member face plate  $b$ , in mm, as measured from its web, shall not be more than:

$$b = 200s_{f,p}/\sqrt{R_{eH}} \quad (1.7.3.1)$$

where  $s_{f,p}$  = thickness of member face plate, in mm.

The thickness of face plate shall not normally exceed a triple thickness of the web plate.

**1.7.3.2** Where  $h/s_w > 60\sqrt{\eta}$  (for  $h$  and  $s_w$  in mm, refer to 1.7.3.1), the webs of members (except for those whose buckling strength shall be checked in accordance with 1.6.5) shall be stiffened by tripping brackets and stiffeners (Fig. 1.7.3.2).

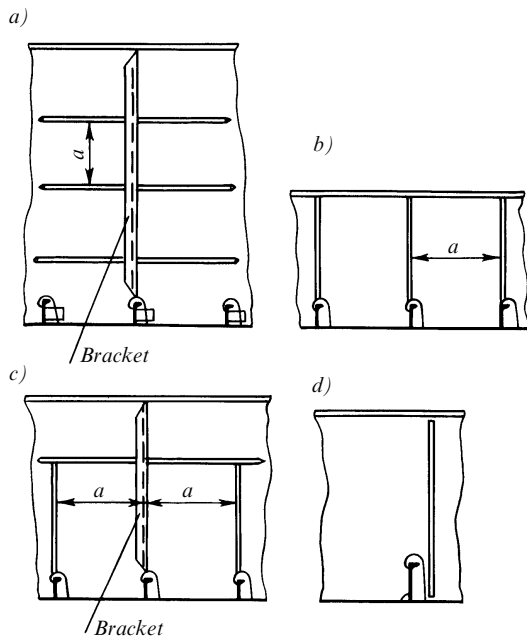


Fig. 1.7.3.2

**1.7.3.2.1** Where  $h/s_w \geq 160\sqrt{\eta}$ , the webs of members shall be stiffened with the stiffeners fitted parallel to the member face plate (refer to Fig. 1.7.3.2 a). Where  $h/s_w < 160\sqrt{\eta}$ , stiffening may be carried out as shown in Fig. 1.7.3.2 b,c.

The spacing of stiffeners (width of non-stiffened web area), in mm, shall not be greater than  $a = 90s_w/\sqrt{\eta}$ .

On agreement with the Register, the structure shown in Fig. 1.7.3.2 d may be permitted.

In way of portions equal to  $0,2l$ , but not less than  $1,5h$  from supports ( $l$  and  $h$  are the span and depth of member web respectively), the spacing  $a$  shall be reduced 1,5 times.

Stiffeners fitted normal to the face plate of the member supporting primary members (e.g. longitudinals, bulkhead stiffeners, frames, etc.) shall be fitted not further than in line with every second member in question.

Variation from the above spacing of stiffeners may be allowed on the basis of the results of direct strength calculation.

**1.7.3.2.2** The thickness of stiffener shall not be less than  $0,8s_w$ . Moment of inertia of the stiffeners is determined according to 1.6.5.6.

**1.7.3.2.3** The tripping brackets stiffening deep members shall be fitted at the toes of brackets securing the members in way of roundings and struts as well as in way of span of the member (refer to Fig. 1.7.3.2 a and b). In any case, the spacing of brackets shall not exceed 3,0 m or  $15b_{f,p}$  ( $b_{f,p}$  = full width of face plate, in mm), whichever is less.

The thickness of the tripping brackets shall be not less than required for the member web. The brackets shall be extended to the member face plate and be welded to it if the width of the face plate exceeds 150 mm, as measured from the member web to the free edge of face plate. The width of the bracket section being welded shall be at least 10 mm smaller than the face plate width. Where the width of face plates symmetric to the member web exceeds 200 mm, small brackets shall be fitted at the opposite side of the web in line with the tripping bracket. The width of the tripping brackets, measured at the base shall not be less than half their depth.

The bracket shall have a face plate or flange if the length of free edge  $l > 60s$  ( $s$  = thickness of bracket, in mm). The width of the face plate or flange shall not be less than  $l/s$ .

**1.7.3.3** Lightening holes, cut-outs for the passage of framing members, etc. are permitted in the member webs.

The total depth of openings in the same section shall not exceed 0,5 of the member depth. For deck transverses, deck girders, webs and girders of watertight bulkheads in dry cargo ships, this value may be increased to 0,6 of the member depth.

The distance from the edges of all openings in deep members to the edges of cut-outs for the passage of primary members shall not be less than the depth of these members. The openings in deep member

webs, except for cut-outs for the passage of primary members, shall be located at a distance not less than half the deep member depth from the toes of brackets attaching this member. Where it is impossible to satisfy this requirement, compensation shall be provided by local thickening of the web, fitting of collars, etc.

In all cases, the sectional area of a deep member (excluding openings) shall not be less than required in the relevant chapters of this Part of the Rules.

For requirements regarding openings in floors, side girders and centre girder, refer to 2.4.2.7.

#### 1.7.4 Details of welded structures.

**1.7.4.1** The face plates and/or webs shall be sniped at the member ends depending on the construction used for attachment of members.

**1.7.4.2** The width of flange (face plate) of brackets shall not be less than 8 bracket thicknesses unless expressly provided otherwise in the relevant chapters of this Part of the Rules.

**1.7.4.3** The edges of brackets, face plates and webs of the members shall be welded all round and shall have no craters. This requirement also applies to air and drain holes and cut-outs for the passage of framing members and welded joints.

Where these openings are carried to the deck or bottom shell plating, their length as measured at the plating, shall comply with the requirements of 1.7.5.8.

**1.7.4.4** Welded joints shall be arranged in least stressed structural sections, as far as practicable from abrupt changes of sections, openings and details which were subject to cold forming.

**1.7.4.5** The butt joints of face plates of the intersection girders under variable dynamic loads (e.g. in regions with high level of vibration) shall be made with smooth transition by means of diamond plates.

**1.7.4.6** It is recommended that local concentration of welds, crossings of welds at an acute angle, as well as close locations of parallel butts or fillet welds and butt welds, be avoided. The distance between parallel welded joints, whatever their direction, shall not be less than:

200 mm between parallel butt welds;

75 mm between parallel fillet and butt welds;

50 mm between parallel fillet and butt welds on a length not exceeding 2 m.

On agreement with the Register, the distance between welded joints may be reduced.

The angle between two butt welds shall not be less than 60° (Fig. 1.7.4.6).

**1.7.4.7** The butts (seams) in assembling joints of the plating shall be located at a distance not less than 200 mm from the bulkheads, decks, inner bottom plating, deep members fitted parallel to the above-mentioned joints.

In assembling joints, the welded butts of built-up

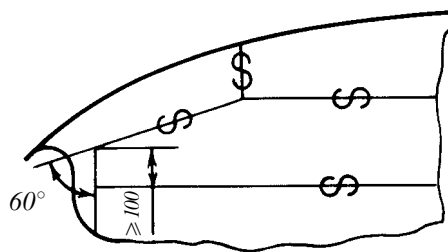


Fig. 1.7.4.6

members shall be arranged so that the butts of a member web are not less than 150 mm clear of the butts of this member face plate.

On agreement with the Register, the butts of webs and face plates may be arranged in the same plane provided that:

full penetration welding is ensured at the connection of the web to face plate on a length of at least 100 mm each side of the butt by non-destructive testing of the welded butt in every third member;

overlapping of the butt by the framing elements (knees, brackets, etc., fitted in line with the web) is ensured on a length not less than the face plate width each side of the butt.

#### 1.7.5 Types and dimensions of fillet welds.

**1.7.5.1** The design throat thickness  $a$ , in mm, of fillet welds for tee-connections for manual and semi-automatic welding shall not be less than:

$$a = \alpha\beta s \quad (1.7.5.1)$$

where  $\alpha$  = weld factor given in Table 1.7.5.1-1. For structures inside cargo tanks of tankers  $\alpha$  shall be increased by 0,05;  
 $\beta$  = factor given in Table 1.7.5.1-2 depending on the ratio of weld pitch  $t$ , in mm, to weld length  $l$ , in mm (Fig. 1.7.5.1-1);  
 $s$  = thickness of the lesser of the parts joined.

The relationship between the leg length of the fillet weld and the height of the isosceles triangle inscribed into the cross section of the weld (Fig. 1.7.5.1-2) shall be assumed as  $k = 1,4a$  or  $a = 0,7k$ . When automatic welding is employed instead of the proposed manual welding, the weld throat or leg length, whichever is adopted in calculation, may be reduced in height for single-run welds by not more than 30 per cent. For multirun welds the percentage of the above reduction is subject to special consideration by the Register.

If the thickness of the thinner of the items to be joined is less than half the thickness of the thicker item, then the leg lengths are subject to special consideration by the Register.

The throat thickness  $a$  of a fillet weld shall not be less than:

2,5 mm for  $s \leq 4$  mm;



Table 1.7.5.1-1

Nos	Connection of structural members	Weld factor $\alpha$
<b>1</b>	<b>Double bottom</b>	
1.1	Centre girder and duct keel to plate keel	0,35
1.2	Ditto to inner bottom plating	0,25
1.3	Ditto to inner bottom plating in the engine room and in way of thrust bearings	0,35
1.4	Floors to centre girder and duct keel under engines, boilers, thrust bearings and within 0,25L from F.P.	0,35
1.5	Floors to centre girder and duct keel elsewhere	0,25
1.6	Floors to margin plate and inner bottom plating under the corrugated bulkhead plates	0,35
1.7	Watertight floors, portions of side girders or centre girder round the boundaries of tanks, plating of bilge wells to their bottom plates and to inner bottom, floors and side girders	0,35
1.8	Floors and side girders to shell plating within 0,25L from F.P.	0,25
1.9	Ditto, elsewhere	0,2
1.10	Floors and side girders to inner bottom plating under engines, boilers and thrust bearings	0,25
1.11	Ditto, elsewhere	0,15
1.12	Floors to side girders within 0,25L from F.P.	0,25
1.13	Ditto, elsewhere	0,2
1.14	Margin plate to shell plating	0,35
1.15	Inclined margin plate to inner bottom plating	0,35
1.16	Bracket floors: bottom frames and brackets to shell plating	0,15
1.17	Reverse frames and brackets to inner bottom plating	0,1
1.18	Brackets, frames (refer to 2.4.4.5) to duct keel, plate keel, shell and inner bottom plating	0,35
1.19	With longitudinal framing, bottom transverses to shell, inner bottom plating, centre girder and duct keel, margin plate where the floor spacing is less than 2,5 m outside the regions defined in 1.4 and 1.7	0,25
1.20	Ditto, with floor spacing 2,5 m and more, in all regions	0,35
1.21	Longitudinals to shell plating within 0,25L from F.P.	0,17
1.22	Ditto, elsewhere	0,13
1.23	Longitudinals to inner bottom plating	0,1
1.24	Brackets (refer to 2.4.2.5.2) to shell plating, margin plate, inner bottom plating and longitudinals	0,25
<b>2</b>	<b>Single bottom</b>	
2.1	Centre girder to plate keel	0,35
2.2	Centre girder to face plate	0,25
2.3	Floors to centre girder and longitudinal bulkheads	0,45
2.4	Floors and side girder webs to their face plates and to shell plating under engines, boilers and thrust bearings, as well as in the after peak	0,25
2.5	Floors and side girder webs to shell plating elsewhere	refer to 1.8, 1.9, 1.19 and 1.20
2.6	Floors and side girder webs to their face plates elsewhere	0,15
2.7	Side girder webs to floors	0,2
2.8	Bottom longitudinals to shell plating	refer to 1.21 and 1.22
<b>3</b>	<b>Side framing</b>	
3.1	Frames (including web frames) and side stringers to shell plating within 0,25L from F.P. in tanks, in the engine room, in way of ice strengthening and strengthening of sides of ships mooring at sea alongside other ships or offshore units	0,17
3.2	Ditto, elsewhere	0,13
3.3	Frames (including web frames) and side stringers to their face plates in regions defined in 3.1	0,13
3.4	Ditto, elsewhere	0,1
3.5	Frames (including web frames) and side stringers to shell plating in the after peak	0,25
3.6	Ditto to their face plates	0,17
3.7	Side stringers to web frames	0,25
3.8	Side longitudinals to shell plating	0,17
3.9	Ditto to face plates	0,13
3.10	Bilge brackets to margin plate and face plates of floors outside double bottom	0,35 <sup>1</sup>
3.11	Ditto to shell plating	0,25
<b>4</b>	<b>Deck framing and decks</b>	
4.1	Deck transverses and girders to deck plating	0,17
4.2	Ditto to their face plates	0,13
4.3	Cantilever beams to deck plating and to their face plates	0,25
4.4	Webs of deck transverses to girder webs and bulkheads	0,25
4.5	Beams in way of tanks, fore and after peaks, as well as hatch end beams, to deck plating	0,15
4.6	Ditto, elsewhere	0,1
4.7	Deck longitudinals to deck plating and their face plates	0,1
4.8	Stringer plate of strength deck to shell plating	0,45 <sup>2</sup>
4.9	Ditto for other decks and platforms	0,35 <sup>1</sup>
4.10	Hatch coamings to deck plating at hatch corners	0,45 <sup>2</sup>
4.11	Ditto, elsewhere	0,35 <sup>3</sup>
4.12	Face plates of hatch coamings to vertical plates of same	0,25
4.13	Stays, horizontal and vertical stiffeners to vertical plates of hatch coamings	0,2
4.14	Side and end bulkheads of superstructures and deckhouses to deck plating	0,35

Nos	Connection of structural members	Weld factor $\alpha$
4.15	Other bulkheads of superstructures and deckhouses to deck plating	0,25
4.16	Bulwark stays to bulwark plating	0,2
4.17	Bulwark stays to deck and guard rails	0,35
4.18	Pillars to deck and inner bottom, pillar brackets to pillars, decks, inner bottom and other structures	0,35
5	<b>Bulkheads and partitions</b>	
5.1	Fore and after peak bulkheads, tank (cargo oil tank) boundaries, bulkheads (including wash bulkheads) inside after peak around the perimeter	0,35
5.2	Other watertight bulkheads (including wash bulkheads) to bottom shell or inner bottom plating, shell plating in way of the bilge	0,35
5.3	Ditto to sides and deck	0,25
5.4	Vertical box corrugations of corrugated bulkheads to inner bottom plating and upper strake of lower stool	0,35
5.5	Shaft tunnel plating all round	0,35
5.6	Vertical and horizontal stiffeners to bulkhead plates under 5.1, and to wash bulkheads	0,15
5.7	Ditto of other bulkheads	0,1
5.8	Vertical webs and horizontal girders to bulkhead plates according to 5.1, and to wash bulkheads	0,17
5.9	Ditto to their face plates	0,13
5.10	Vertical webs and horizontal girders to plating of other bulkheads	0,13
5.11	Ditto to their face plates	0,1
5.12	Transverse bulkheads to wash bulkheads	0,35 <sup>1</sup>
6	<b>Brackets and stiffeners</b>	
6.1	Brackets for interconnection of structural members	0,35 <sup>3</sup>
6.2	Stiffeners and tripping brackets (refer to 1.7.3.2) of deep members, floors, etc.	0,1
7	<b>Foundations for main engines, boilers and other machinery</b>	
7.1	Vertical plates to shell, inner bottom and deck plating	0,35 <sup>4</sup>
7.2	Top plates (face plates) to longitudinal girders, brackets, knees	0,45 <sup>2</sup>
7.3	Brackets and knees of foundations to vertical plates, shell plating, inner bottom (floor face plates) and to deck plating	0,35 <sup>4</sup>
7.4	Brackets and knees to their face plates	0,25

<sup>1</sup> Double continuous weld shall be applied.  
<sup>2</sup> Full penetration welding shall be provided.  
<sup>3</sup> Fillet welds attaching face plates to member webs shall be welded in way of brackets with weld factor 0,35.  
The face plates shall be welded to the brackets by the same weld as that of the face plate of the member in the span between the brackets.  
<sup>4</sup> The structures under the girder webs, brackets and knees of foundations shall be welded to the inner bottom and decks by double continuous fillet welds with factor 0,35.

Table 1.7.5.1-2

Type of fillet weld	$\beta$
Double continuous	1,0
Staggered, chain and scalloped	$t/l$
Single continuous	2,0
Single intermittent	$2t/l$

3,0 mm for  $4 < s \leq 10$  mm;

3,5 mm for  $10 < s \leq 15$  mm;

0,25s for  $s > 15$  mm.

The dimensions of fillet welds taken from calculations shall not exceed  $a \leq 0,7s$  ( $k \leq s$ ).

**1.7.5.2** Overlapping connections, if allowed (refer to 1.7.2.1), shall be welded all round by continuous weld with factor 0,4. The length of overlap, in mm,

shall be not less than  $b = 2s + 25$ , but not more than 50 mm ( $s$  = thickness of the thinner of the plates joined).

**1.7.5.3** The primary members (beams, deck longitudinals, frames, bulkhead stiffeners, etc.) shall be connected to supporting members (deck girders, deck transverses, side stringers, horizontal girders, etc.) by welds with factor 0,35.

The sectional area  $f$ , in cm<sup>2</sup>, of the welds connecting the primary members to supporting members shall not be less than determined by the formula

$$f = 25pa/\sigma_n \quad (1.7.5.3)$$

where  $p$  = pressure, in kPa, specified in appropriate chapters of this Part of the Rules;  
 $a$  = spacing of members, in m;  
 $l$  = span of member, in m;  
for  $\sigma_n$ , refer to 1.1.4.3.

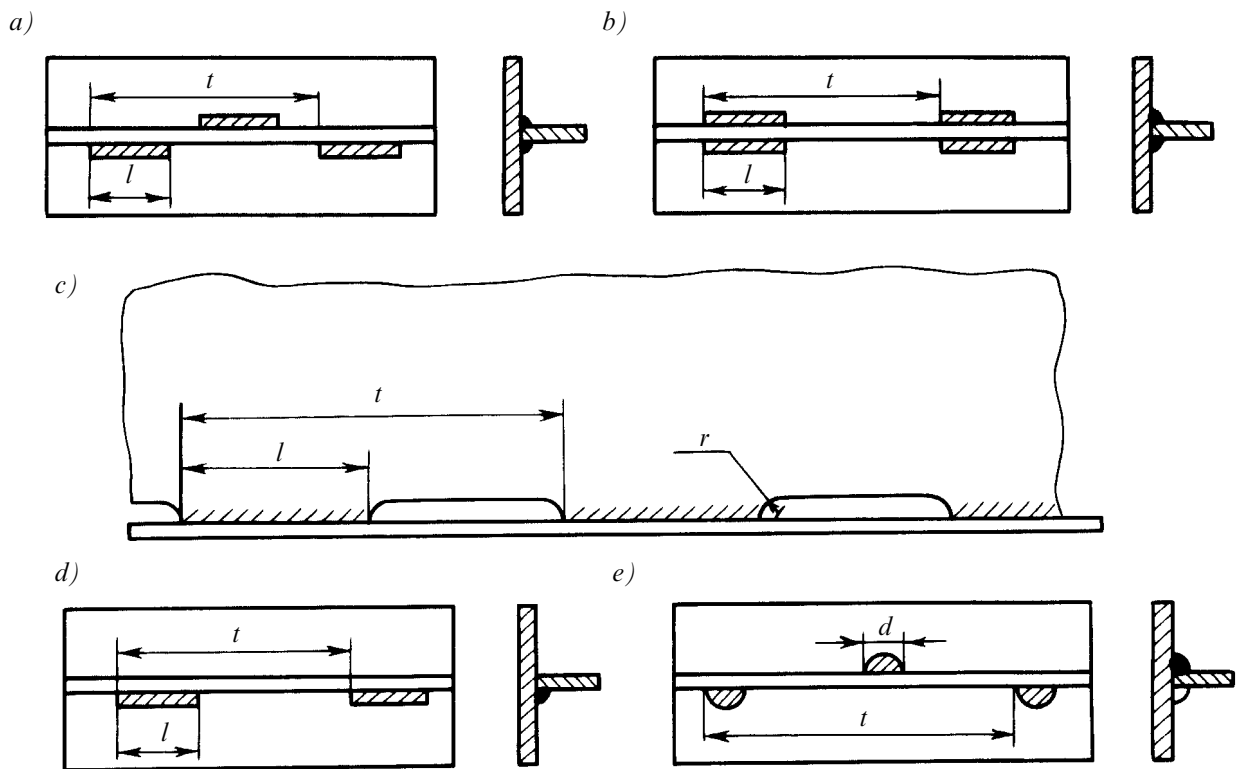


Fig. 1.7.5.1-1

Weld types:

a — staggered intermittent; b — chain intermittent; c — scalloped; d — single intermittent; e — staggered spot

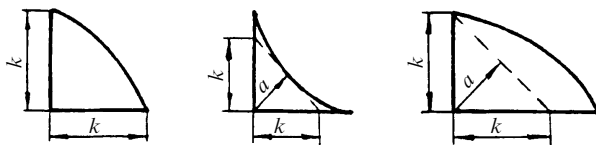


Fig. 1.7.5.1-2

The weld sectional area  $f$  is determined by summing up the results obtained by multiplying the throat thickness by the weld length of each portion of the connection of member web to supporting member.

**1.7.5.4** The framing members cut at intersection with other structures shall be in good alignment. A non-alignment shall not exceed half the thickness of the member. Where continuity is obtained by directing welding of the members to the structure involved, the throat thickness of the weld shall be determined considering the thickness of the member concerned. Otherwise, through penetration welding shall be performed. If the thickness of the thinner of the parts joined is less than 0,7 of the thickness of the other part, the throat thickness shall be calculated with regard to the particular loading conditions in way of the intersection.

Where longitudinals are cut at transverse bulkheads, the construction used for their attachment shall comply with the following requirements:

**.1** when the brackets are fitted in line on both sides of the bulkhead, the area  $f_1$ , in  $\text{cm}^2$ , of the weld connecting the brackets (and the longitudinal butt ends, if they are welded) to transverse bulkheads (Fig. 1.7.5.4 a) shall not be less than determined by the formula

$$f_1 = 1,75S_0 \quad (1.7.5.4.1)$$

where  $S_0$  = cross-sectional area of the longitudinal (effective flange excluded), in  $\text{cm}^2$ ;

**.2** if one continuous bracket plate welded in the appropriate slot cut in the bulkhead plating is fitted

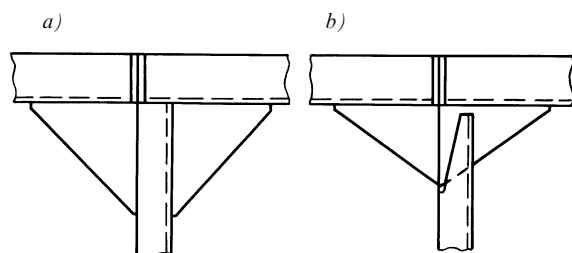


Fig. 1.7.5.4

(Fig. 1.7.5.4 *b*), the sectional area of the bracket at the bulkhead shall not be less than  $1,25S_0$ ;

**.3** the arm length  $l_{br}$  of the bracket, in mm, over the longitudinals shall not be less than determined by the formula

$$l_{br} = \frac{1,75S_0 - S_1}{2a} \cdot 10^2 \quad (1.7.5.4.3)$$

where  $S_1$  = area of weld connecting longitudinal butt ends to transverse bulkheads, in  $\text{cm}^2$ ;

$a$  = accepted design thickness of fillet weld connecting bracket to longitudinal, in mm.

**1.7.5.5** Where plate thickness exceeds 18 mm, for connections made by fillet welds in which excessive stress in Z-direction may be caused by welding process or by external loads, Z-steel (refer to 1.2.2.2) shall be used or structural measures shall be taken to prevent lamellar tearing. In all cases, reducing of residual stress level shall be provided.

**1.7.5.6** Double continuous welds shall be used in the following regions (refer also to Note 1 to Table 1.7.5.1-1):

**.1** within  $0,25L$  from the forward perpendicular in ships with length  $L \geq 30$  m, for connection of framing members to bottom shell, and in case of only a single bottom in this region, also for welding of the webs of centre girder, side girders and floors to face plates of these members;

**.2** in region I of ice strengthening in ships of categories **Arc9**, **Arc8**, **Arc7**, **Arc6**, **Arc5**, **Arc4** and in region AI of category **Ice3** ships, for connection of side framing to shell plating;

**.3** in way of foundations for machinery and equipment which may constitute a source of vibration (refer to 1.7.1.6), for connection of framing members to bottom and inner bottom platings, deck framing to deck plating;

**.4** for the structures in the after peak;

**.5** in way of supports and member ends, for connection of framing members to the plating (refer to 1.7.5.8);

**.6** in tanks (including double bottom tanks), exclusive the tanks for fuel oil or lubricating oil;

**.7** for structures providing tightness.

**1.7.5.7** Single continuous welds shall not be used:

**.1** within  $0,2L$  from F.P. for connection of side framing to shell plating, and within  $0,25L$  from F.P. for connection of bottom framing to shell plating;

**.2** for structures subject to intense vibration (refer to 1.7.1.6);

**.3** in region I of ice strengthening of ships;

**.4** for welding of side framing in ships mooring alongside other ships at sea or offshore units;

**.5** for connections where the angle between a member web and the plating differs by more than  $10^\circ$  from a right angle.

**1.7.5.8** For all types of intermittent joints the weld length (refer to Fig. 1.7.5.1-1) shall not be less

than  $15a$  (for  $a$ , refer to 1.7.5.1) or 50 mm, whichever is the greater. The spacing of welds ( $t-l$ ) — for chain welds and scalloped framing, and  $(t-2l)/2$  — for staggered welds) shall not exceed  $15s$  ( $s$  = plate thickness or web thickness, whichever is less). In any case, the spacing of welds or scallop length, where scalloped frames are used, shall not exceed 150 mm.

Intermittent or single continuous welds connecting the framing members to the plating shall be substituted in way of supports and member ends by double continuous welds having the same throat thickness as the intermittent or single continuous welds of the remaining part of the members. The length of joints welded from both sides shall be not less than the sum of bracket arm and the web depth, if a bracket is fitted, and shall be twice the web depth if no bracket is fitted. Where the framing members pass through supporting structures (deck transverses, deck girders, floors, etc.), the aforesaid reinforcement shall be provided on both sides of supporting member. Where single continuous welds are used, back runs at least 50 mm long and spaced not more than 500 mm apart shall be welded on the reverse side of the detail joined. The throat thickness of back weld shall be the same as that of the single continuous weld.

**1.7.5.9** Staggered spot welds and single intermittent welds (refer to Fig. 1.7.5.1-1 *d*, *e*) may be used in the structures of deckhouses and superstructures of the second tier and above, on decks inside first tier superstructures, casings, enclosures inside the hull, not subject to intense vibration and impact loads and not affected by active corrosion, provided that the maximum plate or member web thickness is not more than 7 mm. The spot diameter  $d$ , in mm, shall not be less than:

$$d = 1,12\sqrt{\alpha ts} \quad (1.7.5.9)$$

where  $t$  = pitch of spot weld (refer to Fig. 1.7.5.1-1);

$t_{\max} = 80$  mm;

for  $\alpha$  and  $s$ , refer to 1.7.5.1.

If  $d > 12$  mm, as determined by the Formula (1.7.5.9), the weld pitch shall be increased or another type of weld shall be chosen.

**1.7.5.10** Scalloped construction shall not be used:

**.1** for side framing within  $0,2L$  from F.P. and for connection of framing members to bottom shell plating within  $0,25L$  from F.P.;

**.2** in regions with high level of vibration (refer to 1.7.1.6);

**.3** for side and bottom framing in region I of ice belt and for side framing in ships mooring at sea alongside other ships or offshore units;

**.4** for connection of bottom centre girder to plate keel;

**.5** for deck and inner bottom framing in locations where containers, trailers and vehicles may be stowed

and for upper deck framing under deckhouses in way of their ends at a distance less than 0,25 of the deckhouse height from the intersection of deckhouse side and end bulkhead.

**1.7.5.11** In scalloped construction (refer to Fig. 1.7.5.1-1) the welding shall be carried round the ends of all lugs. The depth of scallop in member web shall not exceed 0,25 of the member depth or 75 mm, whichever is less. The scallops shall be rounded with radius not less than 25 mm. The spacing of lugs  $l$  shall be not less than the length of the scallop.

Scallops in frames, beams, stiffeners and similar structures shall be kept clear of the ends of structures, as well as intersections with supporting structures (decks, side stringers, deck girders, etc.) by at least twice the member depth, and from the toes of the brackets by at least half the member depth.

**1.7.5.12** In the framing of tanks (including double-bottom tanks and the tanks of tankers), provision shall be made for openings to ensure free air flow to air pipes, as well as an overflow of liquid.

It is recommended that openings in longitudinals shall be elliptical with a distance from the edge of opening to deck plating or bottom shell plating not less than 20 mm.

In way of air and drain holes, cut-outs for the passage of framing members and welded joints the

joints shall be welded as double welds on a length of 50 mm on both sides of the opening.

**1.7.5.13** Where welding of tee-joints by fillet welds is impracticable, plug welds (Fig. 1.7.5.13 a) or tenon welds (Fig. 1.7.5.13 b) may be used.

The length  $l$  and pitch  $t$  shall be determined as for scalloped frames under 1.7.5.11.

For plug welding, the slots shall be of circular or linear form, with throat thickness of weld equal to 0,5 of plate thickness. In general, the ends of slots in plug welding shall be made semicircular. The linear slots shall be arranged with longer side in the direction of the parts to be joined (refer to Fig. 1.7.5.13 b).

Complete filling of slot is not permitted.

In regions of high level of vibration (refer to 1.7.1.6) welded joints with complete root penetration and permanent backing ring (Fig. 1.7.5.13 c) are recommended instead of tenon welds or plug welds.

**1.7.5.14** Where aluminium alloy structures are welded according to Table 1.7.5.1-1, it is not permitted:

**1** to use intermittent welds (except in scalloped construction);

**2** to use scalloped construction in regions of high level of vibration (refer to 1.7.1.6).

The throat thickness of welds shall be not less than 3 mm, but not more than  $0,5s$  (for  $s$ , refer to 1.7.5.1).

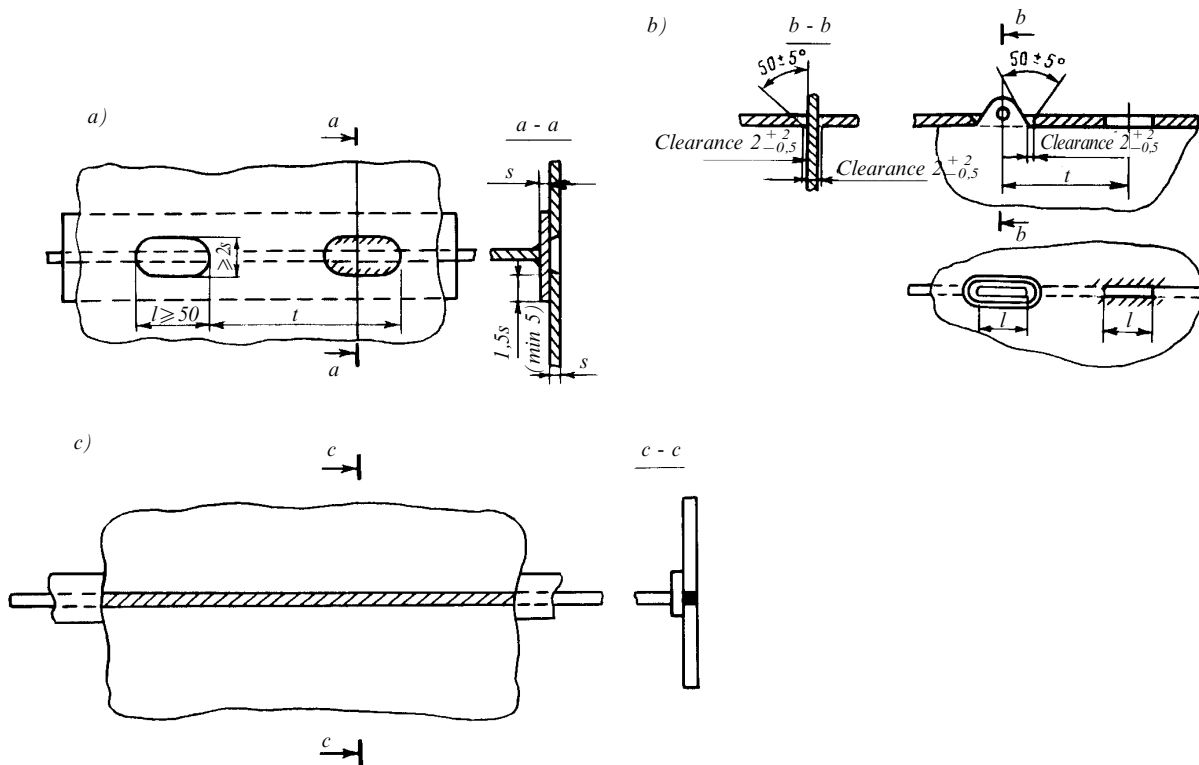


Fig. 1.7.5.13

## 2 GENERAL REQUIREMENTS FOR HULL STRUCTURES

### 2.1 GENERAL

#### 2.1.1 Application.

The requirements given in this Section apply to sea-going ships of all types and purposes, having regard to additional provisions of Section 3.

The Section contains the requirements for hull structures: shell plating, platings, primary and deep members, pillars, stems, sternframes, seatings, etc.

#### 2.1.2 Symbols.

For the purpose of this Chapter, the following symbols have been adopted:

$L_1$  = length of the compartment, in m, measured as follows:

with plane bulkheads, as the distance between bulkhead platings;

with corrugated bulkheads, as the distance between corrugation axes or the axes of trapezoidal stools at the inner bottom level;

with cofferdam bulkheads, as the distance between middle cofferdam axes;

$B_1$  = breadth of the compartment, in m, measured at its mid-length as follows:

for single skin construction, as the distance between the sides or between the side and the longitudinal bulkhead at the upper edge of the floor;

for double skin construction, as the distance between inner skins or between the inner skin and the longitudinal bulkhead;

where hopper side tanks are fitted, as the distance between hopper tanks at the inner bottom level or between the longitudinal bulkhead and the hopper side tank;

where several longitudinal bulkheads are fitted, as the spacing of longitudinal bulkheads or as the distance between the longitudinal bulkhead nearest to the side and the appropriate side;

$l$  = span of the member, in m, defined in 1.6.3.1, unless provided otherwise;

$h$  = depth of the member web, in cm;

$a$  = spacing of primary or deep members concerned (longitudinal or transverse framing); where the spacing varies,  $a$  is the half-sum of the distances of adjacent members from the member concerned;

$s$  = plate thickness, in mm;

$W$  = section modulus of members, in cm<sup>3</sup>;

$I$  = moment of inertia of members, in cm<sup>4</sup>;

$\Delta s$  = corrosion allowance to the plate thickness, in mm (refer to 1.1.5.1);

$\omega_c$  = factor taking account of corrosion allowance to the section modulus of members (refer to 1.1.5.3).

### 2.2 SHELL PLATING

#### 2.2.1 General and symbols.

**2.2.1.1** Requirements are given in this Chapter for the thickness of bottom and side shell plating, thickness and width of sheerstrake, plate keel, garboard strakes, as well as the requirements for the minimum structural thicknesses of these members and construction of openings therein. The requirements are applicable to all regions over the ship's length and depth unless additional requirements for shell plating thickness are put forward.

**2.2.1.2** For the purpose of this Chapter the following symbols have been adopted:

$p_{st}$  = design static pressure according to 1.3.2.1;

$p_w$  = design pressure due to the motion of ship hull about wave contour according to 1.3.2.2;

$p_c$  = design pressure from carried liquid cargo, ballast or oil fuel according to 1.3.4.2.1.

#### 2.2.2 Construction.

**2.2.2.1** No openings shall be cut in the upper edge of sheerstrake or in the side shell plating if the distance between the upper edge of opening and the strength deck is less than half the opening depth. All other cases shall be specially considered by the Register.

Rectangular openings cut in the side shell plating shall have their corners rounded with the radius equal to 0,1 of the opening depth or width, whichever is less, but not less than 50 mm.

In all cases when the openings may result in considerable reduction of longitudinal or local strength of the ship, provision shall be made for reinforcement of such areas.

Reinforcement by means of thickened insert plates is required for openings located within 0,35 $L$  from the midship region, the distance from their upper edge to the strength deck being less than the depth of opening. The minimum width of thickened insert plates, as measured from the upper or lower edge of opening, shall be equal to 0,25 of the depth or length of the opening, whichever is less; the total width measured outside the opening shall be greater than the minimum thickness by at least 0,25 of the depth or length of the opening, whichever is less. The minimum distance from the end of the thickened insert plate to the nearest edge of opening, as measured along the length, of the ship shall be equal to at least 0,35 of the depth or length of opening, whichever is less. The corners of the thickened insert plate shall be rounded. The thickness of the thickened insert plate shall not be less than:

1,5s when  $s < 20$  mm;  
 30 mm when  $20 \leq s \leq 24$  mm;  
 1,25s when  $s > 24$  mm

where  $s$  = thickness of shell plating in way of the opening.

A thickened insert plate may be fitted around the perimeter of the opening.

**2.2.2.2** The area of transition from sheerstrake to deck stringer may be rounded. In this case, the radius of curvature of sheerstrake shall not be less than 15 times the sheerstrake thickness. No openings are permitted in the rounded area.

**2.2.3 Loading on shell plating.**

The external pressure  $p$ , in kPa, on the bottom and side shell plating is determined by the formula

$$p = p_{st} + p_w. \quad (2.2.3-1)$$

For ships with double bottom and double skin side construction intended for liquid ballast and for tankers with neither double bottom nor double skin side construction, the internal pressure  $p = p_c$  shall be determined additionally by the Formulae (1.3.4.2.1). Where  $p_{st} > p_w$ , counterpressure shall be considered:

$$p = p_c - (p_{st} - p_w). \quad (2.2.3-2)$$

For ships with double bottom and double skin side construction,  $p_{st}$  and  $p_w$  shall be determined in accordance with 1.3.2 as in the case of the ballasted ships.

As the design pressure, both external and internal pressure may be adopted, whichever is the greater.

The pressure  $p_w$  above the summer load waterline shall not be less than  $p_{min}$ , in kPa, determined by the formula

$$p_{min} = 0,03L + 5. \quad (2.2.3-3)$$

Where  $L > 250$  m,  $L$  shall be taken equal to 250 m.

For ships of restricted area of navigation, the value of  $p_{min}$  may be reduced by multiplying by the factor  $\varphi_r$  obtained from Table 1.3.1.5.

**2.2.4 Scantlings of plate structures of shell plating.**

**2.2.4.1** The thickness of bottom and side shell plating shall not be less than determined by the Formula (1.6.4.4) taking:

$$m = 15,8;$$

for bottom shell plating

$k_\sigma = 0,3k_B \leq 0,6$  in the midship region for  $L \geq 65$  m and transverse framing system;

$k_\sigma = 0,6$  in the midship region for  $L = 12$  m and transverse framing system.

Where  $12 < L < 65$ ,  $k_\sigma$  shall be determined by linear interpolation taking  $k_\sigma = 0,45$  for  $L = 65$  m;

$k_\sigma = 0,6$  in the midship region for longitudinal framing system;

$k_\sigma = 0,7$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_\sigma$  shall be determined by linear interpolation;

for side shell plating in way of  $(0,4 - 0,5)D$  from the base line

$k_\sigma = 0,6$  in the midship region;

$k_\sigma = 0,7$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_\sigma$  shall be determined by linear interpolation.

For region below  $0,4D$  from the base line,  $k_\sigma$  is determined by linear interpolation between the values of  $k_\sigma$  for bottom shell plating and those for side shell plating in way of  $(0,4 - 0,5)D$  from the base line.

For region above  $0,5D$  from the base line,  $k_\sigma$  is determined by linear interpolation between  $k_\sigma$  for upper deck level and  $k_\sigma$  for side shell plating in way of  $(0,4 - 0,5)D$  from the base line.

$k_\sigma$  for upper deck level is determined in the same way as  $k_\sigma$  for bottom shell plating, parameter  $k_D$  being substituted for parameter  $k_B$ .

$$k_B = W_B^F / \eta W; k_D = W_D^F / \eta W \quad (2.2.4.1)$$

where  $W$  = Rules' hull section modulus amidships in accordance with 1.4.6 and assuming  $\eta = 1$ ;

$W_B^F$  and  $W_D^F$  = actual section moduli for bottom and deck amidships according to 1.4.8;

$\eta$  = factor indicating application of the steel mechanical properties for the member for which  $k_\sigma$  is determined, to be established on the basis of 1.1.4.3.

**2.2.4.2** The buckling strength of bottom plating, strake above bilge, sheerstrake and strake below in the midship region of ships over 65 m in length shall be verified in accordance with 1.6.5.

**2.2.4.3** The thickness of bilge strake shall be adopted equal to that of bottom or side shell plating, whichever is the greater.

**2.2.4.4** The width of plate keel  $b_k$ , in mm, shall not be less than:

$$b_k = 800 + 5L; \quad (2.2.4.4)$$

in this case,  $b_k$  need not exceed 2000 mm.

The thickness of plate keel shall be 2 mm greater than that of bottom shell plating.

**2.2.4.5** The sheerstrake width  $b_s$ , in mm, shall not be less than determined by the Formula (2.2.4.4) taking  $b_s$  not greater than 2000 mm.

The sheerstrake thickness amidships shall not be less than that of adjoining strakes of side shell or deck plating (stringer plate), whichever is the greater. At ends, the sheerstrake thickness may be equal to that of side shell plating in this region.

**2.2.4.6** The shell plates adjoining the sternframe, as well as the plates to which the arms of propeller

shaft brackets are attached, shall have a thickness  $s$ , in mm, of not less than:

$$s = 0,1L + 4,4 \text{ for } L < 80 \text{ m}; \quad (2.2.4.6-1)$$

$$s = 0,055L + 8 \text{ for } L \geq 80 \text{ m}. \quad (2.2.4.6-2)$$

Where  $L > 200$  m,  $L$  shall be taken equal to 200 m.

The aforesaid thickness shall be ensured after hot bending, if applied.

**2.2.4.7** The thickness of garboard strakes directly adjoining the bar keel shall not be less than that required for the plate keel, and their width shall not be less than half the width required for the plate keel in accordance with 2.2.4.4.

**2.2.4.8** In any case, the thickness of shell plating  $s$ , in mm, shall not be less than:

$$s_{\min} = 3,1 + 0,12L \text{ for } L < 30 \text{ m}; \quad (2.2.4.8-1)$$

$$s_{\min} = (5,5 + 0,04L)\sqrt{\eta} \text{ for } L \geq 30 \text{ m} \quad (2.2.4.8-2)$$

where for  $\eta$ , refer to 1.1.4.3.

Where  $L > 300$  m,  $L$  shall be taken equal to 300 m.

Where the adopted spacing is less than the standard one (refer to 1.1.3) for ships of unrestricted area of navigation and restricted area of navigation **R1**, a reduction of minimum thickness of shell plating is permitted in proportion to the ratio of adopted spacing to standard spacing but not more than 10 per cent.

### 2.2.5 Special requirements.

**2.2.5.1** The grade of steel used for the sheerstrake shall be the same as that used for the strength deck. The upper edge of sheerstrake shall be smooth, and their corners shall be well rounded in the transverse direction.

**2.2.5.2** For ships of 65 m and above, within  $0,6L$  amidships no parts shall be welded to the upper edge of sheerstrake or to the sheerstrake rounding.

**2.2.5.3** Bilge keels shall be attached to the shell plating by means of an intermediate member, i.e. a flat bar welded to the shell plating with an all-round continuous fillet weld. Connection of the bilge keel to this member shall be weaker than that of the member to the shell plating. However, the connection shall be strong enough to keep the bilge keels under the ordinary operating conditions of the ship. The intermediate member shall be made continuous over the length of bilge keel. Bilge keels shall terminate in the stiffened area of shell plating and shall be gradually tapered at ends.

The bilge keel and the intermediate member shall be of the same steel grade as the shell plating in this region.

**2.2.5.4** In bottom-and-side fittings, the welded branch wall thickness shall not be less than that of shell plating determined according to 2.2.4.8, or 12 mm, whichever is the greater.

## 2.3 SINGLE BOTTOM

### 2.3.1 General and symbols.

**2.3.1.1** Requirements are given in this Chapter for the bottom framing of ships having no double bottom and in way where it is omitted, as well as for the floors, centre girder, bottom longitudinals and the brackets by which they are connected.

**2.3.1.2** For the purpose of this Chapter the following symbols have been adopted:

$L_1$  = length of the compartment concerned (hold, tank, engine room, etc.), in m;

$B_1$  = breadth of the compartment concerned, in m;

$B_x$  = breadth of ship in m, in way of considered section at the level of summer load waterline.

### 2.3.2 Construction.

**2.3.2.1** In tankers of 80 m and above, longitudinal framing shall be provided for single bottom.

**2.3.2.2** The structure of centre girder shall satisfy the following requirements:

**1** the centre girder shall extend throughout the ship's length as far as practicable. In ships greater than 65 m in length, a continuous centre girder is recommended between transverse bulkheads;

**2** when the bottom is framed longitudinally, the centre girder shall be stiffened on both sides with flanged brackets fitted between the bottom transverses and between bottom transverse and transverse bulkhead. The distance between brackets, between bracket and bottom transverse or between bracket and transverse bulkhead shall not exceed 1,2 m.

The brackets shall be carried to the face plate of the centre girder if the web of the latter is stiffened vertically or to the second horizontal stiffener from below if the centre girder web is stiffened horizontally.

In way of bottom plating, the brackets shall extend to the nearest bottom longitudinal and shall be welded thereto.

**2.3.2.3** When the bottom is framed transversely, floors shall generally be fitted at every frame.

Where the floors are cut at the centre girder, their face plates shall be butt-welded to the face plate of the centre girder. If the actual section modulus of floors exceeds the value required by 2.3.4.1.2 less than 1,5 times, the width of their face plates shall be doubled, where attached to the centre girder face plate, or horizontal brackets of adequate size shall be fitted.

The floor face plates may be replaced by flanges.

Flanged floors are not permitted in way of engine room, in the after peak, and in ships of 30 m and above; they are not permitted within  $0,25L$  from the fore perpendicular, either.



**2.3.2.4** When the bottom is framed longitudinally, brackets shall be fitted in line with the bottom transverse web on both sides of the centre girder where the girder is higher than the bottom transverse at the place of their connection. A bracket shall be welded to bottom transverse face plate and to centre girder web and face plate. The free edge of the bracket shall be stiffened with a face plate, and the angle of its inclination to bottom transverse face plate shall not exceed  $45^\circ$ .

Similar requirements apply to the connections of the stringer to bottom transverse where the stringer is higher than the bottom transverse at the place of connection.

**2.3.2.5** When the bottom is framed longitudinally, the spacing of side girders and the distance from the centre girder or ship's side to the side girder shall not exceed 2,2 m.

The side girder plates shall be cut at floors and welded thereto.

The face plates of side girders shall be welded to those of floors.

**2.3.2.6** In tankers, the side girders, if fitted, shall form a ring system together with vertical stiffeners of transverse bulkheads and deck girders.

Deep side girders having the same depth as the centre girder, as well as conventional side girders having the same depth as bottom transverses, shall run continuous from one transverse bulkhead to another with  $L_1/B_1 < 1$ .

**2.3.2.7** In the engine room, the centre girder may be omitted if the longitudinal girders under engine seating extend from the fore to the after bulkhead of the engine room and terminate with brackets beyond the bulkhead according to 2.3.5.1.

**2.3.2.8** In ships having a length of 65 m and more, the buckling strength of centre girder and side girders in the midship region shall be ensured in accordance with 1.6.5.

The webs of centre girder, side girders and floors shall be stiffened in accordance with 1.7.3.

**2.3.2.9** Connections of bottom longitudinals to transverse bulkheads shall be such that the effective sectional area of the longitudinals is maintained.

### **2.3.3 Single bottom loading.**

**2.3.3.1** The design pressure on single bottom structures of dry cargo ships is the external pressure determined by the Formula (2.2.3-1) for a ship in the ballast condition. When determining  $p_{st}$  in the Formula (2.2.3-1), the ballast draught may be taken as 0,6 of the summer draught.

If a dry cargo ship is designed to operate in a fully loaded condition with some holds empty the static pressure  $p_{st}$  in the Formula (2.2.3-1) for these holds shall be determined at summer draught.

**2.3.3.2** As the design pressure on single bottom structures of tankers, external pressure determined by

the Formula (2.2.3-1) at summer draught is adopted, or the total pressure determined by the Formula (2.2.3-2), whichever is the greater.

### **2.3.4 Scantlings of single bottom members.**

**2.3.4.1** The bottom with transverse framing shall satisfy the following requirements:

**.1** the depth of floors at the centreline shall not be less than  $0,055B_1$ . In any case,  $B_1$  shall not be taken less than  $0,6B_x$ . Allowable reduction of floor depth shall not be more than 10 per cent, the required floor section modulus being maintained.

In the engine room, the height of floor web between longitudinal girders under the seating shall not be less than 0,65 of the required depth at the centreline.

A reduction of floor section modulus by more than 10 per cent as compared to that required by 2.3.4.1.2 is not permitted.

At a distance of  $0,37B_x$  from the centreline, the depth of floors shall not be less than 50 per cent of the required depth of the centreline floors;

**.2** at the centreline, the section modulus of floors shall not be less than determined according to 1.6.4.1 and 1.6.4.2 taking:

$$m = 13;$$

$$k_\sigma = 0,6;$$

$$l = B_1, \text{ but not less than } 0,6B_x;$$

for  $p$ , refer to 2.3.3.1, but it shall not be less than 35 kPa for dry cargo ships and not less than 85 kPa for tankers.

On portions equal to  $0,05B_x$  from ship's side, the floor web sectional area shall not be less than determined according to 1.6.4.3 taking:

$$N_{\max} = 0,4pal;$$

$$k_\tau = 0,6.$$

When determining  $p$  and  $l$ , the above limitations shall be used;

**.3** in accordance with 2.3.4.1.2, the section modulus of centre girder shall be at least 1,6 times greater than the section modulus of a floor at the centreline. The depth of centre girder shall be equal to that of a floor at the place of their connection;

**.4** the section modulus of a side girder shall not be less than the section modulus of a floor at the centreline in accordance with 2.3.4.1.2. The depth of side girder shall be equal to that of the floor at the place of their connection.

**2.3.4.2** If longitudinal system of framing is adopted, the bottom members in way of the cargo tanks in tankers shall satisfy the following requirements:

**.1** the section modulus of bottom longitudinals shall not be less than determined in accordance with 1.6.4.1 and 1.6.4.2 taking:

$$p = \text{as defined in 2.3.3.2};$$

$l = \text{span, in m, equal to the distance between bottom transverses or between bottom transverse and transverse bulkhead};$

$m = 12$ ;

$k_{\sigma} = 0,45k_B \leq 0,65$  in the midship region;

$k_{\sigma} = 0,65$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation.

$k_B$  shall be determined by the Formula (2.2.4.1);

2 the section modulus of a bottom transverse shall not be less than determined from 1.6.4.1 and 1.6.4.2. Bottom transverse web sectional area, excluding openings, shall not be less than stipulated under 1.6.4.3 taking:

$p$  = as defined in 2.3.3.2;

$l = B_1$ ;

$k_{\sigma} = k_{\tau} = 0,6$ ;

for a wing tank

$m = 18$ ;

$N_{\max} = 0,35pal$ ;

for a centre tank,

$m = m_{b,t}$ ;

$N_{\max} = 0,7n_{b,t}pal$ ;

$m_{b,t}$  and  $n_{b,t}$  shall be obtained from Table 2.3.4.2.2 depending upon the parameter  $\mu$  and the number of bottom transverses within a tank;

$\mu = \alpha^{4/3}(L_1/B_1)^3$ ;

$\alpha = W_{b,t}/W_{c,g}$ ;

$W_{b,t}$  = bottom transverse section modulus satisfying the present requirements;

$W_{c,g}$  = centre girder section modulus satisfying the requirements of 2.3.4.2.3.

The value of the parameter  $\alpha$  is optional, but shall not exceed 0,6; the value of the parameter  $\mu$  shall not exceed 1,5.

Bottom transverse section modulus shall not be less than  $\alpha W_{c,g}$ ;

3 centre girder section modulus shall not be less than determined from 1.6.4.1 and 1.6.4.2. The sectional area of centre girder web shall not be less than stipulated under 1.6.4.3 taking:

$p$  = as defined in 2.3.3.2;

$l = L_1$ ;

$m = m_{c,g}$ ;

$N_{\max} = 0,7n_{c,g}pal$ ;

$m_{c,g}$  and  $n_{c,g}$  shall be obtained from Table 2.3.4.2.2 depending upon the parameter  $\mu$  and the number of floors within a tank;  $\mu$  shall be determined in accordance with 2.3.4.2.2;

$k_{\sigma} = 0,35k_B \leq 0,6$  in the midship region;

$k_{\sigma} = 0,6$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

$k_{\tau} = 0,6$ ;

$k_B$  shall be determined by the Formula (2.2.4.1).

The section modulus of centre girder shall not be less than  $W_{b,t}/\alpha$  where  $W_{b,t}$  is bottom transverse

Table 2.3.4.2.2

$\mu$	Number of transverses within a tank															
	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
	$m_{b,t}$				$m_{c,g}$				$n_{b,t}$				$n_{c,g}$			
0,01	96,0	95,9	95,9	95,8	27,3	21,7	25,5	23,3	0,253	0,255	0,256	0,257	0,329	0,370	0,393	0,409
0,02	95,8	95,6	95,4	95,1	27,6	22,1	26,0	23,9	0,256	0,260	0,261	0,264	0,326	0,367	0,387	0,401
0,04	95,4	95,4	93,9	92,7	28,3	22,8	27,1	25,0	0,261	0,269	0,271	0,277	0,318	0,355	0,375	0,387
0,06	94,7	92,7	91,8	89,3	28,9	23,5	28,1	26,2	0,267	0,277	0,281	0,289	0,311	0,346	0,364	0,374
0,08	93,9	90,5	89,2	85,5	29,6	24,3	29,1	27,4	0,272	0,286	0,290	0,301	0,304	0,337	0,354	0,363
0,1	92,9	88,1	86,3	81,5	30,2	25,0	30,2	28,6	0,276	0,293	0,298	0,311	0,298	0,329	0,344	0,352
0,2	86,5	75,1	72,1	64,0	33,4	28,9	35,5	34,7	0,298	0,326	0,333	0,352	0,269	0,294	0,304	0,307
0,3	79,6	64,0	61,1	52,3	36,6	32,8	40,9	41,0	0,316	0,352	0,359	0,382	0,246	0,266	0,273	0,274
0,4	73,3	55,7	53,1	44,7	39,8	36,9	46,5	47,6	0,330	0,373	0,380	0,404	0,226	0,243	0,249	0,249
0,6	63,2	44,9	43,3	36,1	46,2	45,4	58,0	61,6	0,354	0,404	0,409	0,436	0,195	0,206	0,213	0,214
0,8	56,1	38,5	37,6	31,5	52,6	54,4	70,1	76,6	0,371	0,426	0,429	0,457	0,171	0,184	0,188	0,189
1,0	51,0	34,4	34,0	28,6	59,0	64,0	82,8	93,1	0,386	0,443	0,445	0,471	0,153	0,165	0,170	0,171
1,2	47,2	31,6	31,6	26,9	65,4	74,2	96,6	110,8	0,397	0,456	0,456	0,482	0,138	0,150	0,155	0,158
1,5	43,1	28,8	29,1	25,0	75,0	90,7	117,0	141,1	0,410	0,471	0,469	0,492	0,120	0,132	0,139	0,142

section modulus satisfying the requirements of 2.3.4.2.2;  $\alpha$  shall be as stipulated under 2.3.4.2.2;

**.4** in ships of 200 m and above, provision shall be made for side girders midway between longitudinal bulkhead and centre girder, as well as between longitudinal bulkhead and ship's side, in centre and wing tanks.

The section modulus of deep side girders, when fitted in accordance with 2.3.2.6, shall not be less than 0,5 of centre girder section modulus. The centre girder section moduli may be reduced in conformity with 2.3.4.2.3 and those of bottom transverse, in conformity with 2.3.4.2.2 by 15 per cent.

The section modulus of conventional side girders, when fitted in accordance with 2.3.2.6, shall not be less than bottom transverse section modulus;

**.5** alternatively to the requirements of 2.3.4.2.2 to 2.3.4.2.4, the scantlings of bottom transverses, centre girder and side girders may be selected proceeding from the calculation of bottom grillage, using beam models. In this case, design loads shall be chosen in accordance with 2.3.3.2, permissible stress factors, in accordance with 2.3.4.2.2 and 2.3.4.2.3, boundary conditions, proceeding from cargo distribution over the length and breadth of the ship and the type of structures adjoining the calculated one. The effect of brackets shall be considered;

**.6** in the engine room, the bottom transverse and side girder web thickness shall not be less than the centre girder web thickness.

If a girder acts as the vertical plate of engine seating, the girder thickness shall not be less than the vertical plate thickness as required by 2.11.3. The depth of bottom transverse shall be increased in proportion to the height at which engine seatings are fitted.

**2.3.4.3** The thickness, in mm, of single bottom members shall not be less than:

$$s_{\min} = 5,3 + 0,04L \text{ for } L < 80 \text{ m}; \quad (2.3.4.3-1)$$

$$s_{\min} = 6,5 + 0,025L \text{ for } L \geq 80 \text{ m}. \quad (2.3.4.3-2)$$

Where  $L > 250$  m,  $L$  shall be taken equal to 250 m.

For the centre girder,  $s_{\min}$  shall be increased by 1,5 mm, but shall not exceed the plate keel thickness; floor web thickness need not exceed the bottom shell plating thickness.

In tankers, the minimum thickness of single bottom members shall also satisfy the requirements of 3.5.4, whichever is the greater.

### **2.3.5 Special requirements.**

**2.3.5.1** End attachments of bottom members and deep member web stiffening shall satisfy the following requirements:

**.1** centre girder and side girders shall be attached to transverse bulkheads by brackets. For size of brackets, refer to 1.7.2.3;

**.2** in dry cargo ships, the height of brackets may be reduced to half the centre girder depth if the face plate of centre girder is welded to the transverse bulkhead. In case the centre girder face plate is widened to at least twice the normal value in way of abutting upon the transverse bulkhead, the brackets need not be fitted. If the centre girder is not fitted in the engine room, then at discontinuities beyond bulkheads it shall be terminated in gradually tapered brackets of a length equal to twice the centre girder depth, but not less than three spacings;

**.3** in tankers, the bottom transverses shall be attached to side transverses and/or vertical webs of longitudinal bulkheads by brackets. For size of brackets, refer to 1.7.2.3.

**2.3.5.2** If transverse system of framing is adopted, the holes cut in floors shall have a diameter not exceeding half the floor depth in this location. The distance between the hole edge and floor face plate shall not be less than 0,25 times the floor depth in this location. The distance between the edges of adjacent holes shall not be less than the floor depth. Floor plates provided with holes shall be strengthened with vertical stiffeners.

**2.3.5.3** The webs of side girders and floors shall be provided with drain holes.

## **2.4 DOUBLE BOTTOM**

### **2.4.1 General.**

Requirements are given in this Chapter for double bottom structures including bottom framing up to the top of bilge rounding, inner bottom plating and framing, centre girder and duct keel, side girders and half-height girders, margin plate with stiffeners, brackets, knees and intermediate vertical stiffeners in the double bottom space, sea chests and drain wells.

Additional requirements for double bottoms are given in 1.1.6.3 (passenger ships), 1.1.6.4 (cargo ships, other than tankers), 3.1 (container ships), 3.3 (bulk carriers and oil/bulk dry cargo carriers), 3.4 (ore carriers and ore/oil carriers), 3.11 (icebreakers).

### **2.4.2 Construction.**

**2.4.2.1** In tankers of 80 m in length, bulk carriers and ore carriers, as well as in oil/bulk dry cargo carriers and ore/oil carriers, the double bottom shall be framed longitudinally.

**2.4.2.2** The centre girder shall extend fore and aft as far as practicable to the stem and sternframe and shall be attached to them whenever possible. The centre girder shall generally be continuous within at least  $0,6L$  amidships. Where longitudinal framing is adopted in the double bottom, brackets shall be fitted on both sides of centre girder, which shall be spaced

not more than 1,2 m apart, extended to the nearest longitudinal or lightened side girder and welded thereto. The distance between brackets shall not exceed 1,2 m.

**2.4.2.3** In lieu of centre girder, a duct keel may be fitted consisting of two plates arranged on both sides of the centreline. The duct keel shall be wide enough for the access to all its structures to be ensured. A duct keel of more than 1,9 m in width is subject to special consideration by the Register.

Transverse members with brackets shall be fitted at every frame in way of the bottom and inner bottom plating between the side plates of the duct keel.

If longitudinal system of framing is adopted, brackets shall be fitted at every frame on both sides of the duct keel, similar to those used for the centre girder.

Where the duct keel fitted only over a part of the ship's length terminates and is transformed into the centre girder, the duct keel and centre girder plates shall overlap over a length of at least one frame spacing and shall terminate in brackets with face plates. In this case, the length of the brackets shall not be less than three spacings if the transition areas lie within  $0,6L$  amidships, and not less than two spacings elsewhere.

**2.4.2.4** The design of side girders and margin plate shall satisfy the following requirements:

**.1** the spacing of side girders and the distance between a side girder and centre girder or margin plate, as measured at the level of the double bottom plating, shall not exceed 4,2 m for transversely framed double bottom and 5,0 for longitudinally framed double bottom;

**.2** if longitudinal framing is adopted in the double bottom, lightened side girders may be fitted on bottom and double bottom instead of longitudinals (for panels with large openings, refer to 2.4.2.7.2 and 2.4.2.7.4);

**.3** where there are two tunnels symmetrical with regard to the centreline, their design is subject to special consideration by the Register;

**.4** in the engine room, the arrangement of side girders shall be consistent with that of the engine, boiler and thrust block seatings, so that at least one of the longitudinal girders under the seating is fitted in line with the side girder. In this case, an additional side girder shall be provided under the seating in line with the second longitudinal.

Where side girders cannot be arranged under the seatings in line with longitudinal girders, additional side girders shall be fitted under each longitudinal girder.

Additional side girders may be replaced by half height side girders welded to the inner bottom plating and floors only, if approved by the Register;

**.5** inclined margin plate, if fitted, shall extend throughout the double bottom length.

**2.4.2.5** The arrangement and design of floors shall satisfy the following requirements:

**.1** if transverse framing is adopted in the double bottom, plate floors shall be fitted at every frame:

in engine and boiler rooms;

at the fore end within  $0,25L$  from the fore perpendicular;

in the holds intended for the carriage of heavy cargo and ore, as well as in holds from which cargo is regularly discharged by grabs;

in ships which may happen to be aground due to the ebb-tide in ports.

In other regions, plate floors may be fitted five spacings or 3,6 m apart, whichever is less. In this case, provision shall be made for open floors (bracket or lightened).

Bracket floors consist of bottom and reverse frames connected with brackets at centre girder, side girders and margin plate (Fig. 2.4.2.5.1-1).

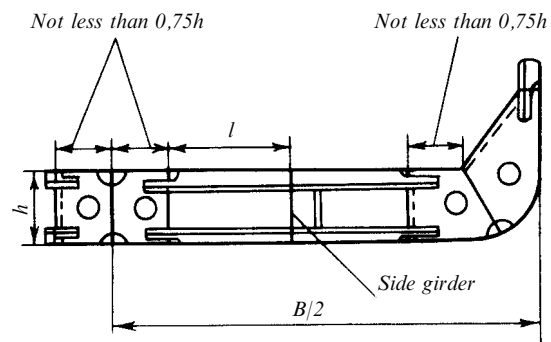


Fig. 2.4.2.5.1-1

Lightened floors consist of plate panels having large openings of a smooth shape between side girders (Fig. 2.4.2.5.1-2);

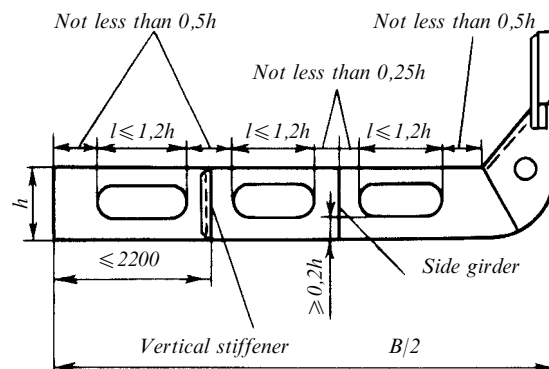


Fig. 2.4.2.5.1-2

**.2** if longitudinal framing is adopted in the double bottom, plate floors shall generally be fitted at a distance not exceeding two spacings from each other:

in engine and boiler rooms;  
 at the fore end within  $0,25L$  from the fore perpendicular;  
 in the holds intended for the carriage of heavy cargo and ore, as well as in holds from which cargo is regularly discharged by grabs;  
 in ships which may happen to be aground due to the ebb-tide in ports.

In other regions, plate floors may be fitted five spacings or 3,6 m apart, whichever is less. Where lightened side girders are fitted in lieu of bottom and double bottom longitudinals (refer to 2.4.2.4.2), the above spacing may be increased, but not more than twice.

When the ship's side is framed transversely and double bottom is framed longitudinally, brackets shall be fitted at every frame between plate floors to stiffen the margin plate, which shall be carried to the nearest bottom and inner bottom longitudinals or to the nearest additional side girder, and welded thereto (Fig. 2.4.2.5.2).

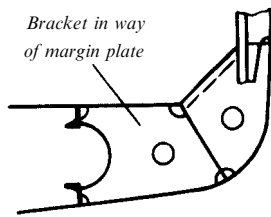


Fig. 2.4.2.5.2

Under the seating of main engine, plate floors shall be fitted at every frame and carried to the nearest side girder outside the main engine seating;

.3 irrespective of the requirements of 2.4.2.5.1 and 2.4.2.5.2, plate floors shall be fitted:

- under pillars and ends of longitudinal partial bulkheads;
- under bearers and boiler bearer ends;
- under transverse bulkheads and sloping plates of low trapezoidal stools of corrugated bulkheads;
- under bracket toes of deep tank bulkhead stiffeners in transversely framed double bottom;
- under block bearing seatings.

In the above cases, the floors need not be fitted throughout the ship's breadth. Partial floors may be fitted and carried to the side girder nearest to the structure being stiffened.

**2.4.2.6 Arrangement of stiffeners on centre girder and duct keel, side girders and floors shall satisfy the following requirements:**

.1 stiffeners shall be provided where transverse system of framing is adopted and plate floors are

more than 900 mm in depth. The spacing of stiffeners shall not exceed 1,5 m. The spacing of stiffeners of lightened floors shall not exceed 2,2 m.

If longitudinal system of framing is adopted, the stiffeners on plate floors shall be fitted in line with bottom and inner bottom longitudinals. The stiffeners shall be carried to the longitudinals and welded thereto.

The stiffeners shall be fitted under the pillars, at bracket toes of end stiffeners of longitudinal partial bulkheads, etc;

.2 watertight floors shall be fitted with vertical stiffeners spaced not more than 0,9 m apart.

**2.4.2.7 Holes (manholes) shall satisfy the following requirements:**

.1 an adequate number of holes (manholes) shall be provided in the inner bottom plating, side girders and floors for access to all portions of double bottom. The size of the holes, including lightening holes, shall satisfy the requirements of standards or other normative documents recognized by the Register.

Air and drain holes, cut-outs for the passage of welded joints, refer to 1.7.5.12;

.2 the holes in centre girder, side girders and floors shall have a smooth rounded shape. The minimum allowable height of the plate adjoining bottom shell plating or inner bottom plating is indicated in Table 2.4.2.7.2. Besides, the minimum height of the plate in way of the hole shall not be less than  $\frac{1}{8}$  of the length of the hole.

Table 2.4.2.7.2

Member	Minimum allowable plate height (in parts of member height)
Centre girder	0,3
Side girders	0,25
Lightened side girders	0,15
Floors:	
plate	0,25
lightened	0,2

The plate height indicated in Table 2.4.2.7.2 may be reduced if suitable stiffening is provided. Besides, lightened side girder and floor plates shall satisfy the requirements of 2.4.4.5.5, and if the plate height  $h_0$ , in mm, exceeds  $25s\sqrt{\eta}$  (where  $s$  is the web thickness, in mm, of a lightened side girder or floor), the free edge of the plate shall be stiffened;

.3 the distance between the edges of adjacent openings in centre girder, side girders and plate floors shall not be less than half the length of the largest opening.

The distance of the edges of openings in the floors from longitudinal bulkheads, centre girder, side girders, inclined margin plate and inner edges of hopper side tanks shall not be less than half the centre

girder depth in this region. The distance of the edge of opening in a lightened floor from the side girder shall not be less than one-quarter of centre girder depth.

In exceptional cases, deviation from the above requirements is permitted;

**.4** one or more consecutive openings may be permitted in a lightened side girder web between adjacent floors or in a lightened floor web between adjacent side girders. In the latter case, vertical stiffeners shall be fitted between openings. The length of one opening shall not exceed 1,2 times the accepted depth of centre girder or 0,7 times the distance between floors (side girders) or between a floor (side girder) and vertical stiffener, whichever is less (refer to Fig. 2.4.2.5.1-2). The distance of the edges of openings in lightened side girders and floors from each other shall not be less than half the centre girder depth in this region;

**.5** normally, openings are not permitted:

in centre girder over a length of  $0,75L$  from the fore perpendicular;

in centre girder and side girders (lightened side girders) under pillars and in sections adjoining transverse bulkheads (between the bulkhead and extreme floor for double bottom with transverse framing and on a length equal to the depth of double bottom with longitudinal framing);

in floors under pillars and in way of partial longitudinal bulkheads;

in floors at the toes of brackets transversely supporting main machinery seatings;

in floors between the side (inner side) and the nearest lightened side girder, provided the spacing of floors is increased in accordance with 2.4.2.5.2.

In exceptional cases, openings are permitted in the above members provided the webs in way of the openings are suitably stiffened;

**.6** circular lightening openings are permitted for brackets, having a diameter not greater than  $1/3$  of the width or height of the bracket, whichever is less.

**2.4.2.8** Where double skin side construction is provided, the inner bottom plating shall extend through the inner skin as far as the shell plating. A side girder shall be fitted in line with the inner skin. Festoon plates may be fitted in lieu of the inner bottom plating inside the double skin side or additional side girder in line with the inner skin.

**2.4.2.9** Connections of bottom and inner bottom longitudinal to watertight floors shall be such that the effective sectional area of these members is maintained.

### 2.4.3 Double bottom loading.

**2.4.3.1** The external pressure on double bottom structures is determined by the Formula (2.2.3-1).

For design ballast condition, the value of  $z_i$  in the Formula (1.3.2.1-2) shall be counted from the design ballast waterline.

#### 2.4.3.2 Double bottom loading from inside:

**.1** design pressure on the double bottom from general cargo is determined according to 1.3.4.1;

**.2** design pressure on the double bottom from liquid cargo or ballast is determined according to 1.3.4.2;

**.3** design pressure on the double bottom from bulk cargo is determined according to 1.3.4.3;

**.4** test loads

$$p = 7,5h_p \quad (2.4.3.2.4)$$

where  $h_p$  = vertical distance, in m, from inner bottom plating to the top of air pipe;

**.5** loads due to the emergency flooding of double bottom compartments

$$p = 10,5(d-h) \quad (2.4.3.2.5)$$

where  $h$  = actual depth of double bottom, in m.

**2.4.3.3** The total design pressure on the double bottom is defined as a difference between the external pressure  $p$  and the cargo (ballast) pressure from inside  $p_c$ . In this case, the value of  $p_c$  is defined as the smallest value of counterpressures determined from 2.4.3.2.1 to 2.4.3.2.3 with  $p > p_c$  and as the greatest of the above values with  $p < p_c$ .

If a hold may be empty during service, the external pressure  $p$  shall be taken as the design pressure.

#### 2.4.4 Scantlings of double bottom members.

**2.4.4.1** At centre girder, the depth of double bottom  $h$ , in m, shall not be less than:

$$h = \frac{L-40}{570} + 0,04B + 3,5 \frac{d}{L} \quad (2.4.4.1)$$

but not less than 0,65 m.

**2.4.4.2** The centre girder and side girders shall satisfy the following requirements:

**.1** the thickness, in mm, of centre girder (duct keel) shall not be less than:

$$s = \alpha_{c,g} h \frac{h}{h_a} \sqrt{\eta} + \Delta s \quad (2.4.4.2.1)$$

where  $h$  = height of centre girder, in m, required by 2.4.4.1;

$h_a$  = actual height of centre girder, in m;

for  $\eta$ , refer to 1.1.4.3;

for  $\Delta s$ , refer to 1.1.5.1;

$\alpha_{c,g} = 0,03L + 8,3$ , but not greater than 11,2.

In any case, the thickness of centre girder shall be 1 mm greater than that of a plate floor.

The thickness of side girders shall not be less than that of plate floors;

**.2** the buckling strength of centre girder web and of side girders, as well as of longitudinal stiffeners fitted along them shall be ensured in accordance with 1.6.5;

**.3** at ends within  $0,1L$  from the fore and after perpendiculars, the centre girder web thickness may be 10 per cent less than that in the midship region, as determined for steel used at ends, but not less than the minimum thickness stipulated under 2.4.4.9.

The thickness of side plates of the duct keel shall not be less than 0,9 of that required for the centre girder in this region;

**.4** the thickness of watertight sections of centre girder and side girders shall not be less than determined by the Formula (1.6.4.4) taking:

$p$  = as determined by the Formulae (1.3.4.2.1-4) and (1.3.4.2.1-5) for the mid-depth of centre girder (side girder), whichever is the greater (where no safety valve is fitted,  $p_v$  shall be taken as zero);

$m = 15,8$ ;

if the centre girder (side girder) is stiffened with vertical brackets or stiffeners,

$k_{\sigma} = 0,6k_B \leq 0,75$  for  $L \geq 65$  m in the midship region;

$k_{\sigma} = 0,75$  for  $L = 12$  m.

For  $12 < L < 65$  m,  $k_{\sigma}$  shall be determined by linear interpolation taking  $k_{\sigma} = 0,68$  for  $L = 65$  m;

if the centre girder (side girder) is stiffened with horizontal stiffeners, in the midship region

$k_{\sigma} = 0,75$ ;

at the ends of the ship within  $0,1L$  from the fore or after perpendicular

$k_{\sigma} = 0,85$ .

For regions between the midship region and above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation.

$k_B$  shall be determined by the Formula (2.2.4.1).

The thickness of the watertight sections of centre girder and side girders need not be greater than that of adjacent shell plating.

**2.4.4.3** Floors shall satisfy the following requirements:

**.1** the thickness, in mm, of watertight floors shall not be less than:

$$s = \alpha k a \sqrt{\eta} + \Delta s \quad (2.4.4.3)$$

where  $\alpha = 0,12L - 1,1$ , but not greater than 6,5 for transversely framed double bottom;

$\alpha = 0,023L + 5,8$  for longitudinally framed double bottom;

$k = k_1 k_2$ ;

$k_1, k_2$  = coefficients given in Tables 2.4.4.3-1 and 2.4.4.3-2 respectively;

$a$  = spacing, in m, of stiffeners, but not greater than the actual depth of double bottom;

for  $\eta$ , refer to 1.1.4.3;

for  $\Delta s$ , refer to 1.1.5.1;

Table 2.4.4.3-1

Coefficient $k_1$					
Framing system	$a_f/a$				
	1	2	3	4	5
Transverse	1	1,15	1,20	1,25	1,30
Longitudinal	—	1,25	1,45	1,65	1,85
Symbols: $a_f$ = distance, in m, between plate floors; $a$ = spacing, in m.					

Table 2.4.4.3-2

Coefficient $k_2$				
Framing system	Number of girders per side			
	0	1	2	3 and above
Transverse	1	0,97	0,93	0,88
Longitudinal	1	0,93	0,86	0,80

**.2** the floors shall be stiffened in accordance with 1.7.3.2.

Between the fore peak bulkhead and  $0,25L$  from the forward perpendicular, in the engine room and peaks, and in the holds of ships which may happen to be aground due to ebb-tide or from which cargo is regularly discharged by grabs, the thickness of plate floors  $s_{\min}$ , in mm, shall not be less than:

for transverse framing system

$$s_{\min} = 0,035L + 5; \quad (2.4.4.3.2-1)$$

for longitudinal framing system

$$s_{\min} = 0,035L + 6; \quad (2.4.4.3.2-2)$$

**.3** the thickness of watertight floors shall not be less than determined by the Formula (1.6.4.4) taking:

$p$  = as determined by the Formula (1.3.4.2.1-5) for the middepth of the floor;

$m = 15,8$ ;

$k_{\sigma} = 0,85$ .

In any case, the thickness of watertight floors shall not be less than that required for plate floors in this region.

**2.4.4.4** Inner bottom plating and margin plate shall satisfy the following requirements:

**.1** the thickness of inner bottom plating, including margin plate, shall not be less than determined by the Formula (1.6.4.4) taking:

$m = 15,8$ ;

$p$  = maximum design pressure as stipulated under 2.4.3.2;

$k_{\sigma} = 0,6k_B \leq 0,8$  in the midship region for  $L \geq 65$  m and transverse framing system;

$k_{\sigma} = 0,8$  in the midship region for  $L = 12$  m and transverse framing system.

Where  $12 < L < 65$  m,  $k_{\sigma}$  is determined by linear interpolation taking  $k_{\sigma} = 0,7$  for  $L = 65$  m,

$k_{\sigma} = 0,8$  in the midship region for longitudinal framing system;

$k_{\sigma} = 0,9$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation.

$k_B$  shall be determined by the Formula (2.2.4.1);

**.2** in any case, the thickness of inner bottom plating  $s_{\min}$ , in mm, shall not be less than:

$$s_{\min} = (3,8 + 0,05L)\sqrt{\eta} \text{ for } L < 80 \text{ m; (2.4.4.4.2-1)}$$

$$s_{\min} = (5 + 0,035L)\sqrt{\eta} \text{ for } L \geq 80 \text{ m, (2.4.4.4.2-2)}$$

where  $\eta$  = as stated in Table 1.1.4.3.

Where  $L > 260$  m,  $L$  shall be taken equal to 260 m.

Where the adopted spacing is less than the standard one (refer to 1.1.3) for ships of unrestricted area of navigation and restricted area of navigation **R1**, the minimum thickness of inner-bottom plating may be reduced in proportion to the ratio of adopted spacing to the standard spacing, but not more than by 10 per cent. In any case, the minimum thickness shall not be less than 5,5 mm.

The thickness of inner bottom plating in holds into which water ballast may be taken, as well as in the cargo (ballast) tanks of tankers shall not be less than stipulated under 3.5.4.

In the engine room and holds under cargo hatches where no wood sheathing is provided,  $s_{\min}$  shall be increased by 2 mm.

In holds where no wood sheathing is provided and cargo is discharged by grabs,  $s_{\min}$  shall be increased by 4 mm;

**.3** in the midship region of ships of 65 m and greater in length, the buckling strength of inner bottom plating and margin plate shall be ensured in accordance with 1.6.5.

**2.4.4.5** Primary members of bottom and inner bottom shall satisfy the following requirements:

**.1** the section modulus of bottom and inner bottom longitudinals, as well as of the bottom and reverse frames of bracket floors and duct keel shall not be less than stipulated under 1.6.4.1 taking:

$p$  = design pressure, in kPa, determined for bottom longitudinals and the bottom frames of bracket floors and duct keel in accordance with 2.4.3.1, and for inner bottom longitudinals and the reverse frames of bracket floors and duct keel, in accordance with 2.4.3.2;

$m = 12$ ;

$l$  = design span, in m, of longitudinal, defined as the spacing of floors for bottom and inner bottom

longitudinals, as the distance between bracket toes or between a bracket toe and side girder for the bottom and reverse frames of bracket floors, as the spacing of webs for duct keel;

for bottom longitudinals

$k_{\sigma} = 0,45k_B \leq 0,65$  in the midship region;

$k_{\sigma} = 0,65$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for inner bottom longitudinals

$k_{\sigma} = 0,6k_B \leq 0,75$  in the midship region;

$k_{\sigma} = 0,75$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for bottom frames of bracket floors and duct keel

$k_{\sigma} = 0,65$ ;

for reverse frames of bracket floors and duct keel

$k_{\sigma} = 0,75$ ;

$k_B$  shall be determined by the Formula (2.2.4.1);

**.2** if intermediate struts are fitted at mid-span between bottom and inner bottom longitudinals, the section modulus of such longitudinals may be reduced by 35 per cent;

**.3** if the ratio of the span of a bottom or inner bottom longitudinal to its depth is less than 10, the sectional area of the longitudinal web shall not be less than determined by the Formula (1.6.4.3-1) taking  $N_{\max} = 0,5pal$  ( $p$ ,  $l$  = design pressure and design span of longitudinal as stipulated under 2.4.4.5.1),  $k_{\tau} = k_{\sigma}$  where  $k_{\sigma}$  is as determined from 2.4.4.5.1 with  $k_B = 1,25$ ;

**.4** in the midship region of ships of 65 m in length and above, the buckling strength of bottom and inner bottom longitudinals shall be ensured in accordance with 1.6.5;

**.5** at the centre of openings in lightened side girders and floors, the section modulus of the plate adjoining the shell plating or inner bottom plating shall comply with the requirements of 2.4.4.5.1 for bottom and inner bottom longitudinals and transverses respectively. In this case, the design span  $l$  shall be taken equal to the greatest opening length minus its rounding-off radius. The plate section shall include the effective flange of shell plating (inner bottom plating), as described under 1.6.3.2 and 1.6.3.3, as well as the flange or horizontal stiffener of the free edge of the plate, if these are fitted.

**2.4.4.6** The stiffeners on the watertight sections of centre girder (duct keel), side girders and floors shall satisfy the following requirements:



**1** the section modulus of vertical stiffeners on the watertight sections of centre girder (duct keel), side girders and floors shall not be less than stipulated under 1.6.4.1 taking:

$p$  = as determined by the Formula (1.3.4.2.1-5) for mid-height of vertical stiffener;

$l$  = span, in m, of stiffener, defined as the spacing of longitudinals to which the stiffener is welded or as double bottom depth if the stiffener is not in line with bottom or inner bottom longitudinals;

$m = 8$  and  $10$  for stiffeners sniped at ends and welded to the bottom and inner bottom longitudinals respectively;

$$k_{\sigma} = 0,75;$$

**2** the section modulus of horizontal stiffeners on the centre girder (duct keel) and side girders shall not be less than stipulated under 1.6.4.1 taking:

$p$  = as determined by the Formula (1.3.4.2.1-5) for the level of the horizontal stiffener considered;

$l$  = distance, in m, between floors or between floors and brackets (refer to 2.4.2.2);

$$m = 12;$$

$$k_{\sigma} = 0,5k_B \leq 0,75 \text{ in the midship region};$$

$k_{\sigma} = 0,75$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation.

$k_B$  shall be determined by the Formula (2.2.4.1);

**3** in the midship region of ships of unrestricted service and of restricted areas of navigation **R1** and **R2**, 65 m and greater in length, as well as of ships of restricted areas of navigation **R2-RSN**, **R3-RSN** and **R3**, 60 m and greater in length, the buckling strength of horizontal stiffeners on the centre girder (duct keel) and side girders shall be ensured in accordance with 1.6.5.

**2.4.4.7** The intermediate struts between bottom and inner bottom longitudinals, as well as between bottom and reverse frames of bracket floors shall satisfy the following requirements:

**1** the sectional area  $f$ , in  $\text{cm}^2$ , of intermediate struts shall not be less than:

$$f = \frac{5pal}{k_{\sigma}\sigma_n} + 0,1h\Delta s \quad (2.4.4.7.1)$$

where  $p$  = design pressure, in kPa, defined as the greater of the values of  $p$  or  $p_c$  according to 2.4.3.1 or 2.4.3.2, whichever is the greater;

$l$  = design span, in m, of stiffened longitudinals;

$$k_{\sigma} = 0,6;$$

$h$  = height, in cm, of the strut cross section;

**2** the inertia moment  $i$ , in  $\text{cm}^4$ , of intermediate struts shall not be less than:

$$i = 0,01fl^2\sigma_n \quad (2.4.4.7.2)$$

where  $f$  = sectional area of intermediate struts as given in 2.4.4.7.1;  
 $l$  = length, in m, of intermediate strut.

**2.4.4.8** The thickness of brackets of centre girder (duct keel) and margin plate, as well as of the brackets of bracket floors and the brackets connecting bottom and inner bottom longitudinals to watertight floors, if the longitudinals are cut at the floors, shall not be less than the thickness of plate floors adopted in this region.

In way of centre girder and margin plate, the thickness of brackets fitted in line with the bracket floor shall not be less than 0,75 of the centre girder depth. The free edges of brackets shall be provided with flanges or face plates. The side girder fitted in line with the bracket floor shall be provided with a vertical stiffener whose profile shall be selected in the same way as that of the reverse frame of the floor.

The arm length of brackets connecting longitudinals on the bottom and inner bottom plating to watertight floors shall not be less than 2,5 times the bottom longitudinal depth (Fig. 2.4.4.8).

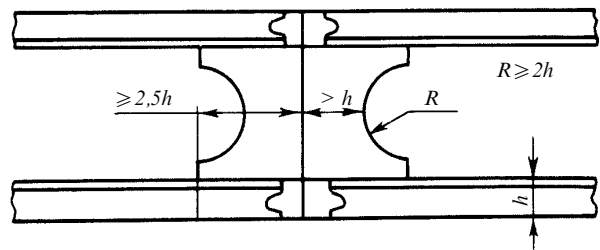


Fig. 2.4.4.8

The scantlings of knees by which bottom and reverse frames of the duct keel are secured shall be determined in accordance with 1.7.2.2.

**2.4.4.9** Structural members inside the double bottom shall have a thickness  $s_{\min}$ , in mm, not less than:

$$s_{\min} = 0,045L + 3,9 \text{ for } L < 80 \text{ m}; \quad (2.4.4.9-1)$$

$$s_{\min} = 0,025L + 5,5 \text{ for } L \geq 80 \text{ m}. \quad (2.4.4.9-2)$$

Where  $L > 250$  m,  $L$  shall be taken equal to 250 m.

For centre girder,  $s_{\min}$  shall be increased by 1,5 mm.

**2.4.4.10** In way of holds designed for the carriage of heavy cargoes, the strength of double bottom structure shall be verified by the calculation of the bottom grillage strength using design loads stated in 2.4.3, as required by 3.3.4.1.1.

#### 2.4.5 Special requirements.

**2.4.5.1** Partial double bottom and stiffening in way of variable double bottom depth shall satisfy the following requirements:

**.1** where the double bottom terminates, gradual transition from longitudinal members of double bottom to those beyond it shall be ensured.

The inner bottom plating shall be gradually tapered (on a length of at least three frame spaces) into the face plates of centre girder and side girders of single bottom. In way of the double bottom boundary, the width of these face plates shall be not less than half the distance between adjacent side girders.

The margin plate shall extend beyond the double bottom as a bracket with the height equal to the margin plate width and the length equal to at least three frame spaces, with a face plate or flange along its free edge;

**.2** where the double bottom depth changes in the form of a knuckle, one end of the knuckle shall be in way of a transverse bulkhead and the other, on the plate floor. However, both the knuckles may be arranged on plate floors in which case the structure is subject to special consideration by the Register;

**.3** where the double bottom depth changes in the form of a step, the latter shall normally be arranged on a transverse bulkhead.

At the step, the inner bottom plating of the lower section should extend for a length of three frame spaces when  $L \geq 80$  m and for two frame spaces when  $L < 80$  m. Forward (or aft) of the end of the extension the general requirements for partial double bottom shall be complied with.

If the step is arranged beyond  $0,5L$  amidships or if the height of the step is less than 660 mm, the double bottom structure in way of the extension is in each case subject to the special consideration by the Register;

**.4** continuity and reduction of stress concentrations shall be ensured in way of the step where a variation of the depth of centre girder, side girders, margin plate and inner bottom longitudinals takes place (if longitudinal system of framing is adopted).

**2.4.5.2** Bilge wells, sea chests and ice boxes shall satisfy the following requirements:

**.1** in cargo ships, the bilge wells shall, as far as practicable, satisfy the requirements of 1.1.6.3.3.

The capacity of bilge wells is specified in Part VIII "Systems and Piping".

The thickness of the walls and bottom plates of a bilge well shall exceed that of watertight floors by not less than 2 mm;

**.2** the thickness of the floors, side girders and inner bottom plating forming the walls of sea chests shall be 2 mm greater than that required by 2.4.4.2 to 2.4.4.4.

In any case, the thickness of sea chest and ice box walls shall be not less than that required by 2.2.4.1 for the shell plating in the region under consideration.

**2.4.5.3** When oil fuel tanks are arranged in the double bottom, the manholes in the tank tops arranged within the engine and boiler rooms for access to the tanks shall be provided with coamings not less than 0,1 m in height, besides the general provisions for the arrangement of fuel oil tanks.

**2.4.5.4** Where the bed plate of main engine and the thrust block are seated directly on the inner bottom plating, insert plates having a thickness not less than stipulated under 2.11.3.1 shall be welded to the plating under the supporting parts of bed plate and thrust block. The size of welded inserts shall be such as to ensure an adequate arrangement of supports and the attachment of machinery, and shall in any case be not less than that of the supporting parts of bed plate. Where the engine bed plate and thrust block are fitted on the inner bottom plating, two girders, or one girder and a half-height girder shall be provided in way of their arrangement along each welded insert plate. The upper part of the girder webs shall have the same thickness as the welded insert for at least 0,2 of the girder depth, or alternatively, the thickness of the webs throughout their depth shall be as required by 2.11.3 for the vertical plates of seatings.

Between the girders, a horizontal stiffener of the size required in the foregoing for the upper part of girder webs shall be fitted, account being taken of the holes for the holddown bolts of the bed plate.

On agreement with the Register, only one side girder may be fitted under the welded insert plate for small power engines.

**2.4.5.5** The plating of the recess under the engine crankcase, as well as the side girders and floors by which it is confined, shall have a thickness 2 mm greater than that of the inner bottom plating in this region.

The minimum distance from the recess plating to the bottom shell plating shall not be less than 460 mm.

## 2.5 SIDE FRAMING

### 2.5.1 General and definitions.

**2.5.1.1** Requirements are given in this Chapter for side frames, web frames (side transverses), side longitudinals, side stringers, cross ties connecting side transverses to vertical webs on longitudinal bulkheads in tankers, as well as for specific structures of double skin side.

**2.5.1.2** By the double skin side construction, a side structure is meant which consists of watertight side shell plating and inner skin, both either strengthened with frames and longitudinals or not, and connected with plate structures perpendicular

thereto: vertical (diaphragms) and/or horizontal (platforms). If no diaphragms or platforms are fitted, the inner skin together with framing shall be considered as longitudinal bulkhead and shall comply with the requirements of 2.7.

### 2.5.2 Construction.

**2.5.2.1** When the ship's side is framed transversely, side stringers may be provided. In tankers with two or more longitudinal bulkheads, fitting of cross ties is recommended between the side stringers and horizontal girders of longitudinal bulkheads.

Web frames may be fitted if the ship's side is framed transversely, and they shall be fitted, if the ship's side is framed longitudinally. They shall be fitted in line with plate floors, as well as with deep beams, if any. In tankers with two or more longitudinal bulkheads, fitting of cross ties is recommended between side transverses and vertical webs of longitudinal bulkheads.

**2.5.2.2** Structures of double skin side shall satisfy the following requirements:

**.1** if the same framing system is adopted for side shell and inner skin, fitting of frames or longitudinals of both side shell and inner skin in line with each other is recommended. In this case, cross ties may be fitted between the frames or longitudinals of the side shell and inner skin, which shall be arranged at mid-span of relevant members;

**.2** diaphragms or platforms shall be stiffened in accordance with 1.7.3.2. In this case, the shorter side, in mm, of panel of the diaphragm or platform being stiffened shall not exceed  $100s\sqrt{\eta}$ , where  $s$  is the thickness, in mm, of the diaphragm or platform;

**.3** an appropriate number of openings (manholes) shall be provided in the diaphragms and platforms for access to all the structures of double skin side. The total breadth of openings in a diaphragm or platform section shall not exceed 0,6 of the double skin side breadth.

The edges of openings in diaphragms and platforms, arranged within  $1/4$  of the span from their supports, shall be reinforced with collars or stiffeners. The distance between the edges of adjacent openings shall not be less than the length of the openings.

Normally, openings are not permitted, with the exception of air and drain holes:

in platforms on a length not less than three frame spaces or 1,5 times the double skin side breadth, whichever is less, from transverse bulkheads or partial bulkheads, which serve as platform supports;

in diaphragms on a length not less than 1,5 times the double skin side breadth from deck plating and/or double bottom, which serve as diaphragm supports.

**2.5.2.3** In the engine room, the side framing shall be strengthened by fitting of web frames and side stringers.

The web frames shall be fitted not more than 5 standard spacings or 3 m apart, whichever is the greater. The web frames shall be arranged taking into account the location of main engine, i.e. they shall be fitted at the extremities of the engine at least. In the engine room, the web frames shall be carried to the nearest continuous platform. Deep beams shall be fitted in line with web frames.

In the engine room, the side stringers shall be fitted so that the vertical distance between them, as well as between a side stringer and deck or tank top (upper edge of floor) at side does not exceed 2,5 m.

### 2.5.3 Side loading.

**2.5.3.1** The design pressure on the side shell shall be determined in accordance with 2.2.3. In way of tanks, the pressure determined in accordance with 1.3.4.2 shall additionally be taken into consideration.

**2.5.3.2** The design pressure on double skin side structures shall be determined as follows:

**.1** the design pressure on the inner skin and framing shall be determined in accordance with 1.3.4.2 or 1.3.4.3 depending on the kind of cargo carried and on whether the double skin side space is used as tank space, but shall not be less than the design pressure on watertight bulkhead structures, as stipulated under 2.7.3.1;

**.2** the scantlings of cross sections of diaphragms and platforms are determined using the design pressure specified in 2.2.3;

**.3** the design pressure on the watertight sections of diaphragms and platforms bounding the tanks in the inter-skin space shall be determined in accordance with 1.3.4.2.

### 2.5.4 Member scantlings of side structures.

**2.5.4.1** If transverse system of framing is adopted, the section modulus of hold frames in dry cargo ships and of side frames in tankers shall not be less than determined from 1.6.4.1 taking:

$p$  = as defined in 2.5.3; the value of  $p$  for the side shell shall not be less than:

$$p_{\min} = 10z + 0,3L + 1 \text{ for } L < 60 \text{ m; } \quad (2.5.4.1-1)$$

$$p_{\min} = 10z + 0,15L + 10 \text{ for } L \geq 60 \text{ m } \quad (2.5.4.1-2)$$

where  $z$  = distance, in m, from the mid-span of the frame to the summer load waterline;

$l$  = span, in m, between adjacent supports, as measured in accordance with 1.6.3.1; unless expressly provided otherwise, the supports of a frame are bottom, deck or platform, side stringers;

$m = 12$  for single skin side construction when determining the section modulus of the supporting section of the frame taking into consideration the bracket, if any, included in the section, as well as for frames of the side shell and inner skin forming double skin side construction;

$m = 18$  for single skin side construction when determining the section modulus in the frame span;

$k_{\sigma} = 0,65$  for frames of the side shell;

$k_{\sigma} = 0,75$  for frames of the inner skin.

For ships of restricted area of navigation, the value of  $p_{\min}$  may be reduced by multiplying by the factor  $\phi_r$  obtained from Table 1.3.1.5.

**2.5.4.2** The section modulus of 'tween deck frames shall not be less than determined from 1.6.4.1 taking:

$p$  = design pressure, as stipulated under 2.5.3;

$l$  = span, in m, between adjacent supports, as measured in accordance with 1.6.3.1; frame supports are decks and platforms;

$m = 10$  for single skin side frames;

$m = 12$  for frames of the side shell and inner skin forming double skin side construction;

$k_{\sigma} = 0,65$  for side shell frames;

$k_{\sigma} = 0,75$  for inner skin frames.

The above applies in case the lower end of 'tween deck frame is not stiffened by a bracket. If the lower end of the frame is stiffened by a bracket of a height not less than  $0,1l$  and the section modulus of the frame in way of deck is not less than  $1,75$  of the section modulus determined above, taking the bracket into consideration, the section modulus of 'tween deck frame may be reduced by 30 per cent.

**2.5.4.3** The section modulus of side longitudinals of all ships shall not be less than determined according to 1.6.4.1 taking:

$p$  = as defined in 2.5.3;

$a$  = spacing of longitudinals, in m;

$l$  = average spacing of web frames or diaphragms, in m;

$m = 12$ ;

for side shell

$k_{\sigma} = 0,65$  within  $(0,4-0,5)D$  from the base line.

For regions below  $0,4D$  from the base line,  $k_{\sigma}$  shall be determined by linear interpolation between  $k_{\sigma}$  for bottom longitudinals in accordance with 2.4.4.5.1 and  $k_{\sigma}$  within  $(0,4-0,5)D$  from the base line.

For regions above  $0,5D$  from the base line,  $k_{\sigma}$  shall be determined by linear interpolation between  $k_{\sigma}$  for strength deck longitudinals in accordance with 2.6.4.2 and  $k_{\sigma}$  within  $(0,4-0,5)D$  from the base line.

For the inner skin,  $k_{\sigma}$  shall be determined as in the case of horizontal stiffeners of longitudinal bulkheads in tankers in accordance with 2.7.4.2.

The buckling strength of three upper and three lower longitudinals in the midship region of ships 65 m and greater in length shall be ensured in accordance with 1.6.5.

**2.5.4.4** In a transversely framed side, the section modulus of side stringers shall not be less than stipulated under 1.6.4.1 taking:

$k_{\sigma}$  is determined in the same way as for side shell longitudinals mentioned under 2.5.4.3;

$p$  = as defined in 2.5.3.1;

$l$  = spacing, in m, of web frames and where these are not fitted, between transverse bulkheads, including end brackets;

$a$  = spacing, in m, of side stringers;

$m = 18$  without cross ties;

$m = 27,5$  with cross ties.

The cross-sectional area, in  $\text{cm}^2$ , of a side stringer web shall not be less than determined according to 1.6.4.3 taking:

$N_{\max} = npal$ ;

$n = 0,5$  without cross ties;

$n = 0,4$  with one cross tie;

$n = 0,375$  with two cross ties;

$n = 0,35$  with three cross ties;

$k_{\tau} = 0,65$ .

If web frames are fitted, the scantlings of side stringer section may be determined on the basis of the calculation of the side grillage using beam models. The design loads shall be determined in accordance with 2.5.3.1, permissible stress factors shall be selected in accordance with this paragraph. Where cross ties are fitted, the calculation shall consider the interaction between side grillage and grillage of the longitudinal bulkhead being connected with the cross ties.

**2.5.4.5** The section modulus of web frames (side transverses) fitted in the holds and 'tween decks of dry cargo ships, as well as in the tanks of tankers, shall not be less than stipulated under 1.6.4.1 and 1.6.4.2 taking:

$p$  = as defined in 2.5.3.1;

$l$  = distance, in m, from the upper edge of a single bottom floor or from inner bottom plating to the lower edge of a deep beam;

$a$  = spacing of web frames, in m;

$m = 10$  for 'tween deck frames;

$m = 11$  for holds and tanks without cross ties;

$m = 18$  with one or two cross ties;

$m = 27,5$  with three cross ties;

$k_{\sigma} = 0,65$ .

The cross-sectional area, in  $\text{cm}^2$ , of a side transverse (web frame) web, excluding openings, shall not be less than stipulated under 1.6.4.3 taking:

$N_{\max} = npal$ ;

$n = 0,5$  without cross ties;

$n = 0,375$  with one cross tie;

$n = 0,35$  with two or more cross ties;

$k_{\tau} = 0,65$ .

When the side is transversely framed, the scantlings of web frames may be determined on the basis of the side grillage calculation in accordance with the requirements of 2.5.4.4. In this case, the permissible stress factors shall be selected in accordance with the requirements of this paragraph.

In single-deck ships, the depth of web frame (side transverse) webs may be taken variable over the ship's depth with reducing at the top end and increasing at the bottom end. Variation of web depth shall not exceed 10 per cent of its mean value.

For stiffening of web frames (side transverses), refer to 1.7.3.

**2.5.4.6** The sectional area  $f$ , in  $\text{cm}^2$ , of a cross tie fitted between deep members of side framing and of longitudinal bulkhead shall not be less than:

$$f = k \frac{10paa_i}{\sigma_{cr}} + 0,05 \Sigma h_i \Delta s \quad (2.5.4.6)$$

where  $p$  = design pressure, in kPa, at mid-length of a cross tie, as determined from 2.2.3 or 2.7.3.2, whichever is the greater;

$a$  = spacing of web frames connected with cross ties, in m;

$a_i$  = mean depth, in m, of side area supported by a cross tie;

$\Sigma h_i$  = perimeter of cross section, in cm, of a cross tie;

$k$  = 2,5 — buckling strength margin;

$\sigma_{cr}$  = critical stresses in accordance with 1.6.5.3 corresponding to the Euler stresses, in MPa, as determined by the formula

$$\sigma_e = \frac{206i}{fl^2}$$

where  $i$  = minimum moment of inertia, in  $\text{cm}^4$ , of a cross tie;

$l$  = cross tie length, in m, as measured between the inner edges of deep members of side framing and of longitudinal bulkhead;

$f$  = as determined by the Formula (2.5.4.6).

**2.5.4.7** The side framing of the engine room and tanks shall satisfy the following requirements:

**.1** the scantlings of main frames in the engine room shall be determined in accordance with 2.5.4.1 taking:

$l$  = span measured between side stringers or between the lower side stringer and inner bottom plating (upper edge of floor), or between the upper side stringer and the lower edge of beam.

The scantlings of longitudinals shall be determined in accordance with 2.5.4.3.

The scantlings of web frames (side transverses) shall be determined in accordance with 2.5.4.5 taking:

$l$  = span measured between inner bottom plating (upper edge of floor) and the lower edge of deep beam;

**.2** in the engine room of ships less than 30 m in length, the web frames and side stringers required by 2.5.2.3 may be omitted on condition that the main frame has a section modulus  $W$ , in  $\text{cm}^3$ , not less than:

$$W = 1,8W_1 \quad (2.5.4.7.2)$$

where  $W_1$  = section modulus of main frame, as stipulated under 2.5.4.7.1;

**.3** in way of the ballast and fuel oil tanks of dry cargo ships 30 m and greater in length, the scantlings of side framing shall satisfy the requirements of 2.5.4.1, 2.5.4.3, 2.5.4.5 for side framing in way of tanks in tankers.

If transverse system of framing is adopted, the section modulus of side stringers shall not be less

than determined according to 1.6.4.1 and 1.6.4.2 taking:

$$k_\sigma = 0,65;$$

$$m = 10.$$

In all other respects, the requirements of 2.5.4.4 shall be complied with;

**.4** in the engine room, the web frames shall have a depth not less than 0,1 of the span, and a web thickness not less than 0,01 of the web depth plus 3,5 mm;

**.5** in the engine room, the web depth of a side stringer shall be equal to that of a web frame.

The web thickness of a side stringer may be 1 mm less than that of a web frame. The side stringer face plate thickness shall be equal to the face plate thickness of a web frame.

**2.5.4.8** The diaphragms and platforms of the double skin side shall satisfy the following requirements:

**.1** the section moduli and cross-sectional areas of diaphragms and platforms shall satisfy the requirements for the section moduli and cross-sectional areas of side stringer webs, as specified in 2.5.4.4, and of web frames, as specified in 2.5.4.5, using the design pressure determined in accordance with 2.5.3.2.2.

In any case, the thickness, in mm, of diaphragm and platform shall not be less than:

$$s_{\min} = 0,018L + 6,2; \quad (2.5.4.8.1)$$

**.2** the stiffeners of diaphragms and platforms shall satisfy the requirements of 1.7.3.2.2;

**.3** the platforms in the midship region and their continuous longitudinal stiffeners, if any, shall comply with the requirements for the buckling strength of longitudinal framing members, as specified in 1.6.5.2, within 0,25D above the base line and 0,25D below the strength deck;

**.4** the thickness of watertight sections of diaphragms and platforms shall not be less than that determined by the Formula (1.6.4.4) taking:

$$p = \text{as defined in 2.5.3.2.3};$$

$$m = 15,8;$$

$$k_\sigma = 0,9;$$

**.5** the section modulus of stiffeners of the watertight sections of diaphragms and platforms shall not be less than determined from 1.6.4.1 taking:

$$p = \text{as defined in 2.5.3.2.3};$$

$l$  = span of stiffener, in m, equal to: the diaphragm spacing, for stiffeners parallel to the shell plating; the distance between the inner edges of primary members of side shell and inner skin if the stiffener is welded thereto, for stiffeners perpendicular to the shell plating; the double skin side breadth if the stiffener ends are sniped;

$m = 12$  for continuous stiffeners parallel to the side plating;

$m = 10$  for stiffeners perpendicular to the side plating and welded to primary framing members;

$m = 8$  elsewhere;

$k_{\sigma} = 0,75$ .

**2.5.4.9** If there are large openings (exceeding 0,7 times the ship's breadth in width) in the deck, stiffening of the diaphragms and frames of the side shell and inner skin may be required on agreement with the Register in connection with the upper deck pliability, which shall be determined by calculation (refer to also 3.1.4).

**2.5.4.10** The thickness of inner skin shall comply with the requirements for the thickness of longitudinal bulkhead plating in tankers, as specified in 2.7.4.1, using the design pressure determined in accordance with 2.5.3.2.1. In any case, this thickness shall not be less than determined by the Formula (2.7.4.1-1).

**2.5.4.11** The cross ties between frames and longitudinals of side shell and inner skin, as mentioned under 2.5.2.2.1, shall comply with the requirements for the intermediate struts of double bottom, as mentioned in 2.4.4.7 using the design pressure determined from 2.5.3.1 or 2.5.3.2.1, whichever is the greater.

If cross ties are fitted, the section modulus of frames complying with 2.5.4.1 and 2.5.4.2, as well as of longitudinals complying with 2.5.4.3, may be reduced by 35 per cent.

**2.5.4.12** In the cargo and ballast tanks of tankers, in holds into which water ballast can be taken and in tanks, the thickness of structural members of side framing shall not be less than that required by 3.5.4.

### **2.5.5 Special requirements.**

**2.5.5.1** If transverse system of framing is adopted, efficient connection of lower ends of frames to bottom structures shall be ensured by means of bilge brackets or other structures of equivalent strength. The bilge brackets shall comply with the following requirements:

**.1** the depth of bilge brackets shall not be less than that of the bilge as a whole. The free edge of a bilge bracket shall be flanged or stiffened with a face plate the dimensions of which shall be in compliance with 1.7.2.2.2.

The thickness of a bilge bracket is taken equal to that of plate floors in the hull region under consideration, but it need not exceed the frame web thickness more than 1,5 times.

Holes cut in bilge brackets shall be such that the width of plating outside the hole is nowhere less than  $\frac{1}{3}$  of the bracket width.

In any case, the size of bilge brackets shall not be less than that required by 1.7.2.2;

**.2** the end attachments of a frame to bilge bracket shall be designed so that at no section the section modulus is less than required for a frame;

**.3** where an inclined margin plate is fitted in the double bottom, the bilge bracket shall be carried to the inner bottom plating, and its face plate (flange) shall be welded to the plating;

**.4** where a horizontal margin plate is fitted in the double bottom or transverse system of framing is adopted in the single bottom, the width of bilge brackets shall be determined proceeding from the condition that their section moduli at the point of connection to the inner bottom plating or upper edge of floor shall be at least twice those of the frame.

The face plate (flange) of a bilge bracket may be welded to either the inner bottom plating or the face plate (flange) of a floor, or it may be sniped at ends. If the face plate (flange) is welded, the floor web shall be stiffened with a vertical stiffener or a bracket at the point of welding, also welded to the inner bottom plating or to the floor face plate (flange).

The depth of a bilge bracket shall not be less than its width;

**.5** if longitudinal system of framing is adopted in the single bottom, the bilge bracket shall be carried at least to the bottom longitudinal nearest to the side and shall be welded thereto. The section modulus of the bracket at the section perpendicular to the shell plating where the bracket width is the greatest shall be at least twice the section modulus of the frame.

**2.5.5.2** In all the spaces, the upper ends of frames shall be carried to the decks (platforms) with minimum gaps if they are cut at the decks (platforms). The beams of transversely framed decks (platforms) shall be carried to the inner edges of frames with minimum gaps.

The uppermost decks of ships (except for those secured alongside other ships at sea) may be designed with beams carried to the shell plating with minimum gaps, and frames carried to the beams.

The brackets by which the upper ends of frames are attached shall be sized in accordance with the requirements of 1.7.2.2. If the deck is framed longitudinally, the bracket shall be carried at least to the deck longitudinal nearest to the deck and welded to that longitudinal.

**2.5.5.3** If the frame is cut at deck, its lower end shall be attached by a bracket complying with the requirements of 1.7.2.2. The bracket may be omitted if the ends of this frame are welded to the deck plating from above and below, and full penetration is ensured.

**2.5.5.4** Side stringers shall be attached to web frames by brackets carried to the web frame face plate and welded thereto.

**2.5.5.5** If cross ties are fitted in the wing tanks of tankers, the side transverse and side stringer webs in way of the cross tie attachments shall be provided

with stiffeners which shall be an extension of the cross tie face plates. Cross tie attachments to side transverse (side stringer) shall comply with the requirements of 1.7.2.3.

## 2.6 DECKS AND PLATFORMS

### 2.6.1 General.

**2.6.1.1** Requirements are given in this Chapter for the deck and platform structures of ships where the width of opening for a single cargo hatch does not exceed 0,7 times the ship's breadth abreast of the opening. Additional requirements for the decks and platforms of ships having greater width of openings and their length exceeding 0,7 times the spacing of centres of transverse deck strips between the openings, as well as for the decks and platforms of ships with twin or triple hatch openings, are specified in 3.1.

Requirements for cantilever beams shall also be found there.

For decks and platforms of ro-ro ships, refer to 3.2.

Requirements for the cargo hatch coamings of bulk carriers are given in 3.3.

Requirements of this Chapter cover plating and framing members of decks and platforms: deck longitudinals, beams, deck transverses, deck girders, hatch end beams, hatch side coamings and hatch end coamings, wash plate in the tanks of tankers.

Additional requirements for the areas of upper deck situated below the superstructures are given in 2.12.5.1 to 2.12.5.3.

### 2.6.2 Construction.

**2.6.2.1** In tankers of 80 m and above, bulk carriers and ore carriers, as well as in oil/dry bulk cargo carriers, and ore/oil carriers, longitudinal system of framing shall be adopted for the strength deck in way of cargo holds (tanks).

Where longitudinal system of framing is adopted, the spacing of deck transverses shall not exceed that of bottom transverses.

**2.6.2.2** Provision shall be made for the structural continuity of deck girders of the strength deck in the midship region. If the deck girders are cut at transverse bulkheads, their web plates shall be welded to the transverse bulkheads and attached thereto by brackets.

The web plates of hatch end coamings, deck transverses, hatch end beams and wash plates shall be strengthened by stiffeners and brackets (refer to 1.7.3).

The face plates of deck girders shall be connected to the face plates of hatch end beams by means of diamond plates (refer to 1.7.4.5) whose thickness shall be equal to the greater face plate thickness.

**2.6.2.3** On the strength deck, the ends of side coamings at the corners of hatchways shall be either

bent along the line of hatch corner rounding and butt welded to the hatch end coaming or extended, in the form of a bracket, beyond the corner of the hatchway. Provision shall be made for a gradual termination of the bracket above the deck girder web.

The upper edges of coamings acting as deck girders shall be stiffened with face plates and the lower edges of the coamings shall be rounded.

The upper edge of hatch side coaming shall be smooth and their corners shall be well rounded in the transverse direction.

**2.6.2.4** The deck girders and deck transverses in way of pillars shall be strengthened by stiffeners or tripping brackets.

Where deck girders are connected to deck transverses and their web height is different, the deck girder web shall be strengthened by brackets fitted in line with the deck transverse. The brackets shall be welded to the face plate of deck transverse, to the web and face plate of deck girder.

Where deck girders are attached to conventional beams, the web of deck girder shall be strengthened by vertical stiffeners.

**2.6.2.5** In the case of connection of deck longitudinals to transverse bulkheads, the effective sectional area of the longitudinals shall be maintained.

**2.6.2.6** In tankers with two effective longitudinal bulkheads, provision shall be made for a wash plate at the centreline.

### 2.6.3 Deck loading.

**2.6.3.1** The design pressure on the weather deck shall not be less than:

$$p = 0,7p_w \geq p_{\min} \quad (2.6.3.1)$$

where  $p_w$  = wave load at the deck level, as defined in 1.3.2.2;

$p_{\min} = 0,1L + 7$  at the fore end within 0,2L from the forward perpendicular;

$p_{\min} = 0,015L + 7$  in the midship region and aft of the midship region; for regions between the fore end and the midship region,  $p_{\min}$  shall be determined by linear interpolation. For ships of restricted area of navigation the value of  $p_{\min}$  may be reduced by multiplying by the factor  $\phi_r$  obtained from Table 1.3.1.5.

**2.6.3.2** For weather decks intended to carry deck cargo (except timber and coke), the design pressure shall be taken equal to the cargo pressure  $p_c$  determined by the Formula (1.3.4.1). For weather decks intended to carry timber and coke, the value of  $h$  in the Formula (1.3.4.1) shall be taken equal to 0,7 times the stowage height of timber and coke on deck.

For lower decks and platforms, the design pressure shall be taken according to 1.3.4.1. For decks where cargo is suspended from beams or deck longitudinals, the design pressure value shall be suitably increased.

For decks and platforms intended for the crew, passengers and equipment, the design pressure shall

be determined by the Formula (1.3.4.1) while the product  $hp_{\sigma}g$  shall not be less than 3,5 kPa.

For platforms in the engine room, the minimum design pressure shall be 18 kPa.

Watertight lower decks and platforms shall be additionally calculated using the test loads, in kPa, as follows:

$$p = 7,5h_t \quad (2.6.3.2)$$

where  $h_t$  = vertical distance, in m, from deck (platform) plating to air pipe top.

**2.6.3.3** The design pressure on the structures of decks and platforms forming boundaries of compartments intended for the carriage of liquids shall be determined in accordance with 1.3.4.2.

#### **2.6.4 Scantlings of deck members.**

##### **2.6.4.1 Thickness of deck plating.**

**2.6.4.1.1** The thickness of strength deck plating outside the line of hatch openings, taking deck longitudinals into account, shall be that necessary to give the hull section modulus for strength deck, as required by 1.4.6.

The adopted thickness of strength deck plating within midship region shall be in accordance with the requirements for buckling strength (refer to 1.6.5).

**2.6.4.1.2** The plating thickness for decks and platforms shall not be less than determined by the Formula (1.6.4.4) taking:

$$m = 15,8;$$

$$p = \text{as defined in 2.6.3};$$

for strength deck

$k_{\sigma} = 0,3k_D \leq 0,6$  in the midship region for  $L \geq 65$  m and transverse framing system;

$k_D$  = as determined by the Formula (2.2.4.1);

$k_{\sigma} = 0,6$  in the midship region for  $L = 12$  m and the deck is transverse framing system.

Where  $12 < L < 65$  m,  $k_{\sigma}$  shall be determined by linear interpolation taking  $k_{\sigma} = 0,45$  for  $L = 65$  m;

$k_{\sigma} = 0,6$  in the midship region for longitudinal framing system;

$k_{\sigma} = 0,7$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for the second continuous deck situated above  $0,75D$  from the base line

$k_{\sigma} = 0,65k_D \leq 0,8$  in the midship region for  $L \geq 65$  m and transverse framing system;

$k_D$  shall be determined by the Formula (2.2.4.1);

$k_{\sigma} = 0,8$  in the midship region for  $L = 12$  m and transverse framing system.

Where  $12 < L < 65$  m,  $k_{\sigma}$  shall be determined by linear interpolation taking  $k_{\sigma} = 0,73$  for  $L = 65$  m;

$k_{\sigma} = 0,8$  in the midship region for longitudinal framing system;

$k_{\sigma} = 0,9$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for other lower decks and platforms,  $k_{\sigma} = 0,9$ .

**2.6.4.1.3** If the engine room is located aft, the plating thickness and the scantlings of deck longitudinals, at the poop (aft deckhouse) front shall be maintained abaft the poop (deckhouse) front for a length of at least the width of machinery casing opening.

If the distance from the fore edge of casing opening to the poop (deckhouse) front is less than the width of the opening, additional strengthening of deck may be required in this region.

**2.6.4.1.4** If the thickness of strength deck plating is taken less than the side plating thickness, a deck stringer plate shall be provided. The width  $b$ , in mm, of the strength deck stringer plate shall not be less than:

$$b = 5L + 800 \leq 1800, \quad (2.6.4.1.4)$$

and the thickness of stringer plate shall not be less than that of side shell plating.

**2.6.4.1.5** The thickness  $s_{\min}$ , in mm, of deck plating and platforms shall not be less than:

for upper deck between the ship's side and line of large openings (tank decks of tankers) in the midship region

$$s_{\min} = (4 + 0,05L)\sqrt{\eta} \text{ for } L < 100 \text{ m}; \quad (2.6.4.1.5-1)$$

$$s_{\min} = (7 + 0,02L)\sqrt{\eta} \text{ for } L \geq 100 \text{ m}; \quad (2.6.4.1.5-2)$$

for upper deck at the ends of the ship and inside the line of large openings, as well as for the second deck

$$s_{\min} = (4 + 0,04L)\sqrt{\eta} \text{ for } L < 100 \text{ m}; \quad (2.6.4.1.5-3)$$

$$s_{\min} = (7 + 0,01L)\sqrt{\eta} \text{ for } L \geq 100 \text{ m}; \quad (2.6.4.1.5-4)$$

for the third deck and other lower decks and platforms

$$s_{\min} = (5 + 0,01L)\sqrt{\eta} \quad (2.6.4.1.5-5)$$

where  $\eta$  = as defined in 1.1.4.3.

Where  $L > 300$  m,  $L$  shall be taken equal to 300 m.

Where the adopted spacing is less than the standard one (refer to 1.1.3) for ships of unrestricted area



of navigation and restricted area of navigation **R1**, the minimum deck plating and platform thickness may be reduced in proportion to the ratio of adopted spacing to the standard spacing, but not more than by 10 per cent.

In any case, the minimum thickness shall not be less than 5,5 mm.

In way of compartments intended for the carriage of liquids, the thickness of plating and deck structural members (including perforated members) shall not be less than required by 3.5.4 for tankers and not less than determined by the Formula (2.7.4.1-2) for other ship types.

**2.6.4.2** The section modulus of deck longitudinals shall not be less than determined according to 1.6.4.1 and 1.6.4.2 taking:

$p$  = as defined in 2.6.3;

$m = 12$ ;

for weather deck

$k_{\sigma} = 0,45k_D \leq 0,65$  in the midship region;

$k_{\sigma} = 0,65$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for other decks

$k_{\sigma} = 0,75$ .

$k_D$  shall be determined by the Formula (2.2.4.1).

**2.6.4.3** When the decks are framed transversely, the scantlings of beams shall satisfy the following requirements:

**.1** the section modulus of beams shall not be less than that determined from 1.6.4.1 taking:

$p$  = as defined in 2.6.3;

$m = 10$ ;

$k_{\sigma} = 0,65$ ;

**.2** the inertia moment  $i_b$ , in  $\text{cm}^4$ , of weather deck beams in the midship region of ships 65 m and greater in length shall be determined on the basis of a buckling strength calculation of deck grillage using beam models in accordance with 1.6.5.

For beams having two or more intermediate rigid supports, the required inertia moment may be determined, alternatively to the grillage calculation, by the following formula:

$$i_b = 6,33(s/a)^3 l^4 \varphi \chi \cdot 10^{-3} \quad (2.6.4.3.2)$$

where  $l$  = beam span, in m, between supports;

$\varphi = 1$  where  $\sigma_c \leq 0,5R_{eH}$ ;

$\varphi = 4 \frac{\sigma_c}{R_{eH}} (1 - \frac{\sigma_c}{R_{eH}})$  where  $\sigma_c > 0,5R_{eH}$ ;

$\chi = \lambda^2 / (4 - 1,5\lambda^4)$ ;

$\lambda = 4 \frac{\sigma_c}{\varphi} (a/s)^2$ , but not more than 1;

$\sigma_c$  = compressive stresses as determined according to 1.6.5.1;  
 $s$  = actual deck plating thickness, in mm.

**2.6.4.4** The scantlings of deck framing members, such as deck transverses, deck girders, hatch coamings and hatch end beams, shall be determined on the basis of deck grillage calculation using beam models, except for cases mentioned under 2.6.4.5 to 2.6.4.8. Design loads shall be chosen in accordance with 2.6.3. Where pillars are fitted, the interaction between deck grillage and upper and/or lower structures shall be considered with regard for the arrangement of pillars.

Permissible stress factors shall be taken as follows:

strength deck

for deck girders and hatch side coamings which are arranged in line with the deck girders

$k_{\sigma} = 0,35k_D \leq 0,65$  in the midship region for  $L \geq 65$  m;

$k_D$  shall be determined by the Formula (2.2.4.1);

$k_{\sigma} = 0,65$  in the midship region for  $L = 12$  m.

Where  $12 < L < 65$  m,  $k_{\sigma}$  shall be determined by linear interpolation taking  $k_{\sigma} = 0,5$  for  $L = 65$  m;

$k_{\sigma} = 0,65$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for deck transverses and half beams, hatch coamings, which are not arranged in line with the deck girders and hatch end beams

$k_{\sigma} = 0,65$ ;

for deep members, which are calculated using the shear stresses

$k_{\tau} = 0,65$ ;

for deep members of other decks and platforms

$k_{\tau} = k_{\sigma} = 0,7$ .

The deep members of weather deck in the midship region shall also comply with the requirements of 2.6.4.9.

**2.6.4.5** In tankers with two effective longitudinal bulkheads and with no deck girders, and where longitudinal system of framing is adopted, the scantlings of deck deep members in the centre tank shall comply with the following requirements:

**.1** the section modulus of deck transverse shall not be less than determined according to 1.6.4.1 and 1.6.4.2, the sectional area of deck transverse web, excluding openings, shall not be less than determined from 1.6.4.3 taking:

$p$  = as defined in 2.6.3;

$k_{\sigma}$  and  $k_{\tau}$  = as determined according to 2.6.4.4;

$l = B_1$ ; ( $B_1$  = breadth, in m, of centre tank);

$m = m_{b,t}$ ;

$N_{\max} = 0,7n_{b,t}pal$ ;  
 $m_{b,t}$  and  $n_{b,t}$  shall be determined from Table 2.3.4.2.2 depending upon the parameter  $\mu$  and the number of deck transverses within the tank;  
 $\mu = \alpha^{4/3}(L_1/B_1)^3$ ;  
 $\alpha = W_{d,t}/W_{w,p}$ .

where  $L_1$  = tank length, in m;  
 $W_{d,t}$  = section modulus of deck transverse complying with the present requirements;  
 $W_{w,p}$  = section modulus of wash plate complying with the present requirements.

The value of the parameter  $\alpha$  is optional, but shall not be greater than 0,6; the value of the parameter  $\mu$  shall not exceed 1,5.

The deck transverse section modulus shall not be less than  $\alpha W_{w,p}$ ;

**.2** the section modulus of wash plate shall not be less than stipulated under 1.6.4.1 and 1.6.4.2, the sectional area of wash plate web, excluding openings, shall not be less than stipulated under 1.6.4.3 taking:

$p$  = as defined in 2.6.3;  
 $k_\sigma$  and  $k_\tau$  = as determined for deck girders in accordance with 2.6.4.4;  
 $l = L_1$ ;  
 $a$  = distance, in m, between the wash plate and longitudinal bulkhead;

$m = m_{c,g}$ ;  
 $N_{\max} = 0,7n_{c,g}pal$ ;  
 $m_{c,g}$  and  $n_{c,g}$  shall be obtained from Table 2.3.4.2.2 depending upon the parameter  $\mu$  and the number of deck transverses within the tank;  $\mu$  shall be determined in accordance with 2.6.4.5.1.

Besides, the section modulus of wash plate shall not be less than  $W_{d,t}/\alpha$  where  $W_{d,t}$  is the deck transverse section modulus complying with the requirements of 2.6.4.5.1;  $\alpha$  shall be determined in accordance with 2.6.4.5.1.

Along the free edge, the wash plate shall be strengthened with a face plate the sectional area of which shall not be less than that of the deck transverse face plate.

**2.6.4.6** The deck transverses of tankers having a single longitudinal bulkhead, tankers with two longitudinal bulkheads and no deck girders or strengthened longitudinals (in wing tanks only), as well as deep half beams, deep beams and hatch end coamings of dry cargo ships, which may be considered as members with rigid supports shall have a section modulus not less than stipulated under 1.6.4.1 and 1.6.4.2 and a web sectional area, excluding openings, not less than stipulated under 1.6.4.3 taking:

$p$  = as defined in 2.6.3;  
 $k_\sigma$  and  $k_\tau$  = as defined in 2.6.4.4;  
 $m = 10$ ;  
 $N_{\max} = 0,5pal$ .

**2.6.4.7** Deck girders and hatch side coamings shall satisfy the following requirements:

**.1** deck girders and hatch side coamings which may be considered as members with rigid supports shall have a section modulus not less than determined in accordance with 1.6.4.1 and 1.6.4.2, and a web sectional area, excluding openings, not less than stipulated under 1.6.4.3 taking:

$p$  = as defined in 2.6.3;  
 $k_\sigma$  and  $k_\tau$  = as defined in 2.6.4.4;  
 $N_{\max} = 0,5pal$ ;  
 $m = 10$  for intercostal deck girders and hatch side coamings;

$m = 12$  for continuous deck girders and hatch side coamings when determining the section modulus at supporting section taking into account the bracket, if any, included in this section;

$m = 18$  for continuous deck girders and hatch side coamings when determining the section modulus in the span of a deck girder, hatch side coaming;

**.2** for ships less than 30 m in length, the deck girder web thickness need not be taken greater than the deck plating thickness, and the hatch coaming web thickness shall be 1 mm greater than the thickness of deck plating;

**.3** if the side coamings of strength deck hatches terminate in brackets, the length  $l_b$ , in m, of these brackets on the deck shall be:

$$\begin{aligned}
 l_b &\geq 0,75h_b \text{ at } R_{eH} \leq 315 \text{ MPa;} \\
 l_b &\geq 1,5h_b \text{ at } R_{eH} = 390 \text{ MPa}
 \end{aligned}
 \quad (2.6.4.7.3)$$

where  $h_b$  = height of coaming above deck, in m.

For the intermediate values of  $R_{eH}$ , the bracket length shall be determined by linear interpolation;

**.4** if containers or other cargo are stowed on cargo hatch covers, the scantlings of stiffeners for vertical coaming plates shall be so chosen as to consider both the horizontal and vertical components of inertia forces acting upon the stiffeners in the event of rolling.

**2.6.4.8** If deck deep member can be considered separately from others, its section modulus shall not be less than stipulated under 1.6.4.1 and 1.6.4.2 using the design loads and factor  $k_\sigma$  determined from 2.6.4.4 and with  $m = 10$ .

The sectional area of such member shall not be less than determined by the Formula (1.6.4.3-1) taking:

$k_\sigma$  = as stipulated under 2.6.4.4;  
 $N_{\max} = 0,5pal$ ;  
 $p$  = as defined in 2.6.3.

**2.6.4.9** In the midship region of a ship 65 m and greater in length, the deep member scantlings of the weather deck shall comply with the buckling strength requirements of 1.6.5, the buckling strength values to be determined by calculation of the deck grillage using beam models.

Where deck is framed longitudinally and no deck girders are fitted, or deck girders serve as rigid supports for deck transverses, the required moment of inertia  $I$ , in  $\text{cm}^4$ , of deck transverses may be determined by the following formula, as an alternative to grillage calculation:

$$I_{d,t} = 0,76(l/c)^3 \frac{l}{a_1} i \varphi \chi \quad (2.6.4.9)$$

where  $l$  = span of deck transverse between supports, in m;

$c$  = distance, in m, between deck transverses;

$a_1$  = spacing of deck longitudinals, in m;

$i$  = actual inertia moment, in  $\text{cm}^4$ , of deck longitudinal provided with a face plate;

$\varphi = 1$  where  $1,15\sigma_c \leq 0,5R_{eH}$ ;

$\varphi = 4,6(1 - 1,15\sigma_c/R_{eH})$  where  $1,15\sigma_c > 0,5R_{eH}$ ;

$\chi$  is determined by the Formula (2.6.4.3) taking  $\lambda = 1,15 \frac{\sigma_c}{\varphi\sigma_e}$ ;

$\sigma_c$  = compressive stress as defined in 1.6.5.1;

$\sigma_e$  = actual Euler stresses in deck longitudinals, determined in accordance with 1.6.5.4.

### 2.6.5 Special requirements.

**2.6.5.1** The requirements for hatch openings as given below apply to single hatches whose scantlings do not exceed those stipulated under 2.6.1.

The openings are supposed to be arranged in the fore-and-aft direction with their greater side. Otherwise, the corner design of openings will be subject to special consideration by the Register.

**2.6.5.1.1** For the strength deck within  $0,6L$  amidships, if  $L \geq 65$  m, and  $0,5L$ , if  $40 \leq L < 65$  m, the corner radii of openings in cargo hatches and engine and boiler casings shall comply with the following requirements:

when the corners are rounded along the circumferential arc with a radius  $r$ , in m,

$$r \geq 0,1ab_1; \quad (2.6.5.1.1-1)$$

when the corners are rounded along the elliptical arc with the ratio of the length of longitudinal half-axis  $d_1$ , in m, to the length of transverse half-axis  $c_1$ , in m, being equal to 2,

$$c_1 \geq 0,07ab_1 \quad (2.6.5.1.1-2)$$

where  $a = 1$ , if the corners of openings are not reinforced by thickened insert plates;

$a = 0,7$ , if the corners of openings are reinforced by thickened insert plates;

$b_1 = c$  when  $c \leq c_0$ , for adjacent edges of successive openings;

$b_1 = b$  when  $c > c_0$ , for adjacent edges of successive openings and in all other cases;

$c$  = distance, in m, between adjacent edges of successive openings (length of landing between openings);

$b$  = breadth, in m, of opening;

$$c_0 = B \frac{b}{l} \left( \frac{2}{\sqrt{b/B}} - 1 \right);$$

$l$  = length of opening, in m.

The size of thickened insert plates by which the corners of openings are reinforced shall be in compliance with Fig. 2.6.5.1.1 or with the requirements of

2.6.5.1.5 where  $r$  shall be determined by the Formula (2.6.5.1.1-1) if the rounding is made along the circumferential arc;  $r = c_1$  for the transverse dimensions of the insert plate, and  $r = d_1$  for its longitudinal dimensions if the rounding is made along the elliptical arc, and  $c_1$  shall be determined by the Formula (2.6.5.1.1-2).

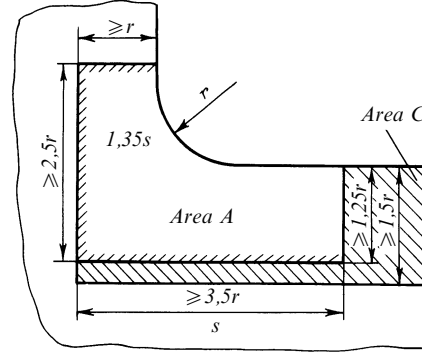


Fig. 2.6.5.1.1

**2.6.5.1.2** For the strength deck outside the area indicated in 2.6.5.1.1 and for the second continuous deck situated above  $0,75D$  from the base line, the corner radii of openings, as required by 2.6.5.1.1, may, in accordance with 1.1.3, be reduced by half in the midship region. The minimum radius shall not be taken less than 0,2 m.

For other regions, other decks and platforms, as well as for ships less than 40 m in length, the minimum corner radius of openings in cargo hatches and engine and boiler casings may be taken equal to 0,15 m.

**2.6.5.1.3** At corners of openings in the cargo hatches of decks (irrespective of their location over the length and depth of the hull) exposed to low temperatures, the radii of curvature shall comply with the requirements for similar structures of the strength deck, situated in the midship region (refer to 2.6.5.1.1).

**2.6.5.1.4** In the area A (refer to Fig. 2.6.5.1.1), butts of deck plating and coaming plates, butt welds of primary and deep longitudinal members, openings welding of shackles, frames, etc., as well as mounting parts, to deck plating are not permitted.

In the area C (refer to Fig. 2.6.5.1.1), only small openings generally of a round or elliptical shape with a minimum size not exceeding  $20s$  ( $s$  = deck plating thickness, in mm) are permitted. Penetration of welds to longitudinal edges of openings shall be avoided as far as practicable.

If the deck plating is terminated at a hatch coaming (or engine casing) and welded thereto, full penetration welds shall be used. Where the deck plating extends inside a hatch coaming, the free edges

of plating shall be smooth within the hatch and free of weld attachments.

If the hatch side coaming terminates in a bracket, the bracket shall not coincide with the butt joint of the deck plating.

**2.6.5.1.5** If the lost cross-sectional area of deck shall be compensated in way of an isolated opening, reinforcement shall be applied as shown in Fig. 2.6.5.1.5. The value of factor  $k$  shall be selected proceeding from the relationship between the deck plating thickness  $s$ , insert plate thickness  $s_1$  and opening width  $b$ , but shall not be taken less than  $k = 0,35s/s_1$ ;

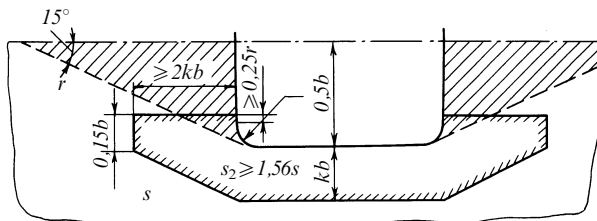


Fig. 2.6.5.1.5

**2.6.5.1.6** The deck plating thickness between transverse edges of adjacent successive openings in cargo hatches and engine casings (refer to 2.6.5.1.1) within their width except for the transverse dimensions of rounding shall not be less than stipulated under 2.6.4.1.5.

The thickness  $s_{min}$  is permitted in way of transverse edges of isolated openings in the area shown in Fig. 2.6.5.1.6.

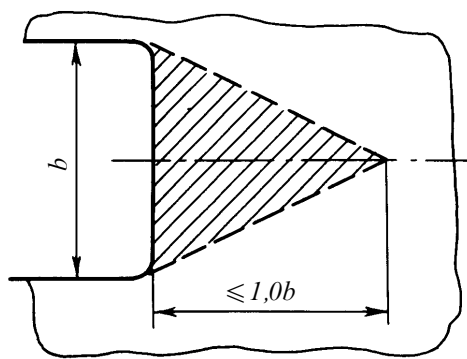


Fig. 2.6.5.1.6

If longitudinal system of framing is adopted, the deck plating between hatch end coamings shall be additionally strengthened by fitting of transverse intercostal stiffeners at every frame.

**2.6.5.1.7** Single openings in the strength deck and in the second continuous deck situated above 0,75D

from the base line, in areas within the midship region, as mentioned in 2.6.5.1.1 and 2.6.5.1.2, and between the ship's side and the line of hatch openings in ships of 40 m and greater in length shall be as small as practicable and be arranged well clear of the corners of openings in cargo hatches and engine and boiler casings, as well as of the ends of superstructures.

Rectangular and circular openings in the above areas need not be reinforced, if their width (diameter) is less than 20 times the deck plating thickness in way of the opening, or 300 mm, whichever is less.

No openings are permitted in the thickened insert plates by which the corners of cargo hatches and engine and boiler casings are reinforced, as well as in the thickened deck stringer plates at the ends of superstructures and at the toes of brackets in which side coamings terminate.

Openings (including rectangular ones) shall not be reinforced when located inside the line of large hatchway openings not more than  $0,25b$  from the centreline and  $0,5b$  from the transverse edges of a cargo hatchway opening (where  $b$  is the width of cargo hatch, in m).

For isolated openings in the area indicated in Fig. 2.6.5.1.6, reinforcement is not required.

If the distance between the edge of an opening in the strength deck and ship's side (or a hatch side coaming) is less than twice the opening width, appropriate reinforcement shall be provided irrespective of the width and shape of opening. The aforesaid distance shall not be less than 75 mm.

The corners of rectangular openings shall be rounded with a radius. In general,  $r_{min} = 0,1b$  (where  $b$  is the width of opening, in m). In any case, the minimum radius of curvature shall not be taken less than twice the plating thickness in way of the opening or 50 mm, whichever is the greater.

**2.6.5.2** The thickness  $s$ , in mm, of the coamings of ventilators (ventilating tubing, ducts, trunks, etc.) on the freeboard deck and quarter deck, as well as on the open decks of superstructures within  $0,25L$  from the forward perpendicular shall not be less than:

$$s = 0,01d_c + 5 \quad (2.6.5.2-1)$$

where  $d_c$  = internal diameter or length of the greater side of a coaming section, in mm.

The thickness  $s$  shall not be less than 7 mm, but it need not be greater than 10 mm.

In ships of restricted areas of navigation **R2**, **R2-RSN**, **R3-RSN** and **R3**, less than 24 m in length, the thickness  $s$ , in mm, of ventilator coamings shall not be less than:

$$s = 0,01d + 4 \quad (2.6.5.2-2)$$

or

$$s = s_d + 1 \quad (2.6.5.2-3)$$

where  $d$  = internal diameter or length of the greater side of a coaming section, in mm;

$s_d$  = thickness of deck plating, in mm,

whichever is the greater.

The thickness of coamings on decks of the first tier superstructures situated outside  $0,25L$  from the forward perpendicular may be reduced by 10 per cent as compared to that required for coamings on freeboard deck and raised quarter deck.

Where the thickness of deck plating is less than 10 mm, a welded insert or doubling plate shall be fitted in way of the coaming, having a thickness equal to at least 10 mm, length and breadth not less than twice the diameter or twice the length of the greater side of the coaming section.

In case of an efficient connection of the coaming to the deck framing, fitting of welded insert or doubling plate is not required.

Where the height of a ventilator coaming is greater than 0,9 m and the coaming is not supported by adjacent hull structures, brackets shall be fitted to attach the coaming to the deck.

The height of ventilator coamings shall be determined in accordance with 7.8, Part III "Equipment, Arrangements and Outfit".

The structure of companionway and skylight coamings shall have strength equivalent to that of cargo hatches, whereas the thickness of the coamings shall not be taken less than 7 mm, but need not exceed the thickness of deck plating in way of the coaming.

## 2.7 BULKHEADS, PROPELLER SHAFT TUNNEL

### 2.7.1 General and definitions.

**2.7.1.1** Requirements are given in this Chapter for various types of bulkheads, propeller shaft tunnel and cofferdams. Requirements for cofferdam bulkheads are given under 3.3.

#### 2.7.1.2 Definitions.

For the purpose of this Chapter, the following definitions have been adopted.

**Watertight (emergency) bulkhead** is a bulkhead restricting the flow of water through ship spaces in the case of emergency.

**Cofferdam bulkhead** is a bulkhead having two parallel tight platings, either strengthened with vertical or horizontal stiffeners or not, which are connected to each other by plate structures perpendicular to the platings: vertical structures (diaphragms) and/or horizontal structures (platforms). If no diaphragms and platforms are fitted, the structure shall be considered as two bulkheads bounding the cofferdam.

**Tight bulkhead** is a bulkhead proof against water and other liquids.

**Wash bulkhead** is a bulkhead with openings, fitted inside a compartment in order to reduce impact pressure due to the movement of liquid therein.

**Tank/cargo tank bulkhead** is a bulkhead bounding a ballast, fuel or other tank, as well as a cargo tank of tanker.

**Partial bulkhead** is a bulkhead fitted in a compartment or part thereof, which shall ensure additional support for deck structures.

**2.7.1.3** The total number of transverse watertight bulkheads, including fore and after peak bulkheads, shall not be less than specified in Table 2.7.1.3. These requirements apply to cargo ships only and are minimum.

Table 2.7.1.3

Length of the ship, in m	Total number of bulkheads	
	Machinery amidships	Machinery aft <sup>1</sup>
Up to 65	4	3
65 to 85	4	4
85 to 105	5	5
105 to 125	6	6
125 to 145	7	6
145 to 165	8	7
165 to 185	9	8
Above 185	On agreement with the Register	

<sup>1</sup>With after peak bulkhead forming after boundary of the engine room.

Where compliance with subdivision requirements shall be ensured, the number and disposition of watertight bulkheads (and of partial watertight bulkheads) shall be determined proceeding from the requirements of Part V "Subdivision".

In special cases, a reduction in number of bulkheads may be permitted by the Register. In this case, two adjacent watertight bulkheads shall be spaced not more than 30 m apart. Increase of this distance shall be a matter of the special consideration of the Register in each case.

All the transverse watertight bulkheads located between fore and after peak bulkheads shall generally be carried to the freeboard deck.

**2.7.1.4** Peak and engine room bulkheads, shaft tunnels shall also comply with the requirements of 1.1.6.1 or 1.1.6.2.

**2.7.1.5** Compartments intended for the carriage of liquid cargoes and ballast, for which  $l > 0,13L$  and/or  $b > 0,6B$  ( $l$  and  $b$  are the length and breadth, in m, of a compartment, as measured in the middle of its height), are subject to special consideration by the Register.

### 2.7.2 Construction.

**2.7.2.1** Tight bulkheads may be either plane or corrugated. Wash bulkheads with openings shall be plane bulkheads.

For the construction of longitudinal tight bulkheads, as well as for the tight bulkheads of log and depth sounder wells, escape trunks, propeller shaft tunnel, etc., the same requirements apply as for transverse tight bulkheads.

In bulkheads, watertight steps and recesses are permitted.

In tankers, the longitudinal bulkheads shall be tight throughout the cargo tank region (including pump rooms and cofferdams) with the exception of the third bulkhead at the centreline which may be constructed as a wash bulkhead.

At intersections of longitudinal and transverse bulkheads, structural continuity of longitudinal bulkheads shall be ensured. The termination of longitudinal bulkheads shall be smooth.

Partial bulkheads shall be plane bulkheads.

**2.7.2.2** In corrugated longitudinal bulkheads, the corrugations shall generally be arranged horizontally, while in transverse bulkheads the arrangement of corrugations may be both horizontal and vertical.

Plane bulkheads shall be strengthened by vertical or horizontal stiffeners. The vertical and horizontal stiffeners of plane bulkheads as well as the vertical and horizontal corrugations of corrugated bulkheads may be supported by horizontal girders or vertical webs respectively.

The horizontal girders and vertical webs shall be stiffened in accordance with the requirements of 1.7.3.

Partial bulkheads shall be strengthened by vertical webs.

**2.7.2.3** The end attachments of bulkhead framing members shall comply with the following requirements:

**1** the ends of vertical webs and horizontal stiffeners of bulkheads shall generally be attached by brackets complying with the requirements of 1.7.2.2. Bracket attachments are required for the ends of main framing of forepeak bulkhead below the freeboard deck;

**2** if transverse system of framing is adopted, the brackets by which the vertical webs of transverse bulkheads are attached to deck plating and inner bottom plating (bottom plating) shall be carried to the beam or floor nearest to the bulkhead and welded thereto.

Where transverse framing system is adopted, the brackets by which the horizontal stiffeners of bulkheads are attached to the side or other bulkhead shall be carried to the frame or vertical stiffener nearest to the bulkhead and welded thereto;

**3** when the vertical stiffeners of bulkheads are cut at decks, platforms or horizontal girders and no brackets are fitted, the stiffener ends shall be welded to deck or platform plating, to horizontal girder web, or sniped at ends;

**4** the end attachments of vertical webs and horizontal girders shall comply with the requirements of 1.7.2.3.

Where there are no horizontal girders on longitudinal bulkheads and/or side stringers at the level of the horizontal girder brackets of transverse bulkheads, the brackets shall be carried to the nearest vertical web on longitudinal bulkhead and/or the nearest frame and welded thereto.

If the vertical web on a transverse bulkhead is not in line with the centre girder or side girder, a bracket shall be fitted in the double bottom under the bracket by which the lower end of the vertical web is attached.

**2.7.2.4** The attachments of corrugated bulkheads shall comply with the following requirements:

**1** where a horizontally corrugated bulkhead is attached to deck and bottom (inner bottom) or a vertically corrugated bulkhead is attached to ship's sides and longitudinal bulkheads, provision shall be made for flat transition areas whose structure, thickness and stiffening shall be in compliance with the requirements for plane bulkheads;

**2** attachment of corrugation ends shall be effected by welding them directly to the inner bottom plating (bottom plating), side plating, deck plating, etc. In so doing, attention shall be given to eliminating hard spots (refer to 1.7.1.4) in the above structures;

**3** requirements for the attachments of corrugated bulkheads in bulk carriers are given in 3.3.2.

### 2.7.3 Bulkhead loading.

**2.7.3.1** The design pressure  $p$ , in kPa, on watertight bulkhead structures and propeller shaft tunnel shall be taken equal to:

$$p = \alpha z_b \quad (2.7.3.1)$$

where  $\alpha = 10$  for forepeak bulkhead structures;

$\alpha = 7,5$  elsewhere;

$z_b$  = distance, in m, as measured at the centreline, from the point of design load application to its upper level; the upper load level is: the bulkhead deck for watertight bulkheads and propeller shaft tunnel, the upper edge of forepeak bulkhead for the forepeak bulkhead.

If partial watertight bulkheads are fitted on the bulkhead deck in line with the watertight bulkheads or in close vicinity to them,  $z_b$  shall be measured to the upper edge of the watertight partial bulkheads.

In any case, the design pressure shall be not less than 12 kPa for watertight bulkhead structures and not less than 16 kPa for forepeak bulkhead structures.

**2.7.3.2** The design pressure on the bulkheads of tanks, cargo tanks and water ballast holds shall be determined in accordance with 1.3.4.2.

The design pressure on the wash bulkheads and plates shall be determined by the Formulae (1.3.4.2.2-1) and (1.3.4.2.2-2), but shall not be less than  $p_{\min} = 25 \text{ kPa}$ .

The design pressure on bulkheads bounding heavy bulk cargo holds shall be determined in accordance with 1.3.4.3.

#### 2.7.4 Scantlings of bulkhead members.

**2.7.4.1** The thickness of bulkhead plating shall be not less than determined by the Formula (1.6.4.4) taking:

$p$  = as defined in 2.7.3;

$m = 15,8$ ;

for the longitudinal bulkheads of tankers 65 m or greater in length, with transverse framing in the midship region

$k_{\sigma} = 0,55k_B \leq 0,8$  at the level of base line;

$k_B$  shall be determined by the Formula (2.2.4.1);

$k_{\sigma} = 0,55k_D \leq 0,8$  at the upper deck level;

$k_D$  shall be determined by the Formula (2.2.4.1);

$k_{\sigma} = 0,8$  in way of  $(0,4 - 0,5)D$  from the base line.

For intermediate regions over the ship's depth,  $k_{\sigma}$  shall be determined by linear interpolation;

$k_{\sigma} = 0,8$  for  $L = 12 \text{ m}$ .

Where  $12 < L < 65 \text{ m}$ ,  $k_{\sigma}$  shall be determined by linear interpolation taking  $k_{\sigma} = 0,68$  for  $L = 65 \text{ m}$  at the level of base line and upper deck;

$k_{\sigma} = 0,9$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

$k_{\sigma} = 0,9$  for other bulkheads.

In ships of 50 m in length, the thickness of watertight bulkhead plating may be reduced by 0,5 mm, and in ships of 40 m in length or below, by 1 mm. For intermediate ship lengths, the reduction in thickness shall be determined by linear interpolation.

In tankers, the thickness of top and bottom strakes of longitudinal bulkheads shall comply with the requirements for side plating, as given in 2.2.4, with regard for the liquid cargo pressure.

The plating thickness  $s_{\min}$ , in mm, of watertight bulkheads and bulkheads of lubricating oil tanks shall not be less than:

$$s_{\min} = 4 + 0,02L. \quad (2.7.4.1-1)$$

Where  $L > 150 \text{ m}$ ,  $L$  shall be taken equal to 150 m.

The thickness of bottom plates of bulkheads shall exceed the above value by 1 mm, but shall not be less than 6 mm.

For tank bulkheads (except lubricating oil tanks), the thickness  $s_{\min}$ , in mm, of plating, face plates and webs of framing members shall not be less than:

$$s_{\min} = 5 + 0,015L; \quad (2.7.4.1-2)$$

$$6,0 \leq s_{\min} \leq 7,5 \text{ mm}.$$

In tankers, the minimum bulkhead plating thickness in way of cargo and ballast tanks shall not be less than that required by 3.5.4.

Bulkhead plating may have a thickness not exceeding that of relevant shell plating strakes and deck plating, where the spans and yield stress values are identical. The same applies to the thickness relationship of bulkhead bottom plating and inner bottom plating (bottom plating).

The breadth of top and bottom strakes of bulkheads shall be determined in accordance with 2.7.5.1.

Where sterntubes penetrate through bulkhead plating, the thickness of the latter shall be doubled.

The thickness of corrugated bulkheads shall be determined in accordance with 1.6.4.5 with regard for the requirements for the section moduli of vertical and horizontal stiffeners, as specified in 2.7.4.2.

**2.7.4.2** The section modulus of vertical and horizontal stiffeners of bulkheads shall not be less than stipulated under 1.6.4.1 and 1.6.4.2 taking:

$p$  = as defined in 2.7.3;

$m$  = as obtained from Table 2.7.4.2;

Table 2.7.4.2

Framing members	$m$
Single span vertical stiffeners:	
both ends sniped	8
upper end sniped, lower end welded to supporting structure	9
both ends welded to supporting structure	10
upper end welded to supporting structure, lower end bracketed <sup>1</sup>	14
both ends bracketed <sup>1</sup>	18
Multispan vertical stiffeners:	
within span	18
within intermediate supporting section, where stiffener is continuous through supporting structure <sup>2</sup>	12
Horizontal stiffeners	12

<sup>1</sup>Additionally, strength in the supporting section shall be verified, considering the bracket as part of the section, with  $m = 12$ .

<sup>2</sup>With regard for a bracket, if fitted, in the supporting section.

for horizontal stiffeners of longitudinal bulkheads fitted in the midship region of tankers 65 m and greater in length

$k_{\sigma} = 0,55k_B \leq 0,75$  at the level of base line;

$k_B$  shall be determined by the Formula (2.2.4.1);

$k_{\sigma} = 0,55k_B \leq 0,75$  at the upper deck level;

$k_D$  shall be determined by the Formula (2.2.4.1);

$k_{\sigma} = 0,75$  within  $(0,4 - 0,5)D$  from the base line.

For intermediate regions over the ship's depth,  $k_{\sigma}$  shall be determined by linear interpolation;

$k_{\sigma} = 0,75$  for  $L = 12 \text{ m}$ ;

Where  $12 < L < 65$  m,  $k_{\sigma}$  shall be determined by linear interpolation, taking  $k_{\sigma} = 0,65$  for  $L = 65$  m at the base line and upper deck level.

$k_{\sigma} = 0,75$  at the ends of the ship within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

$k_{\sigma} = 0,75$  for other girders of bulkhead framing.

$m = 10$  for corrugations;

$m = 13$  for vertical corrugations of bulkheads whose top and bottom ends are attached to deck and bottom or to inner bottom by transverse members of rectangular or trapezoidal section and by supports of trapezoidal section complying with 3.3, respectively.

Horizontal stiffeners of longitudinal bulkheads fitted at a distance of  $0,15D$  from deck and bottom shall comply with the buckling strength requirements of 1.6.5.

For tank bulkheads (except lubricating oil tanks), the thickness of member webs and face plates as well as of their stiffening brackets shall not be less than required by the Formula (2.7.4.1-2), and for the bulkheads of tankers in way of cargo and ballast tanks it shall not be less than stipulated under 3.5.4.

**2.7.4.3** Bulkhead vertical webs and horizontal girders shall satisfy the following requirements:

**.1** the section modulus and web sectional area, excluding openings, of the vertical webs of bulkheads whose structure does not include horizontal girders, and of the horizontal girders of bulkheads whose structure does not include vertical webs, shall not be less than stipulated under 1.6.4.1 to 1.6.4.3 taking:

$$N_{\max} = npal;$$

$p$  = as defined in 2.7.3;

$m$  and  $n$  for the longitudinal bulkheads of tankers shall be determined from Table 2.7.4.3-1 depending upon the number of cross ties fitted in wing tanks between deep members of bulkhead and of ship's side; for other bulkheads for which vertical webs are provided, but horizontal girders are omitted, or vice versa, the values of  $m$  and  $n$  shall be obtained from Table 2.7.4.3-2;

$l$  = span, including the brackets, in m;

$k_{\sigma}$  is determined for horizontal girders of longitudinal bulkheads in tankers in the same way as for the

Table 2.7.4.3-2

Member	$m$	$n$
Vertical web: in holds or tanks in 'tween decks	11 10	0,5 0,5
Horizontal girder: in tanks in wing tanks	10 18	0,5 0,5

horizontal stiffeners of those bulkheads in accordance with 2.7.4.2; for other webs and girders,  $k_{\sigma} = 0,75$ ;

$k_{\tau} = 0,75$ ;

**.2** where the bulkhead structure incorporates both vertical webs and horizontal girders, the scantlings of those members shall be determined on the basis of grillage calculation using beam models, with design loads as stipulated under 2.7.3 and permissible stress factors as stipulated under 2.7.4.3.1;

**.3** for the girders and webs of corrugated bulkheads, the lowest cross section shall be adopted as the design cross section; the face plate width shall be determined in accordance with 1.6.3.6;

**.4** for tank bulkheads (except lubricating oil tanks), the web and face plate thickness of girders and of their brackets and stiffeners shall not be less than required by the Formula (2.7.4.1-2); for tanker bulkheads in way of cargo and ballast tanks, this thickness shall not be less than that required by 3.5.4.

**2.7.4.4** In compartments intended for the carriage of liquid cargoes and ballast, the scantlings of members of wash bulkheads and wash plates shall comply with the following additional requirements:

**.1** in the wash bulkheads, the total area of openings shall not be greater than 10 per cent of the bulkhead area as a whole. The number and size of openings in the top and bottom strakes shall be as small as possible.

The thickness and breadth of the top and bottom plates of wash bulkheads shall comply with the requirements for the bulkhead plating of tanks or cargo (ballast) tanks proceeding from the purpose;

**.2** a wash plate shall be stiffened by framing complying with the requirements for wash bulkhead framing.

The free edge of the wash plate shall be stiffened by a horizontal stiffener or a face plate. Their section modulus shall comply with the requirements for the primary members of wash bulkheads.

Where a wash plate serves as the undeck girder, it shall comply with the requirements of 2.6.

**2.7.4.5** The scantlings of partial bulkhead members shall comply with the following requirements:

**.1** the thickness of partial bulkhead plating shall not be less than that required by the Formula (2.7.4.1-1);

Table 2.7.4.3-1

Member	Parameter	Number of cross ties			
		0	1	2	3
Vertical web	$m$	11	24	24	24
	$n$	0,5	0,325	0,3	0,275
Horizontal girder	$m$	18	36	36	36
	$n$	0,5	0,35	0,3	0,3



**.2** partial bulkhead stiffeners supporting deck transverses and hatch end beams shall be in accordance with the requirements for relevant pillars (refer to 2.9).

In any case, the Euler stresses, in MPa, in a stiffener, to be determined in accordance with 2.9.4.1, shall not be less than:

$$\sigma_e = 200\eta. \quad (2.7.4.5.2)$$

The moment of inertia and sectional area of the stiffener on the basis of which the Euler stresses therein are determined shall be calculated with regard for the face plate of partial bulkhead plating equal in width to half the distance between the stiffeners;

**.3** if the partial bulkhead takes up the load directly from cargo, the scantlings of its members shall comply with the requirements for hold bulkheads with regard for the particular cargo.

**2.7.4.6** The scantlings of shaft tunnel members, its recess included, and those of the tight bulkheads of log and depth sounder wells, escape trunks, etc. shall comply with the requirements for the scantlings of watertight bulkhead members.

If the shaft tunnel passes through a compartment intended for the carriage of liquid cargo or ballast, the scantlings of its members shall comply with the requirements for the scantlings of the members of tight bulkheads bounding the compartment.

If the top plating is well curved, the thickness may be reduced by 10 per cent.

Under hatchways the top plating thickness shall be increased by 2 mm.

#### **2.7.5 Special requirements.**

**2.7.5.1** The breadth of the bottom strake of bulkhead, as measured from inner bottom plating, or, where double bottom is omitted, from the bottom shell, shall be not less than 0,9 m for ships of 40 m and greater in length, and not less than 0,4 m for ships of 12 m in length. For intermediate ship lengths, the breadth of this strake shall be determined by linear interpolation. If the double bottom extends to the bulkhead on one side only, the bottom strake of bulkhead plating shall extend for at least 0,3 m above the inner bottom plating.

In the boiler room, the bottom strake of the bulkhead shall extend for at least 0,6 m above the flooring.

The upper edge of bottom strake of transverse bulkheads in the cargo tanks of tankers shall be at least 100 mm above the upper toes of brackets of bottom longitudinals. The top and bottom strake breadth of longitudinal bulkhead plating shall not be less than  $0,1D$ , but need not exceed 1,8 m.

**2.7.5.2** Cofferdams and the bulkheads forming their boundaries shall comply with the following requirements:

**.1** unless expressly provided otherwise in the other Parts of the Rules, the breadth of vertical cofferdams stipulated under 2.4.7, Part VI "Fire Protection", 4.3.4, Part VII "Machinery Installation" and 13.7.5, 14.5.2, 17.3, Part VIII "Systems and Piping" shall be equal to one spacing, but not less than 0,6 m, and the height of horizontal cofferdams shall not be less than 0,7 m.

In any case, cofferdam dimensions shall be so selected as to make the cofferdams accessible for inspection and repair.

Instead of cofferdams, cofferdam bulkheads may be fitted in accordance with 3.3 unless expressly provided otherwise by the Rules;

**.2** cofferdams adjoining cargo tanks and fuel tanks shall be watertight.

Bulkheads separating cofferdams from tanks shall comply with the requirements for the bulkheads of those tanks.

The bulkheads of cofferdams filled with water shall comply with the requirements for tank bulkheads.

The bulkheads of cofferdams which shall ensure tightness, but which are not filled with water, shall comply with the requirements for watertight bulkheads.

The bulkheads of cofferdams which are non-tight shall comply with the requirements for partial bulkheads as stipulated under 2.7.4.5, except the requirement for vertical webs supporting deck transverses and hatch end beams. They may have openings provided the corners of the openings are rounded and the edges are suitably reinforced. Such openings shall not generally be arranged in the top and bottom strakes of longitudinal bulkheads.

## **2.8 FORE AND AFTER ENDS**

### **2.8.1 General and symbols.**

**2.8.1.1** Requirements are given in this Chapter for the following structures: fore peak and bulb (if any), bottom within  $0,25L$  aft of the fore perpendicular, side within  $0,15L$  aft of the fore perpendicular, structures located aft of the after peak bulkhead, as well as strengthening of bottom and side forward in the region of impact pressure.

It is assumed in this Chapter that the upper boundary of the fore and after peak is formed by a tight deck or platform arranged directly above the summer load waterline.

**2.8.1.2** For the purpose of this Chapter the following symbols have been adopted:

$d_f$  = minimum design draught, in m, in way of forward perpendicular;

$\alpha_x$  = angle, in deg., between a vertical and the straight line connecting the intersection points of

summer load waterline and weather deck with the ship's side at a cross section within  $0,05L$  from the forward perpendicular (Fig. 2.8.1.2-1);

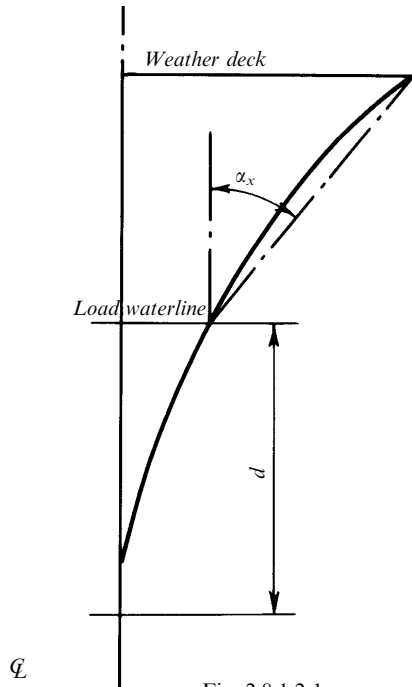


Fig. 2.8.1.2-1  
Determination of angle  $\alpha_x$

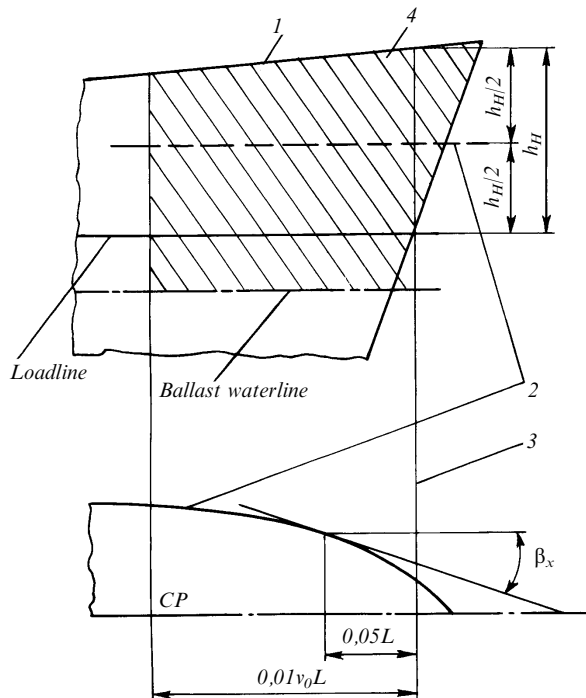


Fig. 2.8.1.2-2  
Diagram for determining the angle and the area (lined) to which the move impact pressure is applied:  
1 — open upper deck; 2 — water line for determining the angle;  
3 — forward perpendicular; 4 — impact pressure area;  
 $h_N$  — vertical distance between the loadline and the open upper deck at forward perpendicular

$\beta_x$  = angle, in deg., between a tangent to the waterline at vertical mid-distance between the summer load waterline and weather deck on forward perpendicular, and a line parallel to the centreline at a cross section within  $0,05L$  from the forward perpendicular (Fig. 2.8.1.2-2).

## 2.8.2 Construction.

**2.8.2.1** The following framing systems are adopted at ends:

transverse system of framing for bottom in peaks;  
transverse or longitudinal system of framing for other structures.

**2.8.2.2** Fore peak floors shall be fitted at every frame. Their height shall not be less than stipulated under 2.4.4.1, but need not exceed 2,25 m, and the thickness shall not be less than required by the Formula (2.4.4.3.1) at  $k = 1$  and  $a = 0,6$  m; however, they need not be thicker than the bottom shell plating in this region. Floor webs shall be strengthened with vertical stiffeners to be spaced not more than 0,6 m apart.

Floor face plates shall have a thickness not less than the floor thickness and a breadth required by 1.7.3.1.

At the centreline an intercostal side girder with a face plate shall be fitted as an extension of centre girder in way of the holds. The height and thickness of girder plates as well as the thickness and width of girder face plate shall be equal to those of the floors.

Where the webs of the girder cannot be arranged, the floor face plates shall be interconnected at the centreline by an angle, tee section, etc. the flanges of which have the same width and thickness as the floor face plates.

**2.8.2.3** If transverse system of framing is adopted in the fore peak side, the side stringers shall be fitted at least up to the deck directly above the summer load waterline. Side stringers shall be so fitted that the distance measured vertically between them does not, in general, exceed 2 m.

Side stringers shall be supported by panting beams fitted at alternate frames and shall, where possible, be supported at the centreline by a longitudinal bulkhead.

The free edge of the side stringers shall be stiffened by a face plate having a thickness not less than that of a stringer web and a breadth in accordance with 1.7.3.1. At every frame, the stringer web shall be stiffened by brackets having the side dimensions not less than half the stringer web height, and where panting beams are fitted, these shall be not less than required by 1.7.2.2 The thickness of brackets shall not be less than that of the stringer web.

Instead of panting beams, the side stringers may be supported by web frames spaced not more than 3 m apart.

It is recommended that non-tight platforms be fitted instead of side stringers with panting beams or

web frames. In this case, the distance between the platforms may be increased to 2,5 m. The beams of non-tight platforms shall be fitted at every frame.

If in the structure with panting beams or web frames the distance from the base line to the nearest deck or platform exceeds 9 m, a non-tight platform shall be fitted at the middle of this length, in which the total area of openings shall not exceed 10 per cent of its area.

With longitudinally framed fore peak side, the spacing of web frames shall not exceed 2,4 m. Deck transverses shall be fitted in way of the web frames passage through or attachment to decks and platforms.

Floors without web frames fitted in line with them shall be attached to the nearest side longitudinal by brackets.

**2.8.2.4** The bulb shall be strengthened by platforms spaced not more than 2 m apart. Beams of the platform shall be fitted at every frame.

If the length of the bulb forward of the forward perpendicular exceeds  $0,03L$ , a non-tight bulkhead shall be fitted at the centreline, with stiffeners arranged at every frame.

If the length of the bulb is less than  $0,03L$ , the bulb may be strengthened by a girder fitted at the centre line in continuation of the centre girder.

The construction of the fore end shall provide for the anchor to be lowered freely past the bulb with the ship listed 5 degrees either side.

In way of eventual touching of the bulb, the shell plating thickness shall be increased and intermediate frames fitted.

**2.8.2.5** In ships with single bottom, the bottom structure in way of the fore end outside the fore peak shall comply with the requirements of 2.3.2, 2.3.4 and, besides, with those given below:

**.1** if transverse system of framing is adopted, the spacing of side girders, as well as the distance from the centre girder or the ship's side to a side girder, shall not exceed 1,1 m within  $0,25L$  from the forward perpendicular.

If longitudinal system of framing is adopted and minimum draught is less than  $0,035L$  in way of the forward perpendicular, in cargo tanks of tankers an additional transverse with a face plate along its free edge shall be fitted midway between the bottom transverses. The depth of this transverse shall not be less than that of bottom longitudinals;

**.2** forward of cargo tanks:

if transverse system of framing is adopted, intercostal side girders with face plates along their free edges shall be fitted in continuation of every second bottom longitudinal, extending forward as far as practicable. The depth and thickness of the side girder webs, as well as the scantlings of the face plates, shall be taken the same as for the floors;

if longitudinal system of framing is adopted, the spacing of floors shall not exceed 2,8 m. An intercostal side girder having the same scantlings as the floors shall be fitted on either side of the ship between the centre girder and longitudinal bulkhead.

**2.8.2.6** In way of the fore end, the double bottom structure outside the fore peak shall comply with the requirements of 2.4.2 and those given below.

Within  $0,25L$  from the forward perpendicular the distance between side girders shall not exceed 2,2 m. If transverse system of framing is adopted, in this region half-height side girders shall be fitted additionally and welded to the bottom and floors. The distance between side girders and half-height girders shall not exceed 1,1 m. These half-height girders shall be extended as far forward as practicable, whereas their free edges shall be reinforced with flanges or face plates.

If longitudinal system of framing is adopted, the floors shall be strengthened with stiffeners in line with each half-height side girder and each bottom longitudinal.

In ships greater than 80 m in length with a minimum draught less than  $0,025L$  in way of the forward perpendicular, the edges of openings in floor, side girder and centre girder webs shall be stiffened within  $0,25L$  from the forward perpendicular.

**2.8.2.7** If transverse framing system is adopted, intercostal side stringers shall be fitted within  $0,15L$  from the forward perpendicular, outside the fore peak, at the level of the fore peak side stringers. The depth and thickness of a stringer plate shall be equal to those of the frame. The intercostal brackets fitted as stringer plates shall be welded to the webs of frames at both ends and to the shell plating. On the free edge of a stringer, a face plate shall be fitted with the thickness not less than that of the web and the breadth in accordance with 1.7.3.1.

The intercostal side stringer may be of the same profile as the frames.

The stringer face plate (flange) shall not be welded to the face plate of frame.

Intercostal stringers shall be attached to the bulkheads by brackets.

The face plates (flanges) of intercostal stringers may be omitted where the spacing of frames does not exceed their double depth. In this case, their thickness  $s$ , in mm, shall not be less than  $s = l/4s + \Delta s$  or  $s = 0,05h$ , whichever is the greater, where  $l$  is the length of the free edge of stringer between frames, in mm;  $h$  is the stringer depth, in mm.

In ships having the characteristic  $(v_0/\sqrt{L}) > 1,5$  or a large bow flare, provision shall be made for web frames and side stringers supported thereby. The spacing of web frames shall not exceed 5 frame spaces.

Where longitudinal framing is adopted in the ship's side forward outside the fore peak, the spacing of side transverses shall not exceed 3 m. In the holds of any ship, as well as in 'tween decks and superstructures of ships with the characteristic  $(v_0/\sqrt{L}) > 1,5$  or with a large bow flare, provision shall be made for a vertical intercostal member having the same scantlings as side longitudinals, to be fitted between side transverses. The structure of the member shall be similar to that of the intercostal side stringers required by transverse framing system. The intercostal member can terminate at the upper and lower side longitudinals of the hold, 'tween decks and superstructure. Every second side longitudinal shall be attached to the side transverses by brackets extended to the frame face plate.

**2.8.2.8** Within  $0,1L$  from the forward perpendicular, the span of weather deck transverses shall not exceed 3 m, and the deck girder span shall not exceed 3,6 m.

Within  $0,2L$  from the forward perpendicular, the section modulus of weather deck transverses shall not be less than required for deck girders with equal spans and spacing of members.

**2.8.2.9** The structure located aft of the after peak bulkhead shall be sufficiently rigid in the vertical and horizontal plane. For this purpose, fitting of additional longitudinal bulkheads or platforms, thickening of deck plating and shell plating, as well as connection of bottom and upper deck longitudinals with pillars or struts may be required. If the stern overhang is large or the after peak width exceeds 20 m at any section, fitting of additional longitudinal non-tight bulkheads is recommended port or starboard.

Where there is a flat of the bottom, additional strengthening may be required to take up the loads due to impact pressure.

**2.8.2.10** Floors in the after peak shall comply with the requirements of 2.8.2.2.

In single screw ships, the floors shall be extended above the sterntube, but in any case to a height of not less than 0,8 m. If this is impracticable, tie plates with face plates on both edges shall be fitted transversely at every frame above the sterntube. The thickness of the tie plates shall not be less than that of the floor. Tie plate exceeding 1,5 m in length shall be provided with a stiffener fitted in the middle of its length.

Floors with flanged edges are not permitted.

In ships greater than 200 m in length, floors shall be extended to the platform located above the sterntube. Longitudinally, the floors shall be stiffened with brackets fitted at the centreline and, if practicable, supporting the floor for a full depth. Brackets above the sterntube are necessary. The brackets shall be carried to the propeller post. They need not be

fitted where a wash plate is located above the floors, with its lower edge extending at least 0,8 m below the face plates of the floors.

The opening in floors for the sterntube shall be reinforced with face plate along the edges. Below the sterntube, the openings shall be reinforced with face plates or stiffeners.

**2.8.2.11** If transverse framing is adopted in the after peak side, panting beams and side stringers, beam knees, frame to side stringer attachments, arrangement and structure of web frames and non-tight platforms shall comply with the requirements of 2.8.2.3. The vertical distance between side stringers shall not exceed 2,5 m, and the frame span, as measured on the side plating, shall not exceed 3,5 m.

In 'twin- and multi-screw ships having a cruiser or transom stern, the distance between stringers, as measured on the side plating, shall not exceed 2 m, with one of the stringers being fitted in way of the top edge of propeller shaft bossing or in line with the shaft bracket. Where web frames are fitted, their spacing shall not exceed 2,4 m.

If longitudinal framing is adopted in the after peak side, relevant requirements of 2.8.2.3 shall be complied with.

**2.8.2.12** The ends of after peak members (including deck, platform and bulkhead framing), as well as the ends of horizontal and, where practicable, vertical stiffeners of floors shall be secured (refer to 1.7.1.4).

The face plates of the after peak floors and deck transverses shall be sniped in way of their attachments to longitudinal bulkheads. Bulkhead stiffeners shall be attached to the floor face plates by brackets fitted on either side of the bulkhead.

This also applies to deck girder and side girder attachments to transverse bulkheads.

**2.8.2.13** The spacing of ordinary and bevel frames may be the same as in the midship region, but shall not exceed 750 mm. A side girder of the same depth as that of floors shall be fitted at the centreline. In case of transom stern and/or flat of the bottom, the side girders shall be spaced not more than 2 m apart.

In full cruiser sterns and where the frame span from the upper edge of floors to the nearest deck exceeds 2,5 m, additional strengthening shall be provided by means of web frames and a side stringer.

**2.8.2.14** If peaks are used as tanks, fitting of a wash bulkhead is recommended at the centreline.

### **2.8.3 Loading on structures at ends.**

**2.8.3.1** The design pressure on the structures at ends is determined using the design loads specified in 2.2 to 2.7 and the extreme loads specified in 2.8.3.2 and 2.8.3.3.

The scantlings of fore end members subject to impact pressure shall be verified by applying extreme loads:

in accordance with 2.8.3.2 for ships greater than 65 m in length with a minimum draught of  $0,045L$  in way of the forward perpendicular;

in accordance with 2.8.3.3 for ships having the characteristic  $(v_0/\sqrt{L}) > 1,5$  or a considerable bow flare.

**2.8.3.2** Under the wave impact upon the bottom of the fore end, the extreme values of the design hydrodynamic pressure  $p_{SL}$ , in kPa, shall be determined by the formula

$$p = 5,5C_1C_2\varphi_r \frac{b_x}{B}(1 - 5d_f/L)(1 - x_1/l_b) \cdot 10^3 \quad (2.8.3.2-1)$$

where  $C_1 = \sqrt{L}$  for  $L \leq 200$  m;

$$C_1 = 5\sqrt{10 - 0,01L} \text{ for } L > 200 \text{ m};$$

$$C_2 = 0,134v_0(1 - 17,1d_f/L)/\sqrt{L};$$

$$l_b = (0,22 + 1,5C_2)L;$$

for  $v_0$ , refer to 1.1.3;

$\varphi_r$  = as obtained from 1.3.1.5 ( $\varphi_r = 1$  for ships of unrestricted service);

$b_x$  = ship breadth, in m, in the considered cross section at the level of  $0,04B$  above the base line, but not greater than  $0,8B$ ;

$x_1$  = distance, in m, from the considered cross section to the forward perpendicular, but not greater than  $l_b$ .

The Formula (2.8.3.2-1) is used for derivation of  $p$  values in a number of sections within the portion  $l_b$ , from which the maximum value of  $p$  (hereinafter — symbol  $p_m$ ) and the value of  $x_1$  (hereinafter — symbol  $x_m$ ) corresponding to  $p_m$  are chosen. The design pressure  $p_{SL}$  (Fig. 2.8.3.2) is determined by the formula

$$p_{SL} = p_f + (p_m - p_f)x_1/(x_m - 0,05L)$$

when  $0 \leq x_1 < x_m - 0,05L$ ;

$$p_{SL} = p_m$$

when  $x_m - 0,05L \leq x_1 \leq x_m + 0,05L$ ;

$$p_{SL} = p_m(0,5L - x_1)/(0,45L - x_m)$$

when  $x_m + 0,05L \leq x_1 \leq 0,5L$

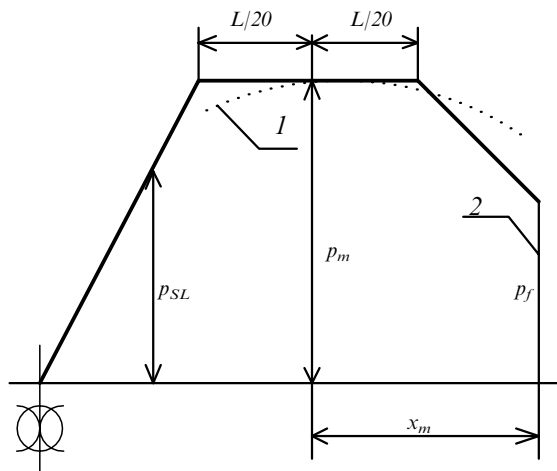


Fig. 2.8.3.2 Determination of design pressure  $p_{SL}$ :  
1 — value of  $p$  determined by the Formula (2.8.3.2-1);  
2 — forward perpendicular

where  $p_f = 0,5p_m$  with bulb;  
 $p_f = 0$  without bulb.

The hydrodynamic pressure as determined by the Formula (2.8.3.2-2) is distributed over a height of  $0,04B$  above the base line.

**2.8.3.3** Under the wave impact upon the side at the fore end, the extreme values of the design hydrodynamic pressure  $p_{SL}$ , in kPa, shall be determined by the formula

$$p_{SL} = 0,9C_3C_4^2 \quad (2.8.3.3)$$

where  $C_3 = 2,2 + 1,5 \tan \alpha_x$ ;

$C_4 = v_0(0,6 - 20/L)(1,2 - 0,2\beta_x/60)\sin \beta_x + 0,6\sqrt{L}$ ;

for  $v_0$ , refer to 1.1.3;

$\alpha_x$  and  $\beta_x$  = as defined in 2.8.1.2.

Depthwise the impact pressure is distributed over the part of the side above the ballast waterline, and lengthwise — over the part of the side extending as far aft as the cross section at  $0,01v_0L$  from the forward perpendicular and as far forward as the intersection of the upper deck with the stem (refer to Fig. 2.8.1.2-2).

#### 2.8.4 Scantlings of structural members at ends.

**2.8.4.1** The shell plating thickness, scantlings of single bottom and double bottom members and of side framing shall comply with the requirements of 2.2.4, 2.3.4, 2.4.4, 2.5.4 using the service loads given in 2.2, 2.3, 2.4, 2.5. Besides, when determining the scantlings of fore and after peak members, the following requirements shall be satisfied:

**.1** the section modulus of frames shall be determined by the Formulae (1.6.4.1) and (1.6.4.2) taking:

$$m = 12;$$

$l$  = spacing of side stringers, as measured along the shell plating;

**.2** scantlings of panting beams shall comply with the requirements of 2.9.4.1;

**.3** in calculating the section modulus and cross-sectional area of web frames,

$$m = 10;$$

$$N_{\max} = 0,5pal \quad (2.8.4.1.3)$$

where  $p$  = design pressure, in kPa, according to 2.5.3;

$a$  = spacing of web frames, in m;

$l$  = span of web frame, in m, as measured between the upper edge of floor and the deck (platform) bounding the fore peak (after peak) or the non-tight platform, if any, nearest to the bottom, or between non-tight platforms, the deck and non-tight platform less the height of deck transverse of the relevant deck (platform);

**.4** plating thickness and framing of non-tight platform shall satisfy the requirements of 2.6.4 for platforms at ends. When determining the design load by the Formula (1.3.4.1), the product  $hp_{cg}$  shall not be less than 3,5 kPa.

The thickness of non-tight platform plating, in mm, shall not be less than:

$$s_{\min} = (5 + 0,02L)\sqrt{\eta}, \quad (2.8.4.1.4)$$

but not less than 5 mm.

Where  $L > 300$  m,  $L$  shall be taken equal to 300 m;

**.5** if the fore peak (after peak) is used as tanks, the scantlings of their members shall also comply with the requirements for the structural members of tanks.

**2.8.4.2** Where exposed to extreme loads to be determined in accordance with 2.8.3.2, the scantlings of bottom framing members at the fore end shall comply with the requirements of 2.2.4, 2.3.4 and 2.4.4, as well as with the following additional requirements:

**.1** the thickness of shell plating shall be determined by the Formula (1.6.4.4) taking:

$$p = 0,4p_{SL} \quad (2.8.4.2.1)$$

where  $p_{SL}$  = as determined by the Formula (2.8.3.2-2);

$$m = 15,8;$$

$$k_{\sigma} = 0,7;$$

**.2** the section modulus, in  $\text{cm}^3$ , of a primary member shall not be less than:

$$W = 0,75 \frac{pal^2}{mk_{\sigma}\sigma_n} \omega_c \cdot 10^3 \quad (2.8.4.2.2)$$

where  $p$  = as determined by the Formula (2.8.4.2.1);

$$k_{\sigma} = 0,65;$$

$m = 16$ , if the members are continuous through the webs of supporting structures;

$m = 8$ , if the members are cut at supports;

$m = 28$ , if the supporting sections of the member are reinforced with brackets on both sides of the supporting structure; the depth and length of brackets are not less than 1,5 of the member depth;

for  $\omega_c$ , refer to 1.1.5.3;

**.3** the cross-sectional area, in  $\text{cm}^2$ , of a primary member or of welds by which intercostal members are connected to supporting structures shall not be less than:

$$f = 5pa \frac{l-0,5a}{k_{\tau}\tau_n} + 0,05\Sigma h_i \Delta s \quad (2.8.4.2.3)$$

where  $p$  = as determined by the Formula (2.8.4.2.1);

$$k_{\tau} = 0,65;$$

$\Sigma h_i$  = length of member section perimeter, in cm;

$\Delta s$  = as obtained from 1.1.5.1.

The cross-sectional area of a member includes the web area, as well as the portion of the sectional area of shell plating, having a breadth  $b_1 = 3s$  (where  $s$  is the thickness, in mm, of shell plating). If the member is of bulb profile, the whole of its face plate is included in the cross-sectional area. In the case of member of T-section, a portion of its breadth  $b_2 = 3s_{f,p}$  is included in the cross-sectional area (where  $s_{f,p}$  is the face plate thickness of the member, in mm);

**.4** the web thickness  $s$ , in mm, of floor, side girder and centre girder shall not be less than:

$$s = 0,75 \frac{pab}{k_{\tau}\tau_n h} + \Delta s \quad (2.8.4.2.4)$$

where  $p$  = as determined by the Formula (2.8.4.2.1);

$a$  and  $b$  = average spacing of floors and girders accordingly (centre girder and side girder); when determining  $b$ , half-height side girders shall be disregarded;

$$k_{\tau} = 0,65;$$

$h$  = depth, in m, of floor, side girder or centre girder accordingly;

$\Delta s$  = as obtained from 1.1.5.1.

**2.8.4.3** Where exposed to extreme loads to be determined in accordance with 2.8.3.3, the scantlings of side framing members at the fore end shall comply with the requirements of 2.2.4 and 2.5.4, as well as with the following additional requirements:

**.1** the thickness of shell plating shall be determined by the Formula (1.6.4.4) taking:

$$p = 0,5p_{SL} \quad (2.8.4.3.1)$$

where  $p_{SL}$  = as determined by the Formula (2.8.3.3);

$$m = 15,8;$$

$$k_{\sigma} = 0,7;$$

**.2** the section modulus of a primary member shall comply with the requirements of 2.8.4.2.2 using the design load determined by the Formula (2.8.4.3.1);

**.3** the cross-sectional area of a primary member shall comply with the requirements of 2.8.4.2.3 using the design load determined by the Formula (2.8.4.3.1).

**2.8.4.4** Within the area of the stern counter, the scantlings of frames shall be not less than those of the after peak frames, unless their span exceeds 2,5 m. With a greater span, the frame scantlings shall be increased accordingly. The thickness of floors and side girders shall not be less than required by 2.8.4.5.

**2.8.4.5** The side stringers of fore and after peaks shall have a web sectional area  $f_s$ , in  $\text{cm}^2$ , not less than:

$$f_s = 12 + 0,45L. \quad (2.8.4.5-1)$$

The side stringer width  $b$ , in m, shall not be less than:

$$b = 0,24 + 0,005L \text{ for } L \leq 80 \text{ m}; \quad (2.8.4.5-2)$$

$$b = 0,4 + 0,003L \text{ for } L > 80 \text{ m}.$$

The web thickness, in mm, of a side stringer shall not be less than:

$$s_{\min} = (5 + 0,02L)\sqrt{\eta}, \quad (2.8.4.5-3)$$

but not less than 5 mm.

Where  $L > 300$  m,  $L$  shall be taken equal to 300 m.

**2.8.4.6** The thickness of shell plating in way of the bulb shall not be less than  $0,08L + 6$ , but it need not

be taken greater than 25 mm. In this case, the shell plating thickness at the lower part of the bulb shall not be less than stipulated under 2.8.4.2.1 for the hull section in way of the forward perpendicular.

### 2.8.5 Special requirements.

#### 2.8.5.1 Visor-type bow doors.

**2.8.5.1.1** The present requirements apply to the construction of visor-type bow doors which form a component part of the fore end of the ship, being mechanically connected with the side and deck structures and capable of moving in the vertical direction to provide access for motor vehicles and/or other transport means.

**2.8.5.1.2** The thickness of visor-type bow door plating shall not be less than that required by 2.8.4 for the appropriate sections of shell plating.

**2.8.5.1.3** The section modulus of primary members shall not be less than that required by 2.8.4 for the appropriate fore end regions. In this case, the design load, in kPa, shall not be less than:

$$p_{\min} = 0,8(1,5v_0 + 0,6\sqrt{L})^2. \quad (2.8.5.1.3-1)$$

The sectional area of member web shall not be less than determined by the Formula (1.6.4.3-1) taking:

$$N_{\max} = 0,5pal \quad (2.8.5.1.3-2)$$

where  $p$  = design load in accordance with 1.3.2.2 or 2.8.3.3, whichever is the greater, but not less than  $p_{\min}$ , in kPa, as determined by the Formula (2.8.5.1).

$$k_{\tau} = 0,7.$$

**2.8.5.1.4** Structural measures shall be taken to ensure rigid attachment of primary members and support members of bow doors.

**2.8.5.1.5** The scantlings of support members shall be obtained by strength calculation using the design loads given in 1.3.2.2 or 2.8.3.3, whichever is the greater, but not less than  $p_{\min}$  determined by the Formula (2.8.5.1.3-1), as well as the permissible stress factors  $k_{\sigma} = k_{\tau} = 0,6$ .

**2.8.5.1.6** The construction of support members shall comply with the requirements of 1.7.3.

**2.8.5.2** In ships provided with fixed propeller nozzles, transverse bulkheads or support members shall be fitted in way of the nozzle attachment to the hull.

**2.8.5.3** In hull curvilinear sections (deadrise, flare), it is recommended that the framing be fitted at an angle of approximately  $90^\circ$  to the shell plating.

**2.8.5.4** In multi-screw ships, the structural strength and rigidity in way of sterntube, shaft bracket and shaft bossing attachments are subject to special consideration by the Register.

## 2.9 PILLARS AND PANTING BEAMS

### 2.9.1 General and symbols.

**2.9.1.1** Requirements are given in this Chapter for the scantlings of pillars fitted in the hull, superstructures and deckhouses and for the panting beams in peaks.

**2.9.1.2** For the purpose of this Chapter the following symbols have been adopted:

$l$  = length of pillar (panting beam), in m, measured: for the pillar — between the face plate of the deck girder (or the deck transverse, if the latter is supported by the pillar) and the deck plating (or the inner bottom plating); for the panting beam — between the inner edges of the starboard and port frames or from the inner edge of the frame to a strong support at the centerline;

$f$  = sectional area of the pillar (panting beam), in  $\text{cm}^2$ ;

$i$  = the least moment of inertia of the pillar (panting beam), in  $\text{cm}^4$ ;

$d_0$  = outer diameter of the pillar, in mm.

### 2.9.2 Construction.

**2.9.2.1** The pillar axes in 'tween deck spaces and holds shall generally be fitted in the same vertical line, the heads and heels of the pillars shall be bracketed.

Where the heel of a tubular pillar with the load  $P < 250$  kN has no brackets, the deck (inner bottom) plating under the heel shall be strengthened with doubling or insert plates ( $P$  = as determined from 2.9.3.1).

The web of a framing member to which the head of a pillar is attached shall be strengthened with brackets to transmit the load to the pillar.

The pillars shall be fitted on plate floors and side girders which shall be strengthened with vertical brackets. Openings in floors and side girders under the pillars are not permitted.

With the load  $P > 250$  kN ( $P$  = as defined in 2.9.3.1), the pillars shall be fitted at the intersection of plate floors and side girders, otherwise the plate floor (side girder) shall be strengthened with vertical brackets attached to the adjacent floors (side girders).

**2.9.2.2** The pillars shall be attached at their heads and heels by brackets or other arrangements approved by the Register, in order to effectively transmit the loads to the hull structures below:

in the holds of ships of ice categories **Arc9**, **Arc8**, **Arc7**, **Arc6**, **Arc5**;

in the tanks under watertight platforms, deckhouses, ends of superstructures, windlasses, winches, capstans, etc.;

at the fore end of ships with the specified speed  $v_0 > 1,5\sqrt{L}$  or large bow flare.

### 2.9.3 Design loads.

**2.9.3.1** Loading on the pillar  $P$ , in kN, is determined by the formula

$$P = pl_m b_m + \sum_i (pl_m b_m)_i \quad (2.9.3.1)$$

where  $p$  = design pressure on the above deck specified in 2.6.3, in kPa;

$l_m$  = distance measured along the deck girders between mid-points of their spans, in m;

$b_m$  = mean breadth of deck area (including the hatchways in the region concerned) supported by the pillar, in m;

$\sum_i (pl_m b_m)_i$  = sum of loads from the pillars fitted above, determined having regard to 2.6.3, which may be transmitted to the pillar considered, in kN.

**2.9.3.2** Loading on the panting beam  $P$ , in kN, is determined by the formula

$$P = pac \quad (2.9.3.2)$$

where  $p = p_{st} + p_w$  — design pressure on the ship's side in way of installation of the panting beam, determined from 1.3.2.1 and 1.3.2.2, in kPa;

$a$  = spacing of frames on which panting beams are fitted, in m;

$c$  = half-sum of frame spans measured vertically above and under the beam considered, in m.

### 2.9.4 Scantlings of pillars and panting beams.

**2.9.4.1** The sectional area of pillars and panting beams  $f$ , in  $\text{cm}^2$ , shall not be less than determined by the iterative method according to the formula

$$f = 10kP/\sigma_{cr} + \Delta f \quad (2.9.4.1)$$

where  $P$  = as determined in accordance with 2.9.3;

$k = 2$  — buckling strength margin;

$\sigma_{cr}$  = critical stress according to 1.6.5.3 at Euler stress determined by the formula

$$\sigma_e = \frac{206i}{f^2},$$

$\Delta f$  = wear allowances, in  $\text{cm}^2$ , determined by the following formulae:

for tubular pillars

$$\Delta f = 0,03d_0\Delta s;$$

for box-shaped pillars

$$\Delta f = 0,1\Sigma h_i\Delta s,$$

where  $\Sigma h_i$  = perimeter length of cross section, in cm;

for built-up pillars and panting beams (I-beams, made of channels, etc.);

$$\Delta f = 0,05\Sigma h_i\Delta s;$$

$\Delta s$  refer to 1.1.5.1.

**2.9.4.2** The wall thickness  $s$ , in mm, of tubular pillars shall not be taken less than:

$$s = (d_0/50) + 3,5. \quad (2.9.4.2-1)$$

The wall thickness of built-up pillars (box-shaped, made of channels or I-beams, etc.)  $s$ , in mm, shall not be less than:

$$s = h_p/50 \quad (2.9.4.2-2)$$

where  $h_p$  = width of the pillar wall, in mm.

The wall thickness of a pillar, in general, shall not be taken less than 6 mm.

In small ships the thickness of the pillar walls may, on agreement with the Register, be reduced to 5 mm, provided the required sectional area of the pillar is maintained.

## 2.10 STEMS, STERNFRAMES, KEELS, RUDDER HORN, PROPELLER SHAFT BRACKETS, FIXED NOZZLES OF PROPELLERS

### 2.10.1 General.

**2.10.1.1** Requirements are given in this Chapter for the construction and scantlings of the stem, sternframe (rudder post, propeller post), solepiece of the sternframe, rudder horn of semi-spade rudders, propeller shaft brackets, bar keel, fixed nozzles of propellers.

### 2.10.2 Construction.

**2.10.2.1** It is recommended to use a bar or plate type welded stem. The lower part of the stem shall be efficiently connected to the bar or plate keel and, whenever possible, to the centre girder.

The welded stem plates shall be stiffened with transverse brackets. Arrangement of transverse brackets of the stem shall, as far as possible, be consistent with the hull framing. Transverse brackets stiffening the stem plate are fitted not more than 1 m apart below and not more than 1,5 m above the summer load waterline. The brackets shall overlap the joints of the stem with the shell plating and shall be extended and welded to the nearest frames.

The brackets which cannot be extended to the framing, except for the brackets in way of ice belt in ships with ice categories, shall have their rear edge made along a smooth curve.

In case where the radius of curvature of the stem is sufficiently large, it is recommended to fit a centerline girder with a face plate.

**2.10.2.2** The construction of sternframe of a single screw ship shall comply with the following requirements:

**1** the sternframe shall have such dimensions as to provide the clearances between sternframe and propeller, and between propeller and rudder (Fig. 2.10.2.2) not less than indicated in Table 2.10.2.2;

Table 2.10.2.2

Dimensions	$a$	$b$	$c$	$d$	$e$
Clearances, in mm	$0,2R_p$	$0,42R_p$	$0,36R_p$	$0,08R_p$	200 — 250
$R_p$ — radius of propeller, in mm.					



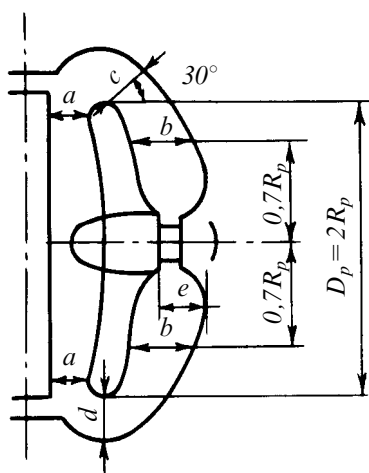


Fig. 2.10.2.2

.2 the solepiece shall be made with a smooth rise in the aft direction;

.3 the propeller post shall be provided with transverse brackets in the case of welded sternframe and webs in the case of cast sternframe. The brackets and webs shall be spaced at least 1 m apart; their arrangement shall be consistent with the hull framing;

.4 the sternframe shall be efficiently attached to the hull.

The lower part of the sternframe shall be extended forward from the propeller post and shall be attached by its brackets (webs) to at least three floors in ships with a length  $L > 120$  m and at least two floors in ships with a length  $L \leq 120$  m. In small ships the sternframe may be attached to one floor only.

The rudder post shall extend over the counter to a height sufficient for its attachment to the transom floor.

In ships of 80 m and above and in ships with cruiser stern, the propeller post shall also be extended upwards to a distance sufficient for its attachment to the additional transom floor.

The thickness of transom floor and additional transom floor shall be increased as compared to that of the floors in the after peak. In general, the above floors shall be extended to the nearest deck or platform.

**2.10.2.3** The sternframe in twin screw ships shall comply with the requirements for the sternframe in single screw ships, as specified in 2.10.2.2. The lower part of the sternframe to be extended forward, may be attached to at least two main floors.

**2.10.2.4** The sternframe of triple screw ships shall comply with the requirements for the sternframe of single screw ships, as specified in 2.10.2.2 and 2.10.4.2.

**2.10.2.5** The rudder horn of semi-spade rudder shall be efficiently connected to the respective floors of the after peak and its centreline wash bulkhead.

The welded rudder horn shall be provided inside with transverse brackets; its main supporting structures shall be extended to the nearest deck or platform; the thickness of the floors to which the rudder horn is connected shall be increased as compared to that of the floors in the after peak.

**2.10.2.6** The struts of two-strut shaft brackets shall form an angle of approximately  $90^\circ$  to each other. Their axes shall intersect at the axis of the propeller shaft.

The construction of propeller shaft brackets with struts arranged at an angle less than  $80^\circ$  and greater than  $100^\circ$ , additional strengthening of the hull within the region of shaft brackets are subject to special consideration by the Register.

The propeller shaft brackets shall be so arranged in relation to the ship's hull that the clearance between the blade tip and the ship's hull is as large as possible and, but, not less than 25 per cent of the propeller diameter.

**2.10.2.7** The outer and inner plating of propeller nozzle shall be strengthened by stiffeners whose arrangement and size as well as connection with outer and inner plating of the propeller nozzle shall be determined according to 2.4.2.2, Part III "Equipment, Arrangements and Outfit".

In general, the transverse web plates shall be arranged in line with the floors of the after peak.

In way of attachment of the nozzle to the hull smooth transition from the nozzle to the ship's hull shall be provided. The bottom part of the nozzle shall be connected to the hull. If the propeller nozzle is attached to the hull by shaft brackets, provision shall be made for an efficient connection of the brackets with the framing in the aft region of the hull and the framing inside the nozzle. The construction of shaft brackets shall satisfy the requirements of 2.10.2.6. Drain plugs of non-corrosive material shall be fitted in the top and bottom parts of outer plating.

### 2.10.3 Design loading.

Design loading for the structures of the solepiece and rudder horn of semi-spade rudders is taken equal to the reaction force of lower support of the rudder  $R_4$  according to 2.2.4.12, Part III "Equipment, Arrangements and Outfit". In the Formulae (2.2.4.7-2) to (2.2.4.7-4) the coefficient  $\alpha_4$  shall be taken equal to zero.

### 2.10.4 Scantlings of stem, sternframe, rudder horn and propeller shaft brackets, bar keel and fixed nozzle of propeller.

**2.10.4.1** The stem shall satisfy the following requirements:

.1 the sectional area  $f$ , in  $\text{cm}^2$ , of a bar stem from the keel to the summer load waterline shall not be less than:

$$f = 1,3L - 4. \quad (2.10.4.1.1)$$

The sectional area may be reduced for ships of restricted areas of navigation:

**R2** and **R2-RSN** — by 10 per cent;

**R3-RSN** and **R3** — by 20 per cent.

Above the summer load waterline the sectional area may be gradually reduced to 70 per cent of the area stated above;

.2 the plate thickness  $s$ , in mm, of welded stem shall not be less than:

$$s = (0,085L + 5,5)\sqrt{\eta}, \quad (2.10.4.1.2)$$

where  $\eta$  = as determined from 1.1.4.3,

but not less than 7 mm.

Where  $L > 220$  m,  $L$  shall be taken equal to 200 m.

The plate thickness of the stem may be reduced for ships of restricted areas of navigation:

**R2** and **R2-RSN** — by 5 per cent;

**R3-RSN** and **R3** — by 10 per cent.

The plate thickness of the stem above the summer load waterline may be gradually reduced to that of shell plates adjoining the stem.

The thickness and width of the stem plates in way of attachment to the plate keel shall not be less than the thickness and width of the latter.

When the distance between the brackets strengthening the stem is reduced by 0,5 m, as compared to that required by 2.10.2.1, the reduction of plate thickness of stem by 20 per cent may be permitted. If the reduction of the distance between the brackets is less than 0,5 m, the permissible reduction of plate thickness shall be determined by linear interpolation;

.3 the thickness of brackets strengthening the stem shall not be less than that of shell plating adjoining the stem.

The thickness of web and face plate of the girder stiffening the stem at the centreline shall not be less than that of the brackets.

**2.10.4.2** The sternframe of a single screw ship shall satisfy the following requirements:

.1 the length  $l_s$  and width  $b_s$ , in mm, of rectangular solid propeller post section, from the keel to the counter, shall not be less than:

$$l_s = 1,30L + 95; \quad b_s = 1,60L + 20 \quad \text{for } L < 120 \text{ m}; \quad (2.10.4.2.1)$$

$$l_s = 1,15L + 110; \quad b_s = 0,675L + 130 \quad \text{for } L \geq 120 \text{ m}.$$

The scantlings of the propeller post may be reduced for ships of restricted areas of navigation:

**R2** and **R2-RSN** — by 5 per cent,

**R3-RSN** and **R3** — by 10 per cent.

Above the counter the sectional area of sternframe may be gradually reduced. And nowhere its sectional area shall be less than 40 per cent of the required area of the propeller post, corresponding to the scantlings stated above;

.2 the scantlings of the propeller post cross section of a cast sternframe with the rudder having top and bottom supports shall be established in accordance with Fig. 2.10.4.2-1 depending on the value  $s_0$ , in mm, determined by the following formulae:

$$s_0 = 0,1L + 4,4 \quad \text{for } L < 200 \text{ m}; \quad (2.10.4.2.2)$$

$$s_0 = 0,06L + 12,4 \quad \text{for } L \geq 200 \text{ m}.$$

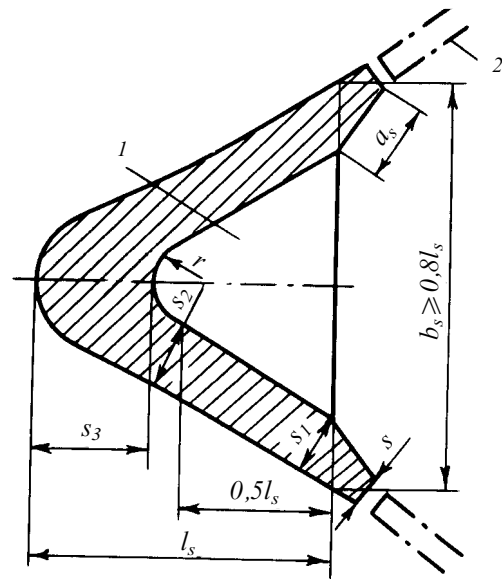


Fig. 2.10.4.2-1:  
1 — web; 2 — adjoining plate of shell;  
 $s_1 = 1,5s_0$ ;  $s_2 = 2,5s_0$ ;  $s_3 = 3,5s_0$ ;  
 $l_s \geq 1,9L + 135$  mm for  $L < 200$  m;  
 $l_s \geq 1,4L + 235$  mm for  $L \geq 200$  m;  
 $r$  — cast radius

The thickness of webs shall be at least 50 per cent greater than that of the shell plating adjoining the sternframe;

.3 the scantlings of the propeller post cross section of a welded sternframe with the rudder having top and bottom supports shall be established according to Fig. 2.10.4.2-2 where  $s_0$  shall be determined in accordance with 2.10.4.2.2. The thickness of transverse brackets shall be at least 20 per cent greater than that of the shell plating adjoining the sternframe.

Welded propeller post of other construction may be used, provided that its strength is equivalent to that of the abovementioned construction;

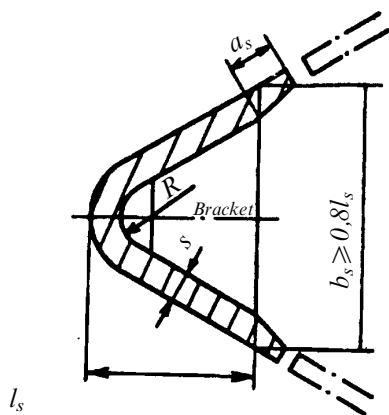


Fig. 2.10.4.2-2:

$s = 1,6s_0$  at  $L < 150$  m;  $s = 1,5s_0$  for  $L \geq 150$  m;  
 $l_s = 2,5L + 180$  mm for  $L < 200$  m;  
 $l_s = 1,4L + 400$  mm for  $L \geq 200$  m;  
 $R$  — bending radius

**.4** the finished thickness of propeller boss shall be not less than 30 per cent of the shaft diameter;

**.5** the section modulus  $W_s$ , in  $\text{cm}^3$ , of the solepiece about the vertical axis shall not be less than:

$$W_s = 8\alpha R_4 x_s \eta \quad (2.10.4.2.5-1)$$

The section modulus  $W_{r,p}$ , in  $\text{cm}^3$ , of the rudder post about the horizontal longitudinal axis shall not be less than:

$$W_{r,p} = 8(1 - \alpha) R_4 l_s \eta \quad (2.10.4.2.5-2)$$

where  $\alpha = 0,85$  if there is a rudder post;

$\alpha = 1$  if there is no rudder post or a bolted rudder post is fitted;

$R_4$  = as determined according to 2.10.3;

$x_s$  = distance from the solepiece section concerned to the centre of the rudder stock ( $x_s$  shall not be taken less than  $0,5l_s$  and more than  $l_s$ );

$l_s$  = span of the solepiece, measured from the centre of the rudder stock to the beginning of rounding of the propeller post, in m;

$l_{r,p}$  = span of the rudder post, measured vertically from the mid-thickness of solepiece at the centre of the rudder stock to the beginning of rounding in the upper part of the rudder post, in m;

$\eta$  = as determined according to 1.1.4.3.

The section modulus of the solepiece about the horizontal transverse axis shall not be less than  $0,5W_s$ , where  $W_s$  shall be determined by the Formula (2.10.4.2.5-1). The section modulus of the rudder post about the horizontal transverse axis shall not be less than  $0,5W_{r,p}$  where  $W_{r,p}$  shall be determined by the Formula (2.10.4.2.5-2);

**.6** the scantlings of the sternframe structural members may be determined on the basis of direct strength calculation taking the permissible stress factor  $k_\sigma = 0,55$  and external loads according to 2.2, Part III "Equipment, Arrangements and Outfit".

**2.10.4.3** The scantlings of the sternframe of twin screw ships shall satisfy requirements for the scantlings of propeller post in single screw ships as given in 2.10.4.2 with the following amendments:

**.1** the section width of the sternframe of a solid rectangular cross section may be reduced by 50 per cent as compared with that required by 2.10.4.2.1;

**.2** the scantlings of the cast or welded sternframe may be reduced as compared with those required by 2.10.4.2.2 and 2.10.4.2.3 respectively, so that their section moduli about the horizontal longitudinal and transverse axes, are reduced by not more than 50 per cent. The thickness of the sternframe wall shall be at least 7 mm.

**2.10.4.4** For semi-spade rudders with one gudgeon upon the horn, the section modulus, in  $\text{cm}^3$ , of the rudder horn about the horizontal longitudinal axis shall not be less than:

$$W = 12R_4 z_s \eta \quad (2.10.4.4)$$

where  $R_4$  = as defined in 2.10.3;

$z_s$  = vertical distance for the mid-thickness of the horn gudgeon to the section concerned, in m ( $z_s$  shall not be taken less than  $0,5l_h$  and more than  $l_h$ );

$l_h$  = horn span measured vertically from the mid-thickness of the horn gudgeon to the point of intersection of the horn axis with shell plating, in m;

$\eta$  = as determined according to 1.1.4.3.

Where the rudder horn is welded of plates, the thickness of the plates, in all cases, shall be at least 7 mm.

The scantlings of the rudder horn may be determined on the basis of direct strength calculation taking the permissible stress factor  $k_\sigma = 0,35$  and external loads according to 2.2, Part III "Equipment, Arrangements and Outfit".

**2.10.4.5** The sectional area of either strut of two-strut shaft brackets shall be equal to not less than 60 per cent of the propeller shaft section in the bracket plane, the strut thickness — to not less than 45 per cent, and the boss thickness — to not less than 35 per cent of the propeller shaft diameter. The length of the boss shall be in accordance with 5.6.1, Part VII "Machinery Installations".

The strength of the welded shaft brackets shall not be less than that specified above. The plate thickness shall not be less than 7 mm.

The weld area of rivets attaching each strut to the hull shall not be less than 25 per cent of the propeller shaft sectional area. Where the struts are attached by means of flanges, the thickness of the latter shall be not less than 25 per cent of the propeller shaft diameter.

**2.10.4.6** The height  $h_s$  and width  $b_s$ , in mm, of the bar keel cross section shall not be less than:

$$\begin{aligned}
 h_s &= 1,3L + 100; \\
 b_s &= 0,7L + 8 \text{ for } L < 60 \text{ m}; \\
 b_s &= 0,4L + 26 \text{ for } L \geq 60 \text{ m}.
 \end{aligned}
 \tag{2.10.4.6}$$

The height and width of the bar keel cross section may be reduced for ships of restricted areas of navigation:

**R2** and **R2-RSN** — by 5 per cent;

**R3-RSN** and **R3** — by 10 per cent.

**2.10.4.7** The thickness of outer and inner plating of fixed propeller nozzle shall comply with the requirements of 2.4.2, Part III "Equipment, Arrangements and Outfit" taking the following into consideration:

width of middle belt of inner plating shall be not less than the distance from  $0,03D_o$  forward of the propeller blade tips and  $0,07D_o$  aft of the propeller blade tips where  $D_o$  is the internal diameter of propeller nozzle;

thickness of forward part of the inner and outer plating shall be not less than required for side shell plating (refer to 2.2.4.1 for transverse framing system).

The width of attachment shall be at least  $0,15D_o$ .

The cross-sectional area of the joint shall be not less than required by 2.10.4.2.5 for the solepiece. If the solepiece serves as support of the rudder, the connection of the nozzle to the solepiece is subject to special consideration by the Register.

For twin screw ships when the propeller nozzle is not attached to the hull at its bottom part, the width of attachment at the top part shall be not less than  $0,3D_o$ .

If the propeller nozzle is attached to the hull by shaft brackets, their strength shall comply with the requirements of 2.10.4.5.

In way of attachment of the nozzle to the hull the thickness of framing members shall not be less than required by the Formula (2.4.2.2-2), Part III "Equipment, Arrangements and Outfit".

## 2.11 SEATINGS OF MACHINERY AND BOILERS

### 2.11.1 General.

**2.11.1.1** Requirements are given in this Chapter for the construction and dimensions of the seatings intended for main machinery and boilers, deck machinery, fishing installations, cargo handling gear, auxiliary machinery, etc.

**2.11.1.2** The requirements laid down in this Chapter are minimum. Requirements concerning construction and dimensions of structural components of a seating, which are contained in the technical documentation of the machinery, unit or device to be installed on the seating concerned, shall also be complied with.

### 2.11.2 Construction of seatings.

**2.11.2.1** The construction of seatings shall satisfy the following requirements:

**.1** the seating shall be of substantial construction to ensure efficient attachment of machinery, gear or device and transmission of forces to the hull framing, which shall be sufficiently strong. If necessary, the framing may be strengthened;

**.2** the seating shall be so constructed that the resonance vibration of the seating as a whole and of its structural components can be avoided under all specified running conditions;

**.3** where the seating in ships with a length  $L > 65$  m is installed on the continuous longitudinals of strength deck and double bottom (bottom) within  $0,5L$  amidships, the height of the vertical plates of the seating at the ends shall be gradually reduced. If the length of the vertical plate is more than six times its height, the vertical plate and its top plate shall be made of the same steel grade as the deck or double bottom (bottom) structural member on which it is installed. The structural components of the seating shall not terminate at the unsupported portions of plating. Attachment of the seating to the upper edge of sheerstrake is subject to special consideration by the Register;

**.4** the seating shall be so designed that the plating beneath is accessible for inspection. Measures shall be taken to prevent water from accumulating under the seating.

In particular cases agreed with the Register, a hermetic construction of the seating is permitted, the inner space of the seating being filled with some chemically neutral material with good adhesion properties.

**2.11.2.2** In general, a seating of main machinery and boilers shall comprise two vertical plates (girder webs) (for medium-speed and high power engines — four vertical plates (two — either side of the engine)) and horizontal face plates (top plates) to which the machinery (boiler) shall be attached directly. The vertical plates shall be strengthened with brackets (knees) having face plates (flanges) along the free edges.

Where the seating comprises four vertical plates, the top plate is attached to two vertical plates fitted on one side of the machinery; the outer plates shall have openings to provide access into the seating. In the case of medium-speed engines, such openings shall not extend to the top plate. The outer plates may be made sloped.

All the vertical plates shall be fitted in line with the main or additional side girders.

**2.11.2.3** Machinery and equipment may be installed on shell plating of the hull, tight bulkheads, decks and platforms (including tank bulkheads and crown), inner bottom and shaft-tunnel platings on

condition they are attached to the framing members and stiffeners (refer to 1.7.1.4), or on cantilevers connected to framing members or stiffeners.

Attachment of small-sized machinery and equipment directly to the above-mentioned structure with the help of welded pads is not permitted.

### 2.11.3 Dimensions of structures of seatings.

**2.11.3.1** The thickness  $s$ , in mm, of structural components of a seating of main machinery or boiler shall not be less than:

$$s = k_0 \sqrt[3]{Q} + k_1 \quad (2.11.3.1)$$

where  $Q$  = mass of machinery (boiler) in working condition, in t;  
 $k_0$  = factor given in Table 2.11.3.1-1;  
 $k_1$  = factor given in Table 2.11.3.1-2.

Table 2.11.3.1-1

Seating of machinery (boiler)	$k_0$		
	Top plates	Vertical plates <sup>1</sup>	Brackets, knees
Main internal combustion engine	4,65	3,0	2,5
Main geared turbine set, main diesel generator and propulsion motor	4,15	2,7	2,7
Boiler	3,65	2,4	2,4

<sup>1</sup>In a seating with four vertical plates the thickness of the plates may be taken equal to the thickness of brackets and knees.

Table 2.11.3.1-2

Mass of machinery (boiler), in t	≤ 20	> 20 ≤ 50	> 50 ≤ 100	> 100 ≤ 200	> 200
$k_1$	4	3	2	1	0

**2.11.3.2** The thickness  $s$ , in mm, of structural components of a seating of main internal combustion engine shall not be less than:

$$s = k_2 \sqrt[3]{N} + k_3 \quad (2.11.3.2)$$

where  $N$  = specified power of the engine, in kW;  
 $k_2, k_3$  = factors given in Table 2.11.3.2,

but not less than required by 2.11.3.1.

Table 2.11.3.2

$N$ , in kW	Number of vertical plates	Factor	Top plates	Vertical plates	Brackets, knees
≤ 1000	2	$k_2$	1,7	1,1	0,9
		$k_3$	6	4	3
	4	$k_2$	1,4	0,9	0,9
		$k_3$	5	3	3
> 1000	2	$k_2$	1,0	1,0	0,7
		$k_3$	13	5	5
	4	$k_2$	0,8	0,7	0,7
		$k_3$	11	5	5

## 2.12 SUPERSTRUCTURES, DECKHOUSES AND QUARTER DECKS

### 2.12.1 General provisions, definitions and symbols.

**2.12.1.1** Requirements are given in this Chapter for short and long bridges extending from side to side of the ship as well as to short bridges which do not extend to the sides of the ship, forecastle, poop, long forecastle and poop extending to ship's sides, short deckhouses and quarter decks.

The applicability of the requirements contained in this Chapter to long superstructures not extending from side to side of the ship as well as to long deckhouses shall be specially agreed with the Register.

**2.12.1.2** For the purpose of this Chapter the following definitions have been adopted.

**Long deckhouse** is a deckhouse of a length not less than that determined by the Formula (2.12.1.2-1), but not less than  $0,20L$ , having no expansion or sliding joints.

**Long bridge** is a superstructure having a length not less than:

$$l_1 = 2l_e, \quad (2.12.1.2-1)$$

but not less than  $0,15L$ .

**Quarter deck** is the after part of upper deck stepped up to a portion of 'tween deck height.

**Short deckhouse** is any deckhouse which is not a long deckhouse. Deckhouses of ships less than 65 m in length are considered as short deckhouses.

**Short bridge** is any bridge which is not a long bridge. Superstructures of ships less than 65 m in length are considered as short superstructures.

**Ends of superstructures and deckhouses** are the ends of the length measured from the end bulkheads, in m:

$$l_e = 1,5(B_2/2 + h). \quad (2.12.1.2-2)$$

**Transition area of quarter deck** is an area measured from the forward edge of break to the after edge of upper deck plating and extending below the quarter deck.

**Long forecastle (poop)** is a forecastle (poop) having a length not less than:

$$l_1 = 0,1L + l_e, \quad (2.12.1.2-3)$$

in ships of 65 m and greater in length.

**2.12.1.3** For the purpose of this Chapter the following symbols have been adopted:

$B_2$  = breadth of superstructure deck measured at its mid-length, excluding the breadth of openings of cargo hatches, machinery casings, if any, in m;

$h$  = height of the first tier of superstructure or deckhouse, in m;

$l_1$  = length of superstructure (deckhouse) measured between the end bulkheads; the length of forecastle (poop) measured from the fore or after perpendicular to the end bulkhead of the forecastle (poop), in m;

$B_x$  = ship's breadth at the level of the upper deck at the section considered, in m;

$b$  = breadth of the deckhouse, in m.

### 2.12.2 Construction.

**2.12.2.1** For the first tier of long bridge outside the end portions, long forecastle (poop) outside the end portion, the requirements of 2.6 for the upper deck and the requirements of 2.2 and 2.5 for the ship's side in way of the upper 'tween deck space shall be complied with.

**2.12.2.2** For the bottom strake of side plating and longitudinal bulkhead plating of short bridge, the ends of 1st tier long bridges and long forecastle (poop), the bottom strake of side plating of steel short deckhouses and the ends of steel long deckhouses fitted on the strength deck, grade of steel and yield stress shall be the same as required for the strength deck in this region. The width of the bottom strake shall not be less than  $0,5h$ .

**2.12.2.3** Whenever practicable, the end bulkheads of superstructures and deckhouses shall be situated in line with the hull transverse bulkheads or as close to the latter as possible.

Web frames or vertical webs, bulkheads or partial bulkheads shall be fitted in superstructures and deckhouses in such a way as to be in line with girder webs or bulkheads of hull structures located below. The vertical webs of end bulkheads shall be fitted in line with the vertical webs of hull bulkheads.

**2.12.2.4** The lower ends of vertical stiffeners of the end bulkheads of the 1st tier superstructures and deckhouses shall be welded to the deck. The lower ends of side vertical stiffeners of 1st tier houses shall be attached to the deck by brackets.

**2.12.2.5** Adequate strengthening shall be provided for the structures of deckhouses and superstructures where launching and recovery appliances for survival craft and rescue boats are fitted.

### 2.12.3 Design loading.

**2.12.3.1** The design loading on the superstructure sides and on the superstructure and deckhouse decks shall satisfy the following requirements:

**1** design pressure on the superstructure sides is determined according to 2.2.3;

**2** design pressure on weather areas of the superstructure and deckhouse decks shall be determined by the formula

$$p = \alpha p_w \quad (2.12.3.1.2)$$

where  $p_w$  = wave load at the deck level according to 1.3.2.2;

$\alpha = 0,9$  for forecastle deck, long forecastle deck or part of long bridge deck within  $0,2L$  from the fore perpendicular;

$\alpha = 0,8$  for poop deck, long poop deck or part of long bridge deck within  $0,2L$  from the after perpendicular;

$\alpha = 0,7$  for short bridge and deckhouse decks, long superstructure and deckhouse decks, long forecastle and poop decks within the midship region. For areas of long bridge and deckhouse decks, long forecastle and poop decks outside the midship region and outside areas situated at  $0,2L$  from the fore or after perpendicular,  $\alpha$  shall be determined by linear interpolation,

but not less than  $p_{\min}$ .

For the 1st tier superstructure and deckhouse decks,  $p_{\min}$ , in kPa, shall be determined by the following formulae:

for forecastle, long forecastle decks or part of long bridge deck within  $0,2L$  from the fore perpendicular

$$p_{\min} = 0,1L + 7;$$

for poop, long poop deck or part of long bridge deck within  $0,2L$  from the after perpendicular

$$p_{\min} = 0,015L + 4 \text{ for } L \leq 80 \text{ m};$$

$$p_{\min} = 0,03L + 2,8 \text{ for } L > 80 \text{ m};$$

for bridge and deckhouse decks, long forecastle and poop decks within the midship region

$$p_{\min} = 0,015L + 4;$$

for areas of bridge and deckhouse decks, long forecastle and poop decks outside the midship region and outside areas situated at  $0,2L$  from the fore or after perpendicular,  $p_{\min}$  shall be determined by linear interpolation.

For decks of the superstructures and deckhouses of the 2nd and upper tiers

$$p_{\min} = 2 \text{ kPa.}$$

For ships greater than 250 m in length,  $p_{\min}$  is determined taking  $L = 250 \text{ m}$ .

For ships of restricted area of navigation,  $p_{\min}$  may be reduced by multiplying by the factor  $\phi_r$  obtained from Table 1.3.1.5.

**2.12.3.2** Pressure on the end bulkheads of superstructures and deckhouses as well as on sides of deckhouses  $p$ , in kPa, is determined by the formula

$$p = 5,1nc_2(kz_0 - z_1) \quad (2.12.3.2)$$

where  $n$  = factor determined from Table 2.12.3.2-1;

$c_2 = 0,3 + 0,7b/B_x$ , in this case,  $c_2 \geq 0,5$ ;

$$k = 1,0 + \left( \frac{x_1/L - 0,45}{C_b + 0,2} \right)^2 \text{ when } x_1/L \leq 0,45;$$

$$k = 1,0 + 1,5 \left( \frac{x_1/L - 0,45}{C_b + 0,5} \right)^2 \text{ when } x_1/L > 0,45;$$

for the sides of deckhouses the factor  $k$  is assumed to vary for the length of bulkhead. For this purpose the deckhouse is subdivided into parts of approximately equal length not exceeding  $0,15L$  each, and  $x_1$  is taken as the distance between the after perpendicular and the middle of the part considered;

$C_b$  shall be taken as not less than 0,6, nor greater than 0,8; for the aft end bulkheads forward of amidships  $C_b = 0,8$ ;

$z_0$  = as given in Table 2.12.3.2-2;

$z_1$  = vertical distance, in m, from the summer load waterline to the mid-point of the plate panel considered or the mid-point of span of the bulkhead stiffener.

Table 2.12.3.2-1

Bulkhead	Structure		$n$
Front	Unprotected	1st tier	$2 + L_0/120$
		2nd tier	$1 + L_0/120$
		3rd tier	$0,5 + L_0/150^1$
	Protected		
Aft end	Aft of amidships		$0,7 + L_0/1000 - 0,8x_1/L$
	Forward of amidships		$0,5 + L_0/1000 - 0,4x_1/L$
$L_0 =$ length of ship, in m (to be taken not greater than 300 m for the purpose of calculation);			
$x_1 =$ distance, in m, between the after perpendicular and the bulkhead under consideration.			
<sup>1</sup> Formula is also used for the deckhouses sides.			

Table 2.12.3.2-2

$L$ , in m	$z_0$ , in m	$L$ , in m	$z_0$ , in m
20	0,87	180	9,85
40	2,59	200	10,25
60	4,07	220	10,55
80	5,42	240	10,77
100	6,6	260	10,92
120	7,69	280	11,0
140	8,63	300	11,03
160	9,35	350	11,05

The above-stated values of factor  $n$  apply to a ship having the freeboard equal to minimum tabular freeboard of Type "B" ships, and a standard height of superstructures according to Section 4 of Load Line Rules for Sea-Going Ships. If the deck of the tier considered is situated higher than the standard position due to an increase of freeboard, as against the tabular value, then the appropriate factor  $n$  may be determined by linear interpolation between the values of that factor for superstructures with standard and actual positions of decks under the superstructures.

In any case, the design pressure shall not be taken less than indicated in Table 2.12.3.2-3.

Table 2.12.3.2-3

$L$ , in m	Design pressure $p$ , in kPa	
	for 1st tier unprotected fronts	elsewhere
$\leq 50$	15,6	7,8
$50 < L < 250$	$13 + 0,052L$	$6,5 + 0,026L$
$\geq 250$	26	13

For ships of restricted area of navigation the design pressure may be reduced by multiplying by the factor  $\phi_r$  obtained from Table 1.3.1.5.

#### 2.12.4 Scantlings of structures of superstructures, deckhouses and quarter decks.

**2.12.4.1** The thickness of side plating of short and long bridges, forecastle and poop, long forecastle and poop shall be determined according to 2.2.4.1 using the design loads given in 2.12.3.1.1. For short bridges, forecastle and poop,  $k_\sigma = 0,7$ .

For long bridge, long forecastle and poop outside the end portions,  $k_\sigma$  is determined according to 2.2.4.1; at sections in way of end bulkheads  $k_\sigma = 0,7$ ; within the end portions  $k_\sigma$  shall be determined by linear interpolation.

The thickness of side plating of long bridges, long forecastle and poop shall satisfy the requirements of 2.2.4.8.

In any case, the thickness  $s_{\min}$ , in mm, of side plating of short bridges, forecastle and poop shall not be less than:

for superstructures of the lowest tier

$$s_{\min} = (4,5 + 0,025L)\sqrt{\eta};$$

for superstructures of other tiers

$$s_{\min} = (4 + 0,02L)\sqrt{\eta}$$

where  $\eta$  is obtained from Table 1.1.4.3.

Where  $L > 300$  mm,  $L$  shall be taken equal to 300 m.

For ships of unrestricted service and ships of restricted area of navigation **R1**, the reduction of minimal thickness, but not more than 10 per cent, is permitted in proportion to the ratio of adopted spacing to standard spacing, where the adopted spacing is less than the standard one (refer to 1.1.3). In any case, for ships of 30 m and greater in length the minimum thickness shall be not less than 5 mm.

**2.12.4.2** The thickness of deck plating of short and long bridges, forecastle and poop, long forecastle and poop, short and long deckhouses shall be determined according to 2.6.4.1.1 and 2.6.4.1.2 using the design loads stated in 2.12.3.1.2. For short bridges, forecastle, poop and short deckhouses,  $k_\sigma = 0,7$ .

For long bridge, long forecastle and poop outside the end portions,  $k_\sigma$  is determined as for the strength deck according to 2.6.4.1.2; at sections in way of end bulkheads  $k_\sigma$  shall be determined by linear interpolation.

The thickness of deck plating of long bridges, long forecastle and poop, long deckhouses shall satisfy the requirements of 2.6.4.1.5 for the upper deck between the side and the line of large openings.

In any case, the thickness  $s_{\min}$  in mm, of deck plating of short bridges, forecastle and poop, short deckhouses shall not be less than:

$$\begin{aligned} &\text{for open forecastle deck} \\ s_{\min} &= (4 + 0,04L)\sqrt{\eta} \text{ for } L < 100 \text{ m}; \quad (2.12.4.2-1) \\ s_{\min} &= (7 + 0,01L)\sqrt{\eta} \text{ for } L \geq 100 \text{ m}; \end{aligned}$$

$$\begin{aligned} &\text{for other decks of superstructures and deck-} \\ &\text{houses of the lowest tier} \\ s_{\min} &= (5 + 0,01L)\sqrt{\eta}; \quad (2.12.4.2-2) \end{aligned}$$

$$\begin{aligned} &\text{for superstructure and deckhouse decks of other} \\ &\text{tiers} \\ s_{\min} &= (4 + 0,01L)\sqrt{\eta} \quad (2.12.4.2-3) \end{aligned}$$

where  $\eta$  is obtained from 1.1.4.3.

Where  $L > 300$  m,  $L$  shall be taken equal to 300 m.

For ships of unrestricted service and ships of restricted area of navigation **R1**, the reduction of minimal thickness, but not more than 10 per cent, is permitted in proportion to the ratio of adopted spacing to standard spacing, where the adopted spacing is less than the standard one (refer to 1.1.3). In any case, the minimum thickness may be reduced to 4 mm for ships of length  $L \geq 50$  m and to 3 mm for ships of length  $L < 20$  m, subject to agreement with the Register.

**2.12.4.3** The plate thickness of the end bulkheads of superstructures, sides and end bulkheads of deckhouses shall not be less than that determined by the Formula (1.6.4.4) taking:

$$\begin{aligned} m &= 15,8; \\ k_{\sigma} &= 0,6 \\ \Delta s &= 0, \\ p &= \text{as defined in 2.12.3.2.} \end{aligned}$$

The thickness of side plating of deckhouses may be not less than that of superstructures as stated in 2.12.4.1, provided they are arranged similarly over the ship's length and depth.

The thickness of bottom plates of end bulkheads in superstructures (deckhouses) of 1st tier shall be increased by 1 mm as compared with the design thickness. The width of bottom plate shall be not less than 0,5 mm.

If the deckhouse front extends in a fair convex form beyond the intersection with the deckhouse sides, the thickness of plating may be taken 0,5 mm less as compared with the design value.

**2.12.4.4** In any case, the plate thickness  $s_{\min}$ , in mm, of superstructure end bulkheads, sides and end bulkheads of deckhouses shall not be less than:

$$\begin{aligned} &\text{for the lowest tier} \\ s_{\min} &= (5 + 0,01L)\sqrt{\eta}; \quad (2.12.4.4-1) \end{aligned}$$

for other tiers

$$s_{\min} = (4 + 0,01L)\sqrt{\eta} \quad (2.12.4.4-2)$$

where  $\eta$  is obtained from 1.1.4.3.

Where  $L > 300$  m,  $L$  shall be taken equal to 300 m.

In any case, the minimum thickness shall not be less than 5 mm for ships of length  $L \geq 50$  m. The minimum thickness may be reduced to 4 mm for ships of length  $L < 20$  m and to 3 mm for ships of length  $L < 20$  m, subject to an agreement with the Register. Reduction of the minimum thickness is not permitted for fronts of bridge and unprotected front of poop in ships of length  $L \geq 20$  m.

**2.12.4.5** Framing of the sides, decks and end bulk-heads of the forecastle, poop and bridge, quarter deck and deckhouse shall satisfy the following requirements:

**1** side framing of the superstructure shall comply with the requirements for side framing in 'tween deck space as specified in 2.5.4.2 to 2.5.4.5 using the design loads given in 2.12.3.1.1. For longitudinals and side stringers of short bridge, forecastle and poop,  $k_{\sigma} = 0,65$ ;

For longitudinals and side stringers of long bridge, long forecastle and poop outside the end portions,  $k_{\sigma}$  is determined according to 2.5.4.3 and 2.5.4.4; at sections in way of the end bulkheads  $k_{\sigma} = 0,65$ ; within the end portions  $k_{\sigma}$  shall be determined by linear interpolation;

**2** underdeck framing of the superstructure and deckhouse shall satisfy the requirements of 2.6.4.2 to 2.6.4.9 using the design loads stated in 2.12.3.1.2. For longitudinals and deck girders of short bridge, forecastle and poop,  $k_{\sigma} = 0,65$ .

For longitudinals and deck girders of long bridge, long forecastle and poop outside the end portions,  $k_{\sigma}$  is determined in accordance with 2.6.4.2 and 2.6.4.4; at sections in way of the end bulkheads  $k_{\sigma} = 0,65$ ; within the end portions  $k_{\sigma}$  shall be determined by linear interpolation;

**3** the section modulus of vertical stiffeners of the end bulkheads of superstructures, deckhouse sides and end bulkheads shall not be less than that determined according to 1.6.4.1 taking:

$$\begin{aligned} k_{\sigma} &= 0,6; \\ \omega_c &= 1; \\ p &= \text{as defined in 2.12.3.2;} \end{aligned}$$

$m = 12$ , if the lower end of the stiffener is attached to the deck by a bracket;

$m = 10$ , if the lower end of the stiffener is welded to the deck;

$m = 8$ , if the lower end of the stiffener is sniped.

The section modulus of stiffeners of deckhouse sides need not be greater than that of frames of superstructures as stated in 2.12.4.5.1, where arranged similarly over ship's length and depth.



**2.12.4.6** The scantlings of members of bulkheads and partial bulkheads inside the superstructures and deckhouses shall satisfy the requirements of 2.7.4.5, unless stated otherwise.

**2.12.5 Special requirements.**

**2.12.5.1** The upper deck areas situated under the long bridge, long forecastle and poop outside the end portions shall satisfy the requirements of 2.6 for the second deck. Requirements for the upper deck areas situated under the ends of long bridge, long forecastle and poop are determined by linear interpolation between the requirements for the upper deck and those for the second deck.

**2.12.5.2** In way of the end bulkheads the following requirements shall be complied with:

**.1** where the superstructure end bulkhead is not in line with the transverse bulkhead of the hull, partial bulkheads or pillars shall be fitted in spaces below the end bulkhead, or frames and beam knees shall be strengthened;

**.2** where the end bulkhead of long deckhouse is not in line with the transverse bulkhead below, short deck girders shall be fitted in line with deckhouse sides under the house deck so as to extend further for three frame spaces forward and aft of the deckhouse end bulkhead;

**.3** at the section, where the end bulkheads of superstructures and deckhouses abut on the undeck longitudinal structures and the sides of deckhouses — on the transverse underdeck structures fitted below (bulkheads, partial bulkheads, undeck girders, deck transverses, etc.), the webs of these underdeck structures shall be stiffened with brackets.

**2.12.5.3** The structure at the ends of superstructures shall satisfy the following requirements:

**.1** at the ends of bridge, long forecastle and poop located within  $0,6L$  midship region of a ship with a length  $L \geq 60$  m the side plating shall be extended beyond the end bulkhead with smooth tapering to the ship's side on a length  $d_1$ , in m, (Fig. 2.12.5.3), determined by the formula

$$d_1 \geq 0,2(B_2/2 + h). \quad (2.12.5.3.1)$$

On agreement with the Register, the value of  $d_1$  may be reduced provided that the thickness of bottom strake of the superstructure side plating, sheer-strake and deck stringer plate within the region shown in Fig. 2.12.5.3 is increased;

**.2** if the end of superstructure (forecastle, poop) is located within  $0,1L$  from the fore or after perpendicular, as well as in ships of length  $L < 65$  m, the value of  $d_1$  in accordance with 2.12.5.3 may be reduced by half. If the end of a superstructure is located outside the above-mentioned regions and outside  $0,6L$  amidships, the value of  $d_1$  shall be determined by linear interpolation;

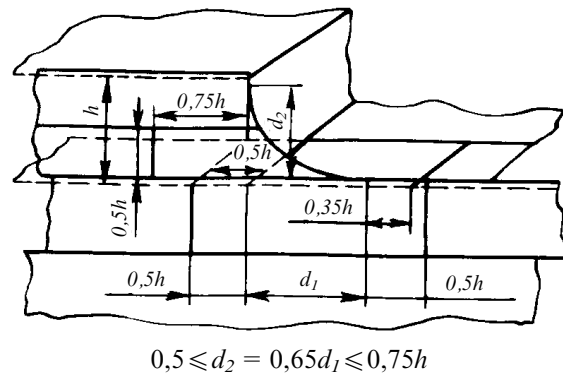


Fig. 2.12.5.3

**.3** the blunted ends of projecting side plates shall be machined flush with the deck.

The curved edge of side plating shall be stiffened by flat bar carried down for 50 mm from the edge. The ends of that bar shall be sniped.

Openings in side plating projecting beyond the ends of a superstructure are normally not permitted. The projecting plates shall be attached to the bulwark by means of flexible joints;

**.4** at the ends of short bridge not extending from side to side of ship the attachment of the side to the deck shall be made similarly to the attachment required by 2.12.5.4 for deckhouses, otherwise gussets shall be used to provide smooth transition from the side to a short deck girder strengthening the deck under that side with simultaneous strengthening of the deck stringer plate within the region shown in Fig. 2.12.5.3.

**2.12.5.4** Attachment of sides of the deckhouse to the end bulkhead arranged within  $0,6L$  amidships of a ship with a length  $L \geq 65$  m shall be performed by rounding with a radius  $r$ , in m, determined by the formula

$$r = \frac{l_1}{100} (1,5 + 0,1l_1/b) \leq 1,4 \quad (2.12.5.4)$$

where  $b$  = breadth of the deckhouse in way of the end bulkhead, in m.

**2.12.5.5** Rectangular openings in outer sides and top plating of long deckhouses shall have their corners well rounded and shall be substantially framed. Door openings in the sides of a deckhouse, arranged within  $0,6L$  amidships, shall be additionally reinforced with thickened plates as shown in Fig. 2.12.5.5. Rectangular openings are not permitted for a length not less than the height of the deckhouse counted from the end bulkhead, if the deckhouse is situated on the strength deck.

If door openings in sides are arranged outside the midship region or if the deckhouse is short, the

thickened plates may be fitted only below the opening as shown in Fig. 2.12.5.5.

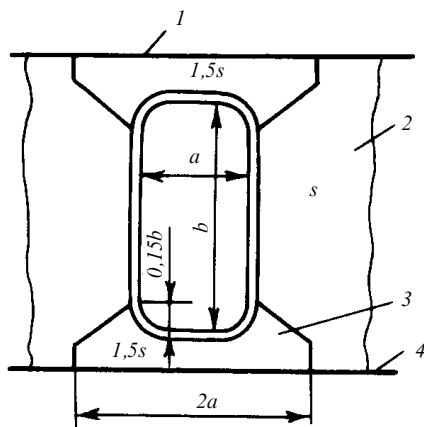


Fig. 2.12.5.5:

1 — deckhouse top; 2 — deckhouse side;  
3 — thickened plate; 4 — strength deck

Where the distance between the expansion or sliding joints is less than a triple height of the deckhouse, it is sufficient to provide the rounding of the corners of openings. Openings for side scuttles shall have the upper and lower edges reinforced with horizontal stiffeners.

**2.12.5.6** Requirements for quarter deck in ships greater than 90 m in length are subject to special consideration by the Register. The structures in way of the break at connection of the upper deck to quarter deck in ships of 90 m and under shall satisfy the following requirements:

**.1** the upper deck plating in way of the break shall extend abaft the break for three frame spaces in ships of 60 m in length and above, and for two frame spaces in ships less than 60 m in length. The upper deck plating of ships less than 40 m in length need not extend abaft the break;

**.2** the upper deck stringer plate shall extend abaft the steel plating for three frame spaces, where  $L \geq 60$  m, and for two frame spaces, where  $L < 60$  m.

The stringer plate so arranged shall be tapered from its full width to a width equal to the depth of frame to which it is welded;

**.3** the stringer plate of quarter deck shall extend forward in the form of a bracket gradually tapered to ship's side on a length of three frame spaces. The quarter deck stringer plate projecting beyond the break shall be adequately stiffened and its free edge shall have a face plate or flange;

**.4** the sheerstrake of quarter deck shall extend forward of the deck stringer plate projecting beyond

the break bulkhead for at least 1,5 times the height of break and shall be smoothly tapered into the upper edge of ship's side sheerstrake. For other structural requirements, refer to 2.12.5.3;

**.5** diaphragm plates spaced not more than 1,5 m apart shall be fitted over the ship's breadth between the overlapping decks in way of the break. The thickness of diaphragms shall not be less than the thickness of the break bulkhead plating.

The diaphragm plates shall be strengthened by vertical stiffeners.

Vertical stiffeners with effective flange shall have a moment of inertia not less than that determined by the Formula (1.6.5.6-1).

Continuous welds shall be used to attach the horizontal edges of diaphragm plates to the decks, and the vertical edges to break bulkhead on one side, and on the other side to an extra supporting bulkhead made of continuous plate welded to the decks over the ship breadth. The plate thickness of that bulkhead shall be not less than the thickness of break bulkhead plating and may have openings between diaphragms;

**.6** where a supporting bulkhead is fitted, the diaphragm plates shall be stiffened with brackets fitted to their ends (Fig. 2.12.5.6.6);

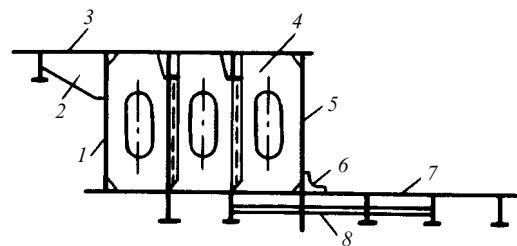


Fig. 2.12.5.6.6:

1 — supporting bulkhead; 2, 6 — brackets; 3 — quarter deck;  
4 — diaphragm; 5 — break bulkhead; 7 — upper deck;  
8 — stiffener in line with bracket

**.7** where a raised quarter deck is adjoining the bridge, it shall extend into that superstructure for two frame spaces beyond the break, the extension being, in any case, not less than the elevation of superstructure above the quarter deck.

The quarter deck stringer plate shall extend forward for two frame spaces with the width gradually reduced as required by 2.12.5.6.2.

Strengthening of the overlapping decks in way of break shall comply with requirements of 2.12.5.6.5 and 2.12.5.6.6 depending on the location of the break along the length of the ship.

The superstructure side plates extending aft of the superstructure shall be smoothly tapered into the sheerstrake on a length of at least 1,5 times the height of break (refer also to 2.12.5.3.1);

**.8** strengthening in case where the break bulkhead is located within  $0,25L$  from the after perpendicular shall comply with the following requirements:

in ships greater than 60 m in length, the supporting bulkhead fitted over the breadth the ship may be omitted. The free edges of diaphragm plates shall, in this case, be stiffened with face plates or flanges of a width equal to at least ten thicknesses of the diaphragm plate;

in ships of 60 m in length and below, the upper deck plating need not extend aft of the break over the ship breadth, however, the upper deck stringer and the raised quarter deck stringer and sheerstrake shall be extended forward and aft as provided in 2.12.5.6.3 and 2.12.5.6.4.

**2.12.5.7** The use of aluminium alloys for the construction of deckhouses is permitted. Decks of accommodation and service spaces situated above the machinery and cargo spaces shall be made of steel.

The scantlings of aluminium deckhouses shall be determined according to 1.6.6. The minimum scantlings shall be the same as those required for steel deckhouses.

The degree to which the deckhouse of aluminium alloys contributes to longitudinal bending of the hull and stresses in ship's hull and deckhouse shall be determined according to the procedure approved by the Register.

**2.12.5.8** The helicopter deck members and supporting structures shall satisfy the following requirements:

**.1** the helicopter deck members, depending on its location over the ship's length and depth, shall satisfy the requirements for members of weather deck as specified in 2.6 or superstructure (deckhouse) decks, as specified in 2.12.4.2 and 2.12.4.5.2. In any case, the design pressure shall not be less than:

$$p_{\min} = 2 \text{ kPa.}$$

**.2** the helicopter deck members shall satisfy the requirements for the members of decks intended for the carriage of cargo, as specified in 2.6. The design loading is determined according to 1.3.4.1 on the basis of the greatest mass of helicopters and equipment stowed on that deck during operation of the ship and the additional pressure of 0,5 kPa from snow cover or ice;

**.3** the helicopter deck members shall satisfy the requirements for deck members of ro-ro ships, as specified in 3.2. The design loading under the helicopter landing conditions is determined on the basis of the following:

$Q_0$  = assumed load on the axle, taken to be equal to the maximum take off weight of helicopter, in kN;

$n_0 = 2$  — assumed number of wheels on the axle;

$n = 1$  — number of wheels forming a group;

$u \times v = 0,3 \times 0,3 \text{ m}^2$  — size of tyre print;

$k_d = 1,5$  — dynamic amplification factor;

**.4** if the helicopter deck is not a superstructure or deckhouse deck, its supporting structures shall satisfy the requirements for pillars as stated in 2.9 and/or partial bulkheads as specified in 2.7.4.5 using the design loads given in 2.12.5.8.1 to 2.12.5.8.3;

**.5** if the helicopter deck has parts protruding beyond the side line, requirements for such a helicopter deck are subject to special consideration by the Register.

## 2.13 MACHINERY CASINGS

### 2.13.1 General.

**2.13.1.1** Openings in decks and platforms over engine rooms shall be protected by strong casings.

The casings may be omitted only in cases where the space on the deck or platform is a part of the engine room.

### 2.13.2 Construction.

**2.13.2.1** Where there are large openings in the deck in way of engine room, additional pillars and deck transverses shall be fitted for strengthening of the deck in way of machinery casing.

**2.13.2.2** For the lower strake of the casing longitudinal wall plating, adjoining the strength deck within the  $0,6L$  midship region of ships with a length  $L \geq 65$  m of steel grade and yield stress shall be the same as for the strength deck plating in this region.

**2.13.2.3** Where the opening for machinery casing is arranged in the strength deck, the requirements of 2.6.5.1 regarding the design of corners and compensation for openings shall be complied with.

### 2.13.3 Scantlings of machinery casing structures.

**2.13.3.1** The part of machinery casing located inside the enclosed spaces ('tween deck spaces, fore-castle, poop, bridge, deckhouse) shall comply with the requirements of 2.7.4.5 for partial bulkheads. The spacing of stiffeners shall not exceed 0,9 m.

The thickness of plating of the part of machinery casing located inside the poop, bridge or deckhouse may be 0,5 mm less than specified.

**2.13.3.2** The part of machinery casing located below the bulkhead deck shall comply with the requirements of 2.7.2.3, 2.7.4.1 to 2.7.4.3 for watertight bulkheads where it is included in subdivision calculation as watertight construction.

**2.13.3.3** The part of machinery casing located above weather deck shall comply with the requirements of 2.12 for deckhouses situated in the same region of the ship. In calculating the design loading by the Formula (2.12.3.2)  $c_2$  shall be taken equal to 1.

## 2.14 BULWARKS

### 2.14.1 General.

Bulwarks of strong construction shall be provided in places specified in 8.6, Part III "Equipment, Arrangements and Outfit".

The construction of bulwarks in the midship region of ships of 65 m and above shall be such that the bulwark contributes to longitudinal bending of the hull.

### 2.14.2 Construction.

**2.14.2.1** The height of the bulwark as measured from the upper edge of the deck plating or from that of planking, if any, to the upper edge of the rail section shall comply with the requirements of 8.6.2, Part III "Equipment, Arrangements and Outfit".

**2.14.2.2** The bulwark plating within the 0,6L midship region of ships of 65 m and above shall be welded to the upper edge of sheerstrake. Outside the above-mentioned region as well as in ships less than 65 m in length, the openings cut in bulwarks shall be so designed as to ensure a smooth transition (with a radius not less than 100 mm) from the bulwark plate to the sheerstrake.

Within 0,07L from the fore perpendicular the welding of bulwark plating to the sheerstrake is necessary.

**2.14.2.3** The bulwark shall be supported by stays spaced not more than 1,8 m apart. In the region of uprights for timber deck cargo, fastening to bulwarks, as well as at the fore end within 0,07L from the fore perpendicular, the spacing of stays shall be not more than 1,2 m. In the ships with large flare of sides and in ships with minimum assigned freeboard, stays may be required to be fitted at every frame within the region considered.

**2.14.2.4** The stays shall be fitted in line with deck beams, brackets and other structures and shall be welded to the rail section, bulwark plate and deck. The attachment of stays to bulwark shall be ensured on a length not less than half the height of the bulwark.

In welding the stays to the deck, holes sufficient in size to allow free passage of water to the scuppers shall be provided in the stays. The welded connection of the beam (bracket) to deck plating under the stay shall not be weaker than the attachment of stay to deck.

Directly under the lower ends of stays no cut-outs in the deck beams and no gaps between frame ends and deck are permitted.

The dimensions of lightening holes in stays shall not exceed half the stay width in any section of the stay.

The free edges of stays shall be stiffened with face plates or flanges.

In general, the flanges (face plates) of stays shall not be welded to deck plating and rail section.

The flanges (face plates) on the outer edge of the stay shall not be welded to horizontal stiffener (flange) of lower edge of the bulwark in way of continuous cut-out.

**2.14.2.5** The rail section shall have a flange (face plate) or shall be of bulb profile.

The lower edge of bulwark shall be stiffened with horizontal stiffener or flange in way of continuous cut-out.

Bulwarks shall be adequately strengthened in way of mooring pipes, fairleads and eyeplates for cargo gear.

**2.14.2.6** Requirements for the design of freeing ports in bulwarks are given in 1.1.6.5.

### 2.14.3 Loading on bulwarks.

The external pressure determined by the Formula (1.3.2.2-2) is the design pressure  $p$ , in kPa, acting on the bulwark. The design pressure shall be taken not less than:

$$p_{\min} = 0,02L + 14, \quad (2.14.3)$$

but not less than 15 kPa.

Where  $L > 300$  m  $L$  shall be taken equal to 300 m.

For ships of restricted area of navigation the value of  $p_{\min}$  may be reduced by multiplying by the factor  $\phi_r$  obtained from Table 1.3.1.5.

### 2.14.4 Scantlings of bulwark structures.

**2.14.4.1** The thickness of the bulwark plating shall not be less than:

$$\begin{aligned} s &= 0,065L + 1,75 \text{ for } L \leq 60 \text{ m and} \\ s &= 0,025L + 4,0 \text{ for } L > 60 \text{ m,} \end{aligned} \quad (2.14.4.1)$$

but not less than 3,0, nor greater than 8,5 mm.

The thickness of bulwark plating of a superstructure located beyond  $1/4$  of the ship's length from the fore perpendicular, as well as that of bulwark plating of 2nd tier deckhouses or superstructures may be reduced by 1 mm.

For 3rd and above tiers of the deckhouses the thickness of the bulwark plating need not exceed the thickness required for the plating of sides of 3rd tier deckhouse.

**2.14.4.2** The section modulus of bulwark stay adjoining the deck plating shall not be less than determined according to 1.6.4.1 taking:

$$p = \text{as defined in 2.14.3;}$$

$$m = 2;$$

$$k_{\sigma} = 0,65.$$

Where the bulwarks are cut to form a gangway or provision is made for expansion joints, the section modulus of stay at the ends of the openings or expansion joints shall be increased by 25 per cent.

The width of stay at the upper end shall be equal to that of the rail section.

**2.14.4.3** Where the deck cargo effect on the bulwark is contemplated, the scantlings of the bulwark stays shall be determined by strength calculation involving effect of the said cargo, with regard for heel

of the ship determined by the Formula (1.3.3.1-5) and acceleration in the horizontal-transverse direction, determined by the Formulae (1.3.3.1-2); the permissible stress factor is determined according to 2.14.4.2.

### 3 REQUIREMENTS FOR STRUCTURES OF SHIPS OF SPECIAL DESIGN

#### 3.1 SHIPS WITH LARGE DECK OPENINGS

##### 3.1.1 General and symbols.

**3.1.1.1** The requirements of this Chapter are additional to those of Sections 1 and 2.

**3.1.1.2** The requirements for deck structure, exclusive of those for cantilever beams, apply to ships with single, twin and triple cargo hatchways which are considered to form a large deck opening meeting the following conditions:

$$b/B \geq 0,7; l/l_m \geq 0,7.$$

The requirements of this Chapter shall be applicable throughout the entire cargo hatch region, including the engine room, provided it is located between the cargo holds.

**3.1.1.3** The requirements for container securing arrangements and hull structures, which take up forces exerted by the said arrangements, apply to container ships.

**3.1.1.4** The cantilever beam is a short deep half beam for which the supporting effect of the side hatch coaming is disregarded in the strength and buckling strength calculation to be made for deck grillage in accordance with 2.6.4.4 and 2.6.4.9 respectively.

**3.1.1.5** For the purpose of this Chapter the following symbols have been adopted:

$b$  = breadth of deck opening determined as the distance between the outer longitudinal edges of hatchway openings at ship's sides, in m;

$l$  = length of hatchway opening, in m;

$l_m$  = distance between centres of transverse deck strips at each end of opening, in m;

$c$  = distance between transverse edges of adjoining openings, in m;

$n$  = total number of 20-ft containers carried by the ship.

##### 3.1.2 Construction.

**3.1.2.1** For ships with a length  $L \geq 80$  m longitudinal framing system is provided for the deck and bottom.

**3.1.2.2** Upper deck and side longitudinals shall be continuous within the region stated in 3.1.1.2.

**3.1.2.3** Ends of cargo hatch continuous side coamings shall be attached as required by 1.7 and 2.6.2. It is not recommended that continuous side coamings be attached to the front bulkhead of the aft superstructure and the aft bulkhead of the forecastle.

**3.1.2.4** Abrupt changes of cross section and shape of members referred to in 3.1.2.2 over the length of the ship is generally not permitted. Where such changes are necessary, arrangements shall be such as to minimize the creation of stress concentration and attention shall be paid to provision of buckling strength.

**3.1.2.5** The attachment of the forward end of the longitudinal strip to the deck where there is a cargo hatch single opening forward of the attachment shall be specially considered by the Register.

**3.1.2.6** It is recommended that transverse and longitudinal deck strips have a box-shaped cross-section.

**3.1.2.7** Transverse deck strips shall be efficiently attached to the underdeck framing members and web frames in line with which they are fitted. Where the plating of the deck strips is arranged in line with the upper flanges of continuous hatch side coamings, the attachment of deck strips to the deck and side shell shall be specially considered by the Register.

**3.1.2.8** Openings in the deck plating in immediate proximity to the attachments of transverse and longitudinal deck strips are not permitted.

##### 3.1.2.9 Large deck openings:

**1** adjacent corners of hatch openings in the upper deck arranged in one line shall be rounded with a radius  $r$ , in m, (Fig. 3.1.2.9) not less than:

$$r = kb \quad (3.1.2.9.1)$$

where  $k = 0,025$  when  $c/b \leq 0,04$ ;

$k = 0,050$  when  $c/b \geq 0,2$ ; the intermediate values of  $k$  shall be obtained by linear interpolation.

In way of longitudinal deck strips the value of  $r$  may be reduced by 40 per cent.

Given below are minimum radii of rounding of opening corners:

$r_{\min} = 300$  mm in way of deck stringer plate;

$r_{\min} = 250$  mm in way of longitudinal deck strips.

Thickened insert plates are required at hatch corners (refer to Fig. 3.1.2.9);

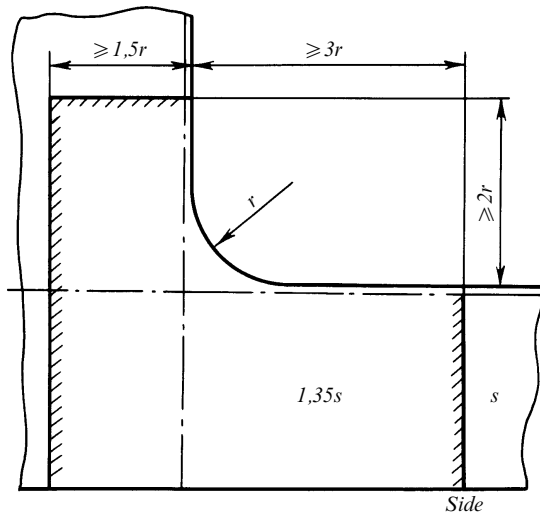


Fig. 3.1.2.9

.2 in way of conjugations of open and enclosed parts of the hull (adjacent to the engine room, bow, etc.) the corner radius of hatch openings shall not be less than:

$$r = 0,07b ; \quad (3.1.2.9.2)$$

.3 hatch corners in the areas where cargo hatchways arranged abreast change in number shall be specially considered by the Register;

.4 for general requirements regarding deck openings, refer to 2.6.5.1.

**3.1.2.10** The cantilever beams shall be fitted in line with web frames. Their connection shall satisfy the requirements of 1.7.2.3.

The cantilever beams shall be fitted with minimum stiffeners as shown in Fig. 3.1.2.10.

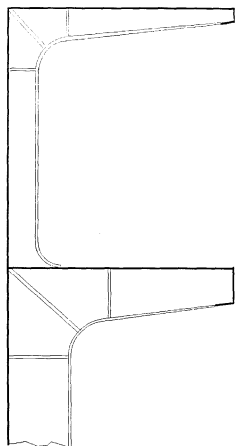


Fig. 3.1.2.10  
Stiffening of cantilever beams

**3.1.2.11** Stiffeners, brackets or deep members shall be fitted under the vertical guides or corner fittings of containers in double bottom of container ships. The inner bottom plating in these locations shall be increased in thickness or the corner fitting sockets shall be welded therein.

The above also applies to lashing pots.

Similar increase in the plating thickness and stiffening in way of container corner fitting pockets and lashing pots shall be provided in deck structure.

### 3.1.3 Design loads.

**3.1.3.1** The design still water bending moment shall be determined in accordance with 1.4.3.

**3.1.3.2** The vertical wave bending moment shall be determined in accordance with 1.4.4.

**3.1.3.3** The design horizontal wave bending moment  $M_h$ , in kN/m, is determined by the formula

$$M_h = 250k_h c_w B L^2 C_b \alpha_h 10^{-3} \quad (3.1.3.3)$$

where  $k_h = a(d/b + 0,3)$ ;

$a = 1 - 4d/L$ ;

for  $c_w$ , refer to 1.3.4.1;

$$\alpha_h = 0,5(1 - \cos \frac{2\pi x}{L}) ;$$

$x$  = distance between the considered section and the after perpendicular, in m.

**3.1.3.4** The design components of a wave torque, in kN/m, are determined by the formulae:

$$M_{tw_1} = 63k_1 c_w B L^2 \alpha_{t_1} \cdot 10^{-3} ; \quad (3.1.3.4-1)$$

$$M_{tw_2} = 63k_2 c_w B L^2 C_b \alpha_{t_2} \cdot 10^{-3} ; \quad (3.1.3.4-2)$$

$$M_{tw_3} = 126k_2 c_w B L^2 C_b \alpha_{t_3} \cdot 10^{-3} . \quad (3.1.3.4-3)$$

where  $k_1 = 2a\chi_0[1 + 3,6(C_{WL} - 0,7)]B/L$ ;

$$k_2 = 10 a_1 \frac{d}{L} \frac{e}{B} ;$$

$$a_1 = 1 - 8d/L ;$$

$$\chi_0 = 1 - 4C_{WL}B/L ;$$

$C_{WL}$  = water plane area coefficient for summer load waterline;

for  $a_1$ , refer to 3.1.3.3;

$e$  = vertical distance from the torque centre to a point at 0,6d above the base line; the torque centre position shall be determined in accordance with the procedure approved by the Register;

$$\alpha_{t_1} = 0,5(1 - \cos \frac{2\pi x}{L}) ;$$

$$\alpha_{t_2} = \sin \frac{3\pi x}{L} ;$$

$$\alpha_{t_3} = \sin \frac{2\pi x}{L} ;$$

for  $x$ , refer to 3.1.3.3.

**3.1.3.5** For container ships, the design statical torque  $M_{ts}$ , in kN/m, is determined by the formula

$$M_{ts} = 30\sqrt{n}B \quad (3.1.3.5)$$

where  $n$  = total number of 20-ft containers carried by ship.

**3.1.3.6** For ships of restricted area of navigation, the horizontal wave bending moment (refer to 3.1.3.3) and the components of a wave torque (refer to 3.1.3.4) shall be multiplied by the reduction factor  $\phi$  determined in accordance with Table 1.4.4.3.

**3.1.3.7** The design loads for cantilever beams are determined in accordance with 2.6.3.

**3.1.3.8** The design loads on container securing arrangements are determined with due regard for the inertia forces caused by ship's accelerations at motions in accordance with 1.3.3.1. The design mass value of ISO series 1 containers is:

24,0 t for 20-ft containers,

30,5 t for 40-ft containers.

When calculating strength of container securing arrangements fitted on weather deck, account shall be taken of loads from the wind in the direction perpendicular to the centreline of the ship. The design value of wind pressure is:

$$p = 1,0 \text{ kPa.}$$

### 3.1.4 Scantlings of structural members.

**3.1.4.1** The combined stresses  $\sigma_{\Sigma}$ , in MPa, in strength deck longitudinals, determined by the Formula (3.1.4.1-1) are not to exceed  $190/\eta$  in any section

$$\sigma_{\Sigma} = \sigma_{sw} + \sigma_{ts} + k_{\Sigma}\sigma_w \quad (3.1.4.1-1)$$

where  $\sigma_{sw}$  = normal stresses, in MPa, in the section considered due to still water bending moment, determined by the formula

$$\sigma_{sw} = \frac{M_{sw}}{W_d} \cdot 10^3; \quad (3.1.4.1-2)$$

for  $M_{sw}$ , in kN/m, refer to 1.4.3;

$W_d$  = actual hull section modulus in way of deck, as defined in 1.4.8;

$\sigma_{ts}$  = normal stresses, in MPa, in the section considered due to the static torque  $M_{ts}$  (refer to 3.1.3.5), determined by the formula

$$\sigma_{ts} = \frac{B_{ts}\bar{\omega}}{I_w \cdot 10^3} \quad (3.1.4.1-3)$$

$B_{ts}$  = bioment in considered section along the length of open part of the ship under the effect of the static torque  $M_{ts}$ , in kN/m<sup>2</sup>;

$\bar{\omega}$  = main sectional area at the considered section point, in m<sup>2</sup>;

$I_w$  = main sectional moment of inertia, in m<sup>6</sup>;

$B_{ts}$ ,  $\bar{\omega}$ ,  $I_w$  are determined according to the procedure approved by the Register;

$\sigma_w$  = normal stresses, in MPa, in considered section due to vertical wave bending moment, determined by the formula

$$\sigma_w = \frac{M_w}{W_d} \cdot 10^3;$$

for  $M_w$ , refer to 1.4.4;

$k_{\Sigma}$  = factor by which vertical bend stresses are increased taking the horizontal bending and torque into account. It is determined by the formula

$$k_{\Sigma} = \sqrt{1 + 0,15(0,85 + L/600)^2(\bar{\sigma}_h + \bar{\sigma}_{tw})^2};$$

$\bar{\sigma}_h = \sigma_h/\sigma_w$ ;

$\sigma_h$  = normal stresses, in MPa, in considered section due to design horizontal wave bending moment, determined by the formula

$$\sigma_h = \frac{M_h}{W_{dz}} \cdot 10^3; \quad (3.1.4.1-4)$$

for  $M_h$ , refer to 3.1.3.3;

$W_{dz}$  = actual hull section modulus about the vertical axis through the centreline of the ship, in cm<sup>3</sup>, determined by the formula

$$W_{dz}^a = \frac{I_z}{y} \cdot 10^2,$$

$I_z$  = actual inertia moment of the hull about the vertical axis, in cm<sup>2</sup>/m<sup>2</sup>;

$y$  = half the ship's breadth in the considered section, in m;

$\bar{\sigma}_{tw} = \sigma_{tw}/\sigma_w$ ;

$\sigma_{tw}$  = total warping stresses, in MPa, under the effects of the torques  $M_{tw1}$ ,  $M_{tw2}$ ,  $M_{tw3}$ , determined by the formula

$$\sigma_{tw} = \sqrt{(\sigma_{tw1} - \sigma_{tw2})^2 + \sigma_{tw3}^2}; \quad (3.1.4.1-5)$$

$\sigma_{tw1}$  = normal warping stresses, in MPa, under the effects of the torques  $M_{tw1}$ ,  $M_{tw2}$ ,  $M_{tw3}$  (refer to 3.1.3.4), determined by the formula

$$\sigma_{tw1} = \frac{B_i \bar{\omega}}{I_w \cdot 10^3}; \quad (3.1.4.1-6)$$

$B_i$  = biomoments in considered section along the length of the open part of the ship under the effects of  $M_{tw1}$ ,  $M_{tw2}$ ,  $M_{tw3}$  respectively, in kN/m<sup>2</sup>. The biomoments are determined by the procedure approved by the Register.

**3.1.4.2** Kinematic parameters of warping shall be determined.

The elongation of hatch opening diagonal under the effect of hull warping shall not exceed 35 mm. Where such elongation obtained by calculation is in excess of 35 mm, measures specially agreed with the Register shall be taken for opening edge reinforcements. The calculation shall be made in accordance with the procedure approved by the Register.

**3.1.4.3** Adequate buckling strength of the longitudinal deck strip between the supports as well as that of its items as regards the compressive stresses due to longitudinal bending shall be ensured.

**3.1.4.4** Where the ratio of the length of the hatch opening to the width of the deck portion from the side shell to the longitudinal edge of the nearest hatch opening exceeds 10, calculation of shape deformation of the deck portion concerned in the horizontal plane in accordance with the procedure approved by the Register and use of the results obtained in assessment of the deck stressed state, design of hatch covers and side framing may be required.

**3.1.4.5** The scantlings of cantilever beams and adjoining web frames shall satisfy the following requirements:

**1** the section modulus, in cm<sup>3</sup>, of cantilever beam at a section in way of the end of a beam knee shall not be less than:

$$W = \left(\frac{1}{2}pal + Q\right) \frac{l}{k_{\sigma}\sigma_n} \omega_c \cdot 10^3 \quad (3.1.4.5.1)$$

where  $p$  = intensity of design loading, in kPa, on the deck plating supported by the cantilever beam, as required by 3.1.3.7;

$a$  = distance between adjacent cantilever beams, in m;

$l$  = span, in m, of a cantilever beam, measured from the section at the end of a beam knee to the hatch side coaming supported;

$Q$  = design load, in kN, transmitted from hatch cover to the cantilever beam;

$$Q = \frac{1}{2}p_1ab_1;$$

$p_1$  = intensity of design loading, in kPa, on the cover of hatch adjoining the cantilever beam as required by 3.1.3.7;  
 $b_1$  = width, in m, of opening for a hatch adjoining the cantilever beam;  
 $k_\sigma = 0,6$ ;  
 $\omega_c$  = as defined in 1.1.5.3.

The sectional area of the web of cantilever beam shall not be less than that determined according to 1.6.4.3 taking:

$k_\sigma = 0,6$ ;

$N_{\max} = p a l + Q$  for the section at the end of the beam bracket;

$N_{\max} = Q$  for the section in way of the hatch side coaming adjoining the cantilever beam;

**2** the section modulus of the web frame connected to the upper deck cantilever beam at the section in way of the end of the beam bracket shall not be less than that determined by the Formula (3.1.4.5.1).

The section modulus of the web frame connected to the cantilever beam of the lower deck and fitted below that deck at the section in way of the end of the beam bracket shall comply with the same requirement but may be reduced by the value of section modulus of the web frame fitted above that deck, at the section in way of the end of the bracket adjoining the deck.

**3.1.4.6** The scantlings of container securing arrangements shall be determined on the basis of strength calculations using the design loads complying with the requirements of 3.1.3.8, and the resulting stresses shall not exceed the permissible ones determined using the permissible stress factors:

$k_\sigma = k_\tau = 0,75$ .

The strength of hull structures taking up forces from the container securing arrangements shall be verified by calculation of the effects produced by these forces, and the resulting stresses shall not exceed the permissible ones specified in Section 2 for the appropriate structures.

### 3.2 ROLL-ON/ROLL-OFF SHIPS

#### 3.2.1 General and symbols.

**3.2.1.1** The requirements of this Chapter apply to ro-ro ships, ro-ro passenger ships and are supplementary to those of Sections 1 and 2.

These requirements also apply to decks and double bottoms of ships carrying wheeled vehicles for use in cargo handling.

**3.2.1.2** For the purpose of this Chapter the following symbols have been adopted:

$Q_0$  = static load on the axle of the wheeled vehicle, in kN;

$n_0$  = number of wheels on an axle;

$n$  = number of wheels forming a design load spot (for a single wheel  $n = 1$ );

$u$  = size of a tyre print normal to the axis of rotation, in m;

$v$  = size of a tyre print parallel to the axis of rotation, in m;

$e$  = spacing between adjacent tyre prints, in m;

$l_a$  = design load spot dimension parallel to the smaller side of the panel (directed across framing members), in m;

$l_b$  = design load spot dimension parallel to the larger side of the panel (directed along framing members), in m;

$a, b$  = smaller and larger sides of panel, respectively, in m;

$l$  = span of the considered girder between supports, in m (refer to 1.6.3.1).

#### 3.2.2 Construction.

**3.2.2.1** Vehicle decks and double bottoms of ro-ro ships and car ferries shall, in general, be longitudinally framed. If framed otherwise, the above structures are subject to special consideration by the Register.

**3.2.2.2** Movable decks fitted temporarily for the carriage of vehicles shall be so fixed as to prevent these decks from taking up longitudinal forces under the hull longitudinal bending.

The Rules provide for movable deck structure consisting of a top decking with a web structure and longitudinals welded thereto. Other forms of movable deck construction shall be specially considered by the Register.

#### 3.2.3 Loads from wheeled vehicles.

**3.2.3.1** The design loads shall be based on specification details of vehicles carried on board the ship and used for cargo handling. The design documentation submitted to the Register for the consideration shall include statical load on vehicle axle, number of wheels on the axle, wheel spacing, tyre print dimensions and tyre type.

Where wheel print details are not initially available, the requirements of 3.2.3.5 shall be applied.

**3.2.3.2** The design load spot dimensions  $l_a$  and  $l_b$  shall be chosen as the overall dimensions of the print of a wheel group consisting of a maximum number of wheels and complying with the following conditions:

when determining the required plating thickness, the prints of all the wheels in a group shall be arranged within the panel surface (i.e.  $l_a \leq a$  and  $l_b \leq b$ , refer to Table 3.2.3.2);

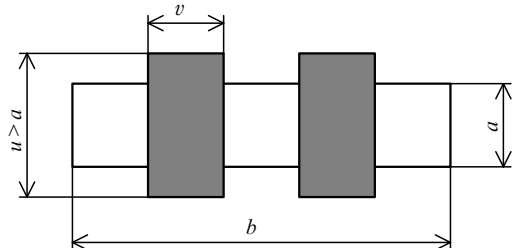
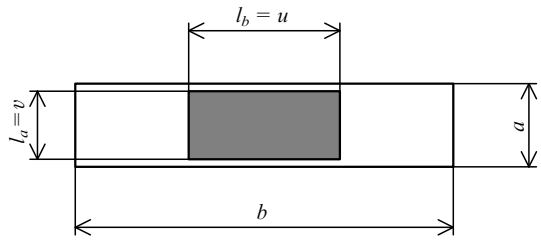
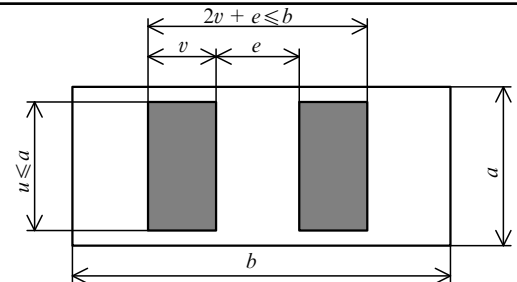
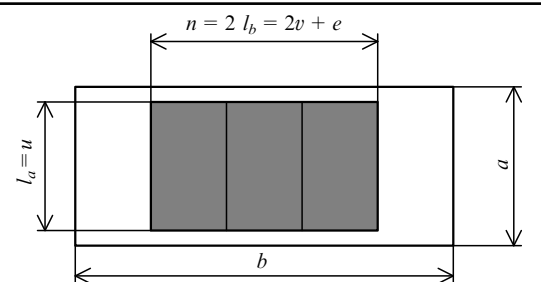
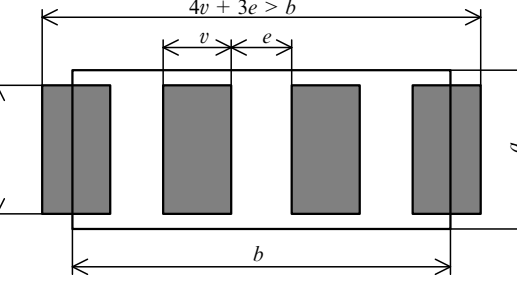
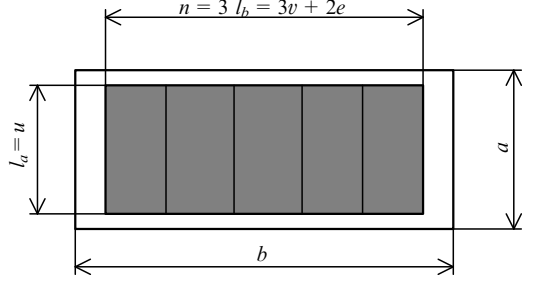
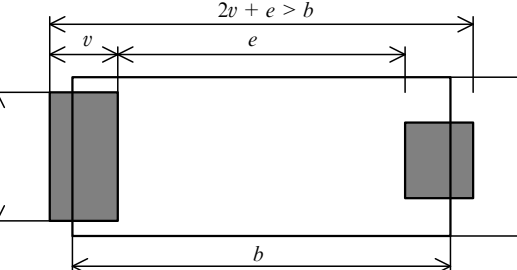
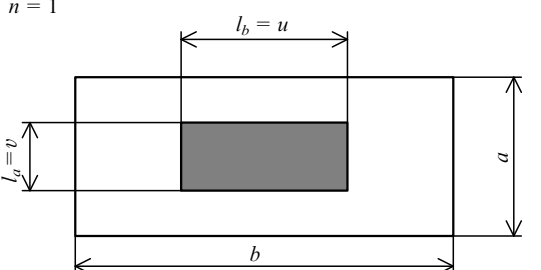
when determining the section modulus and cross section of a main framing girder, the prints of all the wheels of a group shall be fully arranged within the surfaces of two panels adjacent to the girder under consideration (i.e.  $l_a \leq 2a$  and  $l_b \leq l$ , refer to Fig. 3.2.3.2).

The wheels may be united in a group irrespective of the distance between prints provided the overall



Table 3.2.3.2

## Procedures for choosing design load spot dimensions when establishing deck plating thickness

Wheel prints	Design load spot
	$n = 1$ 
	$n = 2 \quad l_b = 2v + e$ 
	$n = 3 \quad l_b = 3v + 2e$ 
	$n = 1$ 

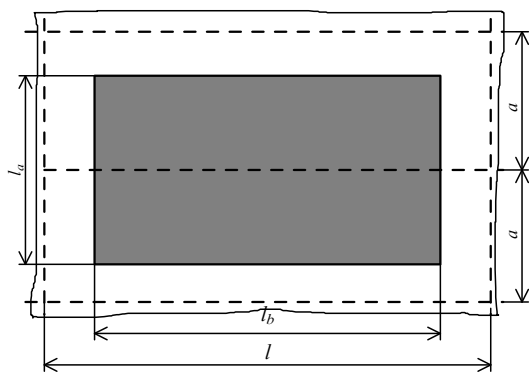


Fig. 3.2.3.2  
Design loaded spots for main framing

dimensions of the group are in accordance with the above limitations.

Where two positions of the design load spot are possible (along and across main framing),  $l_b \geq l_a$  shall be adopted as the design case (i.e. the spot positioned with its larger side along main framing).

**3.2.3.3** To be considered are the loads resulting from the operation of vehicles during cargo handling operations and from stowage of vehicles on the deck under conditions of the ship motions.

**3.2.3.4** The design load  $Q$ , in kN, shall be determined by the formula

$$Q = k_a Q_0 \frac{n}{n_0} \quad (3.2.3.4)$$

where  $k_d = \alpha_1 \alpha_2$  — dynamic coefficient in the process of operation of vehicles used for cargo handling operations;

$\alpha_1$  = factor equal to: 1,10 and 1,05 for vehicles (except fork lift trucks) having an axle load less than 50 kN and 50 kN and more, respectively; 1,0 for fork lift trucks;

$\alpha_2$  = factor equal to: 1,03 and 1,15 for pneumatic and cast-rubber tyres, respectively; 1,25 for wheels with a steel rim;

$k_d = 1 + a_z/g$  — dynamic factor characterizing the ship motions;

$a_z$  = acceleration in the ship section under consideration in accordance with 1.3.3.1.

Where distribution of the load between wheeled vehicle axles is not uniform, the maximum axle load shall be taken as the design load. For fork lift trucks it is assumed that the total load is applied to the forward axle.

**3.2.3.5** Where specifications on tyre print dimensions are not available, the tyre print dimension normal to the wheel axle  $u$ , in m, shall be determined by the formulae:

for wheels with cast tyres

$$u = 0,01Q_0/n_0 \quad \text{where } Q_0/n_0 \leq 15 \text{ kH;} \quad (3.2.3.5-1)$$

$$u = 0,15 + 0,001(Q_0/n_0 - 15) \quad \text{where } Q_0/n_0 > 15 \text{ kH;} \quad (3.2.3.5-2)$$

for wheels with pneumatic tyres

$$u = 0,15 + 0,0025Q_0/n_0 \quad \text{where } Q_0/n_0 \leq 100 \text{ kH;} \quad (3.2.3.5-2)$$

$$u = 0,4 + 0,002(Q_0/n_0 - 100) \quad \text{where } Q_0/n_0 > 100 \text{ kH.}$$

The tyre print dimension of a wheel parallel to the wheel axle  $v$ , in m, shall be determined by the formula

$$v = \frac{Q_0}{n_0 u p_k} \quad (3.2.3.5-3)$$

where  $p_k$  — static specific pressure, in kPa, to be adopted from Table 3.2.3.5.

Table 3.2.3.5

Vehicle	$p_k$	
	Pneumatic tyres	Cast tyres
Cars	200	—
Lorries, motor vans	800	—
Trailers	800	1500
Fork lift trucks	800 (where $n = 1$ ) 600 (where $n \geq 2$ )	1500 1500

**3.2.3.6** If the size of wheel prints is adopted in accordance with 3.2.3.5, the design load  $Q$  shall be increased by 15 per cent.

**3.2.3.7** The design load for train rails  $Q$ , in kN, shall be determined by the formula

$$Q = 0,5k_d Q_0 n_1 \quad (3.2.3.7)$$

where  $k_d = 1,1$  if the vehicle moves about during cargo-handling operations;

$k_d = 1 + a_z/g$  in case of the ship motions;

$a_z$  = acceleration in considered ship section in accordance with 1.3.3.1;

$n_1$  = number of vehicle wheels arranged within the design span of framing member supporting railways.

**3.2.3.8** The design loads for side shell and permanent deck primary members shall be those to satisfy the most severe stowage arrangement of all cargoes carried on deck (including package cargo, containers, wheeled vehicles, etc.) and to allow for statical and inertia forces resulting from the ship motions. Accelerations shall be determined in accordance with 1.3.3.1.

**3.2.3.9** The design load  $Q$ , in kN, for the transverses and girders of movable decks shall be determined by the formula

$$Q = k_d(p_c + p_d)a_2l \quad (3.2.3.9)$$

where  $k_d$  = as defined in 3.2.3.4;

$p_c$  = static deck loading from the cargo carried, in kPa;

$p_d$  = static deck loading from deck own mass, in kPa;

$a_2$  = mean spacing of transverses and girders, in m.

The value of  $(p_c + p_d)$  shall not be taken less than 2,5 kPa.

#### 3.2.4 Scantlings of deck and side shell structures.

**3.2.4.1** The thickness of plating  $s$ , in mm, shall not be less than

$$s = \left( \frac{17Qk_0}{l_a l_b R_{eH} k_1 k_2 k_3} \right)^{0,6} + 2 \quad (3.2.4.1)$$

where  $Q$  = as defined under 3.2.3;

$k_0$  = factor accounting for the effects of total hull bend:

$$k_0 = \frac{1}{1,4 - 0,8W/W_d^f} \geq 1 \quad \text{— for the upper (strength) deck amidships with loads acting at sea;}$$

$k_0 = 1$  elsewhere;

$k_1 = 0,83/\sqrt{a}$ ;

$k_2 = 0,84/\sqrt{l_a} - 0,185$ ;

$k_3 = 0,18/l_b + 0,38$ ;

$W_d^f$  = actual hull section modulus for deck in accordance with 1.4.8.

**3.2.4.2** The section modulus  $W$  of longitudinals and beams, in  $\text{cm}^3$ , shall not be less than obtained from 1.6.4.1 with

$Q$  = as defined in 3.2.3;

$$m = \frac{5,84}{[1 - 0,57l_b/l]k_a};$$

$$k_a = 1 - 0,204(l_a/a)^2 + 0,045(l_a/a)^3;$$

$k_\sigma = 0,8/k_0$  — for cargo handling operations in port;

$k_\sigma = 0,7/k_0$  — with loads applied at sea;

$k_0$  = factor defined in 3.2.4.1.

**3.2.4.3** The web cross-sectional area  $f_c$ , in  $\text{cm}^2$ , of beams and longitudinals shall not be less than obtained from 1.6.4.3 with

$$N_{\max} = Qk_a(1 - 0,47l_b/l); \quad (3.2.4.3)$$

$k_\tau = k_\sigma$

where  $Q$  = as defined in 3.2.3;

$k_a$ ;  $k_\sigma$  = factors defined in 3.2.4.2.

**3.2.4.4** The plating thickness, section modulus and cross-sectional area of beams and longitudinals of movable decks shall be determined in accordance with 3.2.4.1, 3.2.4.2 and 3.2.4.3. Where beams and longitudinals are freely supported by girders and transverses, the factor  $m$  shall be determined by the formula

$$m = \frac{8}{k_a(2 - l_b/l)} \quad (3.2.4.4)$$

where  $k_a$  = factor defined in 3.2.4.2;

Otherwise, the factor  $m$  shall be determined as for beams and longitudinals of permanent cargo decks according to 3.2.4.2.

**3.2.4.5** The section modulus of longitudinals  $W$ , in  $\text{cm}^3$ , supporting fixed rails shall not be less than obtained from 1.6.4.1 with

$Q$  = as defined in 3.2.3.7;

$m$  to be determined by the formula

$$m = \frac{5,85}{1 - k_5 e_2 / l} \quad (3.2.4.5)$$

where  $k_5 = 0$  with  $n_1 = 1$

$k_5 = 0,5n_1$  with  $n_1 \geq 2$ ;

for  $n_1$ , refer to 3.2.3.7;

$e_2$  = mean spacing of centres of wheels arranged within the design member span, in m;

$k_\sigma = 0,7/k_0$ ;

$k_0$  = factor determined by 3.2.4.1.

**3.2.4.6** The scantlings of deep members of sides and permanent cargo decks, as well as of pillars shall be derived by direct calculation using the procedures approved by the Register.

**3.2.4.7** The section modulus of the girders and transverses of movable decks  $W$ , in  $\text{cm}^3$ , shall not be less than obtained from 1.6.4.1 with

$Q$  = as defined in 3.2.3.9;

$m = 12$  for fixed members;

$m = 8$  for freely supported members;

$k_\sigma = 0,7$ .

### 3.2.5 Special requirements.

**3.2.5.1** A side fender protecting the ship side and stern from damage during mooring operations shall be fitted at the lower cargo deck level of ferries.

**3.2.5.2** A longitudinal shall be fitted under each rail on the cargo decks of train ferries.

**3.2.5.3** Where train decks with rails which are flush with the deck plating are provided on ships carrying railway carriages, the actual section modulus and sectional area of deck transverses shall be determined for the section located in the rail recess. Structural continuity of the effective flange of the deck transverse, where it intersects the rail, shall be ensured. In any case, the intersections of the fixed rails with deck transverses shall be specially agreed with the Register.

**3.2.5.4** Where rails for the transport of railway carriages are welded to the deck plating throughout

the entire length, the rail butts shall be welded with full penetration.

## 3.3 BULK CARRIERS AND OIL OR BULK DRY CARGO CARRIERS

### 3.3.1 General.

**3.3.1.1** The requirements of this Chapter apply to bulk carriers and combination carriers for the carriage of bulk cargoes and crude oil (oil products) in bulk of less than 90 m in length.

Bulk carriers of 90 m in length and upwards, contract for construction of which was signed on April 1, 2006 and after, shall comply with the requirements of Part XVIII "Common Structural Rules for Bulk Carriers" (refer also to 1.1.1.1).

**3.3.1.2** The scantlings of structural members bounding the cargo region shall be determined as required by Sections 1 and 2 on assumption of the carriage of bulk or liquid cargo (water ballast) in the holds primarily designed for the purpose concerned. The value to be adopted is the greater of the appropriate strength characteristics of the item.

**3.3.1.3** The requirements for the structures not mentioned in this Chapter shall be as given in Sections 1 and 2.

In any case, the requirements for the hull and its structures shall not be less stringent than those stated in Sections 1 and 2.

**3.3.1.4** The basic structural type of ships is considered to be a single-deck ship with machinery aft, having a flat (or nearly a flat) double bottom in the holds (permissible slope of the inner bottom from the side to the centreline is not over  $3^\circ$ ), hopper side and topside tanks, single or double skin sides, transverse hold bulkheads of plane, corrugated or cofferdam type, which is primarily intended for bulk cargoes.

**3.3.1.5** In combination carrier the length of the holds shall not exceed  $0,1L$ . Holds of a greater length require special consideration by the Register in each case.

It is assumed that when carrying heavy bulk cargo, certain holds remain empty, their numbers shall be indicated in line "Other characteristics" in Classification Certificate as stated in 2.3, Part I "Classification".

**3.3.1.6** Descriptive notation and distinguishing mark (ESP).

**3.3.1.6.1** The descriptive notation **Bulk carrier** and the distinguishing mark (ESP) shall be assigned to sea going self-propelled single deck ships with a double bottom, hopper side tanks and topside tanks and with single or double skin side construction intended for carriage of dry cargoes in bulk. Typical midship sections are given in Fig. 3.3.1.6.1.

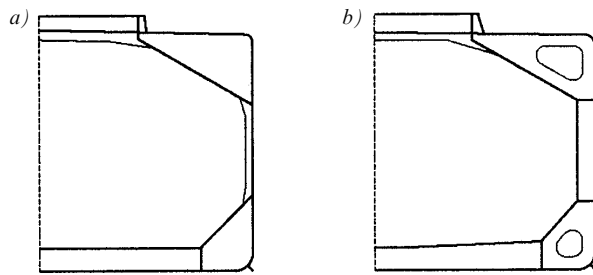


Fig. 3.3.1.6.1

Bulk carrier of single skin side construction means a bulk carrier where one or more cargo holds are bound by the side shell only or by two watertight boundaries, one of which is the side shell, which are:

less than 760 mm apart in bulk carriers, the keels of which are laid or which are at a similar stage of construction before 1 January 2000;

less than 1000 mm apart in bulk carriers, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2000.

**3.3.1.6.2** The descriptive notation **Oil/Bulk/Ore carrier** and the distinguishing mark **(ESP)** shall be assigned to single deck ships of double skin side construction, with a double bottom, hopper side tanks and topside tanks fitted below the upper deck intended for the carriage of oil or dry cargoes, including ore, in bulk. A typical midship section is given in Fig. 3.3.1.6.1, *b*.

### 3.3.2 Construction.

**3.3.2.1** Longitudinal framing shall be adopted for the deck, the side shell in way of topside tanks and the sloped bulkheads of topside tanks. The deck plating between end coamings of adjacent cargo hatches shall be additionally strengthened with intercostal transverse stiffeners fitted at every frame.

The double bottom shall be longitudinally framed. The double bottom structure in which all bottom and inner bottom longitudinals are replaced by side girders may be permitted (refer to 2.4.2.4.2).

The single skin side between topside and hopper side tanks shall be transversely framed.

Longitudinal or transverse framing may be adopted for the double skin side and in the hopper side tanks.

The transverse watertight bulkheads may be plane with vertical stiffeners, corrugated with vertical corrugations or of a cofferdam type.

**3.3.2.2** A hatch side coaming shall be fitted with horizontal stiffeners. At every alternate frame the coaming shall be stiffened with vertical brackets fitted between the coaming flange and the deck.

**3.3.2.3** The slope angle of topside tank walls to the horizontal axis shall not be less than 30°.

Inside topside tanks, in line with hold transverse bulkheads, diaphragms shall be fitted, the plating of which may generally have drain and access holes of minimum size. The plating of transverse bulkheads inside topside tanks shall be strengthened with stiffeners. The ends of vertical stiffeners shall be bracketed.

In topside tanks transverse beams shall be fitted in line with deck transverses.

To stiffen the plates of the tank vertical walls which are in line with the hatch side coaming, brackets shall be placed inside the tanks in line with every stay of side coaming. These brackets shall be extended to the deck and tank sloped bulkhead longitudinals nearest to the centreline.

At every frame, in the lower corner of the tank, brackets shall be fitted in line with the brackets attaching the hold frame to the sloped bulkhead of the tank. These brackets shall be carried to the ship's side and tank sloped bulkhead longitudinals nearest to the lower corner of the tanks and welded to them so as to extend beyond the brackets of frames.

**3.3.2.4** The slope angle of hopper side tank walls to the horizontal shall not be less than 45°. The extension of the tank over the ship breadth at the inner bottom level shall generally not be less than 0,125*B* on one side.

Transverse diaphragms shall be fitted in line with transverse bulkheads and every alternate plate floor. The diaphragms may have drains and access holes. The total height of openings at the section of diaphragm, in the direction along the normal to the tank plating, from a line drawn through the opening centre perpendicularly to that normal, to the plating shall not exceed 0,5 of the height of that section anywhere. The opening edges shall be reinforced with face plates or stiffeners. The diaphragm plating shall be stiffened as required by 1.7.3.2 for the floor stiffeners.

Inside longitudinally framed tank, brackets shall be fitted in line with every frame. These brackets shall be carried to the sloped bulkhead and side longitudinals and welded to them so as to extend beyond the brackets of frames.

At the outboard side girder forming transversely framed hopper side tank wall, brackets shall be fitted in line with every frame. These brackets shall be carried to the nearest bottom and inner bottom longitudinals and welded to them.

**3.3.2.5** Within the cargo area, the single-side structure shall comply with the following requirements:

**.1** the scantlings of side hold frames immediately adjacent to the collision bulkhead shall be increased in order to prevent excessive imposed deformation on the shell plating. As an alternative, supporting structures shall be fitted which maintain the con-

tinuity of fore peak stringers within the foremost hold;

**.2** frame ends shall be attached with brackets. The vertical dimension of the lower and upper brackets, as measured at shell plating, shall not be less than 0,125 of the frame span. On the level of the frame adjoining the bilge and underdeck tank, the breadth of the lower and upper brackets shall not be less than half the web height;

**.3** frames shall be fabricated symmetrical sections with integral upper and lower brackets and shall be arranged with soft toes. The end brackets adjoining the underdeck and bilge tanks shall be blunted, and the flange ends shall be sniped. The side frame flange shall be curved at the connection with the end brackets. The radius of curvature shall not be less than  $r$ , in mm, determined by the formula

$$r = 0,4b_{br}^2 / s_{br} \quad (3.3.2.5.3)$$

where  $b_{br}$  = the flange width, in mm;  
 $s_{br}$  = the thickness of brackets, in mm;

**.4** normal steel frames may be asymmetric. The face plates or flanges of brackets shall be sniped at both ends. The brackets shall be arranged with soft toes;

**.5** where, a frame being connected to an underdeck tank, the frame or its bracket overlaps with a horizontal section of an inclined wall, provision shall be made for the bracket to go over the bent section, and the angle between the plane of the face plate (bracket) and the inclined tank wall shall not be less than 30°;

**.6** the web depth to thickness ratio of frames shall not exceed the following values:

60 $\sqrt{\eta}$  for symmetrically flanged frames;

50 $\sqrt{\eta}$  for asymmetrically flanged frames;

**.7** the outstanding flange shall not exceed 10 $\sqrt{\eta}$  times the flange thickness;

**.8** in way of the foremost hold, side frames of asymmetrical section shall be fitted with tripping brackets which shall be welded to shell plating, webs and face plates of frames;

**.9** double continuous welding shall be adopted for the connections of frames and brackets to side shell, hopper wing tank plating and web to face plates. For this purpose, the strength factor  $\alpha$  for a weld (refer to 1.7.5.1) is adopted equal to:

0,44 where frame webs shall be welded to shell plating on lengths equal to 0,25 of the frame span as measured from the upper and lower frame end, and where bracket webs shall be welded to the plating of underdeck and bilge tanks;

0,4 where frame webs shall be welded to shell plating outside the above end sections.

Where the hull form is such as to prohibit an effective fillet weld, edge preparation of the web of

frame and bracket may be required, in order to ensure the same efficiency as the weld connection stated above.

**3.3.2.6** The ends of plane bulkhead stiffeners shall be bracketed to the inner bottom plating and to deck structures.

**3.3.2.7** The cofferdam bulkheads shall satisfy the following requirements:

**.1** the construction of cofferdam bulkheads, as stipulated under 2.7.1.2, shall consist of two tight platings, diaphragms and/or platforms. To stiffen the plating, vertical or horizontal stiffeners may be fitted;

**.2** the vertical or horizontal stiffeners of both platings shall be identical, form a ring structure and pass continuous through the platforms or, accordingly, diaphragms. The vertical stiffeners of both platings shall be fitted in the same plane parallel to the centreline of the ship; the horizontal stiffeners shall be fitted in the same plane parallel to the base line of the ship.

Cross ties are permitted between the vertical or horizontal stiffeners of both platings, at the mid-span thereof;

**.3** the diaphragms or platforms shall be stiffened in accordance with 1.7.3.2. The smaller side, in mm, of the panel of diaphragm or platform to be stiffened shall not exceed 100 $s\sqrt{\eta}$ , where  $s$  is the thickness of diaphragm or platform, in mm;

**.4** for access to all parts of the cofferdam bulkhead an adequate number of openings (manholes) shall be provided in the diaphragms and platforms. The total width of openings in one section of the diaphragm or platform shall not exceed 0,6 of the cofferdam bulkhead thickness.

Openings other than the air and drain scuppers are generally not permitted:

in the platforms, at a distance not less than 1,5 times the cofferdam bulkhead thickness from the longitudinal bulkheads or side, which act as the platform supports;

in the diaphragms, at the same distance from the inner bottom plating or the upper point of the bulkhead bottom trapezoidal stool, if any, and the upper deck plating or the lower point of the horizontal underdeck stiffener of rectangular or trapezoidal section, being the bulkhead top stool, if any, which act as the diaphragm supports.

Edges of the openings cut in the diaphragms and platforms located within  $\frac{1}{4}$  of the span from their supports shall be reinforced with face plates or stiffeners. The distance between the edges of adjacent openings shall be not less than the length of these openings.

**3.3.2.8** Transverse bulkheads with vertical corrugations shall have plane areas at ship's sides not less than 0,08 $B$  in width. The upper ends of these

bulkheads shall be attached to the deck by horizontal stiffeners of rectangular or trapezoidal section, complying with the requirements of 3.3.2.11, while the lower ends shall be attached directly to the inner bottom plating or to the stools of trapezoidal section fitted on the inner bottom, complying with the requirements of 3.3.2.10. The bulkheads in heavy cargo holds shall be supported by trapezoidal stools.

At lower end of corrugations there shall be fitted vertical and sloped plates so as to cover the concave portion of corrugations on each side of the corrugated bulkhead. The height of the covering plates in oil or bulk dry cargo carriers shall not be less than 0,1 of the corrugation span, and their thickness shall be not less than the lower strake thickness of the corrugation.

**3.3.2.9** Where lower ends of vertical corrugations are attached directly to the inner bottom plating, floors the thickness of which shall be not less than that of the bottom strake of the corrugated bulkheads shall be aligned with transverse faces (those directed athwart the ship).

In this case, web plates (those directed along the ship) of rectangular corrugations shall be in line with inner bottom longitudinals or side girders. Side faces of trapezoidal corrugations shall be arranged so that in way of their intersection with inner bottom longitudinals hard spots are avoided.

**3.3.2.10** The construction of the transverse bulkhead bottom trapezoidal stool shall comply with the following requirements:

**.1** the stool is fitted on the inner bottom athwart the ship under the bulkhead. It shall consist of a top horizontal plate having a width not less than the height of the bulkhead corrugations and two sloped plates resting upon the plate floors. The height of the stool shall not exceed 0,15*D*. Stools of greater height are subject to special consideration by the Register;

**.2** inner bottom longitudinals shall be cut at the floors giving support to the sloped plates of the bottom stools and to be attached to them by brackets. Brackets having a thickness not less than that of the floors, reinforced with stiffeners shall be fitted between the floors in line with the inner bottom longitudinals;

**.3** diaphragms shall be fitted inside the bottom stools in line with the centre girder and side girders. Drain and access holes may be cut in the diaphragms. Size of the openings, their reinforcement as well as stiffening of diaphragms shall comply with similar requirements for the diaphragms of hopper side tanks, as specified in 3.3.2.4;

**.4** the horizontal and sloped plates inside the bottom stool shall be stiffened to form a ring struc-

ture, fitted in line with the inner bottom longitudinals.

**3.3.2.11** The construction of the corrugated bulkhead top stool of rectangular or trapezoidal section shall comply with the following requirements:

**.1** the top stool shall be fitted under the deck athwart the ship, over the bulkhead. It shall consist of a bottom horizontal plate having a width not less than the height of the bulkhead corrugations and two vertical or sloped plates. The height of the top stool shall be approximately equal to 0,1 of the distance between the topside tanks. The dimensions of the top stool shall be such as to provide access into that stool;

**.2** the horizontal and vertical (sloped) plates inside the stool shall be stiffened.

The stiffeners may be fitted in line with the deck longitudinals forming ring structures with them.

Horizontal stiffeners may be fitted. In this case, webs giving intermediate support to these stiffeners as well as brackets ensuring efficient end attachment of corrugations shall be provided inside the top stool;

**.3** where an angle between the sloped plate of the top stool and a vertical axis exceeds 30°, brackets ensuring efficient upper end attachment of corrugations shall be fitted inside the top stool in line with plane faces of trapezoidal corrugations.

### **3.3.3 Design loads.**

**3.3.3.1** The design loads on the inner bottom members, sides and transverse bulkheads shall be calculated as required by 2.2.3, 2.4.3, 2.5.3 and 2.7.3 respectively, taking account of the heaviest of the anticipated bulk cargoes, liquid cargo (water ballast) or empty holds, whichever is appropriate.

**3.3.3.2** The design pressure on the plating and framing of the hopper side tank sloped sides and of the plates of the transverse bulkhead bottom stools shall be determined as required by 1.3.4.3 for the heaviest of the anticipated bulk cargoes and as required by 1.3.4.2 for liquid cargo, whichever is appropriate. In any case, the design pressure need not be taken less than that determined by the Formula (1.3.4.2-4) and for the trapezoidal stools also in accordance with 2.7.3.1.

**3.3.3.3** The design pressure on the plating and framing of the topside tank longitudinal bulkheads and of the plates of the transverse bulkhead top stools of rectangular or trapezoidal section shall be determined as required by 1.3.4.2 for the holds filled with liquid cargo (water ballast). In any case, the design pressure need not be taken less than that determined by the Formula (1.3.4.2.1-4) and for the top stools also in accordance with 2.7.3.1.

**3.3.3.4** Where the hopper side and/or topside tanks, transverse bulkhead bottom and/or top stools, space inside the cofferdam bulkheads and/or inter-skin space are used as tanks, the design pressure shall

be determined with regard for the pressure from the inside as required by 1.3.4.2.

### 3.3.4 Scantlings of structural members.

**3.3.4.1** The scantlings of double bottom members shall satisfy the following requirements:

**.1** the scantlings of centre girder, side girders and floors shall be determined on the basis of strength calculation made for bottom grillages using design pressure stated in 3.3.3 and the following permissible stress factors:

for centre girder and side girders

$k_{\sigma} = 0,3k_B \leq 0,6$  in the midship region, when determining the shell plating stresses;

$k_{\sigma} = 0,35k_B \leq 0,6$  in the midship region, when determining the inner bottom plating stresses;

$k_{\sigma} = 0,6$  at the ship's ends within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for floors

$k_{\sigma} = 0,6$ ;

when the strength is verified using the shear stresses,

$k_{\tau} = 0,6$ ;

$k_B$  shall be determined by the Formula (2.2.4.1).

Where combinations of empty and loaded holds are envisaged, this shall be accounted for in the strength calculation made for the bottom grillage when determining the root flexibility factor of the centre girder and side girders on the bearing contour line of the grillage. Account may be taken of the end root flexibility of floors owing to rotational stiffness of the hopper side tanks. The grillage shall be treated as a system of cross members (structural idealization using beam models);

**.2** the section modulus of the bottom primary members shall be determined in accordance with 2.4.4.5 taking the following permissible stress factors:

for longitudinals

$k_{\sigma} = 0,4k_B \leq 0,65$  in the midship region;

$k_{\sigma} = 0,65$  at the ship's ends within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of the ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for transverse members

$k_{\sigma} = 0,65$ ;

$k_B$  shall be determined by the Formula (2.2.4.1);

**.3** the section modulus of inner bottom primary members shall be determined in accordance with

2.4.4.5 at the design pressure in accordance with 3.3.3 and the following permissible stress factors:

for longitudinals

$k_{\sigma} = 0,5k_B \leq 0,75$  in the midship region;

$k_{\sigma} = 0,75$  at the ship's ends within  $0,1L$  from the fore or after perpendicular.

For regions between the midship region and the above portions of the ship's ends,  $k_{\sigma}$  shall be determined by linear interpolation;

for transverse members

$k_{\sigma} = 0,75$

$k_B$  shall be determined by the Formula (2.2.4.1).

**3.3.4.2** the scantlings of the hopper side tank members shall comply with the following requirements:

**.1** the thickness of the sloped bulkhead plating shall not be less than that determined by the Formula (1.6.4.4) taking:

$m = 15,8$ ;

$p$  = design pressure as defined in 3.3.3;

$k_{\sigma}$  shall be taken as for the longitudinal bulkhead plating of tankers as required by 2.7.4.1, but not more than for the inner bottom plating in accordance with 2.4.4.4.1.

The bottom stake thickness of the tank sloped bulkhead shall not be less than that of the inner bottom plate adjacent to it. The thickness of other stakes, in mm, shall not be less than:

$$s_{\min} = (7 + 0,035L)\sqrt{\eta}, \quad (3.3.4.2)$$

but not greater than the bottom stake thickness, where  $\eta$  shall be obtained from Table 1.1.4.3.

Where the hold and/or tank is used for the carriage of oil, oil products or water ballast, the thickness shall not be less than required by 3.5.4;

**.2** the section modulus of primary members of the sloped bulkhead shall not be less than that determined in accordance with 1.6.4.1 and 1.6.4.2 taking:

$p$  = design pressure as defined in 3.3.3;

$m = 10$  for transverse stiffeners;

$m = 12$  for longitudinal stiffeners;

$k_{\sigma}$  shall be taken as for the bulkhead stiffeners of tankers as specified in 2.7.4.2, but not more than for the inner bottom primary members in accordance with 3.3.4.1.3.

The longitudinal stiffeners shall comply with buckling strength requirements, as specified in 1.6.5.2;

**.3** the thickness of the diaphragm plating shall not be less than that of the abutting plate floors. Stiffening of the diaphragms with openings shall comply with the requirements for stiffeners of the floors, as specified in 1.7.3.1.

The thickness of plating and the scantlings of the stiffening framing members of the watertight diaphragms shall comply with the requirements for the tank bulkheads as specified in 2.7.4.1 and 2.7.4.2.

**3.3.4.3** Where the frame ends are attached directly to the sloped bulkheads of tanks (without transition horizontal area), the section modulus at support section  $W_{sup}$ , in  $\text{cm}^3$ , shall be not less than:

$$W_{sup} = W_0 / \cos^2 \alpha \quad (3.3.4.3)$$

where  $W_0$  = section modulus at the frame support section as required by 2.5.5.1, in  $\text{cm}^3$ ;

$\alpha$  = slope angle of the tank bulkhead to the base line, in deg.

**3.3.4.4** The scantlings of the frames shall be in accordance with the requirements of 2.5.4.1 and with the following requirements:

**.1** the thickness of frame webs  $s_{w \min}$ , in mm, shall not be less than:

$$s_{w \min} = k(7 + 0,03L) \quad (3.3.4.4.1)$$

where  $k = 1,15$  for frame webs in way of the foremost hold;

$k = 1,0$  for frame webs in way of other holds;

**.2** the thickness of the bracket connecting the lower end of frame to the bilge tank shall not be less than that of the frame web or  $s_{w \min} + 2$  mm, whichever is greater. The thickness of the bracket connecting the upper end of frame to the underdeck tank shall not be less than that of the frame web;

**.3** the section modulus of the frame and bracket or integral bracket, and associated shell plating, shall not be less than twice the section modulus required for the frame midspan area.

**3.3.4.5** The scantlings of the topside tank members shall comply with the following requirements:

**.1** the plating thickness of the vertical and sloped bulkheads of the topside tank shall not be less than determined by the Formula (1.6.4.4) taking:

$$m = 15,8;$$

$p$  = design pressure as defined in 3.3.3;

$k_\sigma$  shall be taken as for the longitudinal bulkhead plating of tankers as specified in 2.7.4.1.

The thickness, in mm, of the vertical bulkhead plating and of the adjoining sloped bulkhead plate shall not be less than:

$$s_{\min} = 10 + 0,025L \quad (3.3.4.5.1)$$

The thickness of other sloped bulkhead plates shall be not less than that determined by the Formula (2.7.4.1-2). Where the hold and/or tank is used for the carriage of oil, oil products or water ballast, the thickness shall be not less than that required by 3.5.4;

**.2** the section modulus of longitudinal stiffeners of the vertical and sloped bulkheads shall not be less than that determined according to 1.6.4.1 and 1.6.4.2 taking:

$p$  = design pressure as defined in 3.3.3, but not less than 25 kPa;

$$m = 12;$$

$k_\sigma$  shall be taken as for horizontal stiffeners of longitudinal bulkheads of tankers as specified in 2.7.4.2.

The longitudinal stiffeners of the vertical and sloped bulkheads shall comply with buckling strength requirements of 1.6.5.2;

**.3** the section modulus of the transverse web of the sloped bulkhead shall be not less than that determined in 1.6.4.1 and 1.6.4.2, and the sectional area of the web plate shall not be less than that determined in accordance with 1.6.4.3 taking:

$$N_{\max} = 0,5pal;$$

$p$  = design loading as defined in 3.3.3, but not less than 25 kPa;

$$m = 10;$$

$$k_\sigma = k_\tau = 0,75;$$

**.4** the section modulus and sectional area of the deck transverse web inside the tank shall comply with the requirements of 2.6.4.6.

The section modulus and sectional area of the side transverse web inside the tank shall comply with the requirements of 2.5.4.5 at  $m = 10$ .

The section modulus and sectional area of vertical web plate of the tank vertical bulkhead shall be calculated as the mean of these values for the deck transverse and transverse web of the sloped bulkhead;

**.5** the plate thickness of bulkheads inside the tanks fitted in line with the hold transverse bulkheads shall not be less than that of the latter at the same distance from the inner bottom plating. Stiffening of bulkhead plating shall comply with the requirements of 2.7.4.2 for the tank primary members;

**.6** the thickness of brackets stiffening the tank vertical bulkhead and of brackets fitted at the lower corner of the tank shall not be less than 10 mm.

**3.3.4.6** In any case, the hold bulkhead plating and corrugations shall have a thickness not less than 10 mm.

The height of top rectangular (trapezoidal) stool, bottom trapezoidal stool and of double bottom is not included in the span of the hold bulkhead vertical corrugations.

**3.3.4.7** The scantlings of the transverse bulkhead lower trapezoidal stool members shall comply with the following requirements:

**.1** the thickness of the horizontal and sloped plate shall not be less than that determined by the Formula (1.6.4.4) taking:

$$m = 15,8;$$

$p$  = design pressure as defined in 3.3.3;

$$k_\sigma = 0,9.$$



The thickness of horizontal plate and top strake of the sloped plate shall not be less than that of the corrugation adjoining the stool. The thickness of the bottom strake of the sloped plate shall not be less than that of the inner bottom plating. The thickness of other stakes of the sloped plate shall not be less than that determined by the Formula (3.3.4.2). Where the hold and/or stool is used for the carriage of oil, oil products or water ballast, the thickness shall be not less than that required by 3.5.4;

**.2** the section modulus of the sloped plate stiffeners shall not be less than that determined in accordance with 1.6.4.1 and 1.6.4.2 taking:

$p$  = design pressure as defined in 3.3.3;

$m = 10$ ;

$k_{\sigma} = 0,75$ .

The section modulus of the horizontal plate stiffeners shall not be less than that of the sloped plate stiffeners;

**.3** the thickness of diaphragm shall not be less than that of side girders. Size of the openings cut in diaphragms and their reinforcement shall comply with the requirements for openings and reinforcement of the hopper side tank diaphragms as specified in 3.3.4.2.3.

**3.3.4.8** The scantlings of the transverse bulkhead top rectangular or trapezoidal stool members shall comply with the following requirements:

**.1** the thickness of the horizontal and vertical (or sloped) plates shall not be less than that determined by the Formula (1.6.4.4) taking:

$m = 15,8$ ;

$p$  = design pressure as defined in 3.3.3;

$k_{\sigma} = 0,9$ .

The thickness of the horizontal plate and bottom strake of the vertical (sloped) plate shall not be less than that of the corrugation adjoining the top stool. Where the vertical plate is fitted in line with the hatch end coaming, its thickness shall not be less than that of this coaming as required by 3.3.4.11. The top strake of the sloped plate shall have the same thickness provided that its upper edge is at a distance of less than 0,4 m from the hatch end coaming. In any case, the thickness of the vertical or sloped plate shall not be less than that determined by the Formula (2.7.4.1-2). Where the hold and/or interior of the top stool is used for the carriage of oil, oil products or water ballast, the thickness shall not be less than that required by 3.5.4;

**.2** the section modulus of the stiffeners of vertical or sloped plate shall not be less than that determined according to 1.6.4.1 and 1.6.4.2 taking:

$p$  = design pressure as defined in 3.3.3, but not less than 25 kPa.

$m = 12$  for horizontal stiffeners;

$m = 10$  for other stiffeners;

$k_{\sigma} = 0,75$ .

The section modulus of the stiffeners of horizontal plate shall not be less than that of the stiffeners of vertical or sloped plate;

**.3** the section modulus of the vertical or sloped plate web to be fitted where horizontal stiffeners are provided, as stated in 3.3.2.11.2, shall not be less than that determined from 1.6.4.1 and 1.6.4.2, while the sectional area of the web plate shall not be less than determined according to 1.6.4.3 taking:

$N_{\max} = 0,5pal$ ;

$p$  = design loading as defined in 3.3.3, but not less than 25 kPa;

$m = 10$ ;

$k_{\sigma} = k_{\tau} = 0,75$ .

The section scantlings of webs fitted on the horizontal plate and under the deck shall not be less than those required for the vertical (sloped) plate web;

**.4** the thickness of the brackets fitted inside the top stool to ensure efficient upper end attachment of corrugations shall not be less than that of these corrugations in the upper part of the bulkhead.

**3.3.4.9** The scantlings of the cofferdam bulkhead members shall comply with the following requirements:

**.1** the thickness of the cofferdam bulkhead plating shall not be less than that determined by the Formula (1.6.4.4) taking:

$m = 15,8$ ;

$p$  = design pressure as defined in 3.3.3;

$k_{\sigma} = 0,9$ .

The plating thickness shall not be less than that determined by the Formula (2.7.4.1-2) or according to 3.3.4.6, whichever is the greater. Where the hold or interior of the cofferdam bulkhead is used for the carriage of oil, oil products or water ballast, the plating thickness shall be not less than that required by 3.5.4;

**.2** the section modulus of primary members stiffening the plating of cofferdam bulkheads shall not be less than that determined from 1.6.4.1 and 1.6.4.2 taking:

$p$  = design pressure as defined in 3.3.3 but not less than 25 kPa;

$m = 12$ ;

$k_{\sigma} = 0,75$ ;

**.3** where the construction of the cofferdam bulkhead incorporates only diaphragms or only platforms, their section modulus shall not be less than that determined from 1.6.4.1 and 1.6.4.2, and the sectional area is not less than that determined from 1.6.4.3 taking:

$N_{\max} = 0,5pal$  for platforms,

$N_{\max} = 0,65pal$  for diaphragms;

$p$  = design loading as defined in 3.3.3, but not less than 25 kPa;

$l$  = span, in m, equal to:

for diaphragms — the distance between the deck plating and inner bottom plating, at the centreline;

for platforms — the ship's breadth in way of construction bulkhead for ships having single skin side construction, the distance between the inner skins for ships having double skin side construction;

$m = 10$ ;

$k_{\sigma} = k_{\tau} = 0,75$ ;

**.4** where the construction of the cofferdam bulkhead consists both the diaphragms and platforms, their thickness shall be determined on the basis of the calculation of the grillage as a system using beam models, with the loading specified in 3.3.3 but not less than 25 kPa and the permissible stress factors  $k_{\sigma} = k_{\tau} = 0,75$ ;

**.5** in any case, the thickness of the cofferdam bulkhead diaphragms and platforms shall not be less than that determined by the Formula (2.5.4.8.1). Where the interior of the cofferdam bulkhead is used as a fuel oil or ballast tank, the thickness of the diaphragms and platforms shall not be less than that required by 3.5.4;

**.6** stiffening of the diaphragms and platforms shall comply with the requirements of 1.7.3.2.2;

**.7** the thickness of tight portions of the diaphragms and platforms and their stiffeners shall comply with the requirements of 2.7.4.1 and 2.7.4.2 for tank bulkheads;

**.8** cross ties between the primary members strengthening the cofferdam bulkhead plating shall comply with the requirements for the double bottom intermediate struts, as specified in 2.4.4.7 with the design pressure determined according to 3.3.3, but not less than 25 kPa.

Where cross ties are fitted, the section modulus of the primary members, as specified in 3.3.4.9.2, may be reduced by 35 per cent.

**3.3.4.10** The thickness of the hatch coamings shall not be less than that determined by the Formula (3.3.4.4.1).

The thickness of the hatch side coamings, in mm, shall not be less than:

$$s = 17a \quad (3.3.4.10)$$

where  $a$  = vertical distance between horizontal stiffeners on coaming plate or between the lower stiffener and the deck plating, in m.

Stiffening of the coaming plates shall comply with the requirements of 1.7.3.2. The thickness of coaming plate stiffeners and brackets shall not be less than 10 mm.

The width of the coaming face plate shall comply with the requirements of 1.7.3.1.

**3.3.4.11** The thickness of single-side shell plating located between hopper and upper wing tanks shall

not be less than  $s_{\min}$ , in mm, determined by the formula

$$s_{\min} = \sqrt{L}. \quad (3.3.4.11)$$

### 3.3.5 Special requirements.

**3.3.5.1** Provision shall be made for an efficient corrosion protection coating (epoxy coating or equivalent) for all internal surfaces of the cargo holds, excluding the flat tank top areas and the hopper tanks sloping plating, approximately 300 mm below the toe of frame brackets and for all internal and external surfaces of hatch coamings and hatch covers. In the selection of coating due consideration shall be given to intended cargo conditions expected in service.

**3.3.5.2** All the bulk carriers and combination carriers contracted for construction on or after 1 July 2003 shall comply with the following requirements:

**.1** the ships shall have the forecastle located above the freeboard deck. In case the above requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided the forecastle length is not less than 7 per cent of ship length abaft the forward perpendicular where the ship length – refer to 1.2.1, Part I "General" of Load Line Rules for Sea-Going Ships. The forecastle shall have at least a standard height according to the International Convention on Load Lines, 1966 as amended by the Protocol of 1988 or shall be by 0,5 m above the forward hatch-end coaming of the fore hold No. 1, whichever is greater. In this case, the distance between the aft edge of the forecastle deck and the forward hatch-end coaming of the fore hold No. 1 over the entire breadth of the ship's hull shall not exceed the value, in m, determined by the formula

$$l_F = \sqrt{H_F - H_C} \quad (3.3.5.2.1)$$

where  $H_F$  = forecastle height, m;

$H_C$  = height of the forward hatch-end coaming of the fore hold No. 1, m.

No breakwater is allowed on the forecastle deck for protection of the forward hatch-end coaming and hatch covers of the fore hold No. 1. However, if fitted for other purposes, the breakwater shall be placed at a distance of at least 2,75 its height along the centreline from the aft edge of the forecastle deck;

**.2** a net thickness (no wear allowance) of hatch coamings shall not be less than that determined by the formula

$$s_{\text{net}} = 14,9a\sqrt{1,15p_{\text{coam}}/0,95R_eH} \quad (3.3.5.2.2)$$

where  $a$  = distance between stiffeners, m;

$p_{\text{coam}}$  = pressure equal to 220 kPa; if the requirements of 3.3.5.2.1 are not met, the pressure for the forward hatch-end coaming of the fore hold No. 1 shall be assumed equal to 290 kPa.

The net thickness increased by 1,5 mm shall be taken as the minimum construction thickness.

In any event, the coaming thickness shall not be less than 11 mm;

**.3** the section modulus of longitudinal and transverse stiffeners of hatch coamings at the net thickness of all section elements, in  $\text{cm}^3$ , shall not be less than determined by the formula

$$W_{net} = \frac{1,15a^2 p_{coam}}{0,95m c_p R_{eH}} \cdot 10^3 \quad (3.3.5.2.3)$$

where for  $a$  and  $p_{coam}$ , refer to 3.3.5.2.2;

$l$  = stiffener span, m;

$m$  = coefficient equal to:

16 – for snipped stiffener ends;

12 – in way of hatch corners;

$c_p$  = plastic-to-elastic section modulus ratio for a stiffener with an effective flange  $40s_{net}$  wide, where  $s_{net}$  = net thickness of a coaming. If precise data are lacking,  $c_p$  may be assumed equal to 1,16.

The net thickness of all cross-section elements increased by 1,5 mm shall be taken as the minimum construction thickness;

**.4** stays (brackets) of hatch coamings shall comply with the following requirements:

the section modulus of stays (brackets) in the plane of beams with a net thickness of all section elements shall not be less than that determined by the formula

$$W_{net} = \frac{500aH_c^2 p_{coam}}{0,95R_{eH}} \quad (3.3.5.2.4-1)$$

where  $a$  = distance between stays in the plane of beams, m;

for  $p_{coam}$ , refer to 3.3.5.2.2;

$H_c$  = height of a hatch coaming, m.

In determination of the actual section modulus, the face plate of the coaming stay may be considered only when it is welded to the deck plating with full penetration and appropriately dimensioned stiffeners, knees or brackets are fitted in its plane under the plating. The net thickness of a web of stays in the plane of beams shall not be less than that determined by the formula

$$s_{net} = \frac{1000aH_c p_{coam}}{0,5hR_{eH}} \quad (3.3.5.2.4-2)$$

where  $h$  = depth of a stay web at its attachment to deck plating, mm;

for  $a$  and  $H_c$ , refer to Formula (3.3.5.2.4-1);

for  $p_{coam}$ , refer to 3.3.5.2.2.

The net thickness of all cross-section elements increased by 1,5 mm shall be taken as the minimum construction thickness.

Strength calculations for stays off the plane of beams are subject to special consideration by the Register in each case. The permissible stresses in those calculations shall be assumed equal to 0,8 and 0,46 the steel yield stress for normal and shear stresses accordingly.

The stay web shall be joined to deck plating by a double continuous weld having an effective throat thickness not less than  $0,44s$  where  $s$  is the minimum construction thickness of the stay web, mm. At least 15 per cent of the weld length therewith beginning at the "free" end of the stay shall be made with deep penetration (double-bevel preparation).

The strength of underdeck structures taking forces from coaming stays shall be checked against permissible normal and shear stresses equal to 0,95 and 0,5 the steel yield stress accordingly;

**.5** longitudinal and transverse stiffeners, stays and plate elements of cargo hatch coamings shall be replaced if the actual residual thickness of the coaming element is less than  $t_{net} + 0,5$  mm.

Where the actual residual thickness is greater than  $t_{net} + 0,5$  mm, but less than  $t_{net} + 1,0$  mm, a protective coating instead of replacement may be applied in accordance with the Manufacturer's procedure or annual measurements of the actual residual thickness may be conducted. If the coating is applied, it shall be maintained in GOOD technical condition (refer to 1.1.2.10, Part III "Additional Surveys of Ships Depending on Their Purpose and Hull Material" of the Rules for the Classification Surveys of Ships in Service).

### 3.3.6 Strength control during ship loading.

**3.3.6.1** Ore carriers and combination carriers of 150 m length and more shall be provided with an approved Loading Manual and the Register-approved loading instrument of an approved type.

**3.3.6.2** Loading Manual is a document approved by the Register, which describes:

**.1** the loading conditions on which the design of the ship has been based, including permissible limits of still water bending moments and shear forces;

**.2** the results of the calculations of still water bending moments, shear forces and where applicable, limitations due to torsional loads;

**.3** envelope results and permissible limits of still water bending moments and shear forces in the hold flooded condition according to 3.3.5.2;

**.4** the cargo holds or combination of cargo holds that might be empty at full draught. If no cargo hold is allowed to be empty at full draught, this shall be clearly stated in the Loading Manual;

**.5** maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position;

**.6** maximum allowable and minimum required mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds. This mean draught may be calculated by averaging the draught of the two mid-hold positions;

.7 maximum allowable tank top loading together with specification of the nature of the cargo (density or stowage factor) for cargoes other than bulk cargoes;

.8 maximum allowable load on deck and hatch covers. If the ship is not approved to carry load on deck or hatch covers, this shall be clearly stated in the Loading Manual;

.9 the maximum rate of ballast change together with the advice that a load plan shall be agreed with the terminal on the basis of the achievable rates of change of ballast.

**3.3.6.3** In addition to the requirements given in 1.4.3.1.1, the following conditions, subdivided into departure and arrival conditions as appropriate, shall be included in the Loading Manual:

.1 alternate light and heavy cargo loading conditions at maximum draught, where applicable;

.2 homogeneous light and heavy cargo loading conditions at maximum draught;

.3 ballast conditions. For ships having ballast holds adjacent to double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when double bottom tanks are empty;

.4 short voyage conditions where the vessel shall be loaded to maximum draught but with limited amount of bunkers;

.5 multiple port loading/unloading conditions;

.6 deck cargo conditions, where applicable;

.7 typical loading sequences where the vessel is loaded from commencement of cargo loading to reaching full deadweight capacity, for homogeneous conditions, relevant part load conditions and alternate conditions where applicable. Typical unloading sequences for these conditions shall also be included. The typical loading/unloading sequences shall also be developed to not exceed applicable strength limitations. The typical loading sequences shall also be developed paying due attention to loading rate and the deballasting capability;

.8 typical sequences for change of ballast at sea, where applicable.

**3.3.6.4** A loading instrument is an approved digital system as defined in 1.4.9.4. In addition to the requirements in 1.4.9.4, it shall ascertain as applicable that:

.1 the mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position;

.2 the mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds;

.3 the still water bending moment and shear forces in the hold flooded conditions according to 3.3.5.2;

are within permissible values.

**3.3.6.5** Conditions of approval of loading instruments, as stated in 1.4.9.4, shall include the following:

.1 acceptance of hull girder bending moment limits for all read-out points;

.2 acceptance of hull girder shear force limits for all read-out points;

.3 acceptance of limits for mass of cargo and double bottom contents of each hold as a function of draught;

.4 acceptance of limits for mass of cargo and double bottom contents in any two adjacent holds as a function of draught.

### 3.4 ORE CARRIERS AND ORE OR OIL CARRIERS

#### 3.4.1 General.

**3.4.1.1** The requirements of this Chapter apply to ships for the carriage of ore and other bulk cargoes, as well as to combination carriers for transportation of ore and oil (petroleum products).

**3.4.1.2** The requirements for structures not mentioned in this Chapter shall be as stated in Sections 1 and 2, having regard to those contained in 3.3 as regards structures exposed to the loads from heavy dry bulk and liquid cargoes.

In any case, the requirements for the hull and its structures shall not be less stringent as those of Sections 1 and 2.

**3.4.1.3** The basic structural type of a ship is considered to be a single deck ship, with machinery aft, having longitudinal bulkheads separating the centre ore compartment from the wing tanks and a double bottom throughout the entire breadth of the ship or the centre part between the longitudinal bulkheads.

**3.4.1.4** Descriptive notation and distinguishing mark (**ESP**).

**3.4.1.4.1** The descriptive notation **Ore carrier** and the distinguishing mark (**ESP**) shall be assigned to sea-going self-propelled single deck ships having two longitudinal bulkheads and a double bottom throughout the cargo region and intended for the carriage of ore cargoes in the center holds only. A typical midship section is given in Fig. 3.4.1.4.1.

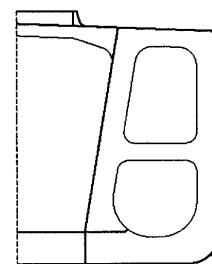


Fig. 3.4.1.4.1

**3.4.1.4.2 Combination carrier** is a general term applied to ships intended for the carriage of both oil and dry cargoes in bulk; these cargoes are not carried simultaneously, with the exception of oil retained in slop tanks.

**3.4.1.4.3** The descriptive notation **Ore/Oil carrier** and the distinguishing mark (**ESP**) shall be assigned to sea-going self-propelled single deck ships having two longitudinal bulkheads and a double bottom throughout the cargo region and intended for the carriage of ore cargoes in the centre holds or of oil cargoes in centre holds and wing tanks. Typical midship sections are given in Fig. 3.4.1.4.3.

#### 3.4.2 Construction.

**3.4.2.1** The deck and bottom (double bottom) shall be longitudinally framed. The side shell and longitudinal bulkheads may, in general, be framed either longitudinally or transversely. Deck plating between end coamings of adjacent cargo hatches shall be strengthened by transverse stiffeners as required by 3.3.2.1.

Transverse bulkheads may be plane with stiffeners arranged vertically, corrugated with vertical corrugations or of a cofferdam type.

**3.4.2.2** Floors in the centre hold and in the wing tanks shall be aligned and to form, in conjunction with side transverses, vertical webs of longitudinal bulkheads and deck transverses, a single transverse ring structure.

**3.4.2.3** Where transverse bulkheads in the wing tanks are not aligned with centre hold bulkheads, transverse ring structures shall be fitted in line with the latter bulkheads.

In this case, provision shall be made in the wing tanks for a smooth tapering of the sloped bulkheads of trapezoidal stools fitted under centre hold bulkheads.

**3.4.2.4** Longitudinal bulkheads shall, in general, be plane with horizontal or vertical stiffening.

Longitudinal bulkheads may be slightly sloped or to have a knuckle.

**3.4.2.5** Where a double bottom in wing tanks is omitted, floors shall be backed by substantial knees or brackets fitted in line with the inner bottom plating of the centre hold.

**3.4.2.6** Diaphragms shall be fitted in line with the longitudinal bulkheads inside the bottom trapezoidal stools and top stools of rectangular or trapezoidal

sections. The diaphragms of the bottom stools shall comply with the requirements of 3.3.2.10.3, the diaphragms of the top stools — with the requirements for the topside tank bulkheads as specified in 3.3.2.3.

#### 3.4.3 Design loads.

**3.4.3.1** The design pressure on the centre hold boundary structures shall be determined according to 1.3.4.3 assuming that the centre hold is loaded with ore or other heavy bulk cargo.

**3.4.3.2** Structures which are likely to be subjected to one-sided pressure of a liquid cargo (ballast water) shall be examined for the design pressure of the liquid cargo as required by 1.3.4.2.

#### 3.4.4 Scantlings of structural members.

**3.4.4.1** The scantlings of structural members of the cargo spaces intended only for the carriage of bulk cargoes or bulk cargoes and oil, oil products or water ballast shall comply with the requirements of Section 2 and 3.3.4.

The scantlings of structural members of the cargo spaces intended only for the carriage of oil, oil products or water ballast shall comply with the requirements of Section 2 and 3.5.4.

**3.4.4.2** The scantlings of longitudinal bulkhead members shall comply with the requirements of 2.7.4 at the design pressure defined in 3.4.3.

In any case, the thickness of longitudinal bulkhead plating shall not be less than that required by the Formula (3.3.4.5.1) or, where oil, oil products or water ballast is carried in any compartment bounded by that bulkhead, it shall be not less than that required by 3.5.4, whichever is the greater.

**3.4.4.3** The scantlings of structural items of diaphragms of transverse bulkhead bottom trapezoidal stool, fitted in line with the longitudinal bulkheads, shall comply with the requirements of 3.3.4.7.3.

**3.4.4.4** The scantlings of structural items of diaphragms of transverse bulkhead top stool, fitted in line with longitudinal bulkheads, shall comply with the requirements of 3.3.4.5.5 for the transverse bulkheads inside the topside tanks.

#### 3.4.5 Special requirements.

**3.4.5.1** All ore carriers shall have the forecastle located above the freeboard deck. The forecastle arrangement and dimensions, as well as the thickness and scantlings of stiffeners and plate elements of cargo hatch coamings shall meet the requirements of 3.3.5.4.

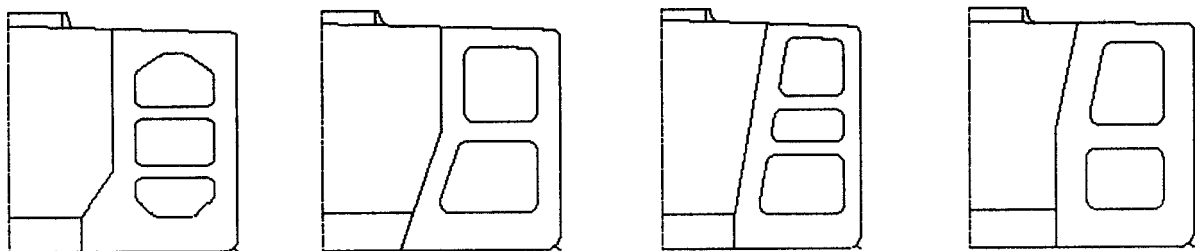


Fig. 3.4.1.4.3

### 3.5 TANKERS

#### 3.5.1 General.

**3.5.1.1** The requirements of this Chapter apply to tankers, chemical tankers, as well as to oil recovery ships and gas carriers, as applicable, with machinery aft, having a single or a double bottom arrangement and one, two or three longitudinal bulkheads. Hull structural members of tankers not covered by this Chapter shall comply with the requirements of Sections 1 and 2.

Double hull oil tankers of 150 m and over in length, which contract for construction is signed on 1 April 2006 or later, shall comply with the requirements of Part XVII "Common Structural Rules for Double Hull Oil Tankers" (refer also to 1.1.1.1).

**3.5.1.2** Descriptive notation and distinguishing mark (ESP).

**3.5.1.2.1** The descriptive notation **Oil tanker** and the distinguishing mark (ESP) shall be assigned to sea-going self-propelled ships having integral tanks and intended for the carriage of oil in bulk. The above mentioned descriptive notation and distin-

guishing mark shall be assigned to tankers of both single and double skin side construction, as well as tankers with alternative structural arrangements, e.g. mid-deck designs. Typical midship sections are given in Fig. 3.5.1.2.1.

**3.5.1.2.2** The descriptive notation **Chemical tanker** and the distinguishing mark (ESP) shall be assigned to sea-going self-propelled ships having integral tanks intended for the carriage of chemicals in bulk. This descriptive notation shall be assigned to tankers of both single or double skin side construction, as well as tankers with alternative structural arrangements. Typical midship sections are given in Fig. 3.5.1.2.2.

#### 3.5.2 Structural configuration.

**3.5.2.1** The scantlings of the cofferdams shall be determined according to 2.7.5.2.

**3.5.2.2** Longitudinal corrugated bulkheads are permitted in ships under 180 m in length.

Longitudinal corrugated bulkheads shall have horizontally arranged corrugations, and their upper and lower strakes for  $0,1D$  from the deck and bottom, respectively, shall be plane.

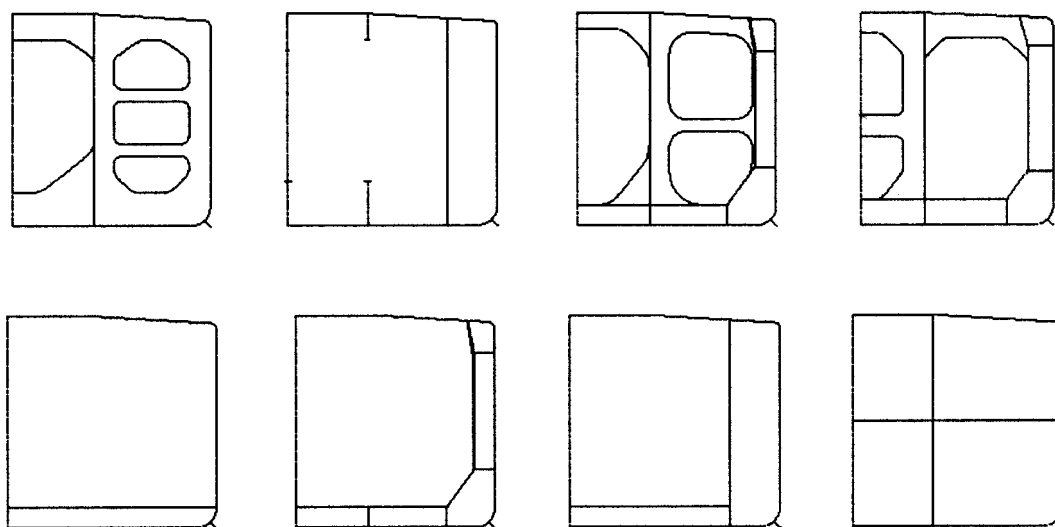


Fig. 3.5.1.2.1

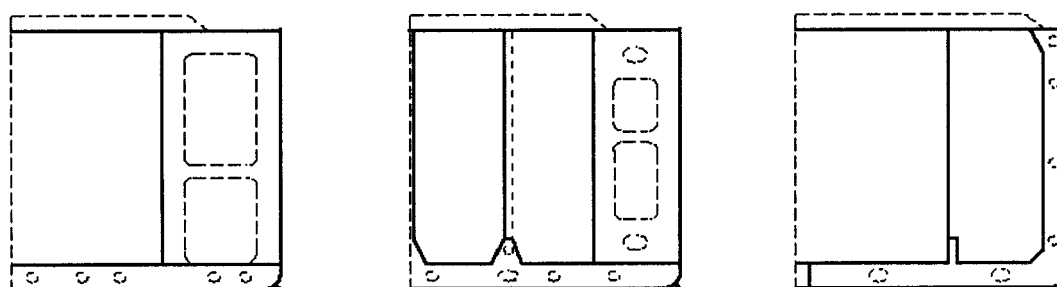


Fig. 3.5.1.2.2

In way of connections between longitudinal and transverse bulkheads, continuity of strength shall be maintained at the top and bottom strakes of the longitudinal bulkheads.

**3.5.2.3** The deck and bottom in the cargo tank region shall be framed longitudinally, for the side shell and longitudinal bulkheads, longitudinal or transverse framing may be adopted. The deck and bottom of ships under 80 m in length may be transversely framed. It is recommended that longitudinal framing be used for side shell and longitudinal bulkheads of ships over 180 m in length. Where the longitudinal framing is adopted, spacing of transverse members shall correspond to that of bottom transverses (refer to 2.3.2.4 and 2.4.2.5).

**3.5.2.4** The longitudinal scantlings of deck, bottom, side shell and longitudinal bulkheads within the midship portion of the ship shall not vary. Structural continuity of the above longitudinals shall be ensured within  $0,1D$  from deck and bottom.

In ships of 150 m in length and more, the above longitudinals shall pass through the transverse bulkheads without cutting.

**3.5.2.5** The primary supporting members (bottom centreline girder, side girders, vertical webs on bulkheads, deck centreline girder, continuous deck girders, side and bottom transverses, side stringers and bulkhead horizontal girders) in way of cargo tanks shall form a transverse ring structure, whenever possible.

**3.5.2.6** Hull structural members shall be interconnected as required by 1.7.2. The webs of primary supporting members shall be supported by horizontal or vertical stiffeners in accordance with 1.7.3.2. The inertia moment of stiffeners shall comply with 1.6.5.6.

### **3.5.3 Design loads.**

Unless provided otherwise in this Chapter, the design loads on hull structures of tankers shall be taken according to 1.3 and relevant chapters of Section 2.

### **3.5.4 Scantlings of structural members.**

The scantlings of structural members of tankers shall be determined in compliance with Section 2, having regard to the provisions of this Chapter.

The thickness  $s_{\min}$ , in mm, of structural members, forming the boundaries of cargo and ballast tanks as well as members fitted inside these tanks shall not be less than:

$$\begin{aligned} s_{\min} &= 5,5 + 0,035L \text{ for } L < 80 \text{ m;} \\ s_{\min} &= 6,7 + 0,02L \text{ for } L \geq 80 \text{ m.} \end{aligned} \quad (3.5.4)$$

Where  $L > 290$  m,  $L$  shall be taken as equal to 290 m. In this case, the minimum thickness of the primary members need not exceed 11,5 mm.

### **3.5.5 Special requirements.**

**3.5.5.1** The number of openings for access to cofferdams, pump rooms, cargo and ballast tanks shall be kept to the minimum required. They shall be

as far distant as practicable from end bulkheads of superstructures. Hatches to wing tanks in line with a centre tank hatch in the athwart direction are not permitted.

Hatch openings shall be either circular or elliptical in shape, the elliptical openings having the major axis fore and aft. Structural continuity of deck girders and longitudinals shall be maintained. The thickness of cargo hatch coamings less than 750 mm high shall be 10 mm, while coamings 750 mm and more in height shall have a thickness equal to 12 mm. Coamings more than 750 mm in height, provided they are more than 1,25 m long, shall be stiffened.

**3.5.5.2** Guard rails, bulwark, gangway or an equivalent arrangement shall be fitted in compliance with 8.6, Part III "Equipment, Arrangements and Outfit".

The gangway, if fitted, shall not contribute to hull longitudinal bending.

## **3.6 VESSELS OF DREDGING FLEET**

### **3.6.1 General.**

**3.6.1.1** The requirements of this Chapter apply to the hulls of the vessels of dredging fleet and floating cranes. Areas where such ships operate and/or transport spoil are called work areas. The transfer of the ship from one work area to another is called a voyage.

**3.6.1.2** As to their purpose, vessels of dredging fleet shall be defined as follows.

**Dredgers** are self-propelled or non-self-propelled ships designed to operate for the purpose of raising the soil (silt, sand, gravel, clay, etc.) using any dredging gear (buckets, suction pipes, grabs, etc.) and having no spaces where the soil may be stored or transported.

**Hopper dredgers** are self-propelled ships having dredging gear for raising the soil and one or two hoppers where the spoil may be stored or transported.

**Hopper barges** are self-propelled or non-propelled ships designed only for transportation of the soil, but having no dredging gear. They can be single-hulled or double-hulled capable of opening.

**Floating cranes and crane ships** — refer to the definitions in 1.1, Part I "Classification".

**3.6.1.3** The basic structural configuration of a vessel of dredging fleet, considered in this Chapter, is a single-deck vessel with ordinary ship lines or of a pontoon shape, having a ladder well or other hull cut-outs.

The pontoon hull shape may be used only in vessels of restricted service **R2**, **R2-RSN**, **R3-RSN** and **R3**.

Use of a pontoon hull in vessels of restricted service **R1** and of unrestricted service shall be specially considered by the Register.

**3.6.1.4** The requirements of this Chapter apply to dredgers, single-hulled and opening double-hulled hopper dredgers and hopper barges, floating cranes and crane ships.

**3.6.1.5** In opening hopper dredgers and hopper barges, subject to the Register supervision are deck and deckhouse hinges, hydraulic presses and their hull connections as well as longitudinal and transverse structures between the hulls and deckhouses.

**3.6.1.6** For the purpose of this Chapter the following symbols have been adopted:

$d_1$  = maximum dredging draught, in m, at which the vessel is designed to operate;

$d_2$  = draught during sea voyage, in m;

$\Delta$  = displacement at the draught  $d_1$  or  $d_2$ , in t;

$\Delta_l$  = light-ship displacement without spoil mixture, in m;

$\Omega$  = mid-section area corresponding to the draught  $d_1$  or  $d_2$ , in m<sup>2</sup>;

$l_h$  = full length of the hopper, in m;

$h_{l.cr}$  = depth of a hopper lower cross-member, in m;

$l_{l.cr}$  = hopper lower cross-member span measured at mid-depth between longitudinal bulkheads of the hopper, in m;

$H_1$  = distance from the mid-depth of the hopper lower cross-member to the deck at side, in m;

$H_2$  = distance from the base line to the upper edge of the coaming, in m;

$h_c$  = coaming height above the deck line at side, in m;

$B_2$  = distance between the side shell and the longitudinal bulkhead at mid-depth of a hopper lower cross-member, in m;

$B_3$  = distance between the side shell and the longitudinal bulkhead at the deck level, in m;

$Q_s$  = maximum mass of the spoil mixture in the hopper, in t;

$\rho_s$  = density of spoil mixture, defined as a ratio of the spoil mass in the hopper at the maximum draught  $d_1$  to the hopper volume up to the level of overflow or to the upper edge of the hopper coaming where there is no overflow, in t/m<sup>3</sup>; it shall not be taken more than 1,8;

$A_{b,k}$ ,  $A_{l.cr}$  = areas enveloped in the contour of the centre line box keel, hopper lower cross-member, respectively, in m<sup>2</sup>; where the centre line keel and/or a hopper lower cross-member are an ordinary girder (web with a face plate), it is assumed that  $A_{b,k} = A_{l.cr} = 0$ ;

$b_{b,k}$  = centre line box keel width at lower portion, in m;

$b_b$  = bottom breadth from the side shell to the point of intersection of the hopper longitudinal bulkhead with the bottom, in m;

$b_{f.p}$  = width of the coaming upper face plate, in m;

$a$  = spacing of frames, hopper side stiffeners, longitudinals, in m;

$b$  = spacing of transverse ring structures, in m;

$l_1$ ,  $l_2$  = length of the upper and lower face plate of the hopper lower cross-member, measured from the hopper longitudinal bulkhead to the centre line box keel, in m;

$R_{up.cr}$ ,  $R_{l.cr}$  = axial force acting on the hopper upper and lower cross-member, respectively, in kN;

$N$  = design axial force, in kN.

$\Delta s$  = corrosion allowance, in mm, for plate thickness (refer to 1.1.5.1);

$\omega_k$  = factor taking corrosion allowance into account with regard to the section modulus of members (refer to 1.1.5.3).

Some of the symbols are shown in Fig. 3.6.1.6.

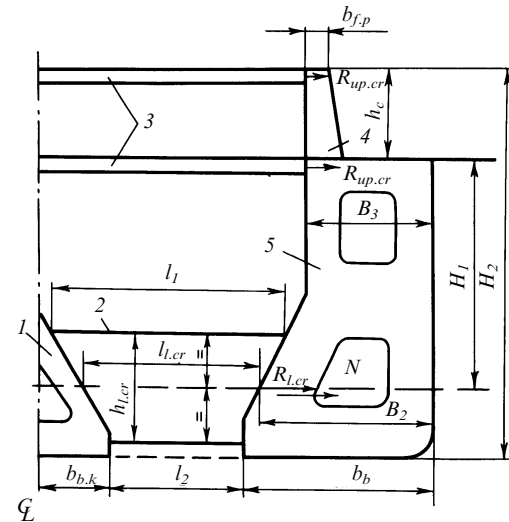


Fig. 3.6.1.6:

1 — centre line box keel; 2 — hopper lower cross member;

3 — hopper upper cross member;

4 — stay of coaming; 5 — diaphragm

### 3.6.2 Construction.

**3.6.2.1** Main hull structures shall comply with the requirements of Section 2, having regard to the provisions and additions given in this Chapter.

Referred to the particular structures of vessels of dredging fleet are:

hopper longitudinal and transverse bulkheads;

hopper lower and upper cross-members;

centre line box keels, hopper coamings;

diaphragms and transverse ring structures in buoyancy spaces (refer to 3.6.2.11).



For floating cranes strengthening shall be provided of the pontoon hull beneath the fixed crane tower supporting the upper crane structure, this strengthening including the crane tub, the bulkhead cross and the bearing contour (Fig. 3.6.2.1). Other construction of the pontoon strengthening in way of the tower shall be specially considered by the Register.

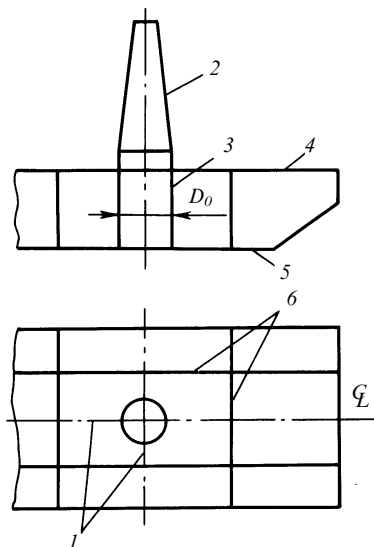


Fig. 3.6.2.1:

1 — bulkhead of the cross; 2 — fixed crane tower; 3 — tub;  
4 — upper deck; 5 — bottom;  
6 — bulkheads of the bearing contour

### 3.6.2.2 Shell plating.

**3.6.2.2.1** Corners of hopper and well openings in the bottom plating shall be rounded and insert plates, the dimensions of which shall be approved by the Register, shall be fitted at the corners.

**3.6.2.2.2** The cutting of overflow discharge trunk openings in the sheerstrake shall be avoided wherever practicable. Where such openings cannot be dispensed with, their upper edge shall not be within 800 mm of the deck line at side. They shall have corner radii of not less than 150 mm.

**3.6.2.2.3** Angular connection of the side shell plating or longitudinal bulkhead of the well with the bottom plating shall be made by means of section steel (rod, bar).

### 3.6.2.3 Single bottom.

**3.6.2.3.1** The bottom centre girder in way of the hopper and well of hopper dredgers shall not be fitted.

**3.6.2.3.2** The depth of floors abreast of hoppers in hopper dredgers and barges with transverse framing and abreast of dredging wells in hopper dredgers shall not be less than  $\frac{1}{18} B_1$ .

The breadth  $B_1$  is taken:

in way of the hopper, equal to the breadth of the vessel after deducting the breadth of the hopper at bottom, but not less than  $0,6B$ ;

in way of the well, equal to the breadth of the vessel after deducting the breadth of the well.

**3.6.2.3.3** Side girders shall be fitted in side buoyancy tanks of hopper dredgers and hopper barges where the tank width between the vessel's side and the longitudinal bulkhead exceeds 3,5 m in transversely framed vessels, and 4 m in longitudinally framed vessels.

Side girders in opening hopper barges may be omitted.

**3.6.2.3.4** In the pump rooms of hopper dredgers, the bottom framing shall be identical to that of the engine room.

In the area where soil pumps are located, the depth of floors and side girders may be reduced with the required section modulus and web area being maintained. Otherwise a calculation proving the strength of the bottom grillage in the region concerned shall be submitted to the Register.

**3.6.2.3.5** In floating cranes plate floors shall be fitted at every frame within  $0,2L$  from the forward perpendicular over the entire breadth of the hull and additional bottom transverses or longitudinals spaced not more than 0,35 m apart shall be fitted.

### 3.6.2.4 Double bottom.

**3.6.2.4.1** In lieu of the bottom centre girder, two side girders may be fitted on each side of ship's centre line at a distance not exceeding 1 m from each other and passing into the webs of the centre line box keel or into the well sides (Fig. 3.6.2.4.1).

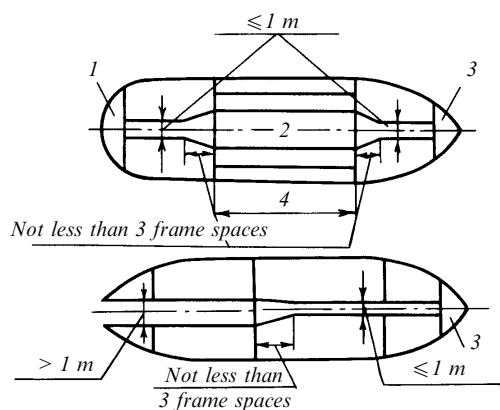


Fig. 3.6.2.4.1:

1 — after peak; 2 — centre line box keel;  
3 — fore peak; 4 — hopper space

**3.6.2.4.2** Additional side girders extending over a distance of not less than three spacings from the end of the bracket shall be fitted in the double bottom under the lower brackets of longitudinal bulkheads of the hopper space or the well and under the brackets of the centre line box keel.

**3.6.2.5 Side framing:**

**3.6.2.5.1** In floating cranes, hopper dredgers designed to work in conjunction with hopper barges, and in hopper barges, the side framing shall be reinforced as follows:

two rows of efficient fenders, one fitted at the deck level or 200 mm below it, the other 200 to 300 mm above the lowest operating waterline amidships;

the upper and lower fenders in hopper dredgers shall be connected by vertical fenders fitted in line with frames;

it is recommended that a side stringer required by 2.5.4.4 which shall be taken into account in determining the scantlings of the frames or an intercostal side stringer be fitted at a level of the lower fenders.

**3.6.2.5.2** In floating cranes the strengthening of the side framing within  $0,2L$  from the forward perpendicular shall comply with the requirements of 3.6.2.8. Web frames shall be spaced not more than four spacings apart.

**3.6.2.5.3** In floating cranes, intermediate frames of the same scantlings as the main frames shall be fitted in the fore peak and in areas extending forward for  $0,1L$  from the stern transom and inboard for  $0,1B$  over the entire depth. The extension and end attachments of intermediate frames shall comply with the requirements of 3.10.

**3.6.2.6 Decks and platforms.**

**3.6.2.6.1** Corners of openings in the deck plating in way of the hopper and the well shall be rounded. Insert plates, the dimensions of which shall be approved by the Register, shall be fitted at the corners.

**3.6.2.6.2** In hopper side buoyancy spaces, the hopper lower cross members shall be fitted in line with the web frames unless partial bulkheads are fitted.

**3.6.2.7 Watertight bulkheads.**

**3.6.2.7.1** Bulkheads forming the ends of the hopper shall extend from side to side.

**3.6.2.7.2** In bucket dredgers, protective bulkheads shall be provided parallel to the well sides at a distance of not less than 600 mm from them.

The extension of protective bulkheads shall be such as to prevent the ship from flooding in case of damage to the shell plating by objects brought up in the dredge buckets.

A protective bulkhead shall be also provided at the end of the well. The scantlings of framing members and the plating thickness of the protective bulkheads shall be determined as for permanent watertight bulkheads of dry cargo ships. The framing inside the cofferdam formed by the well side and the protective bulkhead may consist of brackets with openings cut therein. Cofferdams shall have access openings for maintenance.

**3.6.2.7.3** Bulkheads forming the ladder well in hopper dredgers shall be protected against possible damage by the ladder when moved.

**3.6.2.7.4** Longitudinal bulkheads of the hopper and well sides shall terminate at deck and bottom in brackets. The length of the arms of the brackets shall not be less than  $0,25D$  and their thickness shall not be less than the plating thickness of the longitudinal bulkhead. The brackets shall be strengthened with stiffeners and to have a face plate over the free edge. The top bracket shall be extended by a deck girder, the bottom bracket by a side girder for at least three spacings beyond the bracket end.

**3.6.2.7.5** In floating cranes the bulkheads forming the cross shall be rigidly connected with the bulkheads forming the bearing contour. These bulkheads shall be carried to the nearest transverse and longitudinal bulkheads (sides, transoms).

**3.6.2.8** In ships with a pontoon shape of the forward and after ends, the following structural requirements shall be fulfilled:

**.1** the fore and after peak bulkheads shall be fitted at a distance of  $0,1L$  from the forward and after transoms, but not less than one spacing from the line connecting the raked part and flat of the bottom;

**.2** frame spacing in peaks shall be not more than 550 mm;

**.3** the bottom framing within  $0,15L$  from the forward and after perpendiculars shall consist of plate floors fitted at every frame, with side girder spaced not more than 1 m apart.

The scantlings of floors and side girders shall be determined as for the midship region;

**.4** the side framing within  $0,2L$  from the forward and after perpendiculars shall be strengthened with web frames and side stringers.

The web frames shall be fitted not more than three or four spacings.

The side stringers shall be fitted so that the distance between the side stringers measured over the vessel's side in way of the floor nearest to the fore peak bulkhead, the distance from the side stringer to the upper edge of the floor, as well as from the side stringer to the deck is not more than 2 m.

The scantlings of main frames fitted between the web frames shall comply with the requirements of 3.6.4.7 as for the midship region where side stringers are not provided.

The side stringers shall have the same scantlings as the web frames and terminate at the bulkhead or at the web frame (refer to 2.5.4.7.2).

Construction and end attachments of the web frames shall comply with the requirements of 2.5.5;

**.5** the transom bulkheads shall be strengthened with vertical stiffeners spaced not more than 0,5 m apart, and with horizontal girders arranged at the side stringer level.

Vertical webs shall be fitted in line with side girders. The scantlings of the vertical webs and horizontal girders shall be the same as those of web frames and side stringers in the fore peak. The scantlings of vertical stiffeners shall be the same as those of the frames. The attachments of stiffener ends with brackets shall comply with the requirements of 2.7.2 for watertight bulkheads.

**3.6.2.9** Structural requirements for hull members of opening vessels.

**3.6.2.9.1** Opening vessels consist of two separate semihulls with asymmetrical lines, connected by hinges positioned above the deck at the ends of the hopper. When discharging the spoil, the semi-hulls are opened about a common longitudinal axis on the centre line of the ship by means of hydraulic devices.

The structure of each semi-hull shall comply with the requirements of Section 2 with due regard for 3.6.2; transverse or longitudinal or both framing systems may be adopted. In hopper side buoyancy tanks transverse ring structures spaced as required by 3.6.2.11.1 shall be fitted.

**3.6.2.9.2** Where hinges are installed in opening hopper dredgers and hopper barges, deck plating and framing shall be strengthened. Hinge eyes shall pierce the decks.

**3.6.2.9.3** Stops shall be fitted in the opening vessels between semi-hulls forward and aft from the hopper space. The stops shall be arranged at the levels of the bottom and the deck and shall prevent the hulls from displacement relative to one another.

**3.6.2.9.4** Scantlings of brackets connecting framing members of each semi-hull shall comply with the requirements of 3.6.2.11.3.

**3.6.2.9.5** Longitudinal bulkheads and coamings of the hopper shall be extended with brackets as required by 3.6.2.7.4 and 3.6.2.11.7.

**3.6.2.10** Fixing of dredging gear.

**3.6.2.10.1** Hull framing shall be strengthened in way of the main and ladder gallows.

The stanchions of the ladder gallows may terminate at the deck. In such case, pillars, vertical webs or other equivalent structures shall be provided under the stanchions or longitudinal and transverse bulkheads shall be fitted.

The stanchions of the main gallows shall extend to the bottom and be efficiently connected with longitudinal and transverse framing, otherwise transverse bulkheads shall be fitted under the stanchions.

**3.6.2.10.2** In way of grab crane, spuds and other dredging gear adequate strengthening shall be provided.

**3.6.2.11** Specific structures.

**3.6.2.11.1** Whatever the hull framing of single-hull hopper dredgers and barges in way of the hopper is adopted, transverse ring structures consisting of the following items shall be fitted:

solid platforms or ring structures in the side buoyancy spaces and centre line box keel;

a lower cross member in the bottom part of the hopper, connecting the centre line box keel with longitudinal bulkheads of the hopper;

an upper cross member inside the hopper at a level of the main deck and upper edge of the coaming where its height more than 0,2 m (where the requirements of 3.6.4.11.10 are complied with, upper cross members need not be fitted);

vertical webs on the hopper coaming.

The maximum distance between transverse ring structures shall not be less than  $b = (0,012L + 2,9)$  m.

**3.6.2.11.2** The construction of diaphragms shall comply with the requirements of 2.5.2.2. Diaphragms which are more than 1 m in width shall be strengthened by vertical and horizontal stiffeners. Where longitudinal framing is adopted, horizontal stiffeners shall be fitted in line with side and bulkhead longitudinal. In lieu of the diaphragms watertight (non-tight) bulkheads complying with the requirements of 2.7.2 may be used.

**3.6.2.11.3** The transverse ring structure in the side buoyancy space, fitted in lieu of the diaphragm, shall consist of side shell, bulkhead, bottom and deck transverses. The longitudinal bulkhead and side shell transverses shall be connected by means of cross ties which shall be so positioned that the distance between them, between a cross tie and a bottom or deck transverse is not more than 3 m. In lieu of the cross ties, use may be made of braces connecting a bulkhead transverse with a bilge or deck transverse bracket. Where platforms are fitted in side buoyancy spaces at the same distance as cross ties, cross ties and braces may be omitted.

The brackets connecting transverse ring structure items in the side buoyancy space shall have the length of the arms not less than one-twelfth of the greater span of the connected members. The free edge of the bracket shall have a face plate of the same width as that of the face plate of the greater member connected. The bracket thickness shall be equal to the web thickness of the greater member connected.

**3.6.2.11.4** Hopper lower cross members may consist of a web with openings and face plates provided on the upper and lower edges or may take the form of a hollow box, generally of triangular cross-section.

The web thickness of the hopper lower cross member shall be taken equal to the plating thickness of the hopper longitudinal bulkheads at the corresponding level.

A cross member web shall be strengthened with stiffeners spaced 900 mm apart.

The upper face plate of the hopper lower cross member shall be made of a tube, section, round or flat

bar, the lower face plate shall be fabricated of a flat bar having a thickness not less than that of the bottom plating.

The hopper lower cross members shall be connected with the hopper longitudinal bulkhead and centre line box keel by brackets having length of the arms equal to one-tenth of the length of the cross member upper face plate. The thickness of brackets shall be taken equal to the thickness of the cross member web. Where the depth of the cross member and centre line box keel is the same, brackets on the centre keel need not be fitted. The structure of box-type cross members is similar to that of the centre box keel. Where cross members are of a box shape, their lower and upper face plates shall be welded to the plating of the buoyancy spaces and centre line box keel.

**3.6.2.11.5** The centre line box keel fitted in the hopper is generally fabricated as a closed box structure. The plating thickness of the sides shall be equal to that of hopper longitudinal bulkheads at the corresponding level, but not less than 8 mm for vessels of 60 m in length and less than 10 mm for vessels of more than 60 m in length. The thickness of the centre line keel bottom strake shall be not less than that of the plate keel. Where the transverse framing is adopted, the stiffeners in the upper part of the centre line box keel shall be connected with brackets, the thickness of which shall be not less than that of the floor and height not less than 2,5 times the depth of the stiffener web.

Where the breadth of the centre line box keel at bottom exceeds 1 m, but not more than 2 m, a bottom longitudinal shall be fitted on centre line box keel bottom, the depth of which shall be equal to half the floor depth. Where the breadth of the centre line keel is more than 2 m, an intercostal side girder having the same scantlings as the floor shall be fitted in lieu of the above longitudinal. The scantlings of floors are assumed the same as those of floors fitted in correspondingly framed buoyancy spaces.

On the top, the centre line box keel shall terminate in a bar, or an angle, or a cover plate, the thickness of which shall be equal to that of the centre line box keel.

The centre line box keel sides shall extend beyond the hopper transverse bulkheads by brackets, the arm lengths of which shall be equal to the depth of the centre line box keel, and the thickness equal to that of the centre line box keel side.

**3.6.2.11.6** The upper cross members of the hopper space may consist of a web with openings and face plates on the upper and lower edges or be fabricated in the form of a hollow box generally of a triangular or another cross-section.

It is recommended that the upper cross members be attached to the hopper longitudinal bulkhead by

brackets the arm lengths of which shall be equal to the depth of the upper cross member, and the thickness to its web thickness.

The upper cross members shall be connected to the centre line box keel by pillars, where such a keel is fitted.

**3.6.2.11.7** The hopper coaming may be transversely or longitudinally framed. The upper edge of the coaming shall be stiffened with a face plate having a width not less than one-tenth of the coaming height and a thickness not less than a coaming thickness.

In case of longitudinal framing, the coaming shall be strengthened by longitudinals spaced not more than 900 mm apart.

In case of transverse framing, vertical stiffeners shall be fitted between stays at every frame.

The hopper side coamings shall be extended beyond the hopper ends by the brackets for a distance equal to 1,5 times the coaming height. Deck girders extending not less than three frame spaces from a bracket end shall be fitted under the brackets.

**3.6.2.11.8** In floating cranes, the tub plating shall not be cut at the upper deck. No horizontal welds are permitted in the tub plating within the area extending for  $0,2h$  up and down from the upper deck (where  $h$  is the distance between the bottom and the upper deck in way of the tub position).

**3.6.2.11.9** Diaphragms shall be fitted inside the crane tub in line with the upper deck and platform.

**3.6.2.11.10** For outer plating of specific structures 20 mm and more in thickness in way of the hopper steel of not lower than grade D shall be utilized. Use of plates having a thickness 50 mm and more is subject to special consideration by the Register.

### 3.6.3 Design loads.

**3.6.3.1** Design loads on the main hull structures shall be determined in compliance with Sections 1 and 2 at draughts  $d_1$  and  $d_2$  and the wave coefficient  $c_w$  under dredging conditions and during voyage. For dredging conditions, the wave coefficient  $c_w$  shall not be taken greater than  $2(D + h_c - d_1)$ .

**3.6.3.2** The maximum value of the design load for vessel's extremities during voyages shall be obtained as required by 2.8.3 using the draught at the section  $0,1L$  from the forward perpendicular. For the transom bulkhead angles  $\alpha_x = 0$  and  $\beta_x = 90^\circ$  are assumed.

**3.6.3.3** The design bending moments and shear forces in vessels of dredging fleet having  $L \geq 60$  m shall be determined for voyage and for dredging conditions.

For voyage the hopper space is considered to be filled with water up to the effective waterline (or empty if such case is possible), stores and outfit are taken as 100 per cent, all gear being stowed for sea.

For the case of dredging operations, the hopper space is considered to be filled with homogeneous soil up to the upper overflow level (coaming), there are no stores on board, the draught is equal to  $d_1$ , gear being stowed for sea.

Wave bending moments and shear forces shall be determined as required by 1.4.4.

#### 3.6.3.4 Opening vessels.

**3.6.3.4.1** In opening vessels, still water and wave bending moment is created both by vertical and horizontal forces. Bending moments are calculated first in  $vGu$  coordinate system and then re-calculated for the basic inertia axes  $x$  and  $y$  of each semi-hull (Fig. 3.6.3.4.1). A fully loaded hopper space at the maximum draught of the vessel is taken as a design case. Bending of each semi-hull hopper is considered separately. Deck hinges and hydraulic cylinders are assumed to be supports located at the hopper ends.

Besides, the following cases are considered:

sailing in the work area with soil in the hopper, dredging gear stowed for sea;

voyage with water in the hopper space or in the ballast condition (the hopper is empty, wherever practicable). Stores and outfit are taken in full, all gear stowed for sea.

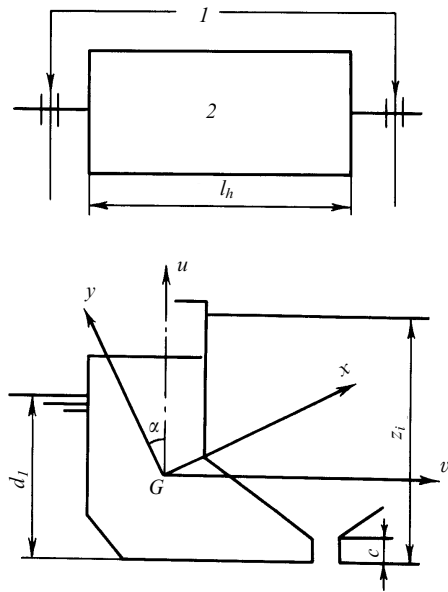


Fig. 3.6.3.4.1:  
1 — hinges; 2 — hopper space

**3.6.3.4.2** The type of supporting structures and the clearance between two semi-hulls in the fore and aft ends of the hopper space determine the conditions of horizontal moments calculation.

Where supporting structures fitted at the deck or bottom level forward or aft of the hopper space provide the absence of any clearance between the

semi-hulls, and the length of the supporting structures creates adequate fixing against the horizontal forces acting athwart the hopper space, the horizontal force calculation is made assuming that a semi-hull is rigidly restrained at each hopper end.

Otherwise a semi-hull is considered to be freely supported.

#### 3.6.3.4.3 Vertical loads.

The vertical bending moment at any section  $M_v$ , in kN·m, acting on each semi-hull shall be determined by the formula

$$M_v = 0,5(M_{swx} + M_{wx}) \quad (3.6.3.4.3)$$

where  $M_{swx}$  = still water bending moment to be obtained by load integration of the vessel with connected hulls for loading conditions referred to in 3.6.3.4.1, in kN·m;

$M_{wx}$  = wave bending moment for the vessel with connected hulls, to be determined as required by 1.4.4., in kN·m.

Vertical moments are considered positive in case of hogging and negative in case of sagging.

#### 3.6.3.4.4 Horizontal loads.

The horizontal bending moment  $M_{hi}$ , in kN/m, acting on each semi-hull at the sections taken in the middle and at ends of the hopper space shall be determined by the formula

$$M_{hi} = M_{swhi} + M_{whi} \quad (3.6.3.4.4-1)$$

where  $M_{swhi}$  and  $M_{whi}$  = horizontal still water and wave bending moments at the section under consideration, respectively, in kN·m.

Horizontal moments are considered positive where the outer side of one semi-hull is subjected to tensile stresses.

The horizontal moment acting on a semi-hull depends on the fixing used at the ends of the hopper space.

Where a semi-hull is considered rigidly fixed at the ends of the hopper space, the horizontal moment shall be determined using the following formulae:

in still water:

at the section taken in the middle of the hopper space

$$M_{swh} = 0,10pl_h^2; \quad (3.6.3.4.4-2)$$

at the hopper end sections

$$M'_{swh} = -0,10pl_h^2 \quad (3.6.3.4.4-3)$$

where  $p = 0,5g(\rho_s H_2^2 - \rho d_1^2)$  kN/m;

in waves:

at the section taken in the middle of the hopper space

$$M_{wh} = M_{wx} \frac{d_1}{B} (\psi_1 + \psi_2 \frac{E}{d_1}); \quad (3.6.3.4.4-4)$$

at the hopper end sections

$$M'_{wh} = -M_{wx} \frac{d_1}{B} (\psi_3 + \psi_4 \frac{E}{d_1}); \quad (3.6.3.4.4-5)$$

where  $\psi_1 = 0,61l_h/L - 0,103$ ;

$\psi_2 = 0,50l_h/L - 0,100$ ;

$\psi_3 = 0,85l_h/L - 0,112$ ;

$\psi_4 = 0,37l_h/L - 0,050$ ;

$E = \kappa(C_b + 0,7)[1,38 - 0,128(\frac{300-L}{100})^{3/2}]$ ;

$\kappa = 1,35L/100 - 0,215$ .

Where the semi-hull is not fixed at the hopper ends, the horizontal moment at the section at the middle of the hopper space shall be determined by the following formulae:

in still water:

$$M_{sw} = 0,15p_l^2; \quad (3.6.3.4.4-6)$$

in waves:

$$M_{wh} = M_{wx} \frac{d_1}{B} (1 + \psi_5 \frac{E}{d_1}) \quad (3.6.3.4.4-7)$$

where  $\psi_5 = 1,23(l_h/L - 0,5)$ .

The still water and wave horizontal bending moments at the hopper end sections are equal to zero.

The sign of  $M_{wx}$  shall be taken into account in determination of  $M_{wh}$  and  $M'_{wh}$ .

It is assumed that  $M_{sw}$  and  $M'_{sw}$  are equal to zero during voyage whatever the fixing conditions are.

**3.6.3.5** Bending moments acting on the hull of the floating crane shall be determined for operating conditions in the work area and a voyage.

For the operation in the work area the design vertical bending moment  $M_{op}$ , in kN m, shall be determined by the formula

$$M_{op} = M_{sw} + M_g + M_w \quad (3.6.3.5)$$

where  $M_{sw}$  = still water bending moment according to 1.4.3, in kN·m;

$M_g$  = bending moment due to the weight of the load suspended on the crane hook, in kN·m;

For a voyage  $M_g$  is assumed to be equal to zero.

$M_w$  = wave bending moment for work areas and a voyage to be determined using a procedure approved by the Register for a specified length and height of the wave.

**3.6.3.6** The design pressure  $p_s$ , in kPa, on the bulkheads bounding the hopper space, on the structures of the enclosed watertight centre line box keel shall be determined by the formula

$$p_s = \rho_s g z_i \quad (3.6.3.6)$$

where  $z_i$  = distance of the load application point from the upper weir level (upper edge of the coaming), in m.

**3.6.3.7** The design load  $p_1$ , in kPa, on a partial bulkhead (diaphragm) or a transverse ring structure of the side buoyancy space at a level of the mid-height of

the hopper lower cross member due to soil pressure, having regard to the outer counterpressure, shall be determined by the formula

$$p_1 = g(0,8\rho_s H_1 - 1,5\rho_s h_c - 0,1\rho H_1 \varepsilon) \quad (3.6.3.7)$$

where  $\varepsilon = 0$  for  $D \leq 4$  m;

$\varepsilon = 0,2D - 0,8$  when  $d_1/D \leq 0,75$  } for  $D > 4$  m.

$\varepsilon = 0,4D - 1,6$  when  $d_1/D > 0,75$  }

**3.6.3.8** The vertical design load  $p_2$ , in kPa, due to soil pressure, having regard to the counterpressure of the water on the lower cross member of the hopper space shall be determined by the formula

$$p_2 = g[\rho_s H_2 - (\rho d_1 + 0,5\rho c_w) - \frac{\rho_s(l_{l,cr} - b_{b,k})A_{l,cr}}{bl_{l,cr}} - \frac{1,5\rho_s A_{b,k}}{l_{l,cr}}] \quad (3.6.3.8)$$

**3.6.3.9** The horizontal design load  $p_3$ , in kPa, due to the dredged spoil pressure on face plates of the hopper lower cross member shall be determined by the formulae:

for the upper face plate

$$p'_3 = \frac{1}{6} g \rho_s h_{l,cr}; \quad (3.6.3.9-1)$$

for the lower face plate

$$p''_3 = \frac{1}{3} g \rho_s h_{l,cr} \quad (3.6.3.9-2)$$

**3.6.3.10** The design load  $p_4$ , in kPa, on the framing members and on the plating of the hopper coaming shall be determined by the formula

$$p_4 = g \rho_s h_c \quad (3.6.3.10)$$

The value  $p_4$  shall be taken not less than 15 kPa.

**3.6.3.11** The design axial force  $N$ , in kN, acting at the mid-height level of the hopper lower cross member on a diaphragm or a transverse ring structure of the side buoyancy space shall be determined by the formula

$$N = gbH_1[0,40\rho_s H_1 + 0,63\rho_s h_c - 0,03\rho H_1 m] \quad (3.6.3.11)$$

where  $m = 0$  for  $D \leq 3,5$  m;

$m = 1$  for  $D > 3,5$  m,  $d_1/D \leq 0,75$ ;

$m = (9D - 31,5)(d_1/D - 0,75)$  for  $D > 3,5$  m,  $d_1/D > 0,75$ .

**3.6.3.12** The design axial force  $R_{l,cr}$ , in kN, acting on the lower cross member of the hopper space shall be determined by the formula

$$R_{l,cr} = 0,163 \frac{b}{gH_1} [\rho_s H_2^2 (3D - H_2) - \rho(d_1 - 0,5c_w)^2 (3D - d_1 + 0,5c_w)] \quad (3.6.3.12)$$

**3.6.3.13** The design axial force  $R_{up.cr}$ , in kN, acting on the upper cross members of the hopper space shall be determined by the following formulae:

**.1** for the upper cross member fitted at the deck level

$$R_{up.cr} = R_1 - R_2 - R_3 - R_4 \quad (3.6.3.13.1)$$

where  $R_1$  = pressure of dredged soil on the upper cross member determined as

$$R_1 = g\rho_s \frac{0,082bH_2^2}{H_1} (2H_2 - 3h_{l.cr});$$

$R_2$  = external hydrostatic pressure on the upper cross member determined as

$$R_2 = g\rho \frac{0,082b(d_1 - 0,5c_w)^2}{H_1} (2d_1 - c_w - 3h_{l.cr});$$

$R_3$  = reaction due to supporting bending moment at the junction of the diaphragm with the lower cross member determined as

$$R_3 = p_2 \frac{bl_{l.cr}^2}{12H_1};$$

$R_4$  = force resulting from supporting reactions of the hopper lower cross member determined by the formula

$$R_4 = \frac{bl_{l.cr}b_2}{4H_1} (p_2 + \frac{g\rho_s 0,5A_{k,b}}{l_{l.cr}});$$

**.2** for the upper cross member fitted at the upper face plate of the hopper coaming

$$R_{up.cr} = g\rho_s b h_c^2 \quad (3.6.3.13.2)$$

**3.6.3.14** The design load on deck shall be not less than 20 kPa.

**3.6.3.15** The design loads on the structures of each semi-hull of opening vessels shall be determined in compliance with 3.6.3.1 to 3.6.3.14.

**3.6.3.16** In opening hopper dredgers and hopper barges, for each hydraulic press, the horizontal static force  $F_H$ , in kN, necessary to keep the hull closed is determined by the formula (refer also to Fig. 3.6.3.16)

$$F_H = \frac{1}{n_1 a_3} [-F_h a_1 + F_d a_2 + \frac{1}{2} (g\Delta b_1 - g\Delta_l b_2 - gQ_s b_3)] \quad (3.6.3.16-1)$$

where  $n_1$  = number of hydraulic presses;

$F_h$  = horizontal force of water pressure on the hull, determined by the formula

$$F_h = 0,5\rho g h_h (d_1 - 0,5c)^2;$$

$F_d$  = horizontal force of dredged soil pressure on the hull, determined by the formula

$$F_d = 0,5\rho_s g h_h (H_2 - c)^2;$$

for  $c$ , refer to Fig. 3.6.3.4.1;

$a_1, a_2, a_3, b_1, b_2, b_3$  = force arms, in m (refer to Fig. 3.6.3.16).

For design force  $F_{des}$ , the maximum pressure value achieved by the hydraulic press is adopted, with  $F_{des} \geq F_H$ .

The horizontal static force in each hinge  $F_{hm}$ , in kN, is determined by the formula

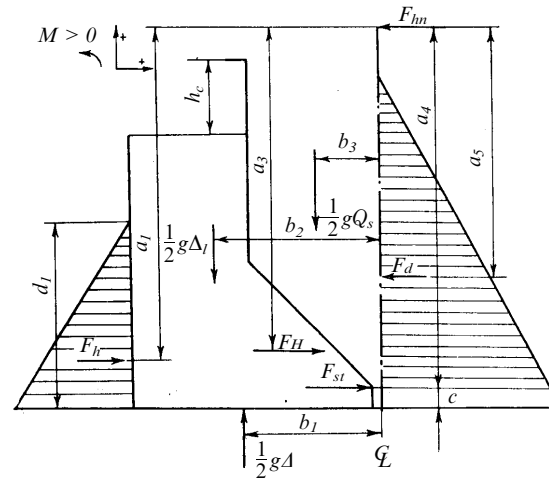


Fig. 3.6.3.16

$$F_{hm} = \frac{1}{2} [F_h + n_1 F_H - F_d - \frac{n_1 a_3}{a_4} (F_{des} - F_H)] \quad (3.6.3.16-2)$$

where  $a_4$  = arm of the force acting upon the stop, in m.

The horizontal static force acting upon each stop is determined by the formula

$$F_{st} = \frac{n_1 a_3}{n_2 a_4} (F_{hm} - F_H) \quad (3.6.3.16-3)$$

where  $n_2$  = number of stops.

The vertical components of static forces in hinges are assumed equal to zero.

**3.6.3.17** The dynamic forces acting on hydraulic cylinders and deck hinges shall be determined by calculations of vessel's motions in a seaway, with various course angles, in light-ship and full-load conditions. Based on these calculations, maximum vertical and horizontal forces acting on the hydraulic presses are determined. The calculation shall be made using a procedure approved by the Register.

### 3.6.4 Scantlings of structural members.

**3.6.4.1** Scantlings of structural members shall be determined in compliance with Sections 1 and 2, having regard to the provisions of this Chapter.

**3.6.4.2** The required hull section modulus of a single-hull vessel of 60 m in length and over shall be determined as required by 1.4.6 for deck, bottom, upper edge of the hopper coaming, having regard to specified work areas and voyages. The greater value obtained for the work area or voyage (refer to 3.6.3.3 and 3.6.3.4) shall be taken.

For opening hopper dredgers and hopper barges the required section modulus shall be determined for the case when both semi-hulls are connected (refer to 3.6.3.4).

**3.6.4.3** When calculating the actual section modulus of the hull in way of the hopper space as

required by 1.4.8, account shall be taken of all continuous longitudinals, longitudinal bulkheads and the hopper space coamings with longitudinals, 85 per cent of the total area of centre line box keel longitudinal members, provided they are properly interconnected with the longitudinal framing members beyond the hopper and fitting of transverse members regulated by the Rules, inside the hopper.

The continuous deck plating longitudinally framed above the hopper space and a wash bulkhead in the hopper may be included in the actual section modulus calculation using a procedure approved by the Register.

**3.6.4.4** Longitudinal strength of each semi-hull of opening hopper dredgers and hopper barges shall be checked for vertical and longitudinal bending moments in asymmetrical bending (refer to Fig. 3.6.3.4.1).

**3.6.4.4.1** Normal stresses arising in cross-section points under conditions of asymmetrical bending shall be determined amidships and at the end bulkhead sections of the hopper space (from inside the hopper), provided the hulls at this position are rigidly restrained.

Stresses  $\sigma$ , in MPa, shall be determined by the formula

$$\sigma = (M_x \frac{y}{I_x} - M_y \frac{x}{I_y}) \cdot 10^{-3} \quad (3.6.4.4.1-1)$$

where  $M_x = M_v \cos \alpha - M_h \sin \alpha$ ;

$M_y = M_v \sin \alpha + M_h \cos \alpha$ ;

for  $M_v$  and  $M_h$ , refer to 3.6.3.4.3 and 3.6.3.4.4;

$\alpha$  = rotation angle of main inertia axes (positive value of  $\alpha$  — rotation  $Gu$  axis counter-clockwise), it shall be determined by the formula

$$\operatorname{tg} 2\alpha = 2I_{uv} / (I_u - I_v); \quad (3.6.4.4.1-2)$$

$I_{uv} = \sum u_i v_i dS_i$  = centrifugal inertia moment about axes  $Gu$ ,  $Gv$  with no regard for wear allowance, in  $\text{m}^4$ ;

$u_i$ ,  $v_i$  = distance of the centre of gravity of  $i$ -th member area from the axes  $Gu$ ,  $Gv$ , in  $\text{m}$ ;

$dS_i$  =  $i$ -th member area, in  $\text{m}^2$ ;

$I_u$ ,  $I_v$  = inertia moments of the semi-hull cross-section about axes  $Gu$ ,  $Gv$  with no regard for wear allowance, in  $\text{m}^4$ ;

$x$ ,  $y$  = coordinates of the section point under consideration about main axes  $Gx$ ,  $Gy$  (refer to Fig. 3.6.3.4.1), in  $\text{m}$ ;

$I_x$ ,  $I_y$  = inertia moments of the semi-hull cross-section about the main axes with no regard for wear allowance, in  $\text{m}^4$ .

**3.6.4.4.2** Normal stresses acting in the semi-hull cross-section (for normal strength structural steel) shall not exceed:

150 MPa for the lower edge of the deck stringer;

145 MPa for the upper edge of the plate keel;

165 MPa in the face plate of the hopper coaming.

**3.6.4.4.3** Permissible shear stresses for members made of normal strength structural steel and participating in the longitudinal bending are assumed equal to 115 MPa. Equivalent stresses  $\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2}$  at the sections where substantial normal stresses and shear stresses (at the hopper ends) act shall be not more than 170 MPa.

**3.6.4.4.4** Buckling strength of compressed members according to 1.6.5 shall be ensured.

### 3.6.4.5 Bottom framing.

**3.6.4.5.1** When the bottom is transversely framed, the moment of inertia and scantlings of floors in side buoyancy spaces shall be determined as required by 2.3.4.1.1; in this case, to be taken as  $B_1$  is doubled breadth of the buoyancy space over the bottom.

**3.6.4.5.2** Where a single bottom is longitudinally framed, the section modulus of bottom longitudinals in buoyancy spaces shall be not less than that determined in compliance with 2.3.4.2.1. The floors shall be fitted in line with transverse ring structures, their section modulus and cross sectional area shall be not less than determined from 2.3.4.2.3 and 2.3.4.2.4. The section modulus and depth of a side girder shall be not less than those required for the floor. The floor web depth shall not be less than  $0,13B_1$  (refer to 3.6.4.5.1).

**3.6.4.5.3** The scantlings of the bottom framing members in each semi-hull of opening vessels shall be determined as required by 2.3.4.2; to be taken as breadth  $B_1$  is the breadth of one semi-hull at the section under consideration. There is no bottom centre girder in opening vessels.

**3.6.4.5.4** The scantlings of double bottom members in way of the hopper space are determined as for dry cargo ships having double skin construction according to 2.4 with regard to 3.6.2.4; beyond the hopper as for dry cargo ships with single skin construction in compliance with the requirements of the same paragraphs.

The plate floor spacing shall not exceed the maximum spacing of transverse ring structures, specified in 3.6.2.11.1.

**3.6.4.5.5** For floating cranes the section modulus of bottom transverses shall be as required by 2.3, and additional bottom longitudinals shall have the same section modulus as for main longitudinals.

**3.6.4.5.6** In calculating the section modulus and the depth of floors in accordance with 2.3,  $B_1$  is assumed to be the floor span between the side shell and the longitudinal bulkhead or between the longitudinal bulkheads, but not less than 0,4 of the full breadth of the ship.

**3.6.4.5.7** In case of longitudinally framed bottom, the scantlings of floors and bottom longitudinals of floating cranes beyond the double bottom area shall be determined in accordance with 2.3.4.2.

### 3.6.4.6 Shell plating.

**3.6.4.6.1** Shell plate scantlings are determined in accordance with 2.2.4.

The thickness of the bottom strakes to which hopper longitudinal bulkheads or well sides are connected shall be increased by 15 per cent as against that of the bottom plating. Where there is no centre line box keel, the thickness of the bottom strakes abutting on the hopper longitudinal bulkhead shall be increased by 50 per cent.



**3.6.4.6.2** The side shell plating thickness at the hopper ends shall not be less than required by 1.4.7.

**3.6.4.6.3** In vessels with pontoon hulls, the thickness of the bottom and side shell plating within  $0,15L$  from the forward and after perpendiculars shall not be less than the plating thickness within the midship region.

**3.6.4.6.4** The thickness of the well side plating shall be equal to the thickness of the side shell plating in area concerned, but not less than 8 mm.

**3.6.4.6.5** In opening vessels the shell plating thickness shall be determined with regard for 3.6.4.4.

The thickness of the bottom strakes at the hopper longitudinal bulkhead need not be increased.

**3.6.4.6.6** In floating cranes the thickness of the bottom plating within  $0,2L$  from the forward perpendicular shall be increased over the entire breadth of the hull by 30 per cent as against the minimum thickness required by 2.2.4.8.

In the fore peak and the areas extending forward for  $0,1L$  from the stern transom corners and inboard for  $0,1B$ , the thickness of the side shell plating shall be increased over the entire depth by 30 per cent as compared to the minimum thickness required by 2.2.4.8 (refer also to 3.6.2.5.2).

In other regions along the hull length, the minimum thickness of the shell plating shall be increased by 10 per cent as against that prescribed by 2.2.4.8.

**3.6.4.6.7** The plating thickness of the bow and stern transoms in floating cranes shall not be less than required by 3.6.4.6.3.

#### **3.6.4.7 Side framing.**

The scantlings of the side framing members shall be determined in compliance with 2.5, having regard to 3.6.2.5, 3.6.2.11 and the requirements given below:

**.1** the section modulus of frames in transversely framed side buoyancy spaces shall be determined from 2.5.4.1 as for dry cargo ships.

Where a side stringer is fitted at a level of fenders, main frame span may be determined in compliance with 2.5.1.2 as for side transverses of tankers, provided the structure of the side stringer meets the requirements of 3.6.4.7.2. Where no transverse ring structures are fitted, braces may be provided in line with horizontal girders of longitudinal bulkheads;

**.2** the scantlings of side stringers shall be determined as required by 2.5.4.4 as for the case of fitting web frames. The width of the side stringer shall not be less than  $0,08l$  ( $l$  = stringer span as measured between web frames or between those and tight transverse bulkheads) or 2,5 times the frame depth, whichever is the greater. Side stringers shall be aligned with cross ties of the transverse ring structures;

**.3** the section modulus of side longitudinals shall be determined as required by 2.5.4.3 with  $k_{\sigma}$  values taken as for dry cargo ships;

**.4** the section modulus and cross-sectional area of web frames which are a part of a transverse ring structure shall be not less than those required in 2.5.4.5 for side transverses of tankers.

A web frame span shall be measured between the inner edges of the floor and an inner edge of the beam.

The depth of the web frame shall not be less than  $0,1l$  or 2,5 times the width of longitudinals (whichever is the greater) and may be assumed varying with reduction at the upper end and increase at the lower end by 10 per cent as against the average value;

**.5** the section modulus of well longitudinal bulkhead stiffeners shall not be less than required for side frames;

**.6** in floating cranes, the section modulus of main and intermediate frames in the fore peak shall be increased by 20 per cent as compared to that required by 2.8.4.2.2;

**.7** the section modulus of web frames in floating cranes  $W$ , in  $\text{cm}^3$ , within the region specified in 3.6.2.5.3 shall not be less than:

$$W = 0,95(300 + \frac{120}{\sigma_n} bpl^2)\omega_c \quad (3.6.4.7.7)$$

where  $l$  = web frame span measured between the deck and the upper edge of the floor, in m;

$p$  = as defined in 3.6.3, but not less than  $0,5pgl$ , in kPa;

**.8** the scantlings of the framing members of the bow and stern transoms shall not be less than required by 3.6.4.7.2 to 3.6.4.7.4 and 3.6.4.7.6.

#### **3.6.4.8 Decks.**

**3.6.4.8.1** The plating thickness of the strength deck within the midship region shall be taken not less than the sheerstrake thickness.

The minimum thickness of the deck plating in vessels of dredging fleet shall be determined according to 2.6.4.2 as for the strength deck. For floating cranes the minimum thickness of the upper deck shall be increased by 10 per cent as against that prescribed by 2.6.4.2 as for the strength deck.

**3.6.4.8.2** Compressive stresses in deck shall be determined under the action of bending moment components according to 3.6.3. The buckling strength requirements of 1.6.5 shall be met.

**3.6.4.8.3** The depth of deck transverses in buoyancy spaces which form a part of the transverse ring structure shall be equal to two-thirds of the floor depth, while the thickness of the web plate and sizes of the face plate shall be equal to those of the vertical webs. The depth of the deck transverse shall be not less than 2,5 times the height of the deck longitudinal.

**3.6.4.8.4** For floating cranes the section modulus of deck girders shall be determined as required by 1.6.4.1 with  $k_{\sigma} = 0,6$  and  $m = 12$ .

**3.6.4.8.5** The deck plating thickness under the seats of special arrangements fitted on the deck (cat cranes of suction tubes, transfer appliances, grab

cranes, etc.) and where special metal structures pass through the deck (main and ladder galleys) shall be increased by 25 per cent.

**3.6.4.9** The scantlings of side and deck framing members, the thicknesses of deck plating, bulkhead framing and plating, and coamings of opening vessels shall be determined with regard for 3.6.4.4.

Where vertical webs and web frames are connected by cross ties or braces, the scantlings of vertical webs, web frames and braces shall be submitted to the Register for consideration.

**3.6.4.10** In vessels with pontoon hulls, the scantlings of side stringers at the forward end of the vessel shall be prescribed as required by 2.8.4.5, the height and thickness of vertical webs and web frames shall be the same as the width and thickness of the stringer.

**3.6.4.11** Specific structures of vessels of dredging fleet:

**3.6.4.11.1** The section modulus  $W$ , in  $\text{cm}^3$ , of the diaphragm of the buoyancy space after deduction of openings, or the total section modulus of a vertical web and a web frame of the transverse ring structure at the section of a mid-point of the hopper lower cross member depth shall not be less than:

$$W = \frac{10^3 b H_1^2}{m k_\sigma \sigma_n} p_1 \omega_c \quad (3.6.4.11.1)$$

where for  $H_1$ , refer to Fig. 3.6.1.6;

$m = 12$ ;  
 $k_\sigma = 0,6$ ;  
 $p_1 =$  as defined in 3.6.3.7.

**3.6.4.11.2** The cross-sectional area  $f$ , in  $\text{cm}^2$ , of the diaphragm, or the total sectional area of a vertical web and a web frame of the transverse ring structure at a level of a mid-point of the hopper lower cross member depth shall be not less than:

$$f = \frac{10N}{k_\tau \tau_n} + 0,1 \Delta f_i \quad (3.6.4.11.2)$$

where  $N =$  as defined in 3.6.3.11;

$k_\tau = 0,65$ ;  
 $\Delta f_i = \Delta s b_i$ ;  
 $b_i =$  typical member scantlings (half-breadth of deck, web height of longitudinal, etc.), in cm.

The scantlings of the transverse ring structure members (bottom transverse, vertical web, side and deck transverses) shall be not less than required by the relevant paragraphs of this Chapter for such members.

**3.6.4.11.3** The section modulus  $W$ , in  $\text{cm}^3$ , sectional area of the hopper lower cross member web  $f_w$ , in  $\text{cm}^2$ , after deducting openings, sectional area of the floor with face plates  $f_0$ , in  $\text{cm}^2$ , shall not be less than:

$$W = \frac{10^3 b l_{l.cr}^2}{m k_\sigma \sigma_n} p_2 \omega_c; \quad (3.6.4.11.3-1)$$

$$f_w = 5 \frac{b l_{l.cr}}{k_\tau \tau_n} (p_2 + \frac{0,5 p_{sg}}{l_{l.cr}} A_{b,k}) + 0,1 \Delta f_i; \quad (3.6.4.11.3-2)$$

$$f_0 = \frac{10 R_{l.cr}}{k_\sigma \sigma_n} + 0,1 \Delta f_i \quad (3.6.4.11.3-3)$$

where  $m = 12$ ;  
 $k_\sigma = 0,45$ ;  
 $k_{\sigma_p} = 0,2$ ;  
 $k_\tau = 0,45$ ;  
 $p_2 =$  as defined in 3.6.3.8;  
 $R_{l.cr} =$  as defined in 3.6.3.12;  
for  $\Delta f_i$ , refer to 3.6.4.11.2.

**3.6.4.11.4** The section modulus of the face plates of the hopper lower cross members  $W$ , in  $\text{cm}^3$ , about the horizontal axis and sectional area  $f_{f,p}$ , in  $\text{cm}^2$ , shall not be less than:

for the upper face plate

$$W = \frac{10^3 h_{l.cr} l_1^2}{m k_\sigma \sigma_n} [3 - \frac{(l_1 - l_2)^2}{l_1^2}] p'_3 \omega_c; \quad (3.6.4.11.4-1)$$

$$f_{f,p} = \frac{2,5 h_{l.cr} (l_1 + l_2)}{k_\tau \tau_n} p'_3 + 0,1 \Delta f_i; \quad (3.6.4.11.4-2)$$

for the lower face plate

$$W = \frac{10^3 h_{l.cr} l_2^2}{m_1 k_\sigma \sigma_n} 2 p''_3 \omega_c; \quad (3.6.4.11.4-3)$$

$$f_{f,p} = 5 \frac{h_{l.cr} l_2}{k_\tau \tau_n} p''_3 + 0,1 \Delta f_i \quad (3.6.4.11.4-4)$$

where for  $l_1$  and  $l_2$ , refer to Fig. 3.6.1.6;

$m = 24$ ;  
 $m_1 = 12$ ;  
 $k_\sigma = 0,6$ ;  
 $k_\tau = 0,45$ ;  
 $p'_3, p''_3 =$  as defined in 3.6.3.9;  
 $\Delta f_i =$  as defined in 3.6.4.11.2.

**3.6.4.11.5** The section modulus of bulkhead vertical webs, horizontal girders, vertical stiffeners and longitudinals of the hopper longitudinal bulkheads shall be determined as for side framing according to 3.6.4.7 with substitution of  $p$  according to 2.5.3 by  $p_s$  according to 3.6.3.6. For the longitudinal bulkhead stiffeners  $m = 11$  and  $k_\sigma = 0,75$ .

The depth of the vertical web shall be not less than  $0,12l$  and may be assumed varying with reduction at the upper end and increase at the lower end by 10 per cent as compared to the average value.

Two upper longitudinals shall be taken the same as the third longitudinal from the deck.

Besides, three upper and three lower longitudinals shall be checked according to 1.6.5.4.

The width of the horizontal girder shall be equal to that of the bulkhead vertical web.

**3.6.4.11.6** The plating thickness of the hopper longitudinal and end bulkheads shall be determined as required by 1.6.4.4 assuming  $p = p_s$  (where  $p_s$  shall be obtained from 3.6.3.6),  $k_\sigma = 0,7$ ,  $m = 15,8$ .

The upper strake thickness of the hopper longitudinal bulkhead at  $0,1D$  below the deck shall not be less than the sheerstrake thickness. The lower strake thickness of the longitudinal bulkhead at  $0,1D$  from the base line shall not be less than the bottom plating thickness.

**3.6.4.11.7** The minimum thickness of hopper bulkhead plating shall be equal to 8 mm for vessels having the length  $L < 60$  m and 10 mm for vessels having the length  $L \geq 80$  m. For intermediate values of  $L$ , the minimum thickness shall be determined by linear interpolation.

**3.6.4.11.8** The section modulus  $W$ , in  $\text{cm}^3$ , of vertical stiffeners and stanchions of the hopper coaming shall not be less than determined by the formula<sup>1</sup>

$$W = \frac{10^3 a h_c^2 p_4}{m k_\sigma \sigma_n} \omega_c \quad (3.6.4.11.8-1)$$

where  $p_4$  = as defined in 3.6.3.10;

$m = 15$  for stanchions where upper cross members are fitted in line with transverse ring structures at the coaming top;

$m = 6$  for stanchions where no upper cross members are fitted at the coaming top;

$m = 15,6$  for vertical stiffeners where transverse framing is adopted;

$k_\sigma = 0,6$ .

The section modulus  $W$ , in  $\text{cm}^3$ , of horizontal stiffeners and face plate of the coaming shall not be less than:

$$W = \frac{10^3 a b^2 p_4 z_i}{m k_\sigma \sigma_n h_c} \omega_c \quad (3.6.4.11.8-2)$$

where  $z_i$  = distance between the coaming top and horizontal stiffeners, but not less than half the coaming height, in m;

$m = 12$ ;

$k_\sigma = 0,2$ .

The sectional area  $f_{st}$  of the coaming stanchion, in  $\text{cm}^2$ , at deck shall not be less than:

$$f_{st} = 4 \frac{a h_c p_4}{k_\tau \tau_n} + 0,1 \Delta f_i \quad (3.6.4.11.8-3)$$

where  $k_\tau = 0,45$ ;

$\Delta f_i$  = as defined in 3.6.4.11.2.

The plate thickness of the side (end) coaming shall be determined as for the longitudinal (end) bulkhead of the hopper  $p_s$  according to 3.6.3.6 as measured at the deck level, but it shall be taken not less than the upper strake thickness of the longitudinal bulkhead.

The depth of the stanchion at deck shall be not less than  $0,12h_c$  and the thickness not less than the coaming thickness.

The plate thickness of the coaming and moment of inertia of the horizontal stiffeners and face plate of

the coaming shall meet the buckling strength requirements according to 1.6.5.

**3.6.4.11.9** The sectional area of the upper cross members spanning hopper space at deck level and/or coaming level  $f_{up.cr}$ , in  $\text{cm}^2$ , shall not be less than:

$$f_{up.cr} = 0,085 R_{up.cr} + 0,1 \Delta f_i \quad (3.6.4.11.9-1)$$

where  $\Delta f_i$  = as defined in 3.6.4.11.2.

Where a load from bottom closing appliances is applied to the upper cross members, their strength shall be checked using the stress given below

$$\sigma_{eq} = \sqrt{\sigma_{\max}^2 + 3\tau_{sh}^2} \leq 0,75\sigma_n \quad (3.6.4.11.9-2)$$

where  $\sigma_{\max} = 10 R_{up.cr} / f_{up.cr} + (M_b / W) 10^3$ ;

$\tau_{sh} = 10 N_{sh} / f_w$ ;

$M_b$  and  $N_{sh}$  = maximum bending moment, in kN.m, and shear force, in kN, due to transverse load;

$W$  = actual section modulus of the upper cross member, in  $\text{cm}^3$ ;

$f_{up.cr}$ ,  $f_w$  = full sectional area of the upper cross member and sectional area of the cross member web, in  $\text{cm}^2$ .

**3.6.4.11.10** Where no upper cross members are fitted at a deck level in line with transverse ring structures, a part of the coaming structure with the upper portion of the side buoyancy space located at  $0,1D$  below the deck line (Fig. 3.6.4.11.10) shall have a section modulus  $W$ , in  $\text{cm}^3$ , about a horizontal axis not less than:

$$W = \frac{550 R_{up.cr} (l_h - b)^2}{b \sigma_n} \omega_c \quad (3.6.4.11.10-1)$$

The thickness of the deck plating  $s$ , in mm, shall not be less than:

$$s = \frac{1,11 R_{up.cr} (l_h - b)}{b B_3 \tau_n} + \Delta s \quad (3.6.4.11.10-2)$$

where for  $B_3$ , refer to Fig. 3.6.4.11.10.

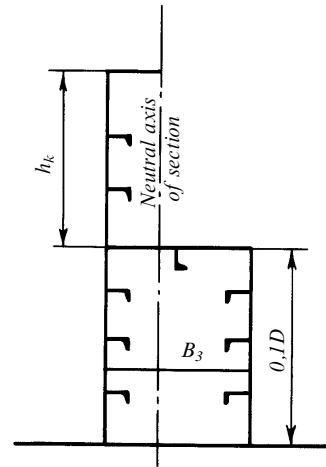


Fig. 3.6.4.11.10

<sup>1</sup>For stanchions  $b$  is substituted for  $a$ .

**3.6.4.11.11** The scantlings of hull structural items in places where hinges and hydraulic presses are arranged shall be determined by direct calculation as regards the action of statical and dynamical forces in compliance with 3.6.3.16.

The calculations shall be submitted to the Register for consideration.

**3.6.4.11.12** Hydraulic presses shall be positioned in special spaces at the hopper ends. The strength calculation of foundations and attachments of hydraulic presses shall be made as regards the action of forces determined in accordance with 3.6.4.11.11 and is subject to consideration by the Register.

**3.6.4.12** Specific structures of floating cranes.

**3.6.4.12.1** The diameter of the tub  $D_0$ , in m, at the upper deck beneath the fixed tower supporting the upper structure of the crane shall not be less than:

$$D_0 = 0,37M/P \quad (3.6.4.12.1)$$

where  $M$  = total bending moment due to load and weight of the movable upper structure of the crane, applied to the supporting tower, in kN.m;

$P$  = total vertical force due to load and weight of the movable upper structure of the crane, applied to the supporting tower, in kN.

**3.6.4.12.2** The thickness of the tub plating, in cm, at the upper deck shall be determined by calculation based on the total bending moment according to 3.6.4.12.1 and a horizontal component of the load for the case when a design safe working load of the crane with the lifting height from the water level at the maximum outreach is used.

Permissible stresses for normal strength steel shall not be more than:  $\sigma = 140$  MPa and  $\tau_{cr} = 80$  MPa.

The buckling strength of the tub plating over its entire height shall be ensured to the value  $\sigma_{cr} = 2,5R_{eH}$ . The calculations shall be submitted to the Register for consideration.

**3.6.4.12.3** The inertia moment  $I_{min}$ , in cm<sup>4</sup>, of the tub vertical stiffeners (if any) shall not be less than:

$$I_{min} = (1,03l - 1,80y)s^3 \quad (3.6.4.12.3)$$

where  $l$  = stiffener span measured between the bottom and the platform or between the platform and the deck, whichever is the greater, in m. Where the platform is omitted, the distance between the bottom and the deck is measured;

$y$  = spacing of stiffeners, measured along the chord line, in m;

$s$  = tub plating thickness at the stiffener mid-span, in mm.

**3.6.4.12.4** The plating thickness of the bulkheads forming a cross and the bearing contour shall not be less than determined according to 2.7.4.1, assuming  $k_{\sigma} = 0,70$ ,  $\Delta s > 4$  mm for bulkheads forming the cross and  $\Delta s \geq 2$  mm for those forming the bearing contour.

For cranes having a safe working load more than 100 t, the stressed condition of framing members and plating of bulkheads forming the cross under the loads transferred from the fixed supporting tower in case of using the design safe working load at the maximum outreach shall be checked according to the procedure approved by the Register.

**3.6.4.12.5** The plating thickness of the upper deck and the bottom  $s'$ , in mm, in way of the crane tub shall not be less than:

$$s' = \alpha s \quad (3.6.4.12.5)$$

where  $s$  = as defined in 3.6.4.12.2;

$\alpha = 0,6$  and  $0,4$  for the upper deck plating and bottom plating, respectively.

The dimensions of the plates of increased thickness shall be taken in accordance with Fig. 3.6.4.12.5.

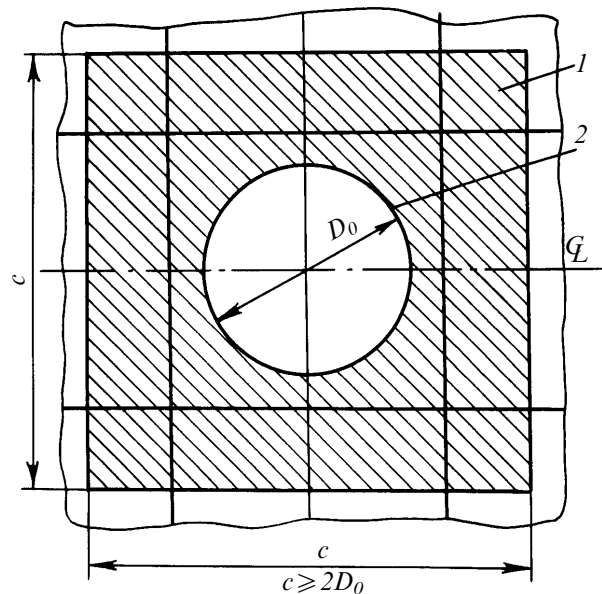


Fig. 3.6.4.12.5:  
1 — thickened plate; 2 — tub

### 3.6.5 Special requirements.

**3.6.5.1** Where vessels are intended to ground during the course of normal service, the bottom of such vessels shall be suitably strengthened, as follows:

**.1** the thickness of the bottom shell plating shall be increased by 20 per cent over the minimum requirement;

**.2** where the double bottom is omitted and transverse framing system is adopted, the bottom shell plating between the bottom side girders shall be strengthened by horizontal stiffeners.

In line with horizontal stiffeners vertical stiffeners shall be fitted. The horizontal stiffeners shall pass

through openings in the floors and be welded to them;

**.3** where double bottom is omitted and longitudinal framing system is adopted, the bottom shell plating shall be strengthened by additional floors, the depth of which shall be not less than 2,5 times the depth of the bottom longitudinal and a thickness equal to that of the main floors. The main floors shall be strengthened by vertical stiffeners fitted in line with bottom longitudinals. Side girders shall not be spaced more than 2,2 m apart. The scantlings of bilge longitudinals shall not be less than those required for the bottom;

**.4** in transversely framed double bottom plate floors shall be fitted at every frame, side girders shall be spaced not more than 2,5 m apart, they shall be also fitted inboard or from longitudinal bulkheads at a distance not exceeding 2,5 m. The bottom shell plating shall be strengthened by horizontal stiffeners fitted between the side girders. Vertical stiffeners shall be fitted in line with horizontal stiffeners at every floor and be welded to them.

In longitudinally framed double bottom floors shall be fitted at every second frame, and side girders shall be spaced 2,5 m apart;

**.5** in way of a recess for vertical girders of suction tubes, the following hull strengthening shall be provided:

side framing shall be reinforced by at least three web frames, the scantlings of which shall be the same as those required for the engine room, and by not less than three intercostal side stringers extending for three spacings from the extreme web frames which shall be fitted not less than 50 mm from the edge of the recess;

side shell plating in way of the recess shall be made of a curved welded-in plate, the vertical butt joint of this plate shall be not less than 100 mm from the edge of the recess;

the thickness of the deck stringer in way of the recess shall be increased by 60 per cent over the length equal to one spacing forward and abaft of web frames.

**3.6.5.2** The requirements of 3.6.5.1 shall not apply to floating cranes for which deep sea service is specified and which are not likely to ground under any conditions of heel and trim.

**3.6.5.3** The thickness of main structural items which are particularly subjected to abrasive wear due to the effect of spoil/water mixture (in particular, in case of special dredging methods used) shall be increased. These items may be made of special wear-resistant materials subject to special agreement with the Register.

**3.6.5.4** Dredging pumps shall be located in special spaces bounded by watertight bulkheads.

**3.6.5.5** The scantlings of deck framing members on deck portions where heavy dredging (cargo handling) gear is installed, as well as where large heavy cargoes may be carried on decks of floating cranes or hopper dredgers shall be determined by calculation for the following conditions:

beams are considered to be rigidly fixed to the supporting structure;

a load (concentrated, partially distributed, etc.) shall be taken into account;

equivalent stresses for items made of normal strength steel  $\sigma_{eq}$ , in MPa, shall comply with the condition

$$\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2} \leq 170 \quad (3.6.5.5)$$

where  $\sigma$  and  $\tau$  = normal and shear design stresses at the section under consideration.

The results of the calculation shall be specially considered by the Register.

### 3.7 FISHING VESSELS AND SPECIAL PURPOSE SHIPS USED FOR PROCESSING OF SEA LIVING RESOURCES

#### 3.7.1 General and symbols.

**3.7.1.1** The requirements of this Chapter apply to fishing vessels having a stern trawling arrangement or a side trawling arrangement and to special purpose ship intended for processing, storage and/or transportation of catch.

**3.7.1.2** The requirements for hull structures not referred to in this Chapter are given in Sections 1 and 2. In no case shall the requirements for hull structures be less stringent than those contained in Sections 1 and 2.

#### 3.7.1.3 Symbols:

For the purpose of this Chapter, the following symbols have been adopted:

$b_{sr}$  = breadth of stern ramp, in m;

$G_1$  = greatest specified mass of catch which can be handled by a special wheeled device or another transport means, in t;

$G_2$  = mass of moving part of special wheeled device or another transport means, in t;

$G$  = mass of processing equipment, in t;

$S_d$  = factory deck area, in m<sup>2</sup>;

$a$  = spacing of framing members under consideration, in m;

$l$  = span of member under consideration (refer to 1.6.3.1);

$b$  = height of design load distribution on a member;

$\Delta s$  = corrosion and wear allowance added to plate thickness, in mm (refer to 1.1.5.1);

$\omega_k$  = factor taking account of corrosion allowance to the section modulus of the to framing member (refer to 1.1.5.3).

**3.7.1.4** The requirements for ships mooring at sea provide for a damping protection of the hull for which purpose pneumatic fenders or other equivalent damping arrangements may be used. These requirements are based on the assumption that ships would be moored at a sea state not above 6.

No side or superstructure strengthening are required when ships are moored at a sea force below 4, provided the above damping protection is used.

**3.7.1.5** The regions of side strengthening of fishing vessels and special purpose ships mooring at sea.

**3.7.1.5.1** Depth dimension:

region A lying between the line drawn lower than the ballast waterline by the value of  $h$  and the line drawn higher than the summer load waterline by the value of  $h$ . The value of  $h$  shall be determined from Table 3.7.1.5.1;

Table 3.7.1.5.1

Sea force No.	$h$ , in m
4	0,8
5	1,2
6	2,0

region B lying between the upper boundary of region A and upper deck;

region C lying between the upper deck and the first tier superstructure deck, forecastle and poop included.

**3.7.1.5.2** Lengthwise, region A lies between sections in which the ship breadth at summer load waterline level is equal to  $(B - 3 \text{ m})$ .

In special purpose ships, region A shall extend for at least  $0,36L$  forward and aft from the midship section.

**3.7.1.5.3** For special purpose ships, one or more fender areas shall be additionally established the boundaries of which are formed by sections lying within  $0,05L$  forward and aft of the forward and aft edges accordingly of a group of floating fenders providing one mooring place for all specified variants of mooring. The boundaries of fender areas shall be determined at extreme positions of fenders and for all specified variants of mooring.

**3.7.1.6** Fishing vessels intended for systematic operation in ice conditions.

**3.7.1.6.1** Fishing vessels intended for systematic operation in ice conditions shall have an ice category not lower than **Ice3** in accordance with the requirements of 3.10.

**3.7.1.6.2** Fishing vessels intended for systematic operation in ice conditions, which have the ice category **Ice3**, shall comply with the requirements of 3.10, as well as with additional requirements contained in 3.7.1.6.4, 3.7.2.6, 3.7.3.4 and 3.7.4.5.

**3.7.1.6.3** No additional requirements are put forward with regard to the ice strengthening of category **Arc4** or above.

**3.7.1.6.4** If the loadline entrance of a fishing vessel of category **Arc3** exceeds  $0,25L$ , an intermediate region of ice strengthening may be established the boundaries of which shall be determined as in the case of a category **Arc4** vessel.

**3.7.2 Construction.**

**3.7.2.1** Stern ramp construction.

**3.7.2.1.1** The after end structure of vessels having a stern ramp and/or stern trawling arrangements shall be strengthened by fitting additional longitudinal and transverse members (girders, transverses, cross ties, bulkheads and partial bulkheads).

The stern ramp shall be so constructed as to avoid flat of bottom in way of stern counter.

The connection of stern ramp sides to transom plating and of the ramp deck to bottom plating shall have a radius of rounding not less than 200 mm. This connection may be made by using a bar not less than 70 mm in diameter.

**3.7.2.1.2** Stern ramp sides shall, in general, be carried downwards to the shell plating and forward to the after peak bulkhead and shall be smoothly tapered into deck girders and transverses.

**3.7.2.1.3** Where the catch is dragged onto the deck, it is recommended that the stern ramp be longitudinally framed with transverses fitted at intervals not exceeding four frame spacings. The stern ramp longitudinals shall be spaced not more than 600 mm apart.

In vessels where special transport means are used to carry the catch onto the deck, the stern ramp shall be framed transversely.

**3.7.2.2** The construction of ships having a side trawling arrangement.

**3.7.2.2.1** It is recommended that vessels more than 30 m in length be fitted up with a forecastle.

**3.7.2.2.2** Within the location of each gallow, determined as the distance between sections at three spacings forward and aft of the gallow ends, the strengthening shall be as follows:

intermediate frames shall be fitted extending from the upper deck down to a level not less than 0,5 m below the ballast waterline and having a section modulus not less than 75 per cent of that required by 2.5.4.2 for the frames in the 'tween deck space concerned;

the upper and lower ends of intermediate frames shall be secured to the decks, platforms and longitudinal intercostal members fitted between the main frames; longitudinal intercostal members shall have the same section as intermediate frames and be aligned with them; the upper longitudinal intercostal member shall be fitted not more than 350 mm below the upper deck;

bulwark stays shall be fitted at every frame.

### 3.7.2.3 Structures in processing shops.

**3.7.2.3.1** Where the number of bulkheads in the processing shops located above the bulkhead deck is less than specified in 2.7.1.3 and where the distance between the bulkheads forming the boundaries of that space exceeds 30 m, partial bulkheads extending inboard for not less than 0,5 m of the 'tween deck height shall be fitted on the bulkhead deck at each side of the vessel in line with watertight bulkheads. The thickness of the partial bulkhead plating shall be not less than that of the top strake of the corresponding watertight bulkhead below the deck where the considered processing shop is located.

Partial bulkheads shall be strengthened with horizontal stiffeners in accordance with 1.7.3.2. Strengthening with vertical stiffeners is permitted with fitting the horizontal stiffeners between the side shell and the nearest vertical stiffener in compliance with 3.7.2.5.4.

Partial bulkheads shall be interconnected with deck transverses supported by pillars in a required number. Alternative structural arrangements may be used if approved by the Register as equivalent.

**3.7.2.3.2** Where multi-tier deckhouses are arranged above the processing shops, the requirements of 2.12.5.2 for rigid members (bulkheads, partial bulkheads) to be fitted in such spaces shall be complied with.

**3.7.2.4** In fishing vessels, bulwark stays shall be fitted at intervals equal to not more than two frame spacings.

**3.7.2.5** Structural strengthening of ships mooring at sea.

**3.7.2.5.1** In regions strengthened for mooring at sea, transverse framing shall be adopted for the vessel's sides. In single-deck ships, the deck and bottom in the above regions shall also be framed transversely. In multi-deck ships, transverse framing shall be adopted for the deck located on the fender level. Longitudinal framing of sides is permissible in the upper 'tween deck space only. In this case, the spacing of web frames shall not exceed three frame spacings or 2,4 m, whichever is less.

**3.7.2.5.2** In the region A, intermediate frames are recommended through the region length in fishing vessels and within fender areas in special purpose ships.

**3.7.2.5.3** In any case, it is recommended that symmetrical sections be used and the minimum possible web depth be ensured for the particular section modulus.

**3.7.2.5.4** Between the ship's side and vertical stiffener nearest to it, transverse bulkheads shall have horizontal stiffeners with a section height not less than 75 per cent of the vertical stiffener height. In

ships with  $L \leq 80$  m, horizontal stiffeners shall be spaced not more than 600 mm apart, and with  $L \geq 150$  m, not more than 800 mm apart. For ships of intermediate lengths, linear interpolation may be used to determine this distance. The ends of horizontal stiffeners shall be welded to vertical stiffeners and sniped at the ship's sides.

**3.7.2.5.5** The bulwark shall be inclined towards the centre line of the ship at not less than one-tenth or be fitted inboard of the ship's side at not less than one-tenth of its height.

**3.7.2.5.6** Bilge keels of ships with the length  $L \leq 80$  m shall be, as far as practicable, so arranged that a tangent drawn to the frame and passing through the outer free edge of the bilge keel would form an angle of not less than 15 deg with the vertical axis. For ships with the length  $L \geq 150$  m, this angle may be zero. For ships of intermediate lengths, the above angle shall be obtained by linear interpolation.

**3.7.2.5.7** The lower end attachments of hold frames shall be as required by 2.5.5.1.

In 'tween decks, the attachments of frame lower ends shall comply with the requirements of 2.5.5.3. The frame ends shall be welded to the deck plating.

Upper ends of frames shall be carried to the deck plating and welded thereto. Beams shall be carried to the inner edges of frames with a minimal gap. Beam knees shall have a face plate or flange.

The ends of intermediate frames shall be attached to longitudinal intercostals, decks or platforms.

**3.7.2.5.8** Side longitudinals shall be attached to transverse bulkheads with knees. The height and width of the knees shall comply with 1.7.2.2.

**3.7.2.5.9** Bulwark stays welded to sheerstrake shall be so constructed as to prevent deck plating damage in case of bumping.

**3.7.2.6** Besides the requirements of 3.10, the ice-strengthening structure of fishing vessels of category **Ice3** intended for systematic operation in ice conditions shall comply with the following requirements:

**.1** for the case of transverse main framing, at least one load distributing side stringer shall be fitted in each grillage in way of region of ice strengthening AI, AII, BI, CI;

**.2** bulbous forebody is not recommended;

**.3** in the forepeak, the spacing of stringers and their dimensions, as well as stem dimensions, shall be in accordance with the requirements of 3.10 for ships of category **Arc4**;

**.4** in the afterbody, provision shall be made for an appendage (ice knife) aft of the rudder to protect the latter on the sternway.

### 3.7.3 Design loads.

**3.7.3.1** Design loads on ramp structures shall be determined as follows:

**3.7.3.1.1** The design pressure  $p$ , in kPa, on the ramp sides and deck in vessels where the catch is dragged in shall be determined by the formula

$$p = 6,5b_{sr}. \quad (3.7.3.1.1)$$

Where the breadth of the ramp varies along its length, the minimum breadth shall be taken as the design value.

**3.7.3.1.2** In vessels equipped with a special wheeled catch-transport arrangement, the design load  $p$ , in kN, for ramp deck plating shall be determined by the formula

$$p = 27 \frac{G_1 + G_2}{n_w} \quad (3.7.3.1.2)$$

where  $n_w$  = number of the wheel axes of the arrangement.

**3.7.3.2** For factory decks, the design pressure  $p$ , in kPa, shall be determined by the formula

$$p = 15 \frac{G}{S_d}. \quad (3.7.3.2)$$

**3.7.3.3** The design pressure  $p$ , in kPa, on the sides and superstructure sides of ships moored at sea shall be determined by the following formulae:

in the region A

$$p = \alpha_1 \alpha_2 (190 + 51 \sqrt{\Delta z \cdot 10^{-3} - 0,464}); \quad (3.7.3.3-1)$$

in the regions B and C

$$p = \alpha_1 \alpha_2 (129 + 59 \sqrt{\Delta z \cdot 10^{-3} - 0,464}) \quad (3.7.3.3-2)$$

where  $\alpha_1$  shall be adopted from Table 3.7.3.3-1 depending on the ship displacement and the sea conditions specified for mooring at sea;

$\alpha_2$  shall be adopted from Table 3.7.3.3-2 depending on the ship purpose and the region of strengthening;

$\Delta$  = design ship displacement, in t. For a fishing vessel  $\Delta$  — displacement to the summer load waterline. For a special purpose ship  $\Delta$  — displacement of the largest ship mooring alongside. In any case  $\Delta$  shall not be taken greater than 7500 t and smaller than 464 t;

$n$  = number of moorings, during a voyage, alongside the ship whose displacement has been adopted as the design value in the Formulae (3.7.3.3-1) and (3.7.3.3-2);

$z$  = distance in m, from the mid-span of member calculated to the summer load waterline.

Where a special purpose ship has the freeboard depth  $h_c$  greater than the freeboard depth  $h_p$  of the ship whose displacement has been adopted as the design value in the Formulae (3.7.3.3-1) and (3.7.3.3-2), the value of  $z$  shall be reduced by the difference of  $(h_c - h_p)$ .

In any case,  $z \geq 1,0$ ; in the region A,  $z = 1,0$ .

Table 3.7.3.3-1

Ship displacement, in t	Factor $\alpha_1$		
	Sea state No.		
	4	5	6
$\leq 2000$	1,00	1,15	1,60
$> 2000$	0,82	1,00	1,16

Table 3.7.3.3-2

Factor $\alpha_2$		
Region of strengthening	Fishing vessel	Special purpose ship
Region A	1,00	0,8
Region A within fender area	—	1,1
Region B	$\frac{1}{0,22z + 0,6}$	$\frac{1 + 0,05n^{1/3}}{0,22z + 0,6}$
Region C	$\frac{1}{0,12z + 1,28}$	$\frac{1 + 0,05n^{1/3}}{0,12z + 1,28}$

$n$  — number of moorings, during a voyage, along the ship whose displacement is adopted for the design value in the Formulae (3.7.3.3-1) and (3.7.3.3-2).  
Note. In the regions B and C of special purpose ships,  $\alpha_2$  is assumed between 1,1 and 1,4.

**3.7.3.4** For fishing vessels of category **Ice3** which are intended for systematic operation in ice conditions, the ice load parameters shall be determined on the basis of the following provisions:

**1** in the forward region of ice strengthening (A), the load parameters shall be determined in accordance with the requirements of 3.10 for the ice category **Ice3**. In the case of a bulbous forebody, the rake angle of frame shall be determined as stipulated in 3.10.3.2.1 for ships of category **Arc4**;

**2** in the intermediate region of ice strengthening (A<sub>I</sub>), the ice load parameters shall be taken equal to:

$$\begin{aligned} p_{A_I I} &= 0,75 p_{A I} \\ p_{A_I II} &= 0,75 p_{A II} \\ b_{A_I} &= b_A \end{aligned} \quad (3.7.3.4.2)$$

$$l_{A_I}^H = l_A^H$$

where  $p_{A_I}$ ;  $p_{A_{II}}$ ;  $b_A$ ;  $l_A^H$  = ice load parameters for the forward region (A), as determined in accordance with the requirements of 3.10, with due regard for 3.7.3.4.1;

**3** in the midship region of ice strengthening (B), the ice-load intensity, in kPa, is determined by the formula

$$p_{wI} = p_{BI}^{\circ} k_B \quad (3.7.3.4.3)$$

where  $p_{BI}^{\circ}$  = ice load intensity in midship region according to 3.10.3.2.3;

$k_B = 2k_1$ , but not less than 1;

$$k_1 = \frac{r^2}{\sqrt{\Delta/1000}} (l_k/L - 0,18);$$

$$r = \frac{17,4 P_b^{1/2} a^{1/2} - B_2}{57,3 P_b^{1/3}};$$

$\Delta$  = displacement, in t, to summer load waterline;

$P_b$  = shaft power, in kW, determined with due regard for power take-off in the trawling condition;

$l_k$  = distance, in m, from forward perpendicular to a section aft where the reduction of summer load waterline breadth begins.



The height and length ( $b_B$  and  $l_B^H$ ) to which the midship region is covered by the ice load shall be determined in accordance with 3.10.3.3.3 and 3.10.3.4.3;

4 the ice load intensity, in kPa, in the aft region of ice strengthening (C) is determined by the formula

$$p_{CI} = p_{CI}^{\circ} k_c \quad (3.7.3.4.4)$$

where  $p_{CI}^{\circ}$  = ice pressure in the aft region according to 3.10.3.2.4;  
 $k_c = 2,5k_1$ , but not less than 1;  
 for  $k_1$ , refer to 3.7.3.4.3.

The height and length ( $b_B$  and  $l_B^H$ ) to which the aft region is covered by the ice load shall be determined in accordance with 3.10.3.3.4 and 3.10.3.4.4.

### 3.7.4 Scantlings of structural members.

3.7.4.1 Requirements for the scantlings of stern ramp framing.

3.7.4.1.1 The section modulus of longitudinals, beams and deck transverses of the stern ramp shall be determined according to 1.6.4.1, taking:

$p$  = as determined by the Formulae (3.7.3.1.1) or (3.7.3.1.2);

$m$  = as obtained from Table 3.7.4.1.1 for vessels where the catch is dragged in;

$m = 9,3l^{2,4}\sqrt[4]{a}$  for vessels where the catch is carried onto the deck by a special wheeled arrangement;

$k_{\sigma} = 0,6$ .

Table 3.7.4.1.1

Factor $m$		
Stern ramp framing	Fishing vessels	Special purpose ship
Deck longitudinals	11,3	7,9
Beams and deck transverses	12,6	8,8

3.7.4.1.2 The section modulus, in  $\text{cm}^3$ , of stern ramp side stiffeners shall not be less than determined by the Formula (1.6.4.1) with the design load  $p$  as determined by the Formula (3.7.3.1.1),  $k_{\sigma} = 0,9$ ,  $m = 17,0$ , or  $22,6$  for fishing vessels and special purpose ships respectively. The stiffener span  $l$  shall be adopted equal to the maximum distance between the ramp deck and the nearest deck above or to the distance between two decks adjoining the ramp side, but shall not be less than 2,6 m.

In vessels engaged in pelagic fishing, the section modulus of ramp side stiffener, in  $\text{cm}^3$ , shall not be less than:

$$W = 45,5 \left(1 - \frac{0,5}{l}\right) \left(\frac{820}{\sigma_n} - \frac{l}{a}\right) \omega_c. \quad (3.7.4.1.2)$$

In no case shall the section modulus of stern ramp side stiffeners be less than required in 2.5.4.2 for the frames of upper 'tween deck and superstructure.

3.7.4.1.3 The length of thickened ramp deck plating sections along the ramp length shall equal:

the ramp width at least, if measured forward of the ramp edge, in way of bottom rounding;

double ramp width at least in way of top rounding.

3.7.4.1.4 Where the connection of the ramp side with transom plating is rounded, the thickness of the plating strake not less than 700 mm broad, if measured from the ramp deck plating, shall not be less than 20 mm. Doubling plates are also permitted.

If a welded half-round bar not less than 70 mm in diameter is fitted to the junction of the rounding and the flat part of the side, but not farther than 200 mm from the transom, the plating thickness may be adopted in accordance with the requirements of 3.7.4.1.6.

3.7.4.1.5 For vessels not engaged in pelagic fishing, the plating strakes of ramp sides shall be thickened, in way of connection with the transom and along the ramp deck, to a value not less than required under 3.7.4.1.6.

The thickened side plating strakes fitted along the ramp length shall have a breadth not less than 0,4 of the ramp breadth, or 1,0 m, whichever is greater. The lower edge of those strakes shall coincide with the ramp deck in vessels where the catch is dragged in and be level with the catch stowage surface in vessels where the catch is carried onto the deck by a wheeled arrangement.

If measured forward of the rounding-to-flat-side-junction line, the length of thickened section of the side plating in way of transom shall not be less than 0,5 of the ramp breadth.

3.7.4.1.6 For vessels where the catch is dragged in, the plating thickness of ramp deck and sides, in mm, shall not be less than determined by the Formula (1.6.4.4), taking:

$m, \Delta s$  = to be adopted from Table 3.7.4.1.6;

$p$  = as determined by the Formula (3.7.3.1.1);

Table 3.7.4.1.6

Ramp structure	Location along ramp length	Fishing vessel		Special purpose ship	
		$m$	$\Delta s$ , in mm	$m$	$\Delta s$ , in mm
Deck	Bottom rounding and stern-counter plating	26,8	10,0	26,8	10,0
	Mid-region	26,8	5,5	26,8	5,5
	Top rounding	26,8	9,5	26,8	5,5
Sides	In way of friction	25,9	5,5	21,9	5,5
	Elsewhere on deck	25,9	4,5	21,9	4,5

$$k_{\sigma} = 0,8;$$

$$k = 1,0.$$

**3.7.4.1.7** Where doubling plates are fitted on the ramp deck in way of bottom rounding or top rounding or where devices to prevent excessive wear of stern ramp plating with wire ropes are installed, the plating thickness may be adopted as for the mid-region.

**3.7.4.1.8** In vessels engaged in pelagic fishing, the lower strake of the side having a width from the stern ramp plating to a point at least 100 mm above the upper half-round bar shall have a thickness  $s$ , in mm, not less than:

$$s = 2 \cdot 10^4 \frac{a_s}{\sigma_n} + 1 \quad (3.7.4.1.8)$$

where  $a_s$  = distance, in m, between adjacent edges of half-round bars.

**3.7.4.1.9** Whatever the mode of carrying the catch along the stern ramp, the thickness of ramp plating in vessels of all types shall be 2 mm greater than required by 2.2.4.8 for the shell plating. This thickness shall be maintained on the length from the stern ramp end to a line at least 600 mm above the bulkhead deck within the particular section of the vessel length. Forward of this region the thickness of stern ramp plating shall be 2 mm greater than required under 2.6.4.1.5 for the upper deck plating at ends.

**3.7.4.1.10** On a length at least 1,0 m forward of the stern ramp edge and at least over the whole ramp breadth, the stern-counter plating shall be 1 mm thicker than stipulated under 2.2.4.1.

**3.7.4.2** Requirements for the member scantlings of vessels having a side trawling arrangement.

**3.7.4.2.1** In vessels over 30 m in length, the side plating and sheerstrake thickness between the galls, determined as the distance between the section three spacings forward of the fore end of forward gallow and the section three spacings abaft the after end of after gallow, shall be 1 mm greater than stipulated under 2.2.4.1.

**3.7.4.2.2** Within the location of each gallow, to be determined in accordance with 3.7.2.2.2, provision shall be made for strengthening as follows:

sheerstrake thickness to be increased by 2 mm;

thickness of strake adjacent to sheerstrake to be increased to equal that of the sheerstrake between galls;

deck stringer thickness to be increased by 3 mm as compared to that required by 2.6.4.1;

bulwark plate thickness to be increased by 2 mm as compared to that required by 2.14.4.1.

**3.7.4.3** Requirements for member scantlings of holds and fish handling spaces.

**3.7.4.3.1** The section modulus of factory deck beams and longitudinals shall be determined as re-

quired by 2.6.4 with the design pressure according to 3.7.3.2 where it exceeds that required by 2.6.3.

**3.7.4.3.2** In holds and fish handling spaces in which non-packed salted catch or salt is stored or which are exposed to the detrimental effect of catch wastes and sea water, the plating thickness shall be increased by 1 mm as compared to that required by the relevant sections of the Rules. Where the structure is so influenced from both sides, relevant thickness shall be increased by 2 mm.

**3.7.4.3.3** The vertical web plate thickness of coamings not acting as deck girders shall not be less than the deck plating thickness, or 7 mm, whichever is greater.

**3.7.4.4** Requirements for member scantlings of ships mooring at sea.

**3.7.4.4.1** The side plating and sheerstrake thickness of ships below 80 m in length shall be by 1 mm greater than required under 2.2.4.8.

**3.7.4.4.2** In strengthened regions, the side plating and sheerstrake thickness, in mm, shall not be less than:

$$s = 21,7a\sqrt{\frac{p}{k_n R_{eH}}} - 0,242 + \Delta s \quad (3.7.4.4.2)$$

where  $a$  = frame spacing, in mm. If panting frames are provided,  $a$  is the distance between main and panting frames;

$p$  = as defined under 3.7.3.3;

$k_n = 1,1$ ;

$\Delta s = 4,0$  mm for region A in case trawling is effected from the vessel side;

$\Delta s = 1,2$  mm for regions B and C;

$\Delta s = 3,0$  mm elsewhere.

**3.7.4.4.3** In region A, the section modulus of frames, in  $\text{cm}^3$ , shall not be less than:

$$W = \frac{pab(2l-b)\omega_K}{mk_n R_{eH}} \cdot 10^3 \quad (3.7.4.4.3)$$

where  $p$  = as determined by the Formula (3.7.3.3-1);

$a$  = spacing, in m, of main frames;

$b = 1,5$  m;

$m = 20,4 k_1 k_2 (1 + k_3 k_4)$ ;

$k_1, k_2$  and  $k_3$  shall be adopted from Table 3.7.4.4.3 proceeding from the number of load distributing side stringers fitted;

$k_4 = 0$  where no panting frames are fitted;

$k_4 = 0,69$  if panting frame ends terminate at longitudinal intercostal members;

$k_4 = 1,0$  if the end attachments of main and panting frames are similar;

$k_n = 1,1$ ;

$l$  = frame span, in m, as measured along the chord between the upper edge of inner bottom plating or floor face plate and the lower edge of deck at side (side stringer where web frames are fitted).

**3.7.4.4.4** In regions B and C, the section modulus of frames, in  $\text{cm}^3$ , shall not be less than determined by the Formula (3.7.4.4.3). The value of  $p$  shall be determined by the Formula (3.7.3.3-2). Where the actual shell plating thickness is greater than 8 mm,  $p$  may be reduced by the value

Table 3.7.4.4.3

Factor	No load distributing side stringers	One load distributing side stringer	Two load distributing side stringers or more
$k_1$	1,0	$1,12 + 0,038 \frac{l}{a} \bar{\omega}$	$1,27 + 0,039 \frac{l}{a} \bar{\omega}$
$k_2$	$1 + 6,8\sqrt{f/l(f/l + 0,28)} - 12,5f_1/l$	$1,0 + 7,0 \frac{f}{l} - 8,0 \frac{f_1}{l}$	
$k_3$	1,0	0,75	0,65

$\bar{\omega} = \frac{W_c}{W}$  = section modulus ratio of load distributing side stringer and frame;  
 $f$  = distance, in m, between a section at the lower support of frame and a tangent to the frame contour in way of the section at the upper support, as measured normal to the tangent (refer to Fig. 3.7.4.4.3);  
 $f_1$  = maximum deflection of frame according to Fig. 3.7.4.4.3, in m.

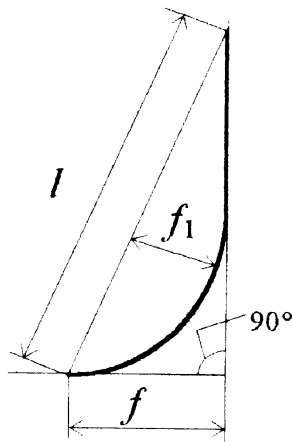


Fig. 3.7.4.4.3

the factor  $k'_3$  is determined in the same way as  $k_3$  with  $a$  equal to the spacing of main and panting frames;  
 $k_n = 1,1$ .

**3.7.4.4.5** If longitudinal framing system is applied for 'tween deck spaces, the section modulus, in  $\text{cm}^3$ , of side longitudinals shall not be less than:

$$W = 24 \frac{p a a_p^2}{R_{eH}} \omega_c \quad (3.7.4.4.5)$$

where  $p$  = as determined by the Formula (3.7.3.3-2);  
 $a$  = spacing, in m, of longitudinals;  
 $a_p$  = web frame spacing, in m.

**3.7.4.4.6** Where superstructure sides of ships mooring at sea are inclined to the centre line at not less than  $1/10$  or fitted inboard at not less than  $1/10$  of their height, no additional strengthening as per 3.7.4.4 is required.

Where the inclination of superstructure sides to the vessel side or the distance between those and the vessel side is less than specified above, the strengthening of their frames and shell plating shall be determined by linear interpolation proceeding from the requirements of 3.7.4.4, 2.2.4.1 and 2.5.4.2.

**3.7.4.5** The member scantlings in the ice strengthened regions of fishing vessels of the ice category **Ice3** which are intended for systematic operation in ice conditions shall be determined in accordance with 3.10.4 where the ice load parameters are as stipulated in 3.7.3.4, bearing the following specification in mind. When determining shell plating thickness in the intermediate region of ice strengthening in accordance with 3.10.4.1, the annual average thickness reduction of shell plating as a result of corrosion wear and abrasion shall be adopted as  $u = 0,25$  mm/year.

### 3.7.5 Special requirements.

#### 3.7.5.1 Stern ramp structure.

**3.7.5.1.1** Transom plating shall be protected from excessive wear with half-round steel bars of at least 70 mm in diameter, which shall be fitted inclined and secured by welding.

$$\Delta p = \frac{2,9 + l}{al} s^2 R_{eH(0)} \cdot 10^{-3} \quad (3.7.4.4.4)$$

where  $s$  = actual shell plating thickness, in mm, but not greater than 20 mm;

$l$  = frame span, in m;

$R_{eH(0)}$  = yield stress, in MPa, of shell plating material;

$a$  = main frame spacing, in m;

$b = 2,2$  m;

$$m = 25,0 \frac{k_1 k_2}{k_3 k_4};$$

$k_1 = 1,3$  for region B of special purpose ships;

$k_1 = 1$  elsewhere;

$k_2 = 1$  where no load distributing stringers are fitted;

$$k_2 = 1,12 + \frac{2,46 \bar{\omega}}{a(8,6 - l)} \text{ with one load distributing stringer;}$$

$$k_2 = 1,15 + \frac{5,06 \bar{\omega}}{a(8,6 - l)} \text{ with two load distributing stringers or more;}$$

$\bar{\omega} = \frac{W_c}{W}$  = section moduli ratio of load distributing stringer and frame;

$k_3 = 2a$  for the fender areas of special purpose ships and within  $(0 - 0,25)L$  of forward perpendicular in fishing vessels;

$k_3 = 2a - 0,1$  within  $(0 - 0,20)L$  of aft perpendicular in fishing vessels;

$k_3 = 2a - 0,2$  elsewhere;

$k_4 = 1$  where no panting frames are fitted;

$$k_4 = \frac{k'_3}{k_3} (1 + 0,5 k_1 k'_3) \text{ where panting frames are fitted;}$$

**3.7.5.1.2** Half-round steel bars of at least 70 mm in diameter shall be welded along the junction line of rounding and flat side, but not farther than 200 mm from the transom.

**3.7.5.1.3** In vessels engaged in pelagic fishing, stern ramp sides shall be stiffened with longitudinal half-round steel bars of at least 70 mm in diameter, welded to the sides and spaced not more than 200 mm apart. The edge of the upper bar shall be not less than 650 mm above the ramp deck plating.

**3.7.5.1.4** Suitable devices are recommended to prevent excessive wear of ramp plating with wire ropes when dragging the catch. Where the rated winch pull exceeds 30 kN on each wire rope, such devices are compulsory.

Devices preventing excessive wear of plating may be substituted by doubling plates in the thickened areas of top and bottom rounding over the full breadth of the ramp, and doubling strips at least 400 mm wide may be fitted at the sides over the rest of the ramp length.

**3.7.5.2** Within the location of each gallow complying with 3.7.2.2.2, bulwark, sheerstrake and shell plating above ballast waterline shall be protected with half-round steel bars fitted inclined and secured by welding.

**3.7.5.3** In way of heavy items of machinery and equipment installed in fish handling spaces, extra strengthening of 'tween deck sides may be required by the Register where the 'tween deck height exceeds 3,5 m.

**3.7.5.4** When determining the requirements for sternframe scantlings of ships having the length  $L < 60$  m, the design length and width of a solid rectangular propeller post shall be those stipulated under 2.10.4.3, as increased by 10 per cent.

### 3.8 SUPPLY VESSELS

#### 3.8.1 General.

The requirements of this Chapter apply to supply vessels. Structural items not covered by this Chapter shall comply with the requirements of Sections 1 and 2.

#### 3.8.2 Construction.

**3.8.2.1** Provision shall be made for longitudinal fenders. At the fore end sloped fenders shall be fitted between the longitudinal fenders.

**3.8.2.2** Inner bulwarks (coamings) and other similar structures protecting deck cargoes shall be properly secured to deck framing members. The scantlings of the above structures shall be agreed with the Register.

**3.8.2.3** Shell in way of stern rollers and in other high load areas shall be suitably reinforced.

**3.8.2.4** In deck areas where concentrated loads are applied (e.g. drilling rig anchors), extra strengthening of decks shall be provided.

**3.8.2.5** The sides of superstructures and the bulwark shall be inclined to the centre line of the vessel at not less than one-tenth or to be fitted inboard from the vessel's side at not less than one-tenth of their height.

**3.8.2.6** The lower ends of stiffeners of the first-tier front bulkheads shall be connected to the underdeck framing members by brackets. The lower ends of other stiffeners shall be welded to the decks. The upper ends of stiffeners shall be connected to the deck beams by means of brackets.

**3.8.2.7** The stay of the bulwark welded to the sheerstrake shall be so constructed as to prevent damage of deck plating in case of bumping.

**3.8.2.8** Extra strengthening of a flat portion of the bottom in way of the stern may be required to take up loads induced by slamming.

#### 3.8.3 Design loads.

Design loads on hull structures of supply vessels shall be taken in compliance with Sections 1 and 2.

#### 3.8.4 Scantlings of structural members.

**3.8.4.1** The thickness of the side shell plating shall be 1 mm greater than required by 2.2.4. In no case is the thickness of the side shell plating to be taken less than 9,0 mm.

**3.8.4.2** The thickness of deck plating shall be determined from 2.6.4, but it shall not be less than 8,0 mm.

**3.8.4.3** The scantlings of deck framing members shall be obtained as required by 2.6.4 with a design load corresponding to the specified value but not less than 35 MPa.

**3.8.4.4** The scantlings of girders and pillars supporting these girders shall be suitable for the weight of the deck cargo, as well as for loads induced by towing winches, supports of separate cargo platforms and other concentrated loads. Account shall be also taken of a vertical and a horizontal components of inertia forces due to the vessel's motions. As the first approximation, accelerations determined according to 1.3.3 may be used.

**3.8.4.5** The section modulus of hold, 'tween deck and forecastle frames shall not be less than determined according to 3.7.4.4.4 with  $p$  to be determined by the Formula (3.7.3.3-1),  $\alpha_1 = 1,16$ ,  $\alpha_2 = 1,0$ .

**3.8.4.6** The section modulus of stiffeners of the fronts, sides and after ends of the deckhouses situated on the forecastle deck shall be not less than that required by 2.12.4.5.2. The assumed head  $p$ , in kPa, shall not be taken less than given in Table 3.8.4.6.

**3.8.4.7** The plate thickness of the fronts, sides and after ends shall be taken not less than 6,5 mm for the first-tier front bulkhead and 6,0 mm for other bulk-

Table 3.8.4.6

Deckhouse tier	$p$ , in kPa		
	Front bulkhead	Side bulkhead	After bulkhead
First	90	60	25
Second and above	75	50	25

heads. These values are applicable in case of stiffener spacing 0,6 m. For stiffener spacings exceeding 0,6 m the thickness shall be increased in proportion to the increased spacings.

**3.8.4.8** The plate thickness of the bulwark shall be at least 7 mm, and the width of the stiffener lower end measured along the weld shall be not less than 360 mm. The distance between stays shall not exceed two spacings or 1,3 m, whichever is the lesser.

### 3.8.5 Special requirements.

**3.8.5.1** In vessels having a double skin construction, structures and scantlings of the inner skin framing shall comply with 2.5. Where the forces acting on the frames may be directly transmitted to the inner skin framing, the scantlings of these members shall be specially considered by the Register.

**3.8.5.2** Scallops and one-sided welds shall not be used in framing-to-side-shell-plating connections.

## 3.9 TUGS

### 3.9.1 General and symbols.

**3.9.1.1** The requirements of this Chapter apply to all tugs irrespective of purpose or service area.

**3.9.1.2** Structural items not covered by this Chapter shall comply with the requirements of Sections 1 and 2.

**3.9.1.3** For the purpose of this Chapter the following symbols have been adopted:

$b_s$  = width of stem cross section, in mm;

$l_s$  = length of stem cross section, in mm.

### 3.9.2 Construction.

**3.9.2.1** Plate floors shall be fitted at each frame.

Where the double bottom is omitted, the floors shall have a symmetrical face plate.

**3.9.2.2** Where a main frame span exceeds 3,0 m, load distributing side stringers shall be fitted along the length of the ship except for the engine room.

**3.9.2.3** In the engine room, web frames shall be fitted between the inner bottom (floor face plates) and the upper deck at a distance not exceeding four spacings. Web frames shall be fitted at main engine ends.

**3.9.2.4** A fender shall be fitted at upper deck and long forecastle deck level.

**3.9.2.5** Areas to which concentrated loads are applied (e.g. due to towing winches) shall be additionally strengthened.

**3.9.2.6** The stems of harbour tugs shall have rounded shape above the summer load waterline.

### 3.9.3 Design loads.

Design loads on hull structures of tugs shall be assumed in compliance with the requirements of Sections 1 and 2.

### 3.9.4 Scantlings of structural members.

**3.9.4.1** The minimum plating thickness of shell and upper deck as well as of watertight bulkheads shall not be less than 5 mm.

**3.9.4.2** The thickness of shell plating adjacent to the stem shall not be less than stipulated under 2.2.4.6.

The shell plating thickness in way of the engine room, when located aft, shall not be less than required for the midship region.

**3.9.4.3** When determining the section modulus of the web frames in accordance with 2.5.4.5, the distance measured from the inner bottom plating (floor upper edge) and the upper deck at side shall be taken as the design span.

**3.9.4.4** The scantlings of load distributing side stringers shall be determined in accordance with 2.8.2.7.

**3.9.4.5** Within the region from the keel to the summer load waterline, the cross-section of a rectangular solid bar stem shall not be less than:

$$l_s = 1,6L + 100; \quad (3.9.4.5-1)$$

$$b_s = 0,5L + 25. \quad (3.9.4.5-2)$$

The scantlings and location of brackets for strengthening the stem shall be determined proceeding from 2.10.4.1.3.

The stem shall be extended abaft the fore peak bulkhead for not less than three spacings.

Ship-handling tugs are not permitted to have reduced cross-section and scantlings of the stem (if constructed of steel plates) above the summer load waterline.

The steel plates of the stem shall be strengthened over their length with horizontal brackets spaced not more than 0,6 m apart, the plate thickness of the stem determined in accordance with 2.10.4.1.2 being not reduced.

**3.9.4.6** Rectangular solid propeller posts shall have scantlings from the keel to the counter not less than:

$$l_s = 1,5L + 100; \quad (3.9.4.6-1)$$

$$b_s = 1,8L + 25. \quad (3.9.4.6-2)$$

The sternframe shall be attached according to 2.10.2.2.4 to two floors, whatever the length of the tug may be.

**3.9.4.7** The thickness of the bulwark plating shall be taken according to 2.14.4.1, but not less than 4 mm.

The section modulus of bulwark stays shall be determined in accordance with 2.14.4.2 where  $m = 1,5$ . Bulwark stays shall be fitted not farther than at alternate frames. Bulwark stays welded to the sheerstrake plate may have a flexible element in their structure.

The bulwark shall be inclined to the centre line of the vessel at not less than  $7^\circ$ .

### 3.9.5 Special requirements.

For unrestricted service tugs above 40 m in length, the number of watertight bulkheads shall be not less than four.

## 3.10 STRENGTHENING OF ICE SHIPS AND ICEBREAKERS

### 3.10.1 General and requirements.

#### 3.10.1.1 Application.

**3.10.1.1.1** The requirements of this Chapter apply to self-propelled ice ships and icebreakers, as well as to ships which may be given the same status proceeding from the conditions of their ice navigation.

Requirements for polar class ships (refer to 2.2.3.1, Part I "Classification") are specified in Section 1, Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships".

**3.10.1.1.2** Self-propelled ice-strengthened ships which comply with the requirements of this Chapter are assigned an ice category mark in their class notation in accordance with 2.2.3, Part I "Classification".

**3.10.1.1.3** Requirements of this Chapter are supplementary with regard to those of other chapters of the Rules which apply to a particular ship, and they establish the minimum strength level necessary to withstand ice loads, as well as hull structure, proceeding from the ice mark in the class notation.

**3.10.1.1.4** The calculation procedures of this Chapter are directly applicable to those ice ships and icebreakers only which have a standard hull form and which comply with the requirements of 3.10.1.2. The possibility of departing from the requirements of 3.10.1.2, as well as of using bow lines (spoon-like, multi-plane) other than standard ones, is subject to special consideration by the Register.

**3.10.1.1.5** In the Rules, an assumption is made that during service the owner will be guided by the requirements contained in the ice certificate of the ship which shall be drawn up by a competent body and shall include a precise outline of conditions under

which safe navigation in ice can be ensured proceeding from the ice category mark, ice situation and icebreaker support.

### 3.10.1.2 Requirements for hull configuration.

**3.10.1.2.1** The hull configuration parameters  $\alpha$ ,  $\alpha_0$ ,  $\beta$ ,  $\varphi$ , in deg., shall be measured in conformity with Figs 3.10.1.2-1 to 3.10.1.2-4.

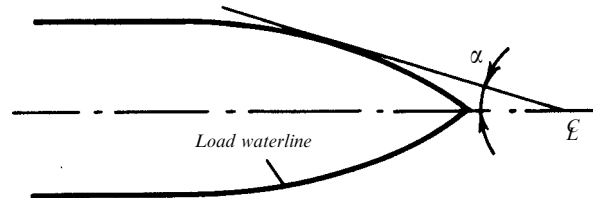


Fig. 3.10.1.2-1:  
 $\alpha$  — slope of summer load waterline at the section considered, in deg.

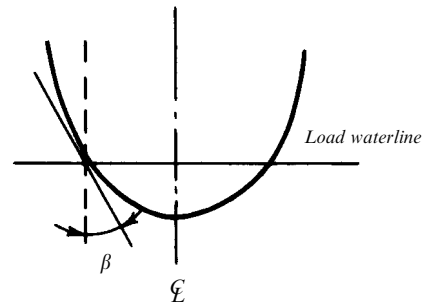


Fig. 3.10.1.2-2:  
 $\beta$  — slope of frame on the level of summer load waterline at the section considered, in deg.

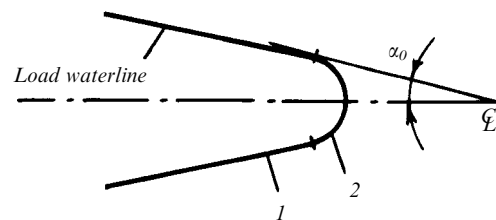


Fig. 3.10.1.2-3:  
 $\alpha_0$  — slope of summer load waterline at the forward perpendicular, in deg;  
1 — shell plating; 2 — stem

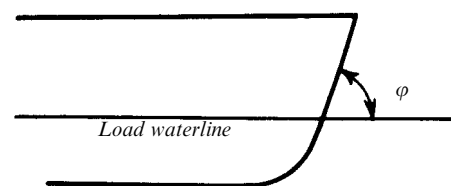


Fig. 3.10.1.2-4:  
 $\varphi$  — slope of stem on the level of summer load waterline, in deg.

**3.10.1.2.2** The hull configuration parameters of ice class ships shall be within the limits stated in Table 3.10.1.2.2.

Table 3.10.1.2.2

Hull configuration parameter	Category of ice strengthening				
	Arc8, Arc9	Arc7, Arc6	Arc5	Arc4	Ice1, Ice2, Ice3
$\phi$ not greater than	25°	30°	45°	60°	—
$\alpha_0$ not greater than	30°	30°	40°	40°	50°
$\beta$ within 0,05L from forward perpendicular, min	45°	40°	25°	20°	—
at main frame, min	15°	—	—	—	—

In the forward and intermediate region of ice strengthening of **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships and icebreakers, there shall be no areas of shell plating within which the configuration parameters  $\alpha$  and  $\beta$  would simultaneously take the values  $\beta = 0$  and  $\alpha > 0$ .

**3.10.1.2.3** The values of hull configuration parameters in icebreakers shall comply with the following requirements.

At 0 — 0,25L from forward perpendicular at service draughts, straight and convex waterlines shall be used. The entrance angle for above waterlines shall be 22° to 30°.

At service draughts, the angle shall not exceed:

30° for **Icebreaker6**, **Icebreaker7** category icebreakers;

25° for **Icebreaker8**, **Icebreaker9** category icebreakers.

The cross section of stem shall be executed in the form of a trapezoid with a bulging forward face.

For icebreakers with standard bow lines, slope angles of frames shall be adopted from Table 3.10.1.2.3-1. In case of departure from the requirements of Table 3.10.1.2.3-1, the ice load values shall be specially considered by the Register.

Table 3.10.1.2.3-1

Distance from section to forward perpendicular	0,1L	0,2 — 0,25L	0,4 — 0,6L	0,8 — 1,0L
Permissible range of the angle variation $\beta$ , in deg.	40° — 55°	23° — 32°	15° — 20°	Approximately coinciding with the angles $\beta$ of within 0 — 0,2L

In way of construction water line, frames shall have a straight-lined or moderately convex shape.

The construction water line projection upon a horizontal plane shall cover the blade tips of side propellers.

The tip clearance shall not be less than stated in Table 3.10.1.2.3-2.

**3.10.1.2.4** In the afterbody of icebreakers and **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships, provision shall be made for an appendage (ice knife) aft of the rudder to protect the latter on the sternway.

Table 3.10.1.2.3-2

Clearance, in mm	Category of icebreaker			
	<b>Icebreaker9</b>	<b>Icebreaker8</b>	<b>Icebreaker7</b>	<b>Icebreaker6</b>
$\delta$	1500	1250	750	500

**3.10.1.2.5** No transom stern (with the transom coming in the region of ice strengthening) is permitted for icebreakers and **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships. For **Arc4** and **Arc5** category ships having a transom stern, the value of ice loads upon the transom is subject to the special consideration by the Register.

**3.10.1.2.6** For icebreakers and **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships, provision shall be made for a step in the lower part of the stem. The height of the step shall be 0,1d at least. The transition from the step to the lower part of the stem shall be smooth.

**3.10.1.2.7** In ships of categories **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9**, bulbous bow is not permitted. In ships of category **Arc4**, this kind of bow is subject to special consideration by the Register.

**3.10.1.3** Region of ice strengthening.

**3.10.1.3.1** The hull length shall be subdivided into regions of ice strengthening as follows:

forward region — A;

intermediate region — A<sub>1</sub>;

midship region — B;

aft region — C.

The hull depth and bottom are subdivided into regions of ice strengthening as follows:

region of alternating draughts and similar regions — I;

region from the lower edge of region I to the upper edge of bilge strake — II;

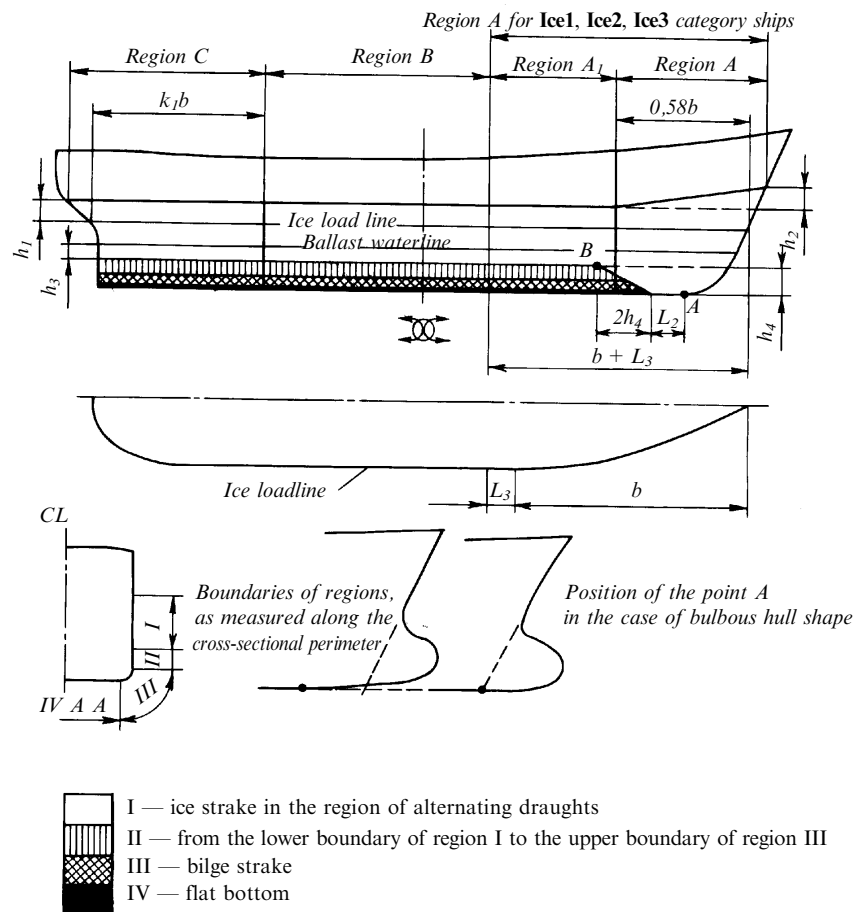
bilge strake — III;

region from the lower edge of bilge strake to the centre line — IV.

**3.10.1.3.2** The length of regions of ice strengthening in ice class ships shall be determined on the basis of Fig. 3.10.1.3.2 and Table 3.10.1.3.2.

Table 3.10.1.3.2

Parameter	Ice category					
	<b>Arc7, Arc8, Arc9</b>	<b>Arc5, Arc6</b>	<b>Arc4</b>	<b>Ice3</b>	<b>Ice2</b>	<b>Ice1</b>
$h_1$ , in m	where $B \leq 20$ m		0,75	0,60	0,50	
	where $B > 20$ m		$\frac{0,5B + 8}{24}$	$\frac{0,5B + 8}{30}$	$\frac{0,5B + 8}{36}$	0,50
$h_2$ , in m	1,4	0,8	0,6	0,2		
$h_3$ , in m	$1,6h_1$	$1,35h_1$	$1,20h_1$	$1,10h_1$	$h_1$	
$L_2$ , in m	0,15L	0,1L	0,05L	0,02L		—
$L_3$ , in m	0,06L	0,05L	0,045L	0,04L	0,02L	
$k_1$	0,84	0,69	0,55	0,53	0,50	—



$b$  — distance from the point of the ice loadline and stem intersection to the section where the ice loadline is the widest, but not greater than  $0,4L$ .

Notes 1. For Ice1 category ships, the lower boundary of the region A is by  $h_3$  distant from the ballast waterline.

2. Point B shall not be further than the aft boundary of the region A<sub>1</sub>.

Fig. 3.10.1.3.2

Regions of ice strengthening of ice class ships

An ice loadline shall be determined as a loadline enveloping all the ship loadlines (heel disregarded) possible during ice navigation.

For Ice1, Ice2, Ice3 category ships no intermediate region of ice strengthening will be established. In this case, it shall be considered that the aft boundary of the forward region of ice strengthening coincides with the forward boundary of the midship region of ice strengthening.

**3.10.1.3.3** The length of regions of ice strengthening in icebreakers shall be determined on the basis of Fig. 3.10.1.3.3 and Table 3.10.1.3.3.

**3.10.1.3.4** Proceeding from the ice category, the requirements of the Chapter apply to the regions of ice strengthening marked with "+" in Ta-

ble 3.10.1.3.4. For the purpose of Table 3.10.1.3.4, the absence of this mark means that the particular region of ice strengthening is not covered by the requirements of the Chapter.

Table 3.10.1.3.3

Parameter	Category of icebreaker			
	Icebreaker9	Icebreaker8	Icebreaker7	Icebreaker6
$h_1$ , in m	where $B \leq 20$ m	1,00	0,80	0,75
	where $B > 20$ m	$\frac{0,5B + 12}{22}$	$\frac{0,5B + 7,6}{22}$	$\frac{0,5B + 8}{24}$
$h_2$ , in m	2	1,7	1,4	1,1
$h_3$ , in m	$1,9 + 1,6h_1 \geq 3,5$	$1,72 + 1,6h_1 \geq 3,0$	$1,6 + 1,6h_1 \geq 2,8$	$0,4 + 1,6h_1 \geq 1,6$



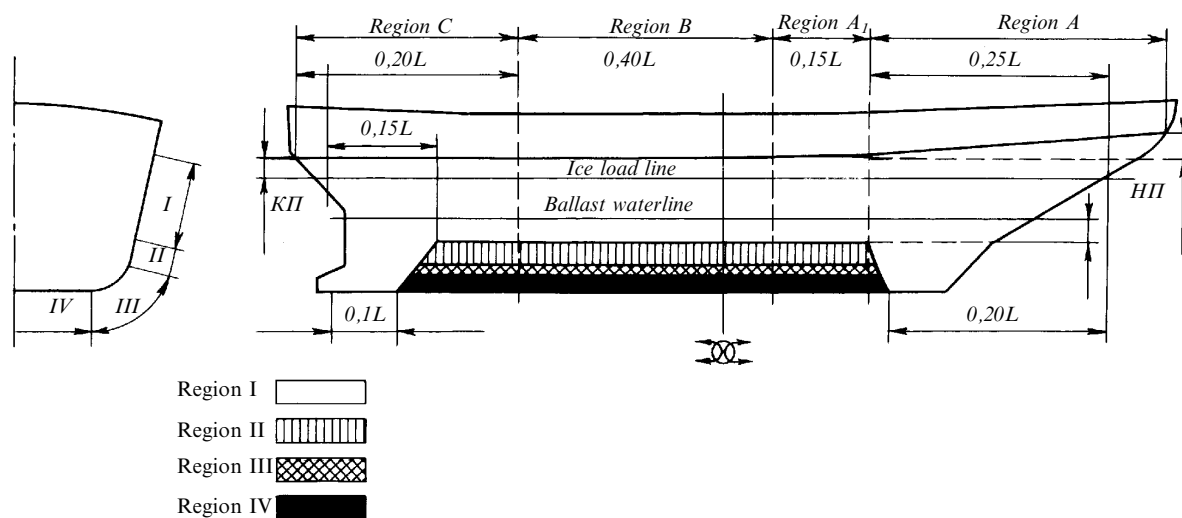


Fig. 3.10.1.3.3  
Regions of ice strengthening of icebreakers

Table 3.10.1.3.4

Ice category	Vertical regioning															
	I				II				III				IV			
	Horizontal regioning															
	A	A <sub>1</sub>	B	C	A	A <sub>1</sub>	B	C	A	A <sub>1</sub>	B	C	A	A <sub>1</sub>	B	C
Icebreaker9, Icebreaker8, Icebreaker7, Arc9, Arc8	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Arc7	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Icebreaker6, Arc6	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Arc5	+	+	+	+	+	+	+	+	+	+	+		+	+		
Arc4	+	+	+	+	+	+	+		+	+			+	+		
Ice3	+		+	+	+											
Ice2	+		+	+												
Ice1	+															

### 3.10.2 Structure.

**3.10.2.1** Side grillage structure where transverse framing is used.

**3.10.2.1.1** A grillage may include vertical girders of main framing which are denoted as conventional frames, vertical web members which are denoted as deep frames, and longitudinals which are denoted as stringers.

Conventional frames are subdivided into:

main frames lying on the same plane as floors or bilge brackets;

intermediate frames not lying on the same plane as floors or bilge brackets.

The presence of intermediate frames within a grillage is not mandatory.

Not more than one intermediate frame may be fitted between every two adjacent main frames.

Stringers are subdivided into:

intercostal stringers by which joint taking-up of local ice loads by the frames is ensured. It is recommended that the stringers shall be inter-costal;

side stringers by which a transition of forces is ensured from conventional frames which directly take up the ice load to deep frames or to transverse bulkheads.

Side grillage structures are permitted as follows:

grillage with transverse main frames which is formed by conventional frames of the same section and by intercostal stringers;

grillage with transverse web frames which is formed by conventional frames, side stringers and deep frames. Intercostal stringers may be fitted together with side stringers.

With a double-bottom structure available, the functions of deep frames are taken over by vertical diaphragms, and those of the side stringers, by horizontal diaphragms.

**3.10.2.1.2** In icebreakers and Arc5, Arc6, Arc7, Arc8, Arc9 category ships, frames shall be attached to decks and platforms with brackets; if a frame is intercostal in way of deck, platform or side stringer, brackets shall be fitted on both sides of it.

**3.10.2.1.3** The end attachments of main frames shall comply with the requirements of 2.5.5. In icebreakers solid floors shall be fitted on each main frame. In Arc8, Arc9 category ships, solid floors shall be fitted on every other main frame.

The end attachments of intermediate frames shall comply with the following requirements.

In Arc4, Arc5, Arc6, Arc7, Arc8, Arc9 category ships and icebreakers, the bottom ends of intermediate frames shall be secured at margin plate stiff-

fened with a lightened margin bracket (or a system of stiffeners) reaching up to longitudinal stiffeners or intercostal members and welded thereto (Fig. 3.10.2.1.3-1).

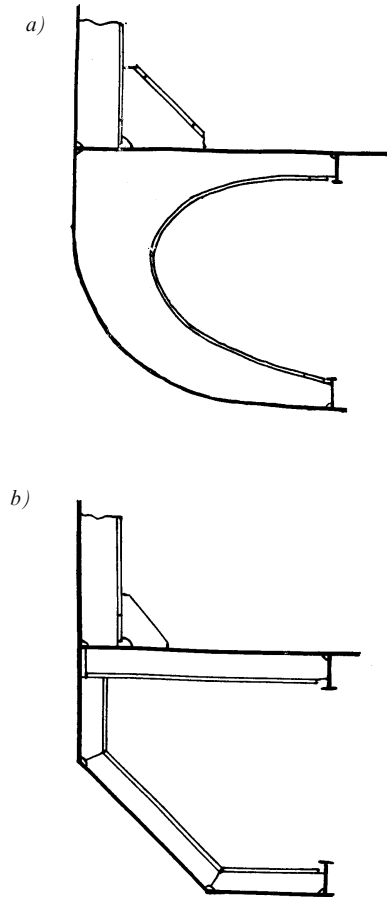


Fig. 3.10.2.1.3-1:

a — lightened margin bracket;  
b — system of stiffeners.

Where there is no double bottom, the intermediate frames shall extend as far as longitudinal stiffeners or intercostal structure and welded thereto. The particular longitudinal stiffener or intercostal structure shall be fitted not higher than the floor face-plate level.

In **Ice1**, **Ice2**, **Ice3** category ships having transverse main framing, the bottom ends of intermediate frames may be secured at intercostal longitudinal fitted 1000 mm beneath the lower boundary of region I.

In **Ice1**, **Ice2**, **Ice3** category ships with deep framing, it is permitted to secure the bottom ends of intermediate frames, except for the region A of category **Ice3**, at a longitudinal (which may be intercostal) fitted 1000 mm below the side stringer lying beneath the lower boundary of region I

(Fig. 3.10.2.1.3-2). In this case, the web area and plastic modulus of the above side stringer shall not be less than required for a stringer fitted in region I.

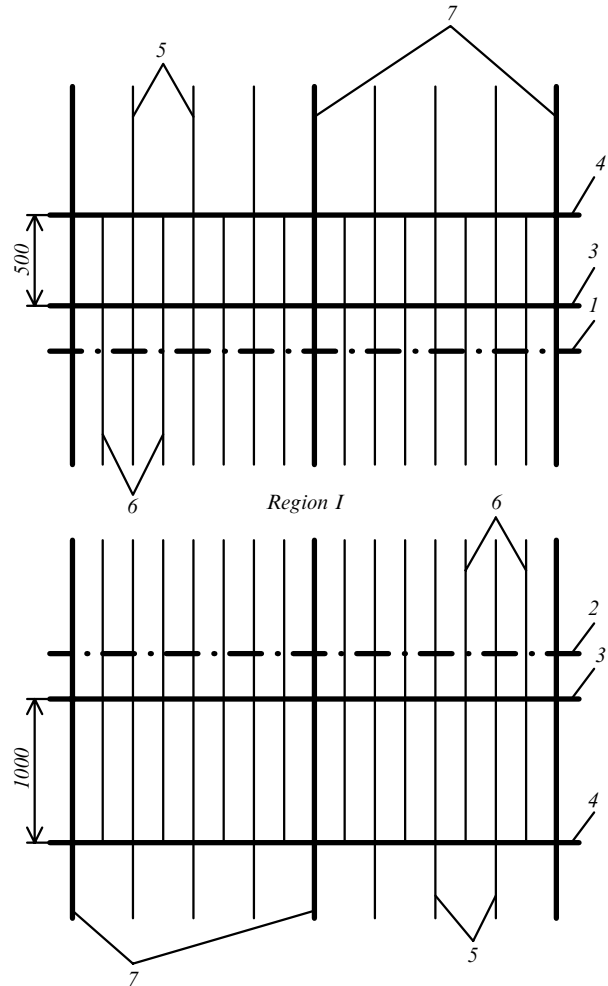


Fig. 3.10.2.1.3-2

Permissible method for securing the ends of intermediate frames in **Ice1**, **Ice2**, **Ice3** category ships with deep framing:

1 — upper boundary of region I; 2 — lower boundary of region I;  
3 — side stringer; 4 — intercostal longitudinal;  
5 — main frames; 6 — intermediate frames;  
7 — deep frames

In icebreakers and **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships, the upper ends of intermediate frames shall be secured on a deck or platform lying above the upper boundary of region I. In **Ice1**, **Ice2**, **Ice3** category ships having transverse main framing, the upper ends of intermediate frames may be secured in way of an intercostal longitudinal fitted 500 mm above the upper boundary of region I.

In **Ice1**, **Ice2**, **Ice3** category ships with deep framing, the upper ends of intermediate frames may be secured in way of a longitudinal (which may be intercostal) fitted 500 mm higher than the side

stringer lying above the upper boundary of region I (refer to Fig. 3.10.2.1.3-2). In this case, the web area (and the ultimate section modulus of the above side stringer shall not be less than required for a stringer fitted in region I.

**3.10.2.1.4** In regions I and II of icebreakers and **Arc4, Arc5, Arc6, Arc7, Arc8, Arc9** category ships, intercostal and/or side stringers shall be fitted the distance between which or the stringer-to-deck or platform distance shall not exceed 2 m, as measured on a chord at side.

For region I of **Ice1, Ice2, Ice3** category ships, this distance shall not exceed 3 m.

Side stringers shall be fitted in the loadline and ballast water line regions. If there is a deck or platform lying on the same level, the side stringer may be omitted. Stringers shall be attached to bulkheads by means of brackets.

**3.10.2.2** Determining the supporting sections of frames in grillages with transverse framing.

**3.10.2.2.1** The supporting sections of conventional and deep frames shall be found in supporting structures only.

For frames, horizontal grillages (decks, platforms, bottom) are considered to be supporting structures. A supporting structure consists of plating (decks, platforms, double bottom) and framing connected thereto

(beams, half-beams, floors, tank-side brackets). Where there is no double bottom, the formulae to be found below shall be used on the assumption that the plating lies level with floor face plates.

**3.10.2.2.2** The supporting section of a conventional frame is considered to be fixed, if one of the following conditions is met at least:

the frame is connected to the framing of a supporting structure;

the frame crosses the plating of a supporting structure.

A supporting section is considered to be simply supported, if a conventional frame is not connected to supporting structure framing and is terminated on the structure plating.

Where a conventional frame terminates on an intercostal longitudinal (intercostal stringer), its end is considered to be free, i.e. with no supporting section.

**3.10.2.2.3** The position of a supporting section of a frame (conventional or deep frame) is determined in the following way.

Where the frame is connected to the supporting structure plating only, the supporting section coincides with the plating surface.

Where the frame is connected to the supporting structure framing, the supporting section:

Table 3.10.2.2

Type of joint in way of the supporting section of the frame	Type of supporting section	Sketch showing structure and the position of supporting section therein
Intersection of supporting structure	Fixed	
Securing on supporting structure with connection to its framing	Fixed	
Securing on supporting structure without connection to its framing	Freely supported	
Securing on intercostal longitudinal	Free end	 No supporting section

coincides with the face plate surface of the supporting structure frame in case of bracketless joint;

lies at bracket end where brackets with a straight or rounded and stiffened edge are concerned;

lies in the middle of the bracket side where brackets with a rounded free edge are concerned.

**3.10.2.2.4** When determining the conditions of fixation and the position of supporting sections in typical structures, one shall be guided by Table 3.10.2.2 (the position of a supporting section is indicated with an arrow in the sketches of the Table), as well as by the requirements of 3.10.2.2.2 and 3.10.2.2.3.

**3.10.2.3** Side grillage structure where longitudinal framing is used.

**3.10.2.3.1** A longitudinally framed side grillage structure is permitted which consists of longitudinals and web frames. Intercoastal additional frames may be fitted between deep frames (refer to 3.10.2.3.3).

In a double-side structure, the functions of deep frames are taken over by vertical diaphragms. Where a double-side structure includes horizontal diaphragms, they are considered to be platforms, and the requirements of 3.10.2.4 and 3.10.4.9 for platforms apply to them. Longitudinal framing system is not recommended for ice and **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships.

**3.10.2.3.2** Longitudinals which are intercoastal in way of plate structures (refer to 3.10.2.4) shall be secured with brackets on both sides of the plate structure, and the webs of the longitudinals shall be welded to the plate structure.

**3.10.2.3.3** In icebreakers and **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships where the spacing of frames is greater than 2 m, additional frames shall be fitted.

The end fixation method shall be the same as in the case of intermediate frames of **Ice1**, **Ice2**, **Ice3** category ships with transverse main framing in accordance with 3.10.2.1.3, irrespective of the ice category.

**3.10.2.4** Plate structures.

**3.10.2.4.1** By plate structures, the sections of deck, platform and double bottom plating, of transverse bulkhead plating, deep frame plates, stringers of side and bottom, centre-plane girder, solid and lightened plate floors and bilge brackets which adjoin the shell plating are meant.

**3.10.2.4.2** For hull members mentioned under 3.10.2.4.1, the areas to be covered by the requirements for plate structures shall be established as follows:

fore peak and after peak bulkheads of icebreakers and **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships throughout their breadth; for ships of other categories, on a breadth of 1,2 m from the shell plating;

other bulkheads in regions I and II of icebreakers and **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships, decks and platforms of icebreakers and **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships, on a breadth of 1,2 m from the shell plating;

other hull members — on a breadth of 0,6 m from the shell plating.

**3.10.2.4.3** In the areas of plate structures mentioned under 3.10.2.4.2, corrugated structures with corrugations arranged along the shell plating (i.e. vertical corrugations on transverse bulkheads and longitudinal corrugations on decks or platforms) are not permitted.

**3.10.2.4.4** The plate structures of icebreakers, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships and region I of **Arc4** category ships shall be provided with stiffeners fitted at right angles approximately to the shell plating. The stiffeners shall be spaced not farther apart than stipulated in Table 3.10.2.4.4.

The plate structures of **Ice1**, **Ice2**, **Ice3**, **Ice4** (except region I) category ships may be provided with stiffeners fitted in parallel approximately to the shell plating.

Table 3.10.2.4.4

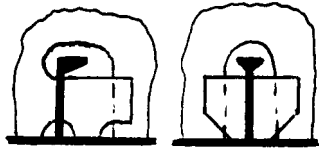
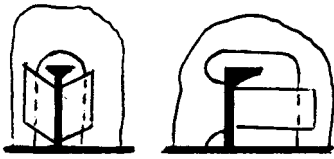
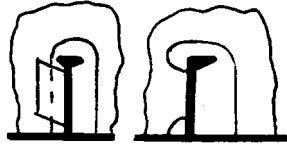
Orientation of main framing fitted at shell plating	Maximum spacing of stiffeners	
	Icebreakers, <b>Arc5</b> (region I), <b>Arc6</b> , <b>Arc7</b> , <b>Arc8</b> , <b>Arc9</b>	<b>Arc5</b> (except region I), <b>Arc4</b> (region I)
Main framing lies across a plate structure	$a$ , but not greater than 0,5 m	$2a$ , but not greater than 1,0 m
Main framing lies parallel to a plate structure	0,6 m	0,8 m
Note. $a$ is the spacing of main framing girder, as measured on the shell plating.		

**3.10.2.4.5** The intersections of plate structures with main framing shall be executed in accordance with Table 3.10.2.4.5. The stiffeners by which the plate structure is strengthened and which lie on the same plane as the main framing girders shall be secured to the above girders. Other methods of attaching the webs of main framing girders to the plate structure may be applied, if found equivalent by the Register.

**3.10.2.4.6** Where main framing girders are intercoastal in way of the plate structure, brackets shall be fitted on both sides of the structure on the same plane as each of the girders, and the girder webs shall be welded to the plate structure.

**3.10.2.4.7** The following requirements are put forward additionally for the intersections (connections) of the plate structures of decks and platforms with main framing.

Table 3.10.2.4.5

Ice category	Sketch of structure		
			
<b>Icebreaker9, Icebreaker8</b>	Fore peak, after peak, region I, region II with longitudinal framing	Regions II, AIII, A <sub>1</sub> III, CIII, AIV, A <sub>1</sub> IV	Other regions as per Table 3.10.1.3.4
<b>Icebreaker7, Icebreaker6</b>	Fore peak, after peak, regions I, II with longitudinal framing	Regions I and II (except fore peak and after peak), AIII, A <sub>1</sub> III, CIII	Ditto
<b>Arc9, Arc8, Arc7</b>	Fore peak, region I with longitudinal framing	Regions I and II (except fore peak), AIII, AIV, A <sub>1</sub> IV, A <sub>1</sub> III	Ditto
<b>Arc6, Arc5</b>	Fore peak, region AI, A <sub>1</sub> I, BI with longitudinal framing	Regions I (except fore peak), II, AIII, A <sub>1</sub> III	Ditto
<b>Arc4</b>	—	Regions I, AII, A <sub>1</sub> II, AIII, A <sub>1</sub> III	Ditto
<b>Ice3, Ice2, Ice1</b>	—	—	All regions
Note. Stiffeners of plate structure and brackets stipulated in 3.10.2.4 are not shown schematically in the sketches.			

Where transverse framing is used for sides, the frames shall be attached to the beams with brackets. In **Arc5** (region I only), **Arc6, Arc7, Arc8, Arc9** category ships, the girders shall be fitted on the same plane as each of the frames (refer also to Table 3.10.2.4.4).

In **Arc5** (except region I) and **Arc4** (region I) category ships, the frame on whose plane no girder is fitted shall be secured to the plate structure with brackets which shall terminate on the intercostal stiffener.

Where longitudinal framing is used for sides, the girders shall be attached to the shell plating with brackets reaching as far as the nearest longitudinal.

**3.10.2.4.8** The distance from the edge of opening or manhole to the shell plating shall not be less than 0,5 m in a plate structure. The distance from the edge of opening or manhole in a plate structure to the edge of opening for the passage of a girder through the plate structure shall not be less than the height of that girder.

**3.10.2.5** Fore peak and after peak structure.

**3.10.2.5.1** A longitudinal bulkhead welded to the stem or sternframe shall be fitted on the centre line of the ship in the fore peak and after peak of icebreakers and **Arc8, Arc9** category ships, and the lower ends of all frames shall be connected to floors or brackets.

**3.10.2.5.2** In the fore peak of icebreakers and **Arc5, Arc6, Arc7, Arc8, Arc9** category ships, platforms with lightening holes shall be fitted instead of stringers and panting beams (refer to 2.8.2.3), the

distance between platforms measured along a chord at side, shall not exceed 2,0 m. This structure is recommended for **Arc4** category ships as well.

**3.10.2.5.3** In the after peak of icebreakers and **Arc5, Arc6, Arc7, Arc8, Arc9** category ships (refer to 2.8.2.10), side stringers and panting beams shall be fitted so that the distance between the stringers as measured along a chord at side, would not be greater than 2,0 m. The dimensions of stringer webs shall not be less than determined by the formulas:

height  $h = 5L + 400$  mm;

thickness  $s = 0,05L + 7$  mm.

Platforms with lightening holes are recommended instead of panting beams and stringers.

**3.10.2.5.4** In icebreakers and **Arc6, Arc7, Arc8, Arc9** category ships, the side stringers in the fore peak and after peak shall generally be a continuation of those fitted in the regions A and C (refer to 3.10.2.1.4).

**3.10.2.5.5** In the case of **Arc4** category ships, the area and inertia moment of panting beams shall be increased by 25 per cent as compared to those required by 2.9.4. The dimensions of stringer webs shall not be less than given by the formulae:

height  $h = 3L + 400$  mm;

thickness  $s = 0,04L + 6,5$  mm.

**3.10.2.5.6** In the fore peak and after peak, the free edges of side stringers shall be stiffened with face plates having a thickness not less than the web thickness and a width not less than ten thicknesses.

The interconnections of frames with side stringers shall be in accordance with Table 3.10.2.4.5, and brackets shall be carried to the face plates of the stringers.

### 3.10.2.6 Stem and sternframe construction.

**3.10.2.6.1 Arc6, Arc7, Arc8, Arc9** category ships shall have a solid section stem made of steel (cast steel is recommended). The stems and sternframes of icebreakers, as well as the sternframes of **Arc5, Arc6, Arc7, Arc8, Arc9** category ships, shall be made of forged or cast steel. Stems and sternframes welded of cast or forged parts are admissible.

**3.10.2.6.2** In **Ice1, Ice2, Ice3, Arc4, Arc5** category ships, a stem of combined structure (a bar with thickened plates welded thereto) or plate structure may be used, and where the ship length is under 150 m with a sharp-lined bow, the stem design shown in Fig. 3.10.2.6 may be used (the value of  $s$  shall be as determined by the Formula (3.10.4.10.1-3).

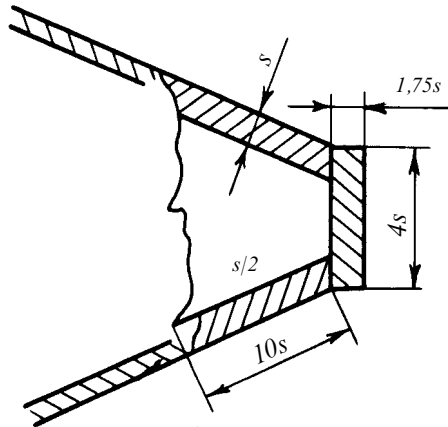


Fig. 3.10.2.6

In **Ice1, Ice2, Ice3, Arc4** category ships, sternframes of combined structure may be used.

**3.10.2.6.3** In **Ice1, Ice2, Ice3, Arc4, Arc5, Arc6, Arc7** category ships, the stem shall, where practicable, be strengthened by a centre line web having its section depth equal to  $h_v$  at least (refer to Table 3.10.4.10.1) with a face plate along its free edge or a longitudinal bulkhead fitted on the ship centre line, on the entire stem length from the keel plate to the nearest deck or platform situated above the level  $H_1$  referred to in 3.10.4.10 and in Table 3.10.4.10.1. The thickness of this plate shall not be less than that of the brackets with which the stem is strengthened (refer to 3.10.2.6.4). In icebreakers and **Arc8, Arc9** category ships, a longitudinal bulkhead may be substituted for the centre line web.

**3.10.2.6.4** Within the vertical extent defined in 3.10.2.6.3, the stem shall be strengthened by horizontal webs at least 0,6 m in depth and spaced not more than 0,6 m apart. The webs shall be carried to the nearest frames and connected thereto. Where in

line with side stringers, the webs shall be attached to them. In stems of combined or plate type, the webs shall be extended beyond the welded butts of the stem and shell plating. Above the deck or platform located, by the value of  $H_1$  at least (refer to 3.10.4.10.1 and Table 3.10.4.1), higher than the upper boundary of region I, the spacing of horizontal webs may gradually increase to 1,2 m in icebreakers and **Arc7, Arc8, Arc9** category ships, and to 1,5 m in ships of other categories.

The web thickness shall be adopted not less than half the stem plate thickness. In icebreakers and **Arc4, Arc5, Arc6, Arc7, Arc8, Arc9** category ships, the free edges of webs shall be strengthened with face plates welded to the frames at their ends. The side stringers of the fore peak shall be connected to the webs fitted in line with them.

In case of a full bow, vertical stiffeners may be required additionally to be fitted to the stem plates.

**3.10.2.6.5** Where the stern frame has an appendage (ice knife), the clearance between the latter and the rudder plate shall not exceed 100 mm. The appendage shall be reliably connected to the stern frame. Securing the appendage to plate structures is not permitted.

**3.10.2.6.6** In icebreakers, the lower edge of sole-piece shall be constructed with a slope of 1:8 beginning from the propeller post.

### 3.10.2.7 Bottom structure.

**3.10.2.7.1** In icebreakers and **Arc5, Arc6, Arc7, Arc8, Arc9** category ships, double bottom shall be provided between the fore peak bulkhead and the after peak bulkhead.

**3.10.2.7.2** In icebreakers, provision shall be made for solid floors at each main frame, and in **Arc8, Arc9** category ships, at each but one main frame.

**3.10.2.7.3** In regions of ice strengthening in way of bottom, as established in accordance with Table 3.10.1.3.4, bracket floors are not permitted.

**3.10.2.7.4** In icebreakers and **Arc8, Arc9** category ships the centre-plane girder height shall not be less than determined by the formula

$$h = \varphi(9L + 800) \quad (3.10.2.7.4)$$

where  $\varphi = 0,8$  for **Arc8** category ships;  
 $\varphi = 0,9$  for **Arc9** category ships;  
 $\varphi = 1$  for icebreakers.

**3.10.2.7.5** In icebreakers and **Arc8, Arc9** category ships, the spacing of bottom stringers shall not exceed 3,0 m.

### 3.10.2.8 Special requirements.

**3.10.2.8.1** In icebreakers, double side structure shall generally be provided between the fore peak bulkhead and the after peak bulkhead.

**3.10.2.8.2** In **Arc7, Arc8, Arc9** category ships double side structure is necessary for engine room,

and for the region mentioned in 3.10.2.8.1 it is recommended.

**3.10.2.8.3** Where the web plate of a girder or a plate structure is considerably inclined to the shell plating (the angle between them being less than  $50^\circ$ ), the framing normal to the shell plating or an inclined plate structure is recommended (Fig. 3.10.2.8.3). Otherwise, special measures shall be taken to prevent the collapsing of the girder or the bulging of the plate structure.

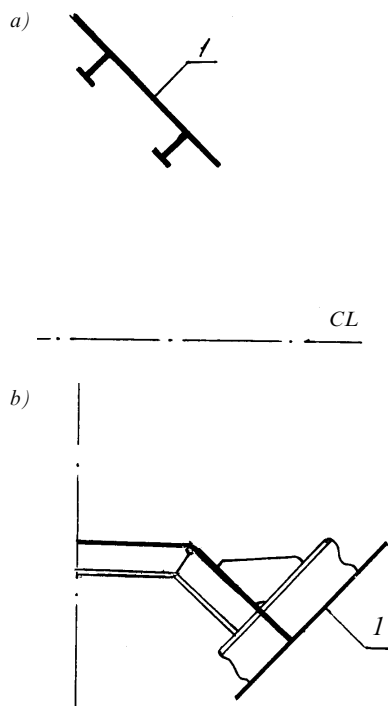


Fig. 3.10.2.8.3:

*a* — framing normal to shell plating; *b* — inclined plate structure;  
*I* — shell plating

### 3.10.3 Ice load.

**3.10.3.1** Ice load is the approximate design load upon the hull due to ice forces, by which the level of requirements for scantlings is determined proceeding from the ice category mark, hull shape and ship displacement.

The ice load depends on three parameters:

*p* — ice pressure being a characteristic of the maximum pressure in the area of dynamic contact between the hull and ice, in kPa;

*b* — vertical distribution of ice pressure characterizing the maximum transverse dimension of the dynamic contact area between the hull and ice, in m;

*l<sup>p</sup>* — horizontal distribution of ice pressure characterizing the maximum longitudinal dimension of the dynamic contact area between the hull and ice, in m.

The ice load is solely intended to determine the scantlings of structural components of ice strengthening on the basis of the formulae included in this Chapter. Using the ice load parameters for strength estimation on the basis of other procedures and programs is not permitted without prior consent of the Register.

The ice-load parameters to be determined according to 3.10.3.2 to 3.10.3.7 apply only to ice ships and icebreakers with hull shape complying with the requirements of 3.10.1.2.2 and 3.10.1.2.3. The ice load for ice ships and icebreakers of other hull shapes is subject to special consideration by the Register.

**3.10.3.2** For ice class ships, the ice pressure, in kPa, shall be determined by the following formulae:

**.1** in region AI

$$p_{AI} = 2500a_1v_m^6\sqrt{\frac{\Delta}{1000}} \quad (3.10.3.2.1)$$

where *a*<sub>1</sub> = factor to be adopted from Table 3.10.3.2.1 proceeding from the ice category;

$\Delta$  = displacement to summer load waterline, in t;

*v<sub>m</sub>* = value of the shape factor *v*, which is the maximum one for the region, as determined at sections within  $x = 0$ ;  $0,05L$ ;  $0,1L$ , etc. from the forward perpendicular on the ice loadline level (as far as **Ice1**, **Ice2**, **Ice3** category ships are concerned, design sections where  $x \leq 0,58b$  shall only be considered; for *b*, refer to Fig. 3.10.1.3.2). The value shall be determined by the formulae:

$$v = (0,278 + \frac{0,18x}{L})^4 \sqrt{\frac{\alpha^2}{\beta}} \text{ PRI } \frac{x}{L} \leq 0,25;$$

$$v = (0,343 - \frac{0,08x}{L})^4 \sqrt{\frac{\alpha^2}{\beta}} \text{ PRI } \frac{x}{L} > 0,25;$$

*x* = the distance between the considered section and the forward perpendicular, in m;

$\alpha$  = angles of summer load waterline inclination which shall be measured in accordance with Figs 3.10.1.2-1 and 3.10.1.2-3 (where  $x = 0$ ), in deg.;

$\beta$  = angles of frame inclination on summer load waterline level which shall be measured in accordance with Fig. 3.10.1.2-2, in deg.; where the frame is concave in the design section, a minimal angle shall be chosen for in the case of **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8**, **Arc9** category ships which is measured on the level of contingent service waterlines.

Table 3.10.3.2.1

Factor	Ice category								
	<b>Ice1</b>	<b>Ice2</b>	<b>Ice3</b>	<b>Arc4</b>	<b>Arc5</b>	<b>Arc6</b>	<b>Arc7</b>	<b>Arc8</b>	<b>Arc9</b>
<i>a</i> <sub>1</sub>	0,36	0,49	0,61	0,79	1,15	1,89	2,95	5,3	7,9
<i>a</i> <sub>2</sub>	—	—	—	0,80	1,17	1,92	3,06	5,75	8,95
<i>a</i> <sub>3</sub>	—	0,22	0,33	0,50	0,78	1,2	1,84	3,7	5,6
<i>a</i> <sub>4</sub>	—	0,5	0,63	0,75	0,87	1	—	—	—

If  $\alpha > 0$  and  $\beta = 0$  in the design section of **Ice1**, **Ice2**, **Ice3** category ships, it shall be considered that  $v = 0,72$  in this section.

If the angle of  $\alpha$  is less than  $3^\circ$  in the design section of **Ice1**, **Ice2**, **Ice3**, **Arc4**, **Arc5** category ships, such a section may be omitted when calculating *v<sub>m</sub>*;

**.2** in region A<sub>1</sub>I

$$p_{A1I} = 2500a_2v_m^6\sqrt{\frac{\Delta}{1000}} \quad (3.10.3.2.2)$$

where  $a_2$  = factor to be adopted from Table 3.10.3.2.1 proceeding from the ice category;

$v_m$  shall be determined by the method described in 3.10.3.2.1;

for  $\Delta$ , refer to 3.10.3.2.1;

**.3** in region BI

$$p_{BI} = 1200a_3\sqrt{\frac{\Delta}{1000}} \quad (3.10.3.2.3)$$

where  $a_3$  = factor to be adopted from Table 3.10.3.2.1 proceeding from the ice category;

for  $\Delta$ , refer to 3.10.3.2.1;

**.4** in region CI of **Ice2**, **Ice3**, **Arc4**, **Arc5**, **Arc6** category ships,

$$p_{CI} = a_4p_{BI} \quad (3.10.3.2.4-1)$$

where  $a_4$  = factor to be adopted from Table 3.10.3.2.1 proceeding from the ice category;

for  $p_{BI}$ , refer to 3.10.3.2.3.

For **Arc7**, **Arc8**, **Arc9** category ships, the ice pressure in region CI is determined by the formula

$$p_{CI} = 0,75p_{AI} \quad (3.10.3.2.4-2)$$

where for  $p_{AI}$ , refer to 3.10.3.2.1;

**.5** in regions II, III and IV, the ice pressure is determined as a part of the ice pressure in region I at the appropriate section of the ship length

$$p_{kl} = a_{kl}/p_{kI} \quad (3.10.3.2.5)$$

where  $k = A, A_1, B, C$ ;

$l = II, III, IV$ ;

$a_{kl}$  = factor to be adopted from Table 3.10.3.2.5.

Table 3.10.3.2.5

Ice category	Region vertically								
	forward and intermediate regions (A and AI)			midship region (B)			aft region (C)		
	Region lengthwise								
	II	III	IV	II	III	IV	II	III	IV
<b>Ice3</b>	0,4	—	—	—	—	—	—	—	—
<b>Arc4</b>	0,5	0,4	0,35	0,4	—	—	—	—	—
<b>Arc5</b>	0,65	0,65	0,45	0,5	0,4	—	0,5	—	—
<b>Arc6</b>	0,65	0,65	0,5	0,5	0,45	—	0,5	0,35	0,15
<b>Arc7</b>	0,65	0,65	0,5	0,5	0,45	—	0,5	0,4	0,2
<b>Arc8</b>	0,7	0,65	0,5	0,55	0,45	0,25	0,55	0,4	0,3
<b>Arc9</b>	0,7	0,65	0,5	0,55	0,45	0,3	0,55	0,4	0,35

**3.10.3.3** The vertical distribution of ice pressure, in m, shall be determined by the following formulae:

**.1** in regions AI, AII, AIII, AIV

$$b_A = C_1k_\Delta u_m \quad (3.10.3.3.1)$$

where  $C_1$  — factor to be adopted from Table 3.10.3.3.1 proceeding from the ice category;

$$k_\Delta = \sqrt[3]{\frac{\Delta}{1000}}, \text{ but not greater than } 3,5;$$

for  $\Delta$ , refer to 3.10.3.2.1;

$u_m$  = maximum value of the shape factor  $u$  for the region, to be determined in sections within  $x = 0; 0,05L; 0,1L$ , etc. from forward perpendicular at the ice loadline level (as far as **Ice1**, **Ice2**, **Ice3** category ships are concerned, design sections where  $x \leq 0,58b$  shall only be considered; for  $b$ , refer to Fig. 3.10.1.3.2). The value shall be determined by the formulae:

$$u_m = k_B(0,635 + \frac{0,61x}{L})\sqrt{\frac{\alpha}{\beta}} \text{ where } \frac{x}{L} \leq 0,25;$$

$$u_m = k_B(0,862 - \frac{0,30x}{L})\sqrt{\frac{\alpha}{\beta}} \text{ where } \frac{x}{L} > 0,25;$$

$$k_B = \begin{cases} 1 & \text{where } \beta \geq 7^\circ \\ 1,15 - 0,15\frac{\beta}{7} & \text{where } \beta < 7^\circ \end{cases}$$

for  $x, \alpha, \beta$ , refer to 3.10.3.2.1.

Table 3.10.3.3.1

Factor	Ice category						
	<b>Ice1</b>	<b>Ice2</b>	<b>Ice3</b>	<b>Arc4</b>	<b>Arc5</b>	<b>Arc6</b>	<b>Arc7, Arc8, Arc9</b>
$C_1$	0,38	0,42	0,44	0,49	0,6	0,62	0,64
$C_2$	—	—	—	0,55	0,7	0,73	0,75
$C_3$	—	0,27	0,30	0,34	0,40	0,47	0,50

If  $\alpha > 0$  and  $\beta = 0$  in the design section of **Ice1**, **Ice2**, **Ice3** category ships, it shall be considered that  $u = 0,92$  for this section.

If the angle of is less than  $3^\circ$  in the design section of **Ice1**, **Ice2**, **Ice3**, **Arc4**, **Arc5** category ships, such a section may be omitted when calculating  $u_m$ ;

**.2** in regions A<sub>1</sub>I, A<sub>1</sub>II, A<sub>1</sub>III, A<sub>1</sub>IV

$$b_{A_1} = C_2k_\Delta u_m, \text{ but not greater than } 1,25b_{AP_{A1}}/p_{A_1I} \quad (3.10.3.3.2-1)$$

where  $C_2$  = factor to be adopted from Table 3.10.3.3.1 proceeding from the ice category;

for  $k_\Delta$ , refer to 3.10.3.3.1;

$u_m$  shall be determined by the procedure described in 3.10.3.3.1;

for  $b_A$ , refer to 3.10.3.3.1;

for  $p_{AI}$ , refer to 3.10.3.2.1;

for  $p_{A_1I}$ , refer to 3.10.3.2.2.

In any case, the vertical distribution  $b_{A_1}$  shall be not less than that determined by the formula

$$b_{A_1} = \rho B b / \rho_{A_1I} \quad (3.10.3.3.2-2)$$

where for  $\rho_{A_1I}$ , refer to 3.10.3.2.2;



for  $\rho_{B_1}$ , refer to 3.10.3.2.3;  
for  $b_B$ , refer to 3.10.3.3.3;

### .3 in regions BI, BII, BIII, BIV

$$b_B = C_3 C_4 k_\Delta \quad (3.10.3.3.3)$$

where  $C_3$  = factor to be adopted from Table 3.10.3.3.1 proceeding from the ice category;

$C_4$  = factor to be adopted from Table 3.10.3.3.3 proceeding from the minimal side inclination angle with regard to normal in the midship region of ice strengthening on summer load waterline level;

for  $k_\Delta$ , refer to 3.10.3.3.1;

Table 3.10.3.3.3

Factor	Angle of side slope amidships, in deg.						
	≤6	8	10	12	14	16	18
$C_4$	1,00	0,81	0,68	0,54	0,52	0,47	0,44

### .4 in regions CI, CII, CIII, CIV

$b_C = 0,8b_B$  — for categories **Ice2**, **Ice3**, **Arc4**, **Arc5**, **Arc6**;

$b_C = b_A$  — for categories **Arc7**, **Arc8**, **Arc9** (3.10.3.3.4)

where for  $b_A$ , refer to 3.10.3.3.1;  
for  $b_B$ , refer to 3.10.3.3.3.

**3.10.3.4** Horizontal distribution of ice pressure, in m, shall be determined by the following formulae:

#### .1 in regions AI, AII, AIII, AIV

$$l_A^p = 11,3\sqrt{b_A \sin \beta_m^A}, \text{ but not less than } 3,5\sqrt{k_\Delta} \quad (3.10.3.4.1)$$

where for  $b_A$ ,  $k_\Delta$ , refer to 3.10.3.3.1;

$\beta_m^A$  = angle  $\beta$  in the design section of region A for which the value of the  $u$  parameter is maximum (refer to 3.10.3.3.1);

#### .2 in regions A<sub>1</sub>I, A<sub>1</sub>II, A<sub>1</sub>III, A<sub>1</sub>IV

$$l_{A_1}^p = 11,3\sqrt{b_{A_1} \sin \beta_m^{A_1}}, \text{ but not less than } 3\sqrt{k_\Delta} \quad (3.10.3.4.2)$$

where for  $b_{A_1}$ , refer to 3.10.3.3.2;

$\beta_m^{A_1}$  = angle  $\beta$  in the design section of region A<sub>1</sub> for which the value of the  $u$  parameter is maximum (refer to 3.10.3.3.1);

for  $k_\Delta$ , refer to 3.10.3.3.1;

### .3 in regions BI, BII, BIII, BIV

$$l_w^p = 6b_w, \text{ but not less than } 3\sqrt{k_\Delta} \quad (3.10.3.4.3)$$

where for  $b_w$ , refer to 3.10.3.3.3;

for  $k_\Delta$ , refer to 3.10.3.3.1;

### .4 in regions CI, CII, CIII, CIV

$$l_s^p = 6b_s, \text{ but not less than } 3\sqrt{k_\Delta} \quad (3.10.3.4.4)$$

where for  $b_C$ , refer to 3.10.3.3.4;

for  $k_\Delta$ , refer to 3.10.3.3.1.

**3.10.3.5** For icebreakers, the ice pressure shall be determined by the following formulae:

#### .1 in region AI

$$p_{AI} = k_p p_{AI}^c \quad (3.10.3.5.1)$$

where  $p_{AI}^c$  = ice pressure in region AI, to be determined in accordance with 3.10.3.2.1 as in the case of a ship whose ice category number coincides with the category number of the icebreaker;

$$k_p = \begin{cases} 1 & \text{where } N_\Sigma \leq N_0; \\ (N_\Sigma/N_0)^{0,4} & \text{where } N_\Sigma > N_0; \end{cases}$$

$N_\Sigma$  = propeller shaft output, in MW;

$N_0$  shall be adopted from Table 3.10.3.5.1;

Table 3.10.3.5.1

Category of icebreaker	$N_0$ , in MW
<b>Icebreaker6</b>	10
<b>Icebreaker7</b>	20
<b>Icebreaker8</b>	40
<b>Icebreaker9</b>	60

#### .2 in regions AII, BI and CI

$$p_{kI} = a_k p_{AI} \quad (3.10.3.5.2)$$

where for  $p_{AI}$ , refer to 3.10.3.5.1;

$a_k$  = factor to be adopted from Table 3.10.3.5.2 proceeding from the region of the ship length and the category of icebreaker;

$k = A_1, B, C$ ;

Table 3.10.3.5.2

Region	Category of icebreaker			
	<b>Icebreaker6</b>	<b>Icebreaker7</b>	<b>Icebreaker8</b>	<b>Icebreaker9</b>
A <sub>1</sub> I	0,65	0,75	0,85	0,85
BI	0,6	0,65	0,7	0,75
CI	0,75	0,75	0,75	0,75

**.3 in regions II, III and IV**, the ice pressure shall be determined as a part of the ice pressure in region I for the appropriate region of ship length.

$$p_{mm} = a_{mn} p_{mI} \quad (3.10.3.5.3)$$

where  $m = A, A_1, B, C$ ;

$n = II, III, IV$ ;

$a_{mn}$  = factor to be adopted from Table 3.10.3.5.3.

Table 3.10.3.5.3

Factor	Region vertically and region lengthwise											
	AII	AIII	AIV	A <sub>1</sub> II	A <sub>1</sub> III	A <sub>1</sub> IV	BII	BIII	BIV	CII	CIII	CIV
$a_{mn}$	0,7	0,65	0,5	0,6	0,55	0,45	0,55	0,45	0,35	0,55	0,40	0,30

**3.10.3.6** As far as icebreakers are concerned, the vertical distribution of ice pressure shall be adopted equal for all regions and shall be determined in ac-

cordance with 3.10.3.3.1, i.e. as for the forward region of the ship whose ice category number coincides with the category number of the icebreaker. When determining  $u_m$ , the values of  $u$  shall be calculated for those sections only which are included in the forward region of ice strengthening of the icebreaker.

**3.10.3.7** As far as icebreakers are concerned, the horizontal distribution of ice pressure shall be adopted equal for all regions and shall be determined in accordance with 3.10.3.4.1, i.e. as for the forward region of the ship whose ice category number coincides with the category number of the icebreaker. When determining  $\beta_m^a$ , only those sections shall be considered which are included in the forward region of ice strengthening of the icebreaker.

#### 3.10.4 Scantlings of ice-strengthening structures.

##### 3.10.4.1 Shell plating.

In regions of ice strengthening, the shell plating thickness  $s_{sp}$ , in mm, shall not be less than determined by the formula

$$s_{sp} = s_{sp0} + \Delta s_{sp0} \quad (3.10.4.1)$$

where

$$s_{sp0} = 15,8a_0\sqrt{\frac{p}{R_{eH}}};$$

$$\Delta s_{sp0} = 0,75Tu;$$

$$a_0 = \frac{a}{1 + 0,5\frac{a}{c}};$$

$p$  = ice pressure in the region under consideration according to 3.10.3.2 or 3.10.3.5, in kPa;

$c = b$  where the grillage is transversely framed in the region under consideration. In this case,  $c$  shall not be greater than the spacing of intercostal stringers or the distance between plate structures;

$c = l$  where the grillage is longitudinally framed in the region under consideration;

$b$  = vertical distribution of ice pressure in the region under consideration according to 3.10.3.3 or 3.10.3.6, in m;

$l$  = distance between adjacent transverse members, in m;

$a$  = spacing of main direction girders, in m;

$T$  = planned ship life, in years;

$u$  = annual reduction of shell plating thickness as a result of corrosion wear and abrasion, in mm per year, to be adopted from Table 3.10.4.1. When taking measures to protect the shell plating from corrosion wear and abrasion (by applying special coats, clad steels, etc.), the magnitude of the value  $u$  is subject to special consideration by the Register.

**3.10.4.2** Procedure for determining the required and actual geometrical characteristics of girder structures.

**3.10.4.2.1** The dependences, as given in 3.10.4.3 to 3.10.4.8, for determining the required geometrical characteristics of girder structure cross sections, such as the ultimate section modulus  $W$  and the web area  $A$ , are based on the ultimate strength criterion. The recommendations of 3.10.4.2.2 to 3.10.4.2.6 shall preferably be considered when determining the values of  $W$  and  $A$ .

**3.10.4.2.2** The required value of the ultimate section modulus  $W$  is proportionate to the factor  $k$

Table 3.10.4.1

Ice category	$u$ , in mm per year	
	Region lengthwise	
	forward and intermediate (A and A <sub>1</sub> )	midship and after (B and C)
<b>Ice1</b>	0,2	In accordance with 1.1.5.2
<b>Ice2</b>	0,25	
<b>Ice3</b>	0,3	
<b>Arc4</b>	0,36	0,26
<b>Arc5</b>	0,38	0,28
<b>Arc6, Arc7, Arc8, Arc9</b>	0,4	0,3
<b>Icebreaker6</b>	0,4	0,3
<b>Icebreaker7</b>	0,5	0,35
<b>Icebreaker8</b>	0,6	0,4
<b>Icebreaker9</b>	0,7	0,4

which varies on the basis of the dependence between the required web area  $A$  and the actual web area  $A_a$  (adopted when choosing the section)

$$W = W_0k; k = k(\gamma); \gamma = A/A_a \quad (3.10.4.2.2-1)$$

where  $W_0$  = required value of  $W$ , web area margin disregarded, to be determined in accordance with 3.10.4.3.1, 3.10.4.4.1, 3.10.4.5.1, 3.10.4.6.1, 3.10.4.7.1.

In the absence of a web area margin ( $A = A_a$ ,  $\gamma = 1$ ), the value of  $W$  is maximum ( $k = 1$ ). The increase of the actual web area as compared with the required one ( $\gamma < 1$ ) makes it possible to reduce the value of  $W$  (assembling  $\gamma = 0,9 — 0,8$ ;  $k = 0,7 — 0,63$ ). Thus, the application of a flexible procedure for choosing the section is ensured which makes it possible to do without redundant margins of material, but provides for several approximations during the calculation. By way of the first approximation, the following assumptions shall be made in the Formulae (3.10.4.3-1), (3.10.4.4-1), (3.10.4.5-1), (3.10.4.6-1), (3.10.4.7-1):

$$\left\{ \begin{array}{l} \gamma_i = 0,9, \text{ i.e. the actual girder web area shall be at least by 10 per cent greater than the required one;} \\ k_f = \frac{1}{F + 0,15j} \text{ — for conventional frames;} \\ k_i = 0,63 \text{ — for other girder types} \end{array} \right. \quad (3.10.4.2.2-2)$$

where  $i$  = girder type index ( $f$  for frame,  $s$  for stringer,  $wf$  for web frame,  $l$  for longitudinal);  
for  $F, j$ , refer to 3.10.4.3-1.

**3.10.4.2.3** For grillages comprising deep frames, provision is made for a procedure to take account of

the redundant margins of material which emerge when choosing girder sections as a result of the actual section modulus  $W_a$  and the actual web area  $A_a$  exceeding the required values of  $W$  and  $A$ . Redundant margins are accounted for by applying the factors

$$\gamma_i \leq 1; \psi_i = \frac{W_{ai}}{W_{0i}} \leq k_i \quad (3.10.4.2.3)$$

where for  $k_i, \gamma_i, W_{0i}$ , refer to 3.10.4.2.2-1;  
for  $i$ , refer to 3.10.4.2.2-2.

If the actual geometrical characteristics of a conventional frame exceed the required ones ( $\gamma_f < 1$ ,  $\psi_f > k_f$ ) in a transversely framed grillage, the required geometrical characteristics of the bearing stringer and deep frame (in the case of the latter, redundant margins, if any, of the bearing stringer ( $\gamma_s < 1$ ,  $\psi_s > k_s$ ) are also considered) are lowered due to this. In a similar way, provision is made in the case of a longitudinally framed grillage for lowering the requirements for the deep frame where longitudinals have redundant margins ( $\gamma_l < 1$ ,  $\psi_l > k_l$ ).

**3.10.4.2.4** Where the section choosing procedures in accordance with 3.10.4.2.2 and the procedures for considering the redundant margins of materials in accordance with 3.10.4.2.3 appear too complicated, a simplified calculation can be carried out, assuming

$$\begin{aligned} \gamma_i &= 0,9; \\ k_f &= \frac{1}{F + 0,15j} \text{ — for conventional frames;} \\ &\quad (3.10.4.2.4) \end{aligned}$$

$$\begin{aligned} k_i &= 0,63 \text{ — for other types of girders;} \\ \psi_i &= k_i. \end{aligned}$$

Precise instructions concerning the simplified calculation procedure shall be found directly in 3.10.4.3 to 3.10.4.7.

No simplified calculation is allowed if plate sections are used for conventional frames.

It shall be borne in mind that the simplified calculation would bring about an increase of girder structural dimensions. Therefore, the simplified calculation is not recommended for icebreakers and **Arc4, Arc5, Arc6, Arc7, Arc8, Arc9** category ships.

**3.10.4.2.5** When choosing girder sections, the face plate and effective flange sections whose breadth is equal to the web thickness (Fig. 3.10.4.2.5) shall be included in the actual web area  $A_a$ , in  $\text{cm}^2$ .

If there are openings in girder webs, they may be ignored in the case of side stringers only provided the openings are not made in the vicinity of supporting sections. The requirements for the area of frame webs (both conventional and deep frames) shall be verified on the basis of net sections.

**3.10.4.2.6** To determine the actual value of the ultimate section modulus of the girders of ice

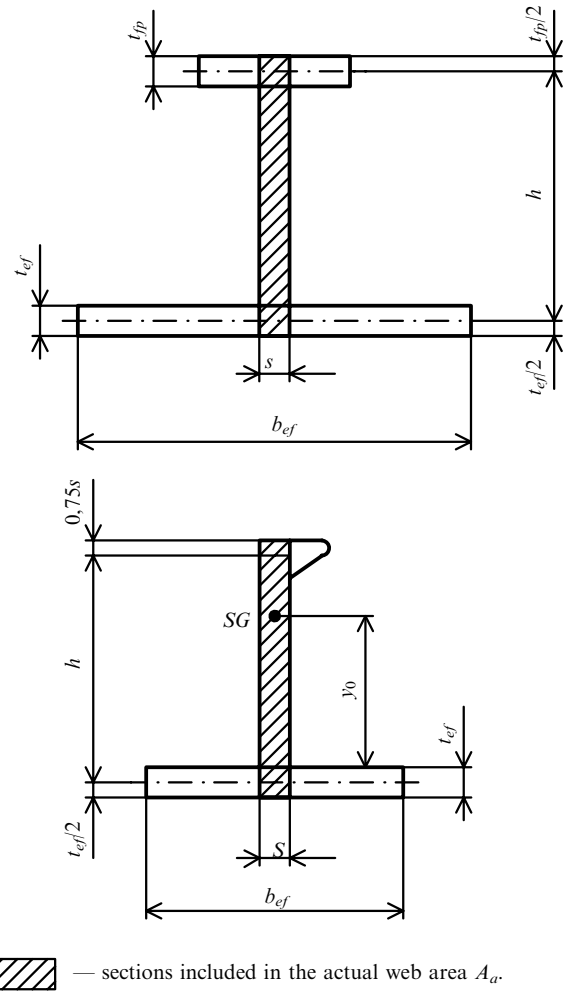


Fig. 3.10.4.2.5

strengthening structures it is recommended to use the formula

$$W_a = h(f_{sec} - 0,5f_w - C), \text{ in cm}^3 \quad (3.10.4.2.6-1)$$

where  $C = 0$  with  $f_{ef} \geq f_{sec}$ ;

$$C = \frac{(f_{sec} - f_{ef})^2}{4f_w} \text{ with } f_{ef} < f_{sec};$$

$f_{sec}$  = girder sectional area minus effective flange of shell plating, in  $\text{cm}^2$ ;

$$f_w = 0,1[h - 0,05(t_{fp} + t_{ef})]s, \text{ cm}^2;$$

$h$  = section height measured from the mid-thickness of effective flange to the mid-thickness of face plate (Fig. 3.10.4.2.5), in cm;

$s$  = section web thickness, in mm;

$f_{ef} = 0,1b_{ef}t_{ef}$  — effective flange area of shell plating, in  $\text{cm}^2$ ;

$t_{ef}$  = effective flange thickness, in mm, of shell plating, to be adopted equal to the average shell plating thickness in way of effective flange breadth;

$t_{fp}$  = face plate thickness, in mm ( $t_{fp} = 1,5s$  to be adopted for bulb steel sections);

$b_{ef}$  = effective flange breadth, in cm, to be adopted equal to: conventional frame spacing, for conventional and deep frames where transverse framing is used; longitudinals spacing, for longitudinals where longitudinal framing is used;

1/6 of deep frame span between decks or platforms, or of frame spacing, whichever is less, for deep frames where longitudinal framing is used;

1/6 of frame spacing, for stringers where web framing is used;  
half the sum of spacings of two adjacent girders of the same direction or 1/6 of girder span, whichever is less, in all other cases.

For rolled sections where  $f_{ef} \geq f_{sec}$ , it may be assumed that

$$W_a = f_{sec}(y_0 + 0,05t_{ef}), \text{ in cm}^3 \quad (3.10.4.2.6-2)$$

where  $y_0$  = distance between the gravity centre of the profile cross section, minus effective flange, and the shell plating, in cm (Fig. 3.10.4.2.5).

**3.10.4.3 Conventional frames where transverse framing is used.**

The requirements of this paragraph apply to conventional frames in grillages with transverse main framing and in grillages with deep frames where transverse framing is used.

In the case of grillages with transverse main framing, the requirements shall be applied to a single span of a conventional frame which lies between the supporting sections of the frame on the upper and lower supporting structures.

In the case of grillages with deep frames, the requirements shall be applied to all the spans of a conventional frame, i.e. between the supporting sections of the upper supporting structure and the upper side stringer, between side stringers ( $m - 1$  section where  $m$  is the number of side stringers), between the lower side stringer and the supporting section of the lower supporting structure.

**3.10.4.3.1** The ultimate section modulus  $W_f$ , in  $\text{cm}^3$ , of a conventional frame shall not be less than determined by the formula

$$W_f = k_f W_{f0} \quad (3.10.4.3.1)$$

where  $k_f = \frac{1}{F + 0,25j\sqrt{1 - k_s \gamma_f^2}}$ ,  $k_f = \frac{1}{F + 0,15j}$  — for the case

of the simplified calculation in accordance with 3.10.4.2.4;

$$k_s = \begin{cases} 1 & \text{for plate sections;} \\ 0,8 & \text{in other cases;} \end{cases}$$

$$F = 1 \text{ with } k = 4;$$

$$F = 0,5 \text{ with } k < 4;$$

$k$  = factor equal to:

as far as grillages with transverse main framing are concerned, refer to Table 3.10.4.3.1-1;

Table 3.10.4.3.1-1

Parameter	Type of intermediate frame end fixation		
	both ends have supporting sections	one end has a supporting section, the other is free (attached to an intercostal member)	both ends are free (attached to an intercostal member)
$k$	4	3	2
$l$	Half the sum of distances between the supporting sections of two adjacent frames	Distance between the supporting sections of main frame	

$k = 4$  for grillages with deep frames;

$j$  = factor equal to:

the number of fixed supporting sections of two adjacent frames  $j \leq 4$  as far as grillages with transverse main framing are concerned,

in the case of grillages with web framing, refer to Table 3.10.4.3.1-2;

$$\gamma_f = \frac{A_f}{A_a};$$

for  $A_f$ , refer to 3.10.4.3.2;

for  $A_a$ , refer to 3.10.4.3.3;

$$W_{f0} = \frac{250}{R_{eH}} p b a l Y k_k E \omega_f;$$

$p$  = ice pressure in the region under consideration in accordance with 3.10.3.2 or 3.10.3.5, in kPa; where the lower boundary of region I is included in the grillage and the requirements of the Chapter cover region of ice strengthening I and II (refer to 3.10.1.3.4), the following values of  $p$  shall be adopted:

$p = p_{kI}$ , if the distance from the plating of the upper supporting structure of the grillage to the lower boundary of region I is greater than  $1,2b$ , otherwise  $p = p_{kII}$ ;

$p_{kI}, p_{kII}$  = ice pressure in regions I and II (refer to 3.10.3.2);

$b$  = vertical distribution of ice pressure, in m, in the region under consideration in accordance with 3.10.3.3 or 3.10.3.6; if  $b > l$ ,  $b = l$  shall be adopted for the purpose of determining  $W_{f0}$  and  $A_f$ ;

$a$  = conventional frame spacing, in m, as measured at side;

$l$  = design frame span, in m, to be determined in accordance with Table 3.10.4.3.1-1 in the case of transverse main framing and with Table 3.10.4.3.1-2 in the case of web framing;

$$Y = 1 - 0,5\beta;$$

$$\beta = \frac{b}{l}, \text{ but not greater than } \beta = 1;$$

$k_k$  = factor equal to 0,9 for conventional frames joined with knees to bearing stringers in a side grillage with deep frames, and equal to 1,0 in other cases;

Table 3.10.4.3.1-2

Position of conventional frame section under consideration		$l$
$j$	Between upper (lower) supporting	Distance between side stringers
Between side stringers	structure and the nearest side stringer	Half the sum of distances between supporting sections on supporting structure and the nearest side stringer for two adjacent

$E$  = factor equal to:

$$E = 4l_f \frac{l - l_i}{l^2} \text{ with } l_i < 0,5l,$$

$$E = 1 \text{ with } l_i \geq 0,5l$$

where  $l_i$  = section of the span length  $l$ , in m, overlapped by the region of ice strengthening;

$\omega_f = 1 + k_c \frac{\Delta s}{s_{af}}$ , for the purpose of simplified calculation in accordance with 3.10.4.2.4.  $\omega_f = 1,15$  may be adopted;

$s_{af}$  = actual frame web thickness, in mm;

for  $\Delta s$ , refer to 1.1.5.1;

$k_c = 0,9$  for rolled profile;

$k_c = 0,85$  for welded profile.

**3.10.4.3.2** The web area  $A_f$ , in  $\text{cm}^2$ , of a conventional frame shall not be less than determined by the formula

$$A_f = \frac{8,7pab}{R_{eH}} k_2 k_3 k_4 + 0,1h_f \Delta s \quad (3.10.4.3.2)$$

where  $k_2 = \frac{4}{k}$ ;

$$k_3 = \frac{1}{1+z+\sqrt{2z}\beta^{2,5}} \text{ or}$$

$k_3 = 0,7$ , whichever is greater;

$$z = \frac{1}{2\beta} (a/l)^2;$$

for  $p, a, b, l, k, \beta$ , refer to 3.10.4.3.1, the values of  $b$  and  $l$  adopted shall not exceed the distance between knee ends;

$$k_4 = \begin{cases} 1 & \text{— where no side stringer is provided;} \\ 0,9 & \text{— where there is a side stringer in the span;} \\ 0,8 & \text{— where there is a side stringer in the frame span for} \\ & \text{which effective flange continuity is ensured;} \end{cases}$$

$h_f$  = frame web height, in cm;  $h_f = 0,89h$  for symmetric bulb steel and  $h_f = 0,84h$  for asymmetric bulb steel;

$h_s$  = rolled section height, in cm;

for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.3.3** The actual web area  $A_a$ , in  $\text{cm}^2$ , shall be determined in accordance with 3.10.4.2.5. When a simplified calculation is made in accordance with 3.10.4.2.4, the value of  $A_a$  shall be at least by 10 per cent greater than the required web area.

**3.10.4.3.4** The web thickness  $s_f$ , in mm, of a conventional frame shall be adopted not less than the greater of the following values:

$$s_f = \frac{k_s}{R_{eH}} pa + \Delta s; \quad (3.10.4.3.4-1)$$

$$s_f = 0,0114h_f \sqrt{R_{eH}} + \Delta s \quad (3.10.4.3.4-2)$$

where  $k_s = 1,4 \frac{W_f}{W_{af}}$ , but not less than  $k_s = 1,0$ ;

for  $W_f$ , refer to 3.10.4.3.1;

$W_{af}$  = actual ultimate section modulus, in  $\text{cm}^3$ , of a conventional frame, to be determined in accordance with 3.10.4.2.6 (as a first approximation or for the purpose of the simplified calculation in accordance with 3.10.4.2.4,  $W_{af} = W_f$  shall be adopted);

for  $p, a$ , refer to 3.10.4.3.1;

for  $h_f$ , refer to 3.10.4.3.2;

for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.3.5** The face plate breadth  $c_f$ , in mm, of a conventional frame made of bulb or T-sections shall not be less than the greater one of the following values:

$$c_f = 0,0145 R_{eH} \frac{W_f}{W_{af}} \sqrt{t_f s_{af}} \left( \frac{h_f}{s_{af}} - 0,98 \right); \quad (3.10.4.3.5-1)$$

$$c_f = 2,5t_f; \quad (3.10.4.3.5-2)$$

$$c_f = 69,6s_{af} \sqrt{\frac{h_f}{t_f} (\beta^2 - 0,0029)} \quad (3.10.4.3.5-3)$$

where  $\beta = \frac{(2-\alpha)l_s}{\alpha h_f}$ , but not less than  $\beta = 0,055$ ;

$$\alpha = \left( \frac{s_{af}}{s_{as}} \right)^2 + 0,01 \frac{h_s s_{as}}{a s_{af}}, \text{ but not less than } \alpha = 1;$$

for  $W_f$ , refer to 3.10.4.3.1;

for  $W_{af}$ , refer to 3.10.4.3.4;

$s_{af}$  = actual web thickness of a conventional frame, in mm;

$t_f$  = face plate breadth of a conventional frame, in mm (for beams made of bulbs,  $t = 1,5s_{af}$  shall be adopted);

for  $h_f$ , refer to 3.10.4.3.2;

$s_{as}$  = actual shell plating thickness, in mm;

for  $a$ , refer to 3.10.4.3.1;

$l_s$  = the greatest spacing, in m, of adjacent stringers crossing the frame span or the greatest distance, in m, between the stringer and the supporting section.

In the case of frames made of standard sections, compliance with the requirements for the face plate breadth may not be verified where a simplified calculation in accordance with 3.10.4.2.4 is carried out.

**3.10.4.3.6** If a conventional frame is made of plate sections, the plate height  $h_f$ , in cm, and the spacing or distance  $l_s$ , in m, shall not be greater than given by the formulae:

$$h_f = \frac{8,98s_{af}}{\left( (R_{eH} \frac{W_f}{W_{af}})^2 (1 + 75a \frac{s_{af}^2}{s_{as}^2}) \right)^{0,2}}; \quad (3.10.4.3.6-1)$$

$$l_s = 0,0541 \frac{\alpha_n h_f}{2 - \alpha_n} \quad (3.10.4.3.6-2)$$

where  $\alpha_n = \left( \frac{s_{af}}{s_{as}} \right)^2 + 0,02 \frac{h_s s_{as}}{a s_{af}}$ , but  $1 \leq \alpha_n \leq 1,9$ ;

for  $l_s, s_{af}, s_{as}, W_f, W_{af}, a$ , refer to 3.10.4.3.5.

**3.10.4.4** Side and intercostal stringers as part of transverse framing with deep frames.

**3.10.4.4.1** The ultimate section modulus  $W_s$ , in  $\text{cm}^3$ , of a bearing side stringer shall not be less than determined by the formula

$$W_s = W_{s0} k_s \quad (3.10.4.4.1)$$

where  $W_{s0} = \frac{125}{R_{eH}} k_s^2 p a_1^2 b Q \omega_s$ ;

$$\begin{cases} k_s = \frac{1}{1 + \sqrt{1 - 0,8\gamma_s^2}} & \text{for the purpose of simplified calculation} \\ & \text{in accordance with 3.10.4.2.4 } k_s = 0,63, \\ & \text{shall be adopted; } \omega_s = 1,15; \\ \omega_s = 1 + 0,95 \frac{\Delta s}{s_{as}}; \end{cases}$$

$$k_s^p = 0,82 - 0,55a_1/l^p \geq 0,6 \text{ with } l^p \geq a_1$$

$$k_s^p = 0,82l^p/a_1 - 0,55 \geq 0,6l^p/a_1 \text{ with } l^p < a_1.$$

for  $l^p$ , refer to 3.10.3.4;

for  $p, b$ , refer to 3.10.4.3.1;

$a_1$  = deep frame spacing, in m, as measured along the side;

$$Q = C_{1i} + C_{2i} \frac{b}{l} + C_{3i} \psi_f + \frac{C_{4i}}{\gamma_f} + C_{5i} \frac{\psi_f}{\gamma_f};$$

for the purpose of simplified calculation in accordance with 3.10.4.2.4,

$$Q = C_{6i} + C_{2i} \frac{b}{l};$$

$i$  = factor taking up the following values:

$i = 1$  with  $m = 1$ ;

$i = 2$  with  $m \geq 2$ ;

$m$  = number of side stringers in a grillage;

for  $C_{1i}, C_{2i}, \dots, C_{6i}$ , refer to Table 3.10.4.4;

for  $l, \gamma_f$ , refer to 3.10.4.3.1;

$\psi_f$  = factor to be adopted equal to the lesser of the following:

$$\psi_f = \frac{W_{af}}{W_{f0}},$$

$\psi_f = 1,4k_f$ ;  
for  $W_{f0}$ ,  $k_f$ , refer to 3.10.4.3.1;  
for  $W_{af}$ , refer to 3.10.4.3.4;

$$\gamma_s = \frac{A_s}{A_a};$$

for  $A_s$ , refer to 3.10.4.4.2;  
for  $A_a$ , refer to 3.10.4.4.3;  
 $s_{as}$  = actual web thickness of a side stringer, in mm;  
for  $\Delta s$ , refer to 1.1.5.1.

Table 3.10.4.4

$i$	$C_{1i}$	$C_{2i}$	$C_{3i}$	$C_{4i}$	$C_{5i}$	$C_{6i}$
1	0,003	0,132	0,398	0,584	-0,785	0,320
2	0,363	0,11	-0,078	0,186	-0,202	0,358

**3.10.4.4.2** The web area  $A_s$ , in  $\text{cm}^2$ , of a side stringer shall not be less than determined by the formula

$$A_s = \frac{8,7k_s^p pab}{R_{eH}} Qn + 0,1h_s\Delta s \quad (3.10.4.4.2)$$

where for  $p$ ,  $a$ ,  $b$ , refer to 3.10.4.3.1;  
 $n$  = number of frames fitted between two adjacent deep frames;  
for  $k_s^p$ ,  $Q$ , refer to 3.10.4.4.1;  
 $h_s$  = web height of a bearing side stringer, in cm;  
for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.4.3** The actual web area  $A_a$ , in  $\text{cm}^2$ , of a side stringer shall be determined in accordance with 3.10.4.3.3.

**3.10.4.4.4** The web thickness  $s_s$ , in mm, of a side stringer shall not be less than determined by the formula

$$s_c = 2,63c_1 \sqrt{\frac{\gamma_c R_{eH}}{5,34 + 4\left(\frac{c_1}{c_2}\right)^2}} + \Delta s \quad (3.10.4.4.4)$$

where  $c_1$ ,  $c_2$  = the shorter and longer side, in m, of the panels into which the stringer web is divided by its stiffeners;  
for an unstiffened web,  $c_1 = 0,01(h_s - 0,8h_f)$ ,  $c_2 = a_1$ ;  
for  $h_s$ , refer to 3.10.4.4.2;  
for  $h_f$ , refer to 3.10.4.3.2;  
for  $a_1$  and  $\gamma_c$ , refer to 3.10.4.4.1;  
for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.4.5** The web height  $h_s$ , in cm, of a side stringer shall not be less than determined by the formula

$$h_s = 2h_f \quad (3.10.4.4.5)$$

where for  $h_f$ , refer to 3.10.4.3.2.

**3.10.4.4.6** The face plate thickness of a side stringer shall not be less than its actual web thickness.

**3.10.4.4.7** The face plate breadth  $c_s$ , in mm, of a side stringer shall not be less than the greater of the following values:

$$c_s = 0,0165R_{eH} \frac{W_{sf}}{W_{as}} \sqrt{t_{sas}} \left( \frac{h_s}{s_{as}} - 2,6 \right); \quad (3.10.4.4.7-1)$$

$$c_s = 7,5t_s \quad (3.10.4.4.7-2)$$

where for  $W_{sf}$ , refer to 3.10.4.4.1;

$W_{sf}$  = actual ultimate section modulus, in  $\text{cm}^3$ , of a side stringer, to be determined in accordance with 3.10.4.2.6 (in first approximation or for the purpose of simplified calculation in accordance with 3.10.4.2.4,  $W_{as} = W_s$  shall be adopted);

$t_s$  = face plate thickness, in mm, of a bearing stringer;

for  $s_{as}$ , refer to 3.10.4.4.1;

for  $h_s$ , refer to 3.10.4.4.2.

Bearing stringer design providing for no face plate (plate section) is not permitted.

**3.10.4.4.8** The web height  $h_{is}$ , in cm, of an intercostal stringer at a section in way of a conventional frame shall not be less than determined by the formula

$$h_{is} = 0,8h_f \quad (3.10.4.4.8)$$

where for  $h_f$ , refer to 3.10.4.3.2.

**3.10.4.4.9** The web thickness of an intercostal stringer shall not be less than that of a conventional frame, as required in accordance with 3.10.4.3.4.

**3.10.4.5** Deep frames as part of transverse framing.

**3.10.4.5.1** The ultimate section modulus  $W_{wf}$ , in  $\text{cm}^3$ , of a deep frame shall not be less than determined by the formula

$$W_{wf} = W_{wf0} k_{wf} \quad (3.10.4.5.1)$$

where  $W_{wf0} = \frac{250}{R_{eH}} k_{wf}^p pab l_{wf} (1 - \frac{0,5b}{l_{wf}} + k_m G) \omega_{wf}$ ;

$k_{wf} = \frac{1}{1 + \sqrt{1 - 0,8\gamma^2}}$ ;  $G = 2nQ_m(1 - R)$ , for the purpose of a simplified calculation in accordance with 3.10.4.2.4;  
 $k_{wf} = 0,63$  shall be adopted;  $G = nQ_m$ ;

for  $n$ , refer to 3.10.4.4.2;

for  $k_m$ , refer to Table 3.10.4.5.1-1;

Table 3.10.4.5.1-1

$m$	1	2	3	4	5	6
$k_m$	1,0	1,33	2,0	2,4	3,0	3,43

$$R = 0,5\sqrt{2\psi_s - (\psi_s \gamma_{s1})^2} \text{ with } \psi_s < \frac{1}{\gamma_{s1}^2};$$

$$R = 0,5/\gamma_{s1} \text{ with } \psi_s \geq \frac{1}{\gamma_{s1}^2};$$

$$\gamma_{wf} = \frac{A_{wf}}{A_f};$$

$$\psi_s = \frac{W_{sf}}{W_{s0}} k_d;$$

$\gamma_{s1}$  = factor to be adopted as the greater of the following:

$$\gamma_{s1} = \frac{\gamma_s}{k_d}$$

$$\gamma_{s1} = 0,7;$$

$$k_d = 1 \text{ with } m \leq 2,$$

$k_d = \frac{Q}{Q_m}$  with  $m > 2$ , for the purpose of a simplified calculation in accordance with 3.10.4.2.4,  $k_d = 1,2$  shall be adopted, with  $m > 2$ ;

$Q_m = Q$  with  $m = 1; 2$ ;

$Q_m = C_{m1} + C_{m2}(0,5\frac{b}{l}(\psi_l - 0,5) - \psi_l)$  with  $m = 3; 4; 5; 6$ ;

$C_{m1}, C_{m2}$  = factors to be determined from Table 3.10.5.1-2;

Table 3.10.4.5.1-2

$m$	3	4	5	6
$C_{m1}$	0,5	0,417	0,333	0,292
$C_{m2}$	0,25	0,167	0,111	0,083

$\omega_{wf} = 1 + 0,95\frac{\Delta s}{s_{awf}}$ , for the purpose of a simplified calculation

in accordance with 3.10.4.2.4,  $\omega_{wf} = 1,15$  may be adopted;

for  $p, a, b$ , refer to 3.10.4.3.1;

for  $m, l, Q, \psi_f, W_{s0}, \gamma_s$ , refer to 3.10.4.4.1;

$l_{wf}$  = span length, in m, of a deep frame, equal to the distance between supporting sections;

for  $W_{as}$ , refer to 3.10.4.4.7;

$k_{wf}^p = 0,82(1 - a_1/l^p) \geq 0,6$  with  $l^p \geq 2a_1$ ;

$k_{wf}^p = 0,41(l^p/a_1 - 1) \geq 0,3l^p/a_1$  with  $l^p < 2a_1$ ;

for  $l^p$ , refer to 3.10.3.4;

for  $a_1$ , refer to 3.10.4.4.1;

for  $A_{wf}$ , refer to 3.10.4.5.2;

for  $A_f$ , refer to 3.10.4.5.3;

$s_{awf}$  = actual thickness, in mm, of a deep frame web;

for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.5.2** The web area  $A_{wf}$ , in  $\text{cm}^2$ , of a deep frame shall not be less than determined by the formula

$$A_{wf} = \frac{8,7pabk_{wf}^p}{R_{eH}} (1 + m/G) + 0,1h_{wf}\Delta s \quad (3.10.4.5.2)$$

where for  $p, a, b$ , refer to 3.10.4.3.1;

for  $m$ , refer to 3.10.4.4.1;

for  $k_{wf}^p, G$ , refer to 3.10.4.5.1;

$h_{wf}$  = deep frame web depth, in cm;

for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.5.3** The actual web area  $A_a$ , in  $\text{cm}^2$ , of a deep frame shall be determined in accordance with 3.10.4.3.3.

**3.10.4.5.4** The web thickness  $s_{wf}$ , in mm, shall be adopted not less than the greater of the following values:

$$s_{wf} = \frac{k_s}{R_{eH}} pa + \Delta s; \quad (3.10.4.5.4-1)$$

$$s_p = 2,63c_1 \sqrt{\frac{\gamma_{wf} R_{eH}}{5,34 + 4(\frac{c_1}{c_2})^2}} + \Delta s \quad (3.10.4.5.4-2)$$

where  $k_s = \frac{1}{1,25\frac{W_{awf}}{W_{wf}} - 0,75}$ , but not less than  $k_s = 1,0$ ;

for  $W_{wf}$  and  $\gamma_{wf}$ , refer to 3.10.4.5.1;

$W_{awf}$  = actual ultimate section modulus, in  $\text{cm}^3$ , of a deep frame, to be determined in accordance with 3.10.4.2.6 (in the first approximation or for the purpose of the simplified calculation in accordance with 3.10.4.2.4,  $W_{awf} = W_{wf}$  shall be adopted);

for  $p, a$ , refer to 3.10.4.3.1;

$c_1, c_2$  = the shorter and the longer side, in m, of panels into which the web of a deep frame is divided by its stiffeners;

for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.5.5** The face plate thickness of a deep frame shall not be less than the actual thickness of its web.

**3.10.4.5.6** The face plate breadth  $c_{wf}$ , in mm, of a deep frame shall not be less than the greater of the following values:

$$c_{wf} = A_1 R_{eH} \frac{W_{wf}}{W_{awf}} \sqrt{t_{wf} s_{awf}} \left( \frac{h_{wf}}{s_{awf}} - A_2 \right); \quad (3.10.4.5.6-1)$$

$$c_s = A_3 t_{wf} \quad (3.10.4.5.6-2)$$

where for  $W_{wf}$ , refer to 3.10.4.5.1;

for  $W_{awf}$ , refer to 3.10.4.5.4;

$t_{wf}$  = face plate thickness, in mm, of a deep frame;

for  $s_{awf}$ , refer to 3.10.4.5.1;

for  $h_{wf}$ , refer to 3.10.4.5.2;

$A_1 = 0,0039; A_2 = 1,4; A_3 = 5$ , if the deep frame web is provided with stiffeners fitted approximately normal to the shell plating;

$A_1 = 0,0182; A_2 = 2,6; A_3 = 10$ , if the deep frame web is provided with stiffeners fitted approximately normal to the shell plating or if it is unstiffened.

Deep frame design providing for no face plate (plate section) is not permitted.

**3.10.4.6** Side and bottom longitudinals as part of longitudinal framing.

**3.10.4.6.1** The ultimate section modulus  $W_b$ , in  $\text{cm}^3$ , of a longitudinal shall not be less than determined by the formula

$$W_l = W_{l0} k_l \quad (3.10.4.6.1)$$

where  $W_{l0} = \frac{125}{R_{eH}} p b_1 l (1 - 0,5a) c^2 \omega_l$ ;

$k_l = \frac{1}{1 + \sqrt{1 - k_s \gamma_l^2}}$ ,  $k_l = 0,63$ ; for the purpose of simplified

calculation in accordance with 3.10.4.2.4, for  $k_s$ , refer to 3.10.4.3.1;

$c = 1$  — for bottom longitudinals and for side longitudinals where no panting frames are fitted;

$c = \frac{1}{1 + \frac{0,25}{e}}$  — for side longitudinals where panting frames are fitted;

$b_1 = k_0 b_2$ ;

$b_2 = b(1 - 0,25\bar{b})$  with  $\bar{b} < 2$ ;

$b_2 = a$  with  $\bar{b} \geq 2$ ;

$e = \bar{b} + 1$ ;

$\bar{b} = \frac{b}{a}$ ;

$k_0 = 1 - \frac{0,3}{\bar{b}}$ ;

$\omega_l = 1 + k_c \frac{\Delta s}{s_{al}}$ ,  $\omega_l = 1,15$ ; may be adopted for the purpose of

the simplified calculation in accordance with 3.10.4.2.4;

for  $p, b$ , refer to 3.10.4.3.1;

$a$  = spacing, in m, of longitudinals;

$l$  = spacing, in m, of deep frames or floors;

$\gamma_l = \frac{A_l}{A_a}$ ;

for  $A_b$ , refer to 3.10.4.6.2;

for  $A_a$ , refer to 3.10.4.6.3;

$s_{al}$  = actual web thickness, in mm, of a longitudinal;  
for  $\Delta s$ , refer to 1.1.5.1;  
for  $k_c$ , refer to 3.10.4.3.1.

**3.10.4.6.2** The web area  $A_l$ , in  $\text{cm}^2$ , of a longitudinal shall not be less than determined by the formula

$$A_l = \frac{8,7}{R_{eH}} p b_1 l c k_1 + 0,1 h_l \Delta s \quad (3.10.4.6.2)$$

where for  $p$ , refer to 3.10.4.3.1;

for  $b_1$ ,  $l$ ,  $c$ , refer to 3.10.4.6.1;

$k_1$  = factor to be adopted as the greater of the following:

$$k_1 = \frac{1}{1 + 0,76 \frac{a_0}{l}}$$

$$k_1 = 0,8;$$

for  $a_0$ , refer to 3.10.4.1;

$h_l$  = web height, in cm, of a longitudinal;

for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.6.3** The actual web area  $A_a$ , in  $\text{cm}^2$ , of a longitudinal shall be determined in accordance with 3.10.4.3.3.

**3.10.4.6.4** The web area  $s_l$ , in mm, of a longitudinal shall be adopted not less than the greater one of the following values:

$$s_l = \frac{k_s}{R_{eH}} p b_1 + \Delta s \quad (3.10.4.6.4-1)$$

$$s_l = 0,013 h_l \sqrt{R_{eH}} + \Delta s \quad (3.10.4.6.4-2)$$

where  $k_s = 1,4 \frac{W_l}{W_{al}}$ , but not less than  $k_s = 1,0$ ;

for  $W_l$ , refer to 3.10.4.6.1;

$W_{al}$  = actual ultimate section modulus, in  $\text{cm}^3$ , of a longitudinal, to be determined in accordance with 3.10.4.2.6 (in the first approximation or for the purpose of the simplified calculation in accordance with 3.10.4.2.4,  $W_{al} = W_l$  shall be adopted);

for  $p$ , refer to 3.10.4.3.1;

for  $b_1$ , refer to 3.10.4.6.1;

for  $h_l$ , refer to 3.10.4.6.2;

for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.6.5** The face plate breadth  $c_l$ , in mm, of a longitudinal having a bulb-plate or T-section shall not be less than the greater of the following values:

$$c_l = 0,0145 R_{eH} \frac{W_l}{W_{al}} \sqrt{t_l s_{al}} \left( \frac{h_l}{s_{al}} - 0,98 \right); \quad (3.10.4.6.5-1)$$

$$c_l = 2,5 t_l; \quad (3.10.4.6.5-2)$$

$$c_l = 69,6 s_{al} \sqrt{\frac{h_l}{t_l} (\beta^2 - 0,0029)} \quad (3.10.4.6.5-3)$$

where  $\beta = \frac{(2-\alpha)l_s}{\alpha h_l}$ , but not less than  $\beta = 0,055$ ;

$$\alpha = \left( \frac{s_{al}}{s_{as}} \right)^2 + \frac{0,01 h_l s_{as}}{a s_{al}}, \text{ but not less than } \alpha = 1;$$

for  $W_l$ , refer to 3.10.4.6.1;

for  $W_{al}$ , refer to 3.10.4.6.4;

$s_{al}$  = actual web thickness, in mm, of a longitudinal;

$t_l$  = face plate thickness, in mm, of a longitudinal (for longitudinals having a bulk-plate section,  $t_l = 1,5 s_{al}$  shall be adopted);

for  $h_l$ , refer to 3.10.4.6.2;

$s_{as}$  = actual shell plating thickness, in mm;

for  $a$ , refer to 3.10.4.6.1;

$l_s$  = maximum spacing, in m, of adjacent transverse members crossing the span of a longitudinal.

As far as longitudinals made of standard sections are concerned, conformance with the requirements for the face plate breadth may not be verified in case of carrying out a simplified calculation in accordance with 3.10.4.2.4.

**3.10.4.6.6** Where a longitudinal is made of plate sections, the plate height  $h_l$ , in cm, and the spacing  $l_s$ , in m, shall not be greater than determined by the formulae:

$$h_l = \frac{8,98 s_{al}}{[(R_{eH} W_l / W_{al})^2 (1 + 75 a s_{al}^2 / s_{al}^3)]^{0,2}}; \quad (3.10.4.6.6-1)$$

$$l_s = \frac{0,0541 \alpha_n h_l}{2 - \alpha_n} \quad (3.10.4.6.6-2)$$

where  $\alpha_n = \left( \frac{s_{al}}{s_{as}} \right)^2 + \frac{0,02 h_l s_{as}}{a s_{al}}$ , with  $1 \leq \alpha_n \leq 1,9$ ;

for  $l_s$ ,  $s_{al}$ ,  $s_{as}$ ,  $W_l$ ,  $W_{al}$ ,  $a$ , refer to 3.10.4.6.5.

**3.10.4.7** Deep frames as part of longitudinal framing.

**3.10.4.7.1** The ultimate section modulus  $W_w$ , in  $\text{cm}^3$ , of a deep frame shall not be less than determined by the formula

$$W_w = W_{w0} k_w \quad (3.10.4.7.1)$$

where  $W_{w0} = \frac{500}{R_{eH}} p a b k_w^p l (1 + k_g) (Q - \frac{k_g R}{e}) \omega_w$ ;

$$k_w = \frac{1}{1 + \sqrt{1 - 0,8 \gamma_w^2}};$$

$$Q = 2 - N;$$

$$N = \sqrt{2 \psi_l \beta - (\psi_l \gamma_l)^2} \text{ with } \psi_l < \frac{\beta}{\gamma_l^2};$$

$$N = \frac{\beta}{\gamma_l} \text{ with } \psi_l \geq \frac{\beta}{\gamma_l^2};$$

$$R = \frac{\beta \psi_l}{\sqrt{(\psi_l \gamma_l)^2 + 4}}.$$

For the purpose of a simplified calculation in accordance with 3.10.4.2.4,  $k_w = 0,63$ ,  $N = 1,1\beta$ ,  $R = 0,33\beta$  shall be adopted;

$$\beta = \frac{b_l e}{b};$$

for  $p$ ,  $b$ , refer to 3.10.4.3.1;

for  $a$ ,  $l$ ,  $b_1$ ,  $e$ ,  $\gamma_l$ , refer to 3.10.4.6.1;

for  $k_w^p$ ,  $\omega_w$ , refer to 3.10.4.5.1;

$k_g$  = factor to be adopted as the lesser of the following:

$$k_g = 0,5 \left( \frac{e Q}{R} - 1 \right);$$

$$k_g = 0,5 (k - 0,25 (e + 1));$$

$k$  = number of longitudinals in a deep frame span;

$$\psi_l = \frac{W_{al}}{W_{l0}};$$

for  $W_{al}$ , refer to 3.10.4.6.4;

for  $W_{l0}$ , refer to 3.10.4.6.1;

$$\gamma_p = \frac{A_{wf}}{A_a};$$

for  $A_{wf}$ , refer to 3.10.4.7.2;

for  $A_a$ , refer to 3.10.4.7.3.



**3.10.4.7.2** The web area  $A_{wf}$ , in  $\text{cm}^2$ , of a deep frame shall not be less than determined by the formula

$$A_{wf} = \frac{8,7}{R_{eH}} p b k_w^p l Q + 0,1 h_{wf} \Delta s \quad (3.10.4.7.2)$$

where for  $p$ ,  $b$ , refer to 3.10.4.3.1;  
for  $l$ , refer to 3.10.4.6.1;  
for  $Q$ , refer to 3.10.4.7.1;  
 $h_{wf}$  = deep frame web height, in cm;  
for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.7.3** The actual web area  $A_a$ , in  $\text{cm}^2$ , of a deep frame shall be determined in accordance with 3.10.4.3.3.

**3.10.4.7.4** The web thickness of a deep frame shall not be less than the greater of the values determined by the Formulae (3.10.4.5.4-1), (3.10.4.5.4-2) while  $W_{wf}$  shall be in accordance with 3.10.4.7.1 and  $a$  shall be in accordance with 3.10.4.6.1.

The requirements of this paragraph apply to the vertical diaphragms of the double side as well.

**3.10.4.7.5** The web height of a deep frame shall not be less than determined by the formula

$$h_{wf} = 2h_l \quad (3.10.4.7.5)$$

where for  $h_l$ , refer to 3.10.4.6.2.

**3.10.4.7.6** The face plate thickness of a deep frame shall not be less than its actual web thickness.

**3.10.4.7.7** The face plate breadth of a deep frame shall be determined in accordance with 3.10.4.5.6 while  $W_{wf}$  shall be in accordance with 3.10.4.7.1. The deep frame design providing for no face plate (plate section) is not permitted.

**3.10.4.8** Additional frames and horizontal diaphragms as part of longitudinal framing.

**3.10.4.8.1** The web height of an additional frame  $h_{ad.f}$ , in cm, (refer to 3.10.2.3) at a section in way of a longitudinal shall not be less than determined by the formula

$$h_{ad.f} = 0,8h_l \quad (3.10.4.8.1)$$

where  $h_l$  = web height, in cm, of a longitudinal.

**3.10.4.8.2** The web thickness of an additional frame shall not be less than that of a longitudinal, as required in accordance with 3.10.4.6.4.

**3.10.4.8.3** The cross-sectional area of a horizontal diaphragm forming part of double-side structure where the outboard side is longitudinally framed shall not be less than the web area of a deep frame (vertical diaphragm) in accordance with 3.10.4.7.2.

**3.10.4.9** Plate structures.

**3.10.4.9.1** The thickness of plate structures forming part of web framing of side grillages (deep frames, side stringers) shall be determined in accordance with 3.10.4.4.4, 3.10.4.5.4, 4.10.4.7.4.

**3.10.4.9.2** The plate structure thickness of decks and platforms, as well as of double bottom, bottom stringers and centre girder shall not be less than  $s_{ps1}$ , in mm, to be determined by the formula

$$s_{ps1} = s_{ps0} + \Delta s \quad (3.10.4.9.2)$$

where  $s_{ps0} = s_{ps01}$ , if the plate structure is provided with stiffeners fitted approximately normal to the shell plating;

$s_{ps0} = s_{ps02}$ , if the plate structure is not provided with stiffeners fitted approximately normal to the shell plating (permitted for **Ice1**, **Ice2**, **Ice3** category ships);

$$s_{ps01} = b \left\{ 0,8 \frac{p_1}{R_{eH}} - 0,0045 k_2 \left[ 1 + 4 \left( \frac{c_{sp}}{k_2 b} \right)^2 \right] \left( \frac{s_{sp0}}{10 c_{sp}} \right)^{3,5} \right\};$$

$$s_{ps02} = \frac{0,95 p_1 b}{R_{eH}};$$

$p_1 = k_1 p$   
for  $k_1$ , refer to Table 3.10.4.9.2;

$$k_2 = k_T \sqrt{k_p};$$

$k_T = 0,17 \Delta^{1/6}$ , but not less than 1,0;

$k_p$  = shall be in accordance with 3.10.3.5.1 as far as ice-breakers are concerned;

$k_p = 1$  for ice ships;

for  $\Delta$ , refer to 3.10.3.2.1;

for  $p$ ,  $b$ , refer to 3.10.4.3.1;

$c_{sp}$  = spacing, in m, of stiffeners in a plate structure or distance, in m, between other framing members fitted approximately normal to the shell plating;

for  $s_{sp0}$ , refer to 3.10.4.1;

for  $\Delta s$ , refer to 1.1.5.1.

Table 3.10.4.9.2

Ice category	$k_1$
<b>Ice1, Ice2, Ice3, Arc5</b>	1,3
<b>Arc6, Icebreaker6</b>	1,2
<b>Arc7, Icebreaker7</b>	1,1
<b>Arc8, Icebreaker8, Arc9, Icebreaker9</b>	1,0

**3.10.4.9.3** In addition to the requirements of 3.10.4.9.2, the thickness of plate structures in decks and platforms, where the side is transversely framed, shall not be less than  $s_{ps2}$ , in mm, to be determined by the formula

$$s_{ps2} = s_{ps0} + \Delta s \quad (3.10.4.9.3)$$

$$\text{where } s_{ps0} = \frac{0,866}{\alpha} \left[ 1,1 \frac{p_1}{R_{eH}} b \left( 1 - \frac{b}{4l} \right) - 0,5 \frac{W_{st} 10^{-3}}{\omega_j a l l_2} \left( \frac{h_f}{10l} \right)^{1,5} - \frac{0,1 f_{st}}{a_1} \right];$$

for  $p_1$ , refer to 3.10.4.9.2;

$$l = \frac{1}{2} (l_1 + l_2);$$

$$\alpha = 1 - \frac{a_2}{a};$$

$l_1, l_2$  = distance, in m, from the plate structure under consideration to the nearest plate structures (decks, platforms, side stringers, inner bottom plating) on both sides;

$a_1$  = spacing, in m, of plate structure stiffeners fitted approximately normal to shell plating and welded thereto;

$f_{st}$  = cross-sectional area of stiffener, in  $\text{cm}^2$ , without effective flange; where stiffeners are fitted parallel to the shell plating or snipped,  $f_{st} = 0$  shall be adopted;

for  $b$ ,  $a$ ,  $\omega_j$ , refer to 3.10.4.3.1;

for  $W_{af}$ , refer to 3.10.4.3.4;  
 for  $h_f$ , refer to 3.10.4.3.2;  
 $a_2$  = length, in m, of unstiffened section of opening in plate structure for the passage of a conventional frame, as measured on the shell plating;  
 for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.9.4** The plate structure thickness in transverse bulkheads where the side is transversely framed and the floor and bilge bracket thickness where the bottom is longitudinally framed shall not be less than  $s_{ps3}$ , in mm, to be determined by the formula

$$s_{ps3} = s_{ps0} + \Delta s \quad (3.10.4.9.4)$$

where  $s_{ps0} = a \left\{ 1,8 \frac{p_2}{R_{eH}} - 0,009 \left[ 1 + \left( \frac{a}{k_g} \right)^2 \right] \left( \frac{s_{sp0}}{10a} \right)^{3,5} \right\}$ ;

$$p_2 = \frac{p_1}{k_2};$$

for  $p_1, k_2$ , refer to 3.10.4.9.2;  
 $k_g = 0,4k_2b$ , but not greater than  $k_g = a$ ;  
 $a$  = spacing, in m, of side (bottom) longitudinals;  
 for  $b$ , refer to 3.10.4.3.1;  
 for  $s_{sp0}$ , refer to 3.10.4.1;  
 for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.9.5** The plate structure thickness of transverse bulkheads in a transversely framed side, and of floors in a transversely framed bottom shall not be less than  $s_{ps4}$ , in mm, to be determined by the formula

$$s_{ps4} = s_{ps0} + \Delta s \quad (3.10.4.9.5)$$

where  $s_{ps0} = a \left\{ 1,8 \frac{p_2}{R_{eH}} - 0,009 \left[ 1 + \left( \frac{a}{k_g} \right)^2 \right] \left( \frac{s_{sp0}}{10a} \right)^{3,5} \right\}$ ;

$k_g = 0,4k_2b$ , but not greater than  $k_g = c_{sp}$ ;  
 for  $b$ , refer to 3.10.4.3.1;  
 for  $k_2, c_{sp}$ , refer to 3.10.4.9.2;  
 for  $p_2$ , refer to 3.10.4.9.4;  
 $a$  = spacing, in m, of conventional frames (for plate structures of bulkheads) or floors (for plate structures of floors);  
 for  $s_{sp0}$ , refer to 3.10.4.1;  
 for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.9.6** In any case, the plate structure thickness of decks and platforms, transverse bulkheads, inner bottom, floors and bilge brackets, bottom stringers and centre girder shall not be less than  $s_{ps}$ , in mm, to be determined by the formula

$$s_{ps} = s_{ps0} + \Delta s, \quad (3.10.4.9.6)$$

where  $s_{ps0} = \sqrt[3]{\frac{q}{n}}$  with  $q \leq q_1$ ;

$$s_{ps0} = 0,455 \left[ \frac{q}{R_{eH}} + \sqrt{\left( \frac{q}{R_{eH}} \right)^2 + \frac{1,32 R_{eH}}{n}} \right] \text{ with } q_1 < q < q_2,$$

$$s_{ps0} = 1,73 \sqrt{\frac{R_{eH}}{n}} \text{ with } q \geq q_2;$$

$q = 0,6p_1b(1 - \frac{0,1bk_2}{a})$  — for plate structures of decks and platforms, inner bottom, bottom stringers and centre girder in a longitudinally framed side or bottom;

$q = 0,89p_2a$  for the rest of plate structures where the bottom is transversely framed and for all plate structures where the bottom and side are framed transversely;

for  $p_1, k_2$ , refer to 3.10.4.9.2;  
 for  $p_2$ , refer to 3.10.4.9.4;

$$q_1 = 0,353 \sqrt{\frac{R_{eH}^3}{n}};$$

$$q_2 = 4,9q_1;$$

$$n = \frac{0,294n_1}{c_1^2},$$

$n_1 = \left[ 1 + \left( \frac{c_1}{c_2} \right)^2 \right]^2$  — where the longer side of plate structure panel adjoins the shell plating,

$n_1 = 4$  where the shorter side of plate structure panel adjoins the shell plating;

$c_1, c_2$  = the shorter and longer sides, in m, of panels into which a plate structure is divided by its stiffeners;

for  $b$ , refer to 3.10.4.3.1;

$a$  = spacing, in m, of main framing girders of shell plating;  
 for  $\Delta s$ , refer to 1.1.5.1.

**3.10.4.9.7** The inertia moment  $i$ , in  $\text{cm}^4$ , of stiffeners by which the plate structures are strengthened and which are fitted approximately normal to the shell plating shall not be less than determined by the formula

$$i = 0,01 R_{eH} l^2 (10 s_{ps} a + f_p) \quad (3.10.4.9.7)$$

where  $l$  = span length, in m, of stiffener, not greater than  $l = 6a$ ;

$s_{ps}$  = thickness, in mm, of plate structure being strengthened;

$a$  = spacing, in m, of stiffeners;

$f_p$  = sectional area of stiffener, in  $\text{cm}^2$ , without effective flange.

**3.10.4.9.8** A horizontal grillage adjoining the shell plating in an region of ice strengthening, but not reaching from side to side (deck or platform in way of large openings, horizontal diaphragm of double side, etc.) may be considered a platform if the sectional area of its plating (on one side) is not less than  $F$ , in  $\text{cm}^2$ , to be determined by the formula

$$F = \frac{6pb l^*}{R_{eH}} \left( 1 - \frac{b}{4l} \right) \quad (3.10.4.9.8)$$

where for  $p$ , refer to 3.10.3.2;

for  $b$ , refer to 3.10.3.3;

$l^*$  = design distribution length, in m, for the load taken up by the transverse main framing of side, to be adopted equal to  $l^p$ , or to  $l^p$  or  $2a_1$ , whichever is less, in the case of framing (transverse or longitudinal) including deep frames;

for  $l^p$ , refer to 3.10.3.4;

for  $a_1$ , refer to 3.10.4.4.1;

for  $l$ , refer to 3.10.4.9.3.

Otherwise, such a structure shall be considered a bearing side stringer.

A structure considered to be a platform shall comply with the requirements of 3.10.4.9 for the plate structures of platforms, and one considered to be a stringer, with the requirements of 3.10.4.4.

### 3.10.4.10 Stems and sternframes.

**3.10.4.10.1** The requirements of this paragraph for the area, section modulus and plate thickness of stem shall be complied with on the stem section from the keel to a level extending above the upper boundary of the ice strake by a value of  $H_1$  (refer to Table 3.10.4.10.1). In the case of icebreakers, this stem section shall extend as far as the nearest deck or

platform lying higher than this level. Outside the borders of the area considered, the stem scantlings may gradually reduce and the cross-sectional area of the bar shall not be less than required in 2.10.4 while the plate thickness of a combined or plate stem shall not be less than  $k_s$  (where  $s$  is the shell plating thickness in way of ice strike in region AI, for  $k$ , refer to Table 3.10.4.10.1).

The cross-sectional area  $S$ , in  $\text{cm}^2$ , of stem irrespective of design shall not be less than determined by the formula

$$S = k_k f(\Delta) \quad (3.10.4.10.1-1)$$

where  $k_k$  = factor whose values shall be obtained from Table 3.10.4.10.1;

$$f(\Delta) = \begin{cases} 0,031\Delta + 137 & \text{with } \Delta < 5000 \text{ t;} \\ \Delta^{2/3} & \text{with } \Delta \geq 5000 \text{ t;} \end{cases}$$

$\Delta$  = displacement, in t.

The section modulus  $W$ , in  $\text{cm}^3$ , of the stem cross-sectional area with regard to an axis perpendicular to the centreline shall not be less than determined by the formula

$$W = 1,16pb \quad (3.10.4.10.1-2)$$

where for  $p$ ,  $b$ , refer to 3.10.4.3.1 as far as region of ice strengthening AI is concerned.

To be included in the design cross-sectional area of a combined or plate stem are areas of shell plates and centreline girder or of longitudinal bulkhead on the centre plane on a breadth not exceeding ten times the thickness of relevant plates.

The plate thickness  $s$ , in mm, of combined and plate stems, as well as of the structure shown in Fig. 3.10.2.6, shall not be less than determined by the formula

$$s = 1,2 \left( s_{sp0} \frac{a_b}{a_{sp}} \sqrt{\frac{R_{eH}^{sp}}{R_{eH}}} + \Delta s_{sp0} \right) \quad (3.10.4.10.1-3)$$

where for  $s_{sp}$ ,  $\Delta s_{sp0}$  refer to 3.10.4.1 as far as the region of ice strengthening AI is concerned;

$a_b$  = spacing, in m, of transverse brackets of stem;

$a_{af}$  = main framing spacing, in m, in way of shell plating in the region of ice strengthening AI, which was adopted when determining  $s_{sp0}$ ;

$R_{eH}^{sp}$  = tensile strength, in MPa, of shell plating material, which was adopted when determining  $s_{sp0}$ .

$R_{eH}$  = tensile strength, in MPa, of stem plate material.

**3.10.4.10.2 Sternframe.** The sectional area  $S$ , in  $\text{cm}^2$ , of propeller post and rudder post shall be as given by the formula

$$S = k S_0 \quad (3.10.4.10.2)$$

where  $k$  = factor to be adopted from Table 3.10.4.10.2;

$S_0$  = sectional area of propeller post or rudder post, in  $\text{cm}^2$ , as required for a ship without an ice category in accordance with 2.10.4.

Table 3.10.4.10.2

Strengthening factor $k$	Ice category								
	Ice1	Ice2	Ice3	Arc4	Arc5	Arc6, Icebreaker6	Arc7, Icebreaker7	Arc8, Icebreaker8	Arc9, Icebreaker9
Propeller post	1,1	1,1	1,15	1,25	1,5	1,75	2	2,5	3
Rudder post and sole-piece	1,15	1,15	1,25	1,5	1,8	2	2,5	3,5	4

For the sternframes of single-screw ships of categories **Ice1**, **Ice2**, **Ice3** having no rudder post or fitted up with a rudder axle for Simplex rudders, the greatest value out of those stipulated by 2.10.4.2.5 (account being taken of 2.2.2.2, Part III "Equipment, Arrangements and Outfit") shall be adopted for the scantlings of the solepiece cross section, or they shall be determined by the Formula (3.10.4.10.2), whichever is greater.

Where the sternframe has a horn for a semi-spade rudder, the scantlings of the rudder horn shall be determined according to 2.10.4.4 with due regard for the requirements of 2.2.2.2, Part III "Equipment, Arrangements and Outfit".

The sternframe sectional area of twin-screw ice ships or icebreakers shall not be less than the rudder post area stipulated in 3.10.4.10.2.

Table 3.10.4.10.1

Parameter	Ice ships									Icebreakers			
	Ice1	Ice2	Ice3	Arc4	Arc5	Arc6	Arc7	Arc8	Arc9	Icebreaker6	Icebreaker7	Icebreaker8	Icebreaker9
Section $H_1$ , in m, from top of ice belt to upper boundary of ice strengthening of the stem	0,5	0,5	0,6	0,7	0,8	0,9	1,0	1,1	1,2	1,0	1,5	1,75	2,0
Factor $k$ of stem plate thickening above the upper boundary of strengthening	1,25	1,2	1,15	1,1	1,1	1,05	1	1	1	1	1	1	1
Factor $k_k$ from the Formula (3.10.4.10.1-1)	0,30	0,34	0,4	0,54	0,66	1,02	1,25	1,4	1,55	1,43	1,75	1,96	2,17
Depth of centreline vertical web $h_v$ , in m, by which the stem is strengthened	0,5	0,5	0,5	0,6	1,0	1,3	1,5	Longitudinal bulkhead in fore peak centreline					

### 3.11 ICE STRENGTHENING OF TUGS

#### 3.11.1 General and requirements.

**3.11.1.1** Tugs provided with ice strengthening in compliance with the requirements stated below are provided with one of the following ice-category marks in their class notation: **Ice2, Ice3, Arc4, Arc5**.

The ultimate and permissible thickness of ice in which ice-strengthened tugs may operate shall be determined on the basis of 2.2.3.4 and 2.2.3.5, Part I "Classification" as in the case of ice transport ships of categories **Ice2, Ice3, Arc4, Arc5**.

**3.11.1.2** The hull form of ice-strengthened tugs shall be in accordance with the requirements of 3.10.1.2 for the hull form of ice ships of the respective category.

#### 3.11.1.3 Regions of ice strengthening.

**3.11.1.3.1** For tugs, the boundaries of regions of ice strengthening shall be established in accordance with 3.10.1.3 as in the case of ice ships, unless specifically provided otherwise below.

**3.11.1.3.2** In tugs with a small length of loadline fore run ( $b + L_3 < 0,35L$ , refer to 3.10.1.3), the intermediate region of ice strengthening (or the forward region where no intermediate region is established) shall be extended aft so that the forward boundary of the midship region would be at least  $0,35L$  away from the forward perpendicular.

**3.11.1.3.3** The parameters  $h_1$ ;  $h_3$ ;  $L_2$  (refer to Fig. 3.10.1.3.2) shall be adopted from Table 3.11.1.3.3.

Table 3.11.1.3.3

Parameter, in m	Ice category	
	Ice2, Ice3	Arc4, Arc5
$h_1$	0,3	0,5
$h_3$	0,6	0,8
$L_2$	0,10L	0,15L

**3.11.1.3.4** In tugs of **Ice2** and **Ice3** categories, an intermediate region of ice strengthening may also be established, and its boundaries shall be determined on the basis of the same regulations as for tugs of higher categories.

**3.11.1.3.5** The regions of ice strengthening of tugs to which the requirements of this Chapter apply shall be determined proceeding from Table 3.10.1.3.4 as in the case of a transport ship of the respective ice category, with due regard for 3.11.1.3.4.

#### 3.11.2 Construction.

**3.11.2.1** The ice-strengthening construction of tugs shall comply with the requirements of 3.10.2 for the construction of ice ships of respective categories.

**3.11.2.2** The hull attachments of ice-protection components of the screw-rudder system shall ensure

their reliable connection to main and web framing and, as far as practicable, to the sternframe and to longitudinal and transverse bulkheads so as to rule out the possibility of crack formation as a result of ice impacts on the stern.

#### 3.11.3 Ice load.

**3.11.3.1** The ice pressure shall be determined by the following formulae:

**.1** in region AI

$$p_{AI} = k_p p_{AI}^c \quad (3.11.3.1.1)$$

where  $p_{AI}^c$  = ice pressure in region AI, as determined in accordance with 3.10.3.2.1 as in the case of a transport ship whose ice category number coincides with the ice category number of the tug;

$$k_p = \begin{cases} 1 & \text{with } N_\Sigma \leq N_0; \\ (N_\Sigma/N_0)^{0,4} & \text{with } N_\Sigma > N_0; \end{cases}$$

$N_\Sigma$  = total shaft power of tug, in kW;  
 $N_0 = C_N \Delta^{2/3}$ ;  
 $C_N$  = factor to be adopted from Table 3.11.3.1.1;  
 $\Delta$  = displacement to summer load waterline, in t;

Table 3.11.3.1.1

Factor	Ice category of tug			
	Ice2	Ice3	Arc4	Arc5
$C_N$	14	16	18	20

**.2** in regions AII, BI and CI

$$p_{kI} = a_k p_{AI} \quad (3.11.3.1.2)$$

where for  $p_{AI}$ , refer to 3.11.3.1.1;

$a_k$  = factor to be adopted from Table 3.11.3.1.2 proceeding from the region of ice strengthening and the ice category of tug;

$k = A_1, B, C$ ;

Table 3.11.3.1.2

Region	Ice category of tug			
	Ice2	Ice3	Arc4	Arc5
A <sub>1</sub> I	0,55	0,6	0,65	0,65
BI	0,4	0,5	0,55	0,6
CI	0,65	0,7	0,75	0,75

**.3** in regions II, III and IV, an ice pressure shall be taken as required by 3.10.3.2.5 as in the case of transport ships with respective ice categories.

**3.11.3.2** For tugs the vertical extension of ice load shall be adopted equal in all regions and shall be determined in accordance with 3.10.3.3.1 as in the case of the forward region of a transport ship whose ice category number coincides with that of the tug. When determining  $u_m$ , the values of  $u$  shall be found for those sections only which are included in the forward region of ice strengthening of the tug.

**3.11.3.3** For tugs the horizontal extension of ice load shall be adopted equal in all regions and shall be

determined in accordance with 3.10.3.4.1 as in the case of the forward region of a transport ship whose ice category number coincides with that of the tug. When determining  $\beta_m$ , only those sections shall be considered which are included in the forward region of ice strengthening of the tug.

#### 3.11.4 Scantlings of ice-strengthening structures.

**3.11.4.1** The scantlings of ice-strengthening structures in tugs shall be determined in accordance with 3.10.4 as in the case of transport ships of the corresponding category, unless expressly provided otherwise below.

**3.11.4.2** When establishing the shell plating thickness in regions of ice strengthening in accordance with 3.10.4.1, the wear allowance  $\Delta S_{sp0}$  may be reduced on agreement with the Register, if special measures are taken to protect the shell plating from corrosion wear and abrasion, but in any case,  $\Delta S_{sp0}$  shall be adopted not less than 2 mm.

**3.11.4.3** In addition to the requirements of 3.10.4.10, the stem and sternframe shall have a sectional area not less than determined by the formula

$$S = kS_0 \quad (3.11.4.3)$$

where  $k$  = factor whose values shall be found in Table 3.11.4.3;

$S_0$  = area of the tug stem or sternframe without ice strengthening, to be determined in accordance with 3.9.4.5 or 3.9.4.6.

Table 3.11.4.3

Structural item	$k$			
	Ice2	Ice3	Arc4	Arc5
Stem	1,2	1,3	1,4	1,5
Sternframe	1,1	1,2	1,3	1,4

### 3.12 FLOATING DOCKS

#### 3.12.1 General.

##### 3.12.1.1 Application.

The requirements of this Chapter apply to hull structures of wing-walled (caisson, pontoon, sectional) docks.

Caisson dock is a structure fitted with a solid pontoon and two wings continuous along the entire length and structurally inseparable (including caisson docks with end pontoons for docking a centre pontoon).

Pontoon dock is a structure fitted with two wings continuous along the entire length and several pontoons connected to the wings by bolts, rivets, welding.

Sectional dock is a structure consisting of several sections, each section being a caisson or a pontoon dock, connected by bolts, welded plates, hinges.

The requirements apply to the docks having a ratio of the length over the pontoon deck to the breadth more than 3,5.

Other structural configurations of docks and their proportions require individual consideration.

**3.12.1.2** For the purpose of this Chapter, the following definitions have been adopted.

**Ballast water** is sea water pumped into ballast compartments in order to change dock's draught and trim.

**Ballast compartment** is a compartment in a pontoon or wing wall of the dock, bounded by water-tight structures and intended for pumping ballast water.

**Dock wing wall** is a part of floating dock hull structurally connected to a pontoon or pontoons and intended to provide stability when the dock is lowered and lifted; a wing wall is divided by decks, platforms, bulkheads into spaces and compartments for arranging dock equipment and ballast.

**Air cushion** is an area of a higher air pressure between the top of compartment and a level of ballast water therein.

**Depth of the dock  $D$**  is the vertical distance measured at the midship section from the base line to the moulded surface of the top deck at the outer wall side.

**Pontoon depth  $D_p$**  is the distance measured at the centre line from the base line to the moulded surface of the pontoon deck.

**Lifting capacity of the dock  $\Delta$** , in tons, is mass of the heaviest ship or ships that the dock shall lift in normal service.

**Length of dock at the pontoon deck  $L_{p,d}$**  is the distance measured along the pontoon deck parallel to the base line between moulded surfaces of the pontoon end bulkheads.

**Length of keel blocks track  $L_k$**  is the distance measured at the centre line parallel to the base line between outer ends of keel blocks.

**Ship weight for docking  $\Delta_s$** , in tons, is weight of the light ship to be docked with necessary stores and ballast to provide the ship's draught and trim as required for docking.

**Design waterline** is a waterline of a floating dock corresponding to its draught with full stores, a ship of a design weight and a required quantity of ballast.

**Crinolines** are cantilever structures of the dock, fitted at the end bulkheads of the dock pontoon at the pontoon deck level, aiming to increase an area available for docking operations at the ship's ends projecting beyond the pontoon deck.

**Light draught  $d_l$**  is a vertical distance measured at the midship section from the base line to the waterline corresponding to the dock displacement with no stores, docked ship and ballast.

Rest water ballast is ballast water which pumps cannot discharge.

Safety deck is the watertight deck in wing walls of the dock, forming a boundary of the ballast compartments from above.

Maximum submersion depth  $d_{m.s}$  is a vertical distance measured at the midship section from the base line to the waterline to which the dock may theoretically be lowered.

Pontoon is a part of the dock hull intended to maintain buoyancy of the dock which is defined by volumes of its compartments.

Compensating ballast water is ballast water pumped into ballast tanks in order to reduce transverse and/or longitudinal bending moments and deflections of pontoon and/or wing wall structures.

Design draught  $d$  is a vertical distance measured from the base line to the design waterline.

Pontoon deck is the deck on which keel blocks or bilge blocks are fitted.

Dry compartment is a compartment below the safety deck (or below the margin line where safety deck is omitted) not intended for pumping ballast water.

Top deck is the uppermost deck of dock wing walls.

Wall breadth at top deck  $b_{t.d}$  is a distance measured normal to the centre line between the moulded surfaces of the inner and outer wall sides at the level of the moulded surface of the top deck.

Wall breadth at pontoon deck  $b_{p.d}$  is the distance measured normal to the centre line between the moulded surfaces of the inner and outer wall sides at the level of the moulded surface of the pontoon deck.

Breadth of the dock  $B$  is the distance measured normal to the centre line between the moulded surfaces of the outer wall sides.

Pontoon deck breadth  $B_{p.d}$  is the distance measured normal to the centre line between the lines of intersection of moulded surfaces of the inner wall sides and the pontoon deck.

### 3.12.1.3 Materials.

3.12.1.3.1 When selecting steel for hull structures of floating docks, provisions of 1.2 shall be applied, having regard to subdivision of structural members into groups according to Table 3.12.1.3.1.

3.12.1.3.2 Plate and beam items of crinolines, walkways and other secondary structures of a floating dock may be fabricated from steel having lower strength characteristics than specified in 1.2.2.1, provided their welding is guaranteed at the shipyard.

### 3.12.1.4 Estimation of wear. Minimum thicknesses.

3.12.1.4.1 The effect of wear on the scantlings of structures is estimated on the basis of specification of strength to the end of the dock service life. Corrosion allowances shall permit operation of the dock during the full specified service life with average corrosion rates of structural items.

3.12.1.4.2 Scantlings and strength characteristics of structures with due regard for wear and corrosion shall be determined in compliance with 1.1.5, with a corrosion allowance  $\Delta s$ , in mm, being determined by the formula

$$\Delta s = kuT \quad (3.12.1.4.2)$$

where  $k$  = factor taking into account zone conditions of floating dock service and equal to: 1,0 for Baltic basin; 1,1 for Northern, Black-and-Azov and Caspian-and-Volga basins; 1,2 for Pacific basin;

$u$  = average annual reduction in thickness of structural members according to Table 3.12.1.4.2, in mm/year;

$T$  = design service life of dock; where service life is not specified, it shall be taken as  $T = 50$  years.

3.12.1.4.3 Average annual thickness reduction of dock structures plates and beams, given in Table 3.12.1.4.2, shall be used when dock structures have appropriate protective paint coatings.

Table 3.12.1.3.1

Dock members	Group of members	
	within midship region	outside midship region (refer to 1.1.3)
Thickened top deck plates in way of openings; bottom plating of pontoon deck wing walls and plate strengthenings of pontoon structures in pontoon docks at sections between pontoons and in adjacent regions, plate members of sectional dock structures in way of dock section connections	III	II
Pontoon deck plating and bottom plating of pontoon (pontoons); transverse and longitudinal framing members of pontoon deck and bottom; plate structures of primary transverse members (non-tight and tight bulkheads) of pontoon (pontoons); bottom strakes of wing walls and adjacent strakes of shell plating, longitudinal bulkhead plating of pontoon docks	II	II
Plating strakes, framing members of top deck, safety deck, wing walls and pontoon shell plating; plates and framing members of wing wall interior structures (other than dock structural members referred to in 1 and 2)	II	I

Table 3.12.1.4.2

Nos	Structure	$u$
1	Top deck plating and wing wall plating above margin line	0,04
2	Safety deck plating	0,08 <sup>1</sup>
3	Wing wall bottom of pontoon docks	0,08
4	Inner and outer wing wall plating from pontoon deck to the margin line	0,08 <sup>1</sup>
5	Pontoon deck plating:	
5.1	in the middle portion	0,10
5.2	at ends over a length $0,1Lp.d$	0,12
6	Side plating and outer transverse wall plating of pontoon (pontoons):	
6.1	top ( $\leq 1,0$ m) and bottom ( $\leq 0,5$ m) strakes	0,09 <sup>1</sup>
6.2	other strakes	0,08 <sup>1</sup>
7	Bottom plating of pontoon (pontoons)	0,08 <sup>1,2</sup>
8	Interior bulkheads of ballast compartments:	
8.1	bottom stake ( $\leq 0,5$ m)	0,09
8.2	other strakes	0,08 <sup>1</sup>
9	Framing members, dock truss items in ballast compartments	0,10 <sup>1</sup>
10	Plates and framing members of internal wing structures above safety deck, top deck and wing wall framing	0,04

<sup>1</sup> In way of compartments heated in winter by live steam,  $u$  shall be increased by 10 per cent.  
<sup>2</sup> For bottom plating in way of ballast system suctions and discharges  $u$  shall be increased by 15 per cent.

Specified corrosion rates may be reduced if special protective arrangements are made on agreement with the Register.

**3.12.1.4.4** Thickness of primary members (including corrosion allowance) shall not be less than given in Table 3.12.1.4.4 and determined depending on the assumed spacing  $a$ .

**3.12.1.5** Guidelines on design of floating dock structures.

When designing floating dock structures, the following sequence is recommended:

**.1** execution of structural layout of pontoon (pontoons) and wing walls (refer to 3.12.2);

**.2** determination of design loads resulting in local and longitudinal deflection of dock hull structures (refer to 3.12.3);

**.3** design of plate items and framing members of dock structures on the basis of local strength and buckling, having regard to minimum thickness restrictions;

**.4** design of structures which provide both transverse and longitudinal strength of dock pontoon. Values of structural parameters obtained in implementation of 3.12.1.5.3 are used here as initial data;

**.5** design of dock hull structures which provide dock longitudinal strength under design operating conditions (docking operations). Values of structural

Table 3.12.1.4.4

Structure	$s_{\min}$ , in mm	Note
Plating of outer structures other than pontoon deck; structural items in ballast compartments and tanks, including framing members	7,5 $7,5 + 10(a - 0,6)$ $8,0 + 6,5(a - 0,6)$	$a < 0,6$ m $a \leq 0,75$ m $a > 0,75$ m
Pontoon deck plating	9,0 $9,0 + 13(a - 0,6)$ $10,0 + 6(a - 0,6)$	$a < 0,6$ m $a \leq 0,75$ m $a > 0,75$ m
Top deck plating; plates and beams of structures above safety deck	$6,5 + 8(a - 0,6)$ 6,5	$a \geq 0,6$ m $a < 0,6$ m

parameters obtained in implementation of 3.12.1.5.3 and 3.12.1.5.4 are used here as initial data;

**.6** design of structures, having regard to the requirements for strengthening (e.g. wing wall decks and sides in way of openings, engine room, etc.);

**.7** check calculations of both longitudinal and transverse, as well as local strength of hull structures under conditions of real ship docking;

**.8** check calculations of both longitudinal and transverse, as well as local strength of dock structures during passage from a place of build to a place of operation. Development of recommendations on dock structure strengthening.

### 3.12.2 Construction.

**3.12.2.1** Framing systems of pontoon (pontoons) and wing walls.

For pontoon (pontoons) of caisson, pontoon and sectional docks transverse framing is preferable.

Wing wall sides and decks of pontoon docks with lifting capacities of 10 000 t and above shall be longitudinally framed; docks having lifting capacities below 10 000 t may be framed transversely.

Wing wall sides and decks of caisson docks above the safety deck shall be longitudinally framed, wing wall sides below the safety deck may be transversely framed.

For pontoon bottom plating portions of caisson docks in way of wing walls a longitudinal framing may be adopted.

For transverse and longitudinal bulkheads of the pontoon and wing walls structures with horizontal and vertical stiffeners are permitted.

Truss arrangements may be used in the pontoon (pontoons) and wing walls.

### 3.12.2.2 Structural layout of pontoons.

Plate and beam structures of the pontoon shall maintain local strength of the appropriate pontoon structures (pontoon deck, bottom, longitudinal and transverse bulkheads, etc.), as well as transverse strength of the pontoon.

Spacing of primary longitudinal and transverse framing members of the pontoon shall be determined according to 1.1.3 with  $L = L_{p,d}$ .

Primary transverse structures of the pontoon (pontoons), i.e. non-tight bulkheads, shall be fitted in 3 to 7 spacings, but they shall not be spaced more than  $(B - b_{p,d})/6$  apart.

A centre line bulkhead shall be fitted under the keel blocks. A box structure formed by two longitudinal bulkheads arranged symmetrically on each side of the centre line may be used in lieu of the centre line bulkhead.

Bulkheads or girders shall be aligned with inner wall sides.

Where transverse framing is adopted for a pontoon (pontoons), additional primary longitudinal supporting

members may be fitted to limit a span of transverse members of the bottom and pontoon deck. They shall be spaced not more than 3 to 5 spacings apart.

### 3.12.2.3 Structural layout of wing walls.

Spacing of primary longitudinal and transverse framing members of wing walls shall be determined as required by 1.1.3.

Where wall sides and decks are longitudinally framed, deck transverses and web frames shall be aligned with primary transverse structures of the pontoon (pontoons) (refer to 3.12.2.2).

Where wall sides are transversely framed, side stringers shall be fitted. Spacing of stringers and distance between stringers and deck shall, in general, not exceed 3,5 m.

Where transverse framing is adopted for wing walls below the safety deck it is advisable to provide web frames on wall sides in line with primary transverse structures of the pontoon, and deck transverses on the safety deck plating.

Primary supporting members of outer and inner wall sides below the safety deck (web frames with longitudinal framing and side stringers with transverse framing) shall be connected by cross ties which shall be fitted in line with each primary transverse of the pontoon (refer to 3.12.2.2).

### 3.12.2.4 Additional provisions.

Use of butt-lap connections for girders and transverses of pontoon (pontoons) and wing walls is permitted.

Where proper quality control of welding joints is provided, assembling joints aligned on plate structures and framing members are permitted.

Hollow square and tubular cross ties and struts shall not be used in ballast compartments and other tanks.

### 3.12.3 Design loads.

**3.12.3.1** Loads for structure design based on local strength.

**3.12.3.1.1** Design pressure  $p$ , in kPa, for plate and beam bottom structures shall be determined by the formulae:

in way of dry compartments

$$p = 10d_{m,s}; \quad (3.12.3.1.1-1)$$

in way of ballast compartments not communicated with wing walls

$$p = 10(d_{m,s} - D_p), \quad (3.12.3.1.1-2)$$

and communicated with wing walls

$$p = 10(d_{m,s} - z_{s,d} + \Delta z) \quad (3.12.3.1.1-3)$$

where  $z_{s,d}$  = distance of the safety deck from the base line, in m;  
 $\Delta z$  = thickness of air cushion, in m.



**3.12.3.1.2** Design pressure  $p$ , in kPa, for plate and beam structures of the pontoon deck in way of dry and ballast compartments shall be determined by the Formula (3.12.3.1.1-2).

**3.12.3.1.3** Design pressure  $p$ , in kPa, for plate and beam structures of pontoon sides and end bulkheads shall be determined by the following formulae:

$$p = 10(d_{m.s} - z_i) \quad (3.12.3.1.3-1)$$

where  $z_i$  = distance of the lower edge of the plate or mid-span of the framing member from the base line, in m;

in way of ballast compartments

$$p = 10(d_0 - D_p) \quad (3.12.3.1.3-2)$$

where  $d_0$  = depth of the dock corresponding to filling of a side ballast compartment up to the safety deck, in m.

$d_0$  shall not be taken more than  $d_{m.s}$ .

As the first approximation, where no special information is available, it may be assumed that

$$d_0 = D_p + G/2L_{p.d}b_{p.d}\rho;$$

$G$  = mass of dock without rest water and compensating ballast;

$\rho$  = sea water density (refer to 1.1.3).

**3.12.3.1.4** Design pressure  $p$ , in kPa, for plate and beam structures of wall sides and end bulkheads shall be determined by the following formulae:

in way of dry compartments, using the Formula (3.12.3.1.3-1);

in way of ballast compartments

$$p = 10(d_0 - z_i) \quad (3.12.3.1.4)$$

where  $z_i$ ,  $d_0$  = as defined above.

**3.12.3.1.5** Design pressure  $p$ , in kPa, for plate and beam structures of the safety deck in way of dry compartments shall be taken equal to 5 kPa; in way of ballast compartments  $p$  shall be determined by the formula

$$p = 10(d_{m.s} - z_{s.d} + \Delta z) \quad (3.12.3.1.5)$$

where  $z_{s.d}$ ,  $\Delta z$  = as defined in 3.13.3.1.1.

**3.12.3.1.6** Design pressure  $p$ , in kPa, for plate and beam structures of inner watertight bulkheads of ballast compartments shall be determined by the formula

$$p = 10(d_{m.s} - z_t + \Delta z) \quad (3.12.3.1.6)$$

where  $z_t$  = distance of ballast compartment top from the base line, in m;

$\Delta z$  = as defined in 3.13.3.1.1.

**3.12.3.1.7** Design pressure  $p$ , in kPa, for plate and beam structures of main watertight bulkheads shall be determined by the Formula (3.12.3.1.3-1).

**3.12.3.1.8** Design pressure for plate and beam structures of the top deck shall be equal to 5 kPa.

**3.12.3.1.9** Design pressure  $p$ , in kPa, for plate and beam structures of fuel oil, lubricating oil, water and other tanks is determined by the following formulae: when internal pressure is calculated

$$p = 10\rho_1(z_{a.p} - z_i) \quad (3.12.3.1.9)$$

where  $\rho_1$  = density of liquid contained in the tank, in t/m<sup>3</sup>;

$z_{a.p}$  = distance of the upper edge of the air pipe from the base line, in m;

when external pressure is calculated, the Formula (3.12.3.1.3-1) shall be used.

For plate structures arranged parallel to the base line,  $z_i$  is the distance of the plate structure from the base line.

**3.12.3.1.10** Design pressure on crinoline structures is assumed to be equal to 5 kPa.

**3.12.3.1.11** Design pressure on walkway structures is assumed to be equal to 3,5 kPa.

**3.12.3.1.12** Design pressure on structures of safety deck, intermediate deck and platforms where equipment of the electric generating plant is arranged are assumed equal to 18 kPa; in way of accommodation and service spaces, 5 kPa.

**3.12.3.2** Loads for structure design based on both transverse and longitudinal strength of pontoon (pontoons).

**3.12.3.2.1** Design loads to be used in design of pontoon structures of caisson, pontoon and sectional docks shall be calculated for the condition when the ship of length  $L_s$  and weight equal to the maximum lifting capacity of the dock is supported on the keel blocks symmetrically about the midship section of the dock. The draught of the dock shall correspond to the design one (refer to 3.12.1.2); ballast water is considered evenly distributed over the length and breadth of the dock.

**3.12.3.2.2** For pontoon and sectional docks an additional condition shall be considered for pontoons loaded by buoyancy forces the value of which corresponds to the condition specified in 3.13.3.2.1 corrected for rest-water counterpressure and gravitational forces of light-dock weight components, opposite in direction.

Where no initial data are available, buoyancy force  $p$ , in kPa, may be determined by the formula

$$p = g\Delta/[BL_{p.d} - (n-1)Ba_0] \quad (3.12.3.2.2)$$

where  $n$  = number of pontoons of pontoon docks or sections of sectional docks;

$a_0$  = distance between pontoons or sections, in m.

**3.12.3.2.3** Design length of the ship  $L_c$  shall be assumed equal to the length of the shortest ship

whose docking weight is equal to the maximum lifting capacity of the dock, but not more than  $0,9L_{p.d.}$ . For docks having lifting capacity more than 40 000 t, the design length of the ship shall not be taken less than  $0,9L_{p.d.}$ .

**3.12.3.2.4** The weight curve of the ship shall be taken as a rectangle with a superimposed parabola of half the area of the rectangle. Linear docking load  $q_x$ , in kN/m, at the section distant at  $x$  forward and aft from the midship section shall be determined by the formula

$$q_x = \frac{g\Delta}{L_s\phi} [1 - 3(1 - \phi)(2x/L_s)^2] \quad (3.12.3.2.4)$$

where  $\phi$  = block coefficient of ship weight curve.

For docks of 40 000 t lifting capacity and less block coefficient of the ship weight curve shall be assumed depending on a design ship type according to Table 3.12.3.2.4.

Table 3.12.3.2.4

Type of ship	$\phi$
Icebreakers	0,67
Ships with engine room amidships	0,75 — 0,8
Ships with engine room aft or semi-aft	1,0

For docks above 40 000 t lifting capacity,  $\phi = 0,8$  shall be assumed.

**3.12.3.2.5** Where it is intended to lift ships simultaneously on keel and side blocks, as well as where different cases of simultaneous docking of several ships are expected, they shall be taken into account in design of structures which provide both longitudinal and transverse strength of the pontoon. Design loads shall be determined using the procedures approved by the Register.

**3.12.3.2.6** Design loads on end pontoons of pontoon and sectional docks or on the end portions of caisson docks and when ships with overhung ends are docked shall be specially considered by the Register.

**3.12.3.3** Loads for design of structures based on longitudinal strength.

**3.12.3.3.1** Design loads shall be determined for the following conditions:

dock's sagging when a ship having the shortest length  $L_s$  expected and a weight equal to the maximum lifting capacity of the dock  $\Delta$  is lifted;

dock's hogging when a ship having the largest length  $L_s$  expected and a weight equal to the maximum lifting capacity of the dock  $\Delta$  is lifted, or two or

more ships installed in line and having a total weight equal to  $\Delta$  are docked.

Ballast water is considered to be evenly distributed over the entire length of the dock.

**3.12.3.3.2** The form of ship weight curve is determined by the Formula (3.12.3.2.4).

**3.12.3.3.3** The design length of the shortest ship shall be as required by 3.12.3.2.3.

The design length of the largest ship or a total length of several ships installed in line over the length of the dock shall not be less than  $1,3L_{p.d.}$ .

**3.12.3.3.4** The design block coefficient of the ship weight curve shall be assigned according to 3.12.3.2.4; for hogging,  $\phi = 1,0$  shall be taken, unless expressly provided otherwise.

### 3.12.4 Scantlings of structural members.

**3.12.4.1** The thickness requirements for plate structures based on local strength.

The plating thicknesses of pontoon (pontoons), wall sides, interior and outer watertight bulkheads, decks and platforms shall be determined by the Formula (1.6.4.4) with  $m = 22,4$  and  $k_\sigma = 1,8$ . A corrosion allowance shall be obtained according to the recommendations given in 3.12.1.4. The design transverse pressure  $p$  is specified in 3.12.3.1.

**3.12.4.2** Scantling requirements for framing members based on local strength.

**3.12.4.2.1** The section modulus of primary members shall be determined as required by 1.6.4.1.

**3.12.4.2.2** The net sectional area of girders and transverses, as well as sectional area of beams and longitudinals having a relationship  $l/h \leq 10$  (where  $l$  = design span, in m;  $h$  = web depth of a beam or longitudinal, in cm) shall be obtained from 1.6.4.3.

**3.12.4.2.3** The design pressure  $p$  shall be determined at a mid-span of framing members as required by 3.12.3.1.

**3.12.4.2.4** The design span  $l$  of framing members shall be selected in accordance with 1.6.3.1.

**3.12.4.2.5** Coefficients of permissible normal and shear stresses specified in 1.6.4.1 and 1.6.4.3 shall be assumed equal to  $k_\sigma = 0,8$  and  $k_\tau = 0,8$ .

**3.12.4.2.6** The factor  $\omega_c$  which takes account of framing member wear as given in 1.1.5.3 shall be taken with  $\Delta_s$  according to 3.12.1.4.

**3.12.4.2.7** Factors of design bending moments  $m$  and shear forces  $n$  shall be assumed as follows:

$m = 12$  and  $n = 0,5$  for bottom transverse and longitudinal members, beams and longitudinals of the pontoon deck; for stiffeners of watertight transverse bulkheads with longitudinally framed bottom and pontoon deck; for stiffeners of interior watertight longitudinal bulkheads with transversely framed bottom and pontoon deck; for longitudinal framing members of wall sides and decks; for safety deck beams with transversely framed wall sides below the safety deck; for

girders and transverses of bottom and pontoon deck and side stringers of outer and inner wall sides;

$m = 8$  and  $n = 0,5$  for stiffeners of watertight transverse bulkheads with transversely framed bottom and pontoon deck; for stiffeners of interior longitudinal bulkheads with longitudinally framed bottom and pontoon deck; for horizontal stiffeners of watertight transverse bulkheads of wing walls with transversely framed wall sides; for safety deck beams with longitudinally framed wall sides;

$m = 13$  and  $n = 0,5$  for wall deck and platform beams with transversely framed wall sides below the considered deck or platform; top deck or safety deck transverses;

$m = 11$  and  $n = 0,6$  for frames and web frames of the pontoon (pontoons), outer and inner wall sides.

**3.12.4.2.8** The scantlings and structures of girders and transverses of the pontoon and wing walls shall satisfy the requirements of 1.7.3.3. For girders and transverses of the wing walls above the safety deck the requirements for similar structures of dry cargo ships may be applied.

**3.12.4.3** Requirements for cross ties, struts and braces.

**3.12.4.3.1** The sectional area of cross ties and struts  $S$ , in  $\text{cm}^2$ , shall not be less than determined by a successive approximation method using the Formula (2.9.4.1) with a design load  $P = 0,5(P_1 + P_2)$ , in kN, and factor  $k = 1,15$  (where  $P_1 = p_1ac$ ,  $P_2 = p_2ac$  are maximum compressive forces acting at the ends of struts and cross ties;  $p_1$  and  $p_2$  are design pressures (refer to 3.12.3.1), in kPa;  $a$  = distance between members supported by struts or cross ties, in m;  $c$  is half-sum of span lengths on each side of the strut or cross tie under consideration, in m).

As a first approximation,  $S$  may be taken as:

$$S = 0,11P$$

and the radius of gyration  $i = \sqrt{I/S}$ , in cm, may be estimated for a suitable section having this area (where  $I$  = minimum central moment of inertia,  $\text{cm}^4$ ). If the area determined by the Formula (2.9.4.1-1) using this radius of gyration differs by more than 10 per cent from the first approximation, a second approximation calculation shall be made. The radius of gyration shall correspond to the mean area of the first and second approximation.

**3.12.4.3.2** The web plates of cross ties and struts of channel or I sections shall be so selected that the ratio of the breadth to the thickness shall not exceed  $42/i$  or 40, whichever is the greater (where  $l$  is length of a cross tie or strut, in m).

For ordinary angle or channel sections, the ratio of the breadth to the thickness of the flanges shall not exceed  $14/i$  or 13, whichever is the greater.

For cross ties of fabricated sections or I sections cross ties, the ratio of the breadth to the thickness of face plates shall not exceed  $28/i$  or 25, whichever is the greater.

The thickness of cross tie or stay items shall not be less than 7,5 mm.

**3.12.4.3.3** The scantlings of trusses shall be determined according to a procedure approved by the Register.

**3.12.4.4** Additional local strength requirements for plates and beams.

If hull structures of the dock are subjected to the loads not covered by 3.12.3.1, the scantlings of plates and beams shall be determined using the procedures approved by the Register.

**3.12.4.5** Scantling requirements for primary transverse and longitudinal members of pontoon (pontoons).

**3.12.4.5.1** The section modulus  $W$ , in  $\text{cm}^3$ , of the primary transverse and longitudinal members of the pontoon (pontoons) shall be determined by the formula

$$W = W' + \Delta W \quad (3.12.4.5.1-1)$$

where  $W'$  = specified section modulus of the end of the dock service life to be determined by the formula

$$W' = M10^3/k_\sigma\sigma_n, \quad (3.12.4.5.1-2)$$

where  $M$  = design bending moment, in kN·m (refer to also 3.12.4.5.6);

$\Delta W$  = corrosion allowance to the section modulus to be determined by the formula

$$\Delta W = 100h[\Delta f_d + \frac{\Delta f_w}{(2-\beta)}], \quad (3.12.4.5.1-3)$$

$h$  = web depth of members of the section under consideration, in m;

$\Delta f_d, \Delta f_w$  = additions to the upper flange and web area of members, respectively, including corrosion allowances as based on the entire service life of the dock, in  $\text{cm}^2$ , determined by the formulae:

$$\Delta f_d = 10\Delta s_d b_{e,f} + \Delta f_{fr};$$

$$\Delta f_w = 10\Delta s_w h;$$

$\Delta s_{d(w)} = u_{d(w)}T$  — reduction, in mm, of the plating thickness of the pontoon deck (member web) due to wear during service life of the dock  $T$  (years) with corrosion rate  $u_{d(w)}$ , in mm/year, according to Table 3.12.1.4.2;

$b_{e,f}$  = width of the effective flange (refer to 3.12.4.5.5), in m;

$\Delta f_{fr}$  = addition to the flange area of the member allowing for corrosion wear of framing members, to be taken as:

for framing members of tee sections or flat

$$\Delta f_{fr} = 0,1n(b_0 + h_0)u_{fr}T; \quad (3.12.4.5.1-4)$$

for framing members of bulb flat

$$\Delta f_{fr} = 0,86nf_0u_{fr}T/s_0; \quad (3.12.4.5.1-5)$$

When addition  $\Delta f_{fr}$  is determined, results obtained in design of framing members based on local strength (refer to 3.12.4.2) are used. Where the sectional area of members does not include primary members,  $\Delta f_{fr} = 0$ ;

$n$  = number of primary members over the breadth  $b_{e,f}$ ;

$b_0$  and  $h_0$  = face plate width and web depth of T-beam, respectively (for members of flat,  $b_0 = 0$ ), in cm;

$f_0$  = area of isolated section;

$s_0$  = web thickness of bulb flat;

$u_{fr}$  = specified corrosion rate for framing members of ballast compartments (refer to Table 3.12.1.4.2), in mm/year;  
 $\beta$  = factor dependent on web areas  $f'_w$  of the upper  $f'_d$  and lower  $f'_b$  face plates, having regard to wear to the end of the service life, to be determined by the formula

$$\beta = (2f'_d + f'_w)/(2f'_d + f'_w); \quad (3.12.4.5.1-6)$$

as a first approximation, it may be assumed that  $\beta = 1.0$ .

**3.12.4.5.2** The sectional area of the web  $f_w$ , in  $\text{cm}^2$ , of primary transverse members of the pontoon (pontoons) shall be determined by the formula

$$f_w = f'_w + \Delta f_w \quad (3.12.4.5.2-1)$$

where  $f'_w$  = specified sectional area, in  $\text{cm}^2$ , of the web to the end of the service life of the dock, to be determined by the formula

$$f'_w = 10N_x/k\tau_n; \quad (3.12.4.5.2-2)$$

$N_x$  = designed shear force (refer to 3.12.4.5.7), in kN;  
for  $\Delta f_w$ , refer to 3.12.4.5.1.

**3.12.4.5.3** The scantlings of the truss (struts and braces) of the pontoon (pontoons) shall be adequate to take shear forces arising in longitudinal bending of the pontoon.

**3.12.4.5.4** To be included in the design section of primary transverse members of the pontoon (pontoons) are all structural items which are continuous between the pontoon sides; design section of primary longitudinal members shall include all structural items which are continuous between the end bulkheads of the pontoon.

**3.12.4.5.5** The width of the effective flanges of the primary transverse members  $b_{e,f}$ , in m, of the bottom and pontoon deck plating shall be taken as:

$$b_{e,f} = \min\{(B - b_{p,d})/6; c\} \quad (3.12.4.5.5)$$

where  $c$  = average distance between the member under consideration and members on the right and on the left thereof, in m.

**3.12.4.5.6** The design bending moments  $M_x$  and  $M_y$ , in  $\text{kN}\cdot\text{m}$ , acting in transverse and longitudinal members at the middle of a continuous pontoon of a caisson dock (Fig. 3.12.4.5.6-1) for the cases referred to in 3.12.3.2, shall be determined by the formulae:

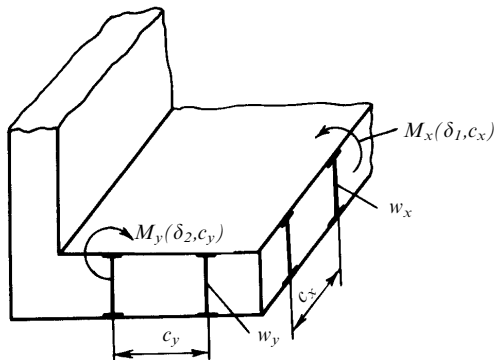


Fig. 3.12.4.5.6-1

$$M_x = q(B - b_{p,d})c_x\delta_1; \quad (3.12.4.5.6-1)$$

$$M_y = q(B - b_{p,d})c_y\delta_2 \quad (3.12.4.5.6-2)$$

where  $q = q\Delta/L_s$  = average value of the linear load of the dock, in  $\text{kN/m}$  ( $L_s$ ,  $\Delta$  as defined in 3.12.3.2);

$B$ ,  $b_{p,d}$  = breadth of the dock and wing wall at the pontoon deck level;

$c_x$ ,  $c_y$  = distance between primary transverse and longitudinal members of the pontoon, respectively, as shown in Fig. 3.12.4.5.6-1, in m;

$\delta_1$ ,  $\delta_2$  = factors to be obtained from the diagrams given in Fig. 3.12.4.5.6-2 and 3.12.4.5.6-3 as dependent on parameters  $L_s/L_{p,d}$ ,  $n = L_{p,d}/(B - b_{p,d})$  and  $\phi$ .

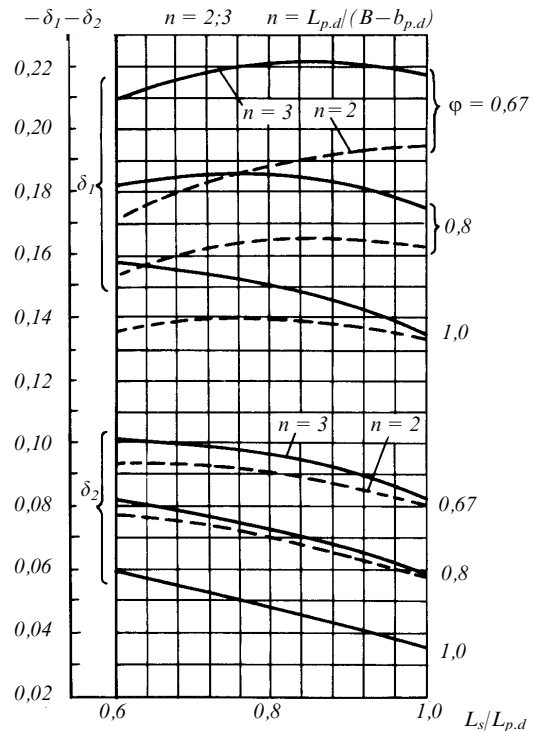


Fig. 3.12.4.5.6-2

For pontoon and sectional docks, the design bending moment in design of primary transverse members  $M_{x_s}$ , in  $\text{kN}\cdot\text{m}$ , shall be equal to the greater of the two values:

$$M_x = 0,25q \frac{c_x}{\phi} (B - b_{p,d})(1 - 0,5\phi \frac{L_s}{L_{p,d}} \frac{B - b_{p,d}}{B}); \quad (3.12.4.5.6-3)$$

or

$$M_x = 0,125pc_x(B - b_{p,d})^2 \quad (3.12.4.5.6-4)$$

where  $p$  = as defined in 3.12.3.2.2,

whichever is the greater.

**3.12.4.5.7** The design shear force  $N_{x_s}$ , in kN, taken by a transverse member of the dock (primary transverse member, or struts and braces of the pontoon truss) shall be determined by the formula

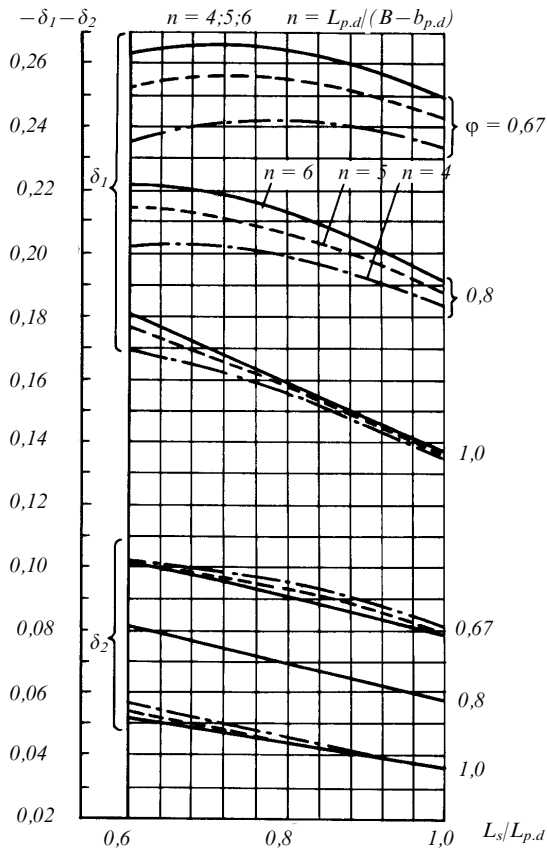


Fig. 3.12.4.5.6-3

$$N_x = 0,75 \frac{g\Delta}{L_s} (1 - 1,33 \frac{L_s}{L_{p.d}} \frac{y}{B}) c \quad (3.12.4.5.7-1)$$

where  $y$  = distance of the section under consideration from the centre line of the dock, in m;  
 $c$  = distance between the members under consideration, in m.

In design of the primary transverse members or struts and braces of the pontoon trusses of pontoon and sectional docks, the design shear force  $N_x$ , in kN, shall not be taken less than:

$$N_x = pcy \quad (3.12.4.5.7-2)$$

where  $p$  = as defined in 3.12.3.2.2.

**3.12.4.5.8** The coefficients of permissible stresses in the Formulae (3.12.4.5.1-2) and (3.12.4.5.2-2) in design of primary transverse members of the pontoon (pontoons) shall be taken as follows:  $k_\sigma = 0,85$ ,  $k_\tau = 0,8$ .

Guidelines on the selection of permissible normal stresses in primary longitudinal members of the pontoon of caisson-type docks are given in 3.12.4.6.5.

**3.12.4.5.9** The web thickness of primary transverse members shall meet the buckling strength re-

quirements under the action of shear and normal stresses arising in transverse bending of the pontoon (pontoons).

The plating thickness of the pontoon deck and bottom shall meet the requirements for buckling strength under the action of compressive stresses arising in transverse bending of the pontoon (pontoons).

**3.12.4.5.10** Buckling strength conditions shall comply with 1.6.5.2 and 1.6.5.3. Factor  $k$  in the Formula (1.6.5.2-1) is taken equal to 0,75.

When Euler's stresses are determined according to the formulae given in 1.6.5.5 it shall be taken that  $s' = s - \Delta s$ , where  $\Delta s$  is obtained in compliance with 3.12.1.4.

**3.12.4.6** The scantling requirements for structures based on strength and buckling conditions in longitudinal bending.

**3.12.4.6.1** The assumed scantlings of dock longitudinal structures (with regard to the provisions of 3.12.4.6.2) shall provide the required hull section modulus of the floating dock.

The hull section modulus  $W$ , in  $\text{cm}^3$ , of a floating dock shall not be less than:

$$W = W' \omega_c \quad (3.12.4.6.1-1)$$

where  $W'$  = specified section modulus to the end of the service life of the dock, in  $\text{cm}^3$ , determined by the formula

$$W' = M \cdot 10^3 / k_\sigma \sigma_n; \quad (3.12.4.6.1-2)$$

$M$  = maximum bending moment determined by the Formula (3.12.4.6.3), in kN-m;

$\omega_c$  = factor which takes account of corrosion allowance to the section modulus for wear determined by the formula

$$\omega_c = (1 - F^{-1} \sum \Delta f_i \varphi_i)^{-1}; \quad (3.12.4.6.1-3)$$

$F$  = sectional area of the floating dock hull, in  $\text{cm}^2$ , corresponding to the Rule section modulus  $W$ ;

$\Delta f_i$  = addition to the sectional area of the  $i$ -th plate strake, which takes account of corrosion allowance to be determined by the formula

$$\Delta f_i = 10 \Delta s_i b_i; \quad (3.12.4.6.1-4)$$

$\Delta s_i = u_i T$  — thickness reduction of the  $i$ -th plate member due to wear during service life  $T$  (years), with a corrosion rate  $u_i$ , in mm/year, taken according to Table 3.12.1.4.2, in mm;

$b_i$  = width of the  $i$ -th member, in m.

Additions to the sectional area of the floating dock hull which take account of corrosive wear of framing members shall be not less than those determined by the following formulae:

for framing members of tee sections or flat

$$\Delta f_i = 0,1 n_i (b_{0i} + h_{0i}) u_{fr} T \quad (3.12.4.6.1-5)$$

where  $n_i$  = number of framing members of the  $i$ -th group;

$b_{0i}$ ,  $h_{0i}$  = face plate width and web depth of T-beam, respectively, in cm (for members of flat,  $b_{0i} = 0$ );

for framing members of bulb flat

$$\Delta f_i = 0,86n_i f_{0i} u_{fr_i} T / s_{0i} \quad (3.12.4.6.1-6)$$

where  $f_{0i}$  = sectional area of bulb flat section proper, in  $\text{cm}^2$ ;  
 $u_{fr_i}$  = corrosion rate of framing members of the  $i$ -th group, in mm/year;  
 $s_{0i}$  = web thickness of bulb flat;  
 $\varphi_i$  = multiplier taking account of the effect of changing sectional area of the  $i$ -th member on the section modulus  $W$ , to be determined by the formula

$$\varphi_i = c_i^2 (F/I) + c_i / z_0 \quad (3.12.4.6.1-7)$$

where  $I$  = hull inertia moment, in  $\text{cm}^2/\text{m}^2$ , of the dock, corresponding to the specified section modulus  $W$ ;  
 $z_0$ ,  $c_i$  = distance of the point at the level of which section modulus is determined and centre of gravity of sectional area of the  $i$ -th member ( $i$ -th group of longitudinal members) from the neutral axis, the position of which corresponds to  $W$  and  $I$ ; in determination of  $z_0$  and  $c_i$  their sign shall be taken into account: positive downwards and negative upwards from the neutral axis.

**3.12.4.6.2** Wing wall and pontoon longitudinals continuous in the middle region of the dock shall be included in the design cross-section of a caisson-type floating dock.

To be included in the design section of a pontoon dock are wing wall longitudinals continuous in the middle region of the dock.

**3.12.4.6.3** The design bending moment  $M$ , in  $\text{kN}\cdot\text{m}$ , shall be determined for the cases referred to in 3.12.3.3, by the formula

$$M = -0,125g\Delta L_{p,d} \left(1 - \frac{3\varphi - 1}{2\varphi} \frac{L_s}{L_{p,d}}\right). \quad (3.12.4.6.3)$$

Recommendations on the choice of design values of  $\varphi$  and  $L_s$  are given in 3.12.3.3.2.

**3.12.4.6.4** The coefficient of permissible stresses due to longitudinal bending referred to in the Formula (3.12.4.6.1-2) shall be taken as  $k_\sigma = 1,0$ .

**3.12.4.6.5** For caisson-type docks the following condition shall be fulfilled:

$$\sigma_1 + \sigma_2 \leq k_\sigma \sigma_n \quad (3.12.4.6.5-1)$$

where  $\sigma_1$  = stresses in primary longitudinal members of the pontoon due to longitudinal bending of the dock;  
 $\sigma_2$  = stresses in primary longitudinal members of the pontoon due to longitudinal bending of the pontoon.

Stresses  $\sigma_1$ , in MPa, shall be determined by the formula

$$\sigma_1 = 10^5 M z / I' \quad (3.12.4.6.5-2)$$

where  $M$  = as defined in 3.12.4.6.3;  
 $z$  = distance of the point under consideration from the neutral axis of the dock, in m;  
 $I'$  = inertia moment of the dock to the end of the service life, in  $\text{cm}^4$ .

Stresses  $\sigma_2$ , in MPa, shall be determined by the formula

$$\sigma_2 = 10^5 M_y z' / I'_y \quad (3.12.4.6.5-3)$$

where  $M_y$  = as defined in 3.12.4.5.6;

$z'$  = distance of the point under consideration from the neutral axis of the section of the primary longitudinal, in m;

$I'_y$  = inertia moment of primary longitudinal, determined with regard to the wear of the members to the end of the service life of the dock and provisions of 3.12.4.5.4, in  $\text{cm}^4$ .

**3.12.4.6.6** In design of the dock hull, the requirements for buckling strength under the action of longitudinal bending of plate structures, girders and longitudinals, such as wall sides and deck plating, shell plating, longitudinal bulkhead plating of the pontoon and pontoon deck plating of caisson-type docks, bottom shell of pontoon dock wings shall be met in the middle region within  $0,4L_{p,d}$ .

The scantlings of top deck beams where transverse framing is adopted, top deck transverses in case of longitudinal framing shall be adequate to provide buckling strength of deck structure portions between deck girders, deck girders and wall sides or between wall sides where deck girders are omitted.

**3.12.4.6.7** The design compressive stresses  $\sigma_c$ , in MPa, obtained in estimation of the buckling strength shall be not less than:

$$\sigma_{ci} = \frac{M}{I'} z_i \cdot 10^5 \quad (3.12.4.6.7-1)$$

where  $M$  = design bending moment causing the compression of the  $i$ -th member under consideration (refer to 3.12.4.6.3), in  $\text{kN}\cdot\text{m}$ ;

$I'$  = actual central inertia moment of the hull girder with regard to wear to the end of the service life, in  $\text{cm}^4$ ;

As a first approximation,  $I'$  value, in  $\text{cm}^4$ , may be determined by the formula

$$I' = W_d'(D_0 - e) \cdot 10^2 \quad (3.12.4.6.7-2)$$

where  $W_d'$  = required section modulus of the hull girder at a level of the lower edge of the top deck plating determined according to the requirements of 3.12.4.6.1, in  $\text{cm}^3$ ;

$D_0$  = depth of wing walls (for pontoon docks), in m;

$D_0 = D$  for caisson-type docks;

$e$  = distance of the neutral axis from the base line for caisson-type docks; distance of the neutral axis from the abutment line of the pontoon deck to the inner wall sides for pontoon docks, in m.

As a first approximation, it may be assumed that  $e = 0,32D$  for caisson-type docks;  $e = 0,5D_0$  for pontoon docks.

$z_i$  = distance of the member under consideration from the neutral axis, in m ( $z_i$  is measured from the edge most distant from the neutral axis for a plate structure; from the middle of the thickness of the effective flange for a beam member of the deck and bottom; from the middle of the thickness of the beam web for a beam of the wall side, side plating and longitudinal bulkhead of the pontoon).

**3.12.4.6.8** The buckling strength conditions shall comply with 1.6.5.2 and 1.6.5.3. Factor  $k$  in the Formula (1.6.5.2-1) shall be taken equal to 0,8 for the top deck plating and wall sides; for the bottom and side plating of the pontoon and pontoon deck plating of caisson-type docks, girders and longitudinals.

**3.12.4.6.9** Euler stresses for plate structures shall be determined according to 1.6.5.5, and for girders

and longitudinals as required by 1.6.5.4 taking  $s' = s - \Delta s$  where  $\Delta s$  is obtained as given in 3.12.1.4.

**3.12.4.6.10** The inertia moment of beams of the transversely framed top deck shall meet the requirements of 2.6.4.3.

The inertia moment of top deck transverses shall be as required by 2.6.4.9.

**3.12.4.6.11** The assumed scantlings of wing wall structures shall provide buckling strength in simple bending of the wing wall in design cases of dock sagging. The procedure of supporting buckling strength in simple bending shall be agreed with the Register.

**3.12.4.7** Deflection control system.

Deflection of the dock hull shall be controlled according to the procedure approved by the Register.

In docks over 80 m in length at least two meters of different types to monitor the deflection of the dock shall be provided.

The maximum deflection stated in the Docking Manual shall be agreed with the Register. The deflections shall not exceed the values determined by the formula

$$\sigma(T) = (0,6 + 0,003T)\sigma_n \quad (3.12.4.7)$$

where  $T$  = service life of the dock to the date of monitoring, years;  
 $\sigma_n$  = as defined in 1.1.4.3.

**3.12.4.8** Requirements for dock towing.

**3.12.4.8.1** The minimum section modulus  $W_{\min}$ , in  $\text{cm}^3$ , required to ensure the strength of the dock during towing shall be determined by the formula

$$W_{\min} = \frac{M}{\sigma_{\text{perm}}} \cdot 10^3 \quad (3.12.4.8.1-1)$$

where  $M$  = design bending moment, in  $\text{kN}\cdot\text{m}$ , determined by the formula

$$M = 5,03k_w h_p B L_{p,d}^2; \quad (3.12.4.8.1-2)$$

$k_w$  = factor of wave bending moment determined by the formula

$$k_w = 7,93 \cdot 10^{-3} + 4,13 \cdot 10^{-3}(L_{p,d}/B) - 0,125(d_{\text{tow}}/L_{p,d}); \quad (3.12.4.8.1-3)$$

$d_{\text{tow}}$  = dock draught amidships during voyage in tow, in m;

$h_d$  = design wave height, in m, determined depending on the length of the dock:

$$h_d = 10,9 - \left( \frac{300 - L_{p,d}}{100} \right)^2 \text{ for } L_{p,d} < 300 \text{ m}, \quad (3.12.4.8.1-4)$$

$$h_d = 10,9 \text{ for } L_{p,d} \geq 300 \text{ m};$$

$\sigma_{\text{perm}}$  = permissible normal stresses in longitudinal bending of the dock, in MPa, taken equal to:  
 150 for docks under 100 m in length;  
 $150 + 0,75(L_{p,d} - 100)$  for docks between 100 and 200 m in length;  
 225 for docks over 200 m in length.

**3.12.4.8.2** The still water bending moment  $M$ , in  $\text{kN}\cdot\text{m}$ , in the midship section of the dock during the voyage in tow shall be reduced to the minimum possible level by suitable ballasting.

**3.12.4.8.3** Sea state considered permissible for voyage in tow is that corresponding to the height of wave of 3 per cent probability of exceeding level, in m, determined by the formula

$$h_{3\%} = h_{3\%}^0 + m(\lambda_1^2/\lambda_2^2 - 1) \quad (3.12.4.8.3-1)$$

where  $h_{3\%}^0$  = rated wave height, in m, permissible for voyage of a floating dock, with a relationship  $L_{p,d}/B = 4,25$ , determined by the formulae:

$$\begin{aligned} h_{3\%}^0 &= 0,313 + 0,0438L_{p,d} \text{ for } L_{p,d} < 130 \text{ m}; \\ h_{3\%}^0 &= 3,10 + 0,0223L_{p,d} \text{ for } 130 \leq L_{p,d} \leq 260 \text{ m}; \\ h_{3\%}^0 &= 0,422 + 0,0326L_{p,d} \text{ for } L_{p,d} > 260 \text{ m}. \end{aligned} \quad (3.12.4.8.3-2)$$

$m$  = factor determined by the formulae:

$$\begin{aligned} m &= 0,483 + 0,0218L_{p,d} \text{ for } L_{p,d} < 130 \text{ m}; \\ m &= 2,42 + 0,00685L_{p,d} \text{ for } 130 \leq L_{p,d} \leq 260 \text{ m}; \\ m &= 0,356 + 0,0148L_{p,d} \text{ for } L_{p,d} > 260 \text{ m}. \end{aligned} \quad (3.12.4.8.3-3)$$

Factors  $\lambda_1$  and  $\lambda_2$  are determined by the formulae:

$$\begin{aligned} \lambda_1 &= M/M^0; \\ \lambda_2 &= 1,276 - 0,065(L_{p,d}/B); \end{aligned} \quad (3.12.4.8.3-4)$$

$M^0$  = basic bending moment, in  $\text{kN}\cdot\text{m}$ , determined by the formula

$$M^0 = 0,77 \cdot 10^{-2} L_{p,d}^{3,65} / \eta; \quad (3.12.4.8.3-5)$$

for  $\eta$ , refer to 1.1.4.3;

$M$  = bending moment, in  $\text{kN}\cdot\text{m}$ , corresponding to the actual section modulus of the floating dock hull, determined by the formula

$$M = k_{\sigma} \sigma_n W \cdot 10^{-3} \quad (3.12.4.8.3-6)$$

where  $W$  = actual minimum section modulus of the dock hull to the moment of voyage;

$k_{\sigma} = 0,8$  = factor of permissible normal stresses;  
 $\sigma_n$  = as defined in 1.1.4.3.

**3.12.4.8.4** Correspondence between permissible sea state during voyage and heights of waves of 3 per cent probability of exceeding level shall be determined according to Table 3.12.4.8.4.

Table 3.12.4.8.4

Permissible sea state	$h_{3\%}$ , in m
5	2,0–3,5
6	3,5–6,0
7	6,0–8,5
8	8,5–11,0
9	11,0

**3.12.4.8.5** A possibility of voyage of a dock in tow whose architecture and relationships of the dimensions differ from those referred to in 3.12.1.1 shall be supported using the procedure approved by the Register.

**3.12.4.8.6** Voyage of a dock in tow within the limits of one and the same sea is permitted when the environmental conditions (sea state) corresponding to the requirements of 3.12.4.8.3 to 3.12.4.8.5 are expected.

## APPENDIX 1

## TIGHTNESS TEST OF SHIP'S HULL

## 1 GENERAL

**1.1 Definitions.**

Hydropneumatic testing is a combination of hydrostatic and air testing, consisting in filling the tank with water up to its top and applying an additional air pressure. The value of the additional air pressure is at the discretion of the Register, but shall be at least as defined in 2.2.

Shop primer is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.

Protective coating is a final coating protecting the structure from corrosion.

Leak testing is an air or other medium test carried out to demonstrate the tightness of the structure.

Hose testing is carried out to demonstrate the tightness of structural items not subjected to hydrostatic or leak testing and of other components which contribute to the watertight and weathertight integrity of the hull.

Structural testing is a hydrostatic test carried out to demonstrate the tightness, as well as the structural adequacy of the design. Where practical limitations prevail and hydrostatic testing is not feasible (for example when it is difficult, in practice, to apply the required head at the top of the tank), hydropneumatic testing may be carried out instead. When hydropneumatic testing is performed, its conditions shall simulate, as far as practicable, the actual loading of the tank.

**1.2 Application.**

The following requirements determine the testing conditions for:

- gravity tanks (including independent tanks) of 5 m<sup>3</sup> and more in capacity;

- watertight or weathertight structures.

The purpose of these tests shall check the tightness and/or strength of structural elements at the time of the ship construction and on the occasion of major repairs.

The tests shall be carried out in the presence of the Surveyor at a stage sufficiently close to completion so that any subsequent work could not impair the strength and tightness of the structure.

For general testing requirements, refer to Section 3.

## 2 TESTING METHODS

**2.1 Structural testing.**

Structural testing may be carried out after the application of shop primer.

Structural testing may be carried out after the protective coating has been applied, provided that one of the two following conditions is satisfied:

- all the welds are completed and carefully inspected visually to the satisfaction of the Surveyor prior to the application of the protective coating;

- leak testing is carried out prior to the application of the protective coating.

In the absence of leak testing, protective coating shall be applied after the structural testing of:

- all erection welds, both manual and automatic;

- all manual fillet weld connections on tank boundaries and manual penetration welds.

**2.2 Leak testing.**

Where leak testing is carried out, in accordance with the table, air pressure of 15 kPa shall be applied during the test.

Prior to inspection, it is recommended that the air pressure in the tank is raised to 20 kPa and kept at this level for about 1 hour to reach a stabilized state, with a minimum number of personnel in the vicinity of the tank, and then lowered to the test pressure.

After the pressure has reached a stabilized state at 20 kPa, the test may be conducted without lowering the pressure, provided the safety of the personnel involved in the test is guaranteed.

Welds shall be coated with an efficient indicating liquid.

A U-tube filled with water up to a height corresponding to the test pressure shall be fitted to avoid overpressure in the compartment tested and verify the test pressure. The U-tube shall have a cross-section larger than that of the pipe supplying air. In addition, the test pressure shall also be verified by means of one master pressure gauge.

Alternative means may be accepted which are considered to be equally reliable. Thus, two pressure gauges and a safety valve may be fitted in the compartment being tested. The connections for the pressure gauges and the safety valve shall be positioned on manhole covers, blank flanges and at other locations



convenient for maintenance. The pressure gauges shall have an accuracy rating of 1,5 to 2,5 and a range by one third greater than the test pressure. The scale factor of the pressure gauges shall not exceed 2 kPa.

Leak testing shall be carried out, prior to the application of a protective coating, on all fillet weld connections on tank boundaries, penetrations and erection welds on tank boundaries excepting welds made by automatic processes. Selected locations of automatic erection welds and pre-erection manual or automatic welds may be required to be similarly tested at the discretion of the Surveyor taking account of the quality control procedures operating in the shipyard. For other welds, leak testing may be carried out, after the protective coating has been applied, provided that these welds were carefully inspected visually.

Any other recognized method may be accepted on agreement with the Register.

### 2.3 Hose testing.

When hose testing is required to verify the tightness of the structures, as defined in the table, the minimum pressure in the hose, at least equal to 200 kPa, shall be applied at a maximum distance of 1,5 m. The nozzle diameter shall not be less than 12 mm.

### 2.4 Hydropneumatic testing.

When hydropneumatic testing is performed, the same safety precautions as for leak testing shall be adopted.

### 2.5 Other testing methods.

Other testing methods may be accepted, at the discretion of the Register, based upon equivalency considerations.

Table

## 3 GENERAL TESTING REQUIREMENTS

Item number	Structure to be tested	Type of testing	Test pressure	Remarks
1	Double bottom tanks	Structural testing <sup>1</sup>	The greater of the following: head of water up to the top of overflow head of water up to the margin line	Compartment boundaries tested from at least one side
2	Double side tanks	Structural testing <sup>1</sup>	The greater of the following: head of water up to the top of overflow 2,4 m head of water above highest point of tank	Compartment boundaries tested from at least one side
3	Tank bulkheads, deep tanks Fuel oil bunkers	Structural testing <sup>1</sup> Structural testing	The greater of the following: head of water up to the top of overflow 2,4 m head of water above highest point of tank setting pressure of the safety relief valves, where relevant <sup>2</sup>	Compartment boundaries tested from at least one side
4	Ballast holds in bulk carriers	Structural testing <sup>1</sup>	The greater of the following: head of water up to the top of overflow 0,9 m head of water above top of hatch	
5	Fore peak and after peak used as tank  Fore peak not used as tank After peak not used as tank	Structural testing  See Note 1 Leak testing	The greater of the following: head of water up to the top of overflow 2,4 m head of water above highest point of tank	Test of the after peak carried out after the sterntube and rudder tube have been fitted
6	Cofferdams	Structural testing <sup>3</sup>	The greater of the following: head of water up to the top of overflow 2,4 m head of water above highest point of tank	
7	Watertight bulkheads	See Note 1 <sup>4</sup>		
8	Watertight doors below freeboard or bulkhead deck	See Note 2		
9	Double plate rudders, spaces between outer and inner plating of fixed and steering nozzles, hollow elements of foil structure	Leak testing		
10	Shaft tunnel clear of deep tanks	Hose testing		
11	Shell doors	Hose testing		
12	Watertight hatch covers in bulk carriers	Hose testing		

Item number	Structure to be tested	Type of testing	Test pressure	Remarks
	Watertight hatch covers in combination carriers	Structural testing <sup>1</sup>	The greater of the following: 2,4 m head of water above the top of hatch cover setting pressure of the safety relief valves, where relevant	At least every 2nd hatch cover to be tested
13	Weathertight hatch covers and closing appliances	Hose testing		
14	Chain locker (if aft of collision bulkhead)	Structural testing	Head of water up to the top	
15	Independent tanks	Structural testing	Head of water up to the top of overflow, but not less than 0,9 m	
16	Ballast ducts	Structural testing	Ballast pump maximum pressure	
17	Independent tanks in edible liquid carriers	Structural testing	Head of water up to the top of overflow, without being less than 0,9 m	Cargo space boundaries tested from at least one side
18	Integral or independent tanks in chemical tankers	Structural testing	The greater of the following: 2,4 m head of water above highest point of tank setting pressure of the safety relief valves, where relevant	

<sup>1</sup> Leak or hydropneumatic testing may be accepted under the conditions specified in 2.2, provided that at least one compartment or tank of each type is structurally tested, to be selected in connection with the design approval. Structural testing of compartments or tanks need not be repeated for subsequent vessels of a series of identical newbuildings. This relaxation does not apply to cargo space boundaries in tankers and combination carriers and tanks for segregated cargoes or pollutants. If structural test reveals weakness or severe faults not detected by the leak test, all compartments or tanks shall be structurally tested.

<sup>2</sup> Where applicable, the highest point of the tank shall be measured to the deck and excluding hatches. In holds for liquid cargo or ballast with large hatch covers, the highest point of the tank shall be taken at the top of the hatch.

<sup>3</sup> Leak or hydropneumatic testing may be accepted under the conditions specified in 2.2 at the discretion of the Register.

<sup>4</sup> Where hose test cannot be performed without damaging the equipment (machinery, cables, switchboards, insulation, etc.) already installed, it may be replaced, at the Register discretion, by a thorough visual inspection of all the crossings and welded joints; where necessary, dye penetrant test or ultrasonic leak test may be required.

Note 1

#### Regulation 14, Chapter II-1 of SOLAS-74

##### Construction and initial testing of watertight bulkheads, etc. in passenger ships and cargo ships

1 Each watertight subdivision bulkhead, whether transverse or longitudinal, shall be constructed in such a manner that it shall be capable of supporting, with a proper margin of resistance, the pressure due to the maximum head of water which it might have to sustain in the event of damage to the ship but at least the pressure due to a head of water up to the margin line. The construction of these bulkheads shall be to the satisfaction of the Administration.

2.1 Steps and recesses in bulkheads shall be watertight and as strong as the bulkhead at the place where each occurs.

2.2 Where frames or beams pass through a watertight deck or bulkhead, such deck or bulkhead shall be made structurally watertight without the use of wood or cement.

3 Testing main compartments by filling them with water is not compulsory. When testing by filling with water is not carried out, a hose test shall be carried out, where practicable. This test shall be carried out in the most advanced stage of the fitting out of the ship. Where hose test is not practicable because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a thorough visual inspection of welded connections, supported where deemed necessary by such means as a dye penetrant test or an ultrasonic leak test or an equivalent test. In any case, a thorough inspection of the watertight bulkheads shall be carried out.

4 The forepeak, double bottoms (including duct keels) and inner skins shall be tested with water to a head corresponding to the requirements of paragraph 1.

5 Tanks which are intended to hold liquids, and which form part of the subdivision of the ship, shall be tested for tightness with water to a head up to the deepest subdivision load line or to a head corresponding to two-thirds of the depth from the top of keel to the margin line in way of the tanks, whichever is the greater; provided that in no case shall the test head be less than 0,9 m above the top of the tank.

6 The tests referred to in paragraphs 4 and 5 are for the purpose of ensuring that the subdivision structural arrangements are watertight and shall not be regarded as a test of the fitness of any compartment for the storage of fuel oil or for other special purposes for which a test of a superior character may be required depending on the height to which the liquid has access in the tank or its connections.

Note 2

#### Regulation 18, Chapter II-1 of SOLAS-74

##### Construction and initial tests of watertight doors, sidescuttles, etc. in passenger ships and cargo ships

1 In passenger ships:

.1 the design, materials and construction of all watertight doors, sidescuttles, gangway, cargo and coaling ports, valves, pipes, ash-shoots and rubbish-shoots referred to in these regulations shall be to the satisfaction of the Administration;

.2 the frames of vertical watertight doors shall have no groove at the bottom in which dirt might lodge and prevent the door closing properly.

2 In passenger ships and cargo ships each watertight door shall be tested by water pressure to a head up to the bulkhead deck or freeboard deck respectively. The test shall be made before the ship is put into service, either before or after the door is fitted.

## APPENDIX 2

**REQUIREMENTS FOR SHIP LOADING INSTRUMENTS****1 GENERAL**

**1.1** The present Requirements shall be applied together with those of Part II, "Hull" of the Rules and Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships when approving the loading instruments of ships whose instruments are not yet approved.

**1.2** The Requirements apply to loading instruments representing a computer-based system consisting of a program for ship load calculation and of hardware for its realization. Requirements pertinent to the program and its functional capabilities shall be found in 3.1 and Section 4 of this Appendix respectively. Requirements pertinent to type approval for hardware shall be found in 1.8 and 3.2 of this Appendix.

**1.3** A loading instrument shall not substitute for an approved Loading Manual.

**1.4** The loading instrument belongs to special equipment carried onboard, and the calculation results obtained by using it apply only to the ship for which it was approved.

**1.5** Ships undergoing major modifications or modernization, such as elongation or deck removal affecting the longitudinal strength of hull, shall be considered new ships for the purpose of the Requirements.

**1.6** For each ship, the loading instrument approval procedure shall include the following:

- basic data verification and loading conditions approval with issuing of a Report (Form 6.3.29) for subsequent testing of the program;

- hardware approval with issuing of a Certificate (Form 6.5.30) where necessary;

- handover tests with a subsequent issuing of a Report (Form 6.3.10).

**1.7** The program for the loading instrument shall be type-approved by the Register which shall be confirmed by issuing a Type Approval Certificate for Computer Program (Form 6.8.5). In such cases, certain stages may be omitted in the basic data verification procedure for a particular ship (refer to 2.1.7).

**1.8** Hardware shall be approved, if there is a single computer for which a Type Approval Certificate (Form 6.3.8) was issued in accordance with the requirements of 3.2 of this Appendix, or there are two computers specially installed for the case one of them fails. If there are two computers, no

type approval is necessary for them but in this case, each computer shall pass handover tests. Besides, computers being a part of the shipboard net shall be approved by the Register which shall be confirmed by issuing a Certificate (Form 6.5.30) in accordance with the relevant requirements of the Rules Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**1.9** A Report (Form 6.3.10) shall be issued for the program on the basis of the satisfactory results of handover tests of the loading instrument carried out onboard the ship in accordance with the requirements of 2.3 of this Appendix.

**2 APPROVAL PROCEDURE****2.1 Basic data verification and approval. Loading conditions approval for program testing.**

**2.1.1** Calculation results and the actual ship data used for the program shall be verified onboard the ship for which the program is intended.

**2.1.2** On receipt of an application for data verification, the Register shall offer to the applicant four loading conditions as a minimum, borrowed from an approved Ship Loading Manual and to be used for program testing. These loading conditions shall ensure the loading of each ship compartment for one time at least. These loading conditions shall generally cover the whole range of possible ship draughts from the greatest one in the loaded condition to the smallest one in the ballasted condition.

**2.1.3** Control points shall generally be positioned on transverse bulkheads or other obvious compartment boundaries. Additional control points may be necessary between the bulkheads of long holds or tanks, or between container stacks.

**2.1.4** If the torque on calm water shall be determined, the program shall provide for thshall be demonstrated on a single test loading condition of the ship.

**2.1.5** It is important that the basic data included in the program are in agreement with those contained in the approved Loading Manual. Special attention shall be paid to the final mass value of the ship in the light condition and the position of its gravity centre adopted on the basis of inclining test or proceeding from the results of the light ship condition verification.

**2.1.6** The following basic data shall be submitted to the Register by the applicant in order to verify whether they are in agreement with the ship constructed:

- principal dimensions, coefficients of fineness of the lines and, where necessary, the lateral projection of the ship;

- position of forward and aft perpendiculars and, where necessary, the procedure for determining the forward and stern draughts at actual draught mark locations;

- light ship displacement and its distribution through the ship length;

- lines drawing and/or tables of offsets, or Bonjean scales including 21st section on the length between perpendiculars;

- compartments description including spacing, volume centres and volume tables (tank capacity tables/tables showing the mass of liquid in a tank filled to different levels) where necessary;

- deadweight composition for each loading condition.

Identification details of the program including the version number shall be verified also.

**2.1.7** The basic data verification procedure may be considered to be completed, if:

- the requirements of 3.1 of this Appendix are fulfilled in respect of the program;

- the purpose of the program is clearly formulated and the calculation methods with the algorithm are in accordance with the requirements of the Rules and Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

- the requirements of Section 4 of this Appendix are fulfilled with regard to the functional capabilities of the program;

- the precision of calculations made on the basis of the program is within the tolerances stipulated by 2.5 of this Appendix;

- ship particulars are in accordance with the requirements of 2.1.5 of this Appendix;

- the program user's manual is clear and brief and complies with the requirements of 2.4 of this Appendix and is checked and duly noted by the Register;

- data are given concerning the minimal requirements for hardware;

- ship loading conditions intended for the program testing are approved which is confirmed by Report (Form 6.3.29).

**2.1.8** Type Approval Certificate for Computer Program (Form 6.8.5) shall be issued on the basis of the requirements of 2.2 of this Appendix. Where the program is type approved, the basic data verification procedure may be considered to be completed, if:

- it is found that the type-approved program is applicable to the ship in question;

- information contained in valid Certificate (Form 6.8.5) is in compliance with the program being identified and its version number;

- the precision of calculations made on the basis of the program is within the tolerances stipulated in 2.5 of this Appendix;

- ship particulars are in accordance with the requirements of 2.1.5 of this Appendix;

- the program user's manual is clear and brief and complies with the requirements of 2.4 of this Appendix and is checked and duly noted by the Register;

- data are given concerning the minimal requirements for hardware;

- ship loading conditions intended for the program testing are approved and there is a Report (Form 6.3.29) on the program operation testing.

**2.1.9** Approved loading conditions given in Ship Loading Manual and the Report (Form 6.3.29) are sent to the Branch Office by the RS Head Office noting the necessity of handover tests to be held. Where the ship is in service, the approved loading conditions and the Report (Form 6.3.29) are sent to the shipowner who shall ensure that they are delivered onboard and that handover tests are held with the Register surveyor participating.

## **2.2 Type approval.**

**2.2.1** A program for the loading instrument may be type approved according to the requirements of this Chapter. If the tests are completed satisfactorily, Type Approval Certificate for Computer Program (Form 6.8.5) shall be issued for the program.

**2.2.2** The Certificate (Form 6.8.5) shall be valid for an identified version of the program only.

**2.2.3** After the application for the type approval of a program has been submitted, the Register will provide the applicant with data for its testing for two ship types at least. Where programs using basic data on hull shape are concerned, the program test data shall be provided for three ship types. These data shall be used by the applicant for running the program in respect of the tested ships. The results (including the data-of-the-lines-plan curve and the interpolation curve output, if applicable) obtained by using the program shall be submitted to the Register in order the precision of calculations might be assessed. The Register shall make parallel calculations using the same basic data and compare their results with those obtained by means of the program submitted.

**2.2.4** The Certificate (Form 6.8.5) may be issued if: the requirements of 3.1 of this Appendix are fulfilled in respect of the program;

- the purpose of the program is clearly formulated and the calculation methods with the algorithm are in accordance with the requirements of the Rules and Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

the requirements of Section 4 of this Appendix are fulfilled with regard to the functional capabilities of the program;

the precision of calculations made on the basis of the program is within the tolerances stipulated in 2.5 of this Appendix;

the program user's manual is clear and brief, and is submitted to the Register for consideration;

data are given concerning the minimal requirements for hardware.

**2.2.5** The Certificate (Form 6.8.5) shall include a detailed description of calculations for which the program is approved and of limitations imposed upon the program.

**2.2.6** The Certificate (Form 6.8.5) shall be issued for a maximum period of 5 years. The Certificate may be extended after the developer has confirmed that the algorithm is unchanged in the program.

**2.2.7** A valid Certificate (Form 6.8.5) will be invalidated, if the algorithm is changed in the program by the developer without prior agreement with the Register. In such a case, the revised program shall be considered a new one.

### **2.3 Handover tests.**

**2.3.1** Handover tests shall be held soon after the loading instrument installation aboard the ship.

**2.3.2** During handover tests, the user, one of the senior officers shall use the instrument for calculating a test loading condition of the ship. The operation shall be confirmed by a surveyor to the Register. Data obtained by means of the instrument shall agree with those stated for the approved test loading conditions. Where the numerical output data given by the instrument do not agree with those stated in the approved test loading conditions, the Report (Form 6.3.10) shall not be issued.

**2.3.3** Handover tests shall also be carried out in respect of the second computer specially installed to be used if the first one fails. Data obtained by means of the loading instrument shall agree with those stated for the approved tests loading conditions. Where the output numerical data of the loading instrument do not agree with those stipulated for the approved tests loading conditions, no Report (Form 6.3.10) shall be issued. If handover tests are effected using a computer for which a Type Approval Certificate (Form 6.8.3) was issued, the second specially installed computer need not be tested.

**2.3.4** Where hardware is not approved, it shall be demonstrated that handover tests results for the program are satisfactory for both the first and the second specially installed computer, subsequent to which a Report (Form 6.3.10) on the program handover tests may be issued.

**2.3.5** After satisfactory completion of handover tests, the Register surveyor shall attach the approved

test loading conditions for the ship, as well as the Program Test Report (Form 6.3.29), to the Program User's Manual formerly duly noted by the Register. Then, the Report (Form 6.3.10) on handover tests of the program will be issued by the Register.

### **2.4 Program User's Manual.**

**2.4.1** The Manual shall be submitted for consideration by the Register. In case of satisfactory results of the consideration, the Manual shall be duly noted by the Register.

**2.4.2** The Manual shall be drawn up in a brief and clear way and shall be provided preferably with drawings and block diagrams.

**2.4.3** The Manual shall include the following information:

general description of the program with indication of its version identification number;

a copy of Type Approval Certificate for Computer Program (Form 6.8.5);

data on minimal required hardware properties necessary for program operation;

description of error messages and warning reports that can be issued by computer and clear instructions concerning the user's subsequent steps in this case;

light ship displacement and gravity centre of the ship coordinates;

full deadweight composition for each test loading condition of the ship;

values of permissible shearing forces and bending moments in calm water given or taken into consideration by the Register;

values of permissible cargo torque, where applicable;

correction factors for shearing forces, where applicable;

local permissible limitations on the loading of particular holds and two adjacent holds proceeding from the maximum cargo mass for each hold in relation to the relevant ship draught, where applicable;

example of ship loading conditions determination with illustrations and computer data out;

example of each display screen data out with explanations.

### **2.5 Allowance for calculation accuracy.**

The accuracy of calculations made using the program shall be within the range of acceptable allowances given in Table 2.5. The accuracy of calculations can be determined by comparing, at each control point, the results of calculations made using

Table 2.5

**Range of allowances for calculation accuracy**

Design value	Allowance (percentage of permissible value)
Shearing force on still water $N_{sw}$	$\pm 5$
Bending moment on still water $M_{sw}$	$\pm 5$
Torque on still water $M_{TSW}$	$\pm 5$

the program to those obtained by using an independent program of the Register or an approved loading manual containing the similar basic data.

#### **2.6 Hardware approval.**

The hardware of a loading instrument shall be in accordance with the requirements of 1.8 and 3.2 of this Appendix if it is type-approved by the Register.

### **3 REQUIREMENTS TO THE SYSTEM**

#### **3.1 Program.**

**3.1.1** It is recommended that the development and release of the program be carried out in accordance with the relevant international quality standards (for instance, ISO 9000-3 or equivalent).

**3.1.2** Software shall be developed so as to render it impossible for the user to modify data files of the ship containing the following information:

- lightweight displacement of the ship, lightweight ship mass distribution and the relevant gravity centres;
- structural restrictions imposed by the Register;
- data essential for hull geometry;
- hydrostatic data;
- description of compartments including spacing, volume centres and volume tables (tank capacity tables/tables showing the volume of liquid in a tank when filled to different levels) where necessary.

**3.1.3** Any changes to software that can influence longitudinal strength shall be introduced by the developer or his appointed representative, and the Register shall be immediately notified accordingly. The absence of a notification of any changes to the program may render the Certificate (Form 6.8.5) issued by the Register invalid. When the Certificate (Form 6.8.5) is found to be invalid by the Register, the modified program will be considered anew in accordance with the requirements of this Appendix.

#### **3.2 Hardware of an independent computer.**

**3.2.1** Type Approval Certificate (Form 6.8.3) and Hardware Approval Certificate (Form 6.5.30) shall be issued by the Register on condition the hardware is in accordance with the requirements contained in 3.2.2 of this Appendix, as well as with the requirements of the Rules and Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**3.2.2** The developer shall submit the detailed information on the hardware shall be installed on board. The following information shall be submitted to the Register for consideration:

- hardware specification;
- the relevant design drawings with indicated materials, catalogues, data sheets, calculations and functional descriptions;

test program suggested for demonstration, confirming that the operational requirements of the above standards can be fulfilled;

certificates and the relevant test reports obtained for the product earlier.

**3.2.3** When considering the documentation mentioned in 3.2.2, the Register may recognize the validity of certificates and reports issued by another certification body or accredited laboratory.

**3.2.4** The operational and climatic tests shall be held in the presence of the Register representative under the standard test conditions so that a type approval could be issued in accordance with Part XV "Automation" of the present Rules and Part IV "Technical Supervision during Manufacture of Products" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships. The following inspections and tests shall be completed satisfactorily:

- external examination;
- functional tests;
- disturbance in electric power supply;
- thermal resistance testing;
- moisture resistance testing;
- vibration tests;
- testing by oscillating and prolonged tilting motion conditions;
- testing of insulation electric strength, insulation resistance measurement;
- cold resistance tests;
- electromagnetic compatibility tests.

**3.2.5** The Register shall be notified of any modifications to hardware specification.

### **4 REQUIREMENTS CONCERNING FUNCTIONAL CAPABILITIES**

#### **4.1 General.**

**4.1.1** The computational functions inherent in the program will depend on the requirements contained in the present Rules and in Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**4.1.2** The program shall be convenient for the user and be developed so as to minimize the possibility of incorrect initial data input by the user.

**4.1.3** Calculations of the fore, midlength and after draughts at relevant perpendiculars shall be submitted in a form easily understandable for the user both in files and as hard copies.

**4.1.4** For the case of the actual ship loadline positions of the, the fore, midlength and after draughts shall be determined and submitted in a form easily understandable for the user both in files and as hard copies. Provision shall be made for submitting the sagging/hogging data for the hull.

**4.1.5** Displacement shall be determined for the particular loading condition of the ship and the corresponding value of the draught, and shall be submitted to the user both in file and as a hard copy.

**4.1.6** The loading instrument shall issue printouts containing output data both in digital and graphic form. The output data in digital form shall be represented both in the absolute values and as percentage of permissible values. Printouts shall contain description of the relevant loading condition of the ship.

**4.1.7** All the electronic and hard copy data shall be represented in a form easily understandable for the user with indication of the identification number of the program version.

#### **4.2 Forces and moments originating in the hull.**

**4.2.1** The program shall ensure an analysis of the following forces and moments in the ship hull in accordance with the requirements of Part II "Hull":

shearing force  $N_{sw}$  in still water, with a correction where applicable;

bending moment  $M_{sw}$  in still water, with a correction where applicable;

torque  $M_{tsw}$  in still water, where applicable.

In case of open ships, particular attention shall be paid to loads under which hull twisting occurs.

**4.2.2** Data to be submitted to or duly noted by the Register are included in Table 4.2.2.

**4.2.3** Forces and moments shall be determined in absolute values and as percentage of permissible values, and shall be submitted both in graphical and tabulated form. The forces and moments determined, as well as their permissible values for each of the control points indicated, shall be submitted both in files and as hard copies. Any limitations concerning hull bending in the vertical direction in still water or hull twisting, for instance, may be considered on the basis of the requirements of the Rules.

#### **4.3 Permissible loads, loading and capacity.**

**4.3.1** The program user shall be timely, clearly and unambiguously informed about the following restrictions imposed by the Register, concerning:

all permissible shearing forces and bending moments in still water;

permissible torques in still water, where applicable;

all local loading restrictions pertinent to both the loading of a particular hold and of the one adjacent thereto, where applicable;

mass of cargo contained in the hold;

ballast tanks and holds capacity;

restrictions on filling.

**4.3.2** Violation of any of the restrictions imposed shall be easily detectable by the program user.

Table 4.2.2

Design value	Data to be submitted to or duly noted by the Register
Shearing force $N_{sw}$ on still water	<ol style="list-style-type: none"> <li>1. Control points (frame numbers) for <math>N_{sw}</math> determination. Such points shall generally be chosen on transverse bulkheads or other obvious boundaries of compartments. Additional control points may be indicated between the bulkheads of long holds or tanks, as well as between container stacks.</li> <li>2. Correction factors for shearing forces and their application procedure.</li> <li>3. Permissible values [of <math>N_{sw}</math>], at sea and in port, for control points mentioned in item 1. Where necessary, an additional range of permissible values [of <math>N_{sw}</math>] can be specified.</li> </ol>
Bending moment $M_{sw}$ on still water	<ol style="list-style-type: none"> <li>1. Control points (frame numbers) for <math>M_{sw}</math> determination. Such points shall generally be chosen on transverse bulkheads, at hold centres or other obvious boundaries of compartments.</li> <li>2. Permissible values [of <math>M_{sw}</math>], at sea and in port, for control points mentioned in item 1. Where necessary, an additional range of permissible values [of <math>M_{sw}</math>] can be specified.</li> </ol>
Torque $M_{tsw}$ on still water (where applicable)	<ol style="list-style-type: none"> <li>1. Control points (frame numbers) for <math>M_{tsw}</math> determination.</li> <li>2. Permissible values [of <math>M_{tsw}</math>] for control points mentioned in item 1.</li> </ol>

## **5 PERFORMANCE TEST**

### **5.1 General.**

When a loading instrument shall be installed on board and Report (Form 6.3.10) or a report on its previous testing by the Register is not available, the Register surveyor shall notify the Register Head Office accordingly.

### **5.2 Extent of survey.**

When a loading instrument is tested, the results obtained on the basis of the program shall be identical to those given in the approved test loading conditions of the ship. If the numerical output data obtained using the loading instrument do not agree with those to be found in the approved test loading conditions, the class assignment requirements shall be applied to the ship and the owner shall be notified accordingly. The program shall be tested on all the computers intended for it (those which are type approved or specially designed for the program).

# PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT

## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The requirements of the present Part of the Rules apply to equipment, arrangements and outfit of sea-going ships navigating in a displacement condition. To hydrofoil boats, air cushion vehicles, hydrogliders and other similar ships, unless expressly provided otherwise below, the requirements of this Part are applicable to the extent that is practicable and reasonable, and the equipment, arrangements and outfit of these ships are subject to special consideration by the Register in each case.

**1.1.2** Ship's equipment, arrangements and outfit designed for special purposes (such as special anchor arrangements of dredgers, a deep-sea anchor arrangement for special purpose ships and similar arrangements) are not subject to the Register supervision.

**1.1.3** The requirements of the present Part of the Rules apply, as far as practicable and reasonable, to floating metallic wing-walled docks, unless expressly provided otherwise. The Rules do not specify conditions for mooring of floating docks in a particular place of operation and selection of types and characteristics of the equipment, arrangements and outfit (anchor, mooring, etc.) used for this purpose.

### 1.2 DEFINITIONS AND EXPLANATIONS

The definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification".

For the purpose of the present Part of the Rules the following definitions have been adopted:

#### **1.2.1 Waterlines.**

**Damage waterlines** are the waterlines of a damaged ship after flooding of corresponding separate compartments or their combinations as provided in Part V "Subdivision".

**Summer load waterline** is the waterline indicated by the upper edge of the line which passes through the centre of the ring of the load line mark for a ship in upright position.

**Summer timber load waterline** is the waterline indicated by the upper edge of the assigned summer timber load line.

**Deepest load waterline** is the waterline indicated by the upper edge of the assigned uppermost regional or seasonal load line, including fresh water load lines.

**Deepest subdivision load waterline** is the uppermost waterline at which the requirements of Part V "Subdivision" are still fulfilled.

**Margin line at docking** is the envelope of the waterlines corresponding to the maximum permitted trims of the floating docks and docklift ships when carrying out the docking operations.

#### **1.2.2 Dimensions and draught of the ship.**

**Length of ship  $L$**  is taken as 96 per cent of the total length on a waterline at 85 per cent of the least moulded depth or as the length from the fore side of the stem to the axis of the rudder stock on that waterline, if that be greater.

Where the stem contour is concave above that waterline, the length of the ship shall be measured from the vertical projection to that waterline of the aftermost point of the stem contour (above that waterline).

In ships designed with a rake of keel the waterline on which this length is measured shall be parallel to the design waterline.

**Length of floating dock  $L$**  is the distance measured along the pontoon deck and parallel to the base line, between the inner sides of the pontoon end bulkheads.

**Moulded draught  $d$**  is the vertical distance measured amidships from the top of the plate keel or from the point where the inner surface of the shell (outer surface in a ship with a non-metal shell) abuts upon the bar keel, to the summer load waterline.

**Moulded depth  $D$**  is the vertical distance measured amidships from the top of the plate keel, or from the point where the inner surface of the shell abuts upon the bar keel, to the top of the freeboard deck beam at side.

In ships having rounded gunwales, the moulded depth shall be measured to the point of intersection of the moulded lines of the freeboard deck and side, the lines extending as though the gunwale were of angular design.

Where the freeboard deck is stepped in the longitudinal direction and the raised part of the deck extends over the point at which the moulded depth shall be determined, the moulded depth shall be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

**Moulded breadth  $B$**  is the maximum breadth measured amidships from outside of frame to outside of frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material.

#### **1.2.3 Superstructures, deckhouses.**

**Superstructure** is a decked structure on the freeboard deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4 per cent of the breadth  $B$ .



The superstructure may be either complete, i.e. extending over the entire ship's length  $L$ , or detached, i.e. extending only over a definite part of this length. Both complete and detached superstructures may be arranged either in a single or several tiers.

Deckhouse is a decked structure on the freeboard or superstructure deck which is set in from the sides of the ship for more than 4 per cent of the breadth  $B$  and has doors, windows or other similar openings in the outer bulkheads. The deckhouses may be arranged in a single or several tiers.

Trunk is a decked structure on the freeboard deck which is set in from the sides of the ship for more than 4 per cent of the breadth  $B$  and has no doors, windows or other similar openings in the outer bulkheads.

#### 1.2.4 Tightness.

Tight under pressure head up to... is the term pertaining to closing appliances of openings, which means that under specified pressure the liquid will not penetrate through the openings inside the ship.

Weather tight is the term pertaining to closing appliances of openings in the above-water hull, which means that in any sea conditions water will not penetrate through the openings inside the ship. The above closing appliances shall undergo tests according to the requirements of 2.3, Appendix 1 to Part II "Hull".

It is allowed that the specialized organizations recognized by the Register carry out tests by means of the ultrasonic equipment as well as other test methods approved by the Register.

#### 1.2.5 Decks.

Upper deck is the uppermost continuous deck extending for the full length of the ship.

The upper deck may be stepped.

Raised quarter deck is the after upper part of a stepped deck, the forward lower part of which is taken as a portion of the freeboard deck.

Freeboard deck is the deck from which the freeboard is measured.

In a ship having a discontinuous deck the lowest line of this deck and the continuation of that line parallel to upper part of the deck is taken as a freeboard deck.

Superstructure deck, deckhouse top or trunk deck is the deck forming the top of a superstructure, deckhouse or trunk, respectively.

Superstructure deck or deckhouse top of the first, second, etc. tiers is the deck forming the top of the superstructure or deckhouse of the first, second, etc. tiers, counting from the freeboard deck.

Bulkhead deck is the deck up to which the main transverse watertight subdivision bulkheads are carried.

The bulkhead deck may be discontinuous, i.e. with a step or steps formed both by main transverse watertight bulkheads reaching the keel and transverse watertight bulkheads not reaching the keel.

Lower decks are the decks below the upper deck.

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

Pontoon deck of the dock is the deck on which the ship to be docked is fitted.

Top deck of the dock is the uppermost deck of the dock (the uppermost deck of the wing walls).

#### 1.2.6 Perpendiculars and amidships.

Amidships is at the middle of the ship's length  $L$ .

Forward and after perpendiculars are the vertical lines passing in the centre line at the fore and after ends of the ship's length  $L$ , respectively.

#### 1.2.7 Ships.

Type "A" ship is a ship designed to carry only liquid cargoes in bulk, and in which cargo tanks have only small access openings closed by gasketed covers tight under an appropriate inner pressure of liquid which is carried in the tanks. Furthermore, a type "A" ship shall have some other features, as defined in the Load Line Rules for Sea-Going Ships which permit this ship to be assigned a freeboard based on Tables 4.1.2.3, 6.4.2.2 or 6.4.3.2 of the above Rules.

Type "B" ship is a ship which does not comply with the requirements regarding type "A" ships and which is assigned a freeboard based on Table 4.1.3.2, 6.4.2.3 or 6.4.3.3 of the Load Line Rules for Sea-Going Ships.

A type "B" ship may not be classified as a type "A" ship even though, as a result of her features detailed in the Load Line Rules, a reduction in tabular freeboard is permitted up to the total difference between the values given in Tables 4.1.2.3, 6.4.2.2, 6.4.3.2 and those in Tables 4.1.3.2, 6.4.2.3, 6.4.3.3, respectively, of the above Rules.

Docklift ship is a dry cargo ship adapted to carry out cargo handling operations using the docking principle in ports and protected water areas.

1.2.8 Active means of the ship's steering (AMSS) are special propulsion and steering units and any combination of them or with the main propulsion devices, capable of producing thrust or traction force both at a fixed angle to the centre line plane of the ship and at a variable angle, either under all running conditions or part thereof including small and zero speed.

The active means of the ship's steering comprise steerable propellers including retractable units of all

types, active rudders, vertical-axis propellers, water-jets, propellers in transverse tunnel (athwartship thrusters), separate nozzle rudders and other devices of similar purpose.

Requirements for AMSS construction and design, exclusive of the separate nozzle rudders and rudder section of the active rudders are outlined in Part VII "Machinery Installations". Requirements for AMSS used in the dynamic positioning systems of mobil offshore drilling units shall be fulfilled with consideration for Rules for the Classification and Construction of Mobil Offshore Drilling Units.

#### 1.2.9 Steering gear.

Main steering gear is the machinery, rudder actuators, steering gear power units, if any, ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear, but not including the tiller, quadrant or components serving the same purpose.

Steering gear power unit is:

in the case of electric steering gear an electric motor and its associated electrical equipment;

in the case of electrohydraulic steering gear an electric motor and its associated equipment and connected pump;

in the case of other hydraulic steering gear a driving engine and connected pump.

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components, i.e. tiller, quadrant and rudder stock, or components serving the same purpose.

Steering gear control system is the equipment by which orders are transmitted from the navigating bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

### 1.3 SCOPE OF SURVEY

1.3.1 General provisions on survey of ship's equipment, arrangements and outfit are given in General Regulations for the Classification and Other Activity and in Part I "Classification".

1.3.2 The following items included into ship's equipment, arrangements and outfit are subject to the survey by the Register during their manufacture.

#### 1.3.2.1 Rudder and steering gear:

.1 rudder stocks;

.2 rudder blade;

.3 nozzle rudders;

.4 rudder axles;

.5 pintles of rudders and nozzle rudders;

.6 bushes of pintles;

.7 fastenings of rudder stocks, rudder stock with rudder blade or nozzle rudder, and also of rudder axle with sternframe (muff couplings, keys, bolts, nuts, etc.);

.8 parts of the system of rudder stops;

.9 rudder stock bearings;

.10 active means of the ship's steering (only in the case specified in 2.1.3.2).

#### 1.3.2.2 Anchor arrangement:

.1 anchors;

.2 chain cables or ropes;

.3 anchor stoppers;

.4 devices for securing and releasing the inboard end of chain cable or rope;

.5 anchor hawse pipes.

#### 1.3.2.3 Mooring arrangement:

.1 mooring ropes;

.2 mooring bollards, belaying cleats, fairleaders, chocks, rollers and stoppers.

#### 1.3.2.4 Towing arrangement:

.1 tow lines;

.2 towing bollards, bitts, fairleaders, chocks and stoppers;

.3 tow hooks and towing rails with fastenings for their securing to ship's hull;

.4 towing snatch-blocks.

#### 1.3.2.5 Masts and rigging:

.1 metal, wooden and glass-reinforced plastic spars;

.2 standing ropes;

.3 permanent attachments to masts and decks (eyeplates, hoops, etc.);

.4 loose gear of masts and rigging (shackles, turnbuckles, etc.).

1.3.2.6 Closing appliances of openings in hull, superstructures and deckhouses:

.1 side and deck scuttles;

.2 doors of bow, side and stern openings in the shell plating;

.3 doors in superstructures and deckhouses;

.4 companion hatches, skylights and ventilating trunks;

.5 ventilators;

.6 manholes to deep and other tanks;

.7 hatchway covers in dry cargo ships and tankers;

.8 cargo tank hatchway covers in tankers;

.9 doors in subdivision bulkheads.

**1.3.2.7** Equipment of ship's spaces:

.1 ceiling and battens in cargo holds;

.2 exit doors from ship's spaces in escape routes;

.3 stairways and vertical ladders;

.4 guard rails, bulwark and gangways;

.5 cellular guide members in the holds of container ships.

**1.3.2.8** Emergency outfit:

.1 collision mats;

.2 tools;

.3 materials.

**1.3.3** The Register survey of the manufacture of items specified in 1.3.2.1.7, 1.3.2.1.8, 1.3.2.5, 1.3.2.7.1, 1.3.2.7.5, 1.3.2.8.2 and 1.3.2.8.3 is confined to consideration of the relevant technical documentation.

**1.3.4** For items specified in 1.3.2 the following documents shall be submitted to the Register:

.1 assembly drawing;

.2 calculations (no approval stamps are needed);

.3 detail drawings if parts or assemblies are not manufactured in accordance with standards and specifications approved by the Register.

**1.3.5** Materials used for items specified in 1.3.2.1.1 to 1.3.2.1.5, 1.3.2.2.1, 1.3.2.2.2, 1.3.2.4.3, 1.3.2.6.2 and 1.3.2.6.7 to 1.3.2.6.9 are subject to the Register survey during manufacture.

**1.3.6** The following equipment, arrangements and outfit are subject to the Register survey when the ship is under construction:

.1 rudder and steering gear;

.2 anchor arrangement;

.3 mooring arrangement;

.4 towing arrangement;

.5 masts and rigging;

.6 openings in hull, superstructures and deck-houses and their closing appliances;

.7 arrangement and equipment of ship's spaces;

.8 emergency outfit;

.9 cellular guide members in the holds of container ships;

.10 active means of the ship's steering (refer to 2.1.3).

#### 1.4 GENERAL

**1.4.1** In ships intended to carry in bulk flammable liquids with the flash point 60 °C and below no deck machinery shall be fitted directly on the decks being the top of cargo and fuel tanks. In this case, the deck machinery shall be fitted on special foundations, the construction of which provides for free circulation of air underneath the machinery.

**1.4.2** Towing and mooring arrangements plan containing the relevant information shall be available

on board for the guidance of the master. The information provided on the plan in respect of ship-board equipment shall include:

type and location on the ship;

safe working load (SWL);

purpose (mooring/harbour towing/escort service);

manner of applying tow line or mooring line load including limiting fleet angles.

Also the number of mooring lines together with the breaking strength of each mooring line shall be indicated on the plan.

This information shall be incorporated into the pilot card in order to provide the pilot with the proper information on harbour operations/escort service.

#### 1.5 WORKING AND ALLOWABLE STRESSES

**1.5.1** Wherever the working stresses are mentioned in the text of the present Part of the Rules, they mean combined stresses  $\sigma_{com}$ , in MPa, determined by the formula

$$\sigma_{com} = \sqrt{\sigma^2 + 3\tau^2} \quad (1.5.1)$$

where  $\sigma$  = normal stresses in the section under consideration, in MPa;

$\tau$  = shear stresses in the section under consideration, in MPa.

The strength conditions shall be checked against these stresses.

**1.5.2** Allowable stresses with which the combined stresses shall be compared when verifying the strength conditions are specified in the present Part in fractions of the upper yield stress of the material used; the upper yield stress shall not be taken as more than 0,7 times the tensile strength of this material, unless expressly provided otherwise.

#### 1.6 MATERIALS AND WELDING

**1.6.1** Steel forgings and castings, steel plates, sections and bars and also chain steel used for items specified in 1.3.2.1.1 to 1.3.2.1.5, 1.3.2.1.7, 1.3.2.2.1, 1.3.2.2.2, 1.3.2.4.3, 1.3.2.6.2, 1.3.2.6.7 and 1.3.2.6.9 shall meet the relevant requirements of Part XIII "Materials". Materials for other items of equipment, arrangements and outfit shall meet the requirements specified in the design documentation approved by the Register, unless expressly provided otherwise in the Rules.

**1.6.2** The grades of steel plates and sections (refer to Tables 3.2.2-1 and 3.2.2-2, Part XIII "Materials") for items specified in 1.3.2.1.2 and 1.3.2.1.3 shall be selected according to 1.2.3.1, Part II "Hull" in the same manner as for hull structural members of category II; in this case, for ships of ice categories **Arc4**

and higher and for icebreakers steel not lower than Grade B shall be adopted, and for rudder blades of icebreakers, not lower than Grade D. For items specified in 1.3.2.6.2 the grades of steel plates and sections of the main carrying framing members and plating of cover structures ensuring fixing of items when stowed for sea, as well as essential parts of drivers intended for opening at sea shall be selected according to 1.2.3.1, Part II "Hull" as for hull structural members of category II.

**1.6.3** Welding of structural elements of ship's equipment, arrangements and outfit shall be performed in accordance with the requirements of Part XIV "Welding"; besides, welded structures and joints of items specified in 1.3.2.6.2, 1.3.2.6.7 and 1.3.2.6.9 shall comply with the applicable requirements of 1.7, Part II "Hull".

## 1.7 DESIGN ACCELERATIONS DUE TO HEAVE OF THE SEA

**1.7.1** The dimensionless, gravity related, design accelerations due to heave of the sea as described in this Chapter shall be applied when determining the loads upon equipment, arrangements and batches of cargo items carried by ships of unrestricted service and those of restricted area of navigation **R1**.

With regard to ships of other areas of navigation, accelerations may be applied different from those required herein which shall be substantiated by calculations approved by the Register.

**1.7.2** The dimensionless acceleration  $a_z$  due to heave, pitch and roll normal to the water planes of the ship shall be determined by the formula

$$a_z = \pm a_0 \sqrt{1 + \left(5,3 - \frac{45}{L}\right)^2 \left(\frac{x}{L} - 0,45\right)^2 \left(\frac{0,6}{C_B}\right)^{3/2}} \quad (1.7.2-1)$$

$$\text{where } a_0 = 0,2 \frac{V}{\sqrt{L}} + \frac{34 - 600/L}{L}; \quad (1.7.2-2)$$

$V$  = maximum ahead speed, in knots, with the ship on summer load waterline on still water;

$L$  = ship's length, in m;

$x$  = longitudinal distance from the centre of gravity of equipment, arrangement or batch of cargo items in question to the aft perpendicular;

$C_B$  = block coefficient.

$a_z$  does not include the component of the static weight.

**1.7.3** The dimensionless acceleration  $a_y$  due to transverse displacement, yaw and roll normal to the centre line of the ship shall be determined by the formula

$$a_y = \pm a_0 \sqrt{0,6 + 2,5 \left(\frac{x}{L} - 0,45\right)^2 + k_1 \left(1 + 0,6 k_1 \frac{z}{B}\right)^2} \quad (1.7.3-1)$$

where  $k_1$  = coefficient of stability to be determined by the formula

$$k_1 = \frac{13 \overline{GM}}{B} \quad (1.7.3-2)$$

If  $k_1$  as determined by the Formula (1.7.3-2), is below 1,0,  $k_1 = 1,0$  shall be assumed for calculating  $a_y$ ;

$\overline{GM}$  = transverse metacentric height of loaded ship when the volume and distribution of stores are such as to yield maximum  $\overline{GM}$ , in m;

$B$  = ship's breadth, in m;

$z$  = vertical distance, in m, from the summer load waterline to the centre of gravity of equipment, arrangement or batch of cargo items in question;  $z$  is positive above and negative below the summer load waterline.

$a_y$  includes the component of the static weight in the transverse direction due to rolling.

**1.7.4** The dimensionless acceleration  $a_x$  due to longitudinal displacement and pitch normal to the midship section plane shall be determined by the formula

$$a_x = \pm a_0 \sqrt{0,06 + k_2^2 - 0,25 k_2} \quad (1.7.4-1)$$

where  $k_2$  = factor determined from the formula

$$k_2 = \left(0,7 - \frac{L}{1200} + 5 \frac{z}{L}\right) \frac{0,6}{C_B} \quad (1.7.4-2)$$

$a_x$  includes the component of the static weight in the longitudinal direction due to pitching.

**1.7.5** When determining loads it shall be considered that the accelerations calculated using  $a_x$ ,  $a_y$  and  $a_z$  act independently of each other.

## 2 RUDDER AND STEERING GEAR

### 2.1 GENERAL

**2.1.1** Every ship, except for shipborne barges, shall be provided with a reliable device ensuring her steering and course-keeping facilities (refer to 2.10). Such devices may be rudder, nozzle rudder, etc., approved by the Register.

In the requirement of the case of non-propelled vessels of the dredging fleet with regard to the area of navigation and service conditions the Register may allow to omit such device or provide only stabilizers. The area of navigation and service conditions taken into account when it is allowed to omit such device or to provide only stabilizers are

subject to special consideration by the Register in each case.

**2.1.2** The requirements of the present Section apply only to ordinary streamlined rudders or nozzle rudders with streamlined profiles and rigidly fixed stabilizers.

Unordinary rudders, nozzle rudders with steerable stabilizers, Voith-Schneider propellers, etc. are subject to special consideration by the Register in each case.

**2.1.3 Active means of the ship's steering.**

**2.1.3.1** The active means of the ship's steering may be both the means supplementary to the regulated minimum (refer to 2.1.1) and the main means of the ship's steering.

**2.1.3.2** Taking into account the ship's purpose, design features and intended service conditions it may be permitted, on agreement with the Register, that the regulated steerability of the ship shall be provided at the low speed by simultaneous operation of the devices specified in 2.1.1 and the active means of the ship's steering.

In case where the AMSS are the main means of the ship's steering the regulated steerability shall be ensured under those running conditions of the ship for which the means are intended.

In any case, it shall be demonstrated by the method recognized by the Register that the steerability will not then be at least worse than that ensured in case of fulfilment of the requirements of 2.10.

**2.1.4** The number of rudder pintles supporting the rudder is not regulated by the Register, except for icebreakers and ships of ice categories **Arc4** and higher for which this number shall be not less than that given in Table 2.1.4.

Table 2.1.4

Categories of icebreakers and ice strengthening in ships	Number of rudder pintles
<b>Icebreaker9, Icebreaker8</b>	4
<b>Icebreaker7, Icebreaker6, Arc7, Arc8, Arc9</b>	3
<b>Arc6, Arc5</b>	2
<b>Arc4</b>	1

In exceptional cases, in icebreakers and ships of ice category **Arc7, Arc8, Arc9** the number of rudder pintles indicated in Table 2.1.4, may be reduced to two on agreement with the Register; the conditions under which this reduction may be permitted are subject to special consideration by the Register.

In icebreakers and ships of ice category **Arc7, Arc8, Arc9** the nozzle rudders shall not be fitted.

In ships of ice categories **Arc4, Arc5, Arc6** the arrangement of the nozzle rudder without the lower pintle in the solepiece is not permitted.

**2.1.5** Wherever the upper yield stress  $R_{eH}$  of the material used enters into the formulae of this Section, the provisions of 1.5.2 shall be taken into account,

but in all cases the upper yield stress  $R_{eH}$  of the material shall not be taken more than 390 MPa.

**2.1.6** When checking the rudder or nozzle rudder pintles and rudder stock bearings for surface pressure, the latter shall not exceed the values indicated in Table 2.1.6.

Table 2.1.6

Materials	Surface pressure $p$ , MPa	
	Water lubrication	Oil lubrication
Stainless steel or bronze against lignum vitae	2,4	—
Stainless steel or bronze against textolite or synthetic materials	On special agreement with the Register	—
Stainless steel against bronze or vice versa	6,9	—
Steel against white metal	—	4,4

**2.1.7** In ships of ice category **Arc5, Arc6** the arrangement of two nozzle rudders (in case of twin-screw ships) is subject to special consideration by the Register in each case.

**2.1.8** In ships of ice categories **Arc4** and higher the structural measures for ice protection of nozzle rudders are subject to special consideration by the Register in each case.

## 2.2 INITIAL DESIGN DATA

**2.2.1** The initial design data specified in this Chapter are valid only for the choice of scantlings of ordinary rudders and nozzle rudders with rigidly fixed stabilizers and cannot be used for determination of steering gear output characteristics. Methods of determination of these characteristics are not regulated by the Register, and the relevant calculations are not subject to approval by the Register. The steering gear is checked by the Register during sea trials of the ship to make sure that the steering gear output characteristics comply with the requirements of 2.9.2, 2.9.3 and 2.9.8.

### 2.2.2 Rudder force and rudder torque.

**2.2.2.1** The rudder blade force  $F$ , in kN, for the ahead condition shall be determined by the formula

$$F = F_1 + F_2 \quad (2.2.2.1-1)$$

where

$$F_1 = 5,59 \cdot 10^{-3} k_1 k_2 (6,5 + \lambda) (b_1 - C_B)^2 A V^2; \quad (2.2.2.1-2)$$

$$F_2 = 0,177 k_1 (6,5 + \lambda) \frac{T}{D_p^2} A_p \quad (2.2.2.1-3)$$

where  $k_1$  = factor equal to:

1,0 for rectangular and trapezoidal rudders, except for rudders behind the rudder post;  
0,95 for semispade rudders (rudders of types I, II, VII and VIII in Fig. 2.2.4.1);  
0,89 for rudders behind the rudder post (rudders of types IV, X and XIII in Fig. 2.2.4.1);

$k_2$  = factor equal to:  
 1,0 for rudders operating directly behind the propeller;  
 1,25 for rudders not operating directly behind the propeller;  
 $\lambda$  = value determined by the formula

$$\lambda = h_r^2 / A_t \quad (2.2.2.1-4)$$

where  $h_r$  = mean height of the rudder blade part abaft the centre line of the rudder stock, in m;  
 $A_t$  = sum of the rudder area and lateral area of the rudder horn or rudder post, if any, within the height  $h_r$ , in  $m^2$ . In case of no rudder horn or rudder post, the value of  $A_t$  is taken as  $A$  in the calculations;  
 $A$  = rudder area, in  $m^2$ ;  
 $A_p$  = portion of the rudder area in the wake of the propeller when the rudder is in the non-reversed position, in  $m^2$ ;  
 $b_1$  = value equal to:  
 2,2 for rudders situated at the centre plane of the ship;  
 2,32 for side rudders;  
 $C_B$  = block coefficient with the ship on the summer load waterline;  
 $V$  = maximum ahead speed with the ship on the summer load waterline, in knots;  
 $T$  = propeller thrust at the speed  $V$ , in kN, (refer to 2.2.2.6);  
 $D_p$  = propeller diameter, in m.

**2.2.2.2** The value of the force  $F$  specified in 2.2.2.1 shall not be taken less than  $F_3$ , in kN, determined by the formula

$$F_3 = k_3 A \quad (2.2.2.2)$$

where  $k_3$  = factor equal to:  
 171 — for icebreakers of category **Icebreaker9**;  
 150 — for icebreakers of category **Icebreaker8**;  
 130 — for icebreakers of category **Icebreaker7**;  
 110 — for icebreakers of category **Icebreaker6** and for ships of ice category **Arc9**;  
 95 — for ships of ice category **Arc8**;  
 81 — for ships of ice category **Arc7**;  
 75 — for ships of ice category **Arc6**;  
 66 — for ships of ice category **Arc5**;  
 53 — for ships of ice category **Arc4**;  
 18 — for other ships.

When the value of the force  $F_3$  is greater than that of the force  $F$  specified in 2.2.2.1, in subsequent calculations the value of  $F_3$  is taken instead of  $F$ , and the value  $F_2$  is taken equal to zero.

**2.2.2.3** For the ahead condition the rudder torque  $M_t$ , in  $kN \cdot m$ , shall not be taken less than determined by the formula

$$M_t = F \frac{A}{h_r} \left( 0,35 - \frac{A_1}{A} \right) \quad (2.2.2.3-1)$$

where  $A_1$  = part of the rudder blade area forward of its centre line in  $m^2$ .

For single-plate solid-cast rudders with the leading edge aft of the rudder stock centre line  $A_1$  is taken as the negative value of the area formed by the leading edge of the rudder blade and the rudder stock centre line.

For icebreakers and ships of ice categories **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9** the rudder torque

$M_t$ , in  $kN \cdot m$ , due to the force  $F_3$  specified in 2.2.2.2, shall not be taken less than determined by the formula

$$M_t = 0,35 F_3 b_r \quad (2.2.2.3-2)$$

where  $b_r$  = distance from the centre line to the rear edge of the rudder blade at the level of the midheight of the rudder blade, in m.

**2.2.2.4** For the astern condition the rudder torque  $M_{as}$ , in  $kN \cdot m$ , shall not be taken less than determined by the formula

$$M_{as} = k_4 \frac{A^2}{h_r} \left( 0,7 - \frac{A_1}{A} \right) v_{as}^2 \quad (2.2.2.4)$$

where  $k_4$  = factor equal to:  
 0,185 — for rudders operating directly behind the propeller;  
 0,139 — for rudders not operating directly behind the propeller;  
 $v_{as}$  = maximum specification speed of the ship for the astern condition, but not less than  $0,5v$ , in knots.

**2.2.2.5** For the astern condition the rudder blade force  $F_{as}$ , in kN, shall be determined by the formula

$$F_{as} = M_{as} \frac{h_r}{A \left( 0,7 - \frac{A_1}{A} \right)} \quad (2.2.2.5)$$

When determining the bending moments and reactions of the supports according to the provisions of 2.2.4 to 2.2.7 for the astern condition, the force  $F_{as}$  shall be considered as the force  $F_1$ , and the value of  $F_2$  is then taken equal to zero.

**2.2.2.6** In case reliable data are not available on the value of the propeller thrust mentioned in 2.2.2.1, the value of  $T$ , in kN, may be determined by the formulae:

for fixed-pitch propellers

$$T = 0,0441 \left( \frac{30,6 N_e}{n H_1 \sqrt[3]{z \theta}} - n^2 D_p^4 \right); \quad (2.2.2.6-1)$$

for controllable-pitch propellers

$$T = 0,0441 \left( \frac{110 N_e}{v(b_1 - C_B) \sqrt[3]{z}} - n^2 D_p^4 \right) \quad (2.2.2.6-2)$$

where  $N_e$  = nominal total output of the propulsion plant of the ship divided by the number of the propellers, in kW;  
 $n$  = number of propeller revolutions per second, in  $s^{-1}$ ;  
 $H_1$  = propeller pitch at the zero thrust, in m, determined by the formula

$$H_1 = H + \frac{0,055 D_p}{\theta + 0,3}, \quad (2.2.2.6-3)$$

$H$  = design propeller pitch, in m;  
 $\theta$  = blade area ratio;  
 $z$  = number of propeller blades.

### 2.2.3 Nozzle rudder force and torque.

**2.2.3.1** The total force  $F$ , in kN, acting on the nozzle rudder and stabilizer shall not be taken less than determined by the formula

$$F = F_n + F_{st} \quad (2.2.3.1-1)$$

where  $F_n$  = force acting on the nozzle rudder, in kN;  
 $F_{st}$  = force acting on the stabilizer, in kN.

$F_n$  and  $F_{st}$  are determined by the formulae:

$$F_n = 9,81 \cdot 10^{-3} p D_n l_n v_1^2; \quad (2.2.3.1-2)$$

$$F_{st} = 9,81 \cdot 10^{-3} q m A_{st} v_1^2 \quad (2.2.3.1-3)$$

where  $D_n$  = inner minimum nozzle rudder bore, in m;  
 $l_n$  = nozzle rudder length, in m;  
 $A_{st}$  = area of nozzle rudder stabilizer, in m<sup>2</sup>;  
 $v_1$  = speed, in knots, determined by the formula

$$v_1 = v(1 - W) \quad (2.2.3.1-4)$$

where  $W$  = average wake factor. In case reliable experimental data are not available, the wake factor may be determined by the formula

$$W = 0,165 C_B \sqrt[3]{\Delta / D_p} \quad (2.2.3.1-5)$$

where  $C_B$  = block coefficient of the ship;  
 $\Delta$  = volume displacement, in m<sup>3</sup>, with the ship on summer load waterline;  
 $n$  = number of propellers;  
 $D_p$  = propeller diameter, in m;  
 $v$  = maximum ahead speed, in knots, with the ship on summer load waterline; this speed shall not be taken less than:  
 17 knots for ships of ice category **Arc5** and **Arc6**;  
 14 knots for ships of ice category **Arc4**;  
 11 knots for other ships;  
 $p, q$  = coefficients determined by the formulae:

$$p = 78,4 - 55,6\sqrt{\lambda_n} + (44,0 - 33,4\sqrt{\lambda_n})C_{HB} \quad (2.2.3.1-6)$$

$$q = 7,43 - 5,72\lambda_n + (2,82 - 2,2\lambda_n)C_{HB}. \quad (2.2.3.1-7)$$

$C_{HB}$  being determined by the formula

$$C_{HB} = 9,38 T / (D_p^2 v^2) \quad (2.2.3.1-8)$$

where  $T$  = propeller thrust at speed  $v$ , in kN;  
 $D_p$  = propeller diameter, in m;  
 $\lambda_n$  is determined by the formula

$$\lambda_n = l_n / D_n; \quad (2.2.3.1-9)$$

$m$  = coefficient determined by the formula

$$m = 4,5 - 0,12(\lambda_{st} - 5,43)^2; \quad (2.2.3.1-10)$$

$\lambda_{st}$  is determined by the formula

$$\lambda_{st} = h_{st} / l_{st} \quad (2.2.3.1-11)$$

$h_{st}$  = height of nozzle rudder stabilizer, in m;  
 $l_{st}$  = length of nozzle rudder stabilizer, in m.

**2.2.3.2** A point situated at the level of the longitudinal axis of the nozzle rudder at the distance  $r_n$  from the nozzle rudder leading edge shall be considered as a point of application of force  $F_n$ . The distance  $r_n$ , in m, shall not be less than determined by the formula

$$r_n = l_n (bk + c) \quad (2.2.3.2-1)$$

where  $k$  = coefficient determined by the formula

$$k = l_{r,s} / l_n \quad (2.2.3.2-2)$$

$l_{r,s}$  = distance between the centre line of the rudder stock and the leading edge of the nozzle rudder, in m;  
 $b, c$  = coefficients determined by the formulae:

$$b = 0,796 - 0,011(C_{HB} - 7,18)^2; \quad (2.2.3.2-3)$$

$$c = 0,1585 - 0,0916\sqrt{C_{HB}}. \quad (2.2.3.2-4)$$

A point situated at the level of the nozzle rudder longitudinal axis at the distance  $r_{st}$  from the stabilizer leading edge shall be considered as a point of application of force  $F_{st}$ . The distance  $r_{st}$ , in m, shall not be less than determined by the formula

$$r_{st} = 0,25 l_{st}. \quad (2.2.3.2-5)$$

**2.2.3.3** The total torque  $M_t$ , in kN·m, for the nozzle rudder shall be determined by the formula

$$M_t = M_n - M_{st} \quad (2.2.3.3-1)$$

where  $M_n$  = torque of force  $F_n$ , in kN·m;  
 $M_{st}$  = torque of force  $F_{st}$ , in kN·m;  
 $M_n$  and  $M_{st}$  are determined by the formulae:

$$M_n = F_n(l_{r,s} - r_n), \quad (2.2.3.3-2)$$

$$M_{st} = F_{st}(a + r_{st}) \quad (2.2.3.3-3)$$

where  $a$  = distance between the centre line of the rudder stock and the leading edge of the stabilizer, in m.

In any case, the total torque  $M_t$  for the nozzle rudder shall not be taken less than the minimum value of torque  $M_{\min}$ , in kN·m, determined by the formula

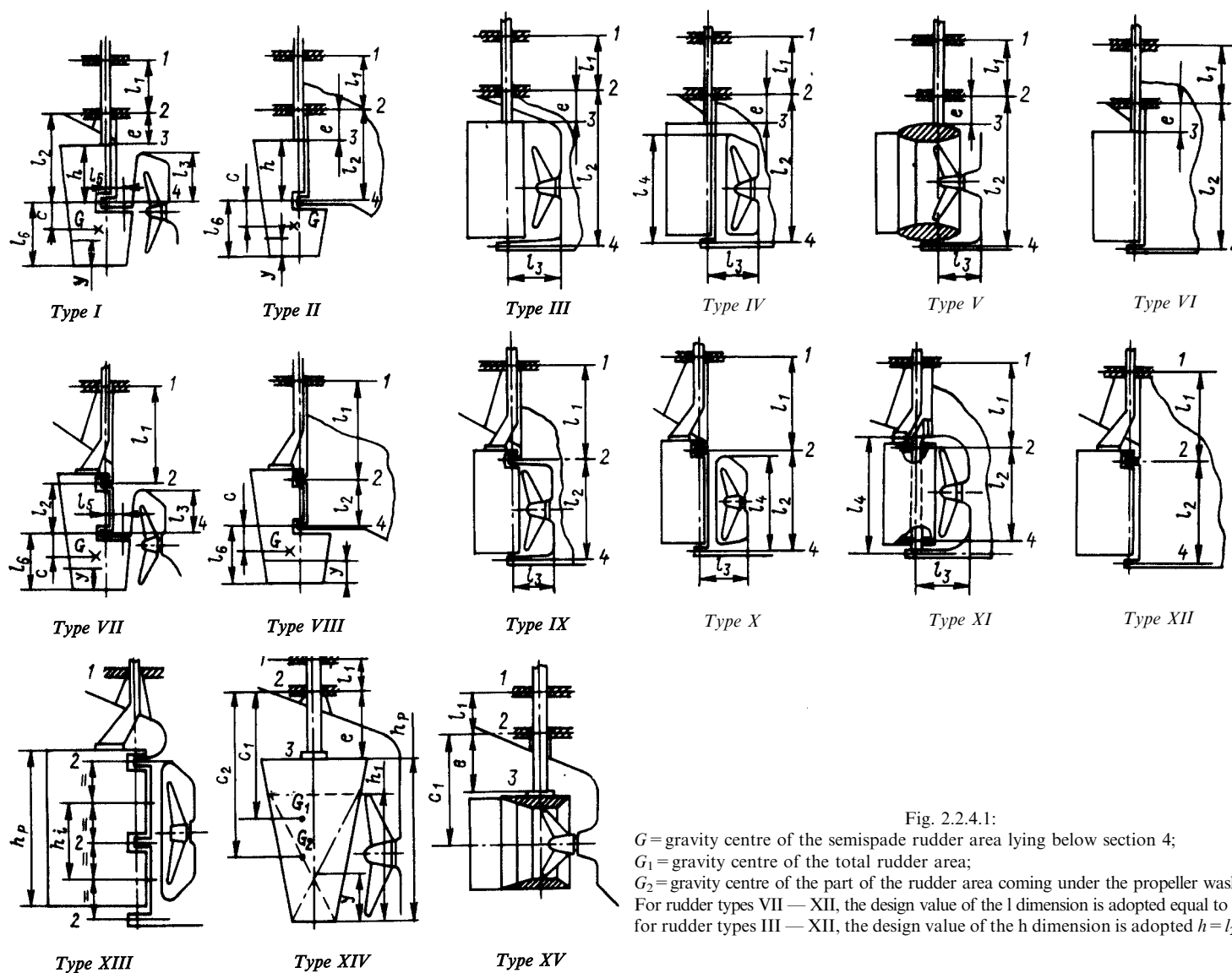
$$M_{\min} = \frac{28,1 F_n}{p} (0,72 l_n - l_{r,s}) + \frac{7,8 F_{st}}{q m} (l_n - l_{r,s} + 0,5 l_{st}). \quad (2.2.3.3-4)$$

### 2.2.4 Bending moments and reactions of supports for rudders of types I — IV, VI — XII and nozzle rudders of type V (Fig. 2.2.4.1).

**2.2.4.1** The design values of the bending moments and reactions of supports shall be determined from the formulae of this Chapter depending on the types of the rudders shown in Fig. 2.2.4.1 having regard to the provisions of Table 2.2.4.1 as well as the type and location of the steering gear as specified in 2.2.4.2.

Table 2.2.4.1

Type of rudder (refer to Fig. 2.2.4.1)	Design value of load $Q_2$	Design value of load $Q_1$
I, II, VII, VIII	$Q_2 = \left( \frac{F_1}{A} + \frac{F_2}{A_p} \right) A_1$	$Q_1 = F - Q_2$
III — VI and IX — XII	$Q_2 = 0$	
<p>Notes: 1. The value of <math>A_1</math> is the portion the semispade rudder area below the lower pintle (below section 4 in Fig. 2.2.4.1), in m<sup>2</sup>.</p> <p>2. For nozzle rudders of type V the design value of the ratio <math>I_{r,s}/I_r</math> is taken equal to zero.</p> <p>3. The force <math>F</math> is taken in accordance with the provisions of 2.2.2 for rudders and of 2.2.3 for nozzle rudders.</p>		





**2.2.4.2** The transverse force  $P$ , in kN, created on the rudder stock by steering gear (quadrant steering gears, steering gears with single-arm tillers and similar steering gears) is determined by the formula

$$P = M_t / r_1 \quad (2.2.4.2)$$

where  $M_t$  = rudder torque, in kN·m, specified in 2.2.2.3 and 2.2.3.3. When considering the astern running of the ship, the rudder torque  $M_t$  is taken as the value  $M_{as}$  specified in 2.2.2.4;

$r_1$  = radius of the steering gear quadrant or tiller resultant force arm measured from the centre line of the rudder stock, in m.

Depending on the location of the steering gear quadrant or tiller indicated in Fig. 2.2.4.2 the value  $P$  for Case I is taken as  $P_I$  and the value  $P_{II}$  is taken equal to zero. For Case II the value of  $P$  is taken as  $P_{II}$  and the value of  $P_I$  is taken equal to zero. The values of  $P_I$  or  $P_{II}$  are assumed to be positive when the quadrant or tiller are located forward of the rudder stock centre line and they are assumed to be negative when the quadrant or tiller are located aft of the rudder stock centre line.

For steering gears the rudder torque of which is transmitted to the rudder stock by a pair (or pairs) of forces (four-piston, rotary vane steering gears or similar) the values of  $P_I$  and  $P_{II}$  are taken equal to zero.

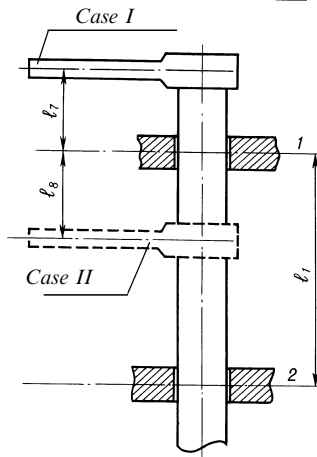


Fig. 2.2.4.2

**2.2.4.3** In the formulae of the present Chapter the numerical indices of symbols of the bending moments ( $M_1, M_2, M_3, M_4$ ) and reactions of supports ( $R_1, R_2, R_4$ ) correspond to the number of the support or section given in Figs 2.2.4.1 and 2.2.4.2 for the relevant type of the rudder.

**2.2.4.4** Unless expressly provided otherwise, in the formulae of the present Chapter the linear dimensions shown in Figs 2.2.4.1 and 2.2.4.2 shall be taken in metres, and the forces, in kN.

**2.2.4.5** The design values of the bending moments and reactions of supports may be taken less than

those specified in 2.2.4.1 on condition that the detailed calculation is submitted where due consideration is given to the flexibility of the rudder supports and to the non-uniformity of the force distribution over the rudder blade area.

**2.2.4.6** For Case I of the quadrant steering gear or tiller location (refer to Fig. 2.2.4.2) the design value of bending moment  $M_1$ , in kN·m, in section I of the rudder stock (at the upper bearing) shall be determined by the formula

$$M_1 = P_I l_7 \quad (2.2.4.6)$$

where for  $P_I$  and  $l_7$ , refer to 2.2.4.2 and 2.2.4.4.

For Case II of the steering gear quadrant or tiller location  $M_1$  is taken equal to zero.

**2.2.4.7** The design value of the bending moment  $M_2$ , in kN·m, acting in section 2 of the rudder stock (at the lower bearing for rudders of types I-VI; in the rudder stock and rudder blade coupling for rudders of types VII-XII) shall be determined by the formula

$$M_2 = \frac{1}{8} Q_1 h \frac{k_5}{k_7} - \frac{1}{2} Q_2 c \frac{k_6}{k_7} - \frac{1}{2} P_I l_7 \frac{k_8}{k_7} + \frac{1}{2} P_{II} l_8 \frac{k_9}{k_7} \quad (2.2.4.7-1)$$

where  $Q_1, Q_2$  = loads determined in accordance with Table 2.2.4.1;

$P_I, P_{II}$  = forces determined in accordance with 2.2.4.2;

$h, c, l_7, l_8$  = linear dimensions (refer to 2.2.4.4);

$k_5, k_6, k_7, k_8, k_9$  = factors determined by the formulae:

$$k_5 = 2\left(\frac{e}{h}\right)^2 \left(3 + \frac{e}{h}\right) + \left(1 + 5\frac{e}{h}\right) \frac{I_{r,s}}{I_r} + 12\left(1 + 2\frac{e}{h}\right) \frac{I_{r,s} \alpha_4}{h^3}, \quad (2.2.4.7-2)$$

$$k_6 = \left(\frac{e}{h}\right)^2 \left(3 + \frac{e}{h}\right) + \left(1 + 3\frac{e}{h}\right) \frac{I_{r,s}}{I_r} - 6\left(1 + \frac{l_2}{c}\right) \frac{I_{r,s} \alpha_4}{h^3}, \quad (2.2.4.7-3)$$

$$k_7 = \left(1 + \frac{e}{h}\right)^2 \left(1 + \frac{e}{h} + \frac{l_1}{h}\right) - 1 + \frac{I_{r,s}}{I_r} + 3 \frac{I_{r,s} \alpha_4}{h^3}, \quad (2.2.4.7-4)$$

$$k_8 = l_1 l_2^2 / h^3; \quad (2.2.4.7-5)$$

$$k_9 = \frac{l_1 l_2^2}{h^3} \left(1 - \frac{l_8^2}{l_1^2}\right) \quad (2.2.4.7-6)$$

where  $e, l_1$  and  $l_2$  = linear dimensions (refer to 2.2.4.4);

$I_{r,s}$  = mean moment of inertia of the rudder stock cross-section, in cm<sup>4</sup>;

$I_r$  = mean moment of inertia of the rudder cross-section at the portion between sections 3 — 4 (rudder types I — VI) or between sections 2 — 4 (rudder types VII — XII), in cm<sup>4</sup>;

$\alpha_4$  = coefficient determined in accordance with the provisions of 2.2.4.17 to 2.2.4.21 depending on the type of the rudder, in m<sup>3</sup>/cm<sup>4</sup>.

**2.2.4.8** The design value of the bending moment  $M_3$ , in kN·m, acting in section 3 of the rudder stock (in the rudder stock and rudder blade coupling for rudders of types I — VI) shall be determined by the formula

$$M_3 = M_2 \frac{h}{l_2} + Q_2 c \frac{e}{l_2} - \frac{l}{2} Q_1 h \frac{e}{l_2}. \quad (2.2.4.8)$$

**2.2.4.9** The design value of the bending moment  $M_4$ , in kN·m, acting in section 4 of the rudder blade for rudders of types I, II, VII and VIII shall be determined by the formula

$$M_4 = Q_2 c. \quad (2.2.4.9)$$

For rudders of these types the value of  $M_4$  is taken as the bending moment acting in any rudder cross-section above support 4 of the rudder.

For other rudders the value of the bending moment  $M_4$  is taken equal to zero.

**2.2.4.10** The design value of the reaction  $R_1$ , in kN, of support 1 of the rudder (of the upper bearing) shall be determined by the formula

$$R_1 = \frac{M_2}{l_1} - P_I \left(1 + \frac{l_7}{l_1}\right) - P_{II} \left(1 - \frac{l_8}{l_1}\right). \quad (2.2.4.10)$$

**2.2.4.11** The design value of the reaction  $R_2$ , in kN, of support 2 of the rudder (of the lower bearing for rudder types I — VI, of the upper bearing of the rudder axle for rudder type XI, of the upper pintle of rudders for types VII — X and XII) shall be determined by the formula

$$R_2 = -M_2 \left(\frac{1}{l_1} + \frac{1}{l_2}\right) + Q_2 \frac{c}{l_2} - \frac{l}{2} Q_1 \frac{h}{l_2} + P_I \frac{l_7}{l_1} - P_{II} \frac{l_8}{l_1}. \quad (2.2.4.11)$$

**2.2.4.12** The design value of the reaction  $R_4$ , in kN, of support 4 of the rudder (of the lower pintle) shall be determined by the formula

$$R_4 = \frac{M_2}{l_2} - \frac{l}{2} Q_1 \left(1 + \frac{e}{l_2}\right) - Q_2 \left(1 + \frac{c}{l_2}\right). \quad (2.2.4.12)$$

**2.2.4.13** The design value of the bending moment  $M_r$ , in kN·m, acting in the considered section of the lower part of the semispade rudder body (below section 4 shown in Fig. 2.2.4.1 for rudder types I, II, VII and VIII) shall be determined by the formula

$$M_r = \frac{1}{2} Q_2 \frac{y^2}{l_6} \quad (2.2.4.13)$$

where  $y, l_6$  = linear dimensions (refer to 2.2.4.4).

**2.2.4.14** The design value of the bending moment  $M_r$ , in kN·m, acting in any cross-section of the rudder blade for rudders of types III, IV, VI and IX — XII shall be determined by the formula

$$M_r = \frac{1}{2} M_2 \frac{h}{l_2} \left(2 - \frac{h}{l_2} - \frac{M_2}{Q_1 l_2}\right) - \frac{1}{8} Q_1 h \left(2 - \frac{h}{l_2}\right)^2. \quad (2.2.4.14)$$

**2.2.4.15** The design value of the bending moment  $M_{ra}$ , in kN·m, acting in the section of the rudder axle near its flange shall be determined by the formula

$$M_{ra} = R_4 l_4 \left[0,42 \frac{(l_4 - l_2)}{l_4} + 0,24 \frac{l_3}{l_4} \frac{I_{rp}}{I_s} + 0,15 \left(\frac{l_3}{l_4}\right)^2\right] \quad (2.2.4.15)$$

where  $l_3, l_4$  = linear dimensions (refer to 2.2.4.4);

$I_{rp}$  = mean moment of inertia of the rudder axle or rudder post cross-section, in cm<sup>4</sup>;

$I_s$  = mean moment of inertia of the solepiece cross-section, in cm<sup>4</sup>.

**2.2.4.16** For Case II of the steering gear quadrant or tiller location (refer to Fig. 2.2.4.2) the design value of the bending moment  $M_s$ , in kN·m, acting in the section of the rudder stock in way of the quadrant or tiller location shall be determined by the formula

$$M_s = R_1 l_8. \quad (2.2.4.16)$$

For Case I of the steering gear quadrant or tiller location  $M_s$  is taken equal to zero.

**2.2.4.17** The coefficient  $\alpha_4$ , in m<sup>3</sup>/cm<sup>4</sup>, for rudders of types I and VII (for the horn of the semispade rudder) shall be determined by the formula

$$\alpha_4 = \frac{1,07 l_3^3}{3 I_1} \left(4 - 3 \frac{b_{h0}}{b_{h1}}\right) + \frac{1,3 l_5^2 l_3}{I_2} \left(1 + \frac{b_{h1}}{b_{h0}}\right) \frac{b_{h1}}{b_{h0}} \quad (2.2.4.17-1)$$

where  $l_5$  = linear dimension (refer to 2.2.4.4);

$I_1$  = moment of inertia of the rudder horn cross-section at its root about the axis parallel to the centre plane of the ship, in cm<sup>4</sup>;

$b_{h0}$  = maximum width of the horizontal section of the rudder horn at the lower pintle (section 4 in Fig. 2.2.4.1), in m;

$b_{h1}$  = maximum width of the horizontal section of the rudder horn at its root, in m;

$I_2$  = polar moment of inertia of the rudder horn cross-section at its root, in cm<sup>4</sup>, determined by the formula

$$I_2 = \frac{4 A_{rh}^2}{n \sum_{i=1}^n l_{oi} s_{oi}} \quad (2.2.4.17-2)$$

where  $A_{rh}$  = area enclosed by the centre line of the rudder horn plating (with the cross-section at the horn root), in cm<sup>2</sup>;

$l_{oi}$  = length of the centre line of the rudder horn plating (in the cross-section at the horn root) of the given thickness, in cm;

$s_{oi}$  = thickness of the considered portion of the rudder horn plating with the length  $l_{oi}$ , in cm;

$n$  = number of portions of the rudder horn plating with the length  $l_{oi}$  and thickness  $s_{oi}$ .

**2.2.4.18** The coefficient  $\alpha_4$ , in m<sup>3</sup>/cm<sup>4</sup>, for rudders of types III, V and IX (for the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3 I_{s1}} \left(4 - 3 \frac{b_{s0}}{b_{s1}}\right) \quad (2.2.4.18)$$

where  $I_{sl}$  = moment of inertia of the solepiece cross-section at its root about the vertical axis, in  $\text{cm}^4$ ;  
 $b_{s0}$  = width of the solepiece cross-section at the rudder stock or nozzle rudder pintle, in cm;  
 $b_{s1}$  = width of the solepiece cross-section at its root, in cm.

**2.2.4.19** The coefficient  $\alpha_4$ , in  $\text{m}^3/\text{cm}^4$ , for rudders of types IV and X (for the rudder post with the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3I_s} \left( 0,075 \frac{I_s}{I_{rp}} + 0,334 \frac{l_4}{l_3} \right). \quad (2.2.4.19)$$

**2.2.4.20** The coefficient  $\alpha_4$ , in  $\text{m}^3/\text{cm}^4$ , for rudders of type XI (for rudder axle with the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3I_s} \left\{ \left( 0,075 \frac{I_s}{I_{rp}} + 0,334 \frac{l_4}{l_3} \right) - 0,282 \frac{(l_4 - l_2)}{l_4} \times \left[ 1,55 \frac{l_4}{l_3} + 0,053 \left( \frac{l_4}{l_3} \right)^2 + \frac{(l_4 - l_2)}{l_4} \frac{I_s}{I_{rp}} \right] \right\}. \quad (2.2.4.20)$$

**2.2.4.21** The coefficient  $\alpha_4$  for rudders of types II, VI, VIII and XII is taken equal to zero.

**2.2.5 Bending moments and reactions of supports for rudder of type XIII (Fig. 2.2.4.1).**

**2.2.5.1** The requirements of 2.2.4.2 to 2.2.4.6 and 2.2.4.16 are also applicable to the rudders of type XIII.

**2.2.5.2** The design value of the bending moment acting in way of the rudder stock and rudder blade coupling shall be taken equal to zero.

**2.2.5.3** The design value of the bending moment  $M_r$ , in  $\text{kN}\cdot\text{m}$ , acting in any cross-section of the rudder blade shall be determined by the formula

$$M_r = 0,1 F h_i^2 / h_r \quad (2.2.5.3)$$

where  $F$  = force determined according to the provisions of 2.2.2.1, 2.2.2.2 and 2.2.2.5, in kN;  
 $h_i, h_r$  = linear dimensions (refer to 2.2.4.4); in this case, the greater of the value  $h_i$  shall be taken as the design value.

**2.2.5.4** The design value of the reaction  $R_1$  of support 1 of the rudder (of the upper bearing) shall be taken equal to zero.

**2.2.5.5** The design value of the reaction  $R_2$ , in kN, of support 2 of the rudder (of any pintle) shall be determined by the formula

$$R_2 = F h_i / h_r. \quad (2.2.5.5)$$

**2.2.6 Bending moments and reactions of supports for rudder of type XIV (Fig. 2.2.4.1).**

**2.2.6.1** The requirements of 2.2.4.2 to 2.2.4.6 and 2.2.4.16 are also applicable to the rudders of type XIV.

**2.2.6.2** The design value of the bending moment  $M_2$ , in  $\text{kN}\cdot\text{m}$ , acting in section 2 of the rudder stock (at the lower bearing) shall be determined by the formula

$$M_2 = F_1 c_1 + F_2 c_2 \quad (2.2.6.2)$$

where  $F_1, F_2$  = forces determined according to the provisions of 2.2.2.1, 2.2.2.2 and 2.2.2.5, in kN;  
 $c_1, c_2$  = linear dimensions (refer to 2.2.4.4), in m.

**2.2.6.3** The design value of the bending moment  $M_3$ , in  $\text{kN}\cdot\text{m}$ , acting in section 3 of the rudder stock (in the rudder stock and rudder blade coupling) shall be determined by the formula

$$M_3 = F_1(c_1 - e) + F_2(c_2 - e) \quad (2.2.6.3)$$

where  $e$  = linear dimension (refer to 2.2.4.4), in m.

**2.2.6.4** The design value of the bending moment  $M_r$ , in  $\text{kN}\cdot\text{m}$ , acting in the considered section of the rudder blade shall be determined by the formulae:

$$\text{for sections with } y < h_1 \\ M_r = \frac{1}{2} \left( \frac{F_1}{h_r} + \frac{F_2}{h_1} \right) y^2; \quad (2.2.6.4-1)$$

for sections with  $y \geq h_1$

$$M_r = \frac{1}{2} \frac{F_1}{h_r} y^2 + F_2 \left( y - \frac{1}{2} h_1 \right) \quad (2.2.6.4-2)$$

where  $h_r, h_1$  and  $y$  = linear dimensions (refer to 2.2.4.4), in m.

**2.2.6.5** The design value of the reaction  $R_1$ , in kN, of support 1 of the rudder (of the upper bearing) shall be determined by the formula

$$R_1 = F_1 \frac{c_1}{l_1} + F_2 \frac{c_2}{l_1} - P_I \left( 1 + \frac{l_7}{l_1} \right) - P_{II} \left( 1 - \frac{l_8}{l_1} \right) \quad (2.2.6.5)$$

where  $l_1$  = linear dimension (refer to 2.2.4.4), in m.

**2.2.6.6** The design value of the reaction  $R_2$ , in kN, of support 2 of the rudder (of the lower bearing) shall be determined by the formula

$$R_2 = F_1 \left( 1 + \frac{c_1}{l_1} \right) + F_2 \left( 1 + \frac{c_2}{l_1} \right) - P_I \frac{l_7}{l_1} + P_{II} \frac{l_8}{l_1}. \quad (2.2.6.6)$$

**2.2.7 Bending moments and reactions of supports for nozzle rudders of type XV (Fig. 2.2.4.1).**

**2.2.7.1** The requirements of 2.2.4.2 to 2.2.4.4, 2.2.4.6 and 2.2.4.16 are also applicable to the nozzle rudder of type XV.

**2.2.7.2** The design value of the bending moment  $M_2$ , in  $\text{kN}\cdot\text{m}$ , acting in section 2 of the rudder stock (at the lower bearing) shall be determined by the formula

$$M_2 = F c_1 \quad (2.2.7.2)$$

where  $F$  = force determined according to the provisions of 2.2.3.1, in kN;  
 $c_1$  = linear dimension (refer to 2.2.4.4), in m.

**2.2.7.3** The design value of the bending moment  $M_3$ , in kN·m, acting in section 3 of the rudder stock (at the rudder stock and nozzle rudder coupling) shall be determined by the formula

$$M_3 = F(c_1 - e) \quad (2.2.7.3)$$

where  $e$  = linear dimension (refer to 2.2.4.4), in m.

**2.2.7.4** The design value of the reaction  $R_1$ , in kN, of support 1 (of the upper bearing) shall be determined by the formula

$$R_1 = F \frac{c_1}{l_1} - P_I \left(1 + \frac{l_7}{l_1}\right) - P_{II} \left(1 - \frac{l_8}{l_1}\right) \quad (2.2.7.4)$$

where  $l_1$  = linear dimension (refer to 2.2.4.4), in m.

**2.2.7.5** The design value of the reaction  $R_2$ , in kN, of support 2 (of the lower bearing) shall be determined by the formula

$$R_2 = F \left(1 + \frac{c_1}{l_1}\right) - P_I \frac{l_7}{l_1} + P_{II} \frac{l_8}{l_1} \quad (2.2.7.5)$$

**2.2.8** The design values of bending moments and reactions of supports for the steering gears which differ from those indicated in Fig. 2.2.4.1 are subject to special consideration by the Register.

## 2.3 RUDDER STOCK

**2.3.1** The diameter of the rudder stock head  $d_0$ , in cm, shall be not less than the greater value determined by the formula

$$d_0 = k_{10} \sqrt[3]{M_t / R_{eH}} \quad (2.3.1)$$

where  $k_{10}$  = factor equal to:

26,1 for the ahead condition;

23,3 for the astern condition;

$M_t$  = torque according to 2.2.2.3, 2.2.2.4 or 2.2.3.3, in kN·m;

$R_{eH}$  = upper yield stress of the rudder stock material, in MPa.

**2.3.2** Under combined action of the torque and bending moment the working stresses (refer to 1.5.1) acting in rudder stock sections 1, 2 or 3 shown in Fig. 2.2.4.1 for the appropriate type of the rudder shall not exceed 0,5 times the upper yield stress for the ahead condition and 0,7 times the upper yield stress of the material for the astern condition (refer to 1.5.2 and 2.1.5). In this case, the normal stress  $\sigma$  and the shear stress  $\tau$ , in MPa, shall be determined by the formulae:

$$\sigma = 10,2 \cdot 10^3 M_b / d_i^3; \quad (2.3.2-1)$$

$$\tau = 5,1 \cdot 10^3 M_t / d_i^3 \quad (2.3.2-2)$$

where  $M_b$  = bending moment acting in the considered section of the rudder stock ( $M_1$ ,  $M_2$  or  $M_3$ ) determined according to the provisions of 2.2.4 to 2.2.7 for the appropriate type of the rudder, in kN·m;

$d_i$  = diameter of the rudder stock in the considered section, in cm.

**2.3.3** The change in the rudder stock diameter between the adjacent sections specified in 2.3.1 and 2.3.2 shall not be more sudden than that permitted by the linear law.

Where the change of the rudder stock diameter is stepped, the steps shall be provided with fillets having as large radius as practicable. The transition of the rudder stock into the flange shall be carried out with a radius of fillet of not less than 0,12 times the diameter of the rudder stock in way of the flange.

## 2.4 RUDDER BLADE AND NOZZLE RUDDER

### 2.4.1 Rudder blade.

**2.4.1.1** The thickness of the streamlined rudder blade side plating  $s$ , in mm, shall be not less than determined by the formula

$$s = ak_{11} \sqrt{\frac{98d + k_{12} \left( \frac{F_1}{A} + k_{13} \frac{F_2}{A_p} \right)}{R_{eH}}} + 1,5 \quad (2.4.1.1-1)$$

where  $d$  = draught of the ship, in m;

$F_1$ ,  $F_2$  = forces according to 2.2.2.1 and 2.2.2.2, kN;

for  $A$  and  $A_p$ , refer to 2.2.2.1;

$a$  = distance between horizontal or vertical web plates, whichever is the less, in m;

$k_{11}$  = factor determined by the formula

$$k_{11} = 10,85 - 2,516 \left( \frac{a}{b} \right)^2; \quad (2.4.1.1-2)$$

$R_{eH}$  = upper yield stress of the rudder blade plating material, in MPa;

$b$  = distance between horizontal or vertical web plates whichever is the greater, in m;

$k_{12}$  = factor equal to:

18,6 for the rudder blade plating within 0,35 of the rudder blade length from its leading edge;

8,0 for the rudder blade plating within 0,65 of the rudder length from its rear edge;

$k_{13}$  = factor equal to:

1 for the rudder blade plating in the wake of the propeller (when rudder is in the non-reversed position);

0 for the rudder blade plating beyond the wake of the propeller (when rudder is in the non-reversed position).

**2.4.1.2** In any case, the thickness of the streamlined rudder blade side plating  $s_{\min}$ , in mm, shall be not less than determined by the formulae:

for ships of less than 80 m in length

$$s_{\min} = 21,5 \frac{L + 51}{L + 240}; \quad (2.4.1.2-1)$$

for ships of 80 m in length and over

$$s_{\min} = 24 \frac{L + 37}{L + 240} \quad (2.4.1.2-2)$$

where  $L$  = length of the ship, in m.

**2.4.1.3** For ice ships the thickness of the rudder blade side plating in way of the ice belt shall be not less than that of the ice belt of the shell plating in the after part of the ship, specified in 3.10.4.1, Part II "Hull", with the frame spacing being equal to the distance between the vertical web plates of the rudder blade.

The thickness  $s$ , in mm, of the rudder blade side plating for the icebreakers shall be not less than determined by the formula

$$s = 9,2k_{16}a\sqrt{\frac{p_a}{R_{eH}}} + 6 \quad (2.4.1.3-1)$$

where  $a$  = distance between horizontal or vertical web plates, whichever is the less, for streamlined welded rudders; distance between rudder arms for single-plate steel solid-cast rudders, m. In any case, in the calculations the value  $a$  shall not be taken less than 0,6 m;  
 $p_a$  = intensity of ice pressure in the CI region determined according to 3.10.3.5.2, Part II "Hull", in kPa;  
 $R_{eH}$  = upper yield stress of the material of the rudder blade plating, in MPa;  
 $k_{16}$  = factor determined for streamlined welded rudders by the formula

$$k_{16} = 1 - 0,38(a/b)^2 \quad (2.4.1.3-2)$$

where  $b$  = distance between horizontal or vertical web plates, whichever is the greater, in m.

For single-plate steel solid-cast rudders the value of  $k_{16}$  shall be taken in the calculations equal to 1.

**2.4.1.4** The streamlined rudder blade side plating shall be stiffened from the inside by horizontal and vertical web plates. The thickness of the web plates shall be not less than that of the rudder blade side plating.

The side plating and web plates shall be welded together by fillet or plug welds with slots of linear form. Dimensions of elements of plug welds are selected according to 1.7.5.13, Part II "Hull".

The horizontal and vertical web plates shall be provided with sufficient number of openings for free drainage of water which may penetrate inside the rudder blade.

The rear edge of the rudder blade shall be rigidly fixed in the proper way.

**2.4.1.5** The streamlined rudder blade shall be provided with top and bottom plates, the thickness of which shall be not less than 1,2 times the greater value of the side plating thickness according to 2.4.1.1. The top and bottom plates shall be fitted with drain plugs of corrosion-resistant metal.

**2.4.1.6** The corners of the openings (in way of the pintles) in the side plating of the semispade rudder

blade shall be rounded off. The radius of curvature shall be not less than 2 times the side plating thickness in this area, and the free edge of the rudder side plating shall be thoroughly stripped.

**2.4.1.7** Near the rotation axis of the streamlined rudder one or several vertical web plates shall be provided ensuring the general strength of the rudder blade. The section modulus of these web plates, including the effective flanges, shall be such that the normal stresses in the considered section are not more than 0,5 times the upper yield stress of the material of the rudder blade side plating (refer to 1.5.2).

The normal stresses  $\sigma$ , in MPa, shall be calculated by the formula

$$\sigma = 1000M_b/W \quad (2.4.1.7)$$

where  $M_b$  = bending moment in the considered section of the rudder blade ( $M_a$  or  $M_r$ ) determined according to the provisions of 2.2.4 to 2.2.6 for the appropriate type of the rudder, in kN·m;

$W$  = section modulus of the considered section of the web plates, including the effective flanges, about the axis of symmetry of the rudder blade profile, in cm<sup>3</sup>.

The dimensions of the effective flanges of the web plates shall be as follows:

the thickness equal to that of the rudder blade side plating;

the width equal to 1/6 of the rudder blade height or 1/2 of the distance between the nearest web plates located on both sides of the considered web plate, whichever is the less.

**2.4.1.8** Special care shall be given to the reliable securing to the rudder blade of the flange for coupling the rudder blade and the rudder stock and of the gudgeons for pintles.

**2.4.1.9** At the leading edge of the single-plate steel solid-case rudders of the ice-breakers the rudder piece shall be provided over the entire height of the rudder blade.

The combined stresses  $\sigma_{com}$ , in MPa, developed in any horizontal section of the rudder piece and determined by the formula given below shall not exceed 0,5 times the upper yield stress of the rudder blade material

$$\sigma_{com} = 1000\sqrt{\left(\frac{M_r}{W}\right)^2 + 3\left(\frac{M_t y}{h_r \rho S}\right)^2} \quad (2.4.1.9)$$

where  $M_r$  = bending moment determined according to the provisions of 2.2.5.3, in kN·m;

$M_t$  = torque according to 2.2.2.3, in kN·m;

$h_r$  = height of the rudder measured on the rudder stock centre line, in m;

$y$  = distance between the considered section and the lower edge of the rudder (Fig. 2.4.1.9), in m;

$W$  = section modulus of the considered cross-section of the rudder piece about the axis  $O_1 - O_2$ , ignoring the rudder blade plating (the rudder piece section taken into account in the calculation of  $W$  is hatched in section I — I of Fig. 2.4.1.9), in cm<sup>3</sup>;

$S$  = area of the considered cross-section of the rudder piece (refer to hatched area in section I — I of Fig. 2.4.1.9), in  $\text{cm}^2$ ;  
 $\rho$  = distance between the centroid of the area  $S$  and the rudder blade centre line, in cm.

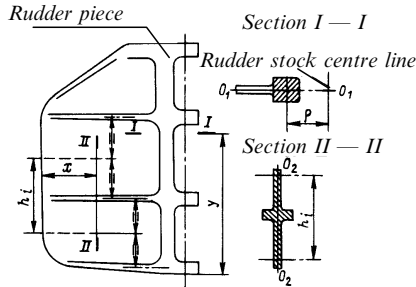


Fig. 2.4.1.9

**2.4.1.10** The single-plate steel solid-case rudder shall be stiffened by the rudder arms founded on both sides of the rudder blade at the level of each gudgeon (refer to Fig. 2.4.1.9).

The section modulus of the considered cross-section of the rudder arms  $W$ , in  $\text{cm}^3$ , (including the body of the rudder blade within the dimension  $h_i$ , refer to section II — II in Fig. 2.4.1.9) about the axis  $O_2 — O_2$  shall be not less than determined by the formula

$$W = \frac{1000 h_i x^2 F}{A R_{eH}} \quad (2.4.1.10)$$

where  $F$  = force determined according to the provisions of 2.2.2.2, kN;  
 $A$  = rudder area, in  $\text{m}^2$ ;  
 $h_i$  = linear dimension, in m (refer to Fig. 2.4.1.9);  
 $x$  = distance between the considered section and the rear edge of the rudder, m (refer to Fig. 2.4.1.9);  
 $R_{eH}$  = upper yield stress of the rudder material, in MPa.

## 2.4.2 Nozzle rudder.

**2.4.2.1** The thickness  $s_0$ , in mm, of the nozzle rudder outside plating shall be not less than determined by the formula

$$s_0 = k_{14} l_1 \sqrt{\frac{98 D_n l_n d + 20 F_n}{D_n l_n R_{eH}}} + 2 \quad (2.4.2.1-1)$$

where  $D_n$  = inner minimum nozzle bore, in m;  
 $l_n$  = length of the nozzle rudder, in m;  
 $d$  = draught of the ship, in m;  
 $F_n$  = force acting on the nozzle rudder according to 2.2.3.1, in kN;  
 $R_{eH}$  = upper yield stress of the material of the nozzle rudder outside plating, in MPa;  
 $k_{14}$  = factor determined by the formula

$$k_{14} = 7,885 - 2,221(l_1/u_1)^2; \quad (2.4.2.1-2)$$

$u_1$  = distance between the longitudinal web plates measured along the length of the nozzle rudder outside plating, in m. This distance shall not exceed 1000 mm;

$l_1$  = distance between transverse web plates or between the transverse web plate and the nearest edge of the nozzle rudder, in m. This distance shall not exceed 600 mm.

**2.4.2.2** The thickness  $s_{in}$ , in mm, of the nozzle rudder inside plating, except for its middle belt, shall be not less than:

$$s_{in} = 6,39 \frac{l_1}{D_n} \sqrt{T} \quad (2.4.2.2-1)$$

where  $T$  = propeller thrust at speed  $v$ , in kN.

The thickness  $s_m$ , in mm, of the middle belt of the nozzle rudder inside plating shall be not less than:

$$s_m = 7,34 \frac{l_2}{D_n} \sqrt{T} + 0,51 \frac{T}{D_n^2} \quad (2.4.2.2-2)$$

where  $l_2$  = distance between transverse web plates situated in way of the middle belt of the inside plating, in m.

In case of application of stainless or clad steel the value of  $s_m$  may be reduced on agreement with the Register.

**2.4.2.3** In any case, the thickness of the outside and inside plating of the nozzle rudder shall be not less than that given in 2.4.1.2.

**2.4.2.4** The middle belt of the nozzle rudder inside plating shall extend not less than  $0,05 D_n$  forward and not less than  $0,1 D_n$  aft of the propeller blade tips. Its breadth shall be at least equal to the maximum breadth of the side projection of the propeller blade.

**2.4.2.5** The outside and inside plating of the nozzle rudder shall be stiffened from the inside by transverse and longitudinal web plates. The spacing of the web plates shall comply with the requirements of 2.4.2.1. At least four longitudinal web plates shall be provided which are equally spaced around the circumference of the nozzle rudder.

The thickness of web plates, except those situated in way of the middle belt of the nozzle rudder inside plating, shall be not less than the thickness of the outside plating according to 2.4.2.1 and 2.4.2.3.

The transverse and longitudinal web plates shall be welded to the nozzle rudder inside plating by double side continuous welds with full penetration on the inside of the nozzle rudder. When the thickness of the web plates is 10 mm and more, edge preparation shall be carried out.

The outside plating and web plates shall be connected by plug welding with slots of linear form or by backing welding. The dimensions of elements of plug welds with slots of linear form are selected according to 1.7.5.13, Part II "Hull".

The transverse and longitudinal web plates shall be provided with sufficient number of openings for free drainage of water which might penetrate inside

the nozzle rudder, and in the lower and upper parts of the outside plating the drain plugs of stainless metal shall be fitted. The distance from the opening edge to the inside and outside plating of the nozzle rudder shall be not less than 0,25 times the web plate height.

It is not allowed to weld on doubling plates to the inside plating of the nozzle rudder.

**2.4.2.6** In way of the middle belt of the nozzle rudder inside plating at least two continuous transverse web plates shall be fitted. The thickness of these web plates shall be not less than the thickness of the inside plating off its middle belt as per the Formula (2.4.2.2-1).

**2.4.2.7** Special care shall be given to the reliable securing of the nozzle flange, welded-in bush and other nozzle rudder welded-in parts for connecting the nozzle rudder welded-in parts for connecting the nozzle rudder with its stock and pintle.

**2.4.2.8** The thickness  $s_{st}$  of the stabilizer plating, in mm, shall be not less than determined by the formula

$$s_{st} = k_{14} l_1 \sqrt{\frac{98 A_{st} d + 20 F_{st}}{A_{st} R_{eH}}} + 2 \quad (2.4.2.8)$$

where  $A_{st}$  = area of the nozzle rudder stabilizer, in m<sup>2</sup>;  
 $F_{st}$  = force acting on the stabilizer according to the Formula (2.2.3.1-3), in kN;  
 $k_{14}$  = factor according to Table 2.4.2.1 when the distance between horizontal web plates equals to  $u_1$ , in m;  
 $l_1$  = distance between vertical web plates or between the web plate and fore or aft edge of the stabilizer, in m;  
 $R_{eH}$  = upper yield stress of material of the stabilizer plating, in MPa.

**2.4.2.9** The nozzle rudder stabilizer plating shall be stiffened from the inside by horizontal and vertical web plates having the thickness not less than that of the plating in accordance with 2.4.2.8.

The stabilizer body shall terminate in top and bottom plates. The thickness of top and bottom plates shall not be less than 1,5 times the thickness of the plating according to 2.4.2.8. Vertical web plates shall be securely connected to top and bottom plates.

The plating and horizontal and vertical web plates shall be welded together by fillet or plug welds. The types of plug welds with slots of linear form are selected according to 1.7.5.13, Part II "Hull".

The horizontal and vertical web plates shall be provided with sufficient number of openings, and top and bottom plates shall be fitted with drain plugs of corrosion-resistant material.

**2.4.2.10** In way of attachment of the stabilizer to the nozzle rudder one or several vertical web plates shall be provided ensuring general strength of the stabilizer. The section modulus  $W_{st}$ , in cm<sup>3</sup>, of these web plates, the effective flange included, shall be not less than determined by the formula

$$W_{st} = 1390 F_{st} h_{st} / R_{eH} \quad (2.4.2.10)$$

where  $F_{st}$  = force acting on the stabilizer according to the Formula (2.2.3.1-3), in kN;

$h_{st}$  = stabilizer height, in m;

$R_{eH}$  = upper yield stress of the material used, in MPa.

The effective flange dimensions shall be as follows: thickness equal to the stabilizer plating thickness; width equal to 1/5 of the stabilizer height.

**2.4.2.11** The nozzle rudder and stabilizer shall be so connected that rigid fixation of the latter is ensured.

The force  $F_{st}$  determined from the Formula (2.2.3.1-3) and uniformly distributed with the height of the stabilizer shall be taken in strength calculations as a force acting on the stabilizer. Depending on the type of connection a torque of force  $F_{st}$  acting on this connection shall be considered with regard to the point of application of this force (refer to the Formula (2.2.3.2-3)). In this case, stresses developed in the connection (refer to 1.5.1) shall not exceed 0,4 times the upper yield stress of the material.

## 2.5 COUPLINGS

### 2.5.1 Horizontal flange coupling.

**2.5.1.1** The diameter of the coupling bolts  $d_1$ , in cm, shall be not less than:

$$d_1 = 0,62 \sqrt{\frac{d_2^3 R_{eH1}}{z_1 r_2 R_{eH2}}} \quad (2.5.1.1-1)$$

where  $d_2$  = diameter of the rudder stock at the coupling flange, in cm;

$z_1$  = number of coupling bolts;

$r_2$  = mean distance from the centre of the bolts to the centre of the system of the flange bolt holes, in cm;

$R_{eH1}$  = upper yield stress of the rudder stock material, in MPa;

$R_{eH2}$  = upper yield stress of the bolt material, in MPa.

The coupling bolt diameter at the bottom of threads  $d_3$ , in cm, shall be not less than determined by the formula

$$d_3 = 76,84 \sqrt{\frac{M_b}{z_1 r_3 R_{eH2}}} \quad (2.5.1.1-2)$$

where  $M_b$  = bending moment acting in the rudder stock section at the flange ( $M_2$  or  $M_3$ ) determined according to the provisions of 2.2.4 to 2.2.7 for the appropriate type of the rudder, in kN·m;

$r_3$  = mean distance from the centre of the bolts to the longitudinal axis of symmetry of the flange, in cm.

The number of bolts  $z_1$  shall be not less than 6.

The mean distance from the centre of the bolts to the centre of the system of the flange bolt holes shall

be not less than 0,9 times the rudder stock diameter according to 2.3.1. When the coupling is under the action of the bending moment, the mean distance from the centre of the bolts to the longitudinal axis of symmetry of the flange shall be not less than 0,6 times the rudder stock diameter at the flange.

**2.5.1.2** Only fitted bolts shall be employed, except the cases of a key setting when it is sufficient to have only two fitted bolts. The nuts shall have standard sizes. The bolts and nuts shall be efficiently secured.

**2.5.1.3** The thickness of the coupling flanges shall not be less than the diameter of the bolts. The centres of the holes for bolts shall be distant from the outside edges of the flange by not less than 1,15 times the diameter of the bolts.

**2.5.1.4** When coupling flanges of nozzle rudders are not built into the nozzle rudder body but connected to it by the structure formed of sheets, the strength of this structure shall be equivalent to that of the rudder stock in accordance with 2.3.2. In this case, the calculated combined stress shall not exceed 0,4 times the upper yield stress of the material used.

### 2.5.2 Keyed cone coupling.

**2.5.2.1** The cone length of the rudder stock fitted to the rudder blade or nozzle rudder shall not be less than 1,5 times the diameter of the rudder stock according to 2.3.2; the cone on the diameter shall be 1:15. The cone shall change into cylindrical portion without any step in the diameter.

**2.5.2.2** A key shall be set on the cone generatrix. The ends of the key shall be fairly rounded. The working sectional area of the key  $A_k$  (product of the key length by its width), in  $\text{cm}^2$ , shall be not less than the greater value determined by the formula

$$A_k = \frac{k_{15} M_t}{d_m R_{eH}} \quad (2.5.2.2)$$

where  $k_{15}$  = factor equal to:

6920 for rudders for the ahead condition and for nozzle rudders;

4950 for rudders for the astern condition;

$M_t$  = torque according to 2.2.2.3, 2.2.2.4 or 2.2.3.3, in  $\text{kN}\cdot\text{m}$ ;

$d_m$  = diameter of the cone section at the middle of the key length, in  $\text{cm}$ ;

$R_{eH}$  = upper yield stress of the key material, in  $\text{MPa}$ .

The height of the key shall be not less than half its width.

The keyway of the rudder stock shall be confined to the cone coupling.

**2.5.2.3** The external diameter of the rudder stock threaded portion shall not be less than 0,9 times the minimum diameter of the cone. The thread shall be fine. The outer diameter and height of the nut shall not be less than 1,5 and 0,8 times the external diameter of the rudder stock threaded portion, respectively. To prevent self-unscrewing, the nut shall be

securely fastened at least by two welded-on strips or one welded-on strip and a split pin.

### 2.5.3 Keyless cone coupling.

**2.5.3.1** The requirements of 2.5.3 are applicable to a keyless fitting of the rudder stock to the rudder blade or nozzle rudder which is made by oil injection method.

**2.5.3.2** The cone length of the rudder stock fitted to the rudder blade or nozzle rudder shall not be less than 1,5 times the diameter of the rudder stock according to 2.3.2; the cone on the diameter shall be 1:15.

**2.5.3.3** The rudder blade or nozzle rudder boss shall be a good fit on the rudder stock cone. During the fit up, and before the push-up load is applied, an area of contact of at least 70 per cent of the theoretical area of contact shall be achieved, and this shall be distributed evenly.

The relationship of the rudder stock and boss cones at which this occurs shall be marked, and push-up length then measured from that point.

In well-founded cases another method of determining the original position of the rudder stock and boss cones relationship can be used on agreement with the Register.

**2.5.3.4** To ensure the required interference in the cone coupling the push-up length of the rudder stock (refer to 2.5.3.3) during its fitting shall be not less than determined by the formula

$$s_1 = \frac{1,1q}{EK} \left[ \frac{2d_m}{1 - \left(\frac{d_m}{d_c}\right)^2} + 35,7 \right] \quad (2.5.3.4-1)$$

where  $s_1$  = push-up length of the rudder stock, in  $\text{mm}$ ;

$d_m$  = mean diameter of the rudder stock cone, in  $\text{mm}$ ;

$d_c$  = outer diameter (or minimum outer dimension) of rudder blade boss or nozzle rudder (in the mean section), in  $\text{mm}$ ;

$E$  = modulus of elasticity of rudder stock material, in  $\text{MPa}$ ;

$K$  = taper of conical coupling, on the diameter;

$q$  = required contact pressure applied to mating surfaces during the push-up, in  $\text{MPa}$ , determined by the formula

$$q = \frac{4,25 \cdot 10^6 n M_t}{d_m^2 L_a} \sqrt{1 + \left( \frac{5 \cdot 10^{-6} Q d_m}{M_t} \right)^2} \times \left( 1 + 0,257 \frac{L_a M_b}{d_m M_t} \right) \quad (2.5.3.4-2)$$

where  $M_t$  = maximum value of design torque according to 2.2.2.3, 2.2.2.4 or 2.2.3.3, in  $\text{kN}\cdot\text{m}$ ;

$M_b$  = maximum bending moment in way of cone coupling determined according to 2.2.4.8, 2.2.6.3 or 2.2.7.3, in  $\text{kN}\cdot\text{m}$ ;

$Q$  = mass of rudder blade or nozzle rudder, in  $\text{kg}$ ;

$L_a$  = actual length of the contact part of cone, excluding the oil distribution grooves and similar devices, in  $\text{mm}$ ;

$n$  = safety factor against friction slip under the action of rated torque.



The spade rudders and nozzle rudders of types XIV and XV (refer to Fig. 2.2.4.1) the value  $n$  shall be taken not less than 2,5; for other types of rudders and nozzle rudders this value shall be not less than 2,0.

If the contact pressure  $q$  determined by the Formula (2.5.3.4-2) is less than 40 MPa, then  $q = 40$  MPa shall be taken in the calculations.

**2.5.3.5** The strength of the maximum loaded part of the coupling shall be checked: the combined stress on the inside of the rudder blade or nozzle rudder boss shall not exceed 0,85 of the yield stress of the boss material. The combined stress on the inside of the boss shall be determined by the formula

$$\sigma_1 = \sqrt{0,5(\sigma_1 - \sigma_2)^2 + 0,5(\sigma_2 - \sigma_3)^2 + 0,5(\sigma_3 - \sigma_1)^2} \quad (2.5.3.5-1)$$

where  $\sigma$  = combined stress, in MPa;

$$\sigma_1 = q_1 \frac{d_c^2 + d_3^2}{d_c^2 - d_3^2}; \quad (2.5.3.5-2)$$

$$q_1 = q + 5,73 \frac{M_b \cdot 10^6}{d_3 L_{s,t}^2}; \quad (2.5.3.5-3)$$

$$\sigma_2 = -q_1; \quad (2.5.3.5-4)$$

$$\sigma_3 = \frac{40Q}{\pi(d_c^2 - d_3^2)} + \frac{M_b \cdot 10^7}{d_3^3}; \quad (2.5.3.5-5)$$

$q_1$  = contact pressure between mating cone surfaces in way of maximum diameter of the rudder stock cone under combined action of torque and bending moments, in MPa;

$d_3$  = maximum diameter of rudder stock cone, in mm;  
 $L_{s,t}$  = length of rudder stock cone, in mm.

**2.5.3.6** The value of oil pressure applied to the mating cone surfaces of the rudder stock and rudder blade boss during mounting and dismounting of the coupling shall not exceed  $P_{\max}$  determined by the formula

$$P_{\max} = 0,55 R_{eH} \left[ 1 - \left( \frac{d_m}{d_c} \right)^2 \right] \quad (2.5.3.6)$$

where  $P_{\max}$  — in MPa;

$R_{eH}$  — yield stress of material of the rudder blade or nozzle rudder boss, in MPa.

**2.5.3.7** The design and dimensions of the stock tail and the nut, as well as the means for securing the nut shall be a subject of special consideration by the Register.

**2.5.4** Where the rudder stock is not made of a solid piece, its parts shall be joined by means of a muff coupling or by other method which will be specially considered by the Register in each case.

## 2.6 RUDDER PINTLES

**2.6.1** The diameter  $d_4$ , in cm, of pintles without liners, as well as of pintles with liners, but before their setting, shall be not less than determined by the formula

$$d_4 = 18 \sqrt{R_i / R_{eH}} \quad (2.6.1)$$

where  $R_i$  = design value of the reaction of the considered pintle ( $R_2$  or  $R_4$ ) determined according to the provisions of 2.2.4 and 2.2.5 for the appropriate type of the rudder, in kN;

$R_{eH}$  = upper yield stress of the pintle material, in MPa.

**2.6.2** The length of the cone part of the pintle in rudder gudgeon, in welded-in bush of the nozzle rudder or in the solepiece shall not be less than the diameter of the pintle according to 2.6.1; the cone on the diameter shall not exceed 1:10. The cone shall change into cylindrical portion without any step in the diameter.

The external diameter of the pintle threaded portion shall not be less than 0,8 times the minimum diameter of the cone. The outer diameter and height of the nut shall not be less than 1,5 and 0,6 times the external diameter of the pintle threaded portion, respectively.

**2.6.3** The ratio of bearing height to diameter measured outside the pintle liners, where fitted, shall not be less than 1, nor more than 1,3.

**2.6.4** The width of material in the rudder gudgeons and welded-in bushes of the nozzle rudder measured outside the hole for the pintle bush shall not be less than 0,5 times the diameter of the pintle without liner.

For rudder pintles of 200 mm and over in diameter it is allowed to reduce the specified width of the gudgeon from 0,5 times the diameter of the gudgeon down to 0,35 times the diameter of the pintle without liner in case the requirements of 2.6.2 and 2.6.3 are met, the following relation is obtained:

$$\frac{l_7}{d_4} \geq \frac{R_{eH(p)}}{R_{eH(g)}} \quad (2.6.4)$$

where  $l_7$  = height of the pintle bush, in cm;

$d_4$  = diameter of the pintle, cm, including its liner, where fitted;

$R_{eH(p)}$  = upper yield stress of the pintle material, in MPa;

$R_{eH(g)}$  = upper yield stress of the gudgeon material, in MPa.

**2.6.5** To prevent self-unscrewing, the nut shall be securely fastened by means of at least two welded-on strips or one welded-on strip and a split pin, and the pintles shall be securely fastened in gudgeons of the rudder or sternframe.

**2.6.6** The chosen dimensions of the pintles shall be checked by the surface loading  $p$ , in MPa, this being taken as

$$p = 10R_i/(d_4' l_7) \quad (2.6.6)$$

where for  $R_i$ , refer to 2.6.1;

$d_4'$  = diameter of the pintle, in cm, including its liner, where fitted;

$l_7$  = height of the pintle bush, in cm.

This surface loading shall not exceed the values specified in Table 2.1.6. Use of the materials different from those specified in this Table for rubbing parts will be specially considered by the Register in each case.

## 2.7 RUDDER AXLE

**2.7.1** The diameter of the rudder axle directly at the flange  $d_5$  shall be such that the normal stresses  $\sigma$  developed in its sections do not exceed 0,5 times the upper yield stress of the rudder axle material. The normal stress  $\sigma$ , in MPa, shall be determined by the formula

$$\sigma = 10^4 M_{ra}/d_5^3 \quad (2.7.1)$$

where  $M_{ra}$  = design value of the bending moment determined according to the provisions of 2.2.4.15, in kN·m;

$d_5$  = diameter of the rudder axle at the flange, in cm.

The diameter of the rudder axle in way of the rudder bearings shall be not less than the diameter  $d_5$ . The diameter of the rudder axle between the rudder blade bearings may be reduced by 10 per cent.

**2.7.2** As regards the cone and threaded portions of the rudder axle and also its nut, the requirements are as stipulated in 2.6.2 for the pintles.

**2.7.3** The diameter of bolts of the rudder axle flange coupling  $d_6$ , in cm, shall be not less than determined by the formula

$$d_6 = 6,77 \sqrt{\frac{R_2 + \frac{M_{ra}}{r_4} \sqrt{1 + \left(0,17 + 0,6 \frac{R_2 r_5}{M_{ra}}\right)^2}}{z_2 R_{eH}}} \quad (2.7.3)$$

where  $R_2$  = design value of the reaction of the rudder axle upper bearing determined according to 2.2.4.11, in kN;

$M_{ra}$  = design value of the bending moment acting in the rudder axle section near its flange determined according to 2.2.4.15, in kN·m;

$r_4$  = mean distance from the centre of the bolts to the centre of the system of the flange bolt holes, in m;

$r_5$  = distance from the centre line of the rudder stock to the contact plane of the rudder axle flanges and the sternframe, in m;

$z_2$  = number of the bolts of the flange coupling;

$R_{eH}$  = upper yield stress of the bolt material, in MPa.

The number of the bolts  $z_2$  shall be not less than 6.

The distance from the centre of any bolt to the centre of the system of the flange bolt holes shall be

not less than 0,7, and to the vertical axis of symmetry of the flange plane, not less than 0,6 times the diameter  $d_5$  of the rudder axle given in 2.7.1.

**2.7.4** Only fitted bolts shall be employed, except the cases of a key setting when it is sufficient to have only two fitted bolts. The nuts shall have standard sizes, and they shall be securely fastened by split pins or weld-on strips.

**2.7.5** The thickness of the coupling flange shall not be less than the diameter of the bolts. The centres of the holes for bolts shall be distant from the outside edges of the flange by not less than 1,15 times the diameter of the bolts.

**2.7.6** Where the diameter of the rudder axle changes, sufficient fillets shall be provided. At transition from the rudder axle to the flange a fillet shall be provided with a radius of not less than 0,12 times the rudder axle diameter.

**2.7.7** To prevent self-unscrewing, the nut of the rudder axle shall be securely fastened at least by two weld-on strips or one weld-on strip and a split pin.

**2.7.8** The requirements of 2.6.6 for pintles are applicable to the rudder blade bearings on the rudder axle.

## 2.8 RUDDER STOCK BEARINGS

**2.8.1** The requirements of 2.6.6 for pintles are applicable to the rudder stock bearings taking lateral load.

**2.8.2** A rudder carrier shall be installed to take the mass of the rudder blade or nozzle rudder and rudder stock. The deck shall be efficiently strengthened in way of the rudder carrier.

Measures shall be taken against axial displacement of the rudder blade or nozzle rudder and rudder stock upwards by a value exceeding that permitted by the construction of the steering gear; furthermore, for nozzle rudder measures shall be taken to provide for guaranteed clearance between propeller blades and nozzle under service conditions.

**2.8.3** A stuffing box shall be fitted in way of passage of the rudder stock through the top of a rudder trunk which is open to sea to prevent water from entering the ship's space. The stuffing box shall be fitted in a place accessible for inspection and maintenance at all times.

## 2.9 STEERING GEAR

**2.9.1** Ships shall be provided with a main steering gear and an auxiliary steering gear, unless expressly provided otherwise.

**2.9.2** The main steering gear and rudder stock shall be capable of putting the rudder or the nozzle rudder over from 35° on one side to 35° on the other side, at maximum operational draught and maximum operational ahead speed of the ship and under the same conditions from 35° on one side to 30° on the other side in not more than 28 s.

**2.9.3** The auxiliary steering gear shall be capable of putting the rudder or nozzle rudder over from 15° on one side to 15° on the other side in not more than 60 s at maximum operational draught and half of the maximum operational ahead speed or 7 knots, whichever is the greater.

**2.9.4** In oil tankers, oil tankers (> 60 °C), combination carriers, gas carriers and chemical tankers of 10000 gross tonnage and upwards, in all nuclear ships and in other ships of 70000 gross tonnage and upwards the main steering gear shall comprise two or more identical power units satisfying the requirements of 2.9.5 (refer also to 6.2.1.8 and 6.2.1.9, Part IX "Machinery").

**2.9.5** Where the main steering gear comprises two or more power units, an auxiliary steering gear need not be fitted if:

**.1** in passenger and nuclear ships as well as in special purpose ships having more than 200 persons of special personnel on board the main steering gear is capable of operating as required in 2.9.2 while any one of the power units is out of operation;

**.2** in cargo ships as well as in special purpose ships having 200 or less persons of special personnel on board the main steering gear is capable of operating as required in 2.9.2 while all power units are in operation;

**.3** the main steering gear is so arranged that after a single failure in its piping system or in any one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained.

**2.9.6** Where according to 2.3.1 the diameter of the rudder head is required to be over 230 mm, excluding strengthening for navigation in ice, provision shall be made for an additional source of electrical power as prescribed in 5.5.6, Part XI "Electrical Equipment" sufficient to ensure operation of the steering gear power unit in compliance with the requirements of 2.9.3.

**2.9.7** The main steering gear may be hand-operated provided it meets the requirements of 6.2.3.2, Part IX "Machinery" and the rudder stock and nozzle rudder diameter specified in 2.3.1 does not exceed 120 mm (excluding strengthening for navigation in ice).

In all other cases, the main steering gear shall be operated by power.

**2.9.8** The auxiliary steering gear may be hand-operated provided it meets the requirements of

6.2.3.3, Part IX "Machinery" and the rudder stock or nozzle rudder diameter specified in 2.3.1 does not exceed 230 mm (excluding strengthening for navigation in ice).

In all other cases, the auxiliary steering gear shall be operated by power.

**2.9.9** The main and auxiliary steering gears shall act on the rudder stock independently of one another, but it is allowed that the main and auxiliary steering gears have some common parts (such as tiller, quadrant, gear box, cylinder block, etc.) provided the respective scantlings of these parts are increased in accordance with 6.2.8.2, Part IX "Machinery".

**2.9.10** The rudder tackle may be considered as an auxiliary steering gear only in the following cases:

**.1** in self-propelled ships of less than 500 gross tonnage;

**.2** in non-propelled ships.

In other cases, the rudder tackle is not considered as a steering gear and shall not necessarily be fitted in ships.

**2.9.11** The rudder shall be provided with a system of stops permitting to put the rudder over either side only to an angle  $\beta^\circ$ :

$$(\alpha^\circ + 1^\circ) \leq \beta^\circ \leq (\alpha^\circ + 1,5^\circ) \quad (2.9.11-1)$$

where  $\alpha^\circ$  = maximum hard-over angle to which the steering gear control system is adjusted but not over 35°; the greater hard-over angle is subject to special consideration by the Register in each case.

All the parts of the system of stops, including those which are at the same time the parts of the steering gear, shall be calculated to take forces corresponding to an ultimate reverse torque  $M_{ult}$ , in kN·m, from the rudder of not less than:

$$M_{ult} = 1,135 R_{eH} d_0^3 \cdot 10^{-4} \quad (2.9.11-2)$$

where  $d_0$  = actual diameter of the rudder stock head, in cm;  
 $R_{eH}$  = upper yield stress of the rudder stock material, in MPa.

The stresses in these parts shall not exceed 0,95 times the upper yield stress of their material. The rudder stops of the system may be fitted on the sternframe, deck platform, bulkhead or other structural members of the ship's hull.

Where the active rudder is provided and there is a need to put the rudder over to an angle exceeding the maximum one, arrangement of stops shall be specially considered by the Register in each case.

**2.9.12** Control of the main steering gear shall be provided both on the navigating bridge and in the steering gear compartment.

**2.9.13** When the main steering gear is arranged according to 2.9.4 or 2.9.5, two independent steering gear control systems shall be provided, each of which shall be operable separately from the navigating

bridge. These systems may have a common steering wheel or level. If the control system comprises a hydraulic telemotor, the Register may waive the requirement for a second independent control system of the steering gear for the ship (with the exception of oil tankers, oil tankers (> 60 °C), combination carriers, gas carriers and chemical tankers of 10 000 gross tonnage and upwards, of other ships of 70 000 gross tonnage and upwards and of nuclear ships).

**2.9.14** The auxiliary steering gear control shall be provided in the steering gear compartment.

For the auxiliary steering gear which is power operated, control shall also be provided from the navigating bridge and shall be independent of the control system for the main steering gear.

**2.9.15** A rudder angle indicator shall be fitted near each control station of the main and auxiliary steering gears and in the steering gear compartment. The difference between the indicated and actual positions of the rudder or nozzle rudder shall be not more than:

1° when the rudder or nozzle rudder is in the centre line or parallel to it;

1,5° for rudder or nozzle rudder angles from 0° to 5°;

2,5° for rudder or nozzle rudder angles from 5° to 35°.

The rudder or nozzle rudder angle indication shall be independent of the steering gear control system.

**2.9.16** In all other respects the steering gear shall meet the requirements of Part IX "Machinery" and Part XI "Electrical Equipment".

## 2.10 EFFICIENCY OF RUDDERS AND NOZZLE RUDDERS

### 2.10.1 General.

**2.10.1.1** The choice of the ship's main characteristics affecting the steerability and the characteristics of the rudder and nozzle rudder is made at the discretion of the designer and shipowner considering the necessity to ensure the proper steerability of the ship according to its purpose and service conditions and to ensure the correspondence between relative areas of rudders and nozzle rudders of the ship under design and the prototype ship provided the total efficiency of the chosen rudders and/or nozzle rudders is not less than that required in the present Chapter.

**2.10.1.2** The requirements of the present Chapter apply to stern rudders and nozzle rudders (refer to 2.1.2) provided according to 2.1.1 in self-propelled ships (other than icebreakers) of 20 m and over in length of unrestricted service and restricted area of navigation **R1** sailing in the displacement condition. For ships of restricted areas of navigation **R2** and **R3**

the standards set forth in 2.10.3 shall be considered as recommendations.

For ships of river-sea navigation **R2-RSN** and **R3-RSN** the standards set forth in 2.10.3 shall also be considered as recommendations, and the fulfilment of these standards does not give the grounds for exemption from the fulfilment of the current standards of steerability for ships of inland navigation.

**2.10.1.3** The requirements of the present Chapter apply to ships having the geometric characteristics of the hull within the following limits:

$$\begin{aligned} L_1/B &= 3,2 - 8,0; & C_B &= 0,45 - 0,85; \\ L_1/d &= 8,3 - 28,6; & C_p &= 0,55 - 0,85; \\ B/d &= 1,5 - 3,5; & \sigma_a &= 0,80 - 0,99 \end{aligned}$$

where  $B$  = breadth of the ship, in m;  
for  $C_B$ ,  $d$ ,  $L_1$ ,  $C_p$  and  $\sigma_a$ , refer to 2.2.2.1, 2.4.1.1 and 2.10.3.3, respectively.

Application of the requirements of the present Chapter to other ships is subject to special agreement with the Register.

**2.10.1.4** The requirements of the present Chapter apply to catamarans with two identical hulls (symmetric about the centre plane of the hulls), each having geometric characteristics according to the provisions of 2.10.1.3, and with two identical rudders and/or nozzle rudders arranged in the centre plane of each hull.

**2.10.1.5** The active means of the ship's steering which are not the main means of the ship's steering (thrusters, active rudders, etc.) are considered as means supplementing the required minimum and are not taken into account when meeting the requirements of the present Chapter (refer also to 2.1.3.2).

### 2.10.2 Estimation of efficiency of rudders and nozzle rudders.

**2.10.2.1** The efficiency of the chosen rudder  $E_r$ , other than rudders of types IV, X and XIII (refer to Fig. 2.2.4.1), shall be determined by the formula

$$E_r = \mu_1 \frac{A}{A_2} \left(1 + C_{HB} \frac{A_p}{A}\right) (1 - W)^2 \quad (2.10.2.1-1)$$

where

$$\mu_1 = \frac{6,28}{1 + \frac{2A}{h_r^2}}; \quad (2.10.2.1-2)$$

$W$  = coefficient:

for rudder arranged in the centre plane behind the propeller

$$W = 0,3 C_B; \quad (2.10.2.1-3)$$

for rudder arranged in the centre plane with no propeller fitted forward of it

$$W = 0; \quad (2.10.2.1-4)$$

for side rudders

$$W=0,4C_B = 0,13; \quad (2.10.2.1-5)$$

$A_2$  = lateral underwater area at the summer load waterline draught, in  $m^2$ ;

for  $A_p$ ,  $h_r$ ,  $C_B$ , refer to 2.2.2.1;

$C_{HB}$  = value determined by the Formula (2.2.3.1-8) with regard to the Formula (2.2.3.1-4) at  $W$  as specified in the present sub-paragraph with regard to 2.2.2.6; for rudders not operating directly behind the propeller the thrust is taken as  $T=0$ .

**2.10.2.2** The efficiency of the chosen rudder  $E_{rr}$  of types IV, X or XIII (refer to Fig. 2.2.4.1) shall be determined by the formula

$$E_{rr} = 1,3\mu_2 \frac{A_t}{A_2} (1 - W)^2 \quad (2.10.2.2-1)$$

$$\text{where } \mu_2 = \frac{6,28\sqrt{b_r/b_t}}{1 + \frac{2b_t^2}{A_t}} + \frac{1,4C_{HB}}{1 + 0,5\left(\frac{b_t^2}{A_t}\right)^2} \quad (2.10.2.2-2)$$

where  $b_r$  = breadth of the rudder, in m;

$b_t$  = total breadth of the rudder and rudder post, in m;

for  $A_t$ , refer to 2.2.2.1;

for  $A_2$ ,  $C_{HB}$ ,  $W$ , refer to 2.10.2.1.

**2.10.2.3** The efficiency of the chosen nozzle rudder  $E_n$  with or without a stabilizer shall be determined by the formula

$$E_n = 2,86\mu_3 \frac{D_o l_n}{A_2} (1 - W)^2 \quad (2.10.2.3-1)$$

where

$$\mu_3 = \left(0,175 + 0,275 \frac{D_n}{l_n}\right) [1 + 0,25(1 + \sqrt{1 + C_{HB}})^2] + 0,25C_{HB} \frac{D_n}{l_n}; \quad (2.10.2.3-2)$$

$W$  = coefficient:

for nozzle rudder arranged in the centre plane of the ship

$$W=0,2C_B; \quad (2.10.2.3-3)$$

for side nozzle rudder

$$W=0,1C_B; \quad (2.10.2.3-4)$$

$D_o$  = outside diameter of the nozzle rudder in the plane of the propeller disk, in m;

for  $C_B$ ,  $D_n$ ,  $l_n$  and  $A_2$ , refer to 2.2.2.1, 2.2.3.1 and 2.10.2.1, respectively;

$C_{HB}$  = value determined by the Formula (2.2.3.1-8) with regard to the Formula (2.2.3.1-4) at  $W$  as specified in the present sub-paragraph with regard to 2.2.2.6.

### 2.10.3 Standards for efficiency of rudders and nozzle rudders.

**2.10.3.1** The total efficiency of all rudders and nozzle rudders (refer to 2.10.2) fitted in the ship (other than catamaran) shall not be less than the greater of the values  $E$ ,  $E_1$  or  $E_2$  given below.

**2.10.3.2** The efficiency of the single rudder or nozzle rudder fitted in the catamaran which is determined according to 2.10.2 shall not be less than the greater of the values  $E_1$ ,  $E_2$  or  $E_3$  estimated according to the provisions specified below considering each hull of the catamaran as an independent single-screw ship. When determining the lateral windage area, all the above-water structures of the catamaran and the deck cargo (if intended to be carried) are considered as belonging to one hull.

**2.10.3.3** For all ships, other than tugs, rescue and fishing vessels, the value of  $E_1$  is determined depending on the values of  $C_p$  and  $\sigma_a$ :

for single-screw ships — according to Fig. 2.10.3.3-1;

for twin-screw and triple-screw ships — according to Fig. 2.10.3.3-2.

For intermediate values of  $C_p$  the value of  $E_1$  is determined by linear interpolation between the curves for two nearest values of  $C_p$  given in Figs 2.10.3.3-1 and 2.10.3.3-2 where  $C_p$  is prismatic coefficient of the

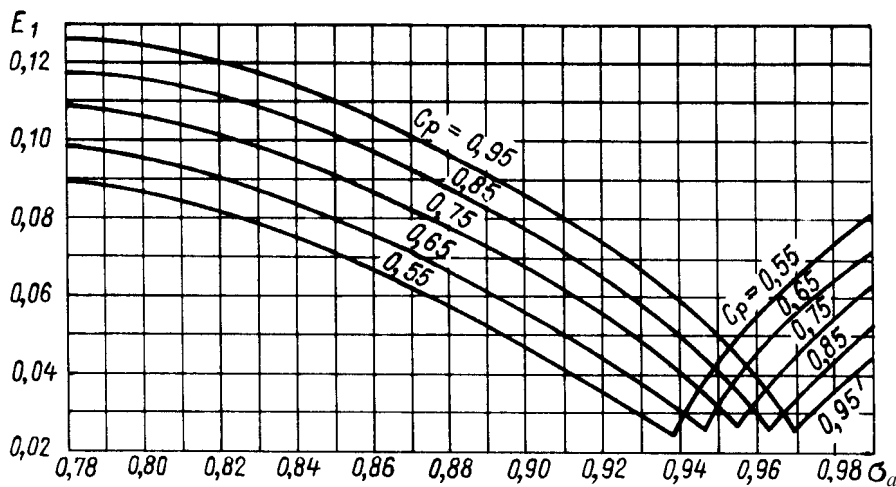


Fig. 2.10.3.3-1

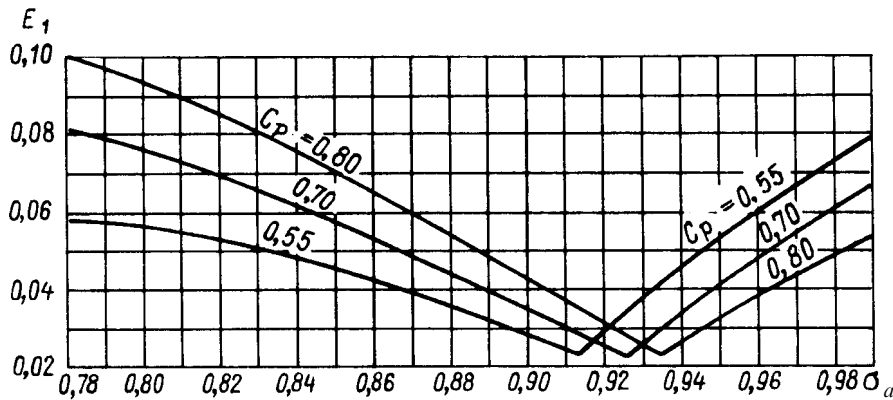


Fig. 2.10.3.3-2

underwater part of the hull at the summer load waterline draught as determined by the formula

$$C_p = C_B / C_m; \quad (2.10.3.3-1)$$

$C_m$  = coefficient of fineness of midship section at the summer load waterline draught;

$\sigma_a$  = afterbody lateral area coefficient at the summer load waterline draught as determined by the formula

$$\sigma_a = 1 - \frac{2(f - f_0)}{L_1 d}; \quad (2.10.3.3-2)$$

$L_1$  = length of the ship measured on the summer load waterline from the fore side of the stem to the after side of the after end of the ship, in m;

$f$  = area of side projection of the stern counter, in  $m^2$ , calculated as the area of the figure bounded by the extension line of the keel lower edge, by the perpendicular to this line from the point of intersection of the summer load waterline and the outline of the centre plane section of the ship's after end and by the sternframe after edge line drawn ignoring the rudder post, solepiece or rudder horn, if any;

$f_0$  = for twin-screw ships — area of the side projection of the propeller cone (or its part) superimposed on the area of the figure  $f$ , in  $m^2$ . In all other cases  $f_0$  shall be taken as zero;

for  $d$ , refer to 2.4.1.1.

**2.10.3.4** For tugs, rescue ships and fishing vessels the value  $E_1$  is determined according to Fig. 2.10.3.4 depending on the value  $\sigma_a$ .

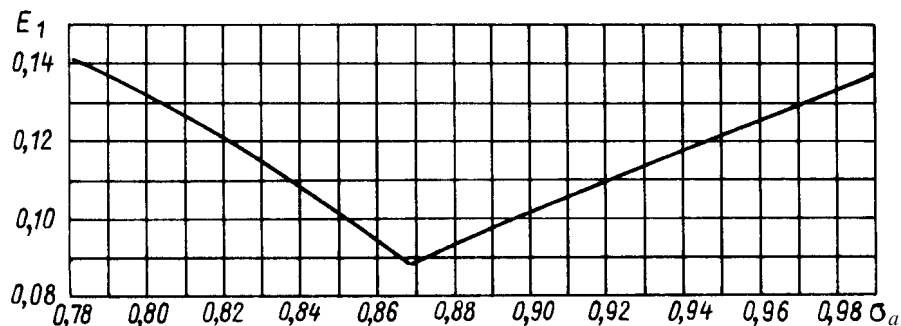


Fig. 2.10.3.4

**2.10.3.5** The value  $E_2$  is determined by the formula

$$E_2 = \frac{3.8A_3}{V^2A_4} \left( 1 - 0.0667 \frac{A_3}{A_4} \right) \left\{ 1 + (\lambda_r - 1)[0.33 + 0.015 \times (V - 7.5)] - 5 \frac{x_0}{L_1} \right\} \quad (2.10.3.5-1)$$

where  $A_3$  = lateral windage area at such a minimum draught at which the rudder blade or nozzle rudder is fully immersed (at the upright position of the ship), in  $m^2$ , to be determined according to 1.4.6, Part IV "Stability";

$A_4$  = lateral underwater area at such a minimum draught at which the rudder blade or nozzle rudder is fully immersed (at the upright position of the ship), in  $m^2$ ;

$x_0$  = horizontal distance from the midship frame (middle of the length  $L_1$ ) to the centroid of the area  $A_3$ , in m. The value of  $x_0$  is taken to be positive in case the centroid is forward of the midship frame, and negative in case of aft position;

$\lambda_r$  = coefficient determined by the formulae:

for all rudders, other than rudders of types IV, X and XIII (refer to Fig. 2.2.4.1)

$$\lambda_r = h_r^2 / A; \quad (2.10.3.5-2)$$

for rudders of types IV, X, XIII (refer to Fig. 2.2.4.1)

$$\lambda_r = h_r^2 / A; \quad (2.10.3.5-3)$$

for nozzle rudders

$$\lambda_r = D_n / l_n; \quad (2.10.3.5-4)$$

for  $V$ ,  $h_r$ ,  $A$ ,  $A_r$ , refer to 2.2.2.1;

for  $D_n$ ,  $l_n$ , refer to 2.2.3.1.

**2.10.3.6** For ships of 70 m in length and more the value  $E_3$  is determined by the formula

$$E_3 = 0,03 + 0,01(\lambda_r - 1) + 0,01 \frac{A_5}{A_2} \left(1 - 3 \frac{x}{L_1}\right) \quad (2.10.3.6)$$

where  $A_5$  = lateral windage area of the ship at the summer load waterline draught, in  $m^2$ , to be determined according to 1.4.6, Part IV "Stability";

$x$  = horizontal distance from the midship frame (middle of the length  $L_1$ ) to the centroid of the area  $A_5$ , in m. The value of  $x$  is taken to be positive in case the centroid is forward of the midship frame and negative in case of aft position.

For ships of less than 70 m in length  $E_3 = 0$  is taken in the calculations.

**2.10.3.7** For all ships (other than rescue and fishing vessels and tugs, with  $\sigma_a > 0,865$ ) it is permitted in the calculations to take  $E_1$  as zero (if the value of  $E_1$  is greater than any of the values of  $E_2$  or  $E_3$ ) provided it is proved by the test of a self-propelled model not less than 2 m in length (at the speed of the model conforming to the ship's speed  $v$ , refer to 2.2.2.1) that:

**1** the steady turning diameter of the ship with the rudder (rudders) or nozzle rudder (rudders) put over

to  $35^\circ$  on either side is not less than four lengths of the ship;

**2** the steady spontaneous turning diameter of the ship with non-reversed rudder (rudders) or nozzle rudder (rudders)  $D_s$  determined by the formula

$$D_s = (D_{ss} + D_{sp})/2 \quad (2.10.3.7)$$

where  $D_{ts}$  and  $D_{tp}$  = steady turning diameter of the ship with the rudder or nozzle rudder put over to  $35^\circ$  on starboard or port side, respectively;

$D_{ss}$  and  $D_{sp}$  = diameter of steady spontaneous turning starboard or port, respectively, with the non-reversed rudder or nozzle rudder,

is not less than  $3,35 (D_{ts} + D_{tp})$ .

If, for technical reasons, the requirement of the present sub-paragraph is not feasible, departure from this requirement is subject to special consideration by the Register.

**2.10.3.8** For ships with the displacement exceeding 60000 t and block coefficient exceeding 0,75 at the summer load waterline draught, the compliance with the requirements of 2.10.3.7.1 and 2.10.3.7.2 shall be proved by testing a self-propelled model of not less than 2 m in length (at the speed of the model conforming to the ship's speed  $v$ , refer to 2.2.2.1), notwithstanding the fulfilment of the requirements of 2.10.3.1.

### 3 ANCHOR ARRANGEMENT

#### 3.1 GENERAL

**3.1.1** Each ship shall be provided with anchor equipment and also with chain stoppers for securing the bower anchors in hawse pipes, devices for securing and releasing the inboard ends of the chain cables and machinery for dropping and hoisting the bower anchors as well as for holding the ship at the bower anchors dropped.

Besides, in cases specified in 3.6.1.1 each bower anchor chain cable shall be provided with a stopper for riding the ship at anchor.

**3.1.2** If a ship in addition to the anchor arrangement or equipment specified in 3.1.1 is provided with some other anchor arrangement or equipment (for example, special anchors and winches on dredgers, mooring anchors on lightships, etc.), such anchor arrangement or equipment is regarded as special one and is not subject to the Register survey. The use of anchor arrangement specified in 3.1.1 as a working special arrangement for moving the dredgers and also for holding the dredgers in place in the course of dredging carried out by grabs is subject to special consideration

by the Register in each case; it is necessary to submit to the Register the required data characterizing the conditions of work of anchor arrangement elements (the value and degree of dynamics of acting forces, the degree of intensity of work and wear rate of the anchor arrangement elements, etc.).

**3.1.3** For all ships, except fishing vessels, the anchor equipment shall be selected from Table 3.1.3-1, for fishing vessels — from Table 3.1.3-2 according to Equipment Number determined in compliance with 3.2 in the case of ships of unrestricted service and of restricted area of navigation **R1** and according to Equipment Number reduced:

by 15 per cent in the case of ships of restricted areas of navigation **R2**, **R2-RSN** and **R3-RSN**;

by 25 per cent in the case of ships of restricted area of navigation **R3**, taking account of the provisions specified in 3.1.4, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 3.4.3, 3.4.7 and 3.4.10.

**3.1.4** For non-propelled ships the anchor equipment shall be selected according to Equipment Number increased by 25 per cent as against that calculated in compliance with provisions specified in 3.1.3.

Table 3.1.3-1

Equipment Number $N_e$		Bower anchors		Mass of stream anchor, in kg	Chain cables for bower anchors				Stream wire or chain		Tow line		Mooring ropes			
Exceeding	Not exceeding	Number	Mass of anchor, in kg		Total length of both chain cables, in m	Diameter			Length, in m	Chain cable breaking load or actual breaking strength of wire rope, in kN	Length, in m	Actual breaking strength, in kN	Number	Length of each rope, in m	Actual breaking strength, in kN	
						Ordinary (grade 1), in mm	Special quality (grade 2), in mm	Extra special quality (grade 3), in mm								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
10	15	2	35	—	110	*	—	—	—	—	—	—	2	30	29	
15	20	2	50	—	137,5		—	—	—	—	—	—	—	2	30	29
20	25	2	65	—	165		—	—	—	—	—	—	—	2	40	29
25	30	2	80	—	165	11,0	—	—	—	—	—	—	2	50	29	
30	40	2	105	35	192,5	11,0	—	—	55	55	120	65	2	50	29	
40	50	2	135	45	192,5	12,5	—	—	70	60	150	81	2	60	29	
50	70	2	180	60	220	14	12,5	—	80	65	180	98	3	80	34	
70	90	2	240	80	220	16	14	—	85	74	180	98	3	100	37	
90	110	2	300	100	247,5	17,5	16	—	85	81	180	98	3	110	39	
110	130	2	360	120	247,5	19	17,5	—	90	89	180	98	3	110	44	
130	150	2	420	140	275	20,5	17,5	—	90	98	180	98	3	120	49	
150	175	2	480	165	275	22	19	—	90	108	180	98	3	120	54	
175	205	2	570	190	302,5	24	20,5	—	90	118	180	112	3	120	59	
205	240	3	660	—	302,5	26	22	20,5	—	—	180	129	4	120	64	
240	280	3	780	—	330	28	24	22	—	—	180	150	4	120	69	
280	320	3	900	—	357,5	30	26	24	—	—	180	174	4	140	74	
320	360	3	1020	—	357,5	32	28	24	—	—	180	207	4	140	78	
360	400	3	1140	—	385	34	30	26	—	—	180	224	4	140	88	
400	450	3	1290	—	385	36	32	28	—	—	180	250	4	140	98	
450	500	3	1440	—	412,5	38	34	30	—	—	180	276	4	140	108	
500	550	3	1590	—	412,5	40	34	30	—	—	190	306	4	160	123	
550	600	3	1740	—	440	42	36	32	—	—	190	338	4	160	132	
600	660	3	1920	—	440	44	38	34	—	—	190	371	4	160	145	
660	720	3	2100	—	440	46	40	36	—	—	190	406	4	160	157	
720	780	3	2280	—	467,5	48	42	36	—	—	190	441	4	170	172	
780	840	3	2460	—	467,5	50	44	38	—	—	190	480	4	170	186	
840	910	3	2640	—	467,5	52	46	40	—	—	190	518	4	170	201	
910	980	3	2850	—	495	54	48	42	—	—	190	559	4	170	216	
980	1060	3	3060	—	495	56	50	44	—	—	200	603	4	180	230	
1060	1140	3	3300	—	495	58	50	46	—	—	200	647	4	180	250	
1140	1220	3	3540	—	522,5	60	52	46	—	—	200	691	4	180	270	
1220	1300	3	3780	—	522,5	62	54	48	—	—	200	738	4	180	284	
1300	1390	3	4050	—	522,5	64	56	50	—	—	200	786	4	180	309	
1390	1480	3	4230	—	550	66	58	50	—	—	200	836	4	180	324	
1480	1570	3	4590	—	550	68	60	52	—	—	220	888	5	190	324	
1570	1670	3	4890	—	550	70	62	54	—	—	220	941	5	190	333	
1670	1790	3	5250	—	577,5	73	64	56	—	—	220	1024	5	190	353	
1790	1930	3	5610	—	577,5	76	66	58	—	—	220	1109	5	190	378	
1930	2080	3	6000	—	577,5	78	68	60	—	—	220	1168	5	190	402	
2080	2230	3	6450	—	605	81	70	62	—	—	240	1259	5	200	422	
2230	2380	3	6900	—	605	84	73	64	—	—	240	1356	5	200	451	
2380	2530	3	7350	—	605	87	76	66	—	—	240	1453	5	200	480	



Table 3.1.3-1 — continued

Equipment Number $N_e$		Bower anchors		Mass of stream anchor, in kg	Chain cables for bower anchors				Stream wire or chain		Tow line		Mooring ropes		
Exceeding	Not exceeding	Number	Mass of anchor, in kg		Total length of both chain cables, in m	Diameter			Length, in m	Chain cable breaking load or actual breaking strength of wire rope, in kN	Length, in m	Actual breaking strength, in kN	Number	Length of each rope, in m	Actual breaking strength, in kN
						Ordinary (grade 1), in mm	Special quality (grade 2), in mm	Extra special quality (grade 3), in mm							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2530	2700	3	7800	—	632,5	90	78	68	—	—	260	1471	6	200	480
2700	2870	3	8300	—	632,5	92	81	70	—	—	260	1471	6	200	490
2870	3040	3	8700	—	632,5	95	84	73	—	—	260	1471	6	200	500
3040	3210	3	9300	—	660	97	84	76	—	—	280	1471	6	200	520
3210	3400	3	9900	—	660	100	87	78	—	—	280	1471	6	200	554
3400	3600	3	10500	—	660	102	90	78	—	—	280	1471	6	200	588
3600	3800	3	11100	—	687,5	105	92	81	—	—	300	1471	6	200	618
3800	4000	3	11700	—	687,5	107	95	84	—	—	300	1471	6	200	647
4000	4200	3	12300	—	687,5	111	97	87	—	—	300	1471	7	200	647
4200	4400	3	12900	—	715	114	100	87	—	—	300	1471	7	200	657
4400	4600	3	13500	—	715	117	102	90	—	—	300	1471	7	200	667
4600	4800	3	14100	—	715	120	105	92	—	—	300	1471	7	200	677
4800	5000	3	14700	—	742,5	122	107	95	—	—	300	1471	7	200	686
5000	5200	3	15400	—	742,5	124	111	97	—	—	300	1471	8	200	686
5200	5500	3	16000	—	742,5	127	111	97	—	—	300	1471	8	200	696
5500	5800	3	16900	—	742,5	130	114	100	—	—	300	1471	8	200	706
5800	6100	3	17800	—	742,5	132	117	102	—	—	300	1471	9	200	706
6100	6500	3	18800	—	742,5	—	120	107	—	—			9	200	716
6500	6900	3	20000	—	770	—	124	111	—	—	Tow lines are not required when ship's length exceeds 180 m		0	200	726
6900	7400	3	21500	—	770	—	127	114	—	—			10	200	726
7400	7900	3	23000	—	770	—	132	117	—	—			11	200	726
7900	8400	3	24500	—	770	—	137	122	—	—			11	200	736
8400	8900	3	26000	—	770	—	142	127	—	—			11	200	736
8900	9400	3	27500	—	770	—	147	132	—	—			13	200	736
9400	10000	3	29000	—	770	—	152	132	—	—			14	200	736
10000	10700	3	31000	—	770	—	—	137	—	—			15	200	736
10700	11500	3	33000	—	770	—	—	142	—	—			16	200	736
11500	12400	3	35500	—	770	—	—	147	—	—			17	200	736
12400	13400	3	38500	—	770	—	—	152	—	—			18	200	736
13400	14600	3	42000	—	770	—	—	157	—	—			19	200	736
14600	16000	3	46000	—	770	—	—	162	—	—			21	200	736
* Chain cables or wire ropes may be used, chain cable breaking load or actual breaking strength of wire rope being not less than 44 kN															

\* Chain cables or wire ropes may be used, chain cable breaking load or actual breaking strength of wire rope being not less than 44 kN.

For self-propelled ships of unrestricted service, restricted areas of navigation **R1**, **R2**, **R2-RSN** and **R3-RSN** having the maximum ahead speed not more than 6 knots at the draught to the summer load waterline and also for ships of restricted area of navigation **R3** having the above speed not more than 5 knots, the anchor equipment shall be selected as in the case of non-propelled ships.

The anchor arrangement of shipborne barges and berth-connected ships shall comply with the requirements of Section 3, Part III "Equipment, Arrangements and Outfit" of Rules for the Classification and Construction of Inland Navigation Ships. For the case of sea passage of berth-connected ships having no permanent anchor arrangement, provision shall be made for anchors and anchor chains to be arranged on board.

Table 3.1.3-2

Equipment Number $N_e$		Bower anchors		Chain cables for bower anchors			Mooring ropes		
Exceeding	Not exceeding	Number	Mass per. anchor, in kg	Total length, in m	Diameter		Number	Length of each rope, in m	Actual breaking strength, in kN
					grade 1, in mm	grade 2, in mm			
1	2	3	4	5	6	7	8	9	10
10	15	1	30	55		—	2	30	29
15	20	1	40	55	*	—	2	30	29
20	25	1	50	82,5		—	2	40	29
25	30	1	60	82,5	*	—	2	50	29
30	40	2	80	165	11,0	—	2	50	29
40	50	2	100	192,5	11,0	—	2	60	29
50	60	2	120	192,5	12,5	—	2	60	29
60	70	2	140	192,5	12,5	—	2	80	29
70	80	2	160	220	14	12,5	2	100	34
80	90	2	180	220	14	12,5	2	100	37
90	100	2	210	220	16	14	2	110	37
100	110	2	240	220	16	14	2	110	39
110	120	2	270	247,5	17,5	16	2	110	39
120	130	2	300	247,5	17,5	16	2	110	44
130	140	2	340	275	19	17,5	2	120	44
140	150	2	390	275	19	17,5	2	120	49
150	175	2	480	275	22	19	2	120	54
175	205	2	570	302,5	24	20,5	2	120	59
205	240	2	660	302,5	26	22	2	120	64
240	280	2	780	330	28	24	3	120	71
280	320	2	900	357,5	30	26	3	140	78
320	360	2	1020	357,5	32	28	3	140	86
360	400	2	1140	385	34	30	3	140	93
400	450	2	1290	385	36	32	3	140	100
450	500	2	1440	412,5	38	34	3	140	108
500	550	2	1590	412,5	40	34	4	160	113
550	600	2	1740	440	42	36	4	160	118
600	660	2	1920	440	44	38	4	160	123
660	720	2	2100	440	46	40	4	160	128

\* Chain cables or wire ropes may be used, chain cable breaking load or actual breaking strength of wire rope being not less than 44 kN.

### 3.2 EQUIPMENT NUMBER

**3.1.5** For remote control systems of the anchor arrangements, if any, the type, extent of automated control and scope of remote control operations are determined by the shipowner.

The additional requirements for the remote-controlled anchor arrangements are given in 3.6.5, the present Part, 6.3.6, Part IX "Machinery", and also in 5.1.3, Part XI "Electrical Equipment".

**3.2.1** The Equipment Number  $N_e$  for all ships, except floating cranes and tugs, is determined by the formula

$$N_e = \Delta^{2/3} + 2Bh + 0,1A \quad (3.2.1-1)$$

where  $\Delta$  = volume displacement, in  $m^3$ , to the summer load waterline;  
 $B$  = breadth of the ship, in m;  
 $h$  = height, m, from the summer load waterline to the top of the uppermost deckhouse, which is determined by the formula

$$h = a + \sum h_i \quad (3.2.1-2)$$

where  $a$  = distance, m, from the summer load waterline amidships to the top of the upper deck plating at side;

$h_i$  = height, in m, at the centre line of each tier of superstructures or deckhouses having a breadth greater than  $0,25B$ .

In case of ships with two or more superstructures or deckhouses along the length, only one superstructure or deckhouse of the considered tier with the greatest breadth is taken into account.

For the lowest tier  $h_1$  shall be measured at the centre line from the upper deck or, in case of a stepped upper deck, from a notional line which is a continuation of the upper deck.

When calculating  $h$ , sheer and trim shall be ignored. Refer also to 3.2.3.

$A$  = area, in  $m^2$ , in profile view of the hull, superstructures and deckhouses above the summer load waterline which are within the ship's length  $L$  and also have a breadth greater than  $0,25B$  (refer also to 3.2.3).

**3.2.2** The Equipment Number  $N_e$  for tugs is determined by the formula

$$N_e = \Delta^{2/3} + 2(Ba + \sum h_i b_i) + 0,1 A \quad (3.2.2)$$

where  $\Delta$ ,  $B$ ,  $a$ ,  $h_i$  and  $A$  are taken according to 3.2.1;

$b_i$  = breadth of the appropriate tier of superstructure or deckhouse, in m. In case of ships with two or more superstructures or deckhouses along the length, the relevant provisions of 3.2.1 shall be followed.

**3.2.3** Containers or other similar cargoes carried on decks and on hatchway covers, masts, derrick booms, rigging, guard rails and other similar structures may be ignored when determining  $h$  and  $A$ ; bulwarks and hatch coamings less than 1,5 m in height may also be ignored. Screens, bulwarks and hatch coamings more than 1,5 m in height shall be regarded as deckhouses or superstructures.

Main galleys, ladders and pile drivers for lifting the ladders of dredgers may be ignored when determining  $h$ ; when determining the value  $A$ , the area in profile view of these structures shall be calculated as the area limited by the contour of the structure.

**3.2.4** The Equipment Number  $N_e$  for floating cranes is determined by the formula

$$N_e = 1,5\Delta^{2/3} + 2Bh + 2S + 0,1A \quad (3.2.4)$$

where  $\Delta$ ,  $B$ ,  $h$  and  $A$  are taken according to 3.2.1; when determining the value of  $A$ , account shall be taken of the area in side profile view of the upper structure of floating crane (stowed for sea) which is calculated as the area limited by the outer contour of the structure;

$S$  = projection on the mid-section of the front area,  $m^2$ , of the upper structure of the floating crane (stowed for sea) situated above the deck of the uppermost deckhouse taken into account in determination of  $h$ , the front area being determined, in this case, as the area limited by the outer contour of the structure.

### 3.3 BOWER AND STREAM ANCHORS

**3.3.1** If the number of bower anchors determined in accordance with provisions of 3.1.3 and 3.1.4 is 3,

one of them is supposed to be a spare anchor. On agreement with the Register, the third (spare) anchor may be stored ashore. The third, i.e. the spare anchor, is not required for ships of restricted areas of navigation **R1**, **R2**, **R2-RSN**, **R3-RSN** and **R3**.

Ships with Equipment Number of 205 and less may have the second bower anchor as a spare one on condition that provision is made for its quick getting ready for use.

Ships of restricted area of navigation **R3** with Equipment Number of 35 and less, if they are not passenger ships, may have only one bower anchor.

For ships of restricted area of navigation **R3** a stream anchor may be omitted.

On ships assigned to restricted navigation areas **R2-RSN** and **R3-RSN** and having Equipment Number in excess of 205 except the values stated in Table 3.1.3-1, provision should be made for a stream anchor with a mass equal to at least 75 per cent.

**3.3.2** For admiralty stocked anchors the anchor mass includes the mass of the stock.

The mass of each bower or stream anchor may differ by  $\pm 7$  per cent from the values determined according to Tables 3.1.3-1 or 3.1.3-2 provided that the total mass of bower anchors is not less than the prescribed total mass thereof.

If high holding power anchors are used, the mass of each anchor may amount to 75 per cent of that determined according to Tables 3.1.3-1 or 3.1.3-2.

Where anchors of super high holding power are used the mass of each anchor shall be not less than 50 per cent of the anchor mass determined according to Tables 3.1.3-1 or 3.1.3-2.

**3.3.3** Anchors of the following types are permitted to be used in ships:

- .1 Hall's;
- .2 Gruson's anchor;
- .3 admiralty anchor.

The mass of the head of Hall's or Gruson's anchors including pins and fittings shall be not less than 60 per cent of the total anchor mass.

For admiralty stocked anchors the mass of the stock shall amount to 20 per cent of the total anchor mass including the anchor shackle.

The equipment of ships with anchors of other types is subject to special consideration by the Register in each case.

In order to recognize the anchor as a high holding power anchor, it is necessary to carry out comparative tests of this anchor and Hall's or Gruson's anchor in pair on various types of bottom; in this case, the holding power of the anchor shall be at least twice as much as that of Hall's or Gruson's anchor of the same mass.

To recognize an anchor as a super high holding power anchor comparative tests shall be made of

such anchor in pair with a Hall's or Gruson's anchor on different types of bottom to prove that a holding power of the anchor is at least four times that of a Hall's or Gruson's anchor of the same mass. Similar comparative tests with a high holding power anchor may be made, in which case a holding power of the super high holding power anchor shall be at least two times that of the high holding power anchor.

The scope and procedure of such tests are subject to special consideration by the Register in each case.

**3.3.4** Super high holding power anchors are suitable for use in ships of restricted areas of navigation **R2**, **R2-RSN**, **R3** and **R3-RSN**. The super high holding power anchor mass shall not generally exceed 1500 kg.

### 3.4 CHAIN CABLES AND ROPES FOR BOWER ANCHORS

**3.4.1** Ship's with the Equipment Number 205 and less, in which the second bower anchor is permitted to be a spare one, and also ships with the Equipment Number 35 and less and provided according to 3.3.1 with only one bower anchor may be equipped with only one chain cable the length of which is two times less than that required in the relevant Equipment Table for two chain cables. For ships of restricted area of navigation **R3** chain cables or wire ropes for a stream anchor may be omitted.

**3.4.2** For ships having "supply vessel" notation added to the character of classification the total length of both chain cables for bower anchors shall be taken 165 m greater than the value specified in Table 3.1.3-1, and the diameter of these chain cables shall be taken not less than that given in Table 3.1.3-1 two lines below the Equipment Number for the considered ship (having regard to the provisions of 3.1.3 and 3.1.4).

For supply vessels having the Equipment Number over 720 at the specification depth of the anchorage over 250 m and for those having the Equipment Number 720 and less at the specification depth of the anchorage over 200 m, the length and diameter of chain cables for bower anchors shall be increased taking account of the specification depths and conditions of the anchorage on agreement with the Register.

**3.4.3** For hopper barges and dredgers not having hoppers to transport spoil, the diameter of chain cables for bower anchors shall be taken not less than that specified in Table 3.1.3-1 two lines below the Equipment Number of the considered ship, and for dredgers having hoppers to transport spoil, one line below (taking account of the provisions of 3.1.3 and 3.1.4).

**3.4.4** Chain cables of bower anchors shall be graded dependent on their strength as specified in 7.1, Part XIII "Materials".

**3.4.5** Tables 3.1.3-1 and 3.1.3-2 specify the diameters of chain cables on the assumption that the links of these chain cables are provided with studs, with the exception of the chain cables less than 15 mm in diameter which are assumed to have no studs. The use of short link chain cables of increased diameter instead of stud link chain cables 15 mm in diameter and over will be specially considered by the Register in each case.

**3.4.6** The chain cables shall be composed of separate chain lengths, except for the chains less than 15 mm in diameter which need not be divided into chain lengths.

The lengths of chains shall be interconnected with joining links. The use of joining shackles instead of joining links shall be specially considered by the Register in each case.

Depending on their location in the chain cable the lengths are divided into:

- anchor length fastened to the anchor;

- intermediate lengths;

- inboard end chain length secured to the chain cable releasing device.

**3.4.7** The anchor length of chain shall consist of a swivel, an end link and a minimum quantity of common and enlarged links required to form an independent length of chains.

The anchor length of chains may consist only of a swivel, an end link and a joining link provided the relation between the dimensions of the chain cable parts allows to form such a length. In chain cables which are not divided into lengths of chains the swivel shall be included into each chain cable as near to the anchor as practicable. In all cases, the pins of swivels shall face the middle of the chain cable.

The anchor length shall be connected with the anchor shackle with the aid of an end shackle the pin of which shall be inserted into the anchor shackle.

**3.4.8** The intermediate lengths of chains shall be not less than 25 m and not over 27,5 m, the chains consisting of the odd number of links. The total length of two chain cables given in the Equipment Tables is a sum of intermediate lengths of chains only without the anchor and inboard end lengths of chains.

If the number of intermediate lengths of chains is odd, the starboard chain cable shall have one intermediate length of chains more than the port chain cable.

**3.4.9** The inboard end length of chains shall consist of a special link of enlarged size (provided, however, that this link is capable of passing freely through the wildcat of the anchor machinery) being secured to the chain cable releasing device, and of

minimum number of common and enlarged links required for forming an independent chain length. The inboard end length of chains may consist of one end link only provided the relation between the dimensions of the chain cable parts and the chain cable releasing device allows to form such a length.

**3.4.10** In all other respects, the chain cables for bower anchors shall comply with the requirements of 7.1, Part XIII "Materials".

**3.4.11** For fishing vessels under 30 m in length and for other ships having the Equipment Number 205 and less the chain cables may be replaced with wire ropes; for fishing vessels between 30 and 40 m in length one of chain cables may be replaced with a wire rope. The actual breaking strength of such ropes shall not be less than the breaking load of the corresponding chain cables, and the length shall be at least 1,5 times the length of the chain cables.

Wire ropes of trawl winches complying with this requirement may be used as anchor cables.

On agreement with the Register, ships having the equipment number 130 and less may be equipped with synthetic fibre ropes instead of chain cables or wire ropes.

**3.4.12** The end of each wire rope shall be spliced into a thimble, clamp or socket and connected to the anchor by means of a chain cable section having a length equal to the distance between the anchor (in stowed for sea position) and the anchor machinery or 12,5 m, whichever is the less; a breaking load of the above chain section shall be not less than the actual breaking strength of the wire rope. The chain cable section shall be secured to the wire rope fitting and the anchor shackle by means of joining shackles being equal to the wire ropes in strength.

The length of the chain cable sections may be included into 1,5 times the length of wire ropes specified in 3.4.11.

**3.4.13** The wire ropes for anchors shall have at least 114 wires and one natural fibre core. The wires of the ropes shall have a zinc coating according to recognized standards.

In all other respects, the wire ropes for anchors shall meet the requirements of 3.15, Part XIII "Materials".

### 3.5 CHAIN CABLE OR WIRE ROPE FOR STREAM ANCHOR

**3.5.1** Stream-anchor chain cables shall meet the applicable requirements of 3.4.

Ships assigned to restricted navigation areas **R2-RSN** and **R3-RSN** and having Equipment Number in excess of 205 shall be equipped with a stream-

anchor chain cable whose length is at least 60 per cent of that required for a bower-anchor chain cable. The chain cable diameter shall be taken not less than that mentioned in Table 3.1.3-1 two lines above the Equipment Number of the ship in question (bearing the provisions of 3.1.3 and 3.1.4 in mind).

Ships having Equipment Number below 205 may be equipped with studless chain cables.

**3.5.2** The requirements of 3.4.12 and 3.4.13 are applicable to the wire rope for the stream anchor.

### 3.6 ANCHOR APPLIANCES

#### 3.6.1 Stoppers.

**3.6.1.1** Each bower-anchor chain cable or rope and each stream-anchor chain cable having a mass of 200 kg and above shall be provided with a stopper holding the anchor in the hawse pipe when stowed for sea or, in addition, intended for riding the ship at anchor.

In ships having no anchor machinery or having the anchor machinery, which is not in compliance with the requirements of 6.3.2.3.2, Part IX "Machinery" provision of stoppers for riding the ship at anchor is obligatory.

**3.6.1.2** Where the stoppers is intended only for securing the anchor in the hawse pipe when stowed for sea, its parts shall be calculated to withstand the chain cable strain equal to twice the weight of the anchor, the stresses in the stopper parts not exceeding 0,4 times the upper yield stress of their material. Where the stopper comprises a chain cable or rope, this shall have safety factor 5 in relation to the breaking load of the chain cable or actual breaking strength of the rope under the action of a force equal to twice the weight of the anchor.

**3.6.1.3** Where the stopper is intended for riding the ship at anchor, its parts shall be calculated on assumption that the stopper will be subjected to a force in the chain cable equal to 0,8 times its breaking load. The stresses in the stopper parts shall not exceed 0,95 times the upper yield stress of their material. Where the stopper comprises a chain cable or rope, they shall have strength equal to that of the chain cable for which they are intended.

**3.6.1.4** In glass-reinforced plastic ships the stoppers shall be fastened by bolts with the use of steel gaskets or wooden pads on the deck and under deck flooring between the framing. Bolt connections shall comply with the requirements of 1.7.4, Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats".

### **3.6.2 Device for securing and releasing the inboard end of the chain cable.**

**3.6.2.1** The parts of the device for securing and releasing the inboard end of the chain cable shall be calculated for strength under the force acting on the device which is equal to 0,6 times the chain breaking load, stresses in these parts not exceeding 0,95 times the upper yield stress of their material.

**3.6.2.2** In ships with Equipment Number of more than 205 the device for securing and releasing the inboard end of the chain cable shall be provided with a drive from the deck on which the anchor machinery is fitted or from other deck, in a place which gives quick and ready access at all times. The screw of the drive shall be self-braking.

**3.6.2.3** The design of the device for securing and releasing the inboard end of the chain cable shall ensure the efficiency of its operation both under the action of and without the strain of the chain cable referred to in 3.6.2.1.

**3.6.2.4** In glass-reinforced plastic ships the device for securing and releasing the inboard end of the chain cable shall be fastened by bolts with the use of steel gaskets on both sides of the bulkhead. Bolt connections shall comply with the requirements of 1.7.4, Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats".

### **3.6.3 Laying of chain cables.**

**3.6.3.1** Laying of chain cables shall provide for their free run when dropping or hoisting the anchors.

In ships with a bulbous bow laying of chain cables shall comply with the requirements of 2.8.2.4, Part II "Hull".

**3.6.3.2** The anchor shank shall easily enter the hawse pipe under the mere action of the chain cable tension and shall readily take off the hawse pipe when the chain cable is released.

**3.6.3.3** The thickness of the hawse pipe shall not be less than 0,4 times the diameter of the chain cable passing through the hawse pipe.

**3.6.3.4** In glass-reinforced plastic ships galvanized or stainless steel plates shall be fitted on the outside plating under the hawse pipes; the plates shall be fastened by countersunk bolts.

Bolt connections shall comply with the requirements of 1.7.4, Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats".

### **3.6.4 Chain lockers.**

**3.6.4.1** For stowage of each bower anchor chain lockers shall be provided.

When one chain locker is designed for two chains, it shall be provided with an internal permeable or watertight division so that separate stowage of each chain is ensured.

**3.6.4.2** The chain locker shall be of shape, capacity and depth adequate to provide an easy direct lead of the cables through the chain pipes, an easy self-stowing of the cables and their free veering away when dropping the anchors.

**3.6.4.3** The chain locker design, as well as chain and hawse pipes shall be watertight up to the weather deck. Upper openings of such pipes shall be fitted with the permanent buckler plates. These may be made both of steel with the relevant cutouts for a chain cable diameter and of canvas with the relevant fastenings to keep the plate closed down.

The openings for access to the chain locker shall be fitted with covers secured with closely spaced bolts.

**3.6.4.4** Drainage of chain lockers shall comply with the requirements in 7.12.1, Part VIII "Systems and Piping", and lighting – with the requirements of 6.7, Part XI "Electrical Equipment".

### **3.6.5 Additional requirements for remote-controlled anchor appliances.**

**3.6.5.1** Stoppers and other anchor appliances for which remote control is provided (refer to 3.1.5) shall also be fitted with means of local manual control.

**3.6.5.2** The anchor appliances and the associated means of local manual control shall be so designed that normal operation is ensured in case of failure of separate elements or the whole of the remote control system (refer also to 5.1.3, Part XI "Electrical Equipment").

## **3.7 ANCHOR MACHINERY**

**3.7.1** Anchor machinery shall be fitted on the deck in the fore part of the ship for dropping and hoisting the anchors, as well as for holding the ship with the bower anchors dropped if the mass of the anchor exceeds 35 kg.

Ships of restricted area of navigation **R2-RSN** and **R3-RSN** shall be fitted with the anchor machinery for dropping and hoisting the stream anchor if its mass exceeds 200 kg.

Ships having Equipment Number 205 and less may be fitted with hand-operated anchor machinery and may also use other deck machinery for dropping and hoisting the anchors.

The requirements for the design and power of anchor machinery are given in 6.3, Part IX "Machinery".

In glass-reinforced plastic ships fastening of the anchor machinery shall comply with the requirements of 3.6.1.4.

### 3.8 SPARE PARTS

**3.8.1** Each ship carrying a spare anchor and equipped with a chain cable (cables) for bower anchor (anchors) accordance with the provisions of 3.3.1 and 3.4 shall have: spare anchor length of chain — 1 pc, spare joining link — 2 pcs, spare end shackle — 1 pc.

**3.8.2** Each ship equipped with a spare anchor and wire rope (ropes) for bower anchor (anchors) in accordance with the provisions of 3.3.1 and 3.4.11 shall have a spare set of parts for joining the wire rope and anchor shackle.

## 4 MOORING ARRANGEMENT

### 4.1 GENERAL

**4.1.1** Each ship shall be supplied with mooring arrangement for warping to coastal or floating berths and for reliable fastening of the ship to them.

For shipborne barges the mooring arrangement shall comply with the requirements of Section 4, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships.

**4.1.2** For all ships, except fishing vessels, the number, length and actual breaking strength of mooring ropes shall be selected from Table 3.1.3-1, and for fishing vessels — from Table 3.1.3-2 according to Equipment Number determined in compliance with 3.2.

**4.1.3** In case the ratio  $A/N_e$  for a ship is more than 0,9, the number of mooring ropes shall be increased as against that prescribed in Table 3.1.3-1 by:

- 1 pc for ships having  $0,9 < A/N_e \leq 1,1$ ;
- 2 pcs for ships having  $1,1 < A/N_e \leq 1,2$ ;
- 3 pcs for ships having  $A/N_e > 1,2$

where  $N_e$  and  $A$  = Equipment Number and area in profile view specified in 3.2, respectively.

**4.1.4** For individual mooring ropes with breaking strength above 490 kN according to Table 3.1.3-1 the latter may be reduced with corresponding increase of the number of mooring ropes, provided that the total breaking strength of all mooring ropes aboard the ship is not less than the value selected from Table 3.1.3-1 with regard to paragraphs 4.1.3 and 4.1.6. The number of ropes shall be not less than 6 and none of the ropes shall have the breaking strength less than 490 kN.

**4.1.5** The length of individual mooring ropes may be reduced by up to 7 per cent as against the prescribed value provided that the total length of all mooring ropes is not less than that specified in Table 3.1.3-1 and 4.1.3 or Table 3.1.3-2.

**4.1.6** In case mooring rope made of synthetic fibre material is used, its actual breaking strength  $F_s$ ,

in kN, shall not be less than determined by the formula

$$F_s = 0,0742 \delta_m F_t^{8/9} \quad (4.1.6)$$

where  $\delta_m$  = mean elongation at breaking of a synthetic fibre rope, in per cent, but not less than 30 per cent. Where no data on  $\delta_m$  are available, it shall be assumed equal to:  
45 per cent for polyamide ropes;  
35 per cent for polypropylene ropes;  
 $F_t$  = actual breaking strength of the mooring rope specified in Table 3.1.3-1 or 3.1.3-2, in kN.

### 4.2 MOORING ROPES

**4.2.1** Mooring ropes may be of steel wire, natural fibre or synthetic fibre material, with the exception of the ropes intended for ships carrying in bulk flammable liquids with the flash point 60 °C and below. In these ships the operations with steel wire ropes are allowed only on the superstructure decks which are not the top of liquid cargo tanks and on condition that no pipelines for loading and unloading the cargo are carried through these decks.

Notwithstanding the breaking strength specified in Tables 3.1.3-1 or 3.1.3-2 or determined by the Formula (4.1.6), the diameter of the mooring rope made from natural or synthetic fibre material shall not be less than 20 mm.

**4.2.2** Steel wire ropes shall have at least 144 wires and not less than 7 fibre cores. The exception is made for wire ropes for automatic mooring winches which may have only one fibre core but the number of wires in such ropes shall be not less than 216. The wires of the ropes shall have a zinc coating according to recognized standards.

In all other respects, the steel wire ropes shall meet the requirements of 3.15, Part XIII "Materials".

**4.2.3** Natural fibre ropes shall be either manilla or sizal. The ships having equipment number 205 and less are permitted to use hemp ropes. The use of hemp ropes in ships with equipment number over 205 is subject to special consideration by the Register in each case.

In all other respects, the natural fibre ropes shall meet the requirements of 6.6, Part XIII "Materials".

**4.2.4** The synthetic fibre ropes shall be manufactured from approved homogeneous materials (polypropylene, capron, nylon, etc.).

Combinations of synthetic fibres of approved different materials are subject to special consideration by the Register in each case.

In all other respects, the ropes of synthetic fibre material shall meet the requirements of 6.6, Part XIII "Materials".

#### 4.3 MOORING APPLIANCES

**4.3.1** The number and position of mooring bollards, fairleaders and other mooring appliances depend on the constructional features, purpose and general arrangement of the ship.

**4.3.2** Bollards may be of steel or cast iron. Small ships equipped only with natural fibre or synthetic fibre ropes are permitted to use the bollards made of light alloys. As to the method of manufacture, the bollards may be welded or cast.

It is not permitted to use bollards cut directly in the deck which is the top of cargo tanks intended for carriage or stowage of flammable liquids with the flash point 60 °C and below.

**4.3.3** The outside diameter of the bollard column shall be not less than 10 diameters of the steel wire rope, not less than 5,5 diameters of the synthetic fibre rope, and not less than one circumference of the natural fibre rope for which the bollard is designed. The distance between the axes of bollard columns shall not be less than 25 diameters of the steel wire rope or 3 circumferences of the natural fibre rope.

**4.3.4** Load-bearing members of the mooring arrangement shall be located on deck stringers, beams and other stiffeners which are a part of the deck structure to assure effective load distribution.

The design load applied to mooring arrangements as well as their supporting hull structures shall be 1,25 times the breaking strength of the mooring line chosen according to Table 3.1.3-1 for the ship's corresponding equipment number.

The design load applied to supporting hull structures for winches shall be 1,25 times the intended maximum brake holding load and, for capstans, 1,25 times the maximum hauling-in force.

**4.3.5** Allowable stresses in supporting hull structures under the design load conditions specified in 4.3.4, shall be as follows:

normal stresses — 100 per cent of the specified minimum yield point of the material;

shearing stresses — 60 per cent of the specified minimum yield point of the material.

No stress concentration factors being taken into account. Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress.

The total corrosion addition, in mm, for both sides of the hull supporting structure shall not be less than the following values:

ships covered by Part XVII "Common Structural Rules for Double Hull Oil Tankers" and Part XVIII "Common Structural Rules for Bulk Carriers" — according to the requirements of the above Parts of the Rules;

other ships — 2 mm.

**4.3.6** Safe Working Load (SWL) of details of mooring appliances shall not exceed 0,8 design load determined in accordance with 4.3.4. All details of the mooring appliances shall be marked with the value of SWL by means of welding or other equivalent method.

#### 4.4 MOORING MACHINERY

**4.4.1** Special mooring machinery (mooring capstans, mooring winches, etc.) as well as other deck machinery (windlasses, cargo winches, etc.) fitted with mooring drums may be used for warping the hawsers.

**4.4.2** The choice of the number and type of mooring machinery is within the owner's and designer's discretion, however, the rated pull of the machinery shall not exceed 1/3 of the actual breaking strength of the mooring ropes used in the ship and, besides, the requirements of 6.4, Part IX "Machinery" shall be satisfied.

### 5 TOWING ARRANGEMENT

#### 5.1 GENERAL

**5.1.1** Each ship shall be provided with towing arrangement which satisfies the requirements of 5.2 and 5.3.

Besides, the ships having the descriptive notation "(tug)" added to the character of classification shall comply with the requirements of 5.4 to 5.6.

**5.1.2** Oil tankers, oil tankers (> 60 °C), combination carriers, gas carriers and chemical tankers of



20 000 t deadweight and over shall comply with the requirements of 5.7.

**5.1.3** The towing arrangements of berth-connected ships shall comply with the requirements of 5.3, Part III "Equipment, Arrangements and Outfit" of Rules for the Classification and Construction of Inland Navigation Ships.

## 5.2 TOW LINE

**5.2.1** The length and the actual breaking strength of the tow line shall be selected from Table 3.1.3-1 according to Equipment Number determined in compliance with 3.2.

For shipborne barges the actual breaking strength of the tow line  $F_b$ , in kN, shall be calculated by the formula

$$F_b = 16nBd \quad (5.2.1)$$

where  $n$  = number of barges intended to be towed in the wake of the tug in tandem;  
 $B$  = breadth of the barge, in m;  
 $d$  = draught of the barge, in m.

The breaking strength of the tow line is used in the strength calculations of the towing appliances of the shipborne barges. At the discretion of the shipowner the tow lines of the shipborne barges may be stored in the barge carrier or tug, and they do not form a part of the equipment of the shipborne barge.

**5.2.2** The tow lines may be of steel wire, natural fibre or synthetic fibre material. The requirements of 4.1.6, 4.2.1 to 4.2.4 for mooring ropes are also applicable to the tow line.

## 5.3 TOWING APPLIANCES

**5.3.1** The number and location of towing bollards and chocks depend on the constructional features, purpose and general arrangement of the ship.

**5.3.2** Requirements of 4.3.2 and 4.3.3 introduced for the mooring bollards also apply to towing bollards.

**5.3.3** Shipboard fittings for towing shall be located on longitudinals, which are part of the deck construction so as to facilitate efficient distribution of the towing load.

**5.3.4** The design load applied to towing arrangements shall be as follows:

**.1** for normal towing operations — 1,25 times the bollard pull;

**.2** for escort service — the breaking strength of the tow line according to Table 3.1.3-1 for the ship's corresponding equipment number.

**5.3.5** Under the design load conditions specified in 5.3.4, the allowable stresses in supporting hull structures as well as the total corrosion addition shall be determined according to 4.3.5.

**5.3.6** The safe working load (SWL) of the shipboard fittings for towing shall not exceed:

0,8 of the design load determined according to 5.3.4.1 for normal towing operations;

the design load determined according to 5.3.4.2 for escort service.

For fittings used for both normal towing operations and escort service, the greater of the design loads according to 5.3.4.1 and 5.3.4.2 shall be used.

The SWL of each shipboard fitting shall be marked by weld bead or equivalent on the deck fittings used for towing.

## 5.4 SPECIAL ARRANGEMENT FOR TUGS

**5.4.1** The number and type of equipment and outfit forming special arrangement for tugs which ensures towing operations under different service conditions are determined by the Shipowner considering that such equipment and outfit shall satisfy the requirements of the present Chapter.

**5.4.2** The main determining factor in providing the tugs with a special arrangement is the rated towing pull  $F$  acting on the tow hook. The rated towing pull shall be taken as:

for tugs of unrestricted service and of restricted areas of navigation **R1** and **R2**, the pull on the tow hook required for towing the prescribed tow at a prescribed speed, but not exceeding 5 knots;

for tugs of restricted area of navigation **R3**, the bollard pull, but in no case the rated towing pull  $F$ , in kN, shall be taken less than:

$$F = 0,133 P_e \quad (5.4.2)$$

where  $P_e$  = total power of the tug's main engines, in kW.

**5.4.2.1** The numerical value of the rated towing pull under operating conditions specified in 5.4.2 is within the owner's and designer's discretion, and all calculations pertaining to the determination of this value are not subject to approval by the Register. Nevertheless, during mooring and sea trials of the tug, the Register will check this value, and, if the parts of the special arrangement prove to be calculated from a smaller value, the Register may require the strengthening of these parts or may introduce restriction of power during towing operations.

**5.4.2.2** The actual breaking strength of the tow line  $F_1$ , in kN, for towing operations on the hook shall not be less than:

$$F_1 = kF \quad (5.4.2.2)$$

where  $F$  = rated towing pull, in kN, according to 5.4.2;

$k$  = safety factor equal to:

5,0 for rated towing pull 98,1 kN and less;

3,0 for rated towing pull 294 kN and over.

For intermediate values of the rated towing pull the safety factor  $k$  is obtained by linear interpolation.

The length of the tow line for towing operations on the hook shall not be less than 150 m.

The tow line for towing operations on the hook may be of steel wire, natural fibre or synthetic fibre material. The requirements of 4.2 for mooring ropes are also applicable to the tow line for towing operations on the hook.

**5.4.3** All stressed parts of the towing arrangement (such as the tow hook, towing rails, etc.) as well as the fastenings for securing these parts to the ship's hull shall be designed to take the actual breaking load of the tow line. The stresses in these parts shall not exceed 0,95 times the upper yield stress of their material.

**5.4.4** The cramp iron of the tow hook shall be calculated as a curvilinear bar. Where such calculations are not carried out, i.e. the formulae for a rectilinear bars are used, permissible stresses shall be reduced by 35 per cent.

**5.4.5** All parts of the towing arrangement which are subjected to tension or bending under the hull of the tow line shall not be manufactured of cast iron.

**5.4.6** The cramp iron of the tow hook shall be either solid forged or manufactured of a solid rolled blank. Percentage elongation of the cramp iron material shall not be less than 18 per cent on 5D.

**5.4.7** Tow hooks shall be of slip-type and have a tow line releasing device operating efficiently in the range of loads on the tow hook from zero to three times the rated towing pull and at any practically possible deflection of the tow line from the centre line of the ship.

The device shall be controlled both at the tow hook and from the navigating bridge. Where the ship is fitted with a spshallow hook, in addition to the main one, this hook need not be of slip-type and have a device for releasing the tow line.

**5.4.8** Each tow hook shall be provided with shock absorbers whose ultimate damping load shall not be less than 1,3 times the rated towing pull.

The tow hooks for tugs of less than 220 kW of restricted area of navigation **R3** may have no shock absorbers.

**5.4.9** Prior to installation on board the ship the tow hooks shall be tested by application of a proof load equal to twice the rated towing pull.

**5.4.10** The wire stopper and its fastenings shall be such that their breaking load is not less than 1,5 times the rated towing pull.

**5.4.11** The requirements of 3.7, Part IV "Stability" shall be taken into consideration when assigning the position of the tow hook and towing winch.

## 5.5 TOWING WINCHES

**5.5.1** The requirements for the design of towing winches are specified in 6.5, Part IX "Machinery".

**5.5.2** Provision shall be made for operating the towing winch from a site at the winch; it is recommended to allow for operating the towing winch from the navigating bridge.

## 5.6 TOW LINE FOR TOWING WINCH

**5.6.1** The length of tow line for towing winch shall not be less than 700 m if the power of the tug's main engines is 2200 kW and over, and at least 500 m if that power is 1470 kW or less. In the tugs with the main engines having the power in the range from 1470 to 2200 kW the length of tow line for the towing winch shall be determined by linear interpolation.

**5.6.2** In all other respects, the tow line for towing winch shall comply with the requirements set forth in 5.4.2.2.

## 5.7 EMERGENCY TOWING ARRANGEMENTS ON SHIPS

**5.7.1** Ships referred to in 5.1.2 shall be fitted with emergency towing arrangements forward and aft of the ship. The arrangements shall be capable of rapid deployment in the absence of main power on the ship to be towed and easy connection to the towing vessel.

**5.7.2** The components of the emergency towing arrangement are listed in Table 5.7.2.

Table 5.7.2

Components of emergency towing arrangement	Non pre-rigged	Pre-rigged
Pick-up gear	Optional	Yes
Towing pennant	Optional	Yes
Chafing gear	Yes	Depending on design
Fairlead	Yes	Yes
Strongpoint	Yes	Yes
Roller pedestal	Yes	Depending on design

**5.7.3** Except the pick-up gear and roller pedestal, the components of the emergency towing arrangement specified in Table 5.7.2 shall have a working strength of at least:

1000 kN for ships of 20 000 t deadweight and over, but less than 50 000 t deadweight,

2000 kN for ships of 50 000 t deadweight and over.

Under the above forces, the stresses shall not exceed 0,5 of the ultimate strength.

The strength shall be sufficient for all relevant angles of towline, i.e. up to 90° from the ship's centreline to port and starboard and 30° vertically downwards.

**5.7.4** The towing pennant shall have a length of at least twice the lightest seagoing ballast freeboard at the fairlead plus 50 m. The towing pennant shall have a hard eye-formed termination allowing connection to a standard shackle.

The bow and stern strongpoints and fairleads shall be located so as to facilitate towing from either side of the bow or stern and minimize the stress on the towing system.

The inboard end fastening shall be a stopper or bracket or other fitting of equivalent strength. The strongpoint can be designed integral with the fairlead.

**5.7.5** Fairleads shall have an opening large enough to pass the largest portion of the chafing gear, towing pennant or towing line.

The fairlead shall give adequate support for the towing pennant during towing operation which means bending  $90^\circ$  to port and to starboard side and  $30^\circ$  vertically downwards. The bending ratio (towing pennant bearing surface diameter to towing pennant diameter) shall be not less than 7 to 1.

The fairlead shall be located as close as possible to the deck and, in any case, in such a position that the chafing chain is approximately parallel to the deck when it is under strain between the strongpoint and the fairlead.

**5.7.6** The chafing gear shall be fitted at the forward and, depending on design, aft ends of the ship. A chafing chain or another design approved by the Register may be used as the chafing gear. The chafing chain shall be a stud link chain.

The chafing chain shall be long enough to ensure that the towing pennant remains outside the fairlead

during the towing operation. A chain extending from the strongpoint to a point at least 3 m beyond the fairlead shall meet this criterion.

**5.7.7** One end of the chafing chain shall be suitable for connection to the strongpoint. The other end shall be fitted with a standard pear-shaped open link allowing connection to a standard bow shackle.

The chafing chain shall be stowed in such a way that it can be rapidly connected to the strongpoint.

**5.7.8** The emergency towing arrangement shall be pre-rigged and be capable of being deployed in a controlled manner in harbour conditions in not more than 15 min.

The pre-rigged pick-up gear shall be designed for manual operation by one person taking into account the absence of power and the potential for adverse environmental conditions that may prevail during such emergency towing operations. The pick-up gear shall be protected against the weather and other adverse conditions that may prevail.

**5.7.9** The non pre-rigged emergency towing arrangement shall be capable of being deployed in harbour conditions in not more than 1 h. To facilitate connection of the towing pennant to the chafing gear and to prevent chafing of the pennant, a suitably positioned pedestal roller may be used.

Pre-rigged emergency towing arrangements at both ends of the ship may be accepted.

A type emergency towing arrangement is shown in Fig. 5.7.9.

**5.7.10** All emergency towing arrangements shall be clearly marked to facilitate safe and effective use even in darkness and poor visibility.

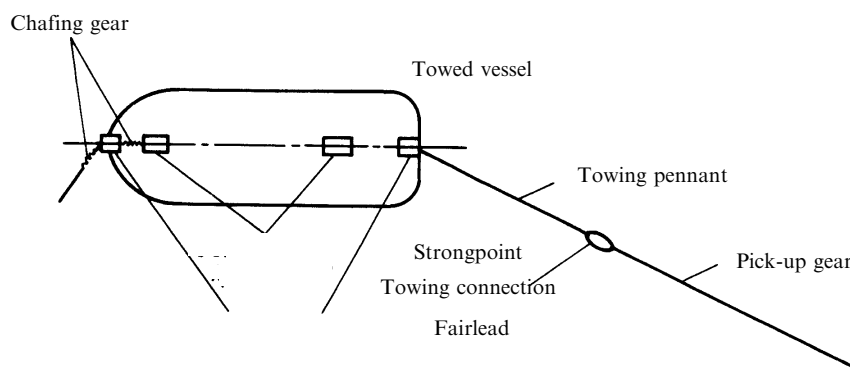


Fig. 5.7.9

## 6 SIGNAL MASTS

### 6.1 GENERAL

**6.1.1** The requirements given in the present Section refer only to the signal masts, i.e. the masts which are intended for carrying the signal means: navigation lights, day signals, aerials, etc. Where the masts or their parts carry derrick booms or other cargo handling gear in addition to the signal means, such masts or their parts shall comply with the requirements of Rules for the Cargo Handling Gear of Sea-Going Ships.

The requirements of 6.2 to 6.4 do not apply to berth-connected ships. The signal masts of berth-connected ships shall be designed to carry prescribed signal means.

**6.1.2** Arrangement, height and provision of signal means on the signal masts shall comply with the requirements of Part III "Signal Means" of Rules for the Equipment of Sea-Going Ships.

**6.1.3** If in ships of restricted areas of navigation **R2-RSN** and **R3-RSN** the signal masts are collapsible, special machinery shall be installed for their operation or provision shall be made for appropriate connection with other deck machinery. The drive of the machinery may be hand-operated provided the machinery is self-braking and the load on the handle is not more than 160 N at any moment of jackknifing or hoisting the mast.

### 6.2 STAYED MASTS

**6.2.1** The outside diameter  $d$  and the plate thickness  $t$ , in mm, at the heel of the masts made of steel having the upper yield stress from 215 up to 255 MPa and stayed by two shrouds on each side of the ship, shall not be less than:

$$d = 22l; \quad (6.2.1-1)$$

$$t = 0,2l + 3 \quad (6.2.1-2)$$

where  $l$  = mast length, in m, from the heel to the shroud eyeplates.

The diameter of the mast may be gradually decreased upwards to a value of  $0,75d$  at the shroud eyeplates, while the thickness of the mast plates is maintained constant throughout the length  $l$ .

The mast length from the shroud eyeplates to the top shall not exceed  $1/3$  of  $l$ .

The mast shall be stayed by the shrouds as follows:

**.1** horizontal distance  $a$ , in m, from the deck (or bulwark) stay eyeplate to the transverse plane through the mast stay eyeplate shall not be less than:

$$a = 0,15h \quad (6.2.1.1)$$

where  $h$  = vertical distance, in m, from the mast stay eyeplate to the deck (or bulwark) stay eyeplate;

**.2** horizontal distance  $b$ , in m, from the deck (or bulwark) stay eyeplate to the longitudinal plane through the mast stay eyeplate shall not be less than:

$$b = 0,30h; \quad (6.2.1.2)$$

**.3** the value  $a$  shall not exceed the value  $b$ .

**6.2.2** The actual breaking strength  $F$  of the ropes, in kN, used for the mast shrouds as specified in 6.2.1 shall not be less than:

$$F = 0,49(l^2 + 10l + 25). \quad (6.2.2)$$

In other respects, the ropes for shroud shall comply with the requirements of 3.15, Part XIII "Materials".

The loose gear of shrouds (shackles, turnbuckles, etc.) shall be such that their safe working load is not less than 0,25 times the actual breaking strength of the ropes referred to above.

**6.2.3** Where:

the mast is made of high tensile steel, light alloys, glass-reinforced plastics or wood (the wood shall be of the 1st grade);

the mast is stayed in a way other than that specified in 6.2.1;

in addition to a yard arm, lights and day signals, the mast is fitted with other equipment having considerable weight, such as radar reflectors with platforms for their servicing, "crow's nests", etc., proceed as specified in 6.4.

**6.2.4** The wires of shrouds shall have a zinc coating according to recognized standards.

### 6.3 UNSTAYED MASTS

**6.3.1** The outside diameter  $d$  and the plate thickness  $t$ , in mm, at the heel of masts made of steel having the upper yield stress from 215 to 255 MPa shall not be less than:

$$d = 3l^2(0,674l + a + 13) \times \left(1 + \sqrt{1 + \frac{51,5 \cdot 10^4}{P(0,674l + a + 13)^2}}\right) \cdot 10^{-2}; \quad (6.3.1-1)$$

$$t = \frac{1}{70} d \quad (6.3.1-2)$$

where  $l$  = length of the mast from heel to top, in m;  
 $a$  = elevation of the mast heel above centre of gravity of the ship, in m.

The outside diameter of the mast may be gradually decreased upwards to a value  $0,5d$  at the distance  $0,75l$  from the heel.

In no case is the thickness of the mast plate to be less than 4 mm.

The mast heel shall be rigidly fixed in all directions.

#### 6.3.2 Where:

the mast is made of high tensile steel, light alloys, glass-reinforced plastics or wood (the wood shall be of the 1st grade);

in addition to a yard arm, lights and day signals, the mast is fitted with other equipment having considerable weight, such as radar reflectors with platforms for their servicing, "crow's nests", etc., proceed as provided in 6.4.

### 6.4 MASTS OF SPECIAL CONSTRUCTION

**6.4.1** In the cases specified in 6.2.3 and 6.3.2 as well as where bipod, tripod and other similar masts are installed, detailed strength calculations of these masts shall be carried out. These calculations shall be submitted to the Register for consideration.

**6.4.2** The calculations shall be performed on the assumption that each part of the mast is affected by a horizontal force  $F_i$ , in kN

$$F_i = \left[ m_i \frac{4\pi^2}{T^2} (\theta z_i + r \sin \theta) + m_i g \sin \theta + p A_i \cos \theta \right] \cdot 10^{-3} \quad (6.4.2)$$

where  $m_i$  = mass of each part, in kg;  
 $z_i$  = elevation of the centre of gravity of each part above that of the ship, in m;  
 $A_i$  = projected lateral area of each part, in m<sup>2</sup>;  
 $T$  = rolling or pitching period, in s;  
 $\theta$  = amplitude of roll or pitch, in rad;  
 $r$  = wave half-height, in m;  
 $g$  = 9,81 m/s<sup>2</sup> — acceleration due to gravity;  
 $p$  = 1960 Pa — specific wind pressure.

The calculations shall be carried out both for rolling and pitching of the ship,  $r$  being taken as equal to  $L/40$  where  $L$  is the ship's length, in m, and  $\theta$ , in rad., as corresponding to an angle of 40° at roll and of 5° at pitch.

**6.4.3** Under the loads specified in 6.4.2, the stresses in the parts of the mast shall not exceed 0,8 times the upper yield stress of their material where they are made of metal, and 12 MPa where they are made of wood. The safety factor of the standing ropes under the same loads shall not be less than 3.

For glass-reinforced plastic masts under the loads specified in 6.4.2 the stresses in the parts of the mast shall not exceed the allowable stress value indicated in Table 3 of Appendix 3, Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats" for the case of short-time action of the load for the relevant type of deformation.

## 7 OPENINGS IN HULL, SUPERSTRUCTURES AND DECKHOUSES AND THEIR CLOSING APPLIANCES

### 7.1 GENERAL

**7.1.1** The requirements of the present Section apply to ships of unrestricted service as well as to ships of restricted areas of navigation **R1**, **R2**, **R2-RSN** and **R3-RSN** engaged on international voyages. The requirements for ships of restricted areas of navigation **R1**, **R2**, **R2-RSN** and **R3-RSN** not engaged on international voyages, as well as for ships of restricted area of navigation **R3** may be relaxed, the extent of relaxation will be specially considered by the Register in each case, unless expressly provided otherwise.

**7.1.2** The requirements of the present Section apply to ships to which a minimum freeboard is assigned. Departures from these requirements may be permitted for the ships to which a greater than minimum freeboard is assigned on condition that the Register is satisfied with safety conditions provided.

**7.1.3** The arrangement of openings and their closing appliances in the hull, superstructures and deckhouses shall also comply with the requirements of Part VI "Fire Protection" and Part XI "Electrical Equipment".

**7.1.4** As far as deck openings are concerned, the following two positions are distinguished in the present Section:

#### 7.1.4.1 Position 1:

.1 upon exposed parts of:

freeboard deck;

raised quarter deck;

superstructure deck and deckhouse top of the first tier situated forward of 0,25 of the ship's length  $L$  from the forward perpendicular;

.2 upon the same parts within the superstructures and deckhouses which are not enclosed.

#### 7.1.4.2 Position 2:

.1 upon exposed parts of superstructure decks and deckhouse tops of the first tier situated abaft 0,25

of the ship's length  $L$  from the forward perpendicular;

**.2** upon the same parts within the superstructures and deckhouses of the second tier which are not enclosed.

**7.1.5** The height of coamings specified in the present Section is measured from the upper surface of the steel deck plating or from the upper surface of the wood or other sheathing, if fitted.

**7.1.6** In supply vessels the access to the spaces situated below the open cargo deck shall preferably be provided from the location inside the enclosed superstructure or deckhouse or from the location above the superstructure deck or deckhouse top. The arrangement of companion or other hatches on the open cargo deck leading to the spaces below this deck is subject to special consideration by the Register in each case, taking account of the degree of protection of these hatches from possible damage during cargo handling operations as well as the volume of spaces flooded in case of damage to the hatch.

**7.1.7** The requirements of the present Section for floating docks apply to openings and their closing appliances arranged above the margin line at docking. Openings and their closing appliances arranged below the margin line at docking are subject to special consideration by the Register.

**7.1.8** In docklift ships, regardless of the provisions of 7.4 to 7.7, it is not permitted to arrange openings for doors, companion hatches, skylights, ventilating trunks and other hatches in sides and boundary bulkheads of holds if their lower edges are below the margin line at docking, with the exception of the openings to the watertight spaces of a restricted volume not communicating with other spaces below the level of the margin line at docking.

**7.1.9** Doors and hatchways in sides and boundary bulkheads of holds in docklift ships, if their sills are above the margin line at docking by less than 600 mm or 0,05 times the distance between the openings and the centre line whichever is the greater, shall be provided with the light signalling system comprising the indicators installed in the control post of the ship's docking operations. The light indicators shall clearly show the position of the door or hatch cover (secured or open).

**7.1.10** The light signals specified in 7.1.9 need not be provided for doors and hatchways to the watertight spaces of a restricted volume not communicating with other spaces below the level which is by 600 mm or 0,05 times the distance between the opening and the centre line, whichever is the greater, above the margin line at docking.

**7.1.11** In cargo ships covered by the requirements of Part V "Subdivision", the openings for access, piping, ventilation, electric cables, etc. in watertight inter-

nal bulkheads and decks shall be provided with watertight doors or hatch covers normally closed when at sea which, in their turn, shall be provided with indication means, positioned in their close proximity and on the bridge, to indicate whether such doors or hatch covers are open or closed. On each side of such a door or hatch cover there shall be an inscription to the effect the closure shall not be left open.

**7.1.12** In ships mentioned under 7.1.11, all external openings which do not, by their location, conform to the requirements of 3.4.4, Part V "Subdivision" shall be fitted with strong enough watertight closures for which, except cargo hatch covers, provision shall be made for bridge indication.

The watertight closures of shell openings located below the bulkhead deck shall be permanently closed at sea shall be fitted with devices preventing their uncontrolled opening. Plates shall be attached to such closures with inscriptions to the effect the openings shall be permanently closed at sea.

**7.1.13** In dry cargo ships not covered by the requirements of 7.1.11 and 7.1.12 all the doors of sliding or hinged type in watertight bulkheads should be fitted up with indication means positioned on the bridge to indicate whether such doors are open or closed. Similar indicators shall be provided for shell doors and other closing appliances which, if left open or not properly secured, can lead to solid flooding of the ship.

**7.1.14** The requirements of Section 7 do not apply to berth-connected ships. For these ships, the following provisions apply:

the coaming height of openings of companion hatches, skylights, ventilation trunks and ventilation heads should not be less than 100 mm;

weathertight hatch covers shall be provided;

the external doors of superstructures shall be watertight, but where the lower edge of an external door is not less than 600 mm away from the waterline corresponding to the maximum draught, such doors may be weathertight;

the lower edge of a side light shall not be less than 150 mm away from the waterline corresponding to the maximum draught;

on the freeboard deck, the superstructure and deckhouse windows shall be watertight.

## 7.2 SIDE SCUTTLES

### 7.2.1 Position of side scuttles.

**7.2.1.1** The number of side scuttles in the shell plating below the freeboard deck shall be reduced to a minimum compatible with the design and proper working of the ship.

Fishing vessels mooring alongside each other or other ships at sea shall not have side scuttles under freeboard deck in the mooring zone, wherever possible. If in this zone side scuttles are fitted in the shell plating, they shall be so positioned that the possibility of their damage during mooring operations is excluded.

No side scuttles are permitted within the boundaries of the ice belt of the shell plating specified in Part II "Hull" in icebreakers and ships with ice strengthening.

**7.2.1.2** No side scuttle shall be fitted in a position so that its sill is below a line drawn parallel to the freeboard deck at side and having its lowest point located 0,025 of the ship's breadth  $B$  or 500 mm, whichever is the greater, above the summer load waterline or above the summer timber load waterline where timber load lines are assigned to the ship.

In ships of restricted areas of navigation **R2**, **R2-RSN**, **R3-RSN** and **R3** not engaged on international voyages the specified distance 500 mm may be disregarded.

If the length of the ship is less than 24 m, the specified distance may be reduced to 300 mm for ships of restricted areas of navigation **R2**, **R2-RSN** and **R3-RSN** and to 150 mm for ships of restricted area of navigation **R3**.

**7.2.1.3** Side scuttles in the shell plating below the freeboard deck, in front bulkheads of enclosed superstructures and deckhouses of the first tier and also in front bulkheads of enclosed superstructures and deckhouses of the second tier within 0,25 $L$  from the forward perpendicular shall be of a heavy type and fitted with efficient deadlights hinged inside (refer to also 2.4.5, Part VI "Fire Protection").

In tugs of restricted areas of navigation **R2** and **R3** the side scuttles fitted below the bulkhead deck shall be not only of heavy but also of non-opening type.

In ships of restricted areas of navigation **R2**, **R2-RSN** and **R3-RSN** having the length below 24 m and in ships of restricted area of navigation **R3** it is allowed to fit side scuttles of normal type instead of those of heavy type.

**7.2.1.4** In ships to which the requirements of Part V "Subdivision" apply the side scuttles outside a floodable compartment or a specified group of compartments, fitted in a position so that their sills are by less than 0,3 m or  $(0,1 + \frac{L-10}{150})$  m, whichever is less, above the corresponding damage waterline and the side scuttles in the floating cranes the sills of which are by less than 0,3 m above the waterline corresponding to the actual maximum statical heel in case the hook is under load, shall be not only of heavy but also of non-opening type.

In ships of restricted areas of navigation **R2**, **R2-RSN** and **R3-RSN** having the length below 24 m

and in ships of restricted area of navigation **R3** it is allowed to fit side scuttles of normal non-opening type instead of those of heavy non-opening type.

**7.2.1.5** Side scuttles in enclosed superstructures and deckhouses of the first tier, except those in their front bulkheads, and also side scuttles in enclosed superstructures and deckhouses of the second tier within 0,25 of the ship's length  $L$  from the forward perpendicular, except those in their front bulkheads, may be of normal type.

In ships of restricted areas of navigation **R2**, **R2-RSN** and **R3-RSN** having the length below 24 m and in ships of restricted area of navigation **R3** it is allowed to fit side scuttles of light type instead of those of normal type. Side scuttles shall be fitted with efficient deadlights hinged inside.

**7.2.1.6** Side scuttles in enclosed superstructures and deckhouses of the second tier, except those fitted in a position within 0,25 of the ship's length from the forward perpendicular shall be as required in 7.2.1.5, provided these side scuttles give direct access to an open stairway leading to spaces situated below.

In cabins and similar spaces of enclosed superstructures and deckhouses of the second tier it is allowed that instead of side scuttles specified in 7.2.1.5, the side scuttles or windows could be fitted without deadlights.

**7.2.1.7** On no account shall the side scuttles be fitted in the outer wall sides of the floating docks and in the sides of the docklift ships so that their sills are below the margin line at docking.

In the inner wall sides of the floating docks and in the boundary bulkheads of the docklift ships installation of the side scuttles is not permitted.

**7.2.1.8** In the outer wall sides of the floating docks and in the sides of the docklift ships the side scuttles, the sills of which are above the margin line at docking by less than 300 mm or 0,025 times the ship's breadth, whichever is the greater, shall be of heavy type, fitted with hinged inside deadlights, and of non-opening type.

**7.2.1.9** In the outer wall sides of the floating docks the side scuttles, the sills of which are above the margin line at docking by 300 mm or more, shall be of normal type and fitted with hinged inside deadlights.

**7.2.1.10** Ships with distinguishing marks **FF1** and **FF2** in the class notation shall be fitted with side scuttles having deadlights permanently attached to their primary structure, wheelhouse windows shall be fitted with detachable screens, except side scuttles and windows in the wheelhouse, and search and rescue operation control station.

**7.2.2 Construction and attachment of side scuttles and windows.**

**7.2.2.1** The Rules distinguish three types of side scuttle construction:

**.1** heavy type with the glass thickness of not less than 10 mm for inner diameter of 200 mm and below, not less than 15 mm for inner diameter from 300 mm to 350 mm and not less than 19 mm for inner diameter of 400 mm. The inner diameter shall not exceed 400 mm. For intermediate inner diameters (from 200 mm to 300 mm and from 350 mm to 400 mm) the glass thickness shall be determined by linear interpolation. In addition, heavy side scuttles if they are of the opening type shall have a nut (instead of one of the ear-nuts securing their frame) being screwed off with the aid of a special wrench;

**.2** normal type with the glass thickness of not less than 8 mm for inner diameter of 250 mm and below, and not less than 12 mm for inner diameter of 350 mm and over, however, the inner diameter shall not exceed 400 mm. For intermediate inner diameters the thickness of the glass shall be determined by linear interpolation;

**.3** light type with the glass thickness of not less than 6 mm for inner diameter of 250 mm and below and not less than 10 mm for inner diameter of 400 mm and over, however, the inner diameter shall not exceed 450 mm. For intermediate inner diameters the thickness of the glass shall be determined by linear interpolation.

**7.2.2.2** Normal and heavy side scuttles may be of non-opening type, i.e. with the glass fixed in the main frame, or of opening type, i.e. with the glass fixed in the glazing bead efficiently hinged on the main frame. Exception shall be made for the cases specified in 7.2.1.3, 7.2.1.4 and 7.2.1.8 where the side scuttles shall be of non-opening type only.

The glasses of side scuttles shall be reliably and weathertight secured by means of a metal ring provided with screws or by other equivalent device and a gasket.

**7.2.2.3** The main frame, glazing bead and deadlight of side scuttles shall have sufficient strength. The glazing bead and deadlight shall be fitted with gaskets and shall be capable of being effectively closed and secured weathertight by means of ear-nuts or nuts being screwed off with the aid of a special wrench.

**7.2.2.4** The main frame, glazing bead, deadlight and ring for securing the glass shall be manufactured from steel, brass or other material approved by the Register.

The ear-nuts and nuts being screwed off by a special wrench shall be made of corrosion-resistant material.

Glass used for the side scuttles shall be hardened.

**7.2.2.5** In glass-reinforced plastic ships side scuttles shall be attached to the outside plating and to the bulkheads of superstructures and deckhouses in accordance with the requirements of 1.7.4, Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats".

**7.2.2.6** The construction of the windows shall comply with the requirements of 7.2.2.2 to 7.2.2.4, except for the requirements for the deadlights.

The thickness of the window glass  $t$ , in mm, shall be not less than determined by the formula

$$t = 0,32kb\sqrt{p} \quad (7.2.2.6-1)$$

where  $b$  = lesser clear size of the window, in m;  
 $p$  = pressure head, in kPa, calculated according to 2.12.3, Part II "Hull"; distance  $z_1$  being taken up to the middle of the window height;  
 $k$  = factor determined by the formula

$$k = 13,42 - 5,125(b/a)^2; \quad (7.2.2.6-2)$$

$a$  = greater clear size of the window, in m.

### 7.3 FLUSH DECK SCUTTLES

**7.3.1** Flush deck scuttles in positions 1 and 2 shall be provided with deadlights hinged or attached by other method (for example, by means of a chain) and capable of being easily and efficiently closed and secured.

**7.3.2** The largest of clear dimensions of the flush deck scuttles shall not be over 200 mm, with the glass being at least 15 mm thick. The flush deck scuttles shall be attached to the metal deck plating by means of frames.

**7.3.3** When secured, the deadlights of the flush deck scuttles shall be weathertight. The tightness shall be ensured by a rubber or other suitable gasket.

For the same purpose, along their contour the glasses of the flush deck scuttles shall be provided with a gasket made of rubber or other suitable material.

**7.3.4** The strength and materials of the flush deck scuttles parts are governed by applicable requirements specified in 7.2.2.3 and 7.2.2.4. As regards attachment of flush deck scuttles in glass-reinforced plastic ships, refer to requirements of 7.2.2.5.

### 7.4 OPENINGS IN SHELL PLATING AND THEIR CLOSING APPLIANCES

#### 7.4.1 General.

**7.4.1.1** This Chapter contains requirements for the arrangement of bow, side and stern doors in the shell plating, strength of structural elements of the doors, securing, locking and supporting devices.

**7.4.1.2** The number of doors shall be reduced to a minimum consistent with the structure and normal operational conditions of the ship.

**7.4.1.3** When closed and secured, doors in the shell plating shall be weathertight. Weathertightness shall be ensured with a rubber or other suitable packing.



**7.4.1.4** The plating thickness of the doors made of steel, irrespective of the fulfilment of the requirements given in 7.4.1.10, shall be not less than the thicknesses referred to in 2.2.4.8 and 2.12.4.1, Part II "Hull" for the appropriate position of the door; the minimum plating thickness of the doors made of other materials is subject to special consideration by the Register in each particular case.

**7.4.1.5** Doors with a clear area of 12 m<sup>2</sup> and more shall be secured by means of a power system or by a hand gear used for securing the door from a readily accessible position.

**7.4.1.6** When power-operated securing devices or devices with a hand gear are used, it is necessary to ensure that the doors shall remain tight in the secured position and shall remain secured in case of failure of any part of the power system or hand gear of the securing device.

Hydraulically operated securing devices shall be manually or mechanically lockable in the secured position.

**7.4.1.7** When power-operated securing devices or devices with a hand gear are used, provision shall be made for the indicators which clearly show whether the door is totally secured or not.

These indicators shall be fitted in a position from which the securing operation is performed, and in case of the power-operated securing device, also on the navigating bridge.

**7.4.1.8** If, due to the ship's purpose, it is specially provided to open and close the doors not only in ports but also at sea, arrangements approved by the Register shall be made (with regard to the operational conditions) to ensure closure and complete securing of the open door, even in case of failure of the door gear and securing device gear, or other arrangements approved by the Register shall be made to prevent penetration of water into the ship spaces when the door is open.

Provision shall be made for devices ensuring proper locking of the door in the open position.

The drives of such doors shall comply with the requirements of Part IX "Machinery" and Part XI "Electrical Equipment".

**7.4.1.9** There shall be a readily seen notice plate near each door, indicating that the door shall be closed and secured before the ship leaves the port; for doors referred to in 7.4.1.8 provision shall be also made for a notice plate indicating that at sea only the master is allowed to open the door.

**7.4.1.10** When doors are under the action of the design loads determined in accordance with 7.4.2 and 7.4.3, except 7.4.2.5, stresses, in MPa, in the primary members of the doors as well as of securing, locking and supporting devices shall not exceed the following values:

bending stress

$$\sigma = 120/k; \quad (7.4.1.10-1)$$

shear stress

$$\tau = 80/k; \quad (7.4.1.10-2)$$

equivalent stress

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 150/k \quad (7.4.1.10-3)$$

where  $k = 1,0$  for steel with upper yield stress of the material  $R_{eH} = 235$  MPa;

$k = 0,78$  for steel with  $R_{eH} = 315$  MPa;

$k = 0,72$  for steel with  $R_{eH} = 335$  MPa.

#### 7.4.2 Bow doors.

**7.4.2.1** Bow doors shall be situated above the freeboard deck.

**7.4.2.2** Where the bow door leads to a complete or long forward enclosed superstructure a weather-tight inner door shall be installed as part of the collision bulkhead above the freeboard deck of the ship.

Bow and inner doors shall be so arranged as to preclude the possibility of the bow door causing structural damage to the inner door or to the collision bulkhead in case of damage to or detachment of the bow door.

**7.4.2.3** The design external pressure  $P_e$ , in kPa, for the scantlings of primary members, securing, locking and supporting devices of the bow doors is determined by the following formula:

$$P_e = C_H(0,6 + 0,41 \tan \alpha)(0,4v \sin \beta + 0,6\sqrt{L})^2 \quad (7.4.2.3)$$

where  $C_H$  is a coefficient equal to:

$C_H = 0,0125L$  for ships less than 80 m in length;

$C_H = 1,0$  for ships 80 m and more in length;

$v$  = contractual ship's forward speed, in knots;

$\alpha$  and  $\beta$  = angles to be obtained from Fig. 7.4.2.3.

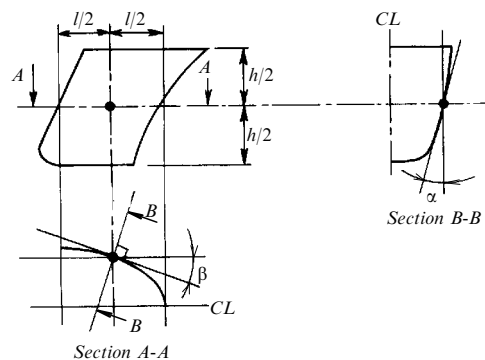


Fig. 7.4.2.3

The design external pressure may be reduced by 20 per cent for ships of restricted service **R2-RSN** and **R3-RSN** and by 40 per cent for ships of restricted service **R3**.

In any case, the design external pressure  $P_e$  shall not be taken less than the values determined ac-

cording to 1.3.2.2 or 2.8.3.3, Part II "Hull", whichever is the greater.

**7.4.2.4** The design internal pressure  $P_i$ , in kPa, for scantlings of primary members, securing, locking and supporting devices of inner doors shall be determined by the formula

$$P_i = 10z \quad (7.4.2.4)$$

where  $z$  = vertical distance from the centre of gravity of the door area to the deck above, in m.

In all cases, the value of the design internal pressure  $P_i$  shall not be less than 25 kPa.

**7.4.2.5** The scantlings of primary members of visor doors shall be chosen in accordance with the requirements of 2.8.5.1, Part II "Hull".

**7.4.2.6** Securing and locking devices of bow doors shall be designed to withstand the forces  $F_e$  or  $F_i$ , in kN, to be determined by the following formulae:

for the doors opening inwards

$$F_e = AP_e + p_p l_p; \quad (7.4.2.6-1)$$

for the doors opening outwards

$$F_i = AP_i + 10Q + p_p l_p \quad (7.4.2.6-2)$$

where  $A$  = clear area of the door, in m<sup>2</sup>;

for  $P_e$ , refer to 7.4.2.3;

for  $P_i$ , refer to 7.4.2.4;

$p_p$  = pressure of the packing when it is compressed for the maximum depth possible, in kN/m, is assumed in calculations equal to at least 5 kN/m;

$l_p$  = length of the packing, in m;

$Q$  = mass of the door, in t.

**7.4.2.7** Securing and locking devices, as well as supports of the visor doors shall be designed to withstand forces  $F_{xf}$ ,  $F_{xa}$ ,  $F_y$  and  $F_z$ , in kN.

The forces acting in the longitudinal direction shall be determined by the following formulae:

bow

$$F_{xf} = \frac{10Qc + P_{xe}a - P_z b}{d}; \quad (7.4.2.7-1)$$

stern

$$F_{xa} = \frac{10Qc - P_{xi}a}{d}. \quad (7.4.2.7-2)$$

The force acting in the transverse direction shall be determined by the formula

$$F_y = P_e A_y. \quad (7.4.2.7-3)$$

The force acting in the vertical direction shall be determined by the formula

$$F_z = P_z - 10Q \quad (7.4.2.7-4)$$

or

$$F_z = 10(V - Q) \quad (7.4.2.7-5)$$

where for  $Q$ , refer to 7.4.2.6;  
for  $P_e$ , refer to 7.4.2.3;

$$P_{xe} = P_e A_x, \text{ in kN} \quad (7.4.2.7-6)$$

$A_x$  = area of the transverse vertical projection of the door (refer to Fig. 7.4.2.7), in m<sup>2</sup>;

$$P_z = P_e A_z, \text{ in kN}; \quad (7.4.2.7-7)$$

$A_z$  = area of horizontal projection of the door (refer to Fig. 7.4.2.7), in m<sup>2</sup>;

$$P_{xi} = P_i A_x, \text{ in kN}; \quad (7.4.2.7-8)$$

for  $P_i$ , refer to 7.4.2.4;

$A_y$  = area of the longitudinal vertical projection of the door (refer to Fig. 7.4.2.7), in m<sup>2</sup>;

$a$  = vertical distance, in m, from visor pivot to the centroid of the transverse vertical projected area of the visor door (refer to Fig. 7.4.2.7);

$b$  = vertical distance, in m, from visor pivot to the centroid of the horizontal projected area of the visor door (refer to Fig. 7.4.2.7);

$c$  = horizontal distance, in m, from visor pivot to the centre of gravity of the visor mass (refer to Fig. 7.4.2.7);

$d$  = vertical distance, in m, from visor pivot to the bottom of the door (refer to Fig. 7.4.2.7);

$V$  = inner volume of the door, in m<sup>3</sup>,

whichever is the greater.

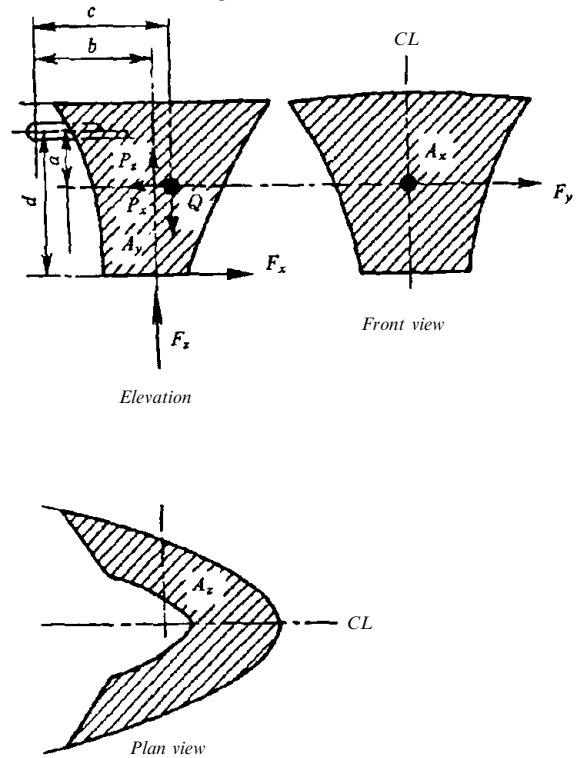


Fig. 7.4.2.7

**7.4.2.8** For side-opening doors, thrust bearing shall be provided in way of girder ends at the closing of two leaves to prevent one leaf shifting towards the other one under effect of unsymmetrical pressure (refer to Fig. 7.4.2.8). Each part of the thrust bearing shall be kept secured on the other part by means of securing devices.

**7.4.2.9** Lifting arms of the visor doors and thrust bearing shall be designed to withstand static and dynamic loads arising when the door is opened and closed with due regard to the minimum wind pressure 1,5 kN/m<sup>2</sup>.

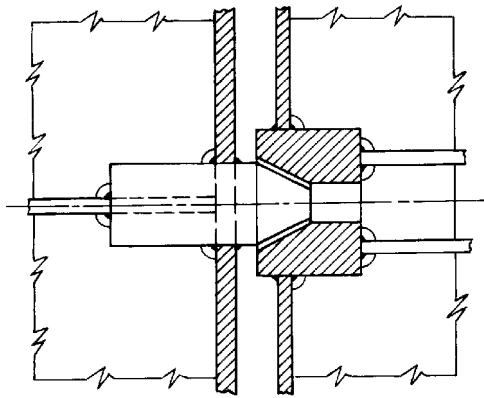


Fig. 7.4.2.8 Thrust bearing

### 7.4.3 Side and stern doors.

**7.4.3.1** The lower edge of the door openings shall not be lower than the line which is parallel to the freeboard deck and has its lowest point at the uppermost cargo waterline.

The deviation from this requirement may be allowed in exceptional cases for side doors of the ships which are not passenger ships, provided it is proved to the Register that safety will not be thus impaired.

In such cases, provision shall be made for: the second (inner) doors, strength and tightness of which is equivalent to those of the outer doors; a device enabling to determine water presence in the space between the doors; water drainage from this space to bilges or drain wells, controlled by a readily accessible valve or other arrangements approved by the Register.

**7.4.3.2** The doors shall open outwards so that forces acting under the effect of the sea press the door against the supporting contour of the sill. Installation of the doors opening inside is subject to special consideration by the Register in each particular case.

**7.4.3.3** The number of securing devices on each edge of the door shall be not less than two; a securing device shall be provided in the vicinity of each door corner. The distance between securing devices shall not exceed 2,5 m.

**7.4.3.4** The design external pressure  $P$ , in kPa, for structural members of doors shall be determined in accordance with the requirements of 1.3.2, Part II "Hull". In any case, the value of  $P$  shall not be taken less than 25 kPa.

**7.4.3.5** Securing and locking devices shall be designed to withstand the forces  $F_1$  or  $F_2$ , in kN, determined by the formulae:

for doors opening inwards

$$F_1 = AP + p_p l_p; \quad (7.4.3.5-1)$$

for doors opening outwards

$$F_2 = F_c + 10Q + p_p l_p \quad (7.4.3.5-2)$$

where for  $A$ ,  $p_p$  and  $l_p$ , refer to 7.4.2.6;

for  $P$ , refer to 7.4.3.4

$F_c$  = an accidental force due to loose cargo, to be uniformly distributed over the area  $A$  and to be taken not less than 300 kN or  $5A$ , in kN, whichever is the greater.

For small doors, such as bunker doors or pilot doors, the value of  $F_c$  may be reduced upon special consideration by the Register. In case the second (inner) door is installed, which is capable to protect the external door from accidental forces due to loose cargoes,  $F_c = 0$ .

for  $Q$ , refer to 7.4.2.6.

Supporting structures of doors shall be designed to withstand forces  $F_3$  and  $F_4$ , in kN, determined by the formulae:

for doors opening inwards

$$F_3 = AP; \quad (7.4.3.5-3)$$

for doors opening outwards

$$F_4 = F_c + 10Q. \quad (7.4.3.5-4)$$

## 7.5 SUPERSTRUCTURES AND DECKHOUSES

### 7.5.1 Construction, openings and closing appliances.

**7.5.1.1** Openings in the freeboard deck other than those defined in 7.3, 7.6 to 7.11 and 7.13 shall be protected by the enclosed superstructure or enclosed deckhouse. The similar openings in the deck of enclosed superstructure or enclosed deckhouse shall be protected by enclosed deckhouse of the second tier.

**7.5.1.2** Superstructures and deckhouses are considered enclosed if:

their construction complies with the requirements of 2.12, Part II "Hull";

all access openings comply with the requirements of 7.5.2 and 7.7;

all other openings in their outside contour comply with requirements of 7.2 to 7.4 and 7.7 to 7.10.

### 7.5.2 Doors in enclosed superstructures and enclosed deckhouses.

**7.5.2.1** All access openings in the end bulkheads of enclosed superstructures and outside bulkheads of enclosed deckhouses shall be fitted with doors (refer to 2.4.4, Part VI "Fire Protection").

**7.5.2.2** The height of the sills to access openings specified in 7.5.2.1 shall be at least 380 mm. However, the bridge or poop shall not be regarded as enclosed unless access is provided for the crew to machinery and other working spaces inside these superstructures from any place in the uppermost continuous open deck or above it by alternative means which are available at all times when bulkhead openings are closed; the height of the sills of the openings in the bulkheads of such bridge or poop shall be at least 600 mm in position 1 and at least 380 mm in position 2.

In ships of restricted area of navigation **R3** having the length of 24 m and over (except for passenger ships) the specified height of the sills to access openings may be reduced from 600 mm down to 450 mm and from 380 mm down to 230 mm, respectively.

In ships of restricted areas of navigation **R2**, **R2-RSN**, **R3-RSN** and **R3** having the length below 24 m the height of the above sills may be reduced to 230 mm for all open decks.

**7.5.2.3** The doors shall be so designed as to withstand the pressure head  $p$  calculated according to 2.12.3, Part II "Hull", the distance  $z_1$  being taken up to the middle of the door height. Under the pressure head  $p$  the stresses in the door elements shall not exceed 0,8 times the upper yield stress of the material.

Whatever the stresses, the thickness of the steel door plate shall be not less than that specified in 2.12.4.4, Part II "Hull". For steel doors manufactured by stamping the minimum thickness of the door plate may be reduced by 1 mm.

The minimum thickness of the door plate made of other materials is subject to special consideration by the Register.

**7.5.2.4** The doors shall be permanently and strongly attached to the bulkhead and fitted with clamping devices or other equivalent means for expeditiously opening, closing and securing them weathertight; such devices shall be so arranged that they can be operated from both sides of the bulkhead. The doors shall open outside, opening of doors inside the superstructure or deckhouse space shall be specially considered by the Register in each case.

**7.5.2.5** The doors shall be weathertight when secured. The tightness shall be ensured by a rubber or other suitable gasket.

**7.5.2.6** The doors shall be made of steel or other material approved by the Register.

**7.5.2.7** In glass-reinforced plastic ships the doors shall be attached to the bulkheads of superstructures and deckhouses in the same manner as the side scuttles, in accordance with the requirements of 7.2.2.5.

**7.5.2.8** In floating docks the height of the sills to access openings in superstructures and deckhouses of the top deck shall be at least 200 mm if access is provided from these superstructures and deckhouses into the spaces situated below.

## 7.6 ENGINE AND BOILER CASINGS

**7.6.1** Engine and boiler space openings in positions 1 and 2 shall be efficiently enclosed by casings of ample strength raised above decks to the extent, which is reasonable and practicable, and being in their turn decked or terminated in skylights. The

construction of the casings shall meet the requirements of 2.13, Part II "Hull", and in case of glass-reinforced plastic ships, with the requirements of Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats".

**7.6.2** Casings shall be made weathertight.

**7.6.3** Casings shall be made of steel or other materials approved by the Register (refer also to 2.1.1.2, Part VI "Fire Protection").

**7.6.4** The access openings in the casings shall be fitted with permanently attached doors complying with the requirements of 7.5.2.3 to 7.5.2.6. The height of the sills to the access openings shall be at least 600 mm in position 1 and at least 380 mm in position 2.

If the length of the ship is less than 24 m, the specified height of the sills may be reduced down to 300 mm for ships of restricted areas of navigation **R2**, **R2-RSN**, **R3-RSN** and **R3**.

In ships of restricted area of navigation **R3** having the length of 24 m and over (except passenger ships) the specified height of the sills may be reduced from 600 mm down to 450 mm and from 380 mm down to 230 mm, respectively.

**7.6.5** In type "A" ships and also in type "B" ships which are permitted to have the tabular freeboard less than that prescribed by Table 4.1.3.2, 6.4.2.3 or 6.4.3.3 of the Load Line Rules for Sea-Going Ships, the engine and boiler casings shall be protected by enclosed poop or bridge of at least standard height, or by a deckhouse of equal height and equivalent strength. However, engine and boiler casings may be exposed if there are no openings giving direct access from the freeboard deck to the machinery space. A door complying with requirements of 7.5.2.3 to 7.5.2.6 may, however, be permitted in the machinery casing provided that it leads to a space or passageway which is as strongly constructed as the casing and is separated from the stairway to the engine and boiler room by a second similar door. The opening for the outside door shall be provided with a sill at least 600 mm in height, and that for the inside door with a sill of at least 230 mm in height.

**7.6.6** In supply vessels the doors in the casings giving access to the engine or boiler rooms shall be located, where possible, inside the enclosed superstructure or deckhouse. The door in the casing for access to the engine or boiler room may be fitted directly on the open cargo deck provided that, in addition to the first outside door, the second inside door is fitted; in this case, the outside and inside doors shall satisfy the requirements of 7.5.2.3 to 7.5.2.6, the height of the outside door sill shall be at least 600 mm, and of the inside door sill, at least 230 mm.

**7.6.7** In floating docks the height of sills to the top deck access openings in the engine and boiler casings shall be at least 200 mm.

### 7.7 COMPANION HATCHES, SKYLIGHTS AND VENTILATING TRUNKS

#### 7.7.1 Design and securing.

**7.7.1.1** Deck openings in positions 1 and 2 intended for stairways to the ship's spaces located below, as well as light and air openings to these spaces shall be protected by strong companion hatches, skylights or ventilating trunks.

Where the openings intended for stairways to the ship's spaces located below are protected by superstructures or deckhouses instead of companion hatches, these superstructures and deckhouses shall comply with the requirements of 7.5.

**7.7.1.2** Height of coamings of companion hatches, skylights and ventilating trunks shall be at least 600 mm in position 1 and at least 450 mm in position 2. In ships of restricted area of navigation **R3** having the length of 24 m and over (except passenger ships) the specified height of coamings may be reduced from 600 mm down to 450 mm and from 450 mm down to 380 mm, respectively. If the length of the ship is less than 24 m, the height of the coamings may be reduced down to 380 mm for ships of restricted areas of navigation **R2**, **R2-RSN** and **R3-RSN** and down to 300 mm for ships of restricted area of navigation **R3**.

Construction of coamings shall comply with the requirements of 2.6.5.2, Part II "Hull" and in case of glass-reinforced plastic ships, with the requirements of Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats".

**7.7.1.3** All the companion hatches, skylights and ventilating trunks shall be provided with covers made of steel or other material approved by the Register and being permanently attached to the coamings.

Where the covers are made of steel, the thickness of their plate shall be equal to at least 0,01 times the spacing of stiffeners, but not less than 6 mm.

The minimum required thickness of 6 mm may be reduced if the cover is made by stamping in accordance with Fig. 7.7.1.3 and Table 7.7.1.3.

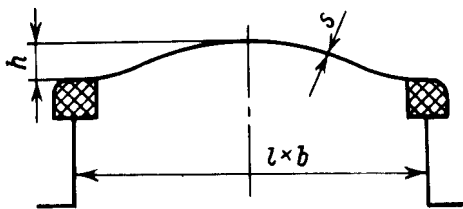


Fig 7.7.1.3

In small ships having the deck thickness less than 6 mm the required minimum thickness 6 mm may be reduced down to the deck thickness regardless of whether the cover is made by stamping, but in no case the plate thickness shall be less than 4 mm.

Table 7.7.1.3

Clear sizes of hatches $l \times b$ , in mm	Material of cover	Height of stamping $h$ , in mm	Minimum thickness $s$ , in mm
450 × 600	Steel	25	4
	Light alloy		
600 × 600	Steel	28	4
	Light alloy		
700 × 700	Steel	40	4
	Light alloy		6
800 × 800	Steel	55	4
	Light alloy		6
800 × 1200	Steel	55	5
	Light alloy		6
1000 × 1400	Steel	90	5

**7.7.1.4** Covers of companion hatches, skylights and ventilating trunks shall have securing devices workable at least from outside of the hatch. However, where the hatches are used as emergency exits in addition to their primary application, the securing device shall be capable of being operated from each side of the cover.

When secured, the covers shall be weathertight. The tightness shall be provided by a rubber or other suitable gasket.

**7.7.1.5** The glass for windows in the covers of skylights shall be hardened and at least 6 mm thick if the inner diameter is 150 mm and below, and at least 12 mm with the inner diameter of 450 mm. For intermediate inner diameters, the thickness of glass shall be determined by linear interpolation. However, where wire-reinforced glass is used, its thickness may be 5 mm, and the requirement relating to its hardening will not be applicable.

Glass shall be efficiently attached to the covers by means of a frame and have on its contour a weathertight gasket of rubber or other equivalent material.

Skylights installed in the machinery spaces of category A, shall comply with the requirements of 2.1.4.2, Part VI "Fire Protection".

**7.7.1.6** Each window or group of adjacent windows shall be provided with portable shields of the same material as the cover being at least 3 mm in thickness and capable of being efficiently fastened outside the cover by means of ear-nuts; such portable shields shall be stowed adjacent to the skylights.

**7.7.1.7** In floating docks the height of coamings of companion hatches, skylights and ventilating trunks situated on the top deck shall be at least 200 mm.

The portable shields mentioned in 7.7.1.6 need not be provided for covers of skylights situated on the top deck of the floating docks.

### 7.7.2 Design and securing of small hatches on the exposed for deck.

**7.7.2.1** The requirements of 7.7.2 apply to hatches generally having an area of not more than 2,5 m<sup>2</sup> located on the exposed deck at a distance of 0,25L from the fore perpendicular of ships of 80 m in length and more, where the height of the exposed deck in way of the hatch is less than 0,1L or 22 m above the summer load waterline, whichever is less.

**7.7.2.2** For rectangular or square steel hatch covers, the plate thickness, stiffener arrangement and scantlings shall be in accordance with Table 7.7.2.2 and Fig. 7.7.2.2. Stiffeners, where fitted, shall be aligned with contact pad points of the hatch cover edge with the welded pad (metal-to-metal contact points)

required in accordance with 7.7.2.6 (refer to Fig. 7.7.2.2). Primary stiffeners shall be continuous. All stiffeners shall be welded to the inner edge stiffener (refer to Fig. 7.7.2.8).

Table 7.7.2.2

Nominal size, mm × mm	Cover plate thickness, mm	Primary stiffeners	Secondary stiffeners
		Flat bar, mm × mm; number	
630 × 630	8	—	—
630 × 830	8	100 × 8; 1	—
830 × 630	8	100 × 8; 1	—
830 × 830	8	100 × 10; 1	—
1030 × 1030	8	120 × 12; 1	80 × 8; 2
1330 × 1330	8	150 × 12; 2	100 × 10; 2

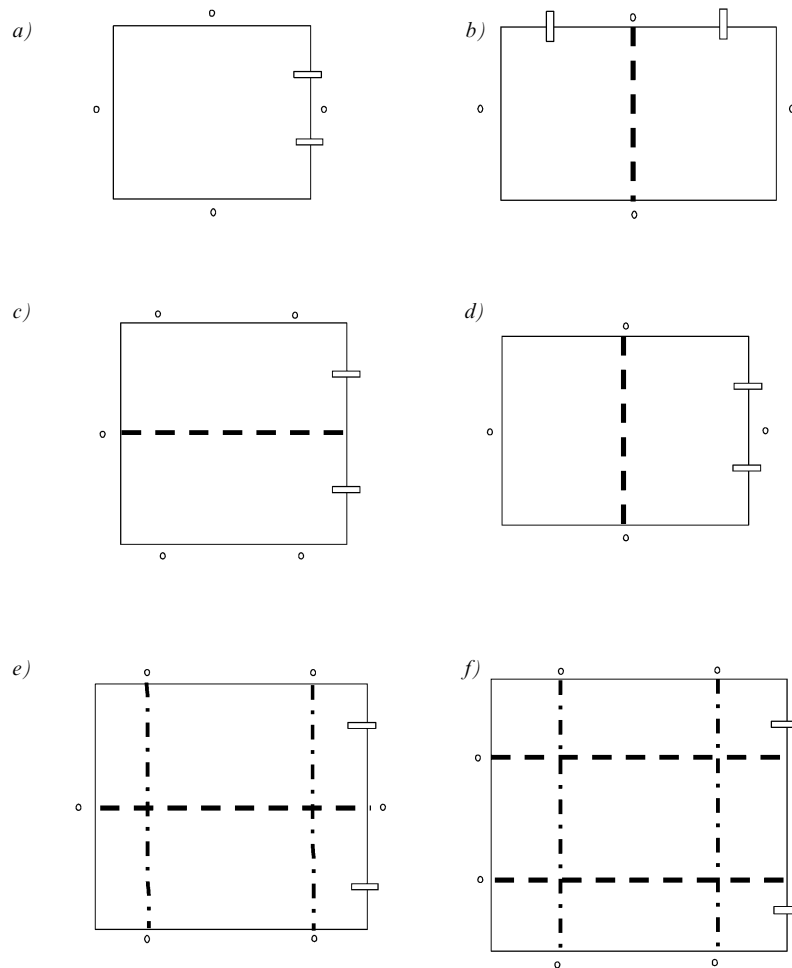


Fig. 7.7.2.2

Nominal sizes of hatch covers

$a = 630 \times 630$  mm;  $b = 630 \times 830$  mm;  $c = 830 \times 830$  mm;  $d = 830 \times 630$  mm;  $e = 1030 \times 1030$  mm;  $f = 1330 \times 1330$  mm

Symbols:

- hinge;
- securing device/metal-to-metal contact;
- primary stiffener;
- secondary stiffener

**7.7.2.3** The hatchway coaming shall be suitably reinforced by a horizontal flat bar, normally not more than 170 to 190 mm from the upper edge of the coaming.

**7.7.2.4** For hatch covers constructed of materials other than steel, the required scantlings shall provide equivalent strength.

**7.7.2.5** Weathertightness of hatch covers shall be ensured by securing devices of the following types: butterfly nuts tightening onto forks (clamps); quick acting cleats; central locking device. Dogs (twist tightening handles) with wedges are not acceptable.

Where the hatch covers are also used as emergency exits, they shall be also fitted with the central quick acting locking device designed for handling on both sides.

**7.7.2.6** The hatch cover shall be fitted with a gasket of elastic material. This shall be designed to allow a contact of the hatch cover edge to the welded pad (metal-to-metal contact) at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The contacts of the hatch cover edge to the welded pad (metal-to-metal contact) shall be arranged close to each securing device in accordance with Fig. 7.7.2.2, and shall be of sufficient capacity to withstand the bearing force.

**7.7.2.7** The primary securing device shall be designed and manufactured so that the designed compression pressure is achieved by one person without the need of any tools.

**7.7.2.8** Where butterfly nuts are used in the primary securing device, the forks (clamps) shall be of the robust design, which minimizes the risk of the butterfly nuts being dislodged while in use. It is ensured by curving the forks upward, a raised surface on the free end, or a similar method (refer to Fig. 7.7.2.8). The plate thickness of unstiffened steel forks (clamps) shall not be less than 16 mm.

**7.7.2.9** For hatch covers located on the exposed deck forward of the fore-most cargo hatch, the hinges shall be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

**7.7.2.10** On hatches located between the cargo hatches, the hinges shall be placed on the fore edge or outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

**7.7.2.11** Hatches, excepting those which may also be used as emergency exits, shall be fitted with an independent secondary securing device like, e.g. a sliding bolt, a hasp or a backing bar of slack fit,

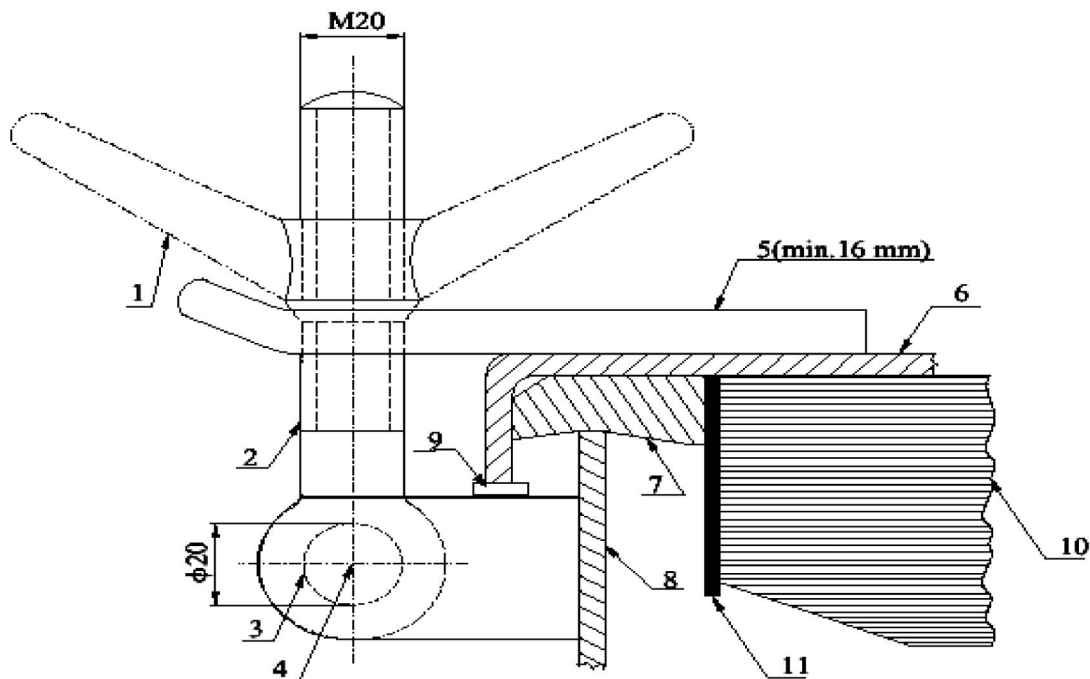


Fig. 7.7.2.8:

1 – butterfly nut; 2 – bolt; 3 – pin; 4 – centre of pin; 5 – fork (damp) plate; 6 – hatch cover; 7 – gasket; 8 – hatch coaming; 9 – bearing pad welded on the bracket for metal-to-metal contact; 10 – stiffener; 11 – inner edge stiffener

which is capable of keeping the hatch cover in place, even in the event that the primary securing device became loosened or dislodged. It shall be fitted on the side opposite to the hatch cover hinges.

#### 7.8 VENTILATORS

**7.8.1** Ventilators to spaces below freeboard deck or deck of enclosed superstructures and deckhouses shall be fitted with coamings efficiently connected to the deck.

The coamings of ventilators shall be at least 900 mm in height in position 1 and at least 760 mm in position 2.

In ships of restricted area of navigation **R3** having the length of 24 m and over (except passenger ships) the specified height of the coamings may be reduced from 900 mm down to 760 mm and from 760 mm down to 600 mm, respectively.

In ships of restricted areas of navigation **R2**, **R2-RSN**, **R3-RSN** and **R3** having the length below 24 m the height of the coamings may be reduced down to 300 mm for all open decks.

Construction of coamings shall comply with the requirements of 2.6.5.2, Part II "Hull" and in case of glass-reinforced plastic ships, with the requirements of Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats".

The strength of ventilators, connections of ventilators to coamings and connections of ventilator parts, if any, shall be equivalent to that of the coaming.

**7.8.2** Ventilators in position 1 the coamings of which extend to more than 4500 mm above the deck and in position 2 the coamings of which extend to more than 2300 mm above the deck need not be fitted with closing appliances. In all other cases, each ventilator shall be fitted with a strong cover made of steel or other material approved by the Register.

In ships of less than 200 m in length, the covers shall be permanently attached; in ships of 100 m in length and over they may be conveniently stowed near the ventilators to which they shall be fitted.

**7.8.3** When secured, the covers of ventilators shall be weathertight. The tightness shall be provided by a rubber or other suitable gasket.

**7.8.4** In supply vessels, in order to minimize the possibility of flooding of the spaces situated below, the ventilators shall be positioned in the protected locations where the probability of their damage by cargo is excluded during cargo handling operations. Particular attention shall be given to the arrangement of ventilators of the engine and boiler rooms for which the location is preferable above the deck level of the first tier of superstructures or deckhouses.

**7.8.5** In floating docks the height of coamings of ventilators situated on the top deck shall be at least 200 mm.

#### 7.9 MANHOLES

**7.9.1** The height of coamings of manholes for deep and other tanks, except for those indicated in 2.4.5.3, Part II "Hull", air spaces, cofferdams, etc. is not regulated by the Register.

**7.9.2** Covers of manholes shall be made of steel or other material approved by the Register.

The thickness of the covers shall not be less than that of the plating on which they are fitted. In sound cases, the Register may permit to decrease the thickness of the covers where the thickness of plating is greater than 12 mm.

**7.9.3** The covers of manholes shall be efficiently attached to the coaming or doubling ring by means of bolts or pins with nuts.

**7.9.4** When secured, the covers shall be tight both for water and liquid cargoes or stores for which the tanks are intended under the inner pressure corresponding to the test pressure of the tank under consideration.

The tightness shall be provided by a rubber or other suitable gasket. The gasket shall be resistant to the liquids referred to above.

#### 7.10 HATCHWAYS OF DRY CARGO HOLDS

##### 7.10.1 General.

The deck openings through which cargoes or ship's stores are loaded and unloaded shall be protected by strong hatchways. If these hatchways are situated in positions 1 and 2, the hatchway covers shall be weathertight. The tightness shall be provided by one of the following two methods:

**.1** by portable covers and tarpaulins as well as battening devices;

**.2** by weathertight covers made of steel or other equivalent material fitted with rubber or other suitable gaskets and clamping devices.

##### 7.10.2 Coamings.

**7.10.2.1** The height of hatchway coamings in positions 1 and 2 shall be at least 600 mm and 450 mm, respectively.

If the length of the ship is less than 24 m, the height of the coamings may be reduced down to 380 mm for ships of restricted area of navigation **R2**, **R2-RSN** and **R3-RSN** and down to 300 mm for ships of restricted area of navigation **R3**. In fishing vessels



the height of cargo hatchway coamings in position 2 may be reduced down to 300 mm.

In ships of restricted area of navigation **R3** having the length of 24 m and over (except passenger ships) the specified height of cargo hatchway coamings may be reduced from 600 mm down to 450 mm and from 450 mm down to 380 mm, respectively.

Construction of coamings in positions 1 and 2 shall comply with the requirements of 2.6, Part II "Hull" and in case of glass-reinforced plastic ships, with the requirements of Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats".

**7.10.2.2** The height of coamings of the hatchways specified in 7.10.1.2 may be decreased in relation to that prescribed by 7.10.2.1 or the coamings may be omitted entirely where the efficiency of the cover tightness and securing means will satisfy the Register.

#### **7.10.3 Materials.**

**7.10.3.1** For steel of hatchway covers, refer to 1.6.

**7.10.3.2** The wood of hatchway covers shall be of good quality and of the type and grade which proved to be satisfactory for this purpose. Wedges shall be of hard wood.

**7.10.3.3** Canvas used for making tarpaulins shall be impregnated to make them moisture-resistant and shall not contain jute thread. Mass of 1 m<sup>2</sup> of canvas before impregnation shall be not less than 0,55 kg. Breaking stress of impregnated canvas band 200 × 50 mm in size shall be at least 3 kN and 2 kN in longitudinal and transverse directions, respectively. When tested for watertightness, the impregnated canvas shall not get wet under water head of 0,15 m acting for 24 hours.

Use of tarpaulins made of synthetic fibre will be specially considered by the Register in each case.

**7.10.3.4** The rubber for packing gaskets of hatchway covers shall be elastic, strong, and resistant to atmospheric changes. The rubber shall be of sufficient hardness.

**7.10.3.5** Adhesives for fastening the rubber in the grooves of hatchway covers shall meet the requirements of 6.5, Part XIII "Materials".

**7.10.3.6** All internal and external surfaces of steel hatch covers in bulk carriers (except inaccessible spaces in box type covers) shall have effective epoxy or other equivalent protective coating applied in accordance with the recommendations of the manufacturer (refer to 1.1.4.7, Part II "Hull").

#### **7.10.4 Design loads.**

**7.10.4.1** Hatchway covers shall be designed to sustain deck cargoes which are intended to be carried on these covers. Where operation of the cargo handling cars on hatchways covers is anticipated in the course of the ship's service, during cargo handling operations, the loads induced by such cars shall be

taken into consideration. For hatchway covers in positions 1 and 2 the design load shall be calculated in accordance with 3.2.5.2 of Load Line Rules for Sea-Going Ships; design of hatch covers shall comply with the requirements of 3.2.5.3 to 3.2.5.5 of the above Rules.

For ships of less than 24 m in length of restricted area of navigation engaged on international voyages and for all ships of restricted area of navigation not engaged on international voyages the load intensity reduced by the following values may be used instead of load intensity specified in 3.2.5.2 of Load Line Rules for Sea-Going Ships:

15 per cent for ships of restricted areas of navigation **R2**, **R2-RSN** and **R3**;

30 per cent for ships of restricted area of navigation **R3** may be taken in calculations instead of the values given in Table 7.10.4.1.

In any case, the design load for open-deck hatch covers shall not be adopted less than  $0,5p_w$  determined in accordance with 1.3.2.2, Part II "Hull".

**7.10.4.2** When deck cargo other than containers and wheeled vehicles is carried, the design load on cargo hatch covers shall not be less than stipulated by 1.3.4.1, Part II "Hull".

**7.10.4.3** When containers of international standard types are carried on hatch covers, the design load  $P_z$ , in kN, concentrated at the points where the corner fittings of the containers are installed is determined, for the purpose of calculating the deck cargo effect as stipulated by 7.10.4.1 and 7.10.4.2, by the following formula:

$$P_z = mg(1 + a_z) \quad (7.10.4.3)$$

where  $m$  = maximum mass of container stack, in t;  
 $g$  = gravity acceleration equal to 9,81 m/s<sup>2</sup>;  
 $a_z$  = dimensionless acceleration factor in accordance with 1.7.2.

Besides, the vertical components of the initial pull of the lashings (if fitted) securing containers shall be included in the calculation as an additional load.

**7.10.4.4** Where cargo-handling cars and wheeled vehicles shall be used on hatch covers during cargo-handling operations, the loads upon hatch covers are determined in accordance with 3.2.3, Part II "Hull".

**7.10.4.5** The hatch covers of lower decks not intended for the carriage of cargo shall be designed to bear:

evenly distributed load of 2 kPa intensity;  
 force of 3 kN applied to any point upon the hatch cover.

**7.10.4.6** In strength and rigidity calculations of hatch covers, their own weight is ignored.

#### **7.10.5 Strength and rigidity criteria.**

**7.10.5.1** Where hatch covers in positions 1 and 2 come under design loads, the stresses in the structural

components shall not exceed the values of Table 7.10.5.1.

Table 7.10.5.1

Type of hatch covers	Design load according to	$\sigma$	$\tau$	$\sigma_{com}$
Portable beams and pontoon hatch covers	7.10.4.2 7.10.4.3 7.10.4.4	$0,5R_{eH}$	$0,35R_{eH}$	
Hatch covers of other designs	7.10.4.2 7.10.4.3	$0,65R_{eH}$	$0,4R_{eH}$	$0,7R_{eH}$
	7.10.4.4	$0,65R_{eH}$	$0,45R_{eH}$	$0,75R_{eH}$

Where  $\sigma$  — normal stresses;  
 $\tau$  — tangential stresses;  
 $\sigma_{com}$  — combined stresses, refer to 1.5.1;  
 $R_{eH}$  — upper yield strength of hatch cover material.

**7.10.5.2** Where the hatch covers of lower decks come under design loads, the stresses in the structural components shall not exceed the values of Table 7.10.5.2.

Table 7.10.5.2

Type of hatch covers	Design load according to	$\sigma$	$\tau$	$\sigma_{com}$
Portable beams	7.10.4.2	$0,5R_{eH}$	$0,35R_{eH}$	—
Pontoon hatch covers and other hatch cover designs	7.10.4.3 7.10.4.4 7.10.4.5	$0,65R_{eH}$	$0,45R_{eH}$	$0,75R_{eH}$

for  $\sigma$ ,  $\tau$ ,  $\sigma_{com}$  and  $R_{eH}$ , refer to 7.10.5.1.

### 7.10.6 Stability of structural components of hatch covers.

The stability of structural components of hatch covers is considered to be guaranteed provided the following conditions are met:

$$\sigma \leq 0,87\sigma_{cr}; \quad (7.10.6-1)$$

$$\tau \leq 0,87\tau_{cr} \quad (7.10.6-2)$$

where  $\sigma$ ,  $\tau$  = normal and tangential stresses in action, in MPa;  
 $\sigma_{cr}$ ,  $\tau_{cr}$  = critical normal and tangential stresses, in MPa, determined in accordance with 1.6.5.3, Part II "Hull".

### 7.10.7 Construction of hatchway covers specified in 7.10.1.1.

The construction of these hatchway covers shall comply with the requirements of 3.2.4 of the Load Line Rules of Sea-Going Ships.

### 7.10.8 Construction of hatchway covers specified in 7.10.1.2.

**7.10.8.1** These covers shall be so constructed as to prevent their accidental opening under the effect of sea and weather.

When secured, the covers shall be pressed against the bearing surface of the coaming without further deformation of the packing gasket.

**7.10.8.2** The scantlings of components of hatch covers made of steel are determined in conformity with the requirements of 7.10.4 to 7.10.6.

For primary members and webs, the effective flange width is determined in accordance with 1.6.3.3 and 1.6.3.4, Part II "Hull", the effective flange thickness is determined in accordance with 1.6.3.2 of the same Part. The application of light alloys is in each case subject to special consideration by the Register.

**7.10.8.3** Irrespective of the provisions of 7.10.8.2 being complied with, the top plating thickness  $t$ , in mm, of steel hatch covers shall not be less than determined by the formula

$$t = 10a \quad (7.10.8.3)$$

where  $a$  = distance between the stiffeners, in m.

In any case, the top plating thickness shall not be less than 6 mm.

**7.10.8.4** Where cargo-handling cars shall be used on hatch covers, the top plating thickness shall not be less than stipulated by 3.2.4.1, Part II "Hull".

**7.10.8.5** The hatchway covers on which containers are carried shall be provided, in way of corner fittings of containers, with structural elements ensuring immediate load transfer from the containers to the cover framing.

If the above-mentioned structural elements are not coincident with the cover stiffeners in way of fitting the former, the additional stiffeners shall be provided having section modulus equal to 0,8 times that of main stiffeners of the cover. In this case, structural bonding of main and additional stiffeners shall be ensured.

**7.10.8.6** Where dry cargo holds are adapted for transportation of dangerous goods (refer to 7.1.2, Part VI "Fire Protection"), cargo hatch covers of the upper deck shall be made of steel; the cargo hatch covers of upper and lower decks shall be provided with drives ensuring smooth movement (without striking) of covers and all parts of hatch covers. The design of the drives shall be such that in the case of their failure no dropping of the covers could occur during closing or opening operations; reliable securing of covers kept open shall be provided. Measures shall be taken to prevent the ingress of working fluid of the drives for these hatch covers into cargo holds (refer also to 7.2.4 and 7.2.17, Part VI "Fire Protection").

**7.10.8.7** Each hatch cover or section of hatch covers shall be fitted with proper securing devices along its transverse and longitudinal sides, which would ensure the weathertightness of the cover.

The number of securing devices shall not be less than two on each side of the section, and the securing devices should be spaced not more than 6 m apart. The securing device fitted in close proximity to the corner of the section is considered to be the device both for the transverse and longitudinal sides of the sections, and the securing device fitted in way of two jointed sections and pressing the corners of the two sections against the coaming is considered to be the device both for the transverse and longitudinal sides of the two sections adjacent to the device.

**7.10.8.8** Each securing device of the hatchway cover shall be calculated for the action of force  $F$ , in N, determined by the formula

$$F = (1/n)[mg(8a_y - K) + pl_p] \quad (7.10.8.8)$$

where  $m$  = total mass of covers of the hatchway under consideration, in kg;  
 $n$  = total number of securing devices along the perimeter of the hatchway under consideration;  
 $l_p$  = clear perimeter of the hatchway under consideration, in m;  
 $p$  = pressure of the packing gasket when compressed to the maximum depth possible for the accepted design, in N/m. Where the value  $p$  is less than 5000 N/m in calculations performed according to the Formula (7.10.8.8),  $p$  is taken equal to 5000 N/m;  
 $g$  = acceleration due to gravity equal to 9,81 m/s<sup>2</sup>;  
 $a_y$  = dimensionless acceleration to be determined in accordance with 1.7 as applied to the centre of gravity of the considered hatchway covers;  
 $K$  = coefficient to be determined by the formula  
 $K = 0,947 - 20,7/L$

where  $L$  = ship's length, in m.

In any case,  $F$  shall not be taken less than 40 kN.

**7.10.8.9** When the securing device is under the effect of the design force specified in 7.10.8.8, the stresses in its parts shall not exceed 0,8 times the upper yield stress of material.

**7.10.8.10** Irrespective of the results calculated in accordance with 7.10.8.8, the free sectional area  $A$ , in cm<sup>2</sup>, of the securing device shall not be less than determined by the formula

$$A = \frac{1,4a}{f} \quad (7.10.8.10)$$

where  $a$  = distance between securing devices, in m, which in any case shall not be adopted less than 2 m;  
 $f$  = factor determined by the formula

$$f = \left( \frac{R_{eH}}{235} \right)^e$$

where  $R_{eH}$  = the upper yield strength of the securing device material, in MPa, and shall not be adopted greater than 0,7 of the tensile strength of the material;

$e$  = index equal to:  
 0,75 for  $R_{eH} > 235$  MPa;  
 1,00 for  $R_{eH} \leq 235$  MPa.

For hatch covers and hatch cover sections having an area in excess of 5 m<sup>2</sup>, the active diameter of bars and bolts of the securing devices shall not be less than 19 mm.

**7.10.8.11** Where the packing gasket is compressed to the maximum depth possible and its pressure exceeds 5000 N/m, the area of securing devices as determined in accordance with 7.10.8.10 shall be increased in a relevant proportion.

**7.10.8.12** The stiffness of the cover corners shall be sufficient to maintain an adequate pressure of the packing gasket between the securing devices. The cross-sectional inertia moment of the corner members of the covers  $I$ , in cm<sup>4</sup>, shall be not less than that determined by the formula

$$I = 6pa^4 \cdot 10^{-3} \quad (7.10.8.12)$$

where  $p$  = pressure of the packing gasket when compressed to the maximum depth possible for the accepted design, in N/m, but not less than 5000 N/m;  
 $a$  = distance between securing devices, in m.

**7.10.8.13** Covers on which cargoes shall be carried shall be provided with securing devices preventing the cover sections from shifting relative to the hatchway coaming during rolling or prolonged statical heel. These securing devices shall be calculated to take up the loads induced therein when the common centre of gravity of the cover with the cargo thereon is affected by the loads directed perpendicular to the centre plane of the ship  $P_y$  and parallel to the centre plane  $P_x$  obtained in N, using the following formulae:

$$P_y = mga_y; \quad (7.10.8.13-1)$$

$$P_x = mga_x \quad (7.10.8.13-2)$$

where  $m$  = total mass of the cover and cargo secured thereon, in kg;  
 $g$  = acceleration due to gravity equal to 9,81 m/s<sup>2</sup>;  
 $a_y, a_x$  = dimensionless accelerations obtained in accordance with 1.7 as applied to the common centre of gravity of the considered cover with cargo thereon. For hatchway covers of shipborne barges, when determining  $a_y$  and  $a_x$ , to be taken as  $L$  and  $B$  are the length and the breadth of the barge carrier (on which the considered shipborne barge is transported), and as  $x$  and  $z$  the maximum possible distances between the centre of gravity of the cover, and the aft perpendicular and the summer load waterline of the barge carrier, respectively, shall be taken.

Stresses arising in the parts of securing devices shall not exceed 0,8 times the upper yield stress of the material of which these devices are made.

**7.10.8.14** In ships having large hatchways for which considerable deformation of the hatchway coamings is possible in seaway:

**1** the design of the securing device shall allow for possible horizontal shifting of the point of attachment of this device to the coaming by a value equal to possible horizontal shifting of the cover section from the coaming;

**2** in the hinged joints of the cover sections to each other and to the hatchway coaming provision shall be

made for clearances adequate for possible horizontal relative shifting of the sections without obstruction;

**.3** over the lower bearing edges of cover sections, an appropriate metal contact surface shall be provided allowing for free gliding of sections over hatch coamings;

**.4** the horizontal stiffener of hatch coaming on which the covers rest shall be properly stiffened to ensure a permanent contact of the cover section and coaming.

**7.10.8.15** Hydraulic drives of hatch covers shall comply with the requirements of Part IX "Machinery".

The hatchway covers and the drives shall be so designed as to make it possible to close the hatch kept open before and to secure it even in case of the main power drive failure. The device for reliable locking of the covers kept open shall be provided. The direction of the cover opening shall ensure, wherever possible, maximum protection of open hatches from exposure to sea.

**7.10.9 Hatch cover designs for lower decks.**

The hatch cover designs for lower decks shall comply with the requirements of 7.10.7 and 7.10.8.

**7.11 HATCHWAYS OF CARGO TANKS IN TYPE "A" SHIPS**

**7.11.1** Openings for hatchways of the cargo tanks on tankers shall be of round or oval form. Height of the coamings of cargo tank hatchways will not be regulated by the Register. Construction of the coamings of cargo tank hatchways shall comply with the requirements of 3.5.5.1, Part II "Hull".

**7.11.2** Covers of hatches and tank cleaning openings shall be made of steel, bronze or brass. Use of other materials is subject to special consideration by the Register in each case.

In ships carrying flammable liquids in bulk use of light alloys for covers of hatches and tank cleaning openings is not permitted.

**7.11.3** Covers of the cargo tank hatchways shall be permanently attached and tight, when secured, under the inner pressure of liquid carried in tanks to a head of at least 2,5 m. Tightness shall be provided by a rubber or other suitable gasket being resistant to the liquids which are carried in the cargo tanks.

**7.11.4** The plate of the cargo tank hatchway covers shall be at least 12 mm in thickness if it is of steel. The cover plate shall be reinforced by stiffeners made of flat bars not less than 80 × 12 mm in size, and spaced at every 600 mm of the cover length, or the cover shall be of spherical shape.

**7.11.5** The hatchway cover shall be provided with a sighting port having an inner diameter of 150 mm and closed by a cover of similar construction.

**7.11.6** Materials and designs of cargo tank hatchway covers in ships intended to carry flammable liquids shall be so selected as to preclude spark formation during opening and closing the covers.

**7.12 OPENINGS IN WATERTIGHT SUBDIVISION BULKHEADS AND THEIR CLOSING APPLIANCES**

**7.12.1 General.**

**7.12.1.1** Unless expressly provided otherwise, the present Chapter covers ships to which the requirements of Part V "Subdivision" apply.

For other ships, the requirements of this Chapter apply to bulkheads only, provided in accordance with 2.7.1.3, Part II "Hull"; for these ships, the requirements may be relaxed, and the degree of relaxation will be specially considered by the Register in each case.

In ships indicated in 7.12.6.1, the requirements of 7.12.2 to 7.12.5 may be relaxed for doors fitted in watertight subdivision bulkheads dividing a cargo space from an adjoining cargo space provided the requirements of 7.12.6 are met.

**7.12.1.2** The number of openings in watertight bulkheads shall be reduced to a minimum compatible with the design and normal service conditions of the ship.

**7.12.1.3** Where piping and electric cables are carried through watertight subdivision bulkheads, the requirements of 5.1, Part VIII "Systems and Piping" and of 16.8.6, Part XI "Electrical Equipment" shall be taken into consideration.

**7.12.2 Doors in watertight subdivision bulkheads. General.**

**7.12.2.1** The doors shall be made of steel. The use of other materials will be specially considered by the Register in each case.

**7.12.2.2** Doors shall withstand the pressure of a water head of the height measured from the lower edge of a doorway at the place of its location to the underside of bulkhead deck plating, the freeboard or the most adverse damage waterline, whichever is greater.

**7.12.2.3** Under the effect of water head specified in 7.12.2.2, the stresses in the door frame and door plate shall not exceed 0,6 times the upper yield stress of their material.

**7.12.2.4** When closed, the doors shall be tight under the pressure of a water head of the height specified in 7.12.2.2.

**7.12.2.5** Each means of operation of the doors shall alone ensure closure of the door with the ship listed 15° either way and with a trim up to 5°. Doors closed by dropping or by the effect of a dropping weight are not permitted. Portable plates secured by bolts only are not permitted.

### **7.12.3 Regulations concerning the positioning of doors.**

#### **7.12.3.1** No doors are permitted in:

collision bulkhead below the bulkhead deck of ships having a subdivision distinguishing mark in the class notation and below the freeboard deck of all other ships;

watertight subdivision bulkheads dividing a cargo space from an adjoining cargo space except where the Register is satisfied that such doors are essential. In this case, the doors may be hinged, sliding or of another equivalent type, but they shall not be remotely controlled.

In passenger ships and special-purpose ships, as well as in ships with subdivision distinguishing mark in the class notation, the outboard vertical edges of the doors shall not be located at less than 0,2 of the ship breadth. This distance shall be measured at right angles to the centre line of the ship at the level of the deepest subdivision loadline.

**7.12.3.2** In addition to doors at entrances to propeller shaft tunnels, not more than one door may be provided in each watertight subdivision bulkhead within spaces containing main engines, boilers and auxiliary machinery.

Where two or more propeller shafts are fitted, their tunnels shall be connected by a passageway. In a twin-screw ship, there shall only be one door between the engine room and tunnel spaces, and if the propellers are more than two, only two doors shall be provided. All the doors shall be located as high as practicable.

Hand gear for operating the doors from above the bulkhead deck and for operating doors at entrances to shaft tunnels shall be fitted outside the engine room.

#### **7.12.4 Doors in cargo ships.**

**7.12.4.1** The requirements of 7.12.4 apply to doors fitted in the subdivision bulkheads of cargo ships except the doors of special purpose ships and those mentioned under 7.12.6.

**7.12.4.2** The doors shall be sliding doors with horizontal or vertical motion, they shall be both hand- and power-operated.

If hand-operated, it shall be possible to open and close the door from both sides of the bulkhead.

If power-operated, closing of the doors from the control station on the navigating bridge shall be possible.

**7.12.4.3** At the door control stations, visual indicators shall be provided to show whether the doors are open or closed. An alarm shall be provided to control the door closing.

Power source, control station and indicators shall be operable in the case of main power source failure. Special attention shall be paid to minimizing the effects of the control system failure.

### **7.12.5 Doors in passenger ships and special purpose ships.**

**7.12.5.1** The requirements of 7.12.5 apply to doors fitted in the subdivision bulkheads of passenger ships and special purpose ships except those mentioned in 7.12.6.

**7.12.5.2** The doors shall be sliding doors with horizontal or vertical motion, they shall be both hand- and power-operated.

The maximum width of the door aperture shall not exceed 1,2 m. Fitting of doors with the aperture width in excess of 1,2 m is subject to special consideration by the Register in each case.

**7.12.5.3** If hand-operated, it shall be possible to open and close the door from both sides of the bulkhead and, in addition, from an accessible position above the bulkhead deck by means of a hand wheel, knob or another similar gear. The force applied to the hand wheel, knob or similar gear while the door is in motion shall not exceed 157 N.

If the door is not visible from the position above the bulkhead deck where the gear is fitted, indicators shall be provided showing the positions of the hand wheel, knob and similar gear at which the door is open or closed.

When hand-operated, the time necessary for a complete closure of the door shall not exceed 90 s with the ship upright.

**7.12.5.4** Door control knobs shall be fitted on either side of the bulkhead at a minimum height of 1,6 m above deck plating and so arranged as to enable persons passing through the doorway to hold both the knobs in a position preventing door closure.

**7.12.5.5** The power gear shall be controllable (i.e. door opening and closing shall be possible) by local control stations on either side of the bulkhead.

Besides being controlled directly at the door, the power gear shall also be controllable (for door closure) from the main control station.

Remote opening of any door from the main control station shall not be possible.

The main control station for doors shall be located in the wheelhouse.

**7.12.5.6** The power gear shall ensure door closure in not more than 40 s and not less than 20 s with the ship upright, as well as a simultaneous closure of all doors within not more than 60 s.

**7.12.5.7** The power gear of the doors shall have either:

a centralized hydraulic system with two independent power sources each consisting of a motor and pump capable of simultaneously closing all doors. In addition, there shall be for the whole installation hydraulic accumulators of sufficient capacity to operate all the doors at least three times, i.e. closed — open — closed; or

an independent hydraulic system for each door with each power source consisting of a motor and pump capable of opening and closing the door. In addition, there shall be a hydraulic accumulator of sufficient capacity to operate the door at least three times, i.e. closed — open — closed; or

an independent electrical system and motor for each door with each power source consisting of a motor capable of opening and closing the door. The power source shall be capable of being automatically supplied by a transitional emergency source of electrical power, as required by 19.1.2.7, Part XI "Electrical Equipment" in the event of failure of either the main or emergency source of electrical power and with sufficient capacity to operate the door at least three times, i.e. closed — open — closed.

**7.12.5.8** Door controls, including hydraulic piping and electric cables, shall be kept as close as practicable to the bulkhead in which the doors are fitted, in order to minimize the likelihood of them being involved in any damage which the ship may sustain.

**7.12.5.9** Each door shall be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever the door is closed remotely by power and which shall sound for at least five seconds, but not more than ten seconds, before the door begins to move, and shall continue sounding until the door is completely closed. In the case of remote hand operation it is sufficient for the audible alarm to sound only when the door is moving.

**7.12.5.10** The central operating console at the navigating bridge shall have a switch with two modes of control:

a "local control" mode which shall allow any door to be locally opened and closed without automatic closure and

a "doors closed" mode which shall allow doors to be opened locally and shall automatically reclose the doors upon release of the local control mechanism.

The switch shall normally be in the "local control" position. The "doors closed" position shall only be used in an emergency or for testing purposes.

**7.12.5.11** The central operating console at the navigating bridge shall be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light shall indicate a door fully open and a green light shall indicate a door fully closed. When a door is closed remotely, the red light shall indicate the intermediate position by flashing. The indicating circuit shall be independent of the control circuit for each door.

**7.12.5.12** Where trunkways or tunnels for access from crew accommodation to the stokehold, for piping, or for any other purpose are carried through

main transverse watertight bulkheads, they shall be watertight. The access to at least one end of each such tunnel or trunkway, if used as a passage at sea, shall be through a trunk extending watertight to a height sufficient to permit access above the margin line. The access to the other end of the trunkway or tunnel may be through a watertight door of the type required by its location in the ship. Such trunkways or tunnels shall not extend through first subdivision bulkhead abaft the collision bulkhead.

**7.12.5.13** Where ventilating trunks in connection with refrigerated cargo and ventilation or forced draught trunks are carried through more than one watertight bulkhead, the means of closure at such openings shall be operated by power and be capable of being closed from a central position situated above the bulkhead deck.

#### **7.12.6 Doors in ships designed for the carriage of vehicles.**

**7.12.6.1** The requirements of 7.12.6 apply to doors fitted in watertight subdivision bulkheads separating a cargo space from an adjacent cargo space in ships designed for the carriage of vehicles and covered by the requirements of Part V "Subdivision", if the total number of persons on board (excluding the master and the members of the crew or other persons employed or engaged in any capacity on board a ship on the business of that ship, and also a child under one year of age) is not greater than the value  $N$  determined by the formula

$$N = 12 + 0,04A \quad (7.12.6.1)$$

where  $A$  = total deck area, in  $m^2$ , of spaces available for the stowage of vehicles where the clear height at the stowage position and at the entrances to such spaces is not less than 4 m.

**7.12.6.2** The doors specified in 7.12.6.1 may be fitted at any level if the Register is satisfied that such doors are essential for the movement of the vehicles in the ship.

The number and arrangement of these doors are subject to special consideration by the Register.

**7.12.6.3** The doors specified in 7.12.6.1 shall be fitted as far from the shell plating as practicable, but in no case shall the outboard vertical edge of the door be situated at a distance from the shell plating that is less than 0,2 of the breadth of the ship, such distance being measured at right angles to the centre line of the ship at the level of the subdivision loadline.

**7.12.6.4** The doors specified in 7.12.6.1 may be of the following types: hinged, sliding or rolling but they should not be controlled remotely. The doors shall be fitted with devices ensuring watertightness, securing and locking.

When the sealing material of the door is not classed as non-combustible (refer to 1.6.3.1, Part VI "Fire

Protection"), the gasket shall be suitably protected from the effects of fire by a method approved by the Register.

The doors shall be fitted with a device which prevents unauthorized opening.

**7.12.6.5** The doors specified in 7.12.6.1 shall be so designed that they could be opened and closed both in case of unloaded and loaded decks, the deck deflections under the effect of the stowed cargo being taken into account.

The securing devices of the door shall be so designed that account is taken of the deck deflections under the effect of the stowed cargo resulting in relative displacement of the structural elements of the bulkhead and the door.

**7.12.6.6** Where watertightness is ensured by rubber or other suitable gaskets and securing devices, at each corner of the door or door section (if any) the securing devices shall be fitted.

The securing devices of such doors shall be designed to withstand the following forces, in kN:

$F_1$  for securing devices fitted at the lower edge of the door;

$F_2$  for securing devices fitted at the upper edge of the door;

$F_3$  for securing devices fitted at the vertical edge of the door.

These forces shall be determined by the formulae:

$$F_1 = \frac{9,81A}{n_1} \left( \frac{H_1}{2} - \frac{h}{6} \right) + 29,42; \quad (7.12.6.6-1)$$

$$F_2 = \frac{9,81A}{n_2} \left( \frac{H_1}{2} - \frac{h}{3} \right) + 29,42; \quad (7.12.6.6-2)$$

$$F_3 = \frac{a}{A} [F_1(n_1 - 1)h_i + F_2(n_2 - 1)(h - h_i)] \quad (7.12.6.6-3)$$

where  $A$  = clear area of the door, in  $m^2$ ;

$H_1$  = vertical distance from the lower edge of the door opening to the lower edge of the plating of the bulkhead deck at the centre line of the ship, in m, but not less than 5 m;

$h$  = clear height of the door, in m;

$h_i$  = vertical distance from the securing device considered to the upper edge of the door, in m;

$a$  = half the sum of the vertical distances from the securing device considered to the nearest upper and lower securing devices, in m;

$n_1$  = number of the securing devices fitted on the lower edge of the door;

$n_2$  = number of the securing devices fitted on the upper edge of the door.

When the securing device is under the effect of the design force  $F_1$ ,  $F_2$  or  $F_3$ , the stresses in its parts shall not exceed 0,5 times the upper yield stress of material.

**7.12.6.7** The operation of the doors specified in 7.12.6.1 shall be by means of local control only. On the bridge indicators shall be provided to show au-

tomatically that each door is closed and all door fastenings are secured.

**7.12.6.8** The requirements of 7.12.2.1 to 7.12.2.4 are also applicable to doors specified under 7.12.6.1.

### **7.12.7 Manholes in watertight subdivision bulkheads.**

**7.12.7.1** The requirements of 7.9 relating to the manholes located on the freeboard deck, raised quarter deck or the first tier of superstructures are generally applicable to the manholes fitted in the watertight subdivision bulkheads.

No manholes are permitted:

**.1** in the collision bulkhead below the bulkhead deck for ships having subdivision distinguishing mark in the class notation, and below the freeboard deck for other ships;

**.2** in watertight subdivision bulkheads separating a cargo space from an adjacent cargo space or a fuel oil tank.

## **7.13 CARGO HATCH COVERS OF BULK CARRIERS, ORE CARRIERS AND COMBINATION CARRIERS**

**7.13.1** The design of cargo hatch covers for bulk carriers, ore carriers and combination carriers shall comply with the requirements in 7.10.1, 7.10.2, 7.10.3.4, 7.10.3.5, and 7.10.4 to 7.10.6 and 7.10.8.

**7.13.2** Cargo hatch covers shall be made of steel. Use of other materials is subject to special consideration by the Register in each case.

**7.13.3** The pressure  $P$ , in kPa, on the hatch cover panels located on the freeboard deck is determined by the formulae:

for ships of 100 m in length and above:

$$P = 34,3 + \frac{P_{FP} - 34,3}{0,25} \left( 0,25 - \frac{X}{L} \right) \geq 34,3 \quad (7.13.3-1)$$

where  $P_{FP}$  = pressure at the fore perpendicular to be determined by the formula

$$P_{FP} = 49,1 + (L - 100)a;$$

$a$  = 0,0726 – for type *B* freeboard ships;

$a$  = 0,356 – for ships with reduced freeboard;

$L$  = ship's length, but not more than 340 m;

$X$  = distance, in m, of the midlength of the hatch cover under consideration from the forward end of  $L$ .

Where a position 1 hatchway is located at least one superstructure standard height higher than the freeboard deck, the pressure  $P$  may be taken equal to 34,3 kPa;

For ships less than 100 m in length:

$$P = 15,8 + \frac{L}{3} \left( 1 - \frac{5X}{3L} \right) - 3,6 \frac{X}{L} \geq 0,195L + 14,9. \quad (7.13.3-2)$$

Where two or more panels are connected by hinges, each individual panel shall be considered separately.

**7.13.4** The normal  $\sigma_a$  and shear  $\tau_a$  stresses in the hatch cover structures shall not exceed the permissible values:

$$\begin{aligned}\sigma_a &= 0,8R_{eH}; \\ \tau_a &= 0,46R_{eH}\end{aligned}$$

where  $R_{eH}$  = upper yield stress of the hatch cover material.

The normal stressing compression of the attached flange of primary supporting members shall not exceed 0,8 times the critical buckling stress of the structure according to the calculations given in 7.13.9 to 7.13.11.

The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members shall be determined by a grillage or a finite element analysis.

When a beam or a grillage analysis is used, the secondary stiffeners shall not be included in the attached flange area of the primary members.

When calculating the stresses  $\sigma$  and  $\tau$ , the net scantlings (no allowance for corrosion and wear) of hatch cover structure elements shall be used.

**7.13.5** The effective flange area  $A_F$ , in  $\text{cm}^2$ , of the attached plating, to be considered for the yielding and buckling checks of primary supporting members or grillages, is obtained as the sum of the effective flange areas of each side of the girder web:

$$A_F = \sum_{nf} (10b_{ef}t) \quad (7.13.5)$$

where  $nf = 2$  if attached plate flange extends on both sides of a girder web;  
 $nf = 1$  if attached plate flange extends on one side of a girder web only;  
 $t$  = thickness of attached plate, mm;  
 $b_{ef}$  = effective breadth, in m, of attached plate flange on each side of a girder web assumed equal to  $b_p$ , but not more than 0,165;  
 $b_p$  = half distance, in m, between the considered primary supporting member and the adjacent one;  
 $l$  = span, in m, of primary supporting members.

**7.13.6** The net thickness  $t$ , in mm, of the hatch cover top plating shall be not less than

$$t = F_p 15,8s \sqrt{\frac{P}{0,95\sigma_F}} \quad (7.13.6)$$

where  $F_p$  = factor equal to:  
 1,9 if ratio  $\sigma/\sigma_a \geq 0,8$ ;  
 1,5 in other cases;  
 $s$  = stiffener spacing, m;  
 $p$  = pressure, in kPa, according to 7.13.3;  
 $\sigma$  = according to 7.13.8;  
 $\sigma_a$  = according to 7.13.4

and not less than 1 per cent of the stiffener spacing or 6 mm, whichever is greater.

**7.13.7** The required minimum section modulus  $Z$ , in  $\text{cm}^3$ , of secondary stiffeners of the hatch cover top plates, based on stiffener net member thickness, are given by

$$Z = \frac{1000l^2 s p}{12\sigma_a} \quad (7.13.7)$$

where  $l$  = secondary stiffener span, in m, to be taken as the spacing of primary supporting members or the distance between a primary supporting member and the edge support, as applicable. When brackets are fitted at both ends of all secondary stiffener spans, the secondary stiffener span may be reduced by an amount equal to 2/3 of the minimum brackets arm length, but not greater than 10 per cent of the gross span, for each bracket;  
 $s$  = secondary stiffener spacing, m;  
 $p$  = pressure, in kPa, according to 7.13.3;  
 $\sigma_a$  = according to 7.13.4.

The net section modulus of the secondary stiffeners shall be determined based on an attached plate width assumed equal to the stiffener spacing.

**7.13.8** The section modulus value and web thickness of primary supporting members, based on member net thickness, shall be such that the normal stress  $\sigma$  in both flanges and the shear stress  $\tau$  in the web do not exceed the permissible values  $\sigma_a$  and  $\tau_a$ , respectively, defined according to 7.13.4.

The width of the primary supporting members flange shall be not less than 40 per cent of their depth for laterally unsupported spans greater than 3,0 m. Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

The flange outstand shall not exceed 15 times the flange thickness.

**7.13.9** The compressive stress  $\sigma$  in the hatch cover plate panels, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress  $\sigma_{c1}$ , to be evaluated as follows:

$$\sigma_{c1} = \sigma_{E1}, \text{ when } \sigma_{E1} \leq \frac{\sigma_F}{2}; \text{ or} \quad (7.13.9-1)$$

$$\sigma_{c1} = \sigma_F [1 - \sigma_F / (4\sigma_{E1})], \text{ when } \sigma_{E1} > \frac{\sigma_F}{2}$$

where  $\sigma_F$  = minimum upper yield stress of the material, N/mm<sup>2</sup>;

$$\sigma_{E1} = 3,6E \left( \frac{t}{1000s} \right)^2;$$

$E$  = modulus of elasticity, N/mm<sup>2</sup>; to be assumed  $2,06 \cdot 10^5$  for steel;

$t$  = net thickness of plate panel, mm;

$s$  = spacing of secondary stiffeners, m.

The mean compressive stress  $\sigma$  in each of the hatch cover plate panels, induced by the bending of primary supporting members perpendicular to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress  $\sigma_{c2}$  to be evaluated as follows:

$$\sigma_{c2} = \sigma_{E2} \text{ where } \sigma_{E2} \leq \frac{\sigma_F}{2}; \text{ or} \quad (7.13.9-2)$$

$$\sigma_{c2} = \sigma_F [1 - \sigma_F / (4\sigma_{E2})] \text{ where } \sigma_{E2} > \frac{\sigma_F}{2}$$

where  $\sigma_F$  = minimum upper yield stress of the material, N/mm<sup>2</sup>;

$$\sigma_{E2} = 0,9mE \left( \frac{t}{1000s_s} \right)^2;$$

$$m = c \left[ 1 + \left( \frac{s_s}{l} \right)^2 \right] \frac{2,1}{\psi + 1,1};$$



$E$  = modulus of elasticity, N/mm<sup>2</sup>;  
 $t$  = net thickness of plate panel, mm;  
 $s_s$  = length of the shorter side of the plate panel, m;  
 $s_l$  = length of the longer side of the plate panel, m;  
 $\psi$  = ratio between the smallest and largest compressive stress;  
 $c$  = factor equal to:  
 1,3 when plating is stiffened by primary supporting members;  
 1,21 when plating is stiffened by secondary stiffeners of angle or T type;  
 1,1 when plating is stiffened by secondary stiffeners of bulb type;  
 1,05 when plating is stiffened by flat bar.

**7.13.10** The compressive stress in the top flange of secondary stiffeners, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress  $\sigma_{CS}$ , to be evaluated as follows:

$$\sigma_{CS} = \sigma_{ES} \text{ where } \sigma_{ES} \leq \frac{\sigma_F}{2}; \text{ or} \quad (7.13.10)$$

$$\sigma_{CS} = \sigma_F [1 - \sigma_F / (4\sigma_{ES})] \text{ where } \sigma_{ES} > \frac{\sigma_F}{2}$$

where  $\sigma_F$  = minimum upper yield stress of the material, N/mm<sup>2</sup>;  
 $\sigma_{ES}$  = ideal elastic buckling stress, N/mm<sup>2</sup>, of the secondary stiffener to be assumed as the minimum between  $\sigma_{E3}$  and  $\sigma_{E4}$  values;

$$\sigma_{E3} = \frac{0,001EI_a}{A^2};$$

$E$  = modulus of elasticity, N/mm<sup>2</sup>;  
 $I_a$  = moment of inertia, in cm<sup>4</sup>, of the secondary stiffener, including an effective flange equal to the spacing of secondary stiffeners;  
 $A$  = cross-sectional area, in cm<sup>2</sup>, of the secondary stiffener, including an effective flange equal to the spacing of secondary stiffeners;  
 $l$  = span, in m, of the secondary stiffener;

$$\sigma_{E4} = \frac{\pi^2 EI_w}{10^4 I_p^2} (m^2 + \frac{K}{m^2}) + 0,385 E \frac{I_t}{I_p};$$

$$K = \frac{Cl^4}{\pi^4 EI_w} \cdot 10^6;$$

$m$  = number of half waves, given by the following table:

$0 < K \leq 4$	$4 < K \leq 36$	$36 < K \leq 144$	$(m-1)^2 m^2 < K \leq m^2 (m+1)^2$
$m = 1$	$m = 2$	$m = 3$	$m$ being determined according to $K$ value

$I_w$  = sectional moment of inertia, in cm<sup>6</sup>, of the secondary stiffener about its connection with the plating;

$$I_w = \frac{h_w^3 t_w^3}{36} 10^{-6} \text{ for flat bar secondary stiffeners;}$$

$$I_w = \frac{f_i b_f^3 h_w^2}{36} 10^{-6} \text{ for T-section secondary stiffeners;}$$

$$I_w = \frac{b_f^3 h_w^2}{12(b_f + h_w)^2} [t_f(b_f^2 + 2b_f h_w + 4h_w^2) + 3t_w b_f h_w] 10^{-6} \text{ for angles and bulb secondary stiffener;}$$

$I_p$  = polar moment of inertia, in cm<sup>4</sup>, of the secondary stiffener about its connection with the plating;

$$I_p = \frac{h_w^3 t_w}{3} 10^{-4} \text{ for flat bar secondary stiffeners;}$$

$$I_p = (\frac{h_w^3 t_w}{3} + h_w^2 b_f t_f) 10^{-4} \text{ for flanged secondary stiffeners;}$$

$I_t$  = moment of inertia, in cm<sup>4</sup>, of the secondary stiffener without an effective flange;

$$I_t = \frac{h_w t_w^3}{3} 10^{-4} \text{ for flat bar secondary stiffeners;}$$

$$I_t = \frac{1}{3} [h_w t_w^3 + b_f t_f^3 (1 - 0,63 \frac{t_f}{b_f})] 10^{-4} \text{ for flanged secondary stiffeners;}$$

$h_w, t_w$  = height and net thickness, in mm, of the secondary stiffener, respectively;

$b_f, t_f$  = width and net thickness, in mm, of the secondary stiffener bottom flange, respectively;

$s$  = spacing of secondary stiffeners, m;

$$C = \left[ \frac{k_p E t_p^3}{3s \left( 1 + \frac{1,33 k_p h_w t_p^3}{1000 s t_w^3} \right)} \right] \cdot 10^{-3};$$

$k_p$  = 1 -  $\eta_p$  but not less than zero. For flanged secondary stiffeners,  $k_p$  need not be taken less than 0,1;

$$\eta_p = \frac{\sigma}{\sigma_{E1}};$$

for  $\sigma$ , refer to 7.13.8;

for  $\sigma_{E1}$ , refer to 7.13.9;

$t_p$  = net thickness, in mm, of the hatch cover plate panel.

For flat bar secondary stiffeners and buckling stiffeners, the ratio  $h/t_w$  shall be not greater than  $15k^{0,5}$

where  $h, t_w$  = height and net thickness of the stiffener, respectively;

$k = 235/\sigma_F$ ;

$\sigma_F$  = minimum upper yield stress of the material, N/mm<sup>2</sup>.

**7.13.11** The shear stress  $\tau$  in the hatch cover primary supporting members web panels shall not exceed 0,8 times the critical buckling stress  $\tau_C$ , to be determined as follows:

$$\tau_C = \tau_E \text{ where } \tau_E \leq \frac{\tau_F}{2}; \quad (7.13.11)$$

$$\tau_C = \tau_F [1 - \tau_F / (4\tau_E)] \text{ where } \tau_E > \frac{\tau_F}{2}$$

where  $\sigma_F$  = minimum upper yield stress of the material, N/mm<sup>2</sup>;  
 $\tau_F = \sigma_F / \sqrt{3}$ ;

$$\tau_E = 0,9 k_t E \left( \frac{t_{pr, n}}{1000 d} \right)^2;$$

$E$  = modulus of elasticity, N/mm<sup>2</sup>, to be assumed equal to  $2,06 \cdot 10^5$  for steel;

$t_{pr, n}$  = net thickness, in mm, of primary supporting member;

$k_t = 5,35 + 4,0/(a/d)^2$ ;

$a$  = greater dimension, in m, of web panel of primary supporting member;

$d$  = smaller dimension, in m, of web panel of primary supporting member.

For primary supporting members perpendicular to the direction of secondary stiffeners or for hatch covers built without secondary stiffeners, a presumed square panel of dimension  $d$  shall be taken for the determination of the stress  $\tau_C$ . In such a case, the average shear stress  $\tau_C$  between the values calculated at the ends of this panel shall be considered.

**7.13.12** The vertical deflection of primary supporting members shall be not more than 0,0056/ $l$ , where  $l$  is the greatest span of primary supporting members.

**7.13.13** Hatch covers shall be fitted with stoppers designed for longitudinal and transverse design loads of 175 kPa.

Where the design and arrangement of the fore-castle on a ship do not meet the requirements in 3.3.5.3, Part II "Hull", the stoppers of the foremost hatch cover (hatch No. 1) shall be designed for a longitudinal load of 230 kPa acting on the forward end of the No. 1 hatch cover.

**7.13.14** The stresses in stoppers and their adjacent structures shall not exceed the permissible values equal to  $0,8\sigma_F$ , where  $\sigma_F$  is minimum upper yield stress of the material.

**7.13.15** For the plating and stiffeners of all type hatch covers, excepting the double skin, the corrosion addition shall be assumed equal to 2 mm. For double skin hatch covers, the corrosion addition shall be 2 mm for the top and bottom plating and 1,5 mm for the internal structures.

**7.13.16** In bulk carriers of 150 m in length and upwards, carrying solid bulk cargoes having a density of  $1000 \text{ kg/m}^3$  and above, contracted for construction before 01.04.2006, the protection of the structure of cargo holds from grab wire damage during loading and unloading operations shall be achieved by structural design features:

wire rope grooving in way of cargo holds openings is to be prevented by fitting suitable protection such as half-round bar on the hatch side girders (i.e. upper portion of top side tank plates)/hatch end beams in cargo hold or upper portion of hatch coamings.

Such ships shall have the distinguishing mark **GRAB(X)** in the class notation (refer to 2.2.12, Part I "Classification").

#### **7.14 ACCESS TO SPACES IN THE CARGO AREA OF OIL TANKERS AND BULK CARRIERS**

**7.14.1** The requirements of 7.14 apply to oil tankers of 500 gross tonnage and above and to bulk carriers of 20000 gross tonnage and above.

**7.14.2** Means of access and passages on ships referred to in 7.14.1 shall comply with the requirements of IMO resolutions MSC.134(76), MCS.151(78) and MSC.158(78)<sup>1</sup>, as well as IACS Unified Interpretation SC191 (Rev.3 March 2006), specified in the Supplement to the present Rules.

#### **7.15 ADDITIONAL REQUIREMENTS FOR OPENINGS AND THEIR CLOSING APPLIANCES IN RO-RO SHIPS**

**7.15.1** Where vehicle ramps are installed in the ship to give access to spaces below the bulkhead deck, their

openings in the bulkhead deck shall be able to be closed weathertight to prevent ingress of water below, alarmed and indicated to the navigating bridge.

**7.15.2** Where fitting of particular accesses to spaces below the bulkhead deck is necessary for the essential working of the ship (e.g. the movement of machinery and stores, etc.) such accesses shall be provided with watertight closures, alarmed and indicated to the navigating bridge.

**7.15.3** Subject to provisions of paragraphs 7.15.1 and 7.15.2 all accesses that lead to spaces below the bulkhead deck shall have a lowest point which is not less than 2,5 m above the bulkhead deck.

**7.15.4** Indicators shall be provided on the navigating bridge for all shell doors, loading doors and other closing appliances which, if left open or not properly secured, could lead to flooding of a special category space or ro-ro cargo space. The indicator system shall be designed on the fail safe principle and shall show by light alarms if the door is not fully closed or if any of the securing arrangements is not in place and fully locked, and by audible alarms if such door or closing appliances become open or the securing arrangements become unsecured.

The indicator panel on the navigating bridge shall be equipped with a mode selection function "harbour/sea voyage" so arranged that an audible alarm is given on the navigating bridge if the ship leaves harbour with the bow doors, inner doors, stern ramp or any other side shell doors not closed or any closing device not in the correct position. The power supply for the indicator system shall be independent of the power supply for operating and securing the doors.

**7.15.5** Television surveillance and a water leakage system shall be arranged to provide an indication to the navigating bridge 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 flooding of special category spaces or ro-ro cargo spaces.

**7.15.6** Special category spaces and ro-ro cargo spaces shall be continuously patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access of passengers thereto can be detected whilst the ship is underway.

**7.15.7** Documented operating procedures for closing and securing all shell doors, loading doors and other closing appliances which, if left open or not properly secured could lead to flooding of special category space or ro-ro cargo space, shall be kept on board and posted at an appropriate place.

**7.15.8** Besides specified in 7.15.7 the Manual on operation and repair of doors in shell plating shall be kept onboard containing the following information:

<sup>1</sup>Refer to Collections of IMO Resolutions Related to the RS Activity, No.7, 2004, and No.8, 2005.

main particulars and structural drawings of doors;  
 door operation safety precautions;  
 ship characteristics, class, availability of relevant certificates;  
 door design loads;  
 manufacturer's recommendations for equipment testing;  
 description of equipment of bow, side and stern doors, internal bow doors, central power station, indication panel on navigating bridge, control panel in engine room;  
 operating characteristics: permissible angles of heel/trim with/without cargo as well as permissible angles of heel/trim during use of doors;

door operating instruction;  
 door operating instruction in case of emergency;  
 operation and repair of doors: description and deadlines of current repair, occurring failures and their acceptable elimination, manufacturer's instructions for operation and repair of doors;  
 record book of examinations including survey of securing, locking and supporting devices, repair and replacement.  
 The above manual on operation and repair of doors in shell plating shall be submitted for the Register approval.

## 8 ARRANGEMENT AND EQUIPMENT OF SHIP'S SPACES, VARIOUS EQUIPMENT, ARRANGEMENTS AND OUTFIT

### 8.1 GENERAL

**8.1.1** The requirements for the arrangement and equipment of machinery spaces are specified in Part VII "Machinery Installations" and those relating to refrigerating machinery spaces, refrigerant storerooms, as well as refrigerated cargo spaces are set forth in Part XII "Refrigerating Plants".

**8.1.2** In berth-connected ships, the arrangement and equipment of spaces, various devices and equipment must comply with the relevant requirements of 8.5 and 8.6.

Furthermore, berth-connected ships which are used as hotels or hostels shall comply with the requirements set out in 8.5 as in the case of passenger ships.

Besides, a berth-connected ship shall have at least two companion ladders fitted as far away from each other as possible. The companion ladders shall be not less than 0,2 m wide where the total of passengers and crew on board does not exceed 50.

For each 10 persons above 50, the companion ladder breadth shall be increased by 5 cm.

### 8.2 LOCATION OF SPACES

**8.2.1** The chart room shall be located in a space adjacent to the wheelhouse. The chart room and the wheelhouse may be situated in a common space.

**8.2.2** No accommodation spaces shall be arranged forward of the collision bulkhead and abaft of the afterpeak bulkhead below the bulkhead deck.

### 8.3 NAVIGATING BRIDGE

#### 8.3.1 General.

**8.3.1.1** The ship's control station shall be located in an enclosed space of the wheelhouse on the navigating bridge. The navigating bridge shall be located so as to ensure:

- proper visual control of the ship's running;
- good visibility with maximum view of water surface;
- good audibility of sound signals of the approaching ships;
- for tugs, possibility of visual control of tow line during towing operations.

It is recommended to arrange the steering control station at the ship's centre line.

**8.3.1.2** Visibility from the navigating bridge shall comply with requirements of 3.2, Part V "Navigational Equipment" of Rules for the Equipment of Sea-Going Ships.

### 8.4 EQUIPMENT OF DRY CARGO HOLDS

**8.4.1** When in ships not having double bottom wooden ceiling is placed on top of the floors, it shall be solid and shall extend up to the bilge. The ceiling is recommended to be made of portable sections of such dimensions and so constructed as to allow of their ready removal at any place.

The thickness of a ceiling shall be:  
 at least 40 mm for ships of 30 m in length and less;

at least 60 mm for ships over 30 m in length;  
at least 70 mm under cargo hatchways.

**8.4.2** When in ships having double bottom wooden ceiling is fitted, it shall have a thickness as follows:

at least 50 mm for ships of 60 m in length and less;

at least 65 mm for ships over 60 m in length.

The application of the ceiling made from synthetic material is subject to special consideration by the Register in each case.

**8.4.3** Where cargo is discharged by grabs or other mechanisms, the thickness of the wooden ceiling fitted under cargo hatchways shall be doubled.

**8.4.4** In holds intended for carriage of grain and other bulk cargoes the wooden ceiling on the inner bottom or, in case the latter is omitted, on the top of floors, shall be fitted so as to prevent wells, bilges and suction pipes of the bilge system from clogging.

**8.4.5** The wooden ceiling shall not be laid directly on the inner bottom metal plating, but shall be embedded in a bituminous or epoxy composition approved by the Register, or placed on battens of 25 to 30 mm in thickness along the floors. The wooden ceiling over the bilges shall be placed so as to be readily removable (refer to also 7.6.9, Part VIII "Systems and Piping").

**8.4.6** It is recommended that the cargo battens made of wood or metal shall be fitted on sides in holds and spaces intended for carriage of general cargoes. The thickness of wooden battens shall be as follows:

at least 40 mm for ships of 70 m in length and less;

at least 50 mm for ships of length exceeding 70 m.

The distance between adjacent battens shall not exceed 305 mm.

The battens shall be attached to side framing so as to be readily removable and replaceable.

**8.4.7** All projecting parts of various equipment in the holds (manholes, air pipes, sounding pipes, etc.) shall be protected with wooden screens, grids, chutes, etc. in places subject to impacts of cargoes, grabs or other hoisting devices. Requirements for laying pipe lines in cargo holds are given in 5.3, Part VIII "Systems and Piping".

**8.4.8 Cellular guide members for the carriage of containers in holds.**

**8.4.8.1** The requirements of 8.4.8 apply to the cellular guide members used for the carriage of containers, manufactured in accordance with Rules for the Construction of Containers, in the holds of cargo ships.

**8.4.8.2** Cellular guide members comprise uprights and horizontal shores arranged breadthwise and lengthwise. In the holds, the cellular guide members may be removable or permanent.

**8.4.8.3** Cellular guide members shall not be integrated in the hull structure. They shall be so designed that no stresses are exerted on them when the hull comes under bending or torsion.

**8.4.8.4** Cellular guide members shall be designed to withstand stresses due to the forces  $F_x$  and  $F_y$  affecting the gravity centre of each container, which shall be determined by the formulae:

lengthwise

$$F_x = mga_x, \text{ in N;} \quad (8.4.8.4-1)$$

breadthwise

$$F_y = mga_y, \text{ in N} \quad (8.4.8.4-2)$$

where  $m$  = maximum gross mass of container, in kg;

$g$  = gravity acceleration,  $g = 9,81 \text{ m/s}^2$ ;

$a_x, a_y$  = dimensionless accelerations to be determined in accordance with 1.7, the coordinates of  $x$  and  $z$  being determined up to the gravity centre of each container volume.

The forces  $F_x$  and  $F_y$  shall be determined for each container, and through the four relevant corner fittings of the end or side wall they are uniformly distributed among the uprights. By way of simplification, maximum  $F_x$  and  $F_y$  values may be adopted for each container. Where a number of adjoining containers are supported by a pair of uprights, the  $F_x$  and  $F_y$  values for the particular container tier shall be summed up and distributed among the respective uprights.

Friction forces arising where the corner fittings of containers touch each other or the inner bottom shall be ignored.

**8.4.8.5** The forces resultant from loads to be determined in accordance with 8.4.8.4, where the container corner fittings rest upon the uprights, shall not exceed 150 kN per fitting breadthwise or 75 kN per fitting lengthwise.

**8.4.8.6** Where the attachment of uprights to the hull structures is not considered as firm fixing (free resting, flexible fixing, etc.), the cellular guide members shall be calculated as three-dimensional frames.

Where the attachment of uprights to the hull structures can be considered as firm fixing, particular vertical surfaces of cellular guide members may be calculated as plane frames.

The stresses in the cellular guide member components shall not exceed 0,8 times the upper yield stress of their material.

The terms of calculating the stability of cellular guide member components shall be found under 8.4.8.14.

**8.4.8.7** In view of the requirements under 8.4.8.6, the displacement of the resting points of corner fittings upon the uprights shall not exceed 25 mm breadthwise or 40 mm lengthwise.

**8.4.8.8** When determining the thickness of the uprights components, the thickness of those especially subject to wear shall be increased by 5 mm to equal 12 mm at least.

**8.4.8.9** Where the uprights comprise separate angular sections, they shall be firmly secured to each other with horizontal plates at the resting points of container corner fittings and at least halfway between those points.

**8.4.8.10** At the upper ends of the uprights, devices shall be fitted to facilitate the insertion of containers into the stowage frames.

**8.4.8.11** Uprights shall, so far as possible without notches, be attached to transverse and longitudinal bulkheads by means of shear- and bend-stiff members.

**8.4.8.12** The total margin between the external scantlings of containers and the internal uprights surfaces shall not exceed 25 mm breadthwise or 40 mm lengthwise.

When fitting the uprights, the deviation from the straight line shall not exceed 5 mm.

**8.4.8.13** Transverse horizontal and longitudinal horizontal shores serve to connect the stand-alone uprights to each other and to secure them to vertical hull structures. The horizontal shores shall, as far as possible, be fitted on the level of the corner fitting rest points and be torsion- and bend-stiff connected to the uprights.

**8.4.8.14** The stability of transverse horizontal and longitudinal horizontal shores and, where necessary, that of uprights shall be checked by a procedure approved by the Register.

When determining the permissible buckling stresses, the relevant safety factor may be adopted equal to 2,0.

The free length of buckling shall be adopted span-equal in the case of a bolted joint or 0,7 times the shore or uprights span in the case of a welded joint. The flexibility shall not exceed 250.

For other types of bar-end fixing, the free length shall be established on agreement with the Register.

**8.4.8.15** The container rest points on the inner bottom and areas containing the connections and attachments of container stowage frames in way of hull structures shall be strengthened in conformity with the requirements of Part II "Hull".

#### **8.4.9 Movable decks, platforms, ramps and other similar structures.**

**8.4.9.1** The requirements of 8.4.9 apply to the movable decks, platforms, ramps and other similar structures designed to be installed in two positions:

in working position when they are used for carriage, loading or unloading of vehicles or other cargoes;

in non-working position when they are not used for carriage, loading or unloading of vehicles or other cargoes.

**8.4.9.2** The movable decks, platforms, ramps and other similar structures and also their supporting elements at ship's sides, decks and bulkheads. the pillars or suspensions for decks and platforms ensuring their proper installation in the working position shall be designed in accordance with the requirements of Part II "Hull".

**8.4.9.3** Arrangements shall be provided for reliable securing of the movable decks, platforms ramps and other similar structures in the non-working position.

**8.4.9.4** When the movable decks, platforms, ramps and other similar structures are secured in the non-working position, the hoisting gear and elements thereof shall not generally be kept under the load.

It is not permitted to secure the movable decks, platforms, ramps and other similar structures by suspending them on ropes.

**8.4.9.5** The structural elements of the arrangements mentioned in 8.4.9.3 and also the associated supporting structures shall be designed to withstand the forces resulting from the application of the loads  $P_x$ ,  $P_y$ ,  $P_z$ , as determined by the formulae given below, to the centres of gravity of the considered section of the deck, platform, ramp or other similar structures:

$$P_x = mga_x; \quad (8.4.9.5-1)$$

$$P_y = mga_y; \quad (8.4.9.5-2)$$

$$P_z = m \cdot g(1 + a_z) \quad (8.4.9.5-3)$$

where  $P_x$  = horizontal load parallel to the centre plane of the ship, in N. Consideration shall be given to the cases when the load  $P_x$  is directed both forward and aft;

$P_y$  = horizontal load parallel to the midstation plane, in N. Consideration shall be given to the cases when the load  $P_y$  is directed both to the nearest ship's side and to the opposite side;

$P_z$  = vertical load directed downward, in N;

$m$  = mass of the considered section of the deck, platform, ramp or other similar structure, in kg;

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

$a_x$ ,  $a_y$ ,  $a_z$  = dimensionless accelerations to be determined in accordance with 1.7.

**8.4.9.6** When determining the forces affecting the structural elements of the arrangements specified in 8.4.9.3 and the associated supporting structures with regard to the provisions of 8.4.9.5, the loads  $P_x$ ,  $P_y$  and  $P_z$  are regarded as separately applied, i.e. no account is taken of their combined action and of the frictional forces originating on the surfaces of the considered sections of decks, platforms, ramps or other similar structures which are in contact with the associated supporting structures.

**8.4.9.7** When the structural elements of the arrangements specified in 8.4.9.3 and the associated supporting structures are under the effect of the loads determined according to the provisions of 8.4.9.5 and

8.4.9.6, the stresses in their parts shall not exceed 0,8 times the upper yield stress of material.

Under the effect of these loads the safety factor of the wire ropes in relation to their actual breaking strength shall be not less than 4; the safety factor of the chain cables in relation to the proof load of the chain shall be not less than 2; the margin of safety against buckling of the elements subjected to the compression stress shall be not less than 2.

**8.4.9.8** Wire ropes used in the arrangements specified in 8.4.9.3 shall satisfy the requirements of 3.15 and chain cables, those of 7.1, Part XIII "Materials".

## **8.5 EXITS, DOORS, CORRIDORS, STAIRWAYS AND VERTICAL LADDERS**

### **8.5.1 General.**

Location and arrangement of exits, doors, corridors, stairways and vertical ladders shall ensure ready access of persons from spaces to the places of embarkation into lifeboats and liferafts.

### **8.5.2 Exits and doors.**

**8.5.2.1** In passenger ships and in special purpose ships each watertight compartment or similarly restricted space or group of spaces situated below the bulkhead deck shall have at least two means of escape, in any case one of which shall be independent of the door in the subdivision bulkhead.

Two means of escape shall be provided from a machinery control room located within a machinery space, at least one of which will provide continuous fire shelter to a safe position outside the machinery space (refer to 2.1.4.5 Part VI "Fire Protection").

**8.5.2.2** In passenger ships and in special purpose ships above the bulkhead deck each main vertical fire zone (refer to 2.2.1.2, Part VI "Fire Protection") or similarly restricted space or group of spaces shall have at least two means of escape one of which shall give access to a stairway forming a vertical means of escape to the places of embarkation into lifeboats and liferafts.

**8.5.2.3** In passenger ships the number and location of means of escape from special category spaces (refer to 1.5.9, Part VI "Fire Protection") are subject to special consideration by the Register, and the degree of safety for escape from these spaces to the places of embarkation into lifeboats and liferafts shall at least correspond to that specified in 8.5.2.1 and 8.5.2.2.

For cargo ships in all ro-ro cargo spaces where the crew is normally employed the number and locations of escape routes to the open deck are subject to special consideration by the Register, but shall in no case be less than two and shall be widely separated.

**8.5.2.4** In cargo ships of 500 gross tonnage and upwards at each level of accommodation spaces there shall be at least two means of escape, as widely separated as possible, from each restricted space or group of spaces; from the spaces situated below the open deck the main means of escape shall be formed by a stairway, the other means of escape may be formed by a casing with a vertical ladder or by a stairway; from the spaces situated above the open deck the means of escape shall be formed by doors of stairways leading to the open deck or combination thereof.

**8.5.2.5** Exceptionally, the Register may dispense with one of the means of escape specified in 8.5.2.1 or 8.5.2.4, due regard being paid to the purpose and location of spaces and to the number of persons who normally might be quartered or employed there.

**8.5.2.6** Stairways serving only a space and a balcony in that space, as well as lifts shall not be considered as means of escape specified in 8.5.2.1 to 8.5.2.4.

**8.5.2.7** Each cinema hall shall be provided with at least two means of escape. Both exits shall be spaced from each other as wide as practicable. A readily seen inscription "Exit" or "Emergency exit" shall be provided above every such exit.

**8.5.2.8** The wheelhouse shall have two exits, one to each side of the navigation bridge, with a passageway through the house from side to side.

**8.5.2.9** The total width of exits from cinema halls shall be determined on the basis of 0,8 m per 50 persons, however, the width of each exit shall be not less than 1,1 m, when the number of seats is more than 50, and not less than 0,8 m when the number of seats is not more than 50.

The width of each exit from accommodation and service spaces shall be not less than 0,6 m. The sizes of the ladderways from cargo holds shall be not less than 0,6 × 0,6 m.

**8.5.2.10** The exit doors and ladderway covers shall be so arranged that they can be operated from both sides.

Doors shall open as follows:

- .1** doors of accommodation and service spaces giving access to a corridor inside the spaces;
- .2** doors of public rooms, outside or each side;
- .3** doors in the end bulkheads of superstructures and in external transverse bulkheads of deckhouses, outside in the direction of the nearest side;
- .4** doors in the external longitudinal bulkheads of deckhouses, outside in the forward direction.

In cargo ships the inner doors duplicating the doors specified in 8.5.2.10.3 and 8.5.2.10.4 may open inside the space.

In ships of 31 m in length and less the doors indicated in 8.5.2.10.1 may open outside (to the

corridor) if they are situated at the end of blind corridors and do not hinder the exits from other spaces.

No sliding doors shall be fitted at exits and means of escape, except for doors of the wheelhouse.

The doors referred to in 8.5.2.10.1 shall not be provided with hooks for holding the door open. It is permitted that such doors be fitted with buffers and spring catchers to fix the door in the open position and to allow for its closure without entering the space.

**8.5.2.11** Doors of accommodation spaces specified in 1.5.2.1 and 1.5.2.2, Part VI "Fire Protection" shall have in their lower portions detachable panels  $0,4 \times 0,5$  m in size, these panels of the passenger cabin doors shall be provided with the following inscription: "Means of escape — knock out in case of emergency".

The detachable panels need not be fitted where the spaces are provided with opening type side scuttles of at least 400 mm in diameter of windows the smaller side of which being at least 400 mm and on condition that persons may get to the corridor or open deck through these side scuttles or windows. The appropriate means shall be provided, if necessary, to facilitate exit through side scuttles or windows.

### **8.5.3 Corridors and passageways.**

**8.5.3.1** All corridors and passageways shall ensure free movement of persons along them. On passenger ships and special purpose ships carrying more than 50 special personnel, a lobby, corridor or part of a corridor shall have more than one means of escape.

Cargo ships and special purpose ships carrying not more than 50 special personnel shall have no dead-end corridors more than 6 m long. By a dead-end corridor, a corridor or part of a corridor is meant which has only one means of escape.

Corridors used as means of escape on cargo ships shall be at least 700 mm wide and shall be fitted with a handrail on either side. Corridors with a width of 1800 mm and more shall be fitted with handrails on each side. Width of a corridor is determined as a distance between a handrail and opposite bulkhead or as a distance between handrails.

**8.5.3.2** The width of main corridors in way of passengers' and crew's accommodation spaces shall not be less than 0,9 m, and that of side corridors shall be at least 0,8 m. Where the number of passengers and crew using the corridor surpasses 50 persons, the widths referred to above shall be increased by 0,1 m.

In ships (including the tugs) below 500 gross tonnage and in tugs of less than 370 kW the width of the main corridors and side corridors may be reduced down to 0,8 and 0,6 m, respectively.

**8.5.3.3** The widths of passageways in the cinema hall and in the entrance hall shall not be less than 1,1 m and 1,4 m, respectively.

The width of the main passageways in the restaurant or dining room and also the messroom shall not be less than 0,9 m and that of the side passageways shall be at least 0,65 m. In ships of less than 500 gross tonnage the width of main passageways in the messroom may be reduced down to 0,65 m.

**8.5.3.4** The width of the main passageway in the seating passenger space shall be at least 1 m with number of passengers up to 50 and at least 1,1 m with number of passengers in excess of 50.

**8.5.3.5** In passenger ships the main corridors adjacent to engine and boiler casings shall be at least 1,2 m in width, however, in ships of less than 500 gross tonnage this width may be reduced down to 0,9 m.

**8.5.3.6** The width of passageway on the bridge shall not be less than 0,8 m in ships of 500 tons gross tonnage and over and at least 0,6 m in ships of less than 500 gross tonnage.

**8.5.3.7** In passenger ships and special purpose ships the width of the deck passageways providing access to the lifeboat and liferaft embarkation deck shall not be less than:

0,9 m if the number of seats in lifeboats is not more than 50 on each side of ship;

1,0 m if the number of seats in lifeboats is 50 and over, but less than 100 on each side of ship;

1,2 m if the number of seats in lifeboats is 100 and over, but less than 200 on each side of ship.

If number of seats in lifeboats is 200 and over on each side of ship, the width of the passageways will be specially considered by the Register in each case.

In other ships the width of the passageways referred to above shall not be less than 0,8 m.

### **8.5.4 Stairways and vertical ladders.**

**8.5.4.1** All between deck stairways shall be of steel frame construction or of equivalent material on agreement with the Register (refer to 1.2, Part VI "Fire Protection"). Special requirements for arrangement of stairway enclosures and protection of means of escape are specified in 2.1.4.3, 2.1.4.5, 2.2.2.4, Part VI "Fire Protection".

**8.5.4.2** On passenger ships and special purpose ships carrying more than 50 special personnel, the following conditions shall be met:

**.1** the width of stairways shall be not less than 900 mm, with handrails on each side. The minimum width of stairways shall be increased by 10 mm for every one person in excess of 90 persons. The maximum width between handrails where stairways are wider than 900 mm shall be 1800 mm. The total number of persons to be evacuated by such stairways shall be assumed to be two-thirds of the crew and the total number of passengers in the areas served by such stairways;

**.2** all stairways sized for more than 90 persons shall be aligned fore and aft;

.3 the doorways, corridors and intermediate landings included in means of escape shall be sized in the same manner as stairways;

.4 stairways shall not exceed 3,5 m in vertical rise without the provision of a landing and shall not have an angle of inclination greater than 45°.

Landings at each deck level shall not be less than 2 m<sup>2</sup> in area and shall increase by 1 m<sup>2</sup> for every 10 persons provided for in excess of 20 persons but need not exceed 16 m<sup>2</sup>, except for those landings servicing public spaces having direct access onto the stairway enclosure;

.5 in any case, the stairway width shall be in accordance with the requirements of the Appendix 1 to the present Part.

**8.5.4.3** Stairways used as means of escape on cargo ships shall be at least 700 mm wide and shall be fitted with a handrail on either side. Stairways with a width of 1800 mm and more shall be fitted with handrails on each side. Angle of slope of ladders shall be usually 45° but not greater than 50°, in the machinery and in small spaces — not greater than 60°. The size of doors providing an access to any stairway shall be of the same size as the stairway.

**8.5.4.4** Vertical ladders and ladder steps in cargo holds, tanks, etc. shall be at least 300 mm wide.

**8.5.5 Low location lighting (LLL) on passenger ships carrying more than 36 passengers and special purpose ships carrying more than 200 special personnel.**

**8.5.5.1** In addition to the emergency lighting stipulated by 19.1.2, Part XI "Electrical Equipment", the means of escape, including stairways and exits, of passenger ships carrying more than 36 passengers and special purpose ships carrying more than 200 special personnel shall be marked by LLL at all points of the escape route including angles and intersections.

**8.5.5.2** Provision shall be made for the following LLL systems:

.1 photoluminescent system which uses photoluminescent material containing a chemical (example: zinc sulfide) that has the quality of storing power when illuminated by visible light;

.2 electrically powered systems which use incandescent bulbs, light emitting diodes, electroluminescent strips or lamps, electrofluorescent lamps, etc. (refer also to 19.1.4, Part XI "Electrical Equipment").

**8.5.5.3** The LLL system shall function at all times for at least 1 hour after its activation. All systems, including those automatically activated or continuously operating, shall be capable of being manually activated by a single action from the main machinery control room.

**8.5.5.4** In all passageways, the LLL shall be continuous except as interrupted by corridors and cabin doors in order to provide a visible delineation along the escape route. The LLL shall be installed at least on one side of the corridor, either on the bulkhead within 300 mm of the deck, or on the deck within 150 mm of the bulkhead. In corridors more than 2 m wide, LLL shall be installed on both sides. In dead-end corridors, LLL shall have arrows placed at intervals of no more than 1 m, or equivalent direction indicators, pointing away from the dead-end.

**8.5.5.5** In all stairways, LLL shall be installed on at least one side at a height less than 300 mm above the steps. LLL shall be installed on both sides if the width of the stairway is two metres or more. The top and bottom of each set of stairs shall be identified to show that there are no further steps.

**8.5.5.6** In all passenger cabins, a placard explaining the LLL system shall be installed on the inside of the cabin door. It shall also have a diagram showing the location of, and the way to, the two closest exits with respect to the cabin.

Materials used in the manufacture of LLL products shall not contain radioactive or toxic materials.

**8.5.5.7** LLL shall indicate the exit door handle; other doors shall not be indicated so.

Sliding, fire-proof and watertight doors shall be provided with LLL sign showing the way of the door opening.

LLL signs shall be also provided at all doors and means of escape. The signs shall be located at a height of 300 mm above the deck or the bottom of the door and be contrast in colour to the background on which they are marked.

All exit door and escape route signs shall be of photoluminescent materials or marked appropriately by lighting.

**8.5.5.8** Photoluminescent (PL) material strips shall be not less than 75 mm wide. The strips having a width less than that stated herein shall be used only if their luminance is increased proportionally to compensate for their width. PL materials shall provide at least 15 mcd/m<sup>2</sup> measured 10 minutes after removal of all external illuminating sources. The system shall ensure luminance values greater than 2,0 mcd/m<sup>2</sup> for 1 hour. Any PL system shall be provided with not less than the minimum level of ambient light necessary to charge the PL material to meet the above luminance requirements.

**8.5.6 Additional requirements for means of escape on ro-ro passenger ships.**

**8.5.6.1** Handrails or other handholds shall be provided in all corridors along entire escape route, so that a firm handhold is available every step of the way, where possible, to the assembly stations and embarkation stations. Such handrails shall be pro-



vided on both sides of longitudinal corridors more than 1,8 m in width and transverse corridors more than 1 m in width. Particular attention shall be paid to the need to be able to cross lobbies, atriums and other large open spaces along escape routes. Handrails and other handholds shall be of such strength as to withstand a distributed horizontal load of 750 N/m applied in the direction of the centre of the corridor or space, and a distributed vertical load of 750 N/m applied in downward direction. There is no need to apply the two loads simultaneously.

**8.5.6.2** Means of escape shall not be obstructed by furniture and other obstructions, with the exception of tables and chairs which may be cleared away to provide open space. Cabinets and other heavy pieces of furniture in public spaces and along escape routes shall be secured in place to prevent shifting if the ship heels or lists. Floor coverings shall also be secured in place. When the ship is underway, means of escape shall be kept clear of obstructions.

**8.5.6.3** Means of escape shall be provided from every normally occupied space on the ship. These means of escape shall be arranged so as to provide the shortest route possible to the assembly stations and survival craft embarkation stations and shall be marked with appropriate symbols.

**8.5.6.4** Where enclosed spaces adjoin an open deck, openings from the enclosed space to the open deck shall, where it is practicable, be capable of being used as an emergency exit.

**8.5.6.5** Decks shall be sequentially numbered, starting with "1" at the tank top or the lowest deck. These numbers shall be prominently displayed at stair landings and lifts in the lobbies. Decks may also be named, but the deck number shall always be displayed along with the name.

**8.5.6.6** Simple and clear plans showing the "you are here" position and means of escape marked by arrows shall be prominently displayed on the inside of each cabin door and in public spaces.

**8.5.6.7** Cabin and stateroom doors shall not require keys to be unlocked from the inside. Neither shall there be any doors along any designed escape route which require keys to be unlocked.

**8.5.6.8** The lowest 0,5 m of bulkheads along escape routes shall be able to sustain a load of 750 N/m to allow them to be used as walking surfaces with the ship at large angles of heel.

**8.5.6.9** The escape routes from cabins to stairway enclosures shall be as direct as possible, with a minimum number of direction changes. It shall not be necessary to cross from one side of the ship to the other to reach means of escape. It shall not be necessary to climb more than two decks up or down to reach an assembly station or open deck from any passenger space.

**8.5.6.10** External means of escape to the survival craft embarkation stations shall be provided from all open decks, referred to in 8.5.6.9.

## 8.6 GUARD RAILS, BULWARK AND GANGWAYS

**8.6.1** All exposed parts of the freeboard decks, superstructure decks and deckhouse tops shall be provided with efficient guard rails or bulwarks; in case of ships intended for carriage of timber deck cargo collapsible railing or storm rails shall be fitted on this cargo.

**8.6.2** The height of the bulwark or guard rails above the deck shall not be less than 1 m. However, where this height would interfere with the normal operation of the ship, a lesser height may be approved provided the adequate protection of passengers and crew is ensured to the satisfaction of the Register.

**8.6.3** The distance between the stanchions of the guard rails shall be not more than 1,5 m. At least every third stanchion shall be supported by a stay.

Removable and hinged stanchions shall be capable of being locked in the upright position.

It is allowed to use flat steel stanchions with increased breadth at the stanchion weld to the deck. Fig. 8.6.3 shows the installation diagram and the spacing between the stanchions depending on the breadth of the lower edge to be welded to the deck. In places of the stanchion weld to the deck, the deck shall be supported by a min. 100 × 12 mm stiffener. For deck plating exceeding 20 mm the support may be omitted.

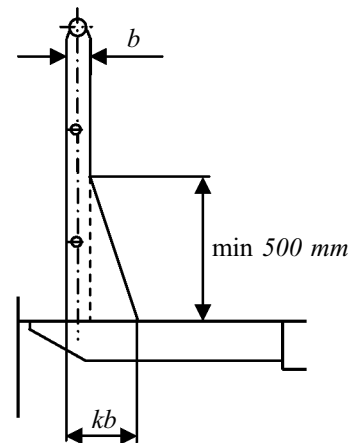


Fig. 8.6.3

1. Where  $kb \geq 2,9b$  — at least every third stanchion shall be of increased breadth;
2. Where  $2,4b \leq kb < 2,9b$  — at least every second stanchion shall be of increased breadth;
3. Where  $1,9b \leq kb < 2,4b$  — at least every stanchion shall be of increased breadth.

The stanchion breadth,  $b$ , shall be chosen according to the design standards

**8.6.4** The gunwale, hand rails and guard rails shall be generally of rigid construction; wire ropes may only be accepted in lieu of guard rails in special circumstances and then only in limited lengths; wire ropes shall be made taut by means of turn-buckles.

Lengths of chains may only be accepted in lieu of rigid guard rails if they are fitted between two fixed stanchions or between the fixed stanchion and bulwark.

**8.6.5** The opening below the lowest course of the guard rails shall not exceed 230 mm. The other courses of rails shall not be more than 380 mm apart. An exception is made for the guard rails above the timber deck cargo where the height from the base to the lowest course and other course spacings shall not exceed 330 mm. In the case of ships with rounded gunwale, the guard rail supports shall be placed on the flat of the deck.

**8.6.6** Type "A" ships with bulwarks as well as type "B" ships with a freeboard reduced to that required for type "A" ships shall have open rails fitted for at least half the length of the exposed parts of the weather deck, or other effective water freeing arrangements. The upper edge of the sheerstrake shall be kept as low as practicable.

Where superstructures are connected by trunks, open rails shall be fitted for the whole length of the exposed parts of the freeboard deck.

**8.6.7** The bulwark, if arranged, shall comply with the requirements of 2.14, Part II "Hull".

**8.6.8** Satisfactory means (in the form of life lines, gangways, 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 ship.

**8.6.9** A fore and aft permanent gangway shall be provided on type "A" ships at the level of the superstructure deck between the poop and the midship superstructure or deckhouse, where fitted, or equivalent means of access shall be provided to carry out the purpose of the gangway, such as underdeck passages. The width of the passages shall be not less

than 1 m. The gangways over the entire length of the plating on either side shall be fitted with longitudinal guarding bars. Reliable guard rails, the dimensions of which shall comply with the requirements of 8.6.2, 8.6.3 and 8.6.5 of this Part, and 3.5.5.2, Part II "Hull" shall be provided.

The gangways shall be constructed of a fire-resisting material, and the plating shall be made, in addition, of a nonslip material.

In ships not having a midship superstructure arrangements to the satisfaction of the Register shall be made to safeguard the crew in reaching all parts of the ship while at sea.

**8.6.10** Safe and convenient ladders from the level of the gangways to the deck shall be provided; they shall not be spaced more than 40 m apart.

Where the length of the deck is more than 70 m, special tripartite shelters (bow — sides) shall be provided along the gangways or other means of access for protection of the crew from bad weather. Such shelters shall be designed for at least one person and shall be spaced not more than 45 m apart. Pipes or other deck equipment shall not impede safe passage.

**8.6.11** Requirements of 8.6.1 to 8.6.5 and 8.6.9 are not applied to the shipborne barges. In such case, at least guard rails shall be provided.

## 8.7 HOISTING GEAR OF SHIPBORNE BARGES

**8.7.1** The elements of the hoisting gear of the shipborne barges to be lifted by the crane on board the barge carrier (lugs, eye plates, rings, shackles, grips, etc.) shall be designed to withstand the forces resulting from lifting the shipborne barge uniformly loaded with the specification cargo and gripped in two points diagonally positioned. Under these forces the stresses in the elements of the hoisting gear shall not exceed 0,7 times the upper yield stress of material.

# 9 EMERGENCY OUTFIT

## 9.1 GENERAL

**9.1.1** The items listed in Tables 9.2.1, 9.2.2-1, 9.2.2-2 and 9.2.3 available in the ship, but intended for other purposes may be included into the emergency outfit, provided these items have corresponding markings and their permanent storage places are situated above the bulkhead deck.

## 9.2 ITEMS REQUIRED

**9.2.1** All ships except those specified in 9.2.4 and 9.2.6 shall have emergency outfit in the scope not less than listed in Table 9.2.1.

For the unmanned non-self-propelled ships no emergency outfit is required. The manned non-self-propelled ships shall be supplied with the emergency outfit in accordance with 9.2.10 like floating docks

Table 9.2.1

Nos	Item, unit	Size	Quantity for ships of length <i>L</i> , in m				Quantity for tankers <sup>1</sup>
			150 and over	from 150 to 70 incl.	from 70 to 24 incl.	below 24	
1	Armoured collision mat, pc	4,5 × 4,5 m	1	—	—	—	—
2	Lightened collision mat, pc	3,0 × 3,0 m	—	1	—	—	1
3	Thrummed collision mat, pc	2,0 × 2,0 m	—	—	1	—	—
4	Thrummed pad, pc	0,4 × 0,5 m	4	3	2	1	2
5	Set of rigging tools	as per Table 9.2.3	1	1	1	1	1
6	Set of fitter's tools	as per Table 9.2.3	1	1	1	1	1
7	Pine bar, pc	150 × 150 × 4000 mm	8	6	—	—	—
8	Pine bar, pc	80 × 100 × 2000 mm	2	2	4	—	4
9	Pine plank, pc	50 × 200 × 4000 mm	8	6	2	—	—
10	Pine plank, pc	50 × 200 × 2000 mm	4	2	2	—	2
11	Pine wedge, pc	30 × 200 × 200 mm	10	6	4	—	4
12	Birch wedge, pc	60 × 200 × 400 mm	8	6	4	—	4
13	Pine plugs for ships with side scuttles, pc	side scuttle diameter	6	4	2	2	4
14	Pine plugs, pc	10 × 30 × 150 mm	10	6	4	2	4
15	Unbleached canvas, m <sup>2</sup>	—	10	6	4	2	—
16	Coarse felt, m <sup>2</sup>	10 mm in thickness	3	2	1	—	—
17	Rubber plate, m <sup>2</sup>	5 mm in thickness	2	1	0,5	—	0,5
18	Tarred tow, kg	—	50	30	20	10	5
19	Wire (low-carbon steel), pc	3 mm in dia, coils, 50 m each	2	2	1	—	1
20	Construction shackles, pc	12 mm in dia	12	8	4	—	4
21	Hexagon-head bolt, pc	M16 × 400 mm	10	6	2	—	—
22	Hexagon-head bolt, pc	M16 × 260 mm	4	2	2	2	—
23	Hexagonal nut, pc	M16	16	10	6	4	—
24	Washer for bolt, pc	M16	32	20	12	8	—
25	Construction nails, kg	70 mm long	4	3	2	1	1
26	Construction nails, kg	150 mm long	6	4	2	1	1
27	Cement (quick setting), kg	—	400	300	100	100	100
28	Sand, natural, kg	—	400	300	100	100	100
29	Accelerator for concrete setting, kg	—	20	15	5	5	5
30	Minium, kg	—	15	10	5	5	5
31	Technical fat, kg	—	15	10	5	—	5
32	Carpenter's axe, pc	—	2	2	1	1	1
33	Saw, cross-cut, pc	1200 mm in length	1	1	1	—	—
34	Hack-saw, pc	600 mm in length	1	1	1	1	1
35	Shovel, pc	—	3	2	1	1	1
36	Bucket, pc	—	3	2	1	1	1
37	Sledge hammer, pc	5 kg	1	1	1	—	—
38	Lantern of explosion-proof type, pc	—	1	1	1	1	1
39	Stop of telescopic type, pc	—	3	2	1	1	1
40	Emergency screw clamp, pc	—	2	1	1	—	—

<sup>1</sup>Whatever the ship length, ice class and navigation area are.

Table 9.2.2-1

with no permanent direct communication with the shore.

**9.2.2** Additional set of emergency outfit, above that listed in Table 9.2.1, shall be provided:

in accordance with Table 9.2.2-1 for passenger and special purpose ships, of 70 m in length and over, except those of glass-reinforced plastics;

in accordance with Table 9.2.2-2 for glass-reinforced plastic ships.

**9.2.3** The sets of rigging and fitter's tools specified in Table 9.2.1 shall be completed according to Table 9.2.3.

**9.2.4** For ships of restricted areas of navigation **R1**, **R2-RSN** and **R3-RSN** except those specified in 9.2.5, equipment with emergency outfit and materials

Nos	Item	Quantity
1	Portable autogenous cutting torch complete with set of fully charged gas cylinders	1
2	Hand jack, hydraulic	1
3	Blacksmith's sledge hammer	1
4	Forge chisel with haft	1
5	Crowbar	2
6	Jack 9,8 kN	1
7	Jack 19,6 kN	1

Table 9.2.2-2

Nos	Item	Quantity
1	Glass fabric	25 m <sup>2</sup>
2	Glass roving	3 kg
3	Resin binder with hardener	5 kg

Table 9.2.3

Nos	Item	Size	Quantity per set	
			rigging	fitter's
1	Tape measure	2000 mm long	1	—
2	Bench hammer	0,5 kg	1	1
3	Sledge hammer	3,0 kg	—	1
4	Rigger's mallet	—	1	—
5	Puncher (dumb iron)	—	1	—
6	Chisel	20 mm wide, 200 mm long	1	1
7	Marline spike	300 mm long	1	—
8	Carpenter's chisel	20 mm wide	1	—
9	Screw auger	18 mm in dia	1	—
10	Tongs	200 mm long	1	—
11	Hollow punch	18 mm in dia	—	1
12	Hollow punch	25 mm in dia	—	1
13	Triangular file	300 mm long	—	1
14	Half-round file	300 mm long	—	1
15	Multi-purpose tongs	200 mm long	—	1
16	Screw driver	10 mm wide	—	1
17	Adjustable wrench	Jaw width up to 36 mm	—	1
18	Wrench	Jaw width of 24 mm	—	1
19	Rigger's knife	—	1	—
20	Hack-saw frame	—	—	1
21	Hack-saw blade	—	—	6
22	Kit-bag	—	1	1

may be laid down as for the nearest lower group of ship's division depending on their length according to Table 9.2.1.

The minimum amount of emergency outfit for ships of restricted area of navigation **R3** will be specially considered by the Register in each case.

**9.2.5** For ships with ice strengthening of **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9** categories, equipment with emergency outfit and materials shall be established as for the nearest higher group of ship's division according to their length as per Table 9.2.1.

**9.2.6** For glass-reinforced plastic ships provision of emergency outfit listed under 6, 9, 17, 21 to 24, 26 to 29, 31, 35, 36, 39, and 40 of Table 9.2.1 is not required.

**9.2.7** In ships intended to carry flammable and explosive cargoes tools of emergency outfit shall be made of non-sparking materials wherever practicable.

**9.2.8** The tugs of restricted area of navigation **R3** need not be equipped with emergency outfit, except for the sets of rigging and fitter's tools required in accordance with Table 9.2.3.

**9.2.9** For tugs of unrestricted service and restricted area of navigation **R1** with ice strengthening of **Arc5** and higher category equipment with emergency outfit and materials shall be established as for the nearest higher group according to Table 9.2.1.

**9.2.10** The floating docks which are not in permanent direct communication with the shore shall have emergency outfit as indicated under items 5, 6, 19 to 26, 32 to 34 and 37 of Table 9.2.1, length of the floating dock *L* being taken in this case instead of the ship's length *L*.

The floating docks which are in permanent direct communication with the shore need not be provided with emergency outfit.

**9.2.11** For berth-connected ships, the emergency outfit shall be chosen by the owner.

**9.2.12** Ships having a distinguishing mark **FF1**, **FF1WS**, **FF2**, **FF2WS** and **FF3WS** in the class notation shall have two searchlights capable of providing an efficient horizontal and vertical range of illumination of a surface not less than 10 m in diameter at a distance up to 250 m at the minimum illumination intensity up to 50 lx at dark time and clear atmosphere.

### 9.3 STORAGE OF EMERGENCY OUTFIT

**9.3.1** The emergency outfit indicated in 9.2 shall be stored at least in two emergency stations, one of which shall be situated in the machinery space. Emergency stations may be special spaces, boxes or places allocated on the deck or in spaces.

In the emergency station of the machinery space the outfit necessary for carrying out the emergency operations inside the space shall be stored; the rest of the emergency outfit shall generally be stored in the emergency stations located above the bulkhead deck; in ships of less than 45 m in length it is allowed to locate the emergency station below the bulkhead deck on condition that free access to this station is provided at all times.

In ships of 31 m in length and below it is allowed to store the emergency outfit only in one emergency station.

**9.3.2** A free passage shall be provided in front of the emergency station; the passage width shall be selected depending on the overall dimensions of the outfit stored in the station but not less than 1,2 m. In ships of less than 70 m in length the passage width is allowed to be reduced to 0,8 m and in ships of 31 m in length and below to 0,6 m.

The passages to the emergency stations shall be as straight and short as practicable.

#### 9.4 MARKING

**9.4.1** Items of the emergency outfit and cases for their storage (apart from collision mats) shall be painted blue either entirely or in a stripe. The cases for emergency equipment storage shall have the distinct inscription to indicate the name of the material, weight and warranted storage period.

**9.4.2** The emergency stations shall be provided with distinct inscriptions "Emergency Station". Moreover, in the passages and on the decks notices shall be posted showing location of the emergency stations.

#### 9.5 COLLISION MATS

**9.5.1** Collision mats shall be made of water-resistant canvas or other equivalent fabric and be provided with either a soft or wire interlayer depending on the type of the collision mat. The collision mats shall be edged by a leech rope with four thimbles fitted into its corners. Moreover, cringles shall be provided according to the number of ropes specified in Table 9.5.1.

Basic data on the collision mats are given in Table 9.5.1 and Fig. 9.5.1.

**9.5.2** The pads shall be made of natural fibre rope strands and be thrummed with natural fibre spun yarn. A canvas shall be sewn on the bottom side of the pad.

**9.5.3** Sheets and guys of armoured collision mats shall be made of flexible steel wire ropes, control lanyards — of natural fibre ropes and hogging lines for all collision mats — of flexible steel wire ropes or chains having suitable diameter.

Wires of steel ropes shall have heavy zinc coating in accordance with the national standards.

The length of the sheets shall be chosen so that a hole may be shut up in any place of the shell plating and the ends of the ropes may be efficiently secured on the deck.

The actual breaking load of the whole sheets shall exceed that of the leech ropes by not less than 25 per cent.

**9.5.4** The blocks of emergency outfit may have hooks as hangers. The permissible load of the shackles joining the ropes shall not be less than 0,25 times the actual breaking load of the whole ropes referred to above.

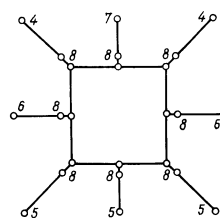


Fig. 9.5.1

Table 9.5.1

Nos	Item	Quantity		
		Armoured collision mat, 4,5 × 4,5 m	Lightened collision mat, 3,0 × 3,0 m	Thrummed collision mat, 2,0 × 2,0 m
1	Canvas layers	4	2	2
2	Interlayer	1 wire net with leech rope	1 felt padding	1 pad
3	Fastening of stiffeners	—	In pockets (pieces of wire rope or pipes)	—
4	Sheets	2	2	2
5	Hogging lines	3	2	2
6	Guys	2	2	—
7	Control lanyard with marking	1	1	1
8	Shackles	12	9	6
9	Tackles (safe working load)	4	2	2
		(14,7 kN)	(9,8 kN)	(9,8 kN)
10	Snatch blocks (safe working load)	4	2	2
		(14,7 kN)	(9,8 kN)	(9,8 kN)

## APPENDIX

**CALCULATION OF THE WIDTH OF STAIRWAYS FORMING MEANS OF ESCAPE  
ON PASSENGER SHIPS AND ON SPECIAL PURPOSE SHIPS CARRYING  
MORE THAN 50 SPECIAL PERSONNEL**

1. The calculation method considers evacuation from enclosed spaces within each main vertical zone individually and takes into account all of the persons using the stairway enclosures in each zone, even if they enter that stairway from another main vertical zone.

2. For each main vertical zone the calculation shall be completed for the night time (case 1) and day time (case 2) and the largest dimension from either case used for determining the stairway width for each deck under consideration.

3. For multi-deck ships, the total stairway width  $W$ , in mm, which allows for the timely flow of persons evacuating from adjacent decks is determined using the following calculation method:

when joining two decks

$$W = (N_1 + N_2) \cdot 10; \quad (3-1)$$

when joining three decks

$$W = (N_1 + N_2 + 0,5N_3) \cdot 10; \quad (3-2)$$

when joining four decks

$$W = (N_1 + N_2 + 0,5N_3 + 0,25N_4) \cdot 10 \quad (3-3)$$

where  $N_1$  = the number of persons to be evacuated from deck with the largest number of persons using the stairway;

$N_2$  = the number of persons to be evacuated from the deck with the next largest number of persons directly entering the stairway etc., i.e.  $N_1 > N_2 > N_3 > N_4$ .

When joining five or more decks, the total stairway width shall be determined by the Formula (3-3) with regard for the number of tiers and their capacity (Fig. 3.1).

The calculated value of  $W$  may be reduced where available landing area is provided in stairways at the deck level (Fig. 3.2).

The doors to the muster station shall have an aggregate width of at least  $D = 900 + 9355 = 10255$ .

4. The stairway shall not decrease in width in the direction of evacuation to the muster station, except in the case of several muster stations in one main vertical zone the stairway width shall not decrease in the direction of the evacuation to the most distant muster station.

5. Where the passengers and crew are held at a muster station which is not at the survival craft embarkation position the dimensions of stairway width and doors from the muster station to this position

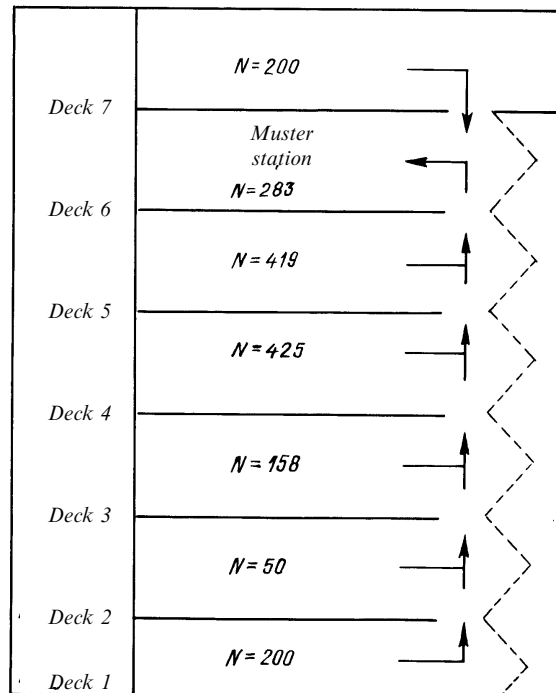


Fig. 3.1 Minimum stairway width calculation example:

Deck 1:  $N_1 = 200$ ,  
 $W = 200 \cdot 10 = 2000$ ;  
 Deck 2:  $N_1 = 200$ ,  $N_2 = 50$ ,  
 $W = (200 + 50) \cdot 10 = 2500$ ;  
 Deck 3:  $N_1 = 200$ ,  $N_2 = 158$ ,  $N_3 = 50$ ,  
 $W = (200 + 158 + 0,5 \cdot 50) \cdot 10 = 3830$ ;  
 Deck 4:  $N_1 = 425$ ,  $N_2 = 200$ ,  $N_3 = 158$ ,  $N_4 = 50$ ,  
 $W = (425 + 200 + 0,5 \cdot 158 + 0,25 \cdot 50) \cdot 10 = 7165$ ;  
 Deck 5:  $N_1 = 425$ ,  $N_2 = 419$ ,  $N_3 = 158$ ,  $N_4 = 50$ ,  
 $W = (425 + 419 + 0,5 \cdot 158 + 0,25 \cdot 50) \cdot 10 = 9355$ ;  
 Deck 7:  $N_1 = 200$ ,  
 $W = 900$ .

shall be based on the number of persons in the controlled groups. The width of these stairways and doors need not exceed 1500 mm unless larger dimensions are required for evacuation from these spaces under normal conditions.

6. The calculations of stairway width shall be based upon the crew and passenger load on each deck. For the purpose of the calculation the maximum capacity of a public space shall be defined by either of the following two values: the number of seats or similar arrangements, or the number obtained by assigning 2 m<sup>2</sup> of gross deck surface area to each person.

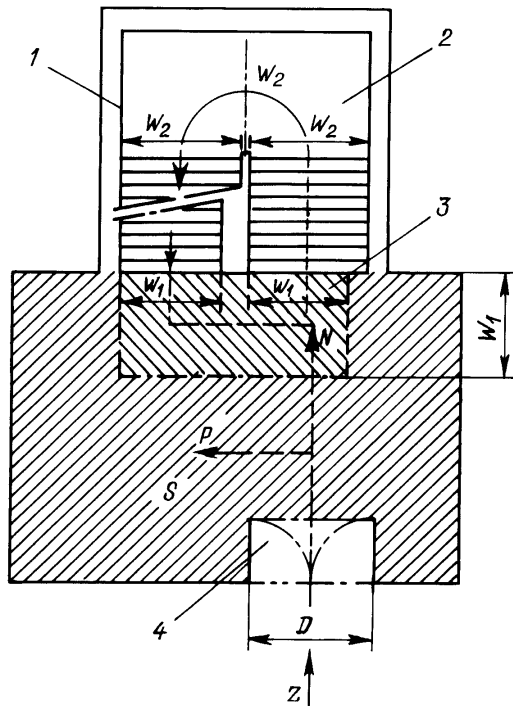


Fig. 3.2 Landing calculation for stairway width reduction:

- 1 — handrail on both sides of the stairway;
- 2 — intermediate landing;
- 3 — necessary flow area for accessing the flow on the stairs;
- 4 — door area

$P = S \times 3 \text{ persons/m}^2$  = the number of persons taking refuge on the landing to a maximum of  $P = 0,25Z$ ;

$N = Z - P$  = the number of persons directly entering the stairway flow from a given deck;

$Z$  = the number of persons to be evacuated from the deck considered;

$S$  = available landing area, in  $\text{m}^2$ , after subtracting the surface area necessary for movement and subtracting the space taken by the door swing area;

$D$  = width of exit doors to the stairway landing area, in mm.

7. The dimensions of the means of escape shall be calculated on the basis of the total number of persons expected to escape by the stairway and through doorways, corridors and landing (Fig. 7).

Calculations shall be made separately for the two cases of occupancy of the spaces specified below. For each component part of the escape route, the dimension taken shall not be less than the largest dimension determined for each case:

#### Case 1:

- passengers in cabins with maximum berthing capacity fully occupied;
- members of the crew in cabins occupied to 2/3 of maximum berthing capacity;
- service spaces occupied by 1/3 of the crew;

#### Case 2:

- passengers in public spaces occupied to 3/4 of maximum capacity;

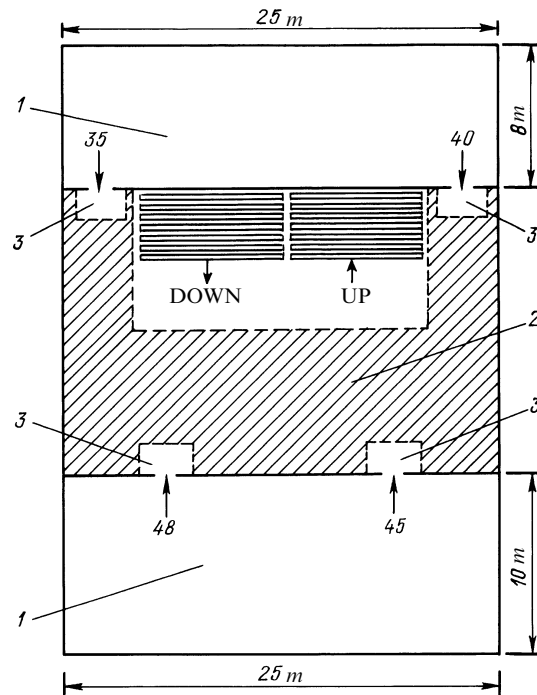


Fig. 7 Occupant loading calculation example:

- 1 — public space;
- 2 — landing credit area;
- 3 — door area;
- DOWN, UP = stairway flow path
- for upper space:

$$Z_{(\text{pers.})} = \frac{25 \text{ m} \cdot 8 \text{ m}}{2 \text{ m}^2} = 100; N_{(\text{pers.})} = 100 \cdot 0,75 = 75;$$

for lower space:

$$Z_{(\text{pers.})} = \frac{25 \text{ m} \cdot 10 \text{ m}}{2 \text{ m}^2} = 125; N_{(\text{pers.})} = 125 \cdot 0,75 = 93.$$

members of the crew in public spaces occupied to 1/3 of maximum capacity;

service spaces occupied by 1/3 of the crew;

crew accommodation occupied by 1/3 of the crew.

8. The maximum number of persons contained in a vertical zone including persons entering stairways from another main vertical zone shall not be assumed to be higher than the maximum number of persons authorized to be carried on board for the calculation of the stairway width only.

#### ADDITIONAL REQUIREMENTS

1. The aggregate width of stairway exit doors to the muster station shall not be less than the aggregate width of stairways serving this deck.

2. Means of escape plans shall be provided indicating the following:

.1 the number of crew and passengers in all normally occupied spaces;

.2 the number of crew and passengers expected to escape by the stairway and through doorways, corridors and landing;

.3 muster stations and survival craft embarkation positions;

.4 primary and secondary means of escape;

.5 width of stairways, doors, corridors and landing areas.

3. Means of escape plans shall be accompanied by detailed calculations for determining the width of escape stairways, doors, corridors and landing areas.



# PART IV. STABILITY

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## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The requirements of the present Part of the Rules apply to decked ships<sup>1</sup> sailing in displacement condition. As to sailing ships navigating under sails the requirements of the present Part apply to them as far as it is reasonable and practicable.

**1.1.2** Unless expressly provided otherwise, the requirements of the present Part apply to ships in service as far as it is reasonable and practicable, but it is, however, compulsory for ships which undergo reconstruction, major repair, alteration or modification if their stability is impaired as a result.

Stability of ships under 24 m in length after reconstruction, major repair, alteration or modification shall comply either with the requirements of this Part or with the requirements applied to such ships before reconstruction, major repair, alteration or modification.

**1.1.3** The requirements set forth in the present Part do not extend to the light-ship condition, except for the provisions given in 2.3.1.

### 1.2 DEFINITIONS AND EXPLANATIONS

**1.2.1** Definitions and explanations concerning the general terminology of the Rules are given in Part I "Classification".

For the purpose of the present Part the following definitions and explanations have been adopted.

**Amplitude of roll** is an assumed rated amplitude of roll.

**Moulded depth** is the vertical distance measured amidships from the top of plate keel or from the point where the inner surface of shell plating abuts upon the bar keel to the top of the beam of the uppermost continuous deck, i.e. of the deck below which the volume of the ship's hull is taken into account in stability calculations. In ships having a rounded gunwale, the moulded depth is measured to the point of intersection of moulded lines of the uppermost continuous deck and side, the lines extending so as if the gunwale were of angular design. If the uppermost continuous deck is stepped and the raised part of the deck extends over the point

at which the moulded depth shall be determined, the moulded depth shall be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

**Hydrostatic curves** are curves of the ship's lines plan particulars.

**Wind pressure** is an assumed rated pressure of wind.

**Diagram of limiting moments** is a diagram of limiting statical moments, on the abscissa of which ship's displacement, deadweight or draught is plotted and on the ordinate, limiting values of the vertical statical moments of masses meeting the complex of various requirements of the present Part for ship's stability.

**Length of ship** is the length as defined in the Load Line Rules for Sea-Going Ships.

**Liquid cargoes** are all liquids on board, including tanker cargo, the ship's liquid stores, ballast water, water in the antirolling tanks and in the swimming pool, etc.

**Stores** are fuel, fresh water, provision, oil, expendable supplies, etc.

**Grain** means wheat, maize (corn), oats, rye, barley, rice, pulses, seeds and processed forms thereof whose behaviour is similar to that of grain in its natural state.

**Information** is Information on Stability.

**Well** is an open space on the upper deck not longer than 30 per cent of the length of the ship, bounded by superstructures and a continuous bulwark provided with freeing ports.

**Heeling moment due to wind pressure** is an assumed rated moment caused by wind pressure.

**Amidships** is at the middle of the ship's length.

**Bulk cargo** is grain and non-grain cargo constituted by separate particles and loaded without packaging.

**Superstructure** is a decked structure on the uppermost continuous deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4 per cent of the greatest breadth of the ship. A raised quarter deck is regarded as a superstructure.

**Homogeneous cargo** is cargo having constant stowage rate.

**Capsizing moment** is an assumed rated minimum heeling moment by which the ship is capsized.

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<sup>1</sup>In Section 1 of the present Part the term "ship" also includes a floating crane, crane ship dock, transport pontoon and berth-connected ship, unless expressly provided otherwise.

Openings considered to be open are openings in the upper deck or hull sides, as well as in decks, sides and bulkheads of superstructures and deckhouses whose closures do not comply with the requirements of Section 7, Part III "Equipment, Arrangements and Outfit" as to their strength, weathertightness and efficiency. Small openings, such as discharges of ship's systems and pipes which actually have no effect on stability in dynamical heeling of a ship are not considered to be open.

Deck timber cargo is a timber cargo carried on open parts of the freeboard deck or superstructure. The said term does not apply to the wood-pulp or similar cargo.

Passage is navigation of a ship outside the prescribed area of navigation.

Voyage is navigation of a ship belonging to the technical fleet within the prescribed area of navigation.

Windage area is the projected lateral area of the above-water portion of the ship (except for a floating crane or crane ship) on the centre line plane with the ship in the upright position.

Correction for free surfaces is a correction allowing for a decrease in the ship's stability due to the effect of free surfaces of liquid cargoes.

Deck house is a decked structure on the upper deck or superstructure deck with its side plating, on one side at least, being inboard of the shell plating by more than 4 per cent of the greatest breadth of the ship measured amidships to the outside of frames and having doors, windows and other similar openings in external bulkheads.

Sister ships are ships built at the same yard according to the same drawings.

A special facility is a system permanently installed in the ship for rapid estimation of her initial stability (e.g. heeling tanks with angle-of-inclination indicators) and approved by the Register for measurement of angles of inclination during the inclining test.

Light ship is a fully ready ship less deadweight. Water ballast is included in the deadweight.

Angle of flooding is the angle of heel at which the ship's interior spaces are flooded by water through openings considered to be open or openings which may be opened as required by operation conditions of the ship in working position.

Universal diagram is a diagram of ship's stability with a non-uniform scale of abscissae proportional to the heeling angle sines, a set of cross-curves of stability for various displacements and a scale of metacentric heights (or of heights of the ship's centre of gravity) along the axis of ordinates for constructing straight half-lines determining the weight stability.

Breadth of ship is the maximum breadth measured on the summer load line from outside of frame to outside of frame in a ship with metal shell and to the outer surface of the hull in a ship with the shell of any other material.

Various symbols used in the present are given in the Table at the end of the present Part.

### 1.3 SCOPE OF SURVEY

**1.3.1** General provisions pertaining to the procedure of classification and surveys, as well as the requirements for the technical documentation submitted to the Register for consideration and approval are contained in General Regulations for the Classification and Other Activity and in Part I "Classification".

**1.3.2** For every ship subject to the requirements of the present Part, the Register shall carry out the following:

**1** prior to the commencement of ship's construction and conversion:

consideration and approval of technical documentation relating to ship's stability;

**2** during ship's construction, conversion and trials:

supervision of the inclining test and light-weight check;

consideration and approval of the Information on Stability;

consideration and approval of Guidelines on the Safe Ballast Water Exchange at Sea;

**3** during special surveys for the purpose of class renewal and after repair or modernization:

inspections to check for changes in the light-ship condition in order to conclude whether the Information on Stability is still applicable;

for passenger ships and fishing vessels, determination of light-ship weight experimentally and supervision of the inclining test and light-weight check.

### 1.4 GENERAL TECHNICAL REQUIREMENTS

**1.4.1** All calculations shall be made by the methods generally accepted in naval architecture. When using a computer, the methods of computation and programme shall be approved by the Register.

#### **1.4.2 Calculation of cross-curves of stability.**

**1.4.2.1** Cross-curves of stability shall be calculated for the waterline parallel to the design waterline.

For ships operating with permanent considerable initial trim, cross-curves of stability shall be calculated with due regard for this trim upon agreement with the Register.

Cross-curves of stability shall be calculated with due regard to the accompanying trim.

**1.4.2.2** When calculating the cross-curves of stability, full account may be taken of those tiers of superstructure which:

**.1** meet the requirements of 7.5, Part III "Equipment, Arrangements and Outfit" for the first tier of superstructure (counting from the freeboard deck); side scuttles as concerns the efficiency of their closures shall be in compliance with 7.2.1.3 to 7.2.1.5 of the said Part;

**.2** have an access for the crew from the above deck to the working spaces inside these superstructures, as well as to the engine room by other means during the whole period when the openings in the superstructure bulkheads are closed.

If a midship bridge or poop complies with the requirements of 7.5, Part III "Equipment, Arrangements and Outfit", but the doors in their bulkheads provide the only exits to the deck, and the upper edge of the sills of the superstructure doors in a fully loaded ship immerses at a heeling angle less than 60°, the effective height of superstructures shall be assumed to be half their actual height and the superstructure doors assumed to be closed. If the upper edge of the door sills of a fully loaded ship immerses at a heeling angle equal to or over 60°, its effective height above the freeboard deck is taken to be its actual height.

**1.4.2.3** When calculating the cross-curves of stability, account may also be taken of those tiers of deckhouse which:

**.1** meet the requirements of 7.5, Part III "Equipment, Arrangements and Outfit" for the first tier of deckhouse (counting from the freeboard deck); side scuttles as concerns the efficiency of their closures shall be in compliance with 7.2.1.3 to 7.2.1.5 of the said Part;

**.2** have an additional exit to the deck above.

With the aforesaid conditions satisfied, account is taken of full height of the deckhouses. If they meet the requirements of 7.5, Part III "Equipment, Arrangements and Outfit", but there is no additional exit to the deck above, such deckhouses shall not be taken into account in calculations of the cross-curves of stability, however, any deck openings inside such deckhouses are assumed as closed, irrespective of whether they are fitted with closures or not. The deckhouses whose closures do not comply with the requirements set forth in 7.5, Part III "Equipment, Arrangements and Outfit" shall not be considered in calculations of the cross-curves of stability. Any deck

openings inside them are regarded as closed only if their coamings and means of closing comply with the requirements of 7.3, 7.7 to 7.10, Part III "Equipment, Arrangements and Outfit".

**1.4.2.4** In ships with hatch covers meeting the requirements of Section 7, Part III "Equipment, Arrangements and Outfit", the volumes of hatches located on the freeboard deck may be taken into account.

**1.4.2.5** The cross-curves of stability shall have a small-scaled scheme of superstructures and deck-houses taken into account, specifying the openings considered to be open.

The point shall be indicated in relation to which the cross-curves of stability are calculated.

#### **1.4.3 Arrangement of compartments.**

A drawing of watertight compartments shall contain data necessary to calculate the positions of the centres of gravity for individual tanks filled with liquid cargoes and values of corrections for the effect of free surfaces of liquid cargoes on stability.

#### **1.4.4 Deck plan.**

**1.4.4.1** Deck plans shall include all data necessary to determine the centres of gravity of deck cargoes.

**1.4.4.2** The deck plans for passenger ships shall indicate the deck area on which passengers can walk freely and maximum permissible crowding of passengers on free areas of the deck, with passengers moving to one side of the ship (refer to 3.1.2).

#### **1.4.5 Arrangement of doors, companionways and side scuttles. Angle of flooding.**

**1.4.5.1** The arrangement plan of doors and companionways shall include all doors and companionways to exposed decks, as well as ports and hatches in the shell plating with appropriate references to their design.

**1.4.5.2** The arrangement plan of side scuttles shall incorporate all side scuttles located below the uppermost continuous deck, as well as the side scuttles in the superstructures and deckhouses taken into account when calculating the cross-curves of stability.

**1.4.5.3** A curve of angles of flooding for the lowest opening in the ship's side, deck or superstructure, assumed to be open, shall be appended to the calculations of cross-curves of stability for each ship. Openings for ventilation of machinery spaces, openings for ventilation of passenger spaces and other openings, which shall be open to allow air inside the ship when navigating in rough weather, shall be assumed open even if fitted with weathertight covers.

#### **1.4.6 Calculation of windage area of a ship (except for a floating crane or crane ship).**

**1.4.6.1** The windage area shall include the projections of all continuous surfaces of the ship's hull,

superstructures and deckhouses on the centre line plane, as well as projections of masts, ventilators, boats, deck machinery, all tents that might be stretched in stormy weather as also the projections of side surfaces of deck cargoes, including timber cargo, if the ship design makes the carriage of it possible.

For ships having auxiliary sails, the projected lateral areas of rolled up sails shall be taken into account separately according to the ship's profile plan and included in the total projected lateral area of the continuous surfaces.

It is recommended that projected lateral areas of discontinued surfaces of rails, spars (except for masts) and rigging of ships having no sails and those of various small objects be taken into account by increasing the total projected lateral area of continuous surfaces calculated for draught  $d_{\min}$  by 5 per cent and the statical moment of this area by 10 per cent with respect to the base plane.

The projected lateral areas of discontinued surfaces of ships subjected to icing is taken into account by increasing the projected lateral area and its statical moment of continuous surfaces calculated for draught  $d_{\min}$  under icing conditions by 10 and 20 per cent or 7,5 and 15 per cent, respectively, depending upon the rates of icing stated in 2.4. In this case, the value of the projected lateral area of discontinued surfaces and the position of its centre of gravity with respect to the base plane are assumed to be constant for all loading conditions.

For container ships the projected lateral area shall be taken into account as a continuous surface having no regard to the clearances between containers.

**1.4.6.2** The application of the said approximate methods for taking into account the projected lateral areas of discontinued surfaces and small objects is not obligatory. These components of windage area can be determined in a more precise way, if deemed necessary by the designer.

For this purpose when calculating the projected lateral area of rails, crane trusses of lattice type, etc., the overall areas taken into consideration, shall be multiplied by filling factors whose values are taken as follows:

For spars, tackle and shrouds of ships with no sails, values of the filling factors shall be adopted in compliance with Table 1.4.6.2 depending upon the ratio  $z_0/b_0$  where  $z_0$  is the height of the point of

Filling factor	No icing	Icing
For rails covered with meshed wire	0,6 0,2	1,2 0,8
For rails without meshed wire	0,5	1,0
For crane trusses of lattice type		

shrouds fastening to the mast over the bulwark;  $b_0$  is the distance between the shrouds at bulwark.

The projections of the hull above the waterline, deckhouses and superstructures shall be taken into account with a flow coefficient 1,0. The projections of circular section structures located separately on the deck (funnels, ventilators, masts) shall be assumed to have a flow coefficient of 0,6. When calculating in detail, the projected lateral areas of small objects, discontinued surfaces, spars, rigging, rails, shrouds, tackle, etc., a flow coefficient shall be taken equal to 1,0. If the projections of individual components of the windage area overlap one another fully or in part, the areas of only one of the overlapping projections shall be included in the calculation.

If the overlapping projections have different flow coefficients, those with higher coefficients shall be taken for the calculation.

**1.4.6.3** The arm of windage area  $z$  for determining the heeling moment due to wind pressure in accordance with 2.1.4 shall be defined as a distance, in metres, between the centre of the windage area and the actual waterline plane for an upright ship in smooth water. The position of the centre of windage area is determined by a method generally applied for determining the coordinates of the centre of gravity for a plane figure.

**1.4.6.4** The windage area and its statical moment shall be calculated for the ship's draught  $d_{\min}$ . These components for other draughts are determined by calculation. The use of linear interpolation is permissible if the second point is assumed at the draught corresponding to the summer load line.

#### **1.4.7 Calculation of the liquid cargo effect.**

**1.4.7.1** Free surface effects will exist whenever the filling level in a tank is less than 100 per cent of its capacity. Where the total free surface effects of nominally full (i.e. 98 per cent or above) tanks is small in relation to the initial metacentric height of the ship, with the agreement of the Register the

Table 1.4.6.2

Filling factors												
$z_0/b_0$	3	4	5	6	7	8	9	10	11	12	13	14
Filling factors:												
no icing	0,14	0,18	0,23	0,27	0,31	0,35	0,4	0,44	0,48	0,52	0,57	0,61
icing	0,27	0,34	0,44	0,51	0,59	0,66	0,76	0,84	0,91	1,0	1,0	1,0

effects for such tanks may be ignored. Free surface effects shall be considered whenever the filling level in a tank is less than 98 per cent.

**1.4.7.2** The tanks to be considered at determining the correction for free surfaces may be referred to one of the two categories, namely:

tanks with a permanent filling level (for example, cargo tank with liquid cargo, water ballast tank). Corrections for free surfaces shall be determined for actual filling level prescribed for each tank;

tanks with a variable filling level (for example, consumable liquids, such as fuel, oil, fresh water as well as liquid cargo and ballast at reception, consumption and transfer operations). Except for the cases stipulated in 1.4.7.4, corrections for free surfaces shall have the maximum values specified within the lower and upper filling boundaries of each tank, provided by the recommendations for ship's operation.

**1.4.7.3** Tanks for every type of liquid cargo and ballast, in which according to the operational conditions may simultaneously be free surfaces, as well as anti-heeling tanks and tanks of roll stabilizing system regardless of the tanks categories shall be included in the number of tanks to be considered at calculation of the liquid cargo effect on stability. For consideration of the free surfaces effect, it is necessary to compile the design combination of single tanks or their combinations per each type of liquid cargo. It is necessary to select tanks, which have the maximum free surfaces effect, out of possible operational combinations of tanks per the separate types of liquid cargoes and ballast, or single tanks. At

that, angles of heel, for which the maximum corrections are determined, shall be selected with respect to the stability criteria applied to the ship.

**1.4.7.4** For a ship engaged in liquids transfer operation, correction for free surfaces at any stage of the operation may be determined for the actual filling level of the tank at a given stage of transfer.

**1.4.7.5** Corrections to the initial metacentric height and the righting lever curve shall be calculated separately as follows.

**1.4.7.5.1** Corrections to the initial metacentric height  $\Delta m_h$  shall be determined as a product of liquid cargoes densities by intrinsic transverse moments of inertia of free surfaces in tanks, calculated for a ship's position without heel in compliance with the categories of tanks specified in 1.4.7.2.

**1.4.7.5.2** Corrections to the righting arms  $\Delta M_\theta$  on agreement with the Register may be determined by one of the following methods:

**1** correction calculation based on using the actual heeling moment due to the liquid flow in tanks for each angle of ship's heel under consideration;

**2** correction calculation based on using the intrinsic transverse moment of inertia of free surfaces in tanks for a ship's position without heel corrected for each angle of ship's heel  $\theta$  under consideration by multiplying by  $\sin \theta$ ;

**3** correction calculation performed for a design combination of tanks in accordance with the Formula (1.4.7.7).

With the exception of 1.4.7.5.2.3 corrections may be calculated according to the tank categories indicated in 1.4.7.2.

Table 1.4.7.7

Factor  $\bar{l}_\theta$ 

$\bar{l}_\theta = \frac{\sin \theta}{12} \left(1 + \frac{\text{tg}^2 \theta}{2}\right) \cdot \frac{b_T}{a_T}, \quad \text{ctg} \theta \geq b_T/a_T$													
$\bar{l}_\theta = \frac{\cos \theta}{8} \left(1 + \frac{\text{tg} \theta}{b_T/a_T}\right) - \frac{\cos \theta}{12(b_T/a_T)^2} \left(1 + \frac{\text{ctg}^2 \theta}{2}\right), \quad \text{где } \text{ctg} \theta < b_T/a_T$													
$\theta, b_T/a_T$	5	10	15	20	30	40	45	50	60	70	75	80	85
20	0,11	0,12	0,12	0,12	0,11	0,10	0,09	0,09	0,09	0,05	0,04	0,03	0,02
10	0,07	0,12	0,12	0,12	0,11	0,10	0,10	0,09	0,07	0,05	0,04	0,03	0,02
5	0,04	0,10	0,11	0,11	0,11	0,11	0,10	0,10	0,08	0,07	0,06	0,05	0,04
3	0,02	0,07	0,09	0,09	0,11	0,11	0,11	0,10	0,09	0,08	0,07	0,06	0,05
2	0,01	0,04	0,06	0,06	0,09	0,11	0,11	0,11	0,10	0,09	0,09	0,08	0,07
1,5	0,01	0,03	0,05	0,05	0,07	0,10	0,11	0,11	0,11	0,11	0,10	0,10	0,09
1	0,01	0,02	0,03	0,03	0,05	0,07	0,09	0,10	0,12	0,13	0,13	0,13	0,13
0,75	0,01	0,01	0,02	0,02	0,02	0,04	0,04	0,05	0,09	0,16	0,18	0,21	0,16
0,5	0,00	0,01	0,02	0,02	0,02	0,04	0,04	0,05	0,09	0,16	0,18	0,21	0,23
0,3	0,00	0,01	0,01	0,01	0,01	0,02	0,03	0,03	0,05	0,11	0,19	0,27	0,34
0,2	0,00	0,00	0,01	0,01	0,01	0,01	0,02	0,02	0,04	0,07	0,13	0,27	0,45
0,1	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,02	0,04	0,06	0,14	0,53

**1.4.7.6** Information on Stability shall contain only a method used for the calculation of corrections to the righting arms. If instructions on manual assessment of stability for a non-typical loading case provide for an alternative method, the instructions shall include an example of correction for free surfaces calculation with explanation of reasons of different results of manual correction calculation and of calculations by the adopted method.

**1.4.7.7** The values of the correction to the righting arms may be determined by the approximation formula

$$\Delta M_{\theta} = \bar{l}_{\theta} v_{\tau} b_{\tau} \gamma \sqrt{C_b} . \quad (1.4.7.7)$$

**1.4.7.8** The tanks complying with the following condition shall not be included in the calculation:

$$\Delta M_{30} < 0,01 \Delta_{\min} ; \quad (1.4.7.8-1)$$

for floating cranes, the tanks complying with the following condition shall not be included in the calculation:

$$\Delta M_{15} < 0,02 \Delta_{\min} ; \quad (1.4.7.8-2)$$

where  $\Delta M_{30}$ ,  $\Delta M_{15}$  = heeling moments due to liquids flow at angles of heel equal to 30° and 15°.

Aggregate correction  $\Delta M_{15}$  for tanks not included in the calculation shall not exceed  $0,05 \Delta_{\min}$ . Otherwise, appropriate corrections shall be considered in the calculation.

Usual residues of liquids in emptied tanks shall not be considered in the calculations provided, that the total number of these residues shall not result in considerable increase of the free surfaces effect on ship's stability.

#### **1.4.8 Loading condition.**

**1.4.8.1** Stability shall be checked under all loading conditions specified in Sections 3 and 4 for various types of ships.

**1.4.8.2** For the types of ships which are not covered by special provisions of Section 3, the loading conditions to be examined shall be as follows:

- .1 ship in fully loaded condition with full stores;
- .2 ship in fully loaded condition with 10 per cent of stores;
- .3 ship without cargo, with full stores;
- .4 ship without cargo, with 10 per cent of stores.

**1.4.8.3** If the loading conditions anticipated in normal service of a ship as regards stability are less favourable than those listed in 1.4.8.2 or specified in Section 3, stability shall also be checked for these conditions.

**1.4.8.4** If there is solid ballast on board, its mass shall be included in the light-ship condition.

**1.4.8.5** In all cases of loading which might occur in the ship's service, except those specified in 1.4.8.2.1 and expressly provided in Section 3, the

weight of ballast water may be included in the deadweight of the ship, where necessary.

#### **1.4.9 Curves of stability.**

**1.4.9.1** Stability curves calculated with due allowance for the corrections of free surfaces shall be plotted for all loading conditions under consideration.

**1.4.9.2** If there are openings considered to be open in the ship's sides, upper deck or superstructures through which water can penetrate inside the hull, the stability curves are considered effective up to the angle of flooding. At the inclinations of the ship exceeding the angle of flooding, the ship may be regarded to have entirely lost her stability and the curves of stability at this angle are cutting short.

**1.4.9.3** If the spread of water coming to a superstructure through openings considered to be open is limited only by this superstructure or a part thereof, such superstructure or its part shall be considered as non-existent at the angles of heel exceeding the angle of flooding. In this case, the righting lever curve becomes stepped and that of dynamical stability broken.

#### **1.4.10 Design data relating to stability checking and summary tables.**

**1.4.10.1** For ships under investigation, all design data relating to stability checking (calculations of loading, initial stability, curves of stability, windage area, amplitudes of roll, heeling due to crowding of passengers on one side, heeling when turning as also that due to icing, etc.) shall be submitted to the Register for consideration.

**1.4.10.2** For all design loading conditions, summary tables presenting the results of calculations of displacement, position of the centre of gravity, initial trim and stability, as well as summary tables of results of stability checking for the compliance with the requirements of the present Part shall be drawn up.

#### **1.4.11 Requirements for Information on Stability.**

**1.4.11.1** To provide adequate stability of ships in service, the Information on Stability approved by the Register and containing the following data shall be issued for each ship:

- .1 particulars of ship;
- .2 information on how the ship conforms to stability criteria and directions based on the Register requirements for stability, to prevent the ship capsizing;
- .3 recommendations concerning stability and other instructions for safe service;
- .4 stability data for typical, predetermined loading conditions;
- .5 advice and documents necessary to estimate trim and stability of the ship for any cases of full and partial loading which might occur in the ship's service.

The trim and stability of the ship shall be determined by calculation.

The Information on Stability shall be drawn up strictly in accordance with the provisions of Appendix 1 to the present Part.

**1.4.11.2** The Information on Stability shall be compiled with regard to the ship's inclining test data.

For ships where the inclining test may be substituted by the light-weight check in compliance with 1.5.2.1, to be used in the Information are the light-ship displacement and longitudinal center of gravity derived from the light-weight check in conjunction with the light-ship vertical center of gravity derived from the inclining test.

For ships, whose light-ship properties deviation is within the limits specified in 1.5.2.2, to be used in the Information are the light-ship displacement and longitudinal center of gravity derived from the light-weight check in conjunction with the higher of either the lead ship's (previous sister ship's) vertical center of gravity or the calculated value.

For ships, whose light-ship properties deviation is within the limits specified in 1.5.3, to be used in the Information are the light-ship displacement and longitudinal center of gravity derived from the light-weight check in conjunction with the higher of either the light-ship vertical center of gravity derived from the inclining test prior to conversion or the design vertical center of gravity following the conversion.

For ships where inclining test may be omitted in compliance with 1.5.7, to be used in the Information are the light-ship displacement and longitudinal center of gravity derived from the light-weight check in conjunction with the light-ship vertical center of gravity determined according to 1.5.7. It shall be stated in the Information that the ship has been subjected to light-weight check instead of inclining test, and the light-ship vertical center of gravity has been calculated in compliance with 1.5.7.

**1.4.11.3** Where bulk cargoes other than grain are carried, special Information on Stability and Strength during Loading, Unloading and Stowage of Bulk Cargoes Other Than Grain shall be available on board, which shall be drawn in accordance with 1.4.9.7, Part II "Hull".

**1.4.12 Requirements for onboard stability instrument.**

Where the ship trim and stability is determined by using software, the latter shall be approved by the Register in accordance with the requirements of Section 12, Part II "Technical Documentation" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships; requirements relating to hardware are set out in Appendix 2, Part II "Hull" of the present Rules.

Availability of the software approved by the Register on board to control the ship's trim and

stability shall not be considered as a ground for deleting any section of the Information on Stability.

The procedure of using software shall be specified in the user manual for the onboard stability instrument. The manual shall be compiled in the user native language and translated into English. The manual shall contain a statement that the serviceability of the onboard stability instrument shall be checked by the crew prior to its use.

**1.4.13 Requirements for the Ballast Water Management Plan.**

When ships in service call ports which require exchange of the water ballast at sea in advance, they shall have Guidelines on the Safe Ballast Water Exchange at Sea.

## 1.5 INCLINING TESTS AND LIGHT-WEIGHT CHECKS

**1.5.1** To be inclined are:

- .1 series-built ships as per 1.5.2;
- .2 every ship of non-series construction;
- .3 every ship after reconstruction;
- .4 ships after major repair, alteration or modification as per 1.5.3;
- .5 ships after installation of permanent solid ballast as per 1.5.4;
- .6 ships whose stability is unknown or gives rise to doubts;
- .7 passenger ships in service at intervals not exceeding five years if stipulated by 1.5.5.
- .8 fishing vessels in service (of 30 metres length and less) at intervals not exceeding fifteen years and fishing vessels over 30 metres length if stipulated by 1.5.5.

**1.5.2** Out of the series of ships under construction at each shipyard the following ships shall be inclined:

- .1 the first ship, then every fifth ship of the series (i.e. sixth, eleventh, etc.). For other ships of the series, upon agreement with the Maritime Administration (for each particular ship), the inclining test may be substituted by the light-weight check in accordance with 1.5.14.

Depending on the seasonal conditions during the delivery of the ship and subject to special agreement with the Register, the inclining test of the next ship of the series may be permitted instead of the ship to be delivered. Beginning from the twelfth ship of the series, the Register may require the inclining of the smaller number of ships if it is demonstrated to the satisfaction of the Register that in the process of constructing the ships of the series stability of their mass and centre of gravity position is ensured within the limits stated in 1.5.2.2;

- .2 a series-built ship if structural alterations therein compared with the first ship of the series, as shown by the calculation, result in:

**.2.1** the changes of the light-ship displacement: for  $L \leq 50$  m — exceeding 2 per cent, for  $L \geq 160$  m — exceeding 1 per cent, for intermediate length — the acceptable deviation is determined by linear interpolation; or

**.2.2** the deviation of the light-ship longitudinal centre of gravity exceeding 0,5 per cent of the length of the lead ship; or

**.2.3** the increase of the light-ship vertical centre of gravity exceeding simultaneously 4 cm (10 cm in the case of floating cranes and crane ships) and the value determined by the formulae:

$$\delta z_g = 0,1 \frac{\Delta_1}{\Delta_0} l_{\max}; \quad (1.5.2.2.3-1)$$

$$\delta z_g = 0,05 \frac{\Delta_1}{\Delta_0} h \quad (1.5.2.2.3-2)$$

where  $\Delta_0$  = light-ship displacement, in t;

$\Delta_1$  = ship's displacement under the most unfavourable loading condition as regards the value of  $h$  or  $l_{\max}$ , in t;

$l_{\max}$  = maximum righting arm under the most unfavourable design loading condition as regards its value;

$h$  = corrected metacentric height under the most unfavourable design loading condition as regards its value,

whichever is the less;

**.2.4** violation of the requirements of the present Part for design loading conditions with  $z_g = 1,2z_{g2}$  —  $0,2z_{g1}$ , where  $z_{g1}$  ( $z_{g2}$ ) is design light-ship vertical centre of gravity prior to (after) structural changes;  $z_g$  is an assumed light-ship vertical centre of gravity.

Such ship shall be considered the first ship of a new series as regards stability, and the inclining test procedure of the subsequent ships shall comply with the requirements of 1.5.2.1.

**1.5.3** After major repair, alteration and modification to be inclined are ships, in which structural changes, as shown by calculation, result in:

**.1** change of load (total mass of loads removed or added) by more than 6 per cent of the light-ship displacement; or

**.2** change in the light-ship displacement by more than 2 per cent or 2 t, whichever is greater; or;

**.3** the deviation of the light-ship longitudinal centre of gravity exceeding 1 per cent of the length of the ship; or

**.4** increase in the light-ship vertical centre of gravity by more than the value obtained as per 1.5.2.2.3; or

**.5** violation of the requirements of the present Part for design loading conditions as specified in 1.5.2.2.4.

If no inclining test is required upon results of the calculation, the light-weight check shall be carried out in accordance with 1.5.14.

Irrespective of the calculations submitted, the Register may require in compliance with 1.5.1.6 the inclining test of the ship to be performed, proceeding from the technical condition of the ship.

**1.5.4** After installation of the permanent solid ballast each ship shall be inclined.

The inclining test of the ship may be omitted if the Register is satisfied that when installing the ballast, efficient control is effected to ensure the design values of mass and centre of gravity position, or these values can be properly confirmed by calculation.

**1.5.5** Light-weight check (experimental determination of the light-ship displacement and the longitudinal centre of gravity) shall be effected periodically for finding whether according to the 1.5.1.7 and 1.5.1.8 the inclining test is required for:

**.1** passenger ships;

**.2** fishing vessels over 30 metres length after 10 years in service from the date of build or last inclining test.

Light-weight check shall be carried out at intervals not more than five years.

If a change in the light-ship displacement by more than 2 per cent or in longitudinal centre of gravity by more than 1 per cent of the ship's length as compared to the approved Information on Stability is found out as a result of the light-weight check then the ship shall be inclined.

**1.5.6** Where the inclining test results for the ship built show that the light-ship vertical centre of gravity exceeds design value to the extent that involves the violation of the requirements of the present Part, calculations with explanation of the reasons of such differences shall be attached to the Inclining Test Report.

Based on the investigation analysis of the documents submitted, or in case such documents are not available, the Register may require the repeated (check) inclining test of the ship to be performed. In this case, both Inclining Test Reports shall be submitted to the Register for consideration.

**1.5.7** Except for the ships engaged on international voyages, at the shipowner's wish the Register may substitute the inclining test of a newly built ship by the light-weight check provided an increase of a light-ship vertical centre of gravity by 20 per cent as against the design value will not result in the violation of the requirements of the present Part.

If the light-weight check results show that the deviation of the light-ship displacement exceeds 2 per cent of the design value or the deviation of the light-ship longitudinal center of gravity exceeds 1 per cent of the design value, the explanatory calculation of such difference shall be attached to the Light-Weight Check Report.

**1.5.8** Ship's loading during the inclining test shall be as far as practicable close to the light-ship displacement. The mass of missing loads shall be not more than 2 per cent of the light-ship displacement, and the mass of surplus loads less inclining ballast and ballast according to 1.5.9, 4 per cent.



**1.5.9** The metacentric height of the ship in the process of the inclining test shall be at least 0,20 m. For this purpose necessary ballast may be taken. When water ballast is taken, the tanks shall be carefully pressed up.

**1.5.10** To determine angles of inclination during the inclining test not less than three pendulums of at least 3 m in length shall be provided onboard. For ships under 30 m in length only two pendulums of at least 2 m in length may be used.

One or more pendulums may be substituted by other measuring devices approved by the Register.

**1.5.11** In well performed inclining test the value of the metacentric height obtained may be used in calculations with no deduction for probable error of the test.

The inclining test is considered to be satisfactory performed, provided:

**.1** for each measurement the following condition is fulfilled:

$$|h_i - h_k| \leq 2 \sqrt{\frac{\sum (h_i - h_k)^2}{n - 1}} \quad (1.5.11.1)$$

where  $h_i$  = metacentric height obtained by individual measurement;

$h_k = \sum h_i / n$  is metacentric height obtained in inclining the ship;  
 $n$  = number of measurements.

Measurements not meeting the above condition are excluded when treating the results with appropriate change of the total number  $n$  and repeated calculation of the metacentric height  $h_k$ .

No more than one measurement is excluded from the calculation (greater number of measurements may be excluded only in well-grounded cases on agreement with the Register);

**.2** probable error of the test

$$t_{zn} \sqrt{\frac{\sum (h_i - h_k)^2}{n(n - 1)}}$$

fulfils the condition

$$t_{zn} \sqrt{\frac{\sum (h_i - h_k)^2}{n(n - 1)}} \leq 0,02(1 + h_k) \text{ if } h_k \leq 2 \text{ m} \quad (1.5.11.2-1)$$

and

$$t_{zn} \sqrt{\frac{\sum (h_i - h_k)^2}{n(n - 1)}} \leq 0,01(4 + h_k) \text{ if } h_k > 2 \text{ m}. \quad (1.5.11.2-2)$$

Factor  $t_{zn}$  is taken from Table 1.5.11;

**.3** the following condition is fulfilled considering  $h$  and  $l_{\max}$  under the most unfavorable design loading conditions:

$$t_{zn} \sqrt{\frac{\sum (h_i - h_k)^2}{n(n - 1)}} \frac{\Delta_0}{\Delta_1} \leq \varepsilon, \text{ where } \varepsilon = 0,05h \text{ or } 0,10l_{\max}, \quad (1.5.11.3)$$

whichever is less, but not less than 4 cm.

Table 1.5.11

Factor $t_{zn}$			
$n$	$t_{zn}$	$n$	$t_{zn}$
8	5,4	13	4,3
9	5,0	14	4,2
10	4,8	15	4,1
11	4,6	16	4,0
12	4,5		

**.4** total number of satisfactory measurements is not less than 8.

**1.5.12** Where the requirements of 1.5.11 are not fulfilled, the value of the metacentric height less the probable error of the test obtained as per 1.5.11.2 may be taken for calculations upon agreement with the Register.

**1.5.13** The inclining test shall be performed in accordance with the Instructions on Inclining Test (refer to 2.17, Part V "Technical Supervision During Construction of Ships" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships) and shall be witnessed by a Surveyor to the Register.

Other methods of experimentally determining the light-ship weight and the coordinates of its centre of gravity may be permitted, provided that it is demonstrated to the satisfaction of the Register that the accuracy of the inclining test results meets the present requirements.

**1.5.14** The light-weight check shall be carried out in accordance with the Instructions on Inclining Test (refer to 2.17, Part V "Technical Supervision During Construction of Ships" of Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships) in the presence of the Register attending Surveyor.

The light-weight check is carried out with the aim to:

**.1** determine the necessity of conducting the inclining test in accordance with 1.5.5;

**.2** correct the Information on Stability for ships of the series and after conversion as specified in 1.4.11.2;

**.3** determine the light-ship properties of the ship exempted from the inclining test in accordance with 1.5.7.

## 1.6 DEPARTURES FROM THE RULES

**1.6.1** If doubts arise with regard to stability of any ship when the requirements of the present Part are formally complied with, the Register may require checking of the ship's stability against additional criteria.

In case where the requirements set forth in the present Part are considered to be too severe, the

Register may permit, on a well-grounded statement of design and service bodies, appropriate departures from these requirements for the ship concerned.

**1.6.2** When a ship navigating in a particular area does not comply with the requirements of the present Part, the Register may, in each particular case, either restrict the ship's area of navigation or place other limitations depending upon the ship's stability characteristics, service conditions and purpose the ship is intended for.

### 1.7 CONDITIONS OF SUFFICIENT STABILITY

**1.7.1** Under the most unfavourable loading conditions with regard to stability, the ship's stability, except for floating cranes, crane ships, pontoons, floating docks and berth-connected ships shall comply with the following requirements:

**.1** the ship shall withstand, without capsizing, simultaneously the effect of dynamically applied wind pressure and rolling the parameters of which are determined in compliance with Section 2;

**.2** numerical values of the parameters of the righting lever curve for the ship on still water and the values of the corrected initial metacentric height shall not be below those specified in Section 2;

**.3** the effect of consequences of probable icing upon stability shall be taken into account in compliance with Section 2;

**.4** stability of a ship shall comply with additional requirements of Section 3.

**1.7.2** The stability of floating cranes, crane ships, transport pontoons, floating docks and berth-connected ships shall comply with the requirements of Section 4.

**1.7.3** For ships to which the requirements of Part V "Subdivision" are applicable, the intact stability shall be sufficient to meet these requirements in damaged condition.

**1.7.4** Stability of ships which have distinguishing marks of provision with means for fighting fires on board other ships in their class notation shall meet the requirements of the present Part in the course of fire-fighting operations on the assumption that all monitors operate simultaneously with the maximum supply rate in the direction corresponding to the minimum stability of the ship.

### 1.8 PASSAGE OF SHIPS FROM ONE PORT TO ANOTHER

**1.8.1** When passing from one port to another, the ship's stability shall meet the requirements imposed upon ships navigating in a region through which the passage is expected to be undertaken.

**1.8.2** The Register may permit the passage of a ship which stability cannot be raised up to that required by 1.8.1 provided that the weather restrictions correspond to its stability.

## 2 GENERAL REQUIREMENTS FOR STABILITY

### 2.1 WEATHER CRITERION<sup>1</sup>

**2.1.1** The requirements for stability set forth in the present Part are differentiated depending upon the ship's area of navigation.

Definitions of restricted areas of navigation are given in 2.2.5, Part I "Classification".

**2.1.2** Stability of ships of unrestricted service and of restricted areas of navigation **R1**, **R2**, **R2-RSN** and **R3-RSN** shall be considered sufficient as to weather criterion *K*, if the requirements of 2.1.2.5 are met under the assumed effects of wind and seas mentioned below, and:

<sup>1</sup> When calculating the weather criterion, the results of model tests may be used carried out in compliance with the requirements of Interim Guidelines for Alternative Assessment of the Weather Criterion (refer to Collection of Regulating Documents. Book Eighteen, 2008)

**.1** the ship is under the effect of a wind of steady speed and direction perpendicular to the ship center plane, to which the lever  $l_{w1}$  of wind heeling moment corresponds (refer to Fig. 2.1.2.1);

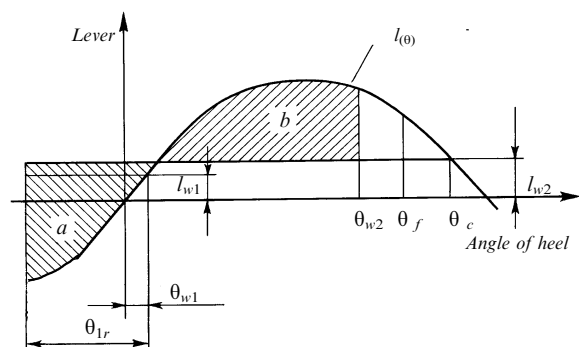


Fig. 2.1.2.1

.2 by the static heeling angle  $\theta_{w1}$  resulting from steady wind and corresponding to the first point of intersection between the horizontal straight line  $l_{w1}$  and the curve of righting levers  $l(\theta)$ , the ship heels to the weather side under the effect of waves, to an angle equal to the roll amplitude  $\theta_{1r}$  (refer to Fig. 2.1.2.1);

.3 the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever  $l_{w2}$ ;

.4 the areas  $a$  and  $b$  are determined and compared, which are shaded in Fig. 2.1.2.1. The area  $b$  is formed by a righting lever curve  $l(\theta)$ , a horizontal straight line corresponding to the heeling lever  $l_{w2}$  and the heeling angle  $\theta_{w2}=50^\circ$ , or the angle of flooding  $\theta_f$  or the heeling angle  $\theta_c$ , corresponding to the second point of intersection between the straight line  $l_{w2}$  and the righting lever curve, whichever angle is less.

The area  $a$  is formed by the righting lever curve, straight line  $l_{w2}$  and heeling angle equal to  $\theta_{w1}-\theta_{1r}$ ;

.5 the ship stability is considered sufficient by the weather criterion  $K=b/a$ , provided the area  $b$  is equal to or greater than the area  $a$ , i.e.  $K \geq 1$ . For meteorological ships, the weather criterion  $K$  is specially considered by the Register in each case; it is recommended this value shall be not less than 1,5.

**2.1.3** The static heeling angle  $\theta_{w1}$  due to steady wind shall not exceed  $16^\circ$  or an angle equal to 0,8 of the open deck edge immersion angle, whichever is less.

The requirements for the static heeling angle of timber carriers and container ships are given in 3.3 and 3.10.

#### 2.1.4 Calculation of heeling lever due to wind pressure.

**2.1.4.1** The heeling lever  $l_{w1}$ , in m, shall be adopted constant for all heeling angles and shall be determined by the formula

$$l_{w1} = p_v A_v z_v / 1000 g \Delta \quad (2.1.4.1-1)$$

where  $p_v$  = wind pressure, in Pa, to be determined from Table 2.1.4.1 proceeding from the area of navigation;

$z_v$  = arm of windage area to be adopted equal to the vertical distance between the windage area centre  $A_v$  and the centre of the underwater hull lateral area projected on the centre plane or, approximately, the half of the ship draught;

$A_v$  = windage area, in  $m^2$ , to be determined in accordance with 1.4.6;

$\Delta$  = ship displacement, in t;

$g$  = gravitational acceleration, equal to  $9,81 \text{ m/s}^2$ .

Table 2.1.4.1

Wind pressure  $p_v$ 

Area of navigation	Wind pressure $p_v$ , in Pa
Unrestricted	504
Restricted <b>R1</b>	353
Restricted <b>R2</b> , <b>R2-RSN</b> , <b>R3-RSN</b>	252

The heeling lever  $l_{w2}$  shall be determined by the formula

$$l_{w2} = 1,5 l_{w1} \quad (2.1.4.1-2)$$

**2.1.4.2** For fishing vessels having a length between 24 m and 45 m, the wind pressure value in the Formula (2.1.4.1-1) may be ascertained from Table 2.1.4.2 proceeding from the distance  $Z$  between the windage area centre and the waterline.

Table 2.1.4.2

$Z$ , in m	1	2	3	4	5	$\geq 6$
$P_v$ , in Pa	316	386	429	460	485	504

**2.1.4.3** At the discretion of the Register, the ships whose stability with respect to the weather criterion does not comply with the requirements for the ships of restricted area of navigation **R2**, may be allowed to operate as ships of restricted area of navigation **R3** with additional restrictions, taking into account the peculiarities of the area and the nature of service.

The requirements for stability of floating cranes and crane ships are stipulated in 4.1.

#### 2.1.5 Calculation of roll amplitude.

**2.1.5.1** The roll amplitude, in deg., for a round-bilged ship shall be determined by the formula

$$\theta_{1r} = 109 k X_1 X_2 \sqrt{r S} \quad (2.1.5.1)$$

where  $k$  = factor taking into account the effects of bilge and/or bar keels and determined in accordance with 2.1.5.2;  $k$  shall be adopted equal to 1 where the keels are not mounted;

$X_1$  = dimensionless factor to be adopted from Table 2.1.5.1-1 proceeding from the breadth-to-draught ( $B/d$ ) ratio;

$X_2$  = dimensionless factor to be adopted from Table 2.1.5.1-2 proceeding from the block coefficient  $C_B$  of the ship;

$r = 0,73 + 0,6(z_g - d)/d$ , while  $r$  shall not be adopted greater than 1;

$S$  = dimensionless factor to be adopted from Table 2.1.5.1-3 proceeding from the area of navigation and the roll period  $T$  to be determined by the formula

$$T = 2cB/\sqrt{h}$$

where  $c = 0,373 + 0,023B/d - 0,043L_{wl}/100$ ;

$h$  = metacentric height corrected for the effect of free surfaces of liquid cargoes;

$L_{wl}$  = length of ship on the waterline.

Table 2.1.5.1-1

Factor  $X_1$ 

$B/d \leq 2,4$	2,6	2,8	3,0	3,2	3,4	3,5	3,6	4,0	4,5	5,0	5,5	6,0	$\geq 6,5$
$X_1$	1,00	0,96	0,93	0,90	0,86	0,82	0,80	0,79	0,78	0,76	0,72	0,68	0,62

Table 2.1.5.1-2

Factor  $X_2$ 

$C_B$	$\leq 0,45$	0,50	0,55	0,60	0,65	$\geq 0,70$
$X_2$	0,75	0,82	0,89	0,95	0,97	1,00

Table 2.1.5.1-3

Area of navigation	Factor <i>S</i>									
	<i>T</i> , in s									
	≤5	6	7	8	10	12	14	16	18	≥20
Unrestricted	0,100	0,100	0,098	0,093	0,079	0,065	0,053	0,044	0,038	0,035
Restricted R1, R2, R2-RSN, R3-RSN	0,100	0,093	0,083	0,073	0,053	0,040	0,035	0,035	0,035	0,035

**2.1.5.2** For ships with bilge keels or bar keel, or both, the factor *k* shall be adopted from Table 2.1.5.2 proceeding from the  $A_k/L_{wl}B$  ratio in which  $A_k$  denotes the total area, in m<sup>2</sup>, of bilge keels or the lateral projected area of the bar keel, or the sum of both areas.

The bilge keels for ships having the **Arc4** to **Arc9** ice category mark in their class notation shall be ignored.

Table 2.1.5.2

Factor <i>k</i>								
$A_k/L_{wl}B, \%$	0	1,0	1,5	2,0	2,5	3,0	3,5	≥4,0
<i>k</i>	1,00	0,98	0,95	0,88	0,79	0,74	0,72	0,70

**2.1.5.3** When calculating the roll amplitude by the Formula (2.1.5.1), coefficient *k* for sharp-bilged ships shall be adopted equal to 0,7.

**2.1.5.4** The roll amplitudes of ships equipped with anti-rolling devices shall be determined without regard for the operation of the latter.

**2.1.5.5** In Tables 2.1.5.1-1 to 2.1.5.2 the intermediate values shall be determined by linear interpolation. The calculated roll amplitude values shall be rounded to integer degrees.

## 2.2 RIGHTING LEVER CURVE

**2.2.1** The area under the righting lever curve shall be not less than 0,055 m·rad up to the heeling angle of 30° and not less than 0,09 m·rad up to the heeling angle of 40°. Besides, the area between the heeling angles of 30° and 40° shall be not less than 0,03 m·rad.

The maximum righting arm  $l_{\max}$  shall be not less than 0,25 m for ships with  $L \leq 80$  m and 0,20 m for ships with  $L \geq 105$  m at the heeling angle  $\theta_m \geq 30^\circ$ . For intermediate values of *L*, the arm value shall be determined by linear interpolation.

On agreement with the Register, the angle corresponding to the maximum of the righting lever curve may be reduced to 25°.

Where the righting lever curve has two maxima due to the influence of superstructures or deckhouses, the first maximum from the upright position shall occur at the angle of heel not less than 25°.

The limit of positive statical stability (the angle of vanishing stability) shall be not less than 60°. However, for the ships of restricted area of navigation **R3-RSN** it may be lowered to 50°, provided that every lowering by 1° is accompanied by an increase of the maximum righting arm by 0,01 m above the specified value.

**2.2.2** Ships with ratio  $B/D > 2$  are allowed to navigate having the angle of vanishing stability and the angle corresponding to the maximum righting arm less than those required by 2.2.1 by the following values:

**.1** angle of vanishing stability, by a value  $\Delta\theta_v$  determined by the formula

$$\Delta\theta_v = 40^\circ \left( \frac{B}{D} - 2 \right) (K - 1). \quad (2.2.2.1)$$

Where  $B/D > 2,5$  and  $K > 1,5$ , the ratio  $B/D = 2,5$  and  $K = 1,5$  shall be adopted. The value of  $\Delta\theta_v$  shall be rounded off to the nearest integer;

**.2** angle corresponding to the maximum righting arm, by a value equal to half the decrease in the angle of vanishing stability. The angle shall not be assumed less than 25°.

**2.2.3** A ship shall comply with the aforesaid requirements when the correction for free surfaces is taken into account in righting lever curves in accordance with the provisions of 1.4.7.

**2.2.4** For ships not complying with the requirements of this Chapter with respect to the angle of vanishing stability because of the curve cut short at the angle of flooding, navigation may be permitted as for ships of restricted service depending upon the value of wind pressure endured when checking stability for compliance with the weather criterion.

On agreement with the Register, for the ships of 105 m in length and over of unrestricted area of navigation, the angle of flooding can be reduced to 50°, provided that every lowering by 1° is accompanied by an increase of the maximum righting arm by 0,01 m above the specified value.

The assignment of navigation area in accordance with the above requirements can be done only on condition that the conventional angle of vanishing stability determined on the assumption of weather-tight closures of the openings through which flooding of hull spaces occurs shall be not less than that required by this Chapter.

**2.2.5** The requirements for the righting lever curve of floating cranes and crane ships, refer to 4.1.

### 2.3 METACENTRIC HEIGHT

**2.3.1** For all ships under all loading conditions, except for the light-ship condition, the value of corrected initial metacentric height shall be not less than 0,15 m.

The minimum corrected initial metacentric height may have other value in cases specified in Section 3.

For all ships, except for fishing vessels, whale factory ships, fish factory ships and other ships used for processing the living resources of the sea and not engaged in catching the same, negative initial metacentric height for a light ship is subject to special consideration by the Register in each case.

**2.3.2** Initial stability of well-deck ships shall be checked for the case of water penetration into the well.

Amount of water in the well and its free surface shall correspond to the water level up to the lower edge of the freeing ports for a ship in upright position allowing for the deck camber.

If a ship has two or more wells, stability shall be checked for the case of flooding of the largest one.

### 2.4 ALLOWANCE FOR ICING

**2.4.1** For ships intended for winter navigation within winter seasonal zones set up by Load Line Rules for Sea-Going Ships, stability with due regard for icing, as specified in this Chapter, shall be checked in addition to the main loading conditions. In the calculation, account shall be taken of increase in displacement, height of the centre of gravity and windage area due to icing. The stability calculation under icing shall be carried out for the worst loading condition as to stability. When checking stability under icing, the mass of the ice is considered as an overload and is not included in the ship's deadweight.

When verifying the stability of floating cranes and crane ships, the allowance for icing shall be made in accordance with 4.1.

**2.4.2** When determining the heeling and capsizing moments for ships navigating in winter seasonal zones to the north of latitude 66°30' N and to the south of latitude 66°00' S, as also in winter in the Bering Sea, the Sea of Okhotsk and in the Tatarski Strait, the assumed rates of icing shall be as specified in 2.4.3 and 2.4.4.

**2.4.3** The mass of ice per square metre of the total area of horizontal projection of exposed weather decks shall be assumed to be 30 kg. The total horizontal projection of decks shall include horizontal projections of all exposed decks and gangways, irrespective of the availability of awnings. The vertical moment due to this loading is determined for heights of the centre of gravity of the corresponding areas of decks and gangways.

The deck machinery, arrangements, hatch covers, etc. are included in the projection of decks and not taken into account separately.

For ships with framing fitted above open deck sections, allowance shall be made for an additional mass of ice having the thickness equal to the main framing height.

**2.4.4** The mass of ice per square metre of the windage area shall be assumed to be 15 kg. In this case, the windage area and the height of the centre of gravity shall be determined for a draught  $d_{\min}$ , as specified in 1.4.6, but without the allowance for icing.

**2.4.5** In other areas of the winter seasonal zone, the rates of icing for winter time shall be assumed to be equal to half those specified in 2.4.3 and 2.4.4, except for the areas where, on agreement with the Register, icing may not be taken into account.

**2.4.6** The mass of ice and vertical moment calculated in compliance with 2.4.3 to 2.4.5 cover all loading conditions when drawing up the Information.

**2.4.7** For the righting lever curves plotted with the allowance for icing, the angle of vanishing stability shall be not less than 55° and the maximum righting arm for ships of restricted service shall be at least 0,2 m at an angle of heeling not less than 25°.

For ships with ratio  $B/D > 2$ , an additional reduction of the angle of vanishing stability  $\theta_v$  is permissible by the values equal to half those determined from the Formula (2.2.2.1).

**2.4.8** For ships navigating in winter in the regions of the Black and Asov Seas northwards of the parallel of latitude 44°00' N, as well as in the region of the Caspian Sea northwards of the parallel of latitude 42°00' N the icing shall be taken into account in compliance with 2.4.5.

### 3 ADDITIONAL REQUIREMENTS FOR STABILITY<sup>1</sup>

#### 3.1 PASSENGER SHIPS

**3.1.1** Stability of passenger ships shall be checked for the following loading conditions:

**.1** ship in the fully loaded condition, with full number of class and unberthed passengers and their effects, and full stores without liquid ballast;

**.2** ship in the fully loaded condition, with the full number of class and unberthed passengers and their effects, but with 10 per cent of stores;

**.3** ship without cargo, but with the full number of class and unberthed passengers and their effects and with full stores;

**.4** ship in the same loading condition as in 3.1.1.3, but with 10 per cent of stores;

**.5** ship without cargo and passengers, but with full stores;

**.6** ship in the same loading condition as in 3.1.1.5, but with 10 per cent of stores;

**.7** ship in the same loading condition as in 3.1.1.2, but with 50 per cent of stores.

When checking stability for the compliance with the weather criterion, class passengers shall be assumed to be in their accommodation and unberthed passengers on their decks. The stowage of cargo in holds, 'tween decks and on decks is assumed as for normal service conditions of the ship. Stability with an allowance for icing shall be checked with no passengers on exposed decks.

**3.1.2** Initial stability of passenger ships shall be such that in the eventual case of crowding of passengers to one side on the upper deck accessible for passengers, as near to the bulwark as possible, the angle of statical heel is not more than the angle at which the freeboard deck immerses or the angle at which the bilge comes out of water, whichever is less; in any case, the angle of heel shall not exceed 10°.

**3.1.3** The angle of heel due to the combined effect of the heeling moments as a result of the crowding of passengers to one side on the promenade decks and on steady turning shall not exceed the angle at which the freeboard deck immerses, or the angle at which the bilge comes out of water, whichever is less, but in any case the angle shall not exceed 12°.

**3.1.4** The heeling moment on turning circle, in kN·m, shall be determined by the formula

$$M_R = 0,196 \frac{V_0^2 \Delta}{L_{wl}} \left( Z_g - \frac{d}{2} \right) \quad (3.1.4)$$

where  $V_0$  = ship's service speed, m/s;

$\Delta$  = displacement, t;

$L_{wl}$  = length of ship on the waterline.

**3.1.5** When calculating ship's stability on turning and for heeling caused by crowding of passengers to one side, no account shall be taken of wind and rolling effects.

**3.1.6** When determining admissible distribution of passengers crowding to one side on their promenade decks, it shall be assumed that the ship's normal operating conditions are duly observed with an allowance for the position of the equipment and arrangements and the regulations concerning the access of passengers to a particular deck area.

**3.1.7** When determining the area where crowding of passengers may be permitted, the passages between benches shall be included in the calculation with factor 0,5. The area of narrow external passages between the deckhouse and the bulwark or railing up to 0,7 m wide shall be included with factor 0,5.

**3.1.8** For the purpose of determination of the angle of heel caused by crowding of passengers to one side, the mass of each passenger shall be assumed to be 75 kg. The assumed density of distribution of passengers is 6 persons per square metre of the free area of the deck. The height of the centre of gravity for standing passengers shall be assumed equal to 1,1 m above the deck level and that for sitting passengers 0,3 m above the seats.

**3.1.9** All calculations of the static heeling angle caused by passengers crowding to one side and by turning shall be carried out taking no account of icing, but with a correction for free surfaces of liquid cargoes as specified in 1.4.7.

#### 3.2 DRY CARGO SHIPS

**3.2.1** Stability of cargo ships shall be checked for the following loading conditions:

**.1** ship having a draught to the summer load line with homogeneous cargo filling cargo holds, 'tween decks, coaming spaces and trunks of cargo hatches, with full stores, but without liquid ballast;

**.2** ship in the same condition as in 3.2.1.1, but with 10 per cent of stores and, where necessary, with liquid ballast;

**.3** ship without cargo, but with full stores;

<sup>1</sup>For additional requirements for ships under 24 m in length, refer to 3.9.

**.4** ship in the same condition as in 3.2.1.3, but with 10 per cent of stores.

**3.2.2** Where cargo holds of a ship in the loading conditions as under 3.2.1.3 and 3.2.1.4 are used to additionally take liquid ballast, ship's stability with liquid ballast in these holds shall be checked. The effect of free surfaces in ship's store tanks is taken into account in compliance with the provisions of 1.4.7 and that in holds with liquid ballast in accordance with their actual filling.

**3.2.3** Where ships are normally engaged in carrying deck cargoes, their stability shall be checked for the following additional conditions:

**.1** ship having a draught to the summer load line (with regard to 3.2.1.1); with holds and 'tween decks filled by homogeneous cargo, with deck cargo, full stores and liquid ballast, if necessary;

**.2** ship in the same loading condition as in 3.2.1.1, but with 10 per cent of stores.

**3.2.4** The corrected initial metacentric height of ro-ro ships in the loaded condition, with icing disregarded, shall not be less than 0,2 m.

**3.2.5** If, during stability verification, it is found out that the value of one of the parameters  $\sqrt{h}/B$  and  $B/d$  at least exceeds 0,08 and 2,5, respectively, the ship's stability shall be checked additionally on the basis of the acceleration criterion  $K^*$  in accordance with 3.12.3. In so doing, if the calculated acceleration value  $a_{cal}$  (in fractions of  $g$ ) is in excess of the maximum permissible one, the possibility of operating the ship under appropriate loading conditions shall be specially considered by the Register. Particular loading conditions under which the ship is permitted to proceed to sea with  $a_{cal} > 0,30$  shall be specified in the Information on Stability.

In the case of a ship in the ballast condition no check of the acceleration criterion may be effected.

**3.2.6** Bulk carriers of less than 150 m in length shall be fitted with the onboard stability instrument complying with the requirements of 1.4.12.

### 3.3 TIMBER CARRIERS

**3.3.1** Stability of timber carriers shall be checked for the following loading conditions:

**.1** ship carrying timber cargo with a prescribed stowage rate (if stowage rate of timber cargo is not specified, the calculation of stability shall be made assuming  $\mu = 2,32 \text{ m}^3/\text{t}$ ) in holds and on deck and having a draught to the summer timber load line, without ballast (taking account of 3.2.1.1), with full stores;

**.2** ship in the same loading condition as in 3.3.1.1, but with 10 per cent of stores and, where necessary, with liquid ballast;

**.3** ship with timber cargo, having the greatest stowage rate specified, in holds and on deck, with full stores, without ballast;

**.4** ship in the same loading condition as in 3.3.1.3, but with 10 per cent of stores and, where necessary, with liquid ballast;

**.5** ship without cargo, but with full stores;

**.6** ship in the same loading condition as in 3.3.1.5, but with 10 per cent of stores.

**3.3.2** The stowage of timber cargo in timber carriers shall comply with the requirements of the Load Line Rules for Sea-Going Ships as well as with the provisions of the Information on Stability or special instructions.

**3.3.3** When calculating the cross-curves of stability for timber carrier, the volume of timber cargo on deck may be included in the calculation with full breadth and height and permeability of 0,25.

**3.3.4** Information on Stability shall include data to enable the master to estimate the ship's stability when carrying a timber cargo on deck the permeability of which differs substantially from 0,25. Where the approximate permeability is not known, at least three values shall be adopted, namely, 0,25, 0,4 and 0,6.

**3.3.5** The corrected initial metacentric height of timber carriers shall be not less than 0,1 m all through the voyage with loading conditions as mentioned under 3.3.1.1 to 3.3.1.4, and not less than 0,15 m with loading conditions as mentioned in 3.3.1.5 and 3.3.1.6.

With loading conditions as mentioned under 3.3.1.1 to 3.3.1.4, the righting lever curve of timber carriers shall be in compliance with the following specific requirements:

the area covered by righting lever curves up to the angle of  $40^\circ$  shall be not less than  $0,08 \text{ m}\cdot\text{rad}$ ;

the maximum righting arm shall be not less than 0,25 m.

The static heeling angle due to steady wind shall not exceed  $16^\circ$ ; criterion of 0,8 of the deck edge immersion angle is not applicable to timber carriers.

**3.3.6** Stability calculations for a ship carrying deck timber cargo for the most unfavorable loading condition out of those specified in 3.3.1.1 to 3.3.1.4 shall be performed with regard to possible increase in mass of the deck timber cargo due to absorption of water.

Where no appropriate data on the extent of water absorption by different kinds of wood are available, it is necessary to increase a mass of deck cargo by 10 per cent in the calculations. This addition in mass shall be considered as an overload and shall not be included in the ship's deadweight.

**3.3.7** For ships carrying deck timber cargo, intended for operation in the areas where icing is required to be considered, as well as navigating in winter within winter seasonable zones stability calculations shall be carried out with regard to

possible icing. When calculating icing the upper surface of the deck timber cargo shall be considered as if it were the deck, while its side surfaces above the bulwark shall be considered as if they were part of the design windage area. Icing rate for these surfaces shall be three times that specified in 2.4.

**3.3.8** If a timber carrier is used for the carriage of other kinds of cargo, its stability shall be checked in compliance with the provisions of Section 2 and 3.2. Cross-curves of stability shall be calculated taking no account of deck timber cargo.

**3.3.9** The requirements of this Chapter apply to other types of ships when they are used for the carriage of deck timber cargo.

In case the stowage of deck timber cargo does not comply with 3.3.2 with respect to fulfillment of the requirements of Load Line Rules for Sea-Going Ships, the buoyancy of timber deck cargo shall not be taken into consideration in the calculations of stability, while the ship stability shall comply with the requirements of 2.1 to 2.3.

**3.3.10** Double bottom tanks of timber carriers where fitted within the midship half-length of the ship shall have adequate watertight longitudinal subdivision.

### 3.4 TANKERS

**3.4.1** Stability of tankers carrying liquid cargoes shall be checked for the following loading conditions:

**.1** ship having draught up to summer load line (with regard to 3.2.1.1), fully loaded and with full stores;

**.2** ship fully loaded, but with 10 per cent of stores;

**.3** ship without cargo, but with full stores;

**.4** ship in the same loading condition as in 3.4.1.3, but with 10 per cent of stores.

Account of the free surface effect in ship's stores tanks shall be taken as specified in 1.4.7 and in cargo tanks according to the extent of their actual filling.

Where coamings are fitted on the open parts of the tanker's decks for prevention of cargo spillage forming an enclosed space (well), such space shall be considered as filled with sea water and it shall be taken into account in calculation of correction to the initial metacentric height.

**3.4.2** For refuelling tankers, stability shall be checked for additional loading condition: a ship with 75 per cent of cargoes and free surfaces in tanks for each kind of cargo, and 50 per cent of stores without liquid ballast.

**3.4.3** The requirements of 3.4.2 apply to oil recovery ships as well.

**3.4.4** Stability of tankers having cargo tank or ballast tank breadths more than 60 per cent of the ship's breadth shall comply with the following additional requirements during cargo loading/unloading operations, including the intermediate stages thereof.

**3.4.4.1** When the cargo loading/unloading operations are performed in port the corrected initial metacentric height shall be not less than 0,15 m and the extent of positive intact stability shall be not less than 20°.

**3.4.4.2** When the cargo loading/unloading operations are performed at sea and on roadstead all requirements of this Part of the Rules shall be met.

**3.4.4.3** When determining correction for the effect of free surfaces of liquids an allowance shall be simultaneously made for maximum free surface effects in all cargo, ballast and consumable tanks.

**3.4.4.4** If the requirements of 3.4.4.1 and 3.4.4.2 are not met, due to application of the requirements of 3.4.4.3, instructions covering the operational restrictions to satisfy the said requirements may be included into the Information on Stability upon agreement with the Register.

**3.4.4.5** Instructions referred to in 3.4.4.4 shall be formulated with consideration for the following:

they shall be in a language understood by the crew member in charge of loading/unloading operations and shall be translated into English;

they shall not require more complicated mathematical calculations than those provided in the other sections of the Information on Stability;

they shall indicate the list of cargo and ballast tanks which may simultaneously have free surfaces at any stage of loading/unloading operations;

they shall include typical versions of loading/unloading operations to satisfy the stability requirements under any load condition specified in the Information on Stability. The versions shall contain lists of cargo and ballast tanks which may simultaneously have free surfaces during various stages of loading/unloading operations;

they shall provide instructions necessary for independent pre-planning loading/unloading operations, including:

maximum heights of the ship's centre of gravity in graphical and/or tabular form which enables control of compliance with the requirements of 3.4.4.1 and 3.4.4.2;

the method of expeditious assessment of effect produced on the stability by the number of tanks which simultaneously have free surfaces at any stage of loading/unloading operations;

description of means available on board for control and monitoring loading/unloading operations from the viewpoint of the effects on stability;



the method used to monitor loading/unloading operations and to give early warning of possible impeding the stability criteria;

description of means available to suspend loading/unloading operations if the stability criteria are under the threat of being impeded;

information on the possibility and procedure of using shipboard computer and various automated systems to monitor loading/unloading operations (including systems of monitoring tank filling, shipboard computer software by which calculations of trim and stability are performed, etc.);

they shall provide for corrective actions to be taken in case of unexpected technical difficulties which can emerge in the course of loading/unloading operations and in case of emergency.

**3.4.4.6** Provisions of the instructions formulated in accordance with 3.4.4.5 shall be specified in the Information on Stability and also in the computer software available on board, by which trim and stability calculations are performed. A copy of the instructions shall be kept at the loading/unloading control station.

**3.4.5** The requirements below are applied to oil tankers of deadweight 5000 and more. The requirements of 3.4.4 are not applicable to the above ships.

**3.4.5.1** Each oil tanker shall comply with requirements set forth in 3.4.5.1.1 to 3.4.5.1.2 (considering instructions in 3.4.5.1.3 and 3.4.5.1.4) for any operation draught under the worst possible loading and ballasting conditions (in accordance with good operation practice) including intermediate stages of operations with liquids. Under all conditions it is considered that there is a free surface of liquid in ballast tanks.

**3.4.5.1.1** At port the corrected initial metacentric height shall be not less than 0,15 m.

**3.4.5.1.2** At sea:

**.1** corrected initial metacentric height shall be not less than 0,15 m;

**.2** the righting lever curve shall comply with the requirements of 2.2.1.

**3.4.5.1.3** While calculating stability, each tank is considered to be fully loaded up to the level, at which the sum of the cargo volume moment in relation to the main plain and the inertia moment of free surface at the heel of  $0^\circ$  reaches its maximum. The density of cargo shall fit the cargo carrying capacity at which the rise of the transverse metacentre over the main plain reaches its minimum at 100 per cent of stores and ballast (equal to 1 per cent of all ballast tanks). In calculations shall be accepted the maximum value of inertia moment of the liquid free surface in ballast tanks. In calculations of the initial metacentric height, the correction for free surface of liquids shall be based on the respective inertia moments of the free

surfaces at upright ship position. The righting arms may be corrected on the basis of actual corrections for the effect of free surfaces of liquids for each angle of heeling.

**3.4.5.1.4** As an alternative to the loading condition specified by 3.4.5.1.3, stability is permitted to be checked at all possible combinations of cargo and ballast tank loading. In so doing, the following shall be suggested:

when making calculations, the mass, centre of gravity co-ordinates and heeling moments due to liquid overflow shall correspond to the real contents of all tanks;

the calculations shall be made considering the following assumptions:

the draughts shall be varied between the light-ship draught and scantling draught specified;

consideration shall be given to the ship loading conditions with consumables including but not restricted to fuel oil, diesel oil and fresh water corresponding to 97 per cent, 50 per cent and 10 per cent content;

for each draught, distribution and amount of the ship's consumables, the available deadweight shall comprise ballast water and cargo such that all combinations between the maximum ballast and minimum cargo and vice versa are covered. In all cases, the number of ballast and cargo tanks loaded shall be chosen to reflect the worst combination of centre of gravity applicate and correction for free surfaces from the stability standpoint. Operational limits on the number and list of tanks, simultaneously having free surfaces, or their exclusion are not permitted. All ballast tanks shall have at least 1 per cent content;

consideration shall be given to cargo densities between the lowest and highest values intended to be carried;

when checking all the combinations of the ship's loading, the interval of the parametric variation shall be such that the worst conditions from the stability standpoint shall be checked. A minimum of 20 intervals for the range of cargo and ballast content, between 1 per cent and 99 per cent of total capacity, shall be examined. More closely spaced intervals near critical parts of the range may be necessary.

**3.4.5.2** Implementation of the requirements of 3.4.5.1 shall be ensured by design measures. For the combination carriers additional simple operation instructions may be allowed. This instructions shall:

**.1** be approved by the Register;

**.2** contain the list of cargo and ballast tanks which may have free surfaces during any operations with liquids and in the range of possible densities of cargo, still the above mentioned stability criteria are met;

.3 be easily understandable for the officer responsible for operations with liquids;

.4 provide possibility of planning the sequence of operations with cargo and ballast;

.5 enable to compare real stability figures with the required criteria presented in graphics and tables;

.6 do not require comprehensive mathematical calculations from the officer responsible for operations with liquids;

.7 contain instructions in respect of corrective actions to be fulfilled by the officer responsible for the operations with liquids in case of deviations from recommended figures and in case of accidents;

.8 be highlighted in Information on Stability and hang out in the cargo operations control station and put into the ship software performing stability calculations.

### 3.5 FISHING VESSELS

**3.5.1** Stability of fishing vessels shall be checked in service for the following loading conditions:

.1 departure for fishing grounds with full stores;

.2 arrival at a port from fishing grounds with full catch in holds and on deck, if provision is made for the deck cargo in the design, and with 10 per cent of stores;

.3 arrival at a port from fishing grounds with 20 per cent of catch in holds or on deck (if provision is made in the design for stowage of cargo on deck), 70 per cent of ice and salt rating and 10 per cent of stores;

.4 departure from fishing grounds to transfer the catch with full catch and amount of stores ensuring the ship's draught up to the load line.

**3.5.2** The amount of full catch is determined depending on the ship's type, capacity of cargo spaces and stability characteristics. It shall correspond to the load line position approved by the Register and shall be specified in stability calculations, as well as in the Information.

**3.5.3** For net fishing vessels, allowance shall be made for wet fishing nets on deck in the second, third and fourth loading conditions.

**3.5.4** Stability of a ship, while being on fishing grounds, shall be checked for compliance with the weather criterion for the following loading conditions: a vessel engaged in fishing, with no catch in holds and the hatches of the holds open, catch and wet nets stowed on deck, 25 per cent of stores and full amount of ice and salt. For vessels where nets and catch are hauled in with the help of cargo booms, account shall also be taken of cargo which is hoisted, with the cargo weight equal to the boom safe working load. The amount of catch allowed to be stowed on

deck shall be specified both in the vessel's design and the Information.

**3.5.5** The ship's amplitude of roll in the loading condition specified in 3.5.4 is assumed to be 10° and the angle of heel at which the coaming of a cargo hatch immerses is regarded as the angle of the ship's flooding through openings considered open. Wind pressure in this loading condition for vessels of unrestricted service is assumed as that for ships of restricted area of navigation **R1**, the wind pressure for vessels of restricted area of navigation **R1** as that for ships of restricted area of navigation **R2**, the wind pressure for vessels of restricted area of navigation **R2** as that for these ships reduced by 30 per cent.

For ships having a length between 24 m and 45 m, the initial wind pressure shall be adopted from Table 2.1.4.1.

**3.5.6** The righting lever curve for ships in the loading condition of 3.5.4 limited by the angle of flooding cutting it short on agreement with the Register need not comply with the requirements set forth in 2.2.1.

For ships, for which the righting lever curve requirements cannot be met in case when relevant fish holds partially or fully flooded, the heeling angle at which progressive flooding of fish holds may occur through hatches remaining open during fishing operations shall not be less than 20°.

**3.5.7** For fishing vessels, the corrected initial metacentric height, including the light ship condition, shall not be less than 0,05 m or 0,003 of the ship's breadth, whichever is the greater.

For single-deck ships, the corrected initial metacentric height shall not be less than 0,35 m. However, in case of ships with continuous superstructures and those which length exceeds 70 m, the corrected initial metacentric height may be reduced to 0,15 m.

**3.5.8** Under all loading conditions, the ship's stability shall conform to 3.1.2 to 3.1.5, 3.1.7 to 3.1.9 where the ships are used for processing fish and other living resources of the sea and have a crew on board of more than 12 persons engaged in catching and processing only. From the point of the above requirements the crew members in question are regarded as passengers.

**3.5.9** In the case of icing the parameters of the righting lever curve shall be in conformity with 2.2.

**3.5.10** The catch shall be duly secured in order to prevent its shifting which may cause the dangerous heel or trim of the ship. The detachable bulkheads of fish holds, if fitted, shall be of approved type.

**3.5.11** Stability of sea fishing vessels of less than 24 m in length shall be checked with regard to the requirements set out in 3.9 of this Part of the Rules and Part IV "Stability and Freeboard" of the Rules for the Classification and Construction of Small Sea Fishing Vessels.

### 3.6 SPECIAL PURPOSE SHIPS

**3.6.1** The stability of whale factory ships, fish factory ships and other ships used for processing the living resources of the sea and not engaged in catching the same shall be checked for the following loading conditions:

**.1** ship with special personnel, full stores, and full cargo of tare and salt on board;

**.2** ship with special personnel, 10 per cent of stores, and full cargo of its production on board;

**.3** ship in the same loading condition as in 3.6.1.2, but with 20 per cent of production and 80 per cent of tare and salt on board;

**.4** ship in the same loading condition as in 3.6.1.1, but with 25 per cent of stores and the cargo being processed on board.

**3.6.2** The stability of research, expeditionary, hydrographic, training and similar ships shall be checked for the loading conditions below:

**.1** ship with special personnel and full stores on board;

**.2** ship in the same loading condition as in 3.6.2.1, but with 50 per cent of stores on board;

**.3** ship in the same loading condition as in 3.6.2.1, but with 10 per cent of stores on board;

**.4** ship in the same loading conditions as in 3.6.2.1, 3.6.2.2 and 3.6.2.3, but with full cargo on board if the carriage of the latter is envisaged.

**3.6.3** The stability of special purpose ships shall be in accordance with 3.1.2 to 3.1.5, 3.1.7 to 3.1.9. From the point of view of the above requirements special personnel shall be regarded as passengers.

**3.6.4** For special purpose ships that are similar to supply vessels, on agreement with the Register, the requirements for the righting lever curve may be reduced, as stated in 3.11.5.

**3.6.5** For whale factory ships, fish factory ships and other ships used for processing the living resources of the sea, the requirements of 3.5.7 concerning the initial metacentric height apply.

**3.6.6** For whale factory ships, fish factory ships and other ships used for processing the living resources of the sea, the requirements of 3.5.9 for the righting lever curve in the case of icing apply.

**.3** ship with full cargo in holds and full stores;

**.4** ship with full cargo in holds and 10 per cent of stores.

**3.7.1.2** In addition to compliance with the requirements of Section 2, the tugs shall have sufficient dynamic stability to withstand the heeling effect of an assumed transverse jerk of the tow line under the same loading conditions, that is the angle of dynamic heeling  $\theta_{dl}$  due to assumed jerk of the tow line shall not exceed the limits given below.

#### 3.7.2 Tugs for inner and outer road.

**3.7.2.1** The angle of dynamic heel for tugs shall not be greater than the angle of flooding or capsizing, whichever is less.

To meet this requirement, the following condition shall be satisfied

$$K_1 = \sqrt{l_{dcaps}/l_{dh}} \geq 1,00 \quad (3.7.2.1)$$

where  $l_{dcaps}$  = arm of dynamical stability defined as an ordinate of the dynamic stability curve for a tug at the angle of heel equal to the angle of flooding (refer to 3.7.2.3) or capsizing  $\theta_{caps}$  determined disregarding roll, whichever is less, in m;

$l_{dh}$  = dynamic heeling arm characterizing the assumed jerk effect of the tow line, in m.

**3.7.2.2** The dynamic heeling arm  $l_{dh}$ , in m, shall be determined by the formula

$$l_{dh} = l'_v \left(1 + 2 \frac{d}{B}\right) \frac{b^2}{(1 + c^2)(1 + c^2 + b^2)} \quad (3.7.2.2-1)$$

where  $l'_v$  = the height of the velocity hydraulic pressure head, in m.  
The values of  $l'_v$  are obtained from Table 3.7.2.2 depending on the power  $N_e$  of the ship's main engines;

Table 3.7.2.2

Height of velocity hydraulic pressure head  $l'_v$

$N_e$ , in kW	$l'_v$ , in m	$N_e$ , in kW	$l'_v$ , in m
0 — 150	0,0862	900	0,147
300	0,0903	1050	0,18
450	0,096	1200	0,22
600	0,104	1350	0,268
750	0,122	1500 and over	0,319

$$c = 4,55 x_H / L; \quad (3.7.2.2-2)$$

$$b = \frac{(z_H/B) - a}{e}; \quad (3.7.2.2-3)$$

$a$  and  $e$  are determined by the formulae:

$$a = \frac{0,2 + 0,3(2d/B)^2 + \frac{z_g}{B}}{1 + 2 \frac{d}{B}}; \quad (3.7.2.2-4)$$

$$e = 0,145 + 0,2 \frac{z_g}{B} + 0,06 \frac{B}{2d}. \quad (3.7.2.2-5)$$

### 3.7 TUGS

#### 3.7.1 General.

**3.7.1.1** Stability of tugs shall be checked for the following loading conditions:

**.1** ship with full stores;

**.2** ship with 10 per cent of stores and for tugs provided with cargo holds, additionally;

**3.7.2.3** When checking stability of tugs for the tow line jerk effect, the angle of flooding shall be determined assuming that all doors leading to engine and boiler casings and to the upper deck superstructures, as well as the doors of all companionways to the spaces below the upper deck, irrespective of their design, are open.

**3.7.2.4** When checking stability of tugs for the tow line jerk effect, no account shall be taken of icing and free surfaces of liquid cargoes.

**3.7.2.5** If special appliances are available for shifting the tow hook downwards or abaft, with the tow line athwartships, the assumption of  $x_H$  and  $z_H$  differing from values given above is subject to special consideration by the Register in each particular case.

### **3.7.3 Tugs for ocean towage.**

**3.7.3.1** The angle of heel for tugs due to the tow line jerk under rolling shall not exceed the angle corresponding to the maximum of the righting lever curve or the angle of flooding, whichever is less.

To satisfy this condition the following requirement shall be met:

$$K_2 = \sqrt{l_{d \max} / l_{dh}} - \Delta K \geq 1,0 \quad (3.7.3.1-1)$$

where  $l_{d \max}$  = ordinate of the dynamical stability curve at an angle of heel corresponding to the maximum of the righting lever curve or the angle of flooding, whichever is less, in m·rad;

$l_{dh}$  = dynamic heeling arm determined in compliance with 3.7.2.2, with  $l_r$  assumed to be 0,20 m;

$\Delta K$  = component of  $K_2$  used to allow for the effect of rolling on resultant angle of heel and determined by the formula

$$\Delta K = 0,03\theta_{2r} \left[ \frac{1+c^2}{b} - \frac{1}{e} \left( a - \frac{z_g}{B} \right) \right] \sqrt{\frac{h_0}{1+2\frac{d}{B}}} \quad (3.7.3.1-2)$$

where  $\theta_{2r}$  is determined in compliance with 2.1.5, in deg.;  
 $c, b, a, e$  are determined in accordance with 3.7.2.2.

The requirements of 3.7.2.3 are not applicable to tugs for ocean towage.

### **3.7.3.2** When checking stability of tugs:

**.1** 3.7.2.5 is valid;

**.2** for righting lever curves with two maxima or an extended horizontal region, the value of the angle at the first maximum or that corresponding to the middle of the horizontal region shall be taken as the angle of maximum specified in 3.7.3.1;

**.3** stability for the tow line jerk effect shall be checked taking no account of the free surfaces of liquid cargoes.

**3.7.3.3** When checking stability of tugs for compliance with the requirements of Section 2 and this Chapter, the icing rates are assumed to be:

**.1** for tugs specially designed for salvage operations, twice as much those given in 2.4;

**.2** for other tugs, in accordance with 2.4.

**3.7.3.4** Where a tug for ocean towage may be used for inner and outer road operations as well, compliance of such a tug with 3.7.2 is subject to special consideration by the Register.

## **3.8 VESSELS OF DREDGING FLEET**

### **3.8.1 Working conditions.**

"Working conditions" means operation of a vessel according to its purpose within the prescribed operation zones:

**.1** Zone 1 — coastal zone up to 20 miles from the coast;

**.2** Zone 2 — zone including the prescribed area of navigation of a vessel.

### **3.8.2 Loading conditions.**

Depending on the type of a vessel of dredging fleet and its dredging gear the following conditions of loading shall be considered.

**3.8.2.1** For vessels of dredging fleet of all types during voyages:

**.1** vessel with full stores, without spoil, dredging gear being secured for sea;

**.2** vessel in the same loading condition as in 3.8.2.1.1, but with 10 per cent of stores.

**3.8.2.2** In operating conditions for hopper dredgers and hopper barges:

**.1** vessel with full stores, with spoil in the hopper, dredging gear being secured for sea;

**.2** vessel in the same loading condition as in 3.8.2.2.1, but with 10 per cent of stores.

For hopper dredgers equipped with grab cranes additional loading conditions, such as with grab cranes operating from one side and crane boom being in the athwartship plane, with spoil in the grab, with maximum loading moment and also with the highest position of the boom with due regard to initial heel shall be considered. These conditions shall be considered for a vessel with 10 per cent of stores and full stores, both with spoil and without it.

**Notes:** 1. The mass of spoil in the grab is taken to be  $1,6V$  t where  $V$  is the volume of the grab, in  $m^3$ .

2. The quantity of spoil in the hopper and the position of the centre of gravity shall be determined assuming that the hopper is filled with homogeneous spoil up to the level of the upper discharge holes or the upper coaming edge, if the discharge holes are not provided, with the vessel having a draught up to the load line permitted when dredging.

**3.8.2.3** In operating conditions for dredgers equipped with bucket ladder:

**.1** vessel with full stores, with spoil in buckets, ladder being secured for sea;

**.2** vessel in the same loading condition as in 3.8.2.3.1, but with 10 per cent of stores.

**Note.** Spoil is taken into the buckets of the upper part of the ladder (from upper to lower drum). The mass of spoil in each bucket is taken to be  $2Vt$  where  $V$  is the full volume of the bucket, in  $m^3$ .

**3.8.2.4** In operating conditions for dredgers, other than those equipped with bucket ladder:

**.1** vessel with full stores, with dredging gear in the highest position possible in normal operation;

**.2** vessel in the same loading condition as in 3.8.2.4.1, but with 10 per cent of stores.

For dredgers equipped with grab cranes the additional loading conditions shall be considered in compliance with 3.8.2.2.

**Notes:** 1. Spoil pipeline within the vessel is assumed to be filled with spoil having density equal to  $1,3 \text{ t/m}^3$ .

2. The mass of spoil in the grab (bucket) is assumed to be  $1,6Vt$  where  $V$  is the volume of the grab (bucket), in  $m^3$ .

### 3.8.3 Calculation of cross-curves of stability and inclining test.

**3.8.3.1** When calculating cross-curves of stability for vessels of dredging fleet, the manholes of air spaces may be considered closed irrespective of the coaming height if they are fitted with covers conforming to 7.9, Part III "Equipment, Arrangements and Outfit".

**3.8.3.2** Hopper barges, dredgers and other vessels in which the watertight integrity of their hoppers cannot be achieved due to the structural peculiarities may be inclined with water in the hoppers which communicates easily with sea water.

### 3.8.4 Checking of stability in working conditions and during voyages.

**3.8.4.1** Stability of vessels of dredging fleet during voyages shall be calculated having regard to the area of navigation prescribed to the vessel concerned. To be stated both in the specification and in the Information on Stability are the conditions of voyages, if any (ballast water available, extent to which the dredging gear is dismantled, the position of the ladder, the possibility of spoil transportation in the hopper beyond the limits of 20-mile coastal zone, etc.). The dredgers equipped with a ladder may undertake voyages in the unrestricted area of navigation only with the bucket chain dismantled.

**3.8.4.2** When calculating stability of vessels of dredging fleet under working conditions, the following is assumed:

**.1** in zone 1 wind pressure shall be taken: for vessels of unrestricted service as for ships of restricted area of navigation **R1**; for vessels of restricted area of navigation **R1** as for this area, but reduced by 25 per

cent; for other areas of navigation, as for restricted area of navigation **R2**; amplitude of roll, as for restricted areas of navigation;

**.2** in zone 2 wind pressure and amplitude of roll shall be taken in accordance with area of navigation prescribed for the vessel concerned.

**3.8.4.3** Amplitude of roll of the dredgers shall be determined in compliance with 2.1.5.

For restricted areas of navigation **R1** and **R2** amplitude of roll determined by the Formula (2.1.5.1) shall be multiplied by factor  $X_3$ , the value of which is taken from Table 3.8.4.3.

For hopper dredges and hopper barges having bottom recesses for flaps factor  $X_1$  is adopted from the Table 2.1.5.1-1 for the ratio  $B/d$ , multiplied by coefficient  $(\nabla + \nabla_v)/\nabla$ , where  $\nabla$  is the volume displacement of the vessel with no regard to bottom recess, in  $m^3$ ;  $\nabla_v$  is the volume of bottom recess, in  $m^3$ .

**3.8.4.4** Stability of dredgers and hopper dredgers equipped with grab cranes when additional loading conditions (refer to 3.8.2.2) are considered shall meet the requirements of 4.1.

**3.8.4.5** Stability of hopper dredgers and hopper barges whose construction of bottom flaps and their drive does not prevent the possibility of spoil discharge from one side shall be checked with due regard to such discharge only for compliance with weather criterion as specified in 3.8.4.6 and 3.8.4.7 for the most unfavourable loading condition out of first and second (refer to 3.8.2.2):

**.1** where the spoil in the hopper has a density less than  $1,3 \text{ t/m}^3$  with the amplitude of roll of  $10^\circ$  with regard to the static heeling angle equal to the sum of the static heeling due to spoil discharge  $\theta_{sp}$  and the static heeling resulting from steady wind  $\theta_{w1}$  in accordance with 2.1.2.2;

**.2** where the spoil in the hopper has a density equal to, or more than  $1,3 \text{ t/m}^3$ , with due regard to the dynamic character of discharge, with an amplitude of roll equal to the sum of  $10^\circ$  and the maximum amplitude of vessel's rolling  $\theta_{3r}$  with respect to static heeling which, in its turn, is equal to the sum of heeling due to spoil discharge  $\theta_{sp}$  and the heeling resulting from steady wind  $\theta_{w1}$  in accordance with 2.1.2.2.

The value of  $\theta_{3r}$ , in deg., is determined by the formula

$$\theta_{3r} = 0,2\theta_{sp}. \quad (3.8.4.5.2)$$

Table 3.8.4.3

Factor $X_3$																	
$\sqrt{h_0/B}$	0,04	0,05	0,06	0,07	0,08	0,09	0,1	0,11	0,12	0,13	0,14	0,15	0,16	0,17	0,18	0,19	0,2
$X_3$	1,27	1,23	1,16	1,08	1,05	1,04	1,03	1,02	1,01	1,0	1,0	1,01	1,03	1,05	1,07	1,10	1,13

**3.8.4.6** The value of horizontal shifting of the vessel's centre of gravity  $y_g$ , in m, when discharging half the spoil from one side out of fully loaded hopper, is determined by the formula

$$y_g = Py / (2\Delta) \quad (3.8.4.6-1)$$

where  $P$  = total mass of spoil in the hopper, in t;  
 $y$  = distance from the centre of gravity of spoil discharged from one side to the centre plane, in m;

$$\Delta = \Delta_{\max} - P/2 \quad (3.8.4.6-2)$$

where  $\Delta_{\max}$  = vessel's displacement prior to spoil discharge, in t.

**3.8.4.7** The vessel's curve of statical stability is calculated by the formula

$$l_1 = l - y_g \cos \theta \quad (3.8.4.7)$$

where  $l$  = arm of statical stability with the vessel's displacement  $\Delta_{\max}$  calculated assuming that the vessel's centre of gravity coincides with the centre plane.

**3.8.4.8** When spoil is discharged by long chute or conveyor methods, stability of a dredger shall be checked for the case of statical action of the moment due to the mass forces of the long chute or the conveyor (in the athwartship plane) filled with spoil (with no regard to the waves and wind effects). In this case, the vessel's stability is considered to be adequate, if maximum statical heel is not more than the angle of flooding or the angle at which the freeboard becomes equal to 300 mm, whichever is less.

### 3.8.5 Effect of liquid cargoes.

When calculating the effect of liquid cargoes as specified in 1.4.7 for hopper dredgers and hopper barges, it shall be assumed that:

**.1** for a vessel with spoil having density over  $1,3 \text{ t/m}^3$ , the spoil is regarded as solid non-overflowing cargo; the lever of statical and dynamical stability is determined for the constant displacement and position of the spoil centre of gravity in the hopper;

**.2** for a vessel with spoil having density equal to, or less than  $1,3 \text{ t/m}^3$  the spoil is regarded as liquid cargo; the lever of statical and dynamical stability is determined at the variable displacement and position of the spoil centre of gravity, taking account of the spoil flowing overboard and reduction of the vessel's draught.

No such calculation is carried out if the vessel is provided with a longitudinal bulkhead in the hopper, the spoil in the latter case being regarded as solid cargo;

**.3** for a vessel without spoil, the hopper is in communication with sea water, that is flaps or valves are open. The lever of statical and dynamical stability is determined for the constant displacement (as for a damaged vessel).

### 3.8.6 Effect of dredging gear icing.

When estimating the effect of icing of vessels of dredging fleet, the horizontal projection of dredging gear is added to the area of horizontal projection of decks (the centre plane projection being included in the windage area). The vertical moment due to this additional ice load is determined by the centre of gravity elevation of the projection of the dredging gear in its working or secured for sea position to the centre line.

### 3.8.7 Righting lever curve.

**3.8.7.1** The righting lever curve of hopper dredgers and hopper barges during voyages and under working conditions shall meet the requirements of 2.2.

**3.8.7.2** The righting lever curve of dredgers equipped with bucket ladder for all loading conditions specified in 3.8.2, as well as when taking account of icing, shall comply with the following requirements:

**.1** the angle of vanishing stability  $\theta_v$  shall be not less than  $50^\circ$ ;

**.2** the maximum righting arm with angle  $\theta_m$  of not less than  $25^\circ$  shall be:

when vessels are operating in zone 1, not less than 0,25 m;

during voyages, passages and when operating in zone 2, not less than 0,4 m.

**3.8.7.3** For bucket dredgers having  $B/D > 2,50$ , angles  $\theta_v$  and  $\theta_m$  may be reduced as compared to those required in 3.8.7.2 by the following values:

**.1** for the angle of vanishing stability, by the value  $\delta\theta_v$  to be determined by the following formula depending on the  $B/D$  ratio and the weather criterion  $K$  and provided the reduction by every  $1^\circ$  is accompanied with an increase of  $l_{\max}$  by 0,01 m as compared to its normative value:

$$\delta\theta_v = 25^\circ (B/D - 2,5)(K - 1). \quad (3.8.7.3.1)$$

Where  $B/D > 3,0$ ,  $B/D = 3,0$  shall be adopted, and where  $K > 1,5$ ,  $K = 1,5$  shall be adopted. The value of  $\delta\theta_v$  is rounded off to the nearest integer;

**.2** for the angle corresponding to the maximum lever of the curve, by a value equal to half the reduction value of the angle of vanishing stability;

**.3** for dredgers of unrestricted service the reduction of angles  $\theta_m$  and  $\theta_v$  is not permitted.

## 3.9 SHIPS UNDER 24 M IN LENGTH

**3.9.1** When determining the cross-curves of stability, it is possible to take into consideration deckhouses of the first tier only which conform to 1.4.2.3.1 and from which there is either an additional exit to the deck above or exits to both the sides.

**3.9.2** Stability as to weather criterion shall not be checked. However, for the operation of the ships, restrictions on the distance to the port of refuge and the sea state shall be introduced.

For small ships, restrictions on the area and conditions of navigation shall be set down and included in the Information on Stability:

**.1** for ships of less than 15 m in length and passenger ships of less than 20 m in length restricted area of navigation **R3** may be prescribed.

For ships 15 m to 20 m in length, other than passenger ships, an area of navigation not higher than **R2** may be prescribed.

For ship 20 to 24 m in length, other than passenger ships, an area of navigation not higher than **R1** may be prescribed;

**.2** non-passenger ships of less than 15 m in length may proceed to sea and be en route at sea state not more than 4, ships 15 m to 20 m in length — not more than 5; ships 20 to 24 m — not more than 6;

**.3** passenger ships of less than 20 m in length may proceed to sea and be en route at sea state not more than 3; ships 20 to 24 m — not more than 4;

**.4** having regard to stability and seaworthiness of ships and depending on the reliable provision of the area of navigation concerned with forecasts, as well as on the operating experience for ships of similar type and the same or approximately the same dimensions, available for this area of navigation, the Register may change the restrictions on the area of navigation and permissible sea state specified in 3.9.2.1 to 3.9.2.3;

**.5** when determining maximum permissible sea state for small craft carried on depot ships (for example, small fishing boats carried on mother ships), in addition to the provisions of 3.9.2.2 and 3.9.2.3, maximum sea state at which the craft can be safely lifted on board the depot ship shall be taken into account;

**.6** at the discretion of the Register, additional restrictions shall be introduced in zones of special sea conditions.

Referred to such zones are:

zones of surf (breaking) waves;

zones of local abrupt increase in wave height and steepness (bars in estuaries, tossing, etc.).

Zones of special sea conditions are set on the basis of the data of local hydrometeorological and hydrographic offices.

**3.9.3** For ships having  $B/D > 2$  the permissible reduction of the angle of vanishing stability shall be determined by the Formula (2.2.2.1) for the constant  $K = 1,5$ .

**3.9.4** Cutting the righting lever curve short at the angle of flooding permitted by 2.2.4 is prohibited at heeling angles less than  $40^\circ$ .

**3.9.5** The righting lever curve of a fishing vessel, when on fishing grounds, under the loading conditions stated in 3.5.4 may not conform to the requirements of 2.2.1 for the maximum arm and the requirements of 2.2.4 for the conventional angle of vanishing stability. Under those loading conditions, the maximum righting arm shall be not less than 0,2 m.

**3.9.6** Under all loading conditions, the corrected initial metacentric height shall be not less than 0,5 m, except for the light ship condition (refer to 2.3.1) and the fishing vessels when under loading conditions stated in 3.5.4 for which it shall be not less than 0,35 m.

**3.9.7** The initial stability of fishing vessels hauling in the nets and catch with cargo booms shall be sufficient (under loading conditions stated in 3.5.4 as well) to ensure that the static heel angle of the ship when handling the nets and operating the cargo boom at its maximum outreach would not exceed  $10^\circ$  or the angle at which the deck is immersed (whichever is less).

**3.9.8** Operation of the ships under conditions of eventual icing shall not, in general, be permitted.

Where due to the mode of operation and purpose the possibility of sailing into regions where icing might occur cannot be completely ruled out for a ship, the values of initial metacentric height and other parameters of righting lever curves drawn taking icing into consideration shall not be less than those stated in 2.2, 3.9.3, 3.9.4 and 3.9.6.

**3.9.9** Information on Stability shall include indications of the permissible speed and angle of rudder shifting in turning. The permissible values of initial turning speed and angle of rudder shifting shall be determined by tests during acceptance trials of the leading ship assuming that the list of the ship in steady turning shall not exceed:

**.1** for non-passenger ships, the angle at which the freeboard deck is immersed or  $12^\circ$ , whichever is less;

**.2** for passenger ships, taking account additionally of the effect of the simulated heeling moment due to passengers crowding to one side (to be determined in accordance with 3.1.2), the angle at which the freeboard deck is immersed or  $15^\circ$ , whichever is less.

The Register may apply the provisions of 3.9.9.2 to the stability of non-passenger ships (for instance, when persons not belonging to the ship's crew are on board).

The requirements of 3.1.3 and 3.1.4 are not applicable to ships of less than 24 m in length.

**3.9.10** The initial stability of passenger ships shall be checked for conformity with 3.1.2. The angle of heel due to passengers crowding to one side shall not be greater than the angle corresponding to 0,1 m freeboard before the deck is immersed or  $12^\circ$ , whichever is less.

If necessary, the Register may apply the requirements of 3.1.2 to the stability of non-passenger ships

(for instance, when persons are on board who are not members of the regular crew). In this case, the heel is determined on the assumption that all persons crowd to one side who are not engaged in handling the ship.

**3.9.11** In the Information on Stability it shall be specified that when the ship is under way in following seas, with the wave length equal to, or exceeding the length of the ship, its speed  $v_s$ , in knots, shall not be greater than determined by the formula

$$v_s = 1,4\sqrt{L} \quad (3.9.11)$$

where  $L$  = length of the ship, in m.

**3.9.12** Application of the requirements of 3.7 to the stability of tugs under 24 m in length is subject to special consideration by the Register in each case.

### 3.10 CONTAINER SHIPS

**3.10.1** In calculating stability of container ships, the vertical centre of gravity position of each container shall be taken equal to half the height of the container of the type concerned.

**3.10.2** Stability of container ships shall be checked for the following loading conditions:

**.1** ship with maximum number of containers, each loaded container having the mass equal to one and the same part of the maximum gross mass for each type of containers, with full stores at the draught up to the summer load line;

**.2** ship in the same loading condition as in 3.10.2.1, but with 10 per cent of stores;

**.3** ship with maximum number of containers, each loaded container having the mass equal to 0,6 of the maximum gross mass for each type of containers, with full stores;

**.4** ship in the same loading condition as in 3.10.2.3, but with 10 per cent of stores;

**.5** ship with containers, each loaded container having the mass equal to the maximum gross mass for each type of containers, with full stores at the draught up to the summer load line;

**.6** ship in the same loading condition as in 3.10.2.5, but with 10 per cent of stores;

**.7** ship with maximum number of empty containers, but with full stores;

**.8** ship in the same loading condition as in 3.10.2.7, but with 10 per cent of stores;

**.9** ship with no cargo, but with full stores;

**.10** ship in the same loading condition as in 3.10.2.9, but with 10 per cent of stores.

When determining the arrangement of containers on board under the loading conditions mentioned above, the allowable loads upon the hull structures shall be considered.

**3.10.3** If other loading conditions different from those listed in 3.10.2 are provided in the technical assignment, stability calculations shall also be made for such conditions with full stores and 10 per cent of stores.

**3.10.4** Stability of container ships for any loading condition with containers shall be such that a heeling angle on steady turning or under the effect of continuous beam wind as determined from the statical stability curve does not exceed half the angle at which the freeboard deck immerses; in any case, the heeling angle shall not exceed  $16^\circ$ .

Where the deck cargo of containers is located on cargo hatch covers only, on agreement with the Register, the angle at which the hatch coaming edge or a container is immersed, whichever angle is less, may be adopted instead of the angle at which the upper deck edge is immersed (provided the containers protrude beyond the coaming in question).

**3.10.5** The heeling moment on steady turning, in kN·m, is determined by the formula

$$M = \frac{0,037\Delta v_s^2}{L} \left( z_g - \frac{d}{2} \right) \quad (3.10.5)$$

where  $v_s$  = ship's speed before entering into steady turning, in knots;  
 $\Delta$  = displacement, in t.

**3.10.6** The moment lever due to wind pressure used to determine the heeling angle according to 3.10.4 shall be determined by the Formula (2.1.4.1-1) in which  $p_v$  is taken equal to that for ships of unrestricted service given in Table 2.1.4.1.

**3.10.7** All calculations of statical heeling angle under the effect of beam wind or turning shall be made with no regard for icing, but having regard for the free surface effect of liquid cargoes as required by 1.4.7.

**3.10.8** Where the requirement of 3.10.4 to the value of the angle of heel at steady turning of a ship at operational speed cannot be complied with, Information on Stability shall contain the maximum permissible ship's speed prior to steady turning, determined at a condition of not exceeding the angle of heel specified in 3.10.4.

**3.10.9** Container ships shall be equipped with tanks or other specific facilities approved by the Register, which permit to check the initial stability of the ship, bearing in mind the Register approved requirements for the in-service inclining test.

**3.10.10** The requirements of this Part are applicable to ships of other types appropriated for the carriage of cargoes in containers on deck.

Where, acting in line with 3.10.2.1 and 3.10.2.5, it is not possible to load the ship to the summer load line the ship may be considered for the relevant loading conditions at the maximum draft possible.





### 3.12 SHIPS OF RIVER-SEA NAVIGATION

**3.12.1** Stability of ships of river-sea navigation (restricted areas of navigation **R2-RSN** and **R3-RSN** according to 2.2.5, Part I "Classification") shall meet the requirements of Sections 1 and 2, as well as additional requirements of Section 3 (depending on the purpose of the ship).

Besides, the stability of dry cargo ships shall be checked by acceleration criterion in compliance with 3.12.3.

**3.12.2** The stability of dry cargo ships of the restricted area of navigation **R2-RSN** shall be checked for the loading conditions listed in 3.2, as well as for the case of holds partly filled with heavy cargoes (ore, scrap metal, etc.) at the draught to the load line.

**3.12.3** The stability as concerns the acceleration criterion  $K^*$  is considered satisfactory if in the loading condition under consideration the calculated acceleration (in fractions of  $g$ ) does not exceed the permissible value, i.e. the following condition is fulfilled:

$$K^* = 0,3/a_{cal} \geq 1 \quad (3.12.3)$$

where  $a_{cal}$  = calculated value of acceleration (in fractions of  $g$ ) determined by the formula

$$a_{cal} = 0,0105 \frac{h_0}{c^2 B} k_0 \theta_r$$

where  $\theta_r$  = calculated amplitude of roll determined in accordance with 2.1.5, in deg.;

$c$  = inertia coefficient determined in accordance with 2.1.5.1;

$h_0$  = initial metacentric height regardless of the correction for the liquid cargo free surfaces;

$k_0$  = coefficient, taking account of the peculiarities of roll for ships of river-sea navigation, adopted from the Table 3.12.3.

Table 3.12.3

Coefficient $k_0$									
$B/d$	$\leq 2,5$	3,0	3,5	4,0	4,5	5,0	5,5	6,0	$\geq 6,5$
$k_0$	1,0	1,08	1,11	1,11	1,20	1,30	1,45	1,56	1,61

**3.12.4** In certain cases, upon well-grounded presentation by the shipowner, Register may allow the operation of the ship with the criterion  $K^* < 1$ . In this case, an additional wave height restriction shall be introduced. The permissible wave height with 3 per cent probability of exceeding level is estimated proceeding from the value of the criterion  $K^*$  as given in Table 3.12.4. The specific loading conditions with  $K^* < 1$  shall be stated in the Information on Stability.

Table 3.12.4

$K^*$	1,0 and more	1,0 — 0,75	0,75 and less
Permissible wave height with 3 per cent probability of exceeding level, in m	6,0	5,0	4,0

## 4 REQUIREMENTS FOR THE STABILITY OF FLOATING CRANES, CRANE SHIPS, TRANSPORT PONTOONS, DOCKS AND BERTH-CONNECTED SHIPS

### 4.1 FLOATING CRANES AND CRANE SHIPS<sup>1</sup>

#### 4.1.1 General.

**4.1.1.1** The requirements of the Chapter cover floating cranes and crane ships for which the hook load mass exceeds  $0,02\Delta$ , in t, under one type of loading conditions at least, as stipulated in 4.1.3.1, or at least one of the following conditions is met:

$$|y_g| > 0,05h \quad (4.1.1.1-1)$$

or

$$|x_g - x_c| > 0,025H. \quad (4.1.1.1-2)$$

Compliance with the requirements of the Chapter may be demanded by the Register even where the above conditions are not met.

**4.1.1.2** As far as unique (single-time, episodal) cargo-handling operations are concerned, particular requirements for the stability of floating cranes and crane ships may be omitted or lowered, if a project of the operations is developed and it is demonstrated to the satisfaction of the Register that special technical and organizational measures have been taken to avoid certain dangerous situations (load drop, etc.).

**4.1.1.3** The design centre of gravity position of the load on the hook is assumed to be at the point of

<sup>1</sup>Relevant paragraphs of the Chapter contain precise instructions concerning the applicability of the paragraphs to both floating cranes and crane ships, exclusively to floating cranes or exclusively to crane ships respectively. In the absence of such instructions in the paragraph headings and texts, the requirements will be equally applicable to floating cranes and crane ships.

its suspension from the boom is to be considered. If cargo-handling operations are carried out using a compound catenary suspension, i.e. two hooks (bifilar suspension), three hooks (trifilar suspension), etc., or the crane structure has an anti-swaying device, or the movement of suspended cargo is limited within the considered range of the floating crane/crane ship inclination angles, the stability shall be verified bearing in mind the actual shift of the cargo mass centre at inclination.

Boom radius is the distance between a vertical line drawn through the cargo suspension point with the floating foundation in the upright position and trimmed on an even keel, and determined up to:

axis of the slewing crane structure rotation;

axis of rotation joint of the non-slewing crane structure boom.

For non-slewing crane structures intended for boom operation in the longitudinal plane, the stability shall be verified with regard for the possibility of unsymmetrical loading on the hooks.

#### 4.1.2 Design conditions:

**.1** working condition (cargo-handling operations and carriage of cargo in the assigned area of navigation and with the boom not secured for sea);

**.2** voyage (navigation and lay-up within assigned area of navigation including both with cargo on deck and/or in hold and with the boom secured for sea);

**.3** non-working condition (lay-up in port with machinery out of operation under the most unfavourable loading conditions in respect of stability and with the boom positions when there is no load on the hook);

**.4** passage (navigation outside the assigned area of navigation by special permission of the Register after conversion on the basis of the Register-approved project).

#### 4.1.3 Loading conditions.

**4.1.3.1** Under working condition stability shall be verified without regard for icing and with liquid ballasting where necessary, for the following loading conditions:

**.1** maximum hook load with the maximum jib radius for the load at the specified slewing angle of the crane structure  $\phi$  with regard to the centre plane of the floating crane/crane ship:

with full load and full stores;

with full load and 10 per cent of stores;

without load and with full stores;

without load and with 10 per cent of stores;

**.2** no hook load, highest position of the crane structure boom at the specified slewing angle of the boom  $\phi$ :

with full load and full stores;

with full load and 10 per cent of stores;

without load and with full stores;

without load and with 10 per cent of stores;

**.3** load drop, i.e. a quick release of the crane structure boom from the load suspended from the hook. In case of load drop, to be verified are the most unfavourable loading conditions with regard to stability, taking into consideration the possibility of unsymmetrical cargo stowage on deck and/or in the hold.

**4.1.3.2** During a voyage the stability shall be verified (taking up liquid ballast where necessary) for the following loading conditions:

with full load and full stores;

with full load and 10 per cent of stores;

without load and with full stores;

without load and with 10 per cent of stores.

Where a deck cargo of hollow structures or pipes is carried, the mass of water therein shall be considered assuming the caves in the structures (taking account of their possible icing) and the pipes to be filled with water, in accordance with 3.11.4 and 3.11.7.

**4.1.3.3** Under non-working condition stability shall be verified for the most unfavourable loading conditions with regard to stability out of those mentioned under 4.1.3.1.2.

**4.1.3.4** For floating cranes/crane ships engaged in winter traffic in winter seasonal zones established by the Load Line Rules for Sea-Going Ships, stability during a voyage/passage and under non-working condition shall be verified with due regard for icing and for the most unfavourable loading conditions as regards stability out of those mentioned under 4.1.3.1.2 and 4.1.3.2. In this case, the allowance for icing shall be adopted in accordance with 4.1.7.

#### 4.1.4 Stability curves calculation.

On agreement with the Register, the arms of stability curves can be calculated taking into account the hook load immersing in water during the inclinations of the floating crane/crane ship.

#### 4.1.5 Calculation of windage area.

**4.1.5.1** The designed windage area component  $A_{vi}$ , in  $m^2$ , is:

**.1** a projected area restricted by the outline of a structure, item of machinery, arrangement, etc., in the case of bulk structures, deck machinery, arrangements, etc.;

**.2** a projected area restricted by the structure outline with apertures between girders deducted, in case of a lattice type structure;

**.3** projected area of fore beam where the beam spacing is less than the fore beam height, in the case of the structure of a boom, crane body frame, etc. comprising several beams of equal height located one after another (refer to Fig. 4.1.5.1.3), or

total projected area of the fore beam plus 50 per cent of the areas of subsequent beams, if the beam

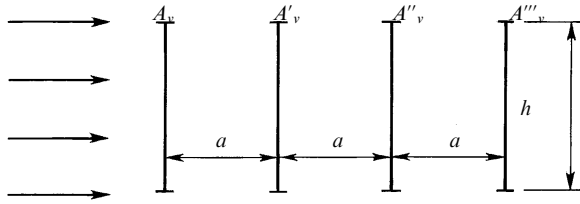


Fig. 4.1.5.1.3

$$\begin{aligned} a < h: & A_{vi} = A_v = A'_v = A''_v = A'''_v; \\ h \leq a < 2h: & A_{vi} = A_v + 0.5(A'_v + A''_v + A'''_v); \\ a \geq 2h: & A_{vi} = A_v + A'_v + A''_v + A'''_v \end{aligned}$$

spacing is equal to, or greater than, the beam height, but is not less than the double height of the beam; or total projected area of all beams, if the beam spacing is equal to, or greater than, the beam double height.

If the beams are not equal in height, parts of subsequent beams not overlapped by those lying in front of them shall be fully taken into account;

4 for a number of ropes of the same diameter arranged one after another at the distance  $a$  (refer to Fig. 4.1.5.1.4-1), the projected area shall be determined by the formula

$$A_{vi} = A_v \frac{1 - K_a^N}{1 - K_a} \quad (4.1.5.1.4-1)$$

where  $A_v$  = projected area of a single rope;

$N$  = number of ropes;

$K_a$  = factor to be taken from Table 4.1.5.1.4 on the basis of the  $a/d_r$  relationship (where  $d_r$  is the rope diameter).

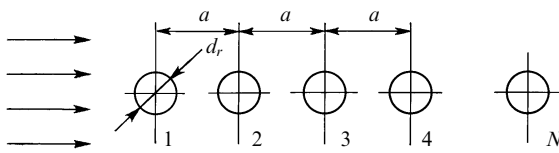


Fig. 4.1.5.1.4-1

Table 4.1.5.1.4

Factor  $K_a$ 

$a/d_r$	3	4	5	6	7	8	9	10	20	30	40	50
$K_a$	0,444	0,492	0,531	0,564	0,592	0,616	0,638	0,657	0,780	0,844	0,883	0,909

Where the angle  $\alpha$  between the rope axis and the wind velocity vector is not equal to  $90^\circ$  (refer to Fig. 4.1.5.1.4-2)

$$A_{vi} = A_v \sin^2 \alpha \quad (4.1.5.1.4-2)$$

shall be adopted.

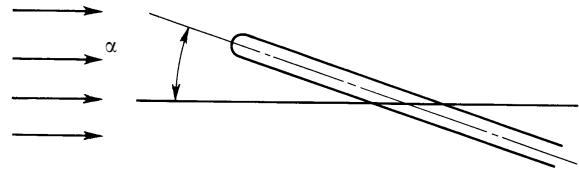


Fig. 4.1.5.1.4-2

4.1.5.2 The design arms of windage area  $z_w$ ,  $z'_w$ , in m, shall be determined by the formulae:

under the effect of constant wind

$$z_w = \frac{\sum k_i n_i A_{vi} z_i}{\sum k_i n_i A_{vi}}; \quad (4.1.5.2-1)$$

under the effect of squall

$$z'_w = \frac{\sum k_i A_{vi} z_i}{\sum k_i A_{vi}} \quad (4.1.5.2-2)$$

where  $i$  = number of the windage area component  $A_{vi}$ ;

$z_i$  = elevation of the centre of gravity of area component  $A_{vi}$  above waterline, in m;

$k_i$  = aerodynamic flow coefficient for component  $A_{vi}$ ;

$n_i$  = zone coefficient for component  $A_{vi}$ .

The values of  $A_v$ ,  $z_w$ ,  $z'_w$  may be determined taking trim into consideration.

4.1.5.3 For some windage area components, the aerodynamic flow coefficients  $k_i$  are given in Table 4.1.5.3.

Table 4.1.5.3

Aerodynamic flow coefficient  $k_i$ 

Windage area components	$k_i$
Trusses and continuous beams	1,4
Above-water part of the hull, superstructures, deckhouses, rectangular cabins, balance weights of crane structure and other box structures with smooth outside surfaces	1,2
Isolated truss structures (crane, boom) made of:	
beams	1,5
tubular components	1,3
Tubular structures (depending on the product of the calculated dynamic wind velocity head $q$ , in Pa, and by the square of the tube diameter $d_p$ , in m) at:	1,2
$q d_p^2 \leq 10$ N;	1,2
$q d_p^2 \geq 15$ N.	0,7
Cargo ropes at:	
$d_r \leq 20$ mm;	1,2
$d_r > 20$ mm.	1,0
Deck machinery and small items on deck	1,4
Cargo (if no data are available for substantiated flow coefficient)	1,2

Notes. 1. The dynamic wind velocity head  $q$  is related to the wind pressure  $p$  by the ratio  $p = k_i q$  where  $k_i$  is the aerodynamic flow coefficient.

2. For intermediate values of  $q d_p^2$ , the  $k_i$  values shall be determined by linear interpolation.

3. The values of  $k_i$  for structural elements not specified in the Table are subject to special consideration of the Register in each case.

4. The value of  $q$  corresponds to the design condition of the floating crane/crane ship under consideration according to Table 4.1.8.6-1 or Table 4.1.10.2.

**4.1.5.4** The height (zone) coefficient  $n_i = (V_{hi}/V_v)^2$  with regard to the increase of wind velocity  $V_{hi}$ , in m/s, according to the height of the upper border of the zone above the waterline, in which the  $i$ -th component of the windage area  $A_{vi}$  lies shall be determined by the formula

$$n_i = (V_{hi}/V_v)^2 = [1 + 2,5 \ln(h_{vi}/10) \sqrt{(0,71 + 0,071 V_v) \cdot 10^{-3}}]^2 \quad (4.1.5.4)$$

where  $V_v$  = design wind velocity, in m/s (average wind velocity during 10 min at a height of 10 m above sea surface);

$V_{hi}$  = wind velocity, in m/s, within the zone at the height  $h_{vi}$  above sea surface;

$h_{vi}$  = above-water height, in m, of the upper border of the zone in which the  $i$ -th component of the windage area  $A_{vi}$  lies (where  $h_{vi} < 10$  m, the coefficient  $n_i = 1,00$ ).

For particular wind velocities corresponding to different service regimes of floating sea structures, the values of the  $n_i$  coefficient can be found in Table 4.1.5.4.

Table 4.1.5.4

Height above sea level, in m	Height (zone) coefficient $n_i$		
	$V_v$ , m/s		
	25,8	36,0	51,5
10	1	1	1
20	1,182	1,208	1,242
30	1,296	1,339	1,396
40	1,379	1,435	1,510
50	1,446	1,513	1,602
60	1,502	1,578	1,680
70	1,550	1,633	1,746
80	1,592	1,682	1,805
90	1,630	1,726	1,858
100	1,664	1,766	1,905
110	1,695	1,802	1,949
120	1,723	1,836	1,990
130	1,750	1,867	2,027
140	1,775	1,896	2,062
150	1,798	1,924	2,095
160	1,820	1,949	2,126
170	1,840	1,973	2,155
180	1,860	1,996	2,183
190	1,879	2,018	2,209
200	1,896	2,039	2,235
210	1,913	2,059	2,259
220	1,929	2,078	2,282
230	1,945	2,097	2,304
240	1,960	2,114	2,326
250	1,974	2,131	2,346

**4.1.5.5** For each design condition of the floating crane/crane ship (working condition, non-working condition, voyage, passage), it is recommended that the windage area of non-continuous surfaces (rails, spars, rigging and various miscellaneous surfaces) shall be taken into account by increasing the maximum total windage area of continuous surfaces by 2 per cent with regard to coefficients  $k_i$  and  $n_i$ , and by increasing the static moment of this area by 5 per cent.

<sup>1</sup> The roll amplitude is obtained from model tests with 1,1 per cent probability.

Under icing conditions this increase shall be taken 4 per cent and 10 per cent or by 3 per cent and 7,5 per cent, respectively, depending on the icing rate for areas lying up to 30 m above the waterline.

The values of non-continuous surface windage areas and of static moments of these areas shall be calculated for minimal draught and, where necessary, be recalculated for particular loading conditions and the relevant condition of the floating crane/crane ship.

**4.1.5.6** The design windage area of the cargo on hook is determined by its actual outline with due regard for its aerodynamic coefficient and maximum lifting height, i.e. as stipulated in 4.1.5.1 taking account of the provisions of 4.1.5.3 and 4.1.5.4.

The centre of the wind pressure to the cargo on the hook shall be assumed at the point of the load suspension to the boom.

With no actual data available, the design windage area of cargo on the hook is adopted from Table 4.1.5.6.

Table 4.1.5.6

Windage area of cargo $k_i A_{vi}$			
Cargo mass, in t	$k_i A_{vi}$ , in m <sup>2</sup>	Cargo mass, in t	$k_i A_{vi}$ , in m <sup>2</sup>
10	12	300	81
20	18	350	88
30	22	400	96
40	26	500	108
50	29	600	120
60	33	700	130
80	38	800	140
100	44	900	150
120	48	1000	159
140	53	1500	200
160	57	2000	235
180	61	2500	265
200	64	3000	295
225	69	3500	322
250	73	4000	348
275	77	5000	380

Note. For intermediate values of cargo mass, the values of  $k_i$ ,  $A_{vi}$  shall be determined by linear interpolation.

#### 4.1.6 Roll amplitude calculation.

##### 4.1.6.1 General.

The roll amplitude shall be obtained from model tests or determined in accordance with 4.1.6.2, 4.1.6.3, 4.1.6.4<sup>1</sup>.

Model tests to obtain roll amplitudes shall be carried out and their results shall be processed in accordance with the Register-approved procedures.

Where the hook load mass exceeds  $0,1\Delta$  for particular loading conditions, the Register may require the roll amplitude to be determined with regard for the effect of cargo swinging.

Wave height with 3 per cent probability  $h_{3\%}$ , in m, shall be adopted as follows:

from Table 4.1.8.6-2 in working condition on the basis of wave intensity at which cargo-handling operations are permitted;

from Table 4.1.10.2 during the voyage or passage of a floating crane proceeding from the area of navigation assigned.

The roll amplitude of a crane ship during a voyage or passage shall be determined in accordance with 4.1.6.4.

Calculated roll amplitude values determined in accordance with 4.1.6 shall be rounded to the tenth part of a degree in working condition and to whole degrees during voyage or passage.

**4.1.6.2** The roll amplitude of a floating crane in a working condition, during the voyage or passage of a floating crane/crane ship.

**4.1.6.2.1** The roll amplitude  $\theta_r$ , in deg., of a floating crane in its calculated conditions as mentioned under 4.1.2.1, 4.1.2.2 and 4.1.2.4 (i.e. in working condition, during voyage and passage), and of a crane ship in working condition shall, under all loading conditions under consideration, be determined by the formula

$$\theta_r = \theta_{ro} X_4 X_5 \quad (4.1.6.2.1)$$

taking into consideration the instructions given in 4.1.6.2.2 to 4.1.6.2.9 and 4.1.6.3.

**4.1.6.2.2** The function  $\theta_{ro}$ , in deg., shall be determined by the formula

$$\theta_{ro} = (Y + \delta\theta_r)Z. \quad (4.1.6.2.2)$$

The function  $\theta_{ro}$  and calculated roll amplitude shall be assumed equal to zero where the parameter  $W = h_{3\%}/\sqrt{C_B B d} \leq 0,1$ .

**4.1.6.2.3** The values of the function  $Y$  shall be adopted from Table 4.1.6.2.3-2 proceeding from the parameters  $W$  and  $K$ . The  $K$  parameter shall be determined by the formula

$$K = [G - 0,505(P - 2,4)]/P^2. \quad (4.1.6.2.3-1)$$

The parameter  $G$  shall be determined by the formula

$$G = \frac{z_g - d}{\sqrt{C_B B d}}. \quad (4.1.6.2.3-2)$$

The parameter  $P$  shall be adopted from Table 4.1.6.2.3-1 proceeding from the values of expression  $(z_m - d)/\sqrt{C_B B d}$ .

Table 4.1.6.2.3-1

Parameter $P$									
$\frac{z_m - d}{\sqrt{C_B B d}}$	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0	1,2
$P$	1,89	1,99	2,07	2,15	2,23	2,30	2,37	2,44	2,56
$\frac{z_m - d}{\sqrt{C_B B d}}$	1,4	1,6	1,8	2,0	2,5	3,0	3,5	4,0	4,5
$P$	2,67	2,77	2,87	2,96	3,17	3,36	3,52	3,67	3,82

Note.  $z_m$  = metacentric height, in m.

Table 4.1.6.2.3-2

Function  $Y$ , in deg.

Parameter $W$	Parameter $K$					
	0,00	0,04	0,08	0,10	0,12	0,14
0,1	0,24	0,10	0,05	0,04	0,04	0,04
0,2	2,83	1,58	0,40	0,27	0,23	0,23
0,6	21,60	22,90	13,85	7,71	3,41	1,14
1,0	28,15	37,53	38,73	26,07	12,74	5,93
1,4	30,18	42,31	53,37	45,02	28,05	13,61

**4.1.6.2.4** The function  $\delta\theta_r$ , in deg., shall be determined by the formula

$$\delta\theta_r = \{(A_4 X + A_3)X + A_2\}X + A_1 \quad (4.1.6.2.4-1)$$

where  $X$  = a factor to be determined by the formula

$$X = 10(F + 0,813K - 0,195) \quad (4.1.6.2.4-2)$$

where the parameter  $F$  shall be determined by the formula

$$F = n \frac{\sqrt{h}}{B} \sqrt[4]{C_B B d} \quad (4.1.6.2.4-3)$$

where  $n$  = factor depending on the slewing angle of the crane structure  $\varphi$  (refer to 4.1.3.1) and determined by the formula

$$n = \frac{0,414}{\sqrt{1 + 0,564 \sin^2 \varphi}}, \quad (4.1.6.2.4-4)$$

as well as in accordance with 4.1.6.2.9-1.

The factors  $A_1, A_2, A_3, A_4$  shall be adopted from Table 4.1.6.2.4 proceeding from the parameters  $W$  and  $K$ .

Table 4.1.6.2.4

Factors  $A_1, A_2, A_3, A_4$ 

Parameter $W$	$A_i$	Parameter $K$					
		0,00	0,04	0,08	0,10	0,12	0,14
0,1	$A_1$	0,61	0,18	0,08	0,08	0,09	0,10
	$A_2$	0,65	0,07	0,12	0,07	-0,02	0,08
	$A_3$	-1,00	-0,33	0,51	0,15	-0,47	0,09
	$A_4$	-2,30	-0,53	0,65	0,15	-0,65	0,12
0,2	$A_1$	2,21	4,14	1,23	0,61	0,58	0,57
	$A_2$	-2,82	-4,83	3,62	0,94	-0,14	1,02
	$A_3$	2,88	-31,90	8,57	2,06	-3,57	3,74
	$A_4$	4,66	-31,44	7,76	2,19	-4,84	5,60
0,6	$A_1$	-17,51	-0,48	22,15	20,28	16,27	4,90
	$A_2$	14,25	-37,97	-18,40	6,86	-16,30	19,34
	$A_3$	123,01	68,09	-16,97	72,58	-204,08	52,58
	$A_4$	-83,49	112,34	13,24	168,08	-264,50	43,24
1,0	$A_1$	-36,34	-42,33	-0,84	51,49	27,78	19,65
	$A_2$	38,54	45,08	-220,45	-61,11	14,01	-52,77
	$A_3$	110,50	108,83	-58,65	-329,54	198,88	-231,50
	$A_4$	123,15	-220,03	348,71	-390,73	371,65	-200,83
1,4	$A_1$	-40,61	-60,76	-55,09	14,98	39,93	29,55
	$A_2$	50,44	103,44	-185,31	-184,15	-132,82	-66,33
	$A_3$	117,86	67,17	170,10	-9,26	-224,91	32,57
	$A_4$	194,79	-230,32	250,47	247,05	-37,89	356,57

**4.1.6.2.5** The function  $Z$  shall be adopted from Table 4.1.6.2.5 proceeding from the parameters  $K$ ,  $P$  and  $W$ .

Table 4.1.6.2.5

Function  $Z$ 

Parameter $P$	Parameter $W$	Parameter $K$					
		0,00	0,04	0,08	0,10	0,12	0,14
2,1	0,1	2,17	1,59	1,56	1,95	2,71	4,51
	0,2	2,23	1,55	1,35	1,58	2,11	4,38
	0,6	3,44	1,59	1,10	1,08	1,06	3,52
	1,0	4,34	1,73	1,28	1,33	1,28	2,56
	1,4	2,30	1,65	1,25	1,28	1,51	2,05
2,5	0,1	1,22	1,21	1,47	1,89	2,36	3,15
	0,2	1,27	1,20	1,28	1,55	1,96	2,81
	0,6	1,32	1,23	1,03	0,97	1,00	1,77
	1,0	1,26	1,27	1,19	1,05	0,72	1,09
	1,4	1,26	1,24	1,16	1,02	0,68	0,51
2,9	0,1 — 1,4	1	1	1	1	1	1
3,3	0,1	0,77	0,85	0,87	0,81	0,68	0,58
	0,2	0,89	0,88	0,91	0,92	0,84	0,62
	0,6	0,84	0,88	0,93	1,03	1,06	0,81
	1,0	0,84	0,81	0,83	0,91	0,94	0,99
	1,4	0,87	0,84	0,87	0,92	0,91	1,02
3,7	0,1	0,61	0,77	0,84	0,75	0,49	0,37
	0,2	0,64	0,82	0,94	0,97	0,87	0,49
	0,6	0,70	0,82	0,98	1,21	1,41	1,04
	1,0	0,72	0,69	0,78	1,00	1,13	1,44
	1,4	0,77	0,77	0,84	1,00	1,00	1,46

**4.1.6.2.6** The factor  $X_4$  shall be adopted from Table 4.1.6.2.6 proceeding from the ratio  $\theta_{ro}/(\theta_v - \theta_o)$  where  $\theta_v - \theta_o$  is the angle range of positive static stability.

**4.1.6.2.7** The factor  $X_5$  shall be adopted from Table 4.1.6.2.7 proceeding from the ratio  $C_{CL}/C_{WL}$  where  $C_{CL}$  is the lateral area coefficient, and  $C_{WL}$  is the waterline area coefficient.

Table 4.1.6.2.6

Factor  $X_4$ 

$\frac{\theta_{ro}}{\theta_v - \theta_o}$	$X_4$
0	1,000
0,2	0,878
0,4	0,775
0,6	0,668
0,8	0,615
1,0	0,552
1,2	0,449
1,4	0,453
1,6	0,413
1,8	0,379
2,0	0,349
2,2	0,323
2,4	0,300
2,6	0,279
2,8	0,261
3,0	0,245

Table 4.1.6.2.7

Factor  $X_5$ 

$\frac{C_{CL}}{C_{WL}}$	$X_5$
0,60	0,326
0,65	0,424
0,70	0,553
0,75	0,646
0,80	0,756
0,85	0,854
0,90	0,932
0,95	0,983
1,00	1,000
1,05	0,983
1,10	0,932
1,15	0,854
1,20	0,756
1,25	0,646
1,30	0,553
1,35	0,424

**4.1.6.2.8** Where the floating crane/crane ship has bilge keels, the roll amplitude  $\theta'_r$ , in deg., shall be determined by the formula

$$\theta'_r = K_{BK} \theta_r. \quad (4.1.6.2.8-1)$$

The factor  $K_{BK}$  shall be adopted from Table 4.1.6.2.8 proceeding from the parameter  $m_{BK}$ , to be determined by the formula

Table 4.1.6.2.8

Factor  $K_{BK}$ 

$m_{BK}$	$K_{BK}$
0	1,00
0,025	0,882
0,050	0,779
0,075	0,689
0,100	0,607
0,125	0,535
0,135 and over	0,500

$$m_{BK} = \frac{1}{2} \frac{A_k}{C_B L B d} \sqrt{(z_g + d)^2 + B^2} \quad (4.1.6.2.8-2)$$

where  $A_k$  = total (on both sides) area of bilge keels, in  $m^2$ ;  
 $L$  = hull length of floating crane/crane ship, in m.

In the case of crane ships having the ice category mark **Arc4** to **Arc9** in their class notations, the bilge keels shall be ignored.

**4.1.6.2.9** In well-grounded cases, the peculiarities of floating crane/crane ship mass distribution and those of the area of navigation may be considered on agreement with the Register when determining the roll amplitude:

**.1** where the inertia coefficient  $c$  is known in the formula of the roll period  $T = 2cB/\sqrt{h}$ , the value of the factor  $n$  in the Formula (4.1.6.2.4-3) can be replaced by a value determined as:

$$n = 1/(4,6c); \quad (4.1.6.2.9.1)$$

**.2** where the frequency of the maximum of wave spectral density  $\omega_m$ , in  $s^{-1}$ , is known, which is characteristic of a particular area of navigation with the specified wave height with 3 per cent probability  $h_{3\%}$ , the roll amplitude  $\theta_r$ , in deg., determined by the Formula (4.1.6.2.1) can be specified using the formula

$$\theta_r = \theta_{ro} X_4 X_5 K_C, \quad (4.1.6.2.9.2-1)$$

where  $K_C$ , in  $m \cdot s^{-2}$ , shall be determined by the formula

$$K_C = 0,27 \omega_m^2 h_{3\%}, \quad (4.1.6.2.9.2-2)$$

while in Tables 4.1.6.2.3-2, 4.1.6.2.4 and 4.1.6.2.5, the value  $(1/K_C)(h_{3\%}/\sqrt{C_B B d}) = (1/K_C)W$  shall be used instead of the value  $W = h_{3\%}/\sqrt{C_B B d}$ .

**4.1.6.3** Corrections to the roll amplitude of a floating crane during the voyage/passage.

Where the roll amplitude  $\theta_r$  or  $\theta'_r$  of a floating crane during the voyage/passage, obtained in accordance with 4.1.6.2 or 4.1.6.2.8, respectively exceeds the angle of deck immersion or the angle  $\theta_b$ , at which the middle of bilge at amidships frame comes out of water the design roll amplitude  $\theta''_r$ , in deg., shall be determined by the following formulae:

$$\text{at } \theta_d < \theta_r \leq \theta_b$$

$$\theta''_r = (\theta_d + 5\theta_r)/6; \quad (4.1.6.3-1)$$

at  $\theta_b < \theta_r \leq \theta_d$

$$\theta''_r = (\theta_b + 5\theta_r)/6; \quad (4.1.6.3-2)$$

at  $\theta_r > \theta_b$  and  $\theta_r > \theta_d$

$$\theta''_r = (\theta_d + \theta_b + 4\theta_r)/6. \quad (4.1.6.3-3)$$

**4.1.6.4** Roll amplitude of a crane ship during voyage/passage.

The roll amplitude of a crane ship during voyage/passage under any loading conditions considered shall be determined in accordance with 2.1.5.

The roll amplitude of a crane ship equipped with anti-rolling devices shall be determined without regard for their operation.

#### 4.1.7 Allowance for icing.

For areas lying up to 30 m above the waterline, allowance for icing shall be made on the basis of the provisions of 2.4.1 to 2.4.6 and 2.4.8. For areas lying higher than 10 m above the waterline, the standard of icing shall be adopted at half the value stated under 2.4.3 and 2.4.4.

The windage area and the height of the centre of the windage area above the waterline shall be determined as follows:

in accordance with 4.1.3.2 under loading conditions with the smallest draught out of those verified;

in accordance with 4.1.3.3 under loading conditions chosen for stability verification purposes.

When pipes or other deck cargoes are carried, their icing shall be considered in accordance with 3.11.6 and 3.11.7 adopting the icing standard stated above.

#### 4.1.8 Stability of a floating crane/crane ship in working condition.

**4.1.8.1** Stability shall be considered adequate provided that:

**.1** the heeling angle  $\theta_{d2}$ , in deg., due to the combined effect of the initial heeling moment (from hook load, balance weight, anti-heel ballast, etc.)  $\theta_o$ , in deg., due to wind  $\theta_s$  (refer to 4.1.8.4) and roll  $\theta_r$ , in deg., does not exceed the angle of deck edge immersion or the middle of the bilge emergence in way mid-section, whichever is less. In any case, the following conditions shall be observed:

$$\theta_o + \theta_s \leq \begin{cases} 0,2(\theta_v - \theta_o) + 2^\circ \\ 10^\circ \end{cases}; \quad (4.1.8.1.1-1)$$

$$\theta_r \leq \begin{cases} 0,15(\theta_v - \theta_o) - 1^\circ \\ 5^\circ \end{cases}. \quad (4.1.8.1.1-2)$$

The above acceptable heel angles static ( $\theta_o + \theta_s$ ) and dynamic ( $\theta_r$ ) shall not exceed relevant angles at

which reliable operation of the crane structure is ensured. These angles shall be in conformity with the delivery specifications of the crane structure and/or with its maintenance manual.

For floating cranes/crane ships, which crane structure operates reliably at large angles of heel, the acceptable angle of heel is subject to special consideration by the Register in each case;

**.2** the vertical distance between the lower edges of openings by which the flooding angle is determined in operation and the waterline corresponding to the static heel and trim is not less than 0,6 m or 0,025B, whichever is greater;

**.3** the area  $A_m$ , in m<sup>2</sup>, of the righting lever curve, between the angles  $\theta_o$  and  $\theta_m$  is in conformity with the following conditions:

$$A_m \geq \begin{cases} 0,115 - 0,00075(\theta_v - 20^\circ) \\ 0,100 \end{cases}; \quad (4.1.8.1.3)$$

**.4** if  $\theta_m - \theta_o \geq 10^\circ$  and  $\theta_v - \theta_o \geq 20^\circ$ ;

**.5** if maximum righting arm  $l_{\max}$  of a floating crane/crane ship equipped with an automatic anti-heel system is not less than 0,25 m where this system fails to operate;

**.6** if capsizing moment (refer to 4.1.8.7) determined with regard to the combined effect of load drop and roll is at least twice the heeling moment due to wind pressure. The value of  $g\Delta l_{\max}$  shall be twice as great as the heeling moment at least. In the case of floating cranes/crane ships equipped with an anti-heel system, the system shall be considered non-working after load drop, and the anti-heel ballast shall be considered to remain in the same position in which it was at the moment of load drop;

**.7** the lower edges of openings considered to be open during the operation of the floating crane/crane ship are above the waterline by the value of  $h_f$  (being not less than 0,6 m or 0,025B, whichever is greater) under conditions of dynamic heel  $\theta_{d3}$ , in deg., due to the combined effect of load drop, wind and roll.

The height  $h_f$  shall be determined by the formula

$$h_f = (z_f - d)\cos \theta_{d3} - y_f \sin \theta_{d3} \quad (4.1.8.1.7)$$

where  $y_f, z_f$  = the ordinate and the applicate, in m, respectively, of the lower edge of the opening in question;  
 $d$  = draught after load drop, in m.

**4.1.8.2** If a floating crane/crane ship shall be engaged in handling a submerged cargo having a mass greater than 0,1Δ, in t, under particular loading conditions, the Register may require calculations to be made to demonstrate that the safety of the floating crane/crane ship against capsizing is ensured for the case of submerged load drop.

**4.1.8.3** Where a floating crane/crane ship does not comply with the above requirements when it has a hook load of a mass equal to the full cargo-lifting



capacity of the crane structure, the cargo-lifting capacity may be limited by a value at which the requirements of the present Section are met.

**4.1.8.4** The heeling angle of a floating crane/ crane ship  $\theta_{d2}$  due to the combined effect of initial heeling moment, wind and roll shall be determined by the Formulae (4.1.8.4.1-2) or (4.1.8.4.2-2) proceeding from the critical value of the parameter  $G_{cr}$  to be determined by the formula below with  $C = 1,0$ :

$$G_{cr} = \{[(z'_w - 0,34z_w)/\sqrt{C_B B d}] - 0,34Cf_1 - f_3\}/f_2 \quad (4.1.8.4)$$

where  $f_1, f_2, f_3$  = factors to be adopted from Tables 4.1.8.4-1, 4.1.8.3-2.

Table 4.1.8.4-1

Factor  $f_1$ 

Parameter $P$	$\theta_o$ , in deg.					
	0	2	4	6	8	10
2,0	0,43	0,44	0,42	0,36	0,27	0,18
2,2	0,64	0,67	0,62	0,47	0,33	0,22
2,4	0,88	0,96	0,92	0,58	0,39	0,26
2,6	1,18	1,28	1,02	0,69	0,46	0,31
2,8	1,53	1,68	1,22	0,80	0,52	0,35
3,0	1,95	2,06	1,43	0,91	0,58	0,39
3,2	2,43	2,48	1,64	1,02	0,64	0,43
3,4	2,99	2,89	1,87	1,13	0,71	0,48
3,6	3,62	3,30	2,09	1,24	0,77	0,52
3,8	4,32	3,71	2,33	1,35	0,83	0,56

Note. The intermediate values of  $f_1$  shall be determined by linear interpolation.

Table 4.1.8.4-2

Factors  $f_2, f_3$ 

$P^2$	Factors		$P^2$	Factors	
	$f_2$	$f_3$		$f_2$	$f_3$
4,0	0,600	0,027	9,0	0,750	0,214
4,5	0,625	0,051	9,5	0,759	0,229
5,0	0,646	0,073	10,0	0,767	0,243
5,5	0,663	0,095	10,5	0,774	0,256
6,0	0,682	0,115	11,0	0,781	0,269
6,5	0,693	0,133	11,5	0,787	0,282
7,0	0,708	0,152	12,0	0,792	0,295
7,5	0,720	0,167	13,0	0,803	0,320
8,0	0,731	0,185	14,0	0,813	0,344
8,5	0,741	0,198			

Note. The intermediate values of  $f_2$  and  $f_3$  shall be determined by linear interpolation.

**4.1.8.4.1** If the parameter

$$G \leq 0,9G_{cr} \quad (4.1.8.4.1-1)$$

it is inherent in pontoon cranes; then

$$\theta_{d2} = \theta_o + \theta_s + \theta_r, \text{ in deg} \quad (4.1.8.4.1-2)$$

where  $\theta_o, \theta_s$  shall be determined by the formulae:

$$\theta_o = 57,3y_g/h, \quad (4.1.8.4.1-3)$$

$$\theta_s = 57,3M_v/g\Delta h; \quad (4.1.8.4.1-4)$$

$M_v$  shall be determined by the Formula (4.1.8.5-1), and the angle  $\theta_r$  shall be determined in accordance with 4.1.6.2.

**4.1.8.4.2** If the parameter

$$G \geq 1,1G_{cr} \quad (4.1.8.4.2-1)$$

it is inherent in crane ships, which lines are similar to those of conventional ships; then

$$\theta_{d2} = \theta_o + \theta'_s + \theta_r, \text{ in deg.}, \quad (4.1.8.4.2-2)$$

where  $\theta'_s$  shall be determined by the formula

$$\theta'_s = 100M_v/g\Delta h; \quad (4.1.8.4.2-3)$$

$M_v$  shall be determined by the Formula (4.1.8.5-2).

The directions of the angles  $\theta_o, \theta_s, \theta'_s, \theta_r$  shall be assumed to coincide. For a floating crane/crane ship, which shall not operate at rough sea, the angle  $\theta_r$  shall be adopted equal to zero.

**4.1.8.5** The heeling moments  $M_v, M'_v$ , in kN·m, shall be determined by:

**1** the Formula (4.1.8.5-1) where the value of the parameter  $G$  is in compliance with condition (4.1.8.4.1-1):

$$M_v = 0,6q(z_w + f_1\sqrt{C_B B d})\Sigma k_i n_i A_{vi}; \quad (4.1.8.5-1)$$

**2** the Formula (4.1.8.5-2) where the value of the parameter  $G$  is in compliance with condition (4.1.8.4.2-1):

$$M'_v = q[z'_w - f_2(z_g - d) - f_3\sqrt{C_B B d}]\Sigma k_i A_{vi}; \quad (4.1.8.5-2)$$

**3** either of the Formulae (4.1.8.5-1) or (4.1.8.5-2) which yields the greater heeling angle, provided the following condition is met:

$$0,9G_{cr} < G < 1,1G_{cr}. \quad (4.1.8.5-3)$$

**4.1.8.6** The values of the rated wind velocity head  $q$  and the wave height with 3 per cent probability  $h_{3\%}$  shall be adopted from Tables 4.1.8.6-1 and 4.1.8.6-2 according to the weather restrictions assigned.

Table 4.1.8.6-1  
Design wind velocity head  $q$   
in squall

Wind restriction assigned, in numbers	$q$ , in kPa
1	0,02
2	0,03
3	0,05
4	0,09
5	0,15
6	0,23
7	0,35
8	0,50

Table 4.1.8.6-2  
Wave height with 3 per cent probability  $h_{3\%}$ 

Wave restriction assigned, in numbers	$h_{3\%}$ , in m
1	0,25
2	0,75
3	1,25
4	2,00
5	3,50
6	6,00

**4.1.8.7** Recommendations concerning the capsizing moment and dynamic heeling angle determination for a floating crane/crane ship in working condition with load drop are given in 1.1, Appendix 2.

The heeling angle before load drop shall be adopted, equal to

$$\theta'_{d2} = \theta_o + \theta_r. \quad (4.1.8.7)$$

**4.1.8.8** The effect of anchoring and mooring upon the stability of a floating crane/crane ship in working condition may be considered using the Register-approved procedure.

**4.1.8.9** When the crane structure is tested by the hook load with the mass exceeding the design one, the stability of the floating crane/crane ship shall be verified with regard to the actual mass of the test load. It shall be demonstrated to the satisfaction of the Register that the floating crane/crane ship safety against capsizing is ensured by the development of special procedures at least, including weather restrictions.

**4.1.9 Stability of a floating crane/crane ship during voyage.**

**4.1.9.1** Stability shall be considered sufficient (bearing 4.1.3.4 in mind) if:

**.1** the range of righting lever curve between the angles  $\theta_o$  and  $\theta_v$  is  $40^\circ$  at least;

**.2** the area of righting lever curve is not less than  $0,160 \text{ m}\cdot\text{rad}$ , between the angles  $\theta_o$  and  $\theta_1$ , the latter angle being obtained from the relationship

$$\theta_1 \geq 15^\circ + 0,5(\theta_v - 40^\circ); \quad (4.1.9.1.2)$$

**.3** the capsizing moment determined with regard to roll and flooding angle is not less than the heeling moment, i.e.  $M_c \geq M_v$ .

For recommendations concerning the capsizing moment determination procedure during voyage, refer to 1.2, Appendix 2.

**4.1.9.2** The heeling moments  $M_v$ ,  $M'_v$ , in  $\text{kN}\cdot\text{m}$ , shall be determined by:

**.1** the Formula (4.1.9.2-1) where the value of the parameter  $G$  is in conformity with condition (4.1.8.4.1-1) at its critical value determined by the Formula (4.1.8.4) with  $C = 0,5$ :

$$M_v = 0,6q(z_v + 0,5f_1\sqrt{C_B B d}) \sum k_i n_i A_{vi}; \quad (4.1.9.2-1)$$

**.2** the Formula (4.1.8.5-2) where the value of the parameter  $G$  is in conformity with condition (4.1.8.4.2-1) at its critical value determined by the Formula (4.1.8.4) with  $C = 0,5$ ;

**.3** either of the Formulae (4.1.9.2-1) or (4.1.8.5-2) which yields the greater heeling angle, provided condition (4.1.8.5-3) is met with  $C = 0,5$ .

**4.1.9.3** Factor  $f_1$  shall be adopted from Table 4.1.8.4-1 proceeding from the value of the parameter  $P$  and with regard for the angle  $\theta_q$ . The values of factors  $f_2$  and  $f_3$  shall be adopted from Table 4.1.8.4-2.

**4.1.9.4** For a floating crane, the wind velocity head  $q$  and the wave height with 3 per cent probability  $h_{3\%}$  shall be adopted from Table 4.1.10.2.

If the floating crane is to operate in a particular geographical region,  $q$  and  $h_{3\%}$  may be specially adopted for that region on agreement with the Register.

**4.1.9.5** For a crane ship, the wind velocity head  $q$  shall be adopted from Table 4.1.10.2.

**4.1.10 Stability of a floating crane/crane ship during passage.**

**4.1.10.1** Where a floating crane/crane ship shall undertake a passage through sea regions lying beyond the prescribed area of navigation, a plan of such passage shall be prepared, which is subject to special consideration by the Register in each case.

**4.1.10.2** Stability shall be checked with due regard for 4.1.3.4 under loading conditions stipulated in 4.1.3.2 and taking into account the preparation arrangements specified in the passage plan (including possible partial or complete dismantling of the crane structure), and is considered to be adequate, if the requirements of 4.1.9 for conditions of passage areas are met.

Table 4.1.10.2

Wind velocity head  $q$  and wave height with 3 per cent probability  $h_{3\%}$

Area of navigation through which voyage or passage is made	$q$ , in kPa	$h_{3\%}$ , in m
Unrestricted	1,40	11,0
Restricted <b>R1</b>	1,00	6,0
Restricted <b>R2</b>	0,80	6,0
Restricted <b>R3</b>	0,60	At the Register discretion in each case

The design wind velocity head  $q$  and wave height with 3 per cent probability  $h_{3\%}$  shall to be adopted from Table 4.1.10.2.

**4.1.11 Stability of a floating crane/crane ship in non-working condition.**

**4.1.11.1** Stability is considered adequate, if the capsizing moment is at least 1,5 times greater than the heeling moment under loading conditions in accordance with 4.1.3.3 and in the absence of rolling ( $\theta_r = 0^\circ$ ) giving regard to 4.1.3.4.

**4.1.11.2** The capsizing and heeling moments shall be determined in accordance with 4.1.9.2 for  $q = 1,4 \text{ kPa}$ . In case mentioned under 4.1.9.2.1, the capsizing moment shall be determined in accordance with 1.3, Appendix 2, and in case mentioned under 4.1.9.2.2, it shall be determined in accordance with 1.2, Appendix 2 for  $\theta_r = \theta_s = 0^\circ$ .

## 4.2 PONTOONS

**4.2.1** This Chapter applies to pontoons with the ratio  $B/D \geq 3$  and the block coefficient  $C_B \geq 0,9$ .

**4.2.2 Loading conditions.**

**4.2.2.1** Stability of a pontoon shall be checked for the following loading conditions:

- .1 with full load;
- .2 without load;
- .3 with full load and icing.

**4.2.2.2** When carrying timber cargo, the stability calculation shall be made with regard to possible addition in mass of timber cargo due to water absorption as under 3.3.7.

**4.2.2.3** When carrying pipes, the stability calculation should be made with regard to trapped water in the pipes as under 3.11.4.

**4.2.3 Calculation of cross-curves of stability.**

When calculating the cross-curves of stability for a pontoon carrying timber cargo, the volume of timber cargo may be included in the calculation with full breadth and height and permeability of 0,25.

**4.2.4 Allowance for icing.**

**4.2.4.1** Rates of icing shall be adopted as under 2.4.

**4.2.4.2** When carrying timber cargo, rates of icing shall be adopted as under 3.3.7.

**4.2.4.3** When carrying pipes, icing is determined as under 3.11.7.

**4.2.5 Stability of a pontoon.**

**4.2.5.1** Stability of a pontoon shall be considered sufficient:

.1 if the area under the righting lever curve up to the angle of heel  $\theta_m$  is not less than 0,08 m·rad;

.2 if the static angle of heel due to wind heeling moment determined according to 4.2.5.2 does not exceed half the angle of immersion of the deck;

.3 if the range of righting lever curve is not less than:  
20° for  $L \leq 100$  m;  
15° for  $L > 150$  m.

For intermediate values of  $L$ , the range of stability is determined by linear interpolation.

**4.2.5.2** The heeling moment  $M_v$ , in kN·m, is determined by the formula

$$M_v = 0,001 p_v z_v A_v \quad (4.2.5.2)$$

where  $p_v$  = wind pressure equal to 540 Pa;  
 $z_v$  = arm of windage area determined according to 2.1.4.1;  
 $A_v$  = windage area, in m<sup>2</sup>, determined according to 1.4.6.

**4.3 FLOATING DOCKS**

**4.3.1** Stability of floating docks shall be checked for the following loading conditions:

- .1 floating dock when supporting a ship;
- .2 floating dock during submersion and emersion.

**4.3.2** Calculation of liquid cargo effect shall be made in conformity with 1.4.7. The correction factor for the effect of free surfaces of liquid ballast shall be

calculated at tank filling levels corresponding to the actual ones under loading condition in question.

**4.3.3 Stability of a floating dock when supporting a ship.**

**4.3.3.1** Stability shall be checked of fully emersed dock with a supported ship under conditions of maximum lifting capacity and moment of sail of the dock — ship system without icing.

**4.3.3.2** Stability is considered to be adequate provided:

.1 angle of heel with dynamically applied heeling moment due to wind pressure according to 4.3.3.5 or 4.3.3.6 does not exceed the permissible heeling angle for dock cranes in non-operating condition or 4°, whichever is less;

.2 angle of heel with dynamically applied heeling moment due to wind pressure according to 4.3.4.4 does not exceed the angle at which safe operation of cranes is ensured;

.3 angle of trim with statically applied trimming moment due to crane weight with maximum load for the most unfavourable service case of their arrangement does not exceed the angle at which efficient operation of cranes is ensured or the angle of pontoon deck immersion, whichever is less.

**4.3.3.3** The dynamic angle of heel of a floating dock, in deg., if it does not exceed the angle of immersion of the pontoon deck, shall be determined by the formula

$$\theta = 1,17 \cdot 10^{-2} p_v A_v z / (\Delta h) \quad (4.3.3.3)$$

where  $z$  = distance from the centre of the windage area to the plane of the waterline of floatation;  
 $p_v$  = wind pressure, P;  
 $\Delta$  = displacement, t.

**4.3.3.4** An angle of heel of floating dock, if it exceeds the angle of immersion of the pontoon deck, is determined from statical or dynamical stability curve when the dock is affected by the dynamically applied heeling moment, in kN·m, determined by the formula

$$M_v = 0,001 p_v A_v z. \quad (4.3.3.4)$$

**4.3.3.5** Wind pressure is assumed to be 1700 Pa.

**4.3.3.6** Wind pressure may be taken from Table 4.3.3.6-1 depending upon the prescribed geographical area of the floating dock operation according to Fig. 4.3.3.6.

To account for the increase of wind pressure with regard to the elevation of some top zones of windage area in the dock — ship system above the actual waterline the wind pressure values from Table 4.3.3.6-1 are multiplied by the relevant zone coefficients from Table 4.3.3.6-2.

In this case, the values of  $p_v$ ,  $A_v$  and  $z$  are determined for each zone separately, the sum of their

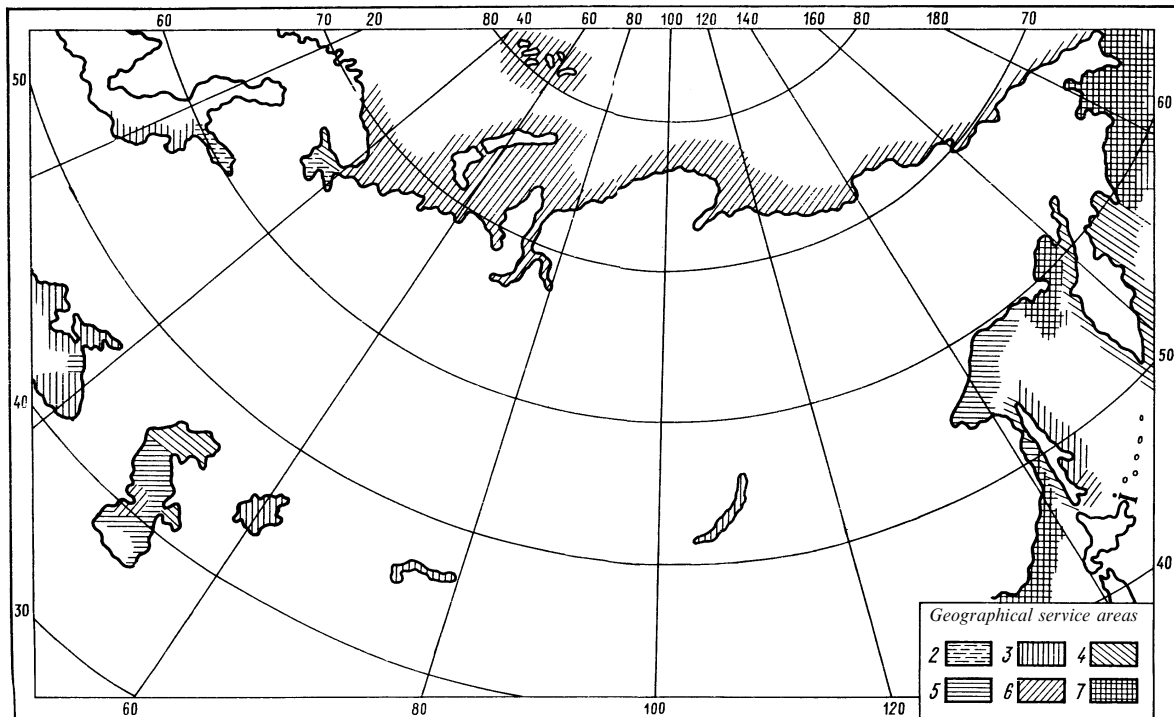


Fig. 4.3.3.6

Table 4.3.3.6-1  
Wind pressure for top zone of 0 — 10 m above  
the actual waterline  $P_v$ , in Pa

Geographical area of floating dock service (Fig. 4.3.3.6)	2	3	4	5	6	7
Pressure $p_v$ , in Pa	460	590	730	910	1110	1300

Table 4.3.3.6-2

Zone coefficient  $n_i$ 

Height above the waterline (zone boundary), in m	$n_i$	Height above the waterline (zone boundary), in m	$n_i$
10	1,0	50 — 60	1,75
10 — 20	1,25	60 — 70	1,84
20 — 30	1,4	70 — 80	1,94
30 — 40	1,55	80 — 90	2,02
40 — 50	1,69	90 — 100	2,1

products for all height zones comprising windage area of the dock — ship system is included in the Formulae (4.3.3.3) and (4.3.3.4).

**4.3.3.7** With geographical service area of the floating dock prescribed, the wind pressure may be taken for this particular area.

**4.3.3.8** With several geographical service areas of the floating dock prescribed, maximum wind pressure for these areas shall be taken.

**4.3.3.9** The angle of trim, in deg., of the floating dock shall be determined by the formula

$$\psi = 57,3 M_{\psi} / (\Delta H). \quad (4.3.3.9)$$

**4.3.4 Stability of a floating dock during submersion or emersion.**

**4.3.4.1** Stability of a floating dock shall be checked in the process of submersion or emersion for the most unfavourable case, as regards stability, of the supported ship displacement, moment of windage area of the dock — ship system and dock ballasting with the cranes not in operation, without icing.

**4.3.4.2** Stability is considered to be adequate if the angle of heel with dynamically applied heeling moment due to wind pressure does not exceed the permissible heeling angle for dock cranes in non-operating condition or  $4^\circ$ , whichever is less.

**4.3.4.3** The angle of heel of the floating dock shall be determined in conformity with 4.3.3.3 and 4.3.3.4.

**4.3.4.4** Specific wind pressure is assumed to be 400 Pa.

**4.3.5** The arm of windage area shall be determined according to 1.4.6.3. On agreement with the Register, in each particular case the arm of windage area  $z$  may be assumed as the elevation of the windage area centre of the dock — ship system above the plane of the positioning system fastening to the dock.

**4.3.6** These requirements apply to floating docks having sufficiently reliable positioning system.

#### 4.4 BERTH-CONNECTED SHIPS

**4.4.1** The stability of a berth-connected ship is considered sufficient provided:

**.1** the metacentric height complies with the requirements of 2.3 with due regard for the distribution of passengers among decks likely to occur in service;

**.2** the angle of heel under dynamically applied wind heeling moment as determined by the Formula (4.3.3.3)

with due regard for the provisions of 4.3.3.5 to 4.3.3.8 (for the case of a berth-connected ship) does not exceed the maximum permissible value.

**4.4.2** Under dynamically applied wind heeling moment, the ship stability is checked for the most unfavourable loading conditions as regards stability.

**4.4.3** As the maximum permissible heel, the angle is assumed at which the freeboard deck or fender edge immerses or the middle of the bilge comes out from water, whichever is less.

These angles are determined considering the immersion or emergence of the ship when inclined to final angles of heel and the actual position of deck edge, fenders and the middle of the bilge. The maximum permissible angle shall not exceed 10°.

### APPENDIX 1

## INSTRUCTIONS ON DRAWING UP INFORMATION ON STABILITY

### 1 GENERAL

**1.1** Each ship shall be provided with the Information on Stability<sup>1</sup> in order to assist the master and the control authorities in maintaining stability of the ship during service in compliance with the requirements of international agreements, Maritime Administrations and the present Rules.

Formal observance of the provisions contained in the Information does not relieve the Master of the responsibility for the stability of the ship.

**1.2** The present Instructions contain provisions concerning the form and contents of the Information.

The scope of the Information may vary depending on the type, purpose, stability reserve and service area of a ship. It shall be selected most carefully and agreed with the Register.

The form of the Information shall comply with the present Instructions.

**1.3** The Information shall contain the following sections:

- .1** Particulars of ship;
- .2** Guidance to the master;
- .3** Technical information;
- .4** Reference information.

The contents of the sections are given below.

**1.4** The Information shall have an identification number.

**1.5** Each sheet (page) of the Information shall be marked with the identification number of the Information, the number of the sheet (page) and

the total number of sheets (pages). The numbering of sheets (pages) shall be continuous, including plans and drawings.

Tables, plans and drawings are not allowed to have identical numbers.

**1.6** The front page shall contain:

**.1** name of the document: Information on Stability;

**.2** identification number;

**.3** name of ship;

**.4** IMO number.

**1.7** The front page shall be succeeded by a table of contents.

**1.8** For ships engaged on international voyages, the Information and the drawings and plans included shall be translated into English. The pages containing the original text and those containing the translation shall alternate. It is not allowed to draw up the translation as a separate volume.

**1.9** The Information shall list the documents on the basis of which it was drawn up.

**1.10** The Information shall contain a Record of Familiarization with the Document.

### 2 PARTICULARS OF SHIP

**2.1** The Section shall contain the following information:

- .1** ship's name;

<sup>1</sup>Hereinafter referred to as "the Information".

- .2 type of ship (dry cargo ship, oil tanker, etc.);
  - .3 purpose of ship (for what kind of cargo the ship is designed according to specification);
  - .4 name of builder and hull number;
  - .5 date on which the keel was laid, date of completion of construction, date of conversion;
  - .6 ship's class, classification society and RS number;
  - .7 ship's flag;
  - .8 port of registry;
  - .9 principal dimensions (length, breadth, depth; where the bulkhead deck does not coincide with the upper deck, the depth up to the bulkhead deck shall be stated);
  - .10 service area and restrictions imposed (sea state, distance to port of refuge, seasons, geographical service areas, etc.).
- For dredgers and floating cranes, restrictions for both operating and voyage conditions shall be stated;
- .11 draughts to the summer load line and summer timber load line, diagram of the load line marks and the corresponding displacement and deadweight;
  - .12 speed;
  - .13 type of anti-rolling devices; dimensions of bilge keels, if any;
  - .14 inclining test data, on which the Information is based (light-ship displacement and center of gravity coordinates for light-ship condition), place and date of the inclining test with the reference to the Inclining Test Report approved by the Register Branch Office or another body. If the data for the light-ship condition have been assumed based on the results of the light-weight check taking into consideration the results of the inclining test performed on a sister ship, the data on the ship light-weight check and on the inclining test performed on a sister ship, including the name and serial number of this ship shall be stated in the Information; the data shall contain reference to the Light-Weight Check Reports and Inclining Test Reports approved by the Register Branch Office or another body;
  - .15 a sketch showing the quantity and location of solid ballast, if any, on board;
  - .16 ship inertia coefficient  $C$  in the Formula for determining the roll period  $\tau = Cb/\sqrt{h_0}$  to be calculated on the basis of the roll period, if determined, during the inclining test;
  - .17 other data deemed necessary by the developer of the Information (for instance, carrying capacity of the ship, designed trim, stores endurance).

### 3 GUIDANCE TO THE MASTER

#### 3.1 General.

3.1.1 The Chapter shall contain the following information:

.1 Statement of the purpose of the document, i.e. to provide the necessary information to the master for ensuring the ship's trim and stability during loading, unloading, ballasting and other operations for which the ship is intended, and to provide guidance on and methods for satisfying the requirements of normative documents;

.2 list of normative documents (IMO, IACS, Maritime Administrations, Rules of RS and other classification societies) on the basis of which the Information was drawn up;

.3 list of stability criteria applicable to the ship with sketches (where necessary) and indication of criteria (criterion) limiting the ship's stability, damage stability criteria included, where these are applicable to the ship and limiting with regard to intact stability;

.4 general instructions to the master to exercise good maritime practice, having regard to the season of the year, the navigational area and weather forecasts, and to take the appropriate action as to speed and course warranted by the prevailing conditions; the instructions shall be developed considering the Revised Guidance to the Master for Avoiding Dangerous Situations in Following and Quartering Seas (refer to Collection of Regulating Documents. Book Eighteen, 2008);

.5 general instructions to the effect that the stability criteria (except for the criteria relevant to the carriage of grain and non-cohesive bulk cargoes) do not take possible cargo shifting into consideration and to prevent such cargo shifting one shall be guided by approved documents regulating the securing and stowage of cargo;

.6 explanations on the use of optional information included in the document at the discretion of the shipowner. It shall be stated that such information falls under the responsibility of the shipowner.

#### 3.2 Terms, symbols and units.

3.2.1 The Chapter shall contain the following information:

.1 a table of symbols showing the terms and symbols used in the Information, relevant explanations (where necessary) and the units of measurement. The unit system shall be uniform throughout the document and it shall be the same as the unit system adopted for Information on Damage Trim and Stability.

The main symbols to be used in the Information are given in Table 3.2.1.1;

.2 a sketch (refer to Fig. 3.2.1.2) explaining the main symbols.

#### 3.3 General explanations to the Information.

3.3.1 The Chapter shall contain explanations and guidance pertinent to all the sections of the Information concerning the use of the following technical data:

Table 3.2.1.1

Main symbols	
Term	Symbol
Length	$L$
Breadth	$B$
Depth	$D$
Draught	$d$
Freeboard	$f$
Displacement volume	$\nabla$
Displacement weight	$\Delta$
Center of gravity:	$G$
abscissa	$x_g$ (XG)
ordinate	$y_g$ (YG)
applicate	KG
Center of buoyancy:	$C$
abscissa	XB
applicate	KB
abscissa of centre of flotation	$x_f$ (XF)
Elevation of metacenter above base line:	
transverse	KMT
longitudinal	KML
Metacentric height:	
transverse	GM
longitudinal	GML
Righting lever	GZ
Cross curve lever	$l_K$ (KL)

.1 coordinate system. The coordinate system for determining mass moments, volumes, buoyancy, draughts, shall be uniform throughout the Information, and it shall be the same as the coordinate system adopted for the Information on Damage Trim and Stability and the design documentation;

.2 rules for the signs of heel and trim;

.3 applicability of hydrostatic data with regard to trim;

.4 applicability of stability limits with regard to trim;

.5 permissible windage area of deck cargo;

.6 accuracy of calculations and interpolation, and other guidance proceeding from the contents of the Information.

### 3.4 Operation of the ship.

3.4.1 The Chapter shall contain the following information:

.1 data on the light ship with regard to its trim, stability and strength. If the light ship has a heel and a trim due to asymmetrical distribution of equipment, instructions shall be given on stowing the ballast, stores and cargo so as to eliminate the heel and reduce the trim. It shall be stated that elimination of

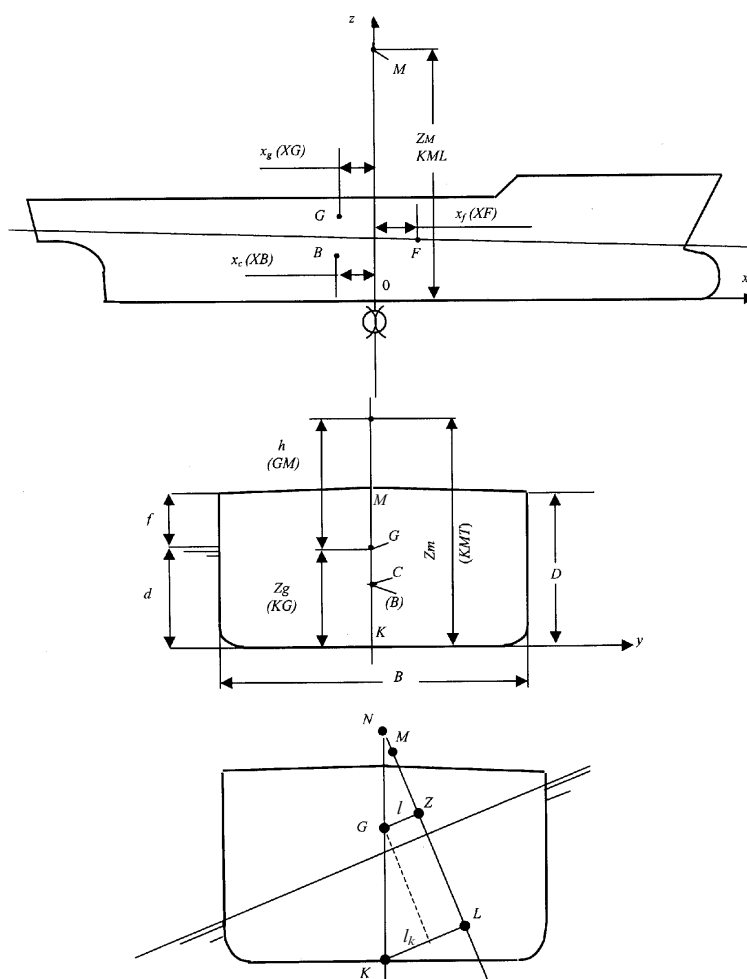


Fig. 3.2.1.2

heel by appropriate stowage of solid bulk cargo is not permitted;

**.2** principles on the basis of which instructions on consuming the stores were drawn up; distribution of 50 per cent and 10 per cent of stores; effect of stores consumption on the vertical centre of gravity of the ship; specific instructions on consuming the stores with indication of conditions proceeding from which the consumption pattern shall be applied (stability, trim and damage stability requirements);

**.3** the procedure for taking ballast during voyage for the compensation of increase of the vertical centre of gravity due to stores consumption; instructions on weather conditions under which ballasting is permitted;

**.4** the principal ballast patterns for the carriage of heavy deck cargo, like containers, or light cargo in the hold, like ro/ro-vehicles, and explanations to the patterns;

**.5** information regarding the effect of hoisted crane booms, filled swimming pool or other heavy top masses on the ship's stability;

**.6** operating limits concerning loading, unloading, ballasting and distribution of cargo shall be listed and explained, as for example:

**.6.1** draught limits and, in particular, statement that the ship's draught shall not exceed the value corresponding to the freeboard according to the ship's Load Line Certificate;

**.6.2** statement that the height of the ship's centre of gravity shall not exceed the maximum allowable value;

**.6.3** statement that the shear forces and bending moments shall not exceed the maximum allowable values;

**.6.4** minimum draught forward and aft with regard to seakeeping and bridge visibility;

**.6.5** numerical values of deck cargo dimensions with regard to bridge visibility;

**.6.6** maximum draught forward due to minimum bow height requirement;

**.6.7** maximum mass for container stacks;

**.6.8** permissible load for plating, decks and hatch covers on which cargo is stowed;

**.6.9** maximum mass per hold for bulk cargo;

**.6.10** ship's speed on the turn;

**.6.11** permissible quantities of fish on the deck of fishing vessels;

**.6.12** deck areas of passenger ships to which the access of passengers is prohibited;

**.6.13** restrictions to the application of anti-rolling devices;

**.6.14** directions for the use of anti-heeling tanks;

**.6.15** other limitations proceeding from the ship's purpose and construction;

**.7** list of openings which shall be closed when at sea to prevent the flooding of spaces in hull, superstructures or deckhouses which shall be taken into consideration for stability calculation purposes. Where necessary, a diagram of the openings shall be attached;

**.8** instructions for the case of damage to bilge keels;

**.9** general instructions concerning tanks which shall be either emptied or pressed up, except for those tanks out of which or into which liquid is taken. An instruction to the effect that the number of tanks with free surfaces shall be reduced to a minimum;

**.10** general instructions to the effect that the heeling of a ship adversely affects stability and, therefore, efforts shall be made to maintain the ship in the upright position;

**.11** instructions to the effect that the cargo shall be secured in accordance with the approved Cargo Securing Manual or in accordance with the recommendations of the master for the safe methods of stowing and securing the carried cargo (for fishing vessels);

**.12** measures to ensure stability when, during a voyage or passage, the ships enter a region where the navigating conditions are more severe than those specified when assigning the area of navigation to the ship (provided such measures are necessary);

**.13** instructions for preserving ship's stability when water is used for fire extinguishing;

**.14** restrictions and instructions aimed at insuring an intact stability sufficient to satisfy the damage trim and stability requirements of the Register where these are compulsory for the ship in question;

**.15** recommendations to the master which shall include recommendations for choosing the direction and speed with regard to the seaway having regard to the danger of parametric resonance of rolling when carrying deck cargo and/or at low initial stability, for minimum draught forward, manoeuvring directions (for instance, permissible speed with regard to heel on the turn for ships carrying containers on deck), recommendations for icing control, scale of forward and aft draught variations as a result of taking cargo on board the ship, directions for operating of heavy derricks (if installed on board the ship), etc.

Recommendations to the master for maintaining sufficient stability, including information deemed useful by the developer. They shall not be overburdened with well-known provisions of good maritime practice.

### **3.5 Typical loading conditions.**

**3.5.1** The Chapter shall contain the following information:

**.1** plan of tanks, cargo spaces, machinery space, spaces intended for crew and passengers; the numbers



and names shall be the same as in the ship documentation;

**.2** tables showing the distribution of stores and ballast among tanks under typical loading conditions with indication of mass and centre of gravity coordinates of the tanks as well as of relevant moments. The numbers and names of the tanks shall be the same as those to be found in plan referred to in 3.5.1.1. The tanks with regard to which corrections for free surfaces were made, taken into consideration for typical loading conditions at 100 per cent, 50 per cent and 10 per cent filling, shall be indicated in the tables;

**.3** mass and centre of gravity position, adopted for calculation purposes, of mass groups, such as passengers with their luggage and crew with their luggage, mass and centre of gravity position of cargo items (vehicles, containers, etc.);

**.4** typical loading conditions including the following:

**.4.1** light-ship condition;

**.4.2** docking condition;

**.4.3** loading conditions required by the Rules, loading conditions for all cargoes mentioned in the specification; marginal conditions of the ship operation in accordance with its purpose to be encountered in practice and conditions of commencement of ballasting during the voyage for the purpose of maintaining stability;

**.5** a summary table of typical loading conditions.

The summary table shall include:

**.5.1** name of the loading condition;

**.5.2** displacement;

**.5.3** trim parameters of the ship (forward and aft draught, draught at perpendiculars, mean draught, trim);

**.5.4** coordinates of the centre of gravity;

**.5.5** free surface correction value to the initial metacentric height;

**.5.6** initial metacentric height with regard to the free surface correction;

**.5.7** height of the centre of gravity of the ship with regard to the free surface effect;

**.5.8** permissible values of the height of the ship's centre of gravity;

**.5.9** standardized parameters and stability criteria (weather criterion, static stability curve parameters, angle of heel due to passengers crowding to one side or angle of heel on the turn, etc.) and their permissible values;

**.5.10** angle of flooding through opening considered to be open in accordance with the present Part of the Rules.

**3.5.2** As typical loading conditions are used to assess the cargo carrying capabilities of the ship, a limited number of conditions with 50 per cent stores shall be included in the typical loading conditions.

**3.5.3** As a rule, the stability calculation for typical loading conditions shall be made for mean draught with initial trim disregarded.

**3.5.4** Typical loading conditions shall be presented on special forms. In one and the same form, two or more loading conditions may be entered which may differ in the quantity of stores and ballast, characterizing the variations of loading during the voyage.

**3.5.5** A form shall contain:

**.1** description (name) of typical loading condition;

**.2** drawing showing the location of basic mass groups on the ship that shall be included in the displacement; a plan and directions for the stowage of deck cargo;

**.3** table for determining the ship's weight, coordinates of its centre of gravity and relevant mass moments with regard to coordinate planes including the weight moments and centre of gravity positions of particular mass groups and of the light ship, and where icing is concerned, taking the ice weight into consideration; correction for the free surface effect of liquid stores and ballast shall be given in the table;

**.4** displacement;

**.5** ship's draught at forward and aft perpendiculars, mean draught, draught at centre of waterline area, draught at draught marks; draught statements shall refer to bottom of keel, which shall be clearly indicated;

**.6** moment to change trim one unit;

**.7** longitudinal position of centre of buoyancy;

**.8** longitudinal position of centre of gravity;

**.9** longitudinal position of centre of waterline area;

**.10** trim over perpendiculars;

**.11** total correction for the effect of free surfaces of liquids;

**.12** vertical position of the transverse metacentre (for trimmed condition if trim exceeds 1 per cent of the length of the ship);

**.13** height of the ship's centre of gravity, its correction to free surface effect and the corrected value;

**.14** initial metacentric height adopted with regard for free surface effect;

**.15** permissible value of the height of the ship's centre of gravity or of the metacentric height determined on the basis of the Rules, and the comparison with the corresponding value obtained;

**.16** stability criteria required for the ship in question by the Rules (weather criterion for the particular loading condition, standardized parameters of righting lever curve, heel angles due to passengers crowding to one side, etc.);

**.17** table of righting arms;

**.18** righting lever curve plotted with regard for free surface effect, the flooding angle indicated (the

scales used in the diagrams shall be the same for all loading conditions);

**.19** statement of the ship's stability under the particular loading condition;

**.20** information, where applicable, with regard to operating limits, ballasting during voyage, water soaking of deck cargo, limitations to stowage factor of cargo, limitations to average container masses per tier; restrictions to the usage of heavy equipment and of swimming pools; and any other important aspects.

**3.5.6** Notwithstanding the fact that for the carriage of grain a ship shall have a separate Information on Ship Stability and Grain Loading drawn up in accordance with the Rules for the Carriage of Grain, typical loading conditions shall contain grain loading conditions, without regard to the shifting (where applicable).

### **3.6 Evaluation of stability for non-typical loading conditions.**

**3.6.1** Where an approved computer and programs for the evaluation of stability are available on board the ship, general data regarding the computer, the programs and the programmer, and the information on the approval of the programs shall be given (by whom, when and for what period they were approved).

**3.6.2** Notwithstanding a computer being available on board the ship, the "manual" method of calculation and evaluation of stability shall be explained in detail. The explanation shall contain a

description of the calculations sequence. As a rule, the description shall include six sections.

#### **3.6.2.1** The first Section shall contain:

**.1** calculation of displacement and of the coordinates of the ship's centre of gravity;

**.2** determination of mean draught and comparison with permissible draught according to load line;

**.3** determination of correction for free surface effect of liquid stores;

**.4** height of the centre of gravity corrected for free surface effect of liquid stores;

**.5** comparison of the value obtained for the height of the centre of gravity with the permissible value and condition of sufficient stability;

**.6** actions and measures to be taken if the condition of sufficient stability is not fulfilled.

A note shall be made when describing the method of calculation adopted for this Section that the calculation shall be presented in the form of a table. The constants adopted (for instance, lightship weight, crew, etc.) shall be specified and entered in the table. The numbers of the tables, diagrams, etc. from which data for the calculation are taken shall be indicated in the text. The recommended table form is given below (refer to Table 3.6.2.1.6).

If containers, vehicles, etc., are carried, auxiliary table forms for determining the weight and the coordinates of the centre of gravity of the cargo and explanations with regard to the use of the tables shall be given.

Table 3.6.2.1.6

**Stability verification and draught calculation**

Nos	Type of loading	Mass, in t	Abscissa, $x_g$ , in m	Moment, $M_x$ , in t·m (3) x (4)	Applicate, $z_g$ , in m	Moment, $M_z$ , in t·m (3) x (6)	Moment of free surface of liquid, $M_{f.s}$ in t·m
1	2	3	4	5	6	7	8
1	Light ship	×	×	×	×	×	
2	Crew	×	×	×	×	×	
3							
$n$	Displacement	$\Delta$		$\Sigma M_x$		$\Sigma M_z$	$\Sigma M_{f.s}$
1	Abscissa of ship centre of gravity $x_g = \Sigma M_x / \Delta = (5)/(3)$						_____ m
2	Centre of gravity elevation above moulded base plane, $z_g = \Sigma M_z / \Delta = (7)/(3)$						_____ m
3	Correction for free surface effect of liquid stores $\Sigma M_{f.s} / \Delta = (8)/(3)$						_____ m
4	Corrected centre of gravity elevation above moulded base plane, $z_{gcorr} = z_g + \Sigma M_{f.s} / \Delta$						_____ m
5	Permitted centre of gravity elevation above moulded base plane						_____ m
6	By the value of $M_x$ as per diagram (table) of forward and aft draughts: draught at forward perpendicular, $d_f$ draught at aft perpendicular, $d_a$ draught amidships, $d_{\otimes} = \frac{d_f + d_a}{2}$						_____ m _____ m _____ m



The Section shall contain the following information:

- .1** the ship's general arrangement plan;
- .2** capacity plan.

The capacity plan shall show the layout of cargo spaces, tanks, stores, machinery spaces and crew and passenger accommodation. Cargo spaces and tanks shall bear names and numbers adopted on board the ship. In addition, the plan shall present:

- .2.1** coordinate axes;
- .2.2** frames, frame spacing and numbering;
- .2.3** location of draught marks;
- .2.4** diagram of the load line marks showing the position of the deck line relative to the ship, draught to the summer load line, draught to the summer timber load line (if any) and corresponding freeboards;
- .2.5** deadweight scale.

It is permitted to incorporate the general arrangement plan and the capacity plan into a single plan;

- .3** cargo space information.

Information on each cargo space shall include:

- .3.1** name and number;
- .3.2** location (frames);
- .3.3** volume at 100 per cent filling;
- .3.4** coordinates of the centre of volume;
- .3.5** bale cargo capacity and grain capacity;
- .3.6** permissible load for plating;
- .3.7** permissible cargo mass for bulk carriers;
- .3.8** on oil tankers, volume at 98 per cent filling and the corresponding moment of inertia of the free surface;

**.3.9** for dry cargo holds intended for the carriage of solid bulk cargoes, volume and coordinates of the centre of gravity depending on the level of filling;

**.3.10** on container ships and ships equipped for the carriage of containers, container stowage plan (including deck containers) on the basis of which one can calculate the masses and the position of the centre of gravity of containers in the assumed loading condition. Maximum stack masses and maximum stack heights of containers shall be specified in the plan. A sketch shall be presented to confirm that the requirement for bridge visibility is fulfilled;

- .3.11** on roll-on/roll-off ships, vehicle stowage plan;
- .3.12** stowage plan for the deck cargo of timber with regard to the stowage factor and the requirements for bridge visibility;

- .4** tank space information.

Information on each tank space, including cargo tanks, shall include:

- .4.1** name and number of tank;
- .4.2** location (frames);
- .4.3** volume, volumetric centre coordinates and the moment of inertia of the free surface depending on the level of filling.

Intervals of 0,10 m shall, as a rule, be adopted for the level of liquid. In justified cases a greater interval may be adopted;

- .5** hydrostatic particulars.

Hydrostatic particulars shall be calculated for the ship on even keel or design trim (without deflection) against displacement over a range from light ship to 115 per cent of the displacement to the load line. The draught intervals shall be 0,05 m. In justified cases, a greater interval may be adopted. The particulars shall be presented in the form of a table.

If the ship is intended for operation with a trim exceeding  $\pm 0,5$  per cent of the ship's length, additional tables of hydrostatic particulars shall be presented for a suitable range of trim. The trim interval shall not exceed 1 per cent of the ship's length.

Draught statements shall refer to bottom of keel;

- .6** cross-curves of stability data.

Cross-curves of stability data shall be provided for heeling angles up to  $20^\circ$  at  $5^\circ$  intervals, and from  $20^\circ$  to  $80^\circ$  at  $10^\circ$  intervals. The displacement range shall correspond to that in 4.5; draught (displacement) intervals shall be 2 per cent of the draught (displacement) range. Cross-curves of stability values shall be presented in the form of a table. The table shall be supplemented by a sketch showing the ship's watertight spaces, which were taken into account for the calculation.

If the ship is intended for operation with a trim exceeding  $\pm 0,5$  per cent of the ship's length, additional tables of cross-curves of stability shall be presented for the ship with a trim. The trim interval shall not exceed 1 per cent of the ship's length.

If the buoyancy of the deck cargo is taken into account when performing stability calculations, an additional separate cross-curves of stability table and a relevant sketch shall be drawn up.

Cross-curves of stability calculations shall be performed having regard to the accompanying trim;

- .7** solid cargo information.

If solid cargo is stowed on board the ship, a sketch shall be presented showing the stowage of the ballast, with a specification containing information on the weight of each ballast group and the coordinates of the centre of gravity;

- .8** information for stability control.

Information for stability control shall include permissible values of the height of the centre of gravity of the ship (or of permissible metacentric heights) depending on displacement (draught). The information shall be presented in the form of a table.

The information may include more than one table for different conditions of the ship's operation (for instance, for operation without deck cargo, with timber cargo on board the ship, with deck cargoes of timber having different permeabilities, under conditions of icing, when carrying one or two or three tiers

of containers on deck, etc.). The permissible values of the height of the ship's centre of gravity shall be calculated with regard to subdivision requirements and damage stability and trim requirements where such requirements are compulsory for a ship.

If the ship is intended for operation with a trim exceeding  $\pm 0,5$  per cent of the ship's length, additional tables (diagrams) of permissible values of the height of the center of gravity of the ship with the trim shall be presented. The trim interval shall not exceed 1 per cent of the ship's length; the tables (diagrams) shall specify the trim range they apply to.

Where necessary, a table shall be presented containing minimum values of the height of the ship's centre of gravity at which the requirements of the Rules for the acceleration criterion are fulfilled;

**.9** information on angles of flooding.

Information on flooding angles in the form of a table (tables) proceeding from displacement or draught with a plan of openings assumed to be open. The names of the openings and their coordinates shall be indicated. Openings for ventilation of machinery spaces which ensure operation of machinery and its maintenance and which may not be closed in rough weather shall be assumed to be open;

**.10** tables showing free surface correction values for liquid cargoes.

Free surface correction values to the initial metacentric height and righting levers for liquid cargoes, in tabular form;

**.11** a diagram of forward and aft draughts.

A diagram (or table) of forward and aft draughts (at perpendiculars) plotted on a graph of displacement versus the longitudinal static mass moment of the ship. The diagram shall enable the master to speedily determine the draughts at forward and aft perpendiculars;

**.12** a diagram (or table) correlating the draughts at perpendiculars with the draughts at draught marks;

**.13** data for direct calculation of weather criterion on the basis of the static or dynamic stability curves. If the weather criterion is not a limiting one, the data mentioned above shall be presented in the Section 5 of the Appendix.

## 5 REFERENCE INFORMATION

**5.1** This Section shall contain information, which may be useful for the master, Port Administration and Flag Administration when resolving matters connected with the ship's stability.

The Section shall contain:

**.1** a detailed diagram of permissible heights of the ship's centre of gravity, including curves for each of

the stability criteria applicable to the ship in question. Resulting curves of permissible heights of the ship's centre of gravity shall be highlighted on the diagram;

**.2** data for direct calculation of weather criterion on the basis of the static or dynamic stability curves (at the discretion of the developer);

**.3** a copy of the Inclining Test Report for the ship or its prototype and a copy of the Light-Weight Check Report (if any);

**.4** any other data included in the Information at the discretion of the shipowner.

### 5.2 Information for floating cranes.

**5.2.1** For floating cranes, the Information shall contain data on their stability as regards the rated criteria for various boom radii and various loads on the hook (by mass and windage area) including loading conditions in which the stability becomes unsatisfactory by any criterion (criteria).

**5.2.2** For floating cranes which stability in case of load drop is limited by the angle of flooding in the working condition, the Information shall contain requirements for reliable battening down of openings which are not to be permanently open during cargo-handling operations.

**5.2.3** Because of the variety of their loading conditions, data on the stability of floating cranes shall be presented in a simple and obvious form (for instance, in tables and diagrams characterizing the loading and stability of the floating crane in each of the loading conditions).

**5.2.4** In the case of floating cranes with luffing booms, the following rule shall be applied: in order to reduce the influence of external forces upon the floating crane the boom shall be lowered to the lowest position (secured for sea) on completion of cargo-handling operations.

**5.2.5** In case of floating cranes with slewing cranes and a cargo platform on deck it is not recommended to perform cargo-handling operations when under way (e. g. carriage of loads hanging on the hook semi-submerged or raised above water: small ships, metal structures, etc.). Where this is performed by floating cranes of any type, restrictions on the area of navigation and weather shall be specified for such a voyage in each case, and arrangements shall be made for reliable securing to prevent the boom, hanger and the hanging load from swinging. The possibility of a voyage with a load on the hook shall be confirmed by calculation and approved by the Register in each case.

**5.3** The Information for the tug shall include a direction to the effect the maneuvering close to a stopped ship without casting off a tow rope is dangerous at the current speed above 1,3 m/s.

## APPENDIX 2

## DETERMINATION OF CAPSIZING MOMENT FOR A FLOATING CRANE

## 1.1 Determination of capsizing moment and the angle of dynamical heel in working condition in case of load drop

To determine the capsizing moment and the angle of dynamical heel after load drop, the curve of dynamical stability (to arm scale) shall be constructed for the loading condition under consideration, but without load on hook. In case the floating crane centre of gravity after the load drop does not coincide with the centre line, the curve is to be constructed with regard to angle of heel  $\theta_0$  due to unsymmetrical loading (including also unsymmetrical arrangement of cargo on deck). A portion of the curve shall be constructed in the negative angle area. To be plotted to the left from the origin of the coordinates is the initial angle of heel  $\theta_{d2}$  of the floating crane with a load on the hook, equal to the sum of the amplitude of roll  $\theta_r$  in the working condition and the angle of statical heel  $\theta_0$  when the load is lifted (Fig. 1.1).

The appropriate point  $C$  is fixed on the curve.

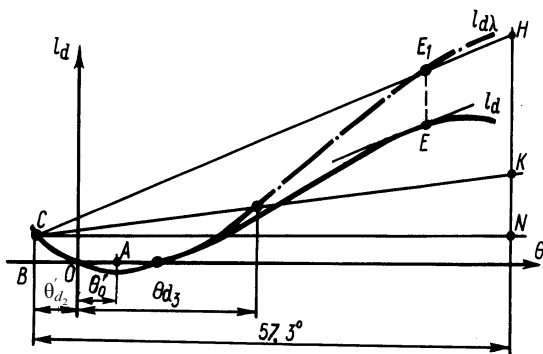


Fig. 1.1 Determination of capsizing moment and the angle of dynamical heel at the indication after load drop

The curve of the reduced arms is plotted to the right from the origin of the coordinates above the curve of statical stability, whose ordinates, in m, are determined by the formula

$$l_{d\lambda} = l_d + \delta l_\lambda \quad (1.1-1)$$

where  $\delta l_\lambda$  = correction taking into account damping forces to be obtained in compliance with 1.4 of the present Appendix.

The secant  $CE_1$  is drawn from the point  $C$  so that the point of its intersection  $E_1$  with the reduced arm curve lies on the same vertical line with point  $E$ , in which the straight line parallel to the secant touches the curve. From point  $C$  segment  $CN$  equal to  $57.3^\circ$  is

laid off parallel to the axis of abscissae. From point  $N$  the perpendicular is erected up to its intersection with the secant at point  $H$ . Segment  $NH$  is equal to the arm of the capsizing moment, in  $\text{kN}\cdot\text{m}$ , with due regard for damping to be determined by the formula

$$M_{c\lambda} = g\Delta\overline{NH} \quad (1.1-2)$$

where  $\Delta$  = displacement, in t.

From point  $N$  segment  $NK$  is laid off equal to the arm of the heeling moment, in m, to be determined by the formula

$$NK = M_v / g\Delta \quad (1.1-3)$$

where  $M_v$  = heeling moment due to wind pressure, in  $\text{kN}\cdot\text{m}$ .

Points  $C$  and  $K$  are connected by the straight line, whose point of intersection with the curve of reduced arms determines the angle of dynamical heel  $\theta_{d3}$  at the inclination after load drop.

Stability may be checked taking no account of damping. In this case, the curve of reduced arms is not constructed, but the tangent is drawn from point  $C$  to the curve of dynamical stability. The angle of dynamical heel  $\theta_{d3}$  is determined by the point of intersection of straight line  $CK$  with the curve.

## 1.2 Determination of capsizing moment during voyage

1.2.1 The capsizing moment  $M_c$  of the floating crane under the effect of rolling and steady wind may be determined both by the curve of dynamical stability and the righting lever curve, some portions of which are constructed for negative angles.

When using the curve of dynamical stability the positions of initial point  $A$  and point  $A_1$  (Fig. 1.2.1) are so selected that tangent  $AC$  is parallel to the

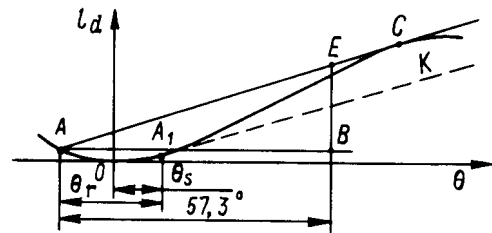


Fig. 1.2.1 Determination of capsizing moment of a floating crane secured for sea from the curve of dynamical stability

tangent  $A_1K$  and the difference of angles of heel corresponding to points  $A_1$  and  $A$  is equal to the amplitude of roll.

Angle  $\theta_s$  obtained therefrom corresponds to the angle of statical heel due to limiting wind pressure, and segment  $BE$  is equal to the capsizing moment if the curve of dynamical stability is plotted to scale of moments, and to the arm of the capsizing moment, if the curve of dynamical stability is plotted to scale of arms.

In the latter case, the capsizing moment, in  $\text{kN}\cdot\text{m}$ , is determined by the formula

$$M_c = \Delta \overline{BE}. \quad (1.2.1)$$

**1.2.2** When the righting lever curve is used, the capsizing moment can be determined assuming the work of the capsizing moment and that of the righting moment to be equal and taking account of the effect of rolling and statical heel due to limiting wind pressure (Fig. 1.2.2). For this purpose, the righting lever curve is continued in the region of negative angles for such a portion that straight line  $MK$  parallel to the axis of abscissae cuts off the cross-hatched areas  $S_1$  and  $S_2$  equal to each other and the difference of angles corresponding to points  $A_1$  and  $A$  is equal to the amplitude of roll.

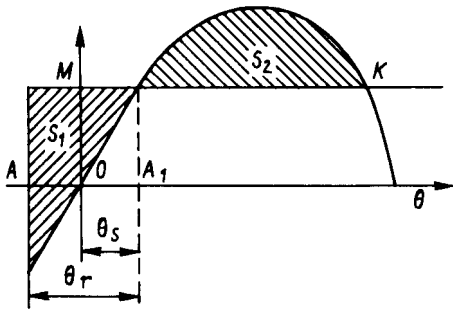


Fig. 1.2.2 Determination of the capsizing moment of a floating crane secured for sea from the righting lever curve

Ordinate  $OM$  will correspond to the capsizing moment, if moments are plotted along the axis of ordinates or to the arm of the capsizing moment, if righting arms are plotted along the axis of ordinates.

**1.2.3** If the curves of statical and dynamical stability are cut short at the angle of flooding, the capsizing moment shall be determined with regard to statical heel and the amplitudes of roll as specified in 1.2.1 and 1.2.2, yet the reserve of stability  $S_2$  is restricted to the angle of flooding  $\theta_f$ .

Capsizing moment  $M'_c$  is determined similar to the moment  $M_c$ , provided the amplitude of roll  $\theta_r$  in the Fig. 1.2.2 is plotted in way of negative abscissa values from the reference point.

### 1.3 Determination of capsizing moment in non-working condition

The capsizing moment is determined from the righting lever curve (Fig. 1.3) for non-working loading condition with due regard for the free surface effect as well as the initial angle of heel  $\theta'_0$  due to the boom turn in the plane of the frame for floating cranes and crane ships with slewing cranes.

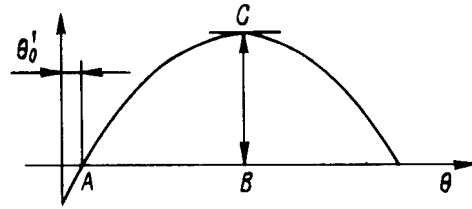


Fig. 1.3 Determination of capsizing moment in non-working condition

Segment  $CB$  is equal to the capsizing moment if the curve is plotted to scale of moments, and to the arm of the capsizing moment  $l_{\max}$  if the curve is plotted to scale of arms. In the latter case, the capsizing moment, in  $\text{kN}\cdot\text{m}$ , shall be determined by the formula

$$M_c = g\Delta l_{\max} \quad (1.3)$$

where  $\Delta$  = displacement, in t.

### 1.4 Determination of the correction to the curve of dynamical stability, taking account of damping forces

Correction  $\delta l_\lambda$ , in m, taking account of damping forces shall be determined by the formula

$$\delta l_\lambda = l_\lambda \sqrt{C_B B d} (\theta_{sw}/57.3)^2 F_5 \quad (1.4-1)$$

where  $B$  = breadth of the ship, in m;

$d$  = moulded draught of the ship, in m;

$C_B$  = block coefficient of the ship;

$\theta_{sw}$  = double swing value counting from the angle equal to the initial heel at the moment of load drop, in deg.;

$l_\lambda$  = factor determined by the formula

$$l_\lambda = F_0 \left( F_1 + \frac{z_g - d}{\sqrt{C_B B d}} F_2 \right) + \frac{z_g - d}{\sqrt{C_B B d}} F_3 + F_4 \quad (1.4-2)$$

$z_g$  = centre of gravity height above the base line, in m;

$F_0$  is taken from Fig. 1.4 depending on characteristic  $F$  and  $P$ ;

$F$  is determined by the Formula (4.1.6.2.4-3);

$F_1, F_2, F_3, F_4$  are taken from Table 1.4-1 depending on  $P$ ;

$F_5$  = factor obtained from Table 1.4-2 depending on the ratio  $(\theta_d + \theta'_{d2})/\theta_p$ ;

$\theta_d$  = angle of deck immersion.

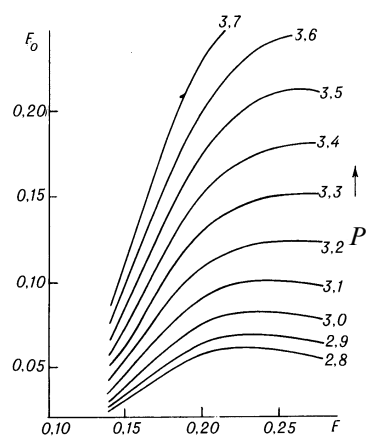


Fig. 1.4

Table 1.4-1

Factors  $F_1, F_2, F_3, F_4$

$P$	$F_1$	$F_2$	$F_3$	$F_4$
2,8	1,987	— 3,435	0,0725	— 0,021
2,9	2,087	— 3,313	0,0856	— 0,028
3,0	2,144	— 3,097	0,1007	— 0,037
3,1	2,157	— 2,823	0,1150	— 0,047
3,2	2,138	— 2,525	0,1273	— 0,057
3,3	2,097	— 2,230	0,1357	— 0,067
3,4	2,043	— 1,955	0,1417	— 0,076
3,5	1,982	— 1,711	0,1454	— 0,084
3,6	1,921	— 1,497	0,1474	— 0,091
3,7	1,861	— 1,312	0,1475	— 0,097

Table 1.4-2

Factor  $F_5$

$\frac{\theta_d + \theta'_d}{\theta_p}$	$F_5$	$\frac{\theta_d + \theta'_d}{\theta_p}$	$F_5$
1,0	1,0	0,5	1,5
0,9	1,053	0,4	1,626
0,8	1,138	0,3	1,747
0,7	1,253	0,2	1,862
0,6	1,374		



TABLE OF SYMBOLS FOR THE VALUES ADOPTED IN PART IV "STABILITY"

Register	IMO	Value
$\Delta$	$\Delta$	Displacement
$\Delta_{\min}$	—	Displacement corresponding to the minimum loading condition of the ship specified by the Rules
$\Delta_{\max}$	—	Full-load displacement
$\Delta_0$	—	Light-ship displacement
$\Delta_1$	—	Ship's displacement in the most unfavourable loading condition as regards values of $h$ and $l_{\max}$
$\gamma$	$\gamma$	Density
$A_v$	$A_v$	Windage area
$A_k$	—	Area of keels
$A_{vi}$	—	Windage area component of a floating crane
$a_{cal}$	—	Calculated value of acceleration (in fractions of $g$ )
$B$	$B$	Breadth of the ship
$b_0$	—	Shroud spacing
$C_B$	$C_B$	Block coefficient of the ship
$C_b$	$C_b$	Tank block coefficient
$c_t, b_t, a_t, v_t$	—	Tank overall length, breadth, height and volume (by base planes)
$c, b$	—	Relative "dynamic" abscissa and ordinate of tow hook suspension point
$D$	$D$	Depth, moulded
$d$	$d$	Draught of the ship, moulded
$d_{\min}$	—	Draught, moulded, for minimum practicable ship's loading condition
$d_{\overline{\overline{00}}}$	—	Draught amidships
$g$	$g$	Acceleration due to gravity
$h$	$GM$	Corrected metacentric height (with correction for free surfaces)
$h_0$	$GM_0$	Initial metacentric height (not corrected for free surfaces)
$h_{3\%}$	—	Calculated wave height with 3 per cent probability
$H$	—	Corrected longitudinal metacentric height of a floating dock, floating crane, crane ship (with correction for free surfaces)
$K$	—	Weather criterion
$K^*$	—	Acceleration criterion
$K_1$	—	Safety factor with respect to tow line jerk for general service and ship-handling tugs
$K_2$	—	Safety factor with respect to tow line jerk for sea-going tugs
$\Delta K$	—	Component of $K_2$ allowing for effect of rolling on resultant angle of heel
$\psi$	—	Angle of trim of a floating dock
$k$	—	Factor allowing for effect of bilge keels
$k_{\Theta}$	—	Coefficient, taking account of the peculiarities of roll for ships of river-sea navigation
$k_i$	—	Aerodynamic flow coefficient for crane structures
$L$	$L$	Length of the ship
$l$	$GZ$	Arm of statical stability corrected for free surfaces
$l_{\max}$	$GZ_m$	Maximum arm of statical stability corrected for free surfaces
$l_d$	$l$	Arm of dynamical stability corrected for free surfaces
$l'_d$	—	Ditto, but not corrected for free surfaces
$l_1; l_{d1}$	—	Arms of statical and dynamical stability with permanent heeling moment due to load, as corrected for free surfaces
$l_{d1}$	—	Ditto, but not corrected for free surfaces
$l_F$	—	Arm of form stability with respect to the centre of buoyancy
$l_M$	—	Arm of form stability with respect to metacentre
$l_P$	—	Arm of form stability with respect to arbitrary pole
$l_K$	—	Arm of form stability with respect to moulded base line
$l_c$	—	Capsizing lever corrected for free surfaces of liquids
$l_{dcaps}$	—	Arm of dynamical stability defined as ordinate of curve of dynamical stability for tug at the angle of heel equal to flooding or capsizing angle, whichever is less
$l_{d,h}$	—	Dynamic heeling lever characterizing assumed jerk of tow line
$l_{d\max}; l_{df}$	—	Ordinate of curve of dynamical stability at the angle of heel equal to angle of the maximum of righting lever curve or angle of flooding, whichever is less
$\overline{l}_0$	$k$	Non-dimensional coefficient for determination of free surface correction at heel of $\theta$
$\theta$	$\theta$	Angle of heel
$\theta_{w1}$	$\theta_{w1}$	Angle of heel for a ship due to effect of a heeling moment resulting from steady wind with lever $l_{w1}$
$\theta_f$	$\theta_f$	Angle of flooding
$\theta_v$	$\theta_v$	Angle of vanishing stability
$\theta_d$	—	Angle of deck immersion
$\theta_b$	—	Angle of coming out of water of bilge middle
$\theta_m$	$\theta_m$	Angle of heel corresponding to the maximum of the righting lever curve
$\theta_{caps}$	—	Capsizing angle
$\theta_{d1}$	—	Angle of dynamical heel of tug due to assumed jerk of tow line
$\theta'_{caps}$	—	Angle of tug capsizing defined as abscissa of the tangency point of dynamical stability curve and tangent to it passing through origin of the coordinates

Register	IMO	Value
$\theta_{sp}$	—	Statical heel after spoil discharge
$\theta_{3r}$	$\theta_r$	Maximum amplitude of dredger rolling with respect to statical inclination immediately after spoil is discharged from one side
$\theta_r$	—	Amplitude of roll of a floating crane, crane ship
$\theta'_r$	—	Amplitude of roll of a floating crane/crane ship taking into account bilge keels
$\delta\theta_r$	—	Correction (function) having regard to the effect of the crane centre of gravity elevation above waterline
$\theta_0$	—	Initial statical heel of a floating crane due to load hook and unsymmetrical stowage of cargo on deck
$\theta_s$	—	Angle of heel of a pontoon floating crane due to heeling moment $M_v$ caused by the permanent wind
$\theta_{d_2}$	—	Angle of heel of a floating crane due to combined effect of initial heeling moment, statical wind effect and rolling
$\theta'_{d_2}$	—	Calculated angle of heel of a floating crane prior to load drop equal to the sum of angles $\theta_o$ and $\theta_r$ minus $\theta_s$
$M_c$	$M_c$	Capsizing moment
$M_v$	$M_v$	Heeling moment due to wind pressure
$M_R$	$M_h$	Heeling moment due to turning
$M_\psi$	—	Trimming moment due to crane mass with maximum load for the most unfavourable service case of crane arrangement on a floating dock
$\Delta M_\theta$	$M_h$	Heeling moment due to liquid overflow at ship's heel of $\theta$
$\Delta m_h$	—	Correction of stability coefficient for liquid cargo effect
$N_e$	—	Shaft power
$n_i$	—	Zone coefficient taking into account changes in wind velocity head depending on the height of windage area centre of gravity of a floating crane
$P$	$P$	Mass of spoil in the hopper
$p_v$	$p_v$	Rated wind pressure
$q$	—	Rated wind velocity head
$v_0$	—	Speed of straightline movement of a ship
$x_H$	—	Longitudinal distance between tow hook suspension point and ship's centre of gravity as measured over horizontal
$X, X_1, X_2, X_{1,2}, X_3, X_4, X_5$	—	Factors for determination of amplitude of roll
$y$	—	Ship's centre of gravity ordinate from centre plane
$y_g$	—	Side shifting of ship's centre of gravity from centre plane
$Y$	—	Factor (function) for determination of amplitude of roll
$z$	—	Arm of windage area above the waterline of floatation
$z_v$	—	Arm of windage area equal to the distance from the centre of the windage area to the half of the ship draught
$z_g$	$KG$	Centre of gravity elevation above moulded base plane
$z_H$	—	Elevation of tow hook suspension point above moulded base plane
$z_0$	—	Elevation of shroud mounting point
$z_i$	—	Height of geometrical centres of areas $A_{vi}$ within a given zone above the actual waterline of a floating crane
$z_w$	—	Arm of windage area of a floating crane due to the permanent wind
$z'_w$	—	Arm of windage area of a floating crane due to effect of squall
$C_{CL}$	—	Lateral area coefficient of a floating crane, crane ship
$C_{WL}$	—	Water-plane coefficient of a floating crane, crane ship
$\theta''_r$	—	Amplitude of roll of a floating crane during voyage/passage with regard to bilge coming out of water at midsection or deck immersion
$\theta'_s$	—	Angle of heel of a crane ship which hull shape is similar to the ship lines, exposed to heeling moment $M'_v$ caused by squall
$X_c$	$X_B$	Abscissa of the centre of buoyancy
$X_g$	$X_G$	Abscissa of the centre of ship gravity

## PART V. SUBDIVISION

### 1 GENERAL

#### 1.1 APPLICATION

**1.1.1** The requirements of the Part apply to ships of the following types:

- .1** passenger ships;
- .2** oil tankers;
- .3** fishing vessels having the length  $L_1 \geq 100$  m;
- .4** type "A" ships and type "B" ships with reduced freeboard as mentioned under 4.1.2.1 and 4.1.3.3 of Load Line Rules for Sea-Going Ships;
- .5** chemical tankers;
- .6** gas carriers;
- .7** special purpose ships;
- .8** supply vessels;
- .9** ships intended for the carriage of radioactive agents;
- .10** cargo ships having the length  $L_s \geq 80$  m not mentioned above;
- .11** dry cargo ships having the length  $L_s < 80$  m (refer to 1.4.9);
- .12** icebreakers having the length  $L_1 \geq 50$  m;
- .13** tugs having the length  $L_1 \geq 40$  m;
- .14** dredgers having the length  $L_1 \geq 40$  m, hopper dredgers having the length  $L_1 \geq 60$  m;
- .15** salvage ships;
- .16** drilling ships;
- .17** lightships;
- .18** ships having the ice strengthening marks **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9** in the class notation;
- .19** berth-connected ships used as floating hotels and/or having over 100 persons on board;
- .20** passenger ro-ro ships, bulk carriers, ore and combination carriers in service, which construction date is stated in Section 5;
- .21** cargo ships having a length ( $L_1$ ) of less than 100 m other than bulk carriers, and a single cargo hold or cargo holds which are not separated by a bulkhead made watertight up to the freeboard deck (refer to 3.4.14).

**1.1.2** For ships to which the present Part of the Rules is not applicable it is recommended that all measures allowed by the type and service conditions of the ship be taken to obtain the best subdivision characteristics possible.

However, if the shipowner wishes a subdivision mark to be introduced in the class notation, the ship shall satisfy all the requirements contained in the Part.

The applicability of the present Part of the Rules to novel craft shall be determined on agreement with the Register.

**1.1.3** Section 4 is applicable to type "A" ships and type "B" ships with reduced freeboard provided com-

pliance with 4.1 of the Load Line Rules as regards the subdivision of those ships is confirmed. When making calculations required by Section 4, calculations as required by Sections 2 and 3 may be considered.

#### 1.2 DEFINITIONS AND EXPLANATIONS

**1.2.1** Definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification".

For the purpose of the present Part of the Rules the following definitions and explanations have been adopted.

**Damage waterline** is the waterline of a damaged ship with one or more adjacent compartments flooded.

**The depth  $D$**  is the least vertical distance measured from the top of the plate keel or from the line where the inner surface of shell plating abuts upon the bar keel, to the inner line of bulkhead deck abutting to the side. In ships having rounded gunwales, this distance is measured to the point of intersection of the continued inner surfaces of bulkhead deck steel plating and the side shell plating at side, as though the gunwale were of angular design. In non-metal ships the above-said shall be referred to the outer surfaces of the deck and plating.

**Moulded depth** is measured in the same way as the depth  $D$ , but up to the top of the freeboard beam.

**Subdivision load line** is the load line of an undamaged ship, which is used in determining the subdivision of the ship.

**The subdivision length of ship  $L_s$ :**

for passenger ships — the largest length of the ship portion located below the bulkhead deck;

for cargo ships — the largest moulded length of the ship's projection at or below the level of the deck or decks limiting the maximum vertical length of flooding  $H_{\max}$  determined in accordance with 2.3.10.

**The ship length  $L_{ice}$**  is the ship length on the waterline corresponding to the draft  $d_{ice}$ .

**The ship length  $L_1$**  is 96 per cent of the total length on a waterline at 85 per cent of the least moulded depth or the length from the fore side of stem to the axis of rudder stock on that waterline if that be greater.

**Permeability of a space  $\mu$**  is the ratio of the volume within that space, which is assumed to be occupied by water to the total volume of that space.

The lightest service draft  $d_0$  is the service draft corresponding to the lightest anticipated loading and associated tankage including such ballast as may be necessary for trim and/or stability.

The ship draft  $d$  is a vertical distance measured at the midpoint of the appropriate ship length from the top of the flat keel or from the point of abutment of the inner surface of the shell (outer surface, for ships with non-metal shell) to the relevant waterline of the ship.

The ship draft  $d_{ice}$  is the smallest ship draft: a draft corresponding to the waterline serving as the upper boundary of the ice strengthening of the hull, or a draft at which the requirements for ice damage trim and stability are met, as contained in 2.4 and 3.4.11.

The subdivision draft  $d_s$  is the draft up to the subdivision load line.

A compartment is an inner space limited by the ship bottom, sides, bulkhead deck and two adjacent transverse watertight bulkheads or a peak bulkhead and an extremity.

Bulkhead deck is the uppermost deck up to which transverse watertight bulkheads are carried over the entire breadth of the ship.

In case of flooding of a compartment or group of adjacent compartments, where there is a watertight deck above the bulkhead deck which, together with the shell plating and watertight bulkhead, restricts progressive flooding this deck may be adopted as relevant bulkhead deck in calculating the flooding case concerned.

The deepest subdivision load line is the waterline, which corresponds to the deepest draft permitted by applicable subdivision requirements.

Midlength is the midpoint of the subdivision length of a ship.

Equalization of a ship is the process of eliminating or reducing heel and/or trim.

The ship breadth  $B$  is the extreme moulded breadth of a ship at midlength at the level of or below the deepest subdivision load line.

**1.2.2** In all calculated cases of flooding only one hole in the hull is assumed and only one free surface of sea water which penetrated after the accident. In this case the hole is considered to have the shape of a rectangular parallelepiped.

**1.2.3** All linear dimensions used in the present Part of the Rules are taken in meters.

### 1.3 SCOPE OF SURVEY

**1.3.1** The provisions pertaining to the procedure of classification, survey of ships under construction and classification surveys, as well as the requirements

for the technical documentation to be submitted for consideration by the Register are contained in General Regulations for the Classification and Other Activity and in Part II "Technical Documentation" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**1.3.2** For every ship meeting the requirements of the present Part of the Rules, the Register shall carry out the following:

**.1** check of compliance of the structural measures taken to ensure subdivision of the ship with the requirements specified in 1.1.6 and 2.7, Part II "Hull", Section 7, Part III "Equipment, Arrangements and Outfit", Sections 2, 4, 5 and 7.1 to 7.11, 10.1, 10.2, 10.4, 12.1, Part VIII "Systems and Piping";

**.2** consideration and approval of Information on Damage Trim and Stability, Operating Manual on Water Level Detection System (refer to 3.4.12.4), Damage Control Plan, as well as consideration of Information on the Effect of Flooding (to be duly noted), as stipulated in 1.4.9;

**.3** checking of correct assignment and marking of additional load lines corresponding to subdivision load lines;

**.4** examination and approval of the computer installed on board the ship and the relevant software where it is used for assessing damage trim and stability.

### 1.4 GENERAL TECHNICAL REQUIREMENTS

**1.4.1** The ship subdivision shall be the most effective bearing in mind the service of the ship. The degree of subdivision shall vary proceeding from the area of navigation, ship length and number of persons on board so that the highest subdivision degree would be characteristic of ships of the greatest length engaged for the most part in the carriage of passengers and of those navigating in the Arctic and the Antarctic.

**1.4.2** In no case shall any subdivision load line be assigned above the deepest subdivision load line in seawater determined on the basis of the ship hull safety or in accordance with the Load Line Rules for Sea-Going Ships.

The subdivision load line assigned to the ship is marked on its sides and recorded in the documents of the Register as required by the Load Line Rules for Sea-Going Ships.

**1.4.3** The volumes and areas shall, in all cases, be calculated to moulded lines. The volumes and free surfaces of water which penetrates the compartments of reinforced-concrete, plastic, wood and composite ships shall be calculated to inboard hull lines.

**1.4.4** When determining the initial metacentric height of a ship in damaged condition, corrections for the effect of free surfaces of liquid cargoes, ship stores and ballast water shall be taken into account in the same manner as in the case of calculating the intact stability of a ship in compliance with 1.4.7, Part IV "Stability".

When plotting static stability curves for a damaged ship, the enclosed superstructures, trunks, deckhouses, angles of flooding through openings in ship's sides, decks, hull and superstructure bulkheads considered open as well as corrections for free surfaces of liquid cargoes shall be taken into account in the same manner as in the case of plotting curves for an intact ship in compliance with 1.4.9, Part IV "Stability".

Superstructures, trunks and deckhouses which sustain damage may only be taken into account with the permeability specified in 1.6, or ignored. The openings in such structures leading to spaces, which are not flooded, are considered open at appropriate angles of heel only when regular weathertight means of closing are not fitted.

**1.4.5** When calculating damage trim and stability, account shall be taken of changes in the initial ship loading (intact ship) due to liquid cargoes being replaced by sea water in damaged tanks, taking into consideration that in the flooded tanks below the damage waterline the free surface of those cargoes disappears.

**1.4.6** Ships to which the present Part of the Rules is applicable shall be provided with approved Information on Damage Trim and Stability with compartments flooded and with Damage Control Plan. These documents shall enable the master operating the ship, to consider the requirements concerning subdivision and to estimate the condition of the ship when compartments are flooded as well as to take measures for maintaining the damaged ship afloat.

**1.4.6.1** Information on Damage Trim and Stability shall include the following:

**.1** data on the ship, including its dimensions and permissible drafts on clear water and in ice conditions, its longitudinal section, deck and double-bottom plans, typical cross-sections with indication of all watertight bulkheads and enclosures with openings therein, means of their closure and drives, openings of air and ventilation pipes, as well as diagrammatic arrangement of systems necessary for the survival of the damaged ship;

**.2** information necessary to maintain the stability of an intact ship sufficient to withstand, in accordance with the requirements of the present Part of the Rules, the most dangerous extent of damage; instructions on loading and ballasting the ship, including recommendations on distributing cargo in the

holds, stores and ballast in a manner reasonable as regards the subdivision adopted and satisfying at the same time the requirements for the trim, stability and strength of the ship; brief list of requirements for damage trim and stability;

**.3** diagram of the limiting gravity-centre heights of the ship (limiting moments or minimum metacentric heights) plotted taking into the account the requirements of this Part and Part IV "Stability";

**.4** list of results of symmetrical and unsymmetrical flooding calculations with data on initial and damage draught, heel, trim and metacentric height both before and after taking measures for the equalization of the ship or for improving its stability as well as measures recommended for these procedures and the period of time required. Parameters of static stability curves anticipated under the worst flooding conditions shall also be included. Where necessary, for ships with **Arc4** to **Arc9** ice strengthening, the information on the characteristics of ice unsinkability, damage trim and stability shall be indicated when sustaining design ice damage;

**.5** data on structural measures to ensure ship subdivision, instructions on the use of covers, cross flooding arrangements and emergency appliances as well as on possible consequences of flooding relating to the particular features of the ship and on advisable and prohibited actions of the crew under normal conditions of service and in case of damage involving flooding.

**1.4.6.2** Damage Control Plan shall be made on the scale acceptable for operation, but not less the 1:200. On passenger ships, the Plan shall be permanently exhibited on the navigating bridge. On cargo ships the Plan shall be permanently exhibited or be readily available on the navigating bridge. The Plan containing the longitudinal section, plans of decks, double bottom and transverse sections shall include:

boundaries of watertight compartments and tanks;

ballast, bilge, overflow (discharge) systems and arrangements to correct heel caused by flooding;

location of openings in watertight compartments, their closing appliances and the location of their local and remote controls, position indicators and alarms;

location of doors in the shell of the ship, position indicators, leakage detection and surveillance devices;

location of weathertight closing appliances above the bulkhead deck and on the lowest exposed weather deck, together with location of controls and position indicators, if applicable;

location of all bilge flood and ballast pumps, their control stations and valves.

**1.4.7** Information on Damage Trim and Stability shall be compiled on the basis of the Information on Stability. The procedure of extending the validity of the Information on Damage Trim and Stability from

one ship to another is similar to that of extending the validity of Information on Stability as specified in 1.4.11.2, Part IV "Stability". Information on Damage Trim and Stability may be incorporated in Information on Intact Stability as a separate section.

**1.4.8** For estimation of the ship damage trim and stability it is recommended to use the onboard computer. The associated software shall have Type Approval Certificate issued by the Register.

A computer is not equivalent to Information on Damage Trim and Stability.

**1.4.9** Dry cargo ships less than 80 m in length shall be provided with Information on the Effect of Flooding. This Information shall contain data and documentation listed in 1.4.6.1 and results of damage trim and stability calculations when engine room and every cargo space are flooded. The calculations shall be made for two draughts one of which shall be the summer load line draught. The maximum permissible position of ship's centre of gravity shall be taken according to Information on Stability. Permeabilities of cargo spaces shall be taken with regard to the cargoes intended to be carried and shall be within 0,60 to 0,90. The Information shall contain a summary table of calculation results with indication of critical factors, as well as details given in 1.4.6.1.5.

**1.4.10** Every ship shall have draught scales prominently marked at bow and stern. Where the draught scales are so placed that they are not clearly visible or where service conditions impede reading the indications of the scale the ship shall be provided with a reliable draught measurement system whereby the forward and aft draughts can be easily determined.

## 1.5 SATISFACTORY SUBDIVISION

**1.5.1** The subdivision of a ship can be considered satisfactory as regards the present Part of the Rules, if:

**.1** the attained (actual) probability subdivision index  $A$  is not lower than the required probability subdivision index  $R$ . The indices  $A$  and  $R$  shall be determined on the basis of Section 2;

**.2** the attained (actual) probability ice subdivision index  $A_{ice}$  is not lower than the required probability ice subdivision index  $R_{ice}$ . The indices  $A_{ice}$  and  $R_{ice}$  shall be determined on the basis of Section 2;

**.3** the requirements under 1.5.1.1 are not applicable to ships for which in Section 2 there are no instructions for determining the indices  $A$  and/or  $R$ ;

**.4** damage stability is in accordance with Section 3, considering 3.3.6.

**1.5.2** A subdivision distinguishing mark is introduced in the class notation of the ship in accordance with 2.2.4, Part I "Classification" provided

under all design loading conditions corresponding to the type of ship concerned its subdivision is considered satisfactory according to 1.5.1, damage trim and stability comply with the requirements of 3.3 when any single ship compartment or any adjacent ship compartments are flooded throughout the ship's length in accordance with the introduced subdivision distinguishing mark, and the compliance of structural measures related to the subdivision of the ship with the requirements of 1.1.6 and 2.7, Part II "Hull" and in Section 7, Part III "Equipment, Arrangements and Outfit" is ensured.

When, in accordance with 3.4 of the present Part of the Rules the number of floodable compartments is changed throughout the ship length, the lowest value shall be stated in the subdivision distinguishing mark.

**1.5.3** Additional conditions under which a subdivision distinguishing mark shall be introduced in the class notation can be found in 3.4.

## 1.6 PERMEABILITY

**1.6.1** In the calculations of damage trim and stability the permeability of flooded space shall be assumed equal to:

**.1** 0,85 for spaces occupied by machinery, electric generating sets and processing equipment on fishing vessels and factory ships;

**.2** 0,95 for accommodation spaces and empty spaces including empty tanks;

**.3** 0,6 for the spaces intended for dry stores.

**1.6.2** Permeability of flooded tanks with liquid cargo or liquid stores or water ballast is determined based on the assumption that all the cargo is discharged from the tank and sea water is ingressed taking into consideration the permeability index being equal to 0,95.

**1.6.3** The permeability of the spaces intended for solid cargoes is given below in the appropriate paragraphs of Sections 2 to 5.

**1.6.4** The permeability of spaces may be assumed lower than specified above only in case a special calculation is performed which is approved by the Register.

When performing such special calculations for cargo spaces including refrigerating ones, the permeability of net cargo shall be assumed equal to 0,6, and that of the cargo in containers, trailers, roll trailers and lorries shall be assumed equal to 0,71.

**1.6.5** Where the arrangement of spaces or the service conditions of the ship are such that the expediency of the application of other permeabilities resulting in more severe requirements is evident, the Register is entitled to require the application of those permeabilities.

## 2 PROBABILITY ESTIMATION OF SUBDIVISION

### 2.1 GENERAL

**2.1.1** The degree of ship unsinkability shall be determined by the obtained probability subdivision indices:

$A$  — when the ship is side-holed due to collision or getting foul;

$A_{ice}$  (ice) — when the ship is side-holed during the navigation in ice conditions.

**2.1.2** The permissible degree of subdivision shall be determined by the required subdivision indices  $R$  and  $R_{ice}$ , i.e. the following conditions shall be met:

$$A \geq R \text{ and } A_{ice} \geq R_{ice}.$$

**2.1.3** The attained probability indices ( $A$  and  $A_{ice}$ ) are determined by the formulae:

$$A = \Sigma W_s \quad (2.1.3-1)$$

and

$$A_{ice} = \Sigma W_{ice}s \quad (2.1.3-2)$$

where  $W$  = the probability of flooding of the compartment or a group of adjacent compartments when a ship is side-holed;

$W_{ice}$  = the probability of flooding of the compartment or a group of adjacent compartments when a ship is ice-holed;

$s$  = the probability of the ship survival after damage to a compartment or a group of adjacent compartments.

Summarising in the Formulae (2.1.3-1) and (2.1.3-2) is carried out through the numbers of all the compartments and groups of adjacent compartments the results of flooding of which are estimated by the damage trim and stability calculations.

**2.1.4** When determining the probabilities  $W$  and  $W_{ice}$  the length of the compartment or a group of adjacent compartments, bounded by one or two watertight transverse bulkheads with steps, is assumed equal to the distance between transverse planes passing through the nearest parts of these bulkheads.

It is allowed not to consider the steps formed by watertight floors in the double bottom.

**2.1.5** For groups of adjacent compartments the values of  $W$  are determined by the following formulae:

for pairs of adjacent compartments

$$W = W_{ij} - W_i - W_j; \quad (2.1.5-1)$$

for groups of three adjacent compartments

$$W = W_{ijk} - W_{ij} - W_{ik} + W_j; \quad (2.1.5-2)$$

for groups of four adjacent compartments

$$W = W_{ijkm} - W_{ijk} - W_{jkm} + W_{jk}. \quad (2.1.5-3)$$

In the above mentioned formulae the following shall be specified:

$W_i, W_j$  — for compartments of the lengths  $l_i$  and  $l_j$ ;

$W_{ij}, W_{jk}$  — for compartments of the lengths  $l_{ij} = l_i + l_j$  and  $l_{jk} = l_j + l_k$ , accordingly;

$W_{ijk}, W_{jkm}$  — for compartments of the lengths  $l_{ijk} = l_i + l_j + l_k$  and  $l_{jkm} = l_j + l_k + l_m$ , accordingly;

$W_{ijkm}$  — for a compartment of the length  $l_{ijkm} = l_i + l_j + l_k + l_m$ .

For stepped bulkheads the compartment lengths for calculation purposes shall be determined in accordance with Fig. 2.1.5.

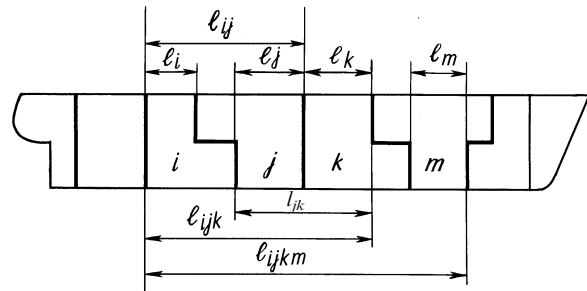


Fig. 2.1.5 Sketch for determining lengths of compartments for calculation purposes

**2.1.6** In case of longitudinal subdivision the following shall be considered separately:

holes which do not damage the longitudinal bulkhead with the probability  $r$ ;

holes which damage the longitudinal bulkhead with the probability  $1 - r$ .

**2.1.7** The values of the probabilities  $W$ ,  $W_{ice}$ ,  $s$  and  $r$  shall be determined by the formulae given in 2.2 to 2.4.

**2.1.8** When calculating the probabilities  $s$  it is assumed that:

the ship has no trim before the damage;

gravity-centre height for each calculated draught is not lower than the maximum permissible value obtained in compliance with the requirements of Part IV "Stability" and the requirements of the present Part;

permeabilities of non-cargo spaces are equal to those stated in 1.6, and for cargo spaces they are assumed according to the requirements of 2.2 to 2.4.

When considering the progressive flooding due to submergence of the openings, as mentioned in 3.3.4,

which lead to undamaged spaces, for the purpose of determination of the probability  $s$ , the components of ship's damage trim and stability at additional flooding of the appropriate undamaged spaces shall be taken into account.

## 2.2 PROBABILITY ESTIMATION OF SUBDIVISION IN PASSENGER SHIPS

**2.2.1** The requirements of this Chapter apply to the ship types listed below:

passenger ships;

special purpose ships having special personnel on board exceeding 200 persons;

roll-on/roll-off ships where transportation of vehicles with accompanying personnel in excess of 12 persons, including passengers, is intended.

When checking compliance with the requirements of the present Chapter, the instructions of 2.1 shall be taken into account.

**2.2.2** The required subdivision index  $R$  shall be determined by the formula

$$R = 1 - \frac{250}{L_s + (N/4) + 375} \quad (2.2.2)$$

where  $N = N_1 + 2N_2$ ;

$N_1$  = the number of persons for whom lifeboats are provided as compared to the total number of persons that shall be on board during the voyage;

$N_2$  = the number of persons (including officers and crew) that the ship is permitted to carry in excess of  $N_1$ .

**2.2.3** The probability  $W$  of a compartment, restricted by transverse bulkheads, being flooded is equal to  $ap$ .

The value of  $a$  determines the conditional effect upon the above probability of the position of a compartment as part of the ship length with regard to the law of abscissae distribution of the middle of the longitudinal extent of damage, the value of  $p$  accounts for the effect of compartment length with regard to the law of distribution of the longitudinal extent of damage.

**2.2.4** The value of  $a$  is determined for each compartment or a group of adjacent compartments by the formula

$$a = 0,4[1 + \xi_1 + \xi_2 + \xi_{12}] \quad (2.2.4)$$

where  $\xi_1 = x_1/L_s$ , if  $x_1 \leq 0,5L_s$ ;

$\xi_2 = x_2/L_s$ , if  $x_2 \geq 0,5L_s$ ;

$\xi_1 = 0,5$ , if  $x_1 > 0,5L_s$ ;

$\xi_2 = 0,5$ , if  $x_2 > 0,5L_s$ ;

$\xi_{12} = (x_1 + x_2)/L_s$ , if  $x_1 + x_2 \leq L_s$ ;

$\xi_{12} = 1,0$ , if  $x_1 + x_2 > L_s$ ;

$x_1$  = the distance from the aft terminal of ship's hull at or below the bulkhead deck to the aft end of the considered compartment or group of adjacent compartments;

$x_2$  = the distance from the aft terminal of ship's hull to the forward end of the considered compartment or group of adjacent compartments.

**2.2.5** The value of  $p$  is determined by the formulae below:

for  $L_s \leq 200$  m

$$p = 4,46(l/L_s)^2 - 6,20(l/L_s)^3, \text{ if } l/L_s \leq 0,24; \quad (2.2.5-1)$$

$$p = 1,072l/L_s - 0,086, \text{ if } l/L_s > 0,24; \quad (2.2.5-2)$$

for  $L_s > 200$  m

$$p = 184[4,46(l/L_s)^2 - 6,20(l/L_s)^3]/(L_s - 16), \text{ if } l/200 \leq 0,24; \quad (2.2.5-3)$$

$$p = 184[1,072l/L_s - 0,086]/(L_s - 16), \text{ if } l/200 > 0,24 \quad (2.2.5-4)$$

where  $l$  = the length of a compartment or a group of adjacent compartments being determined with regard to 2.1.4.

**2.2.6** In case of longitudinal subdivision:

**.1** the probability  $W$  of side compartment flooding

$$W = rap; \quad (2.2.6-1)$$

and that of the side compartment flooding together with the central one

$$W = (1-r)ap; \quad (2.2.6-2)$$

**.2** the value of  $a$  is determined according to 2.2.4, the value of  $p$  — according to 2.2.5;

**.3** the probability of  $r$  is determined by the formulae:

for  $l/L_s \geq 0,2b/B$

$$r = b/B[2,8 + 0,08/(l/L_s + 0,02)], \text{ if } b/B \leq 0,2; \quad (2.2.6.3-1)$$

$$r = b/B + 0,36 + 0,016/(l/L_s + 0,02), \text{ if } b/B > 0,2; \quad (2.2.6.3-2)$$

where  $l/L_s < 0,2b/B$ , the value of  $r$  shall be determined by linear interpolation assuming  $l/L_s = 0$  with  $r = 1,0$ , and with  $l/L_s = 0,2b/B$ , the value of  $r$  shall be determined by the Formulae (2.2.6.3-1), (2.2.6.3-2).

In the Formulae (2.2.6.3-1), (2.2.6.3-2),  $b$  is the transverse distance measured at right angle to the centreline between the shell plating (at subdivision loadline) and the section of longitudinal watertight bulkhead nearest to the shell plating (refer to Fig. 2.2.6.3).

**2.2.7** The value of  $s$  shall be determined by the formula

$$s = 0,45s_1 + 0,33s_2 + 0,22s_3 \quad (2.2.7)$$

where

$s_1$  shall be determined at the draught  $d_1$ ;

$s_2$  shall be determined at the draught  $d_2$ ;

$s_3$  shall be determined at the draught  $d_3$ .



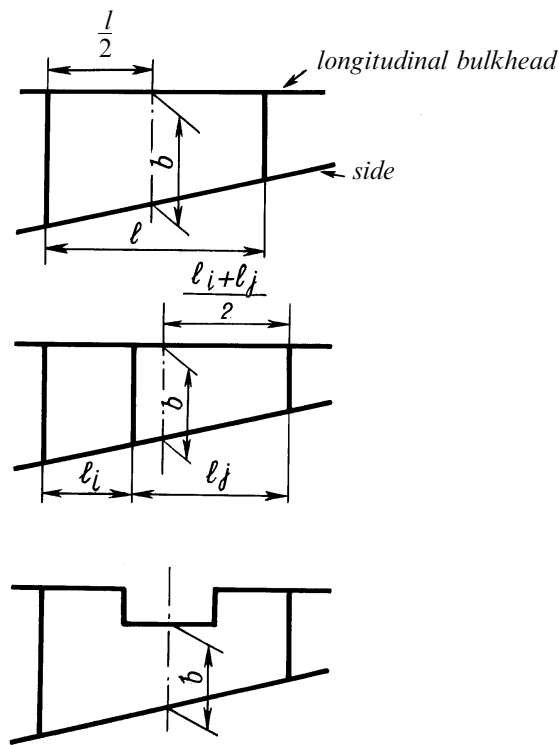


Fig. 2.2.6.3  
Determining of the design value of  $b$

**2.2.8** Draughts  $d_j$  shall be determined by the formulae:

$$d_1 = d_s - 2/3(d_s - d_0); \quad (2.2.8-1)$$

$$d_2 = d_s - 1/3(d_s - d_0); \quad (2.2.8-2)$$

$$d_3 = d_s - 1/6(d_s - d_0). \quad (2.2.8-3)$$

**2.2.9** In calculations for determining of the probabilities  $s_j$ :

**.1** permeability  $\mu_j$  of cargo spaces is assumed equal to

$$\mu_j = 1 - 1,2(d_j - d_0)/d_s - 0,05(d_s - d_j)/(d_s - d_0), \quad (2.2.9.1)$$

but it shall not be taken greater than 0,95 or less than 0,60;

**.2** for spaces intended for cargo loaded by roll-on method (on passenger roll-on/roll-off ships) the permeability  $\mu_j$  is assumed equal to 0,9. Permeability of cargo spaces intended for cargo vehicles and containers shall be specified based on the worst operation conditions by means of calculations where it is assumed that cargo vehicles and containers are not watertight and their permeability is assumed equal to 0,65. For ships engaged in specialised carriage, the

actual permeability value of containers and cargo vehicles may be accepted. However, the permeability of cargo spaces where vehicles and containers are carried shall in no case be assumed lower than 0,60.

**2.2.10** The probability  $s_j$  ( $s_1$ ,  $s_2$  and  $s_3$ ) shall be determined by the formula

$$s_j = 2,58c^4 \sqrt{GZ_{\max} \psi \Omega} \quad (2.2.10)$$

where  $GZ_{\max}$  = the maximum positive righting lever of the static stability diagram for a damaged ship within  $15^\circ$  of the equilibrium, but not greater than 0,1 m;

$\psi$  = the range of positive righting levers of the static stability diagram, but not exceeding  $15^\circ$ ;

$\Omega$  = the area, m.rad, of the static stability diagram, being determined in accordance with 3.4.10, but not exceeding 0,015 m.rad;

$c$  = a coefficient equal to:

$c = 1$ , when the angle of heel in the final stage of flooding  $\theta_e$  does not exceed  $7^\circ$ ;

$c = [(20^\circ - \theta_e)/13^\circ]^{1/2}$ , if  $7^\circ < \theta_e \leq 20^\circ$ ;

$c = 0$ , if the angle  $\theta_e$  exceeds  $20^\circ$ ;

$\theta_e$  = the angle of heel in the final stage of flooding (prior to equalisation), in degrees.

**2.2.11** When damage trim and stability, in case of compartment flooding at the draught  $d_j$ , are in full compliance with the requirements of 3.3 and 3.4.1, the probability  $s_j$  for the particular compartment is assumed equal to 1.

However, the value of  $s_j$  is taken equal to zero for any case of flooding:

the heeling angle exceeds  $20^\circ$  or an angle when any openings are immersed through which spreading of water on the ship may take place during the intermediate stage of flooding or prior to equalisation; or

in the final stage of flooding, the bulkhead deck is immersed excluding the area where the flooded compartment or compartments are located; or

in the final stage of flooding the heeling angle exceeds  $12^\circ$ ; or

in the final stage of flooding the initial meta-centric height is less than 0,05 m.

**2.2.12** As the calculated value of  $s_j$ , the lowest of the  $s_j$  values shall be assumed being determined for the worst cases of flooding of a compartment or a group of adjacent compartments at the draught  $d_j$ .

**2.2.13 Special requirements for subdivision of passenger ships and similar ships (refer to 2.2.1).**

**2.2.13.1** In ships with  $L_s \geq 100$  m the probability  $s$  shall be not less than 1 in case of fore damage of the following length:

0,08 $L_s$  + 3 m if  $L_s \leq 200$  m;

0,03 $L_s$  + 13 m if  $200 < L_s \leq 267$  m;

21 m if  $L_s > 267$  m.

**2.2.13.2** The main transverse bulkhead may be recessed provided that all parts of the recess lie between inner vertical surfaces situated at a distance

from the shell plating equal to 1/5 of the breadth of the ship  $B$  and measured at a right angle to the centreline at the level of the subdivision load line.

Any part of the recess, which lies outside these limits shall be considered.

**2.2.13.3** The scheme of calculating subdivision index  $A$  given in 2.2 is predicated upon the condition that transverse bulkheads extend from side to side. However, a combination of transverse and longitudinal watertight bulkheads may be accepted, wherein some of the transverse watertight bulkheads extend inboard only to longitudinal watertight bulkheads, provided that:

the subdivision index  $A$  calculated with regard to 2.2.6 is not less than the required subdivision index  $R$ ;

watertight floors in the double bottom are in line with watertight transverse bulkheads in the wings or the double bottom is subdivided by other equivalent means;

in passenger ships the inner bottom plating between the longitudinal bulkheads is located not less than  $0,1B$  above the base line.

### 2.3 PROBABILITY ESTIMATION OF SUBDIVISION IN CARGO SHIPS

**2.3.1** The requirements of the present Chapter are applicable to cargo ships having the length  $L_s \geq 80$  m, other than the ships referred to in 1.1.1.2 to 1.1.1.9, 1.1.1.19, 1.1.1.20, roll-on/roll-off ships similar to passenger ships (refer to 2.2.1) and nuclear ships.

The ships having the length  $L_s \geq 80$  m intended for the carriage of timber cargoes in holds and on the upper deck shall meet the requirements of this Chapter both at the draught corresponding to the summer freeboard with regard to 2.3.8 and at the draught corresponding to the summer timber freeboard and in case the specified summer draught is equal to the specified timber summer draught in accordance with 2.3.14.

Requirements of the Explanatory Note to the SOLAS Convention on subdivision and damage stability of cargo ships, which length is 80 m and over, shall be taken into consideration for verification of probability requirements for such ships (refer to Collection of Regulating Documents of the Register. Book 10, 2001.).

**2.3.2** The required subdivision index  $R$ , except for the ships carrying radioactive substances, shall be determined by the formulae:

$$R = R_{100} = (0,002 + 0,0009L_s)^{1/3} \text{ at } L_s \geq 100 \text{ m}; \quad (2.3.2-1)$$

$$R = R_{80} = 1 - \{1/[1 + (L_s/100)(R_{100}/(1 - R_{100}))]\}$$

$$\text{at } 80 \text{ m} \leq L_s < 100 \text{ m}. \quad (2.3.2-2)$$

**2.3.3** For ships carrying radioactive substances the required subdivision index  $R$  shall be specified by the Register. In any case, for ships carrying substances with the total radioactivity above  $2 \times 10^6$  TBq (Terabecquerel) or plutonium with the total radioactivity over  $2 \times 10^5$  TBq the required subdivision index is equal to  $R + 0,2(1 - R)$ , but not less than 0,6, where  $R$  is determined by the Formulae (2.3.2-1), (2.3.2-2).

**2.3.4** In case of no longitudinal subdivision, the probabilities  $W_i$  are assumed equal to the value of  $p_i$  which is determined as follows for every single compartment:

**.1** where the calculated length of the compartment considered extends over the entire ship length  $L_s$  the factor  $p_i = 1$ ;

**.2** where the aft limit of the compartment considered coincides with the forward terminal

$$p_i = F + 0,5ap + q; \quad (2.3.4.2)$$

**.3** where the forward limit of the compartment considered coincides with the forward terminal

$$p_i = 1 - F + 0,5ap; \quad (2.3.4.3)$$

**.4** when both ends of the compartment considered are inside the aft and forward terminals of the ship length  $L_s$

$$p_i = ap. \quad (2.3.4.4)$$

**2.3.5** The values in 2.3.4.1 to 2.3.4.4 shall be determined by the formulae:

$$a = 1,2 + 0,8E, \text{ but not greater than } 1,2; \quad (2.3.5-1)$$

$$F = 0,4 + 0,25E(1,2 + a); \quad (2.3.5-2)$$

$$p = J_{\max} F_1; \quad (2.3.5-3)$$

$$q = 0,4(J_{\max})^2 F_2 \quad (2.3.5-4)$$

where  $E = E_1 + E_2 - 1$ ;

$$E_1 = x_1/L_s;$$

$$E_2 = x_2/L_s;$$

$x_1$  and  $x_2$  shall be adopted in accordance with 2.2.4;

$$J_{\max} = 48/L_s, \text{ but not greater than } 0,24;$$

$$F_1 = y^2 - y^3/3, \text{ if } y < 1;$$

$$F_1 = y - 1/3, \text{ if } y \geq 1;$$

$$F_2 = y^3/3 - y^4/12, \text{ if } y < 1;$$

$$F_2 = y^2/2 - y/3 + 1/12, \text{ if } y \geq 1;$$

$$y = J/J_{\max};$$

$$J = E_2 - E_1.$$

**2.3.6** The values of  $p_i$  determined by the Formulae (2.3.4.2), (2.3.4.3) and (2.3.4.4) where the compartment considered extends over the mid-length  $L_s$  shall be reduced by an amount determined by the Formula (2.3.5-4) in which case  $F_2$  is calculated taking

$$y = J'/J_{\max} \quad (2.3.6)$$

where  $J' = J - E$ , if  $E \geq 0$ ;  
 $J' = J + E$ , if  $E < 0$ .

**2.3.7** For the purpose of ship subdivision by longitudinal watertight bulkheads, for a wing compartment, the probability  $W$  is equal to the value of  $rp$ . The probability  $r$  of non-damage to the longitudinal bulkhead is determined by the following formulae:

**.1** for  $J \geq 0,2b/B$

$$r = b/B[2,3 + 0,08/(J + 0,02)] + 0,1, \text{ if } b/B \leq 0,2; \quad (2.3.7.1-1)$$

$$r = [b/B + 0,36 + 0,016/(J + 0,02)], \text{ if } b/B > 0,2; \quad (2.3.7.1-2)$$

**.2** for  $J < 0,2b/B$  the reduction factor  $r$  shall be determined by linear interpolation between  $r = 1$  for  $J = 0$  and the value of  $r$  determined by the Formulae (2.3.7.1-1), (2.3.7.1-2) for  $J = 0,2b/B$ .

The value of  $b$  shall be determined in conformity with Appendix.

**2.3.8** For a single  $i$  compartment or a group of adjacent compartments, the probability  $s_i$  shall be determined by the formula

$$s_i = 0,5s_l + 0,5s_p \quad (2.3.8)$$

where  $s_l$  = the  $s$ -factor calculated for the deepest subdivision load line corresponding to the summer load line draught;

$s_p$  = the  $s$ -factor calculated for the intermediate draught of the ship, corresponding to the light ship draught plus 60 per cent of the difference between the summer load line draught and light ship draught.

**2.3.9** Unless otherwise specified, the factor  $s$  for any condition of flooding from any initial loading condition permissible in operation shall be:

$$s = C\sqrt{0,5GZ_{\max}\psi} \quad (2.3.9)$$

where  $C = 1$ , if  $\theta_e \leq 25^\circ$ ;

$C = 0$ , if  $\theta_e > 30^\circ$ ;

$C = [(30 - \theta_e)/5]^{1/2}$ , if  $25^\circ < \theta_e \leq 30^\circ$ ;

$GZ_{\max}$  = the maximum positive righting lever within the range  $\theta_+$ , but not more than 0,1 m;

$\psi$  = the range of positive righting levers for a damaged ship, angle of flooding considered, which shall not exceed  $20^\circ$ ;

$\theta_e$  = final equilibrium angle of heel, in deg.

$s = 0$  where, in the final stage of flooding (equalization disregarded), the lower edge of openings through which progressive flooding may take place is immersed. Such openings shall include the openings specified in 3.3.4.

The least of  $s$  values determined at the worst conditions of flooding of the compartment under consideration or the group of adjacent compartments shall be taken as the  $s$  design value.

**2.3.10** When taking into account the horizontal subdivision fitted above the waterline of the ship

being not damaged (waterline positions are defined under 2.3.8)  $s$  shall be determined as follows:

**.1** the value of  $s$  for the compartment or group of adjacent compartments located below the horizontal watertight subdivision located just above the waterline or higher shall be obtained by multiplying the value as determined in 2.3.9 by the reduction factor  $v$  representing the probability that the horizontal watertight subdivision will not be flooded, and determined as follows:

$$v_j = (H - d_j)/(H_{\max} - d_j) \quad (2.3.10.1-1)$$

where  $H$  = the height of watertight horizontal subdivision above the base line, in m, which is assumed to limit the vertical extent of damage;

$H_{\max}$  = the maximum possible vertical extent of damage above the base line, in m, equal to

$$H_{\max} = d_j + 0,056L_s(1 - L_s/500), \text{ if } L_s \leq 250 \text{ m}; \quad (2.3.10.1-2)$$

$$H_{\max} = d_j + 7, \text{ if } L_s > 250 \text{ m}, \quad (2.3.10.1-3)$$

but not more than 1;

**.2**  $v_j = 1$  if the uppermost watertight horizontal subdivision in way of the assumed damaged region is at a height above the base line which is less than  $H_{\max}$ .

**2.3.11** In cases of positive contribution to index  $A$  due to simultaneous flooding of the spaces under the watertight horizontal subdivision and above it, the resulting  $s_j$  value for such a compartment or a group of compartments shall be determined by the formula

$$s_j = v_j s'_j + (1 - v_j) s''_j \quad (2.3.11)$$

where  $s'_j$  is determined for the case of flooding of compartments located below the horizontal subdivision,

$s''_j$  is determined for the case of simultaneous flooding of compartments located below and above the horizontal subdivision.

**2.3.12** In damage stability calculations, for the purpose of determining the probability subdivision index, the permeability of dry cargo holds shall be adopted equal to 0,7.

**2.3.13** With all compartments forward of the collision bulkhead flooded simultaneously, the  $s$  value calculated assuming the ship to be at its deepest subdivision load line and with assumed unlimited vertical extent of damage shall be not less than 1.

**2.3.14 Probabilistic estimation of subdivision in ships intended for the carriage of timber in holds and on the upper deck<sup>1</sup>.**

**2.3.14.1** The required subdivision index  $R$  as applied to the summer timber draught is equal to the index  $R$  for summer draught obtained according to 2.3.2.

<sup>1</sup> When estimating probabilistic requirements for these ships, the appropriate direction given in 2.3.1 shall be taken into consideration.

**2.3.14.2** In calculating the attained subdivision index  $A_{tim}$  for the carriage of timber in the holds and on the upper deck:

**1** in the Formula (2.3.8), the probabilities  $s_l$  shall be determined at the summer timber draught assigned to the ship;

**2** permeability of cargo holds shall be assumed equal to 0,35;

**3** the buoyancy of timber deck cargo with a height equal to one standard height of superstructure shall be taken into account with the permeability of 0,25;

**4** the probabilities  $s_p$  are adopted the same as those calculated in accordance with 2.3.8 and 2.3.9;

**5** the buoyancy of timber deck cargo in the area of assumed damage shall not be taken into consideration.

**2.3.14.3** According to the conditions of unsinkability for timber carriers two curves of limiting heights of ship centre of gravity (limiting moments or minimum metacentric heights) shall be determined:

**1** the first curve shall be determined based on the requirements of 2.1.2 and 2.3.2 to 2.3.13. This curve is applied when transporting timber cargo either in the holds only or on the upper deck only;

**2** the second curve shall be determined based upon condition of  $A_{tim} \geq R$ . This curve is applied in operation of the ship carrying timber cargo in the holds and on the upper deck simultaneously.

**2.3.14.4** Accordingly, the Information on Stability and Information on Damage Trim and Stability shall indicate that the use of curve of limiting height of ship centre of gravity (limiting moments or minimum metacentric heights) determined based on  $A_{tim} \geq R$  is only possible when carrying timber cargoes both in the holds and on the upper deck.

#### 2.4 PROBABILITY ESTIMATION OF SUBDIVISION IN CASE OF ICE DAMAGE

**2.4.1** The requirements of the present Chapter apply to ships with the **Arc9**, **Arc8**, **Arc7**, **Arc6**, **Arc5** and **Arc4** ice marks in class notation.

**2.4.2** The Subdivision will be considered satisfactory from the point of view of this Chapter, if the following is observed within the range of drafts up to the waterline corresponding to the draft  $d_{ice}$ :

**1** the actual subdivision index  $A_{ice}$  determined in accordance with 2.4.5 to 2.4.10 is not lower than the required ice subdivision index  $R_{ice}$  determined in accordance with 2.4.4.;

**2** damage stability is in accordance with the requirements of Section 3 in case of ice damage mentioned under 3.4.11.4 and 3.4.11.5.

Observance of the requirements of this Chapter does not substitute the compliance with the other requirements of the present Part.

**2.4.3** For ships satisfactory from the point of view of Section 3, provided the ice damage is located anywhere in the area mentioned under 3.4.11.4, it is not necessary to check whether the condition  $A_{ice} \geq R_{ice}$  is observed.

**2.4.4** The required ice subdivision index  $R_{ice}$  shall be determined by the formula

$$R_{ice} = \sqrt[5]{R} \quad (2.4.4)$$

where  $R$  = the required subdivision index to be determined in accordance with 2.2.2 for passenger ships and ships similar to them and in accordance with 2.3.2, for non-passenger ships,

but not less than 0,87.

For ships not covered by the requirements of 2.2 and 2.3, the value of  $R_{ice} = 0,87$ .

**2.4.5** The probability ice subdivision index  $A_{ice}$  shall be determined by the formulae:

**1** where horizontal watertight subdivision are not present or may be disregarded

$$A_{ice} = \Sigma W_{ice}s; \quad (2.4.5.1)$$

**2** where horizontal watertight subdivision shall be taken into account

$$A_{ice} = \Sigma W_{ice}r_{ice}s. \quad (2.4.5.2)$$

Summing-up shall be effected on the basis of the numbers of all the compartments and groups of adjacent compartments.

The values  $W_{ice}$ ,  $r_{ice}$  and  $s$  shall be determined in accordance with 2.4.6 to 2.4.10.

**2.4.6** In case of ice damage the probability of a compartment being flooded, which is bounded by transverse bulkheads, shall be determined by the following formulae:

$$W_{ice} = 0,57[F(x_f/L_{ice}) - F(x_a/L_{ice})] + 0,43a_{ice}p_{ice} \quad (2.4.6)$$

where  $F(x/L_{ice}) = 0,196(x/L_{ice} + 0,5)$ , if  $x/L_{ice} \leq 0,092$ ;

$F(x/L_{ice}) = 6,35(x/L_{ice})^2 - 0,97x/L_{ice} + 0,1515$ , if  $0,092 < x/L_{ice} < 0,3$ ;

$F(x/L_{ice}) = 2,84x/L_{ice} - 0,42$ , if  $x/L_{ice} \geq 0,3$ ;

$a_{ice} = [F(x_f/L_{ice}) - F(x_a/L_{ice})]L_{ice}/(x_f - x_a)$ ;

$p_{ice} = 5(l/L_{ice})^2 + 0,255l/L_{ice}$ , if  $l/L_{ice} < 0,08$ ,

$p_{ice} = 1,03(l/L_{ice}) - 0,03$ , if  $l/L_{ice} \geq 0,08$

$x_a$  = the distance from the midlength of  $L_{ice}$  to the aft bulkhead of the compartment or group of adjacent compartments in question, in m;

$x_f$  = the distance from the midlength of  $L_{ice}$  to the fore bulkhead of the compartment or group of adjacent compartments in question, in m;

$l$  = the compartment length, in m.

Values of  $x$  are positive where the bulkhead is located forward of the midlength and negative where it is located aft of the midlength of  $L_{ice}$ .

The extreme points by which the length of peak compartments is determined, when calculating  $W_{ice}$ , shall be chosen on perpendiculars plotted through the extreme points of the length  $L_{ice}$ .

**2.4.7** When using the calculations according to 2.4.6 the provisions of 2.1.4 and 2.1.5 shall be taken into account as regards considering the bulkhead steps where these are by less than 1,2 of the draft  $d_{ice}$  above the base plane.

**2.4.8** With watertight double sides, an inner bulkhead is considered damaged in case of ice damage, if, by any of its points, it is less than 0,76 m away from the shell as measured along the normal.

**2.4.9** With horizontal watertight platforms the probabilities  $r_{ice}$  shall be determined by the formulae below proceeding by the location of the space being flooded:

**.1** above the platform

$$r_{ice1} = 1 - F_b(z/d_{ice}); \quad (2.4.9.1)$$

**.2** below the platform

$$r_{ice2} = 1 - F_a(z/d_{ice}); \quad (2.4.9.2)$$

**.3** both above and below the platform

$$r_{ice3} = F_b(z/d_{ice}) - F_a(z/d_{ice}) \quad (2.4.9.3)$$

where  $F_b(z/d_{ice}) = 2z/d_{ice}$ , if  $z/d_{ice} \leq 0,3$ ;

$F_b(z/d_{ice}) = (0,6z/d_{ice}) + 0,42$ , if  $0,3 < z/d_{ice} < 0,97$ ;

$F_b(z/d_{ice}) = 1$ , if  $z/d_{ice} \geq 0,97$ ;

$F_a(z/d_{ice}) = 4(z/d_{ice})^2$ , if  $z/d_{ice} \leq 0,3$ ;

$F_a(z/d_{ice}) = 1,74z/d_{ice} - 0,69(z/d_{ice})^2 - 0,1$ , if  $0,3 < z/d_{ice} < 1,25$ ;

$F_a(z/d_{ice}) = 1,0$ , if  $z/d_{ice} \geq 1,25$

where  $z$  = the height of the horizontal watertight subdivision above the base plane.

**2.4.10** The values of the probabilities  $s$  shall be determined by the formulae given in 2.2 and 2.3. Hereby, where the draft  $d_{ice}$  is not equal to the draft  $d_s$ , the probabilities  $s_l$  for non-passenger ships and  $s_j$  for passenger ships shall be determined for the case of the draft  $d_{ice}$ .

### 3 DAMAGE TRIM AND STABILITY

#### 3.1 GENERAL

**3.1.1** Under all loading conditions to be encountered in service and which are in agreement with the purpose of the ship (icing disregarded), the trim and stability of an intact ship shall be sufficient for satisfying damage trim and stability requirements.

**3.1.2** Requirements for the ship trim and stability shall be considered satisfied if, in case of damage mentioned in 3.2 and 3.4, with the number of compartments flooded as mentioned in 3.4, and the permeability determined in accordance with 1.6, calculations made in conformity with 3.1.3 to 3.1.7 indicate that the requirements of 3.3 and 3.4 are satisfied.

**3.1.3** Calculations to confirm compliance with the requirements of 3.3 and 3.4 as regards damage trim and stability shall be performed for such a number of loading conditions to be encountered in service and being the most unfavourable from the point of view of trim and stability (within the range of drafts up to the deepest subdivision load line and cargo distribution stipulated by the design), such distribution and extent of damage, to be determined in accordance with 3.2 and 3.4, that, proceeding from those calculations, one could assure that in all other cases the damaged ship would be in a better condition as regards damage stability, the residual freeboard, distance from the damage waterline to openings through which the ship may be flooded and heeling angles. Besides, the following shall be considered: the

actual configuration of damaged compartments, their permeabilities, type of covers, whether intermediate decks, platforms, double sides, longitudinal and transverse bulkheads are provided sufficiently watertight as to render the flow of water through the ship completely or temporarily impossible.

**3.1.4** Where the distance between two consecutive main transverse bulkheads is less than the longitudinal extent of design damage, the relevant compartment shall, at the discretion of the designer, be added to any of the adjacent compartments when checking damage stability. For non-passenger ships relaxation from this provision may be granted where the arrangement of the bulkhead is in agreement with the condition  $A \geq R$ .

Forepeak and afterpeak are considered to be separate compartment regardless of the length.

**3.1.5** Where two adjacent compartments are separated from each other by a stepped bulkhead, the bulkhead shall be held for damaged when the flooding of any of the two compartments is considered.

Where the length of the step does not exceed one frame or 0,8 m, whichever is less, or where the step is formed by floors of the double bottom, this requirement may be dispensed with in case of non-passenger ships.

**3.1.6** If any damage of a lesser extent than stated in 3.2 and 3.4 might result in a more severe condition as regards damage trim and stability, such a damage shall be considered when making check calculations for damage trim and stability.

**3.1.7** Where there are pipes, ducts or tunnels in the area of assumed damage, these shall be so designed that no water enters compartments which are considered not flooded.

**3.1.8** For passenger ships, the equalization time will be established on agreement with the Register proceeding from the ship type.

**3.1.9** The arrangements for righting the ship after damage shall be approved by the Register and shall be self-acting as far as practicable.

Where controllable cross-flooding arrangements are available, side-valve control stations shall be located above the bulkhead deck.

### 3.2 EXTENT OF DESIGN DAMAGE

**3.2.1** Except cases specially provided for, including those stated in 3.1.6, the following extent of side damage shall be assumed when making damage trim and stability calculations to confirm compliance with 3.3 and 3.4:

**.1** longitudinal extent:  $1/3L_1^{2/3}$  or 14,5 m (whichever is less);

**.2** transverse extent measured inboard of ship side at right angles to the centre line at the level of the deepest subdivision load line:  $1/5$  of the ship breadth  $B$  or 11,5 m (whichever is the less);

**.3** vertical extent: from the base line upwards without limit.

**3.2.2** The requirements of 3.3 shall be complied with in case of simultaneous flooding of all compartments located forward of collision bulkhead.

### 3.3 REQUIREMENTS FOR DAMAGE TRIM AND STABILITY CHARACTERISTICS

**3.3.1** In the final stage of flooding, the initial metacentric height of a ship in the upright condition determined by the constant displacement method, shall not be less than 0,05 m before appropriate measures to increase the metacentric height are taken.

For non-passenger ships, a positive metacentric height below 0,05 m may be permitted for the upright condition in the final stage of flooding on the Register approval.

**3.3.2** For unsymmetric flooding the angle of heel shall not exceed:

20° before equalization measures and cross-flooding fittings being used;

12° after equalization measures and cross-flooding fittings being used.

**3.3.3** The static stability curve of a damaged ship shall have a sufficient positive lever arm section. In the final stage of flooding, cross-flooding fittings

disregarded, and after the equalization of the ship, a length of positive lever arm curve, flooding angle considered, shall be ensured not less than 20°. The angle of submersion of the openings which are not equipped with watertight or weathertight covers through which water may spread to undamaged compartments may be taken as flooding angle.

The maximum lever arm shall be at least 0,1 m within this length, i.e. within the heel angle equal to the static one plus 20°.

The positive lever arm section within the said extent shall not be less than 0,0175 m-rad.

In the intermediate stages of flooding, the maximum lever arm of the static stability curve shall be at least 0,05 m, and the length of its positive section shall not be less than 7°.

**3.3.4** Before, during and after equalization, the damage waterline shall be at least 0,3 m or  $0,1 + (L_1 - 10)/150$  m (whichever is less) below the openings in the bulkheads, decks and sides through which progressive flooding could take place. Such openings include the outlets of air and vent pipes and those which are closed by means of weathertight doors and covers.

These do not necessarily include:

**.1** non-opening side and deck scuttles;

**.2** manholes having covers with closely spaced bolts;

**.3** cargo tank hatchways in tankers;

**.4** remotely controlled sliding doors, watertight doors with indication systems (except ships specified in 1.1.1.2, 1.1.1.5, 1.1.1.6 and 1.1.1.8) and access hatches normally closed at sea;

**.5** openings in subdivision bulkheads intended for the passage of vehicles during cargo handling operations which are permanently closed with strong watertight covers while at sea. Such openings are only permitted for ro-ro ships including those mentioned under 3.4.2.2.

The position and arrangement of closures of openings shall meet the requirements of Section 7, Part III "Equipment, Arrangement and Outfit".

The location of spaces for emergency sources of electrical power shall comply with the requirements of 9.2.1, Part XI "Electrical Equipment".

**3.3.5** For cargo ships, immersion of the bulkhead deck and, moreover, of the weather deck is permitted.

**3.3.6** The requirements of 3.3.1 to 3.3.5 apply to ships specified in 3.4 considering the additional requirements for damage trim and stability specific for each ship type.

For ships not mentioned in 3.4 the requirements of 3.3.1 to 3.3.5 apply, if, upon the shipowner's request, the ship's class notation provides for the subdivision distinguishing mark.

### 3.4 ADDITIONAL REQUIREMENTS FOR DAMAGE TRIM AND STABILITY

#### 3.4.1 Passenger ships.

**3.4.1.1** For passenger ships, damage trim and stability shall be checked on the assumption that all the passengers are crowding on the uppermost accessible decks.

In particular deck areas, the distribution of passengers shall be determined proceeding from 3.1.7 and 3.1.8, Part IV "Stability" except when calculating the heeling moments included in the Formula (3.4.1.11.2) in which case the distribution of passengers shall be assumed in accordance with 3.4.1.12.

**3.4.1.2** For the purpose of damage trim and stability calculations, the following extent of damage shall be adopted:

longitudinal extent 3 m plus 3 per cent of the ship length  $L_s$  or 11 m (whichever is less);

transverse and vertical extent shall be adopted on the basis of 3.2.1.2 and 3.2.1.3.

**3.4.1.3** With  $N$  less than or equal to 600, damage stability requirements shall be satisfied when any single ship compartment is flooded, and with  $N$  (refer to 2.2.2) equal to or greater than 1200, those requirements shall be satisfied in the case of any two adjacent compartments being flooded.

**3.4.1.4** In case of passenger ships having  $N$  between 600 and 1200, damage stability requirements shall be satisfied when any pair of adjacent compartments is flooded within that section of ship length where a transverse bulkhead dividing two compartments is fitted closer to the foremost point of  $L_s$  than  $(N/600 - 1)L_s$  and when any single compartment is flooded within that section of ship length where the bulkheads bounding the compartments are spaced farther than  $(N/600 - 1)L_s$  from each other. For such ships, the subdivision distinguishing mark  $\square$  shall be introduced in the character of classification.

Notwithstanding the requirements of 3.4.1.3 and the requirements of this paragraph, passenger ships certified to carry 400 persons or more, which keels were laid on or after 1 July 2002, sustained shall comply with the requirements of this Chapter, assuming the damage applied anywhere within the ship length.

**3.4.1.5** For passenger ships having the length  $L_s$  100 m and more the requirements for damage trim and stability shall be complied with in the case of fore hole of the extent given in 2.2.13.

**3.4.1.6** For unsymmetrical flooding, the angle of heel shall not exceed:

15° before equalization measures and cross-flooding fittings being used;

7° after equalization measures and cross-flooding fittings being used with one compartment flooded and 12° with two or more adjacent compartments flooded.

**3.4.1.7** The equalization time necessary for the above requirements to be fulfilled shall not exceed 10 min.

**3.4.1.8** During the intermediate stages of flooding or equalization, the heel shall not exceed 20°, and the maximum lever arm of the static stability curve shall not be less than 0,05 m with the length of positive section not less than 7°.

**3.4.1.9** After the equalization of the ship and where no equalization shall be effected, after flooding, the damage waterline shall be below the bulkhead deck outside the area flooded.

**3.4.1.10** In case of unsymmetrical flooding, static stability curve of a damaged ship shall have a positive lever arm section not less than 20° as measured from the equilibrium position both before and after equalization and/or cross flooding fittings being used.

The positive lever arm section shall be at least 0,015 m·rad. This area shall be determined for the curve section between the heeling angle corresponding to the equilibrium position of the ship and flooding angle or an angle of 22°, if one compartment is flooded, and an angle of 27°, if two or more adjacent compartments are flooded simultaneously, whichever is less.

**3.4.1.11** Within the length stated under 3.4.1.10, the lever arm of static stability curve shall not be less than the greater of the values:

.1 0,1 m;

.2 value determined by the formula

$$l = M_{heel}/\Delta + 0,04 \text{ m} \quad (3.4.1.11.2)$$

where  $M_{heel}$  = the heeling moment.

In the Formula (3.4.1.11.2) the greater heeling moment shall be used out of those due to:

all passengers crowding to one side (with regard to 3.4.1.12.1 to 3.4.1.12.3);

launching of all life-saving appliances with their full complement of persons on one side (with regard to 3.4.1.12.4 to 3.4.1.12.6);

wind pressure (3.4.1.12.7 to 3.4.1.12.9).

The requirements of this paragraph apply both to symmetrical and unsymmetrical flooding.

**3.4.1.12** The heeling moments as mentioned under 3.4.1.11 shall be determined on the basis of the following assumptions:

.1 the density of the passenger distribution is assumed to be 4 persons per square metre of deck area accessible to them;

.2 the mass of each passenger is assumed to be 75 kg;

.3 passengers are crowding to one side on areas accessible to them of the decks where muster stations are located. Out of all possible variants of the crowding of passengers the one shall be chosen providing for the greatest heeling moment;

.4 all the lifeboats and rescue boats of the side to which the ship has got a heel are assumed fully loaded, swung out and ready for launching. Where the launching of fully loaded lifeboats shall be effected from their stowage position, the maximum heeling moment likely to occur during launching shall be adopted for calculation.

The above assumptions are applicable to liferafts as well for which launching devices are provided;

.5 when determining the heeling moment due to life-saving appliances being launched, persons who are not in lifeboats or liferafts being swung out shall not be considered a source of additional heeling or righting moments;

.6 life-saving appliances on the opposite side are assumed to be stowed for sea;

.7 wind pressure is assumed equal to 120 Pa;

.8 the above-water lateral plane area is determined for the initial draught of an intact ship;

.9 the lever arm of wind-pressure heeling moment is determined as the distance between the centre of effort and the point corresponding to half the mean draught of an intact ship.

**3.4.1.13** When passenger ships of restricted areas of navigation **R1** and **R2** are equipped with life-saving appliances in conformity with 3.1.1.2, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships, the requirements for damage trim and stability shall be satisfied in the case of any pair of adjacent compartments being flooded.

#### **3.4.2 Roll-on/roll-off ships similar to passenger ships.**

**3.4.2.1** Where vehicles accompanied by personnel of more than 12 persons including passengers (if any) shall be carried by roll-on/roll-off ships, such ships, irrespective of their length, shall be considered equal to passenger ships in respect of all relevant requirements to subdivision bearing in mind the provision of 3.3.4.5, if applicable according to 7.12.1.1, Part III "Equipment, Arrangements and Outfit".

**3.4.2.2** The requirements for the damage trim and stability of a roll-on/roll-off ship carrying 400 or more persons shall be met when the damage is located anywhere along the ship length.

#### **3.4.3 Ice-breakers and fishing vessels.**

**3.4.3.1** In Table 3.4.3.1 the number of compartments is indicated after the flooding of which the

requirements of 3.3 for damage stability shall be satisfied.

**3.4.3.2** In areas where double sides are provided, ice breakers having the length  $L_1$  of 50 to 75 m may satisfy the requirements of 3.3 where a single compartment is flooded. The subdivision distinguishing mark  $\square$  shall be introduced in the character of classification of such ships.

#### **3.4.4 Special purpose ships.**

**3.4.4.1** Special purpose ships having special personnel on board in excess of 200 persons shall satisfy the requirements of the present Part of the Rules pertaining to passenger ships carrying an equal number of passengers.

**3.4.4.2** Special purpose ships having special personnel on board in excess of 50 persons but not over 200 persons shall satisfy the requirements of 3.3 when a single compartment is flooded. Moreover, such ships having the length  $L_1 \geq 100$  m shall meet the requirements of 3.3 in the case of forward damage with the extent stated in 2.2.13.1. In case of unsymmetrical flooding due to the forward damage the heeling angle of  $12^\circ$  is permitted.

**3.4.4.3** Special purpose ships having special personnel on board of 50 persons or less shall satisfy the requirements of 3.3 when one of the compartments is flooded, except the engine room.

**3.4.4.4** The requirements for the subdivision of special purpose ships having special personnel on board of 50 persons or less with the length  $L_1 \leq 50$  m and special purpose ships, which gross tonnage is below 500 shall be specially considered by the Register in each case.

**3.4.4.5** In the case of unsymmetrical flooding of a single compartment in special purpose ships, the heel angle after equalization shall not exceed  $7^\circ$ .

#### **3.4.5 Tugs, dredgers, salvage ships and lightships.**

**3.4.5.1** If a single compartment is flooded, the requirements of 3.3 for damage trim and stability shall be satisfied for the following types of ships:

tugs having the length  $L_1 \geq 40$  m;

dredgers having the length  $L_1 \geq 40$  m;

rescue ships and lightships irrespective of length;

hopper dredgers having the length  $L_1 \geq 60$  m.

**3.4.5.2** Bucket dredgers shall comply with the requirements of 3.3 if a single compartment is flooded in way of the bucket opening. The depth of the damage is assumed equal to 0,76 m.

**3.4.5.3** Where hopper dredgers and hopper barges are concerned, damage conditions may not be considered corresponding to ship condition after spoil discharge from one side.

#### **3.4.6 Oil tankers and chemical tankers.**

**3.4.6.1** The damage trim and stability of oil tankers and chemical tankers shall satisfy the requirements of 3.3 both for the case of side and bottom damage.

Table 3.4.3.1

Type of ship	Length $L_1$ , in m	Number of floodable compartments
Icebreakers	50 and upwards	2
Fishing vessels	100 and upwards	1



**3.4.6.2** Extent of bottom damage:

**.1** the longitudinal extent shall be  $1/3L_1^{2/3}$  or 14,5 m (whichever is less) within  $0,3L_1$  from the forward perpendicular and  $1/3L_1^{2/3}$  or 5 m (whichever is less) through the rest of the ship length;

**.2** the transverse extent shall be  $B/6$  or 10 m (whichever is less) within  $0,3L_1$  from the forward perpendicular and  $B/6$  or 5 m (whichever is less) through the rest of the ship length;

**.3** the vertical extent, measured from the moulded line of the shell at centre line, shall be  $B/15$  or 6 m (whichever is less).

**3.4.6.3** In addition to 3.4.6.2, bottom shell damage shall be considered for oil tankers with a deadweight of 20 000 t and upwards, having touched the ground, the extent of damage being as follows:

**.1** length of  $0,6 L_1$  from the forward perpendicular for ships having a deadweight of 75000 t and upwards, and  $0,4 L_1$  from the forward perpendicular for ships having a deadweight below 75 000 t;

**.2** breadth  $B/3$  anywhere in the bottom.

**3.4.6.4** Damage trim and stability requirements shall be satisfied for the following locations of side and bottom damage:

**.1** oil tankers:

where the length  $L_1 > 225$  m — anywhere along the ship length;

where the length  $L_1 > 150$  but not more than 225 m — anywhere in the ship length except for the engine room when this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

where the length  $L_1 \leq 150$  m — anywhere in the ship length between consecutive transverse bulkheads except for the engine room;

where the substances of the Category C are carried under the provisions of Appendix II to MARPOL-73/78, as for chemical tankers 3;

**.2** chemical tankers:

chemical tanker 1 — anywhere along the ship length;

chemical tanker 2 having the length  $L_1$  over 150 m — anywhere along the ship length;

chemical tanker 2 having the length  $L_1 = 150$  m and below — anywhere in the ship length except for the engine room where this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

chemical tanker 3 having the length  $L_1 > 225$  m — anywhere along the ship length;

chemical tanker 3 having the length  $L_1 = 125$  to 225 m — anywhere in the ship length except for the engine room where this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

chemical tanker 3 having the length  $L_1 < 125$  m — anywhere along the ship length except for the

engine room where this is located aft. Nevertheless, damage trim and stability calculations for the conditions of the engine room flooded shall be submitted to the Register for consideration.

**3.4.6.5** Ships which do not comply with the requirements for damage trim and stability when their engine room is flooded, as stipulated by 3.4.6.4.1 and 3.4.6.4.2, are not assigned a subdivision distinguishing mark in their character of classification.

**3.4.6.6** In the final stage of unsymmetric flooding before equalization measures and cross-flooding fittings being used, the angle of heel shall not exceed  $25^\circ$  or  $30^\circ$  where the bulkhead deck is not immersed). After equalization measures, the heeling angle shall not exceed  $17^\circ$ .

**3.4.7 Gas carriers.**

For gas carriers, the requirements of 3.4.6 apply except for the following details:

**.1** damage trim and stability requirements shall be satisfied when side and bottom damage is sustained as stated below:

gas carriers 1G — anywhere along the ship length;

gas carriers 2G having the length  $L_1 > 150$  m — anywhere along the ship length;

gas carriers 2G having the length  $L_1 \leq 150$  m or below — anywhere along the ship length except the engine room where this is located aft. In this case the engine room shall be considered a separate floodable compartment;

gas carriers 2PG — anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length  $L_1 \geq 125$  m — anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length  $L_1 < 125$  m — anywhere in the ship length between subdivision bulkheads except the engine room where this is located aft. However, damage trim and stability calculations for the case of the engine room being flooded shall be submitted for the consideration of the Register. No subdivision distinguishing mark shall be introduced in the character of classification if damage trim and stability requirements are not met;

**.2** the vertical extent of a bottom damage shall be assumed equal to  $B/15$  or 2 m, whichever is less.

**3.4.8 Drilling ships.**

With any single compartment flooded, drilling ships shall comply with the requirements of 3.3, unless more stringent requirements are put forward by the shipowner.

Drilling ships shall have sufficient reserve of damage stability to withstand the wind heeling moment produced by wind with a speed of 25,8 m/s (50 knots) acting from any direction. Under these conditions the final waterline after flooding shall be

located below the lower edge of any opening through which the undamaged compartments may be flooded by the sea.

#### **3.4.9 Ships intended for the carriage of radioactive agents.**

Damage trim and stability of ships intended for the carriage of packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes with the total radioactivity below 4000 TBq shall in each case be specially considered by the Register.

The requirements for the damage trim and stability of ships carrying packaged irradiated nuclear fuel or high-level radioactive wastes with the total radioactivity below  $2 \times 10^6$  TBq or plutonium with the total radioactivity below  $2 \times 10^5$  TBq shall be met for the case of specified damage anywhere along the ship length between the consecutive transverse bulkheads.

The requirements for damage trim and stability of the ships carrying packaged irradiated nuclear fuel or high-level radioactive wastes with the total radioactivity above  $2 \times 10^6$  TBq or plutonium with the total radioactivity  $2 \times 10^5$  TBq and above shall be met in the case of the calculated damage anywhere along the ship length.

On the Register approval the possible probability estimation of the ship subdivision may be considered being an alternative to the requirements indicated.

#### **3.4.10 Supply vessels.**

**3.4.10.1** The requirements of the present Part of the Rules apply to all supply vessels having the length  $L_1 \leq 100$  m.

The subdivision and damage stability of supply vessels having a length over 100 m shall in each case be specially considered by the Register.

#### **3.4.10.2** The extent of damage:

**.1** longitudinal extent shall be 3 m plus 3 per cent of the ship's length for ships with the length ( $L_1$ ) greater than 43 m. For those with length ( $L_1$ ) not greater than 43 m, 10 per cent of the ship's length;

**.2** transverse extent of damage shall be assumed as 0,76 m, measured inboard from the side of the ship perpendicularly to the centerline at the level of the summer load waterline;

**.3** vertical extent: from the underside of the cargo deck, or the continuation thereof, for the full depth of the ship.

**3.4.10.3** A transverse watertight bulkhead extending from the ship's side to a distance inboard of 760 mm or more measured perpendicularly to the centerline at the level of the summer load line joining longitudinal watertight bulkheads may be considered as a transverse watertight bulkhead for the purpose of the damage trim and stability calculations.

**3.4.10.4** Where a transverse watertight bulkhead is located within the transverse extent of assumed

damage and is stepped in way of a double bottom or side tank by more than 3,0 m, the double bottom or side tanks adjacent to the stepped portion of the transverse watertight bulkhead shall be considered as damaged;

**3.4.10.5** In the final stage of unsymmetrical flooding the angle of heel shall not exceed  $15^\circ$  before equalization measures are taken and cross-flooding fittings are used. This angle may be increased up to  $17^\circ$  if no deck immersion occurs.

#### **3.4.10.6** Number of floodable compartments.

The damage stability requirements of 3.3 shall be met in the case of single compartment flooding proceeding from the extent of damage stated under 3.2.1.1, 3.2.1.3 and 3.4.10.2.

**3.4.10.7** Ships complying with the requirements of 3.4.10.2 only will receive no subdivision distinguishing mark in the character of classification.

**3.4.10.8** If preferred by the shipowner, a supply vessel may receive a subdivision distinguishing mark with the number of floodable compartments indicated in the class notation. In this case, the transverse extent of damage shall be assumed in accordance with 3.2.1.2. The number of compartments at the flooding of which the damage trim and stability requirements shall be met shall be determined by the shipowner.

#### **3.4.11 Ships with the ice marks Arc4, Arc5, Arc6, Arc7, Arc8 and Arc9 in the class notation.**

**3.4.11.1** The requirements of this paragraph apply to all ice strengthened ships of categories **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9**. The damage trim and stability requirements shall be met as far as the draught  $d_{ice}$  is concerned except for the requirement of 3.4.11.2.

**3.4.11.2** Where the extent of damage is in accordance with 3.2, within range of the summer load line draught assigned to the ship the damage trim and stability requirements of 3.3 shall be met if a single compartment is flooded in ships having the following distinguishing marks in the character of classification:

ice category marks **Arc7**, **Arc8** and **Arc9** irrespective of ship length;

ice category marks **Arc5** and **Arc6** with the ship length  $L_1 \geq 120$  m.

The subdivision distinguishing mark **I** shall be introduced in the character of classification of such ships.

**3.4.11.3** Ships with the ice strengthening marks for categories **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9** (irrespective of their length) shall comply with the requirements of 3.3 with relevant ice damage stated in 3.4.11.4 and the number of floodable compartments given in 3.4.11.5.

Where compliance with the requirements of other chapters of this Section also testifies to 3.4.11 being complied with, no additional damage trim and sta-

bility calculations need be made for damage conditions mentioned under 3.4.11.4 and 3.4.11.5.

**3.4.11.4** For the purpose of damage trim and stability calculations, the following extent of ice damage shall be assumed:

**.1** longitudinal extent  $0,045L_{ice}$ , if the centre of damage lies within  $0,4L_{ice}$  from the forward perpendicular, and  $0,015L_{ice}$  in other areas;

**.2** damage depth 0,76 m as measured along the normal to the shell at any point in the area of assumed damage;

**.3** vertical extent  $0,2d_{ice}$ ;

**.4** location of damage from the base line to the level of  $1,2d_{ice}$  within  $L_{ice}$ .

**3.4.11.5** When performing damage trim and stability calculations, the number of floodable compartments shall be determined proceeding from the location of the assumed ice damage listed in Table 3.4.11.5.

**3.4.11.6** In all cases, irrespective of the requirements stated in items 11 and 12 of Table 3.4.11.5, the calculations of damage trim and stability for the case of the engine room being flooded shall be submitted for the consideration of the Register.

**3.4.11.7** For oil tankers, chemical tankers 2 and 3, gas carriers 2G and 3G below or equal to 150 m in length, the necessity of considering a simultaneous flooding of the engine room and an adjacent compartment shall be specially considered by the Register.

**3.4.11.8** Ships conforming with the requirements of 3.4.11.3 to 3.4.11.7 only will receive no subdivision distinguishing mark in the character of classification.

**3.4.12 Bulk carriers, ore carriers and combination carriers.**

**3.4.12.1** Bulk carriers having the length  $L_1$  of 150 m and upwards, which carry solid bulk cargoes with density of  $1000 \text{ kg/m}^3$  and above, shall meet the requirements of 4.4 at flooding of any cargo hold bounded by the side shell only or being double side skin construction with the width less than  $B/5$  or 11,5 m (whichever is the less) in all cases of draught up to the summer load line.

**3.4.12.2** When calculating damage stability the following permeabilities shall be taken:

0,90 for loaded holds;

0,95 for empty holds.

Ships assigned with the reduced freeboard in accordance with Section 4 are regarded of satisfying the requirements of 3.4.12.1.

Information on compliance with these requirements shall be included in the Information on Stability and Strength for the Ship Loaded with Solid Bulk Cargoes other than Grain as required by 1.4.9.7, Part II "Hull".

**3.4.12.3** Ships are fitted with water level detectors:

**.1** in each cargo hold, giving audible and visual alarms, one when the water level above the inner

Table 3.4.11.5

Nos	Type of ship and/or ice strengthening category	Location of ice damage mentioned under 3.4.11.4
1	Ice-strengthened ships of <b>Arc7</b> , <b>Arc8</b> and <b>Arc9</b> categories except fishing vessels	Anywhere in the ice damage area
2	Passenger ships allowed to carry over 400 passengers including the crew	Ditto
3	Special purpose ships allowed to carry over 400 passengers including the crew	—"
4	Ships intended for the carriage of radioactive agents	—"
5	Chemical tankers	—"
6	Oil tankers	—"
7	Gas carriers	—"
8	Drilling ships	—"
9	Ice-strengthened salvage ships with ice categories <b>Arc5</b> , <b>Arc6</b> , <b>Arc7</b> , <b>Arc8</b> and <b>Arc9</b>	—"
10	Ice-strengthened fishing vessels and refrigerated fish carriers with ice categories <b>Arc7</b> , <b>Arc8</b> and <b>Arc9</b>	Between watertight bulkheads, platforms, decks and plating <sup>1</sup>
11	Ice-strengthened ships with ice categories <b>Arc5</b> and <b>Arc6</b> not mentioned in 2 to 9	Between watertight bulkheads, platforms, decks and plating <sup>1</sup> . With the hull length $L_1 < 100 \text{ m}$ it is permitted not to comply with the requirements for damage trim and stability where engine room located aft is flooded in case of ice damage The same refers to the flooding of engine rooms of tugs less than 40 meters in length irrespective of the engine room location
12	Ice-strengthened ships with ice category <b>Arc4</b> not mentioned in 2 to 9	Between watertight bulkheads, platforms, decks and plating <sup>1</sup> . With the hull length $L_1 < 125 \text{ m}$ it is permitted not to comply with the requirements for damage trim and stability where engine room located aft is flooded in case of ice damage. The same refers to the flooding of engine rooms of tugs less than 40 meters in length irrespective of the engine room location

<sup>1</sup> Where the distance between two consecutive watertight structures is less than the extent of damage, relative adjacent compartments shall be considered a single floodable compartment when checking damage trim and stability.

bottom in the hold reaches a height of 0,5 m high, and another at a height not less than 15 per cent of the cargo hold depth but not more than 2,0 m; it is allowed to use one detector instead of two provided its design allows to give alarm at both levels of hold

flooding. The detectors are fitted in the aft end of the cargo hold as close to the centerline as practicable. If detectors cannot be placed within a distance equal to one corrugation space or one bulkhead vertical stiffener space from the centerline, they shall be located at both the port and starboard sides of the cargo hold;

.2 in any ballast tank forward of the collision bulkhead required in 1.1.6, Part II "Hull" giving an audible and visual alarm when the liquid in the tank reaches a level not exceeding 10 per cent of tank capacity;

.3 in any dry or void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold, giving an audible and visual alarm at a water level of 0,1 m above the deck. Such alarms need not be provided in enclosed spaces, the volume of which does not exceed 0,1 per cent of the ship's maximum displacement volume.

Detectors in cargo holds shall be protected by a robust construction from damage by cargoes or mechanical handling equipment associated with bulk carrier operations.

**3.4.12.4** Operating Manual on Water Level Detection System shall be provided on board the ship and shall contain the following information and operational instructions:

.1 a description of the equipment for detection and alarm arrangements together with a listing of procedures for checking that, as far as practicable, each item of equipment is working properly during any stage of ship operation;

.2 Type Approval Certificate for the detection system;

.3 line diagrams of the detection and alarm system showing the positions of equipment;

.4 installation instructions for orientation, setting, securing, protecting and testing;

.5 list of cargoes, for which the detector protected by guard is suitable for operating in a 50 per cent seawater slurry mixture;

.6 procedures to be followed in the event of equipment not functioning correctly;

.7 maintenance requirements for equipment and system.

Manual shall be compiled in the language known to the ship officers, as well as in English.

**3.4.12.5** The Water Level Detection System shall meet the requirements of 7.10, Part XI "Electrical Equipment".

### **3.4.13 Berth-connected ships.**

**3.4.13.1** Damage stability requirements stated in 3.3 shall be complied with in the case of any single flooded compartment lying along the ship periphery and having the length not less than the length of damage given in 3.4.13.2.2.

**3.4.13.2** For the purpose of damage trim and stability calculations, the following extent of damage shall be assumed:

.1 transverse extent measured from the inner skin at right angles to the centreline on the level of the deepest waterline permitted by the load line — 0,76 m;

.2 longitudinal extent —  $1/6L_1^{2/3}$  or 7,2 m (whichever is less);

.3 vertical extent in accordance with 3.2.1.3.

**3.4.13.3** No subdivision distinguishing mark will be introduced in the character of classification of berth-connected ships which comply solely with the requirements of this Chapter and for which regard to 3.4.13.2 shall be taken.

**3.4.13.4** If the depth of waters on which the berth-connected ship floats is such that the lowermost deck accessible to passengers cannot be immersed not to mention capsizing of the ship, the requirements of this Part of the Rules may be waived.

### **3.4.14 Cargo ships of less than 100 m in length other than bulk carriers.**

**3.4.14.1** Single hold cargo ships other than bulk carriers (refer to 1.1.1.21) shall comply with the present requirements not later than the date of the first intermediate or renewal survey of the ship, whichever comes first, but, anyway, not later than 31 December 2009.

**3.4.14.2** Ships having a length ( $L_1$ ) of less than 80 m, or less than 100 m if constructed before 1998, and a single cargo hold below the freeboard deck or cargo holds below the freeboard deck which are not separated by at least one bulkhead made watertight up to that deck, shall be fitted in such space or spaces with water level detectors, which give an audible and visual alarm at the navigation bridge when the water level above the inner bottom in the cargo hold reaches a height of not less than 0,3 m, and another when such level reaches not more than 15 per cent of the mean depth of the cargo hold.

**3.4.14.3** Water level detectors shall be fitted at the aft end of the hold, or above its lowest part where the inner bottom is not parallel to the designed waterline. If detectors cannot be placed within a distance equal to one corrugation space or one bulkhead vertical stiffener space from the centerline, they shall be located at both sides of the cargo hold. Where webs or partial watertight bulkheads are fitted above the inner bottom, the Register may require the fitting of additional detectors. It is allowed to use one detector vertically instead of two provided its design allows giving alarm at both levels of hold flooding.

**3.4.14.4** The water level detectors need not be fitted in ships complying with the requirements of 3.4.12.3, or in ships having watertight side compartments each side of the cargo hold length extending vertically at least from inner bottom to freeboard deck.

**3.4.14.5** The water level detection system shall comply with the requirements of 7.10, Part XI "Electrical Equipment".

**3.4.14.6** Operating Manual on Water Level Detection System shall be provided on board the ship, which shall be developed in compliance with the requirements of 3.4.12.4.

## 4 SPECIAL REQUIREMENTS FOR TYPE "B" SHIPS WITH REDUCED FREEBOARD AND FOR TYPE "A" SHIPS

### 4.1 GENERAL

**4.1.1** This Section applies to type "A" and type "B" ships specified in 1.1.3.

The requirements of the Section shall be fulfilled irrespective of meeting the requirements of other sections by these ships.

**4.1.2** The requirements are considered fulfilled where it is demonstrated by calculations that a ship being in assumed loading condition specified in 4.2 after the flooding of the number of compartments required by 4.1.3 to 4.1.5 caused by damages stipulated in 4.3 remains afloat and in a condition of equilibrium it meets the requirements of 4.4.

**4.1.3** For type "A" ships above 150 m in length ( $L_1$ ), when they are assigned a freeboard less than that of the appropriate ships of the type "B" the requirements of this Section are to be complied with in the case of any single compartment being flooded.

**4.1.4** For type "B" ships above 100 m in length ( $L_1$ ) for which the permitted reduction of tabular freeboard does not exceed 60 per cent of the difference between its values as per Tables 4.1.2.3 and 4.1.3.2 of Load Line Rules for Sea-Going Ships, the following cases of flooding shall be considered:

**.1** any single compartment with the exception of the engine room;

**.2** any single compartment including the engine room where the ship length exceeds 150 m.

**4.1.5** Type "B" ships, having the length  $L_1$  over 100 m, for which the permitted reduction in the tabular freeboard exceeds 60 per cent of the difference between its values as per Tables 4.1.2.3 and 4.1.3.2 of Load Line Rules for Sea-Going Ships shall be considered for the following cases of flooding:

**.1** any two adjacent compartments, except for the engine room;

**.2** any two adjacent compartments and the engine room considered separately in ships over 150 m in length.

**4.1.6** The following permeabilities shall be assumed in calculations required by 4.1.2:

0,95 for any floodable compartments and spaces, except for the engine room;

0,85 for floodable engine room.

The permeability value of 0,95 is applicable to cargo spaces and tanks as well which shall be considered full when determining the height of the ship centre of gravity in conformity with 4.2.3.

**4.1.7** In addition to the requirements of 4.1.4 and 4.1.5, ships intended for carriage of deck cargoes shall comply with the requirements of 2.3. Height of the centre of gravity used for demonstration of compliance with the requirements of 4.4 during the deterministic analysis of damage stability shall be equal to the height of the centre of gravity used for calculation of damage stability at probabilistic assessment at assumption of the highest loadline. The diagram of ultimate elevation of the ship centre of gravity (limiting moments or minimum metacentric heights) with deck cargo drawn taking into consideration the fulfilment of the requirements of 2.3 shall be included into the Information on Stability and Information on Damage Trim and Stability.

### 4.2 TRIM AND LOADING CONDITION OF THE SHIP PRIOR TO DAMAGE

**4.2.1** All cases of flooding shall be analyzed under one assumed initial loading condition of the ship, as specified in 4.2.2 to 4.2.4.

**4.2.2** The ship is considered to be loaded by homogeneous cargo to its summer load line draught in sea water on an even keel.

**4.2.3** The height of the centre of gravity of the ship shall be calculated for the following assumed loading condition:

**.1** all cargo spaces, except for those under 4.2.3.2, including the anticipated in service, partly filled spaces are considered to be fully loaded with dry cargo and to be 98 per cent loaded with liquid cargo;

**.2** where the ship when loaded to the summer load line is to operate with some spaces not loaded or filled with dry or liquid cargo, such spaces shall be assumed empty provided that the height of the centre of gravity of the ship, calculated with regard to empty compartments is not less than that calculated on the assumption that all the spaces are occupied with cargoes;

**.3** the amount of every type of the ship's stores and consumable liquids is taken to be equal to 50 per cent of the full capacity. Tanks, except for those

under 4.2.4.2, are assumed to be empty or completely filled, the distribution of the stores in the tanks resulting in the highest position of the centre of gravity of the ship. The centres of gravity of the contents of the tanks mentioned in 4.2.4.2 are taken to be in the centres of gravity of their volumes;

.4 loading of the ship as regards consumable liquids and ballast water shall be estimated on the basis of the following values of their density, in  $t/m^3$ :

Sea water . . . . .	1,025
Fresh water . . . . .	1,000
Fuel oil. . . . .	0,950
Diesel oil. . . . .	0,900
Lubricating oil . . . . .	0,900

**4.2.4** In estimating the height of the centre of gravity of the ship account shall be taken of the effect of free surfaces of liquids:

.1 for liquid cargo, proceeding from loading specified in 4.2.3.1;

.2 for consumable liquids, proceeding from the assumption that for every type of liquid at least one centreline tank or one transverse pair of tanks have free surfaces. To be taken into consideration are the tanks or the combination of tanks where the effect of free surfaces is the greatest.

It is recommended that the correction for free surfaces effect be taken into account in accordance with 1.4.7, Part IV "Stability."

#### 4.3 EXTENT OF DAMAGE

**4.3.1** The vertical extent of damage shall be assumed from the base line upwards without limit.

**4.3.2** The transverse extent of damage measured inboard from the ship's side, at a right angle to the centreline at the level of the summer load waterline shall be assumed equal to 1/5 of the breadth of the ship, or 11,5 m, whichever is the less.

**4.3.3** If any damage of lesser extent than indicated in 4.3.1 and 4.3.2 would result in a more severe condition, such damage shall be assumed in the calculations.

**4.3.4** Transverse bulkheads are considered effective if the distance between them or between the transverse planes passing through the nearest portions of the stepped bulkheads is at least  $1/3L_1^{2/3}$ , or 14,5 m, whichever is the less. In case of lesser distance, one or more of these bulkheads shall be assumed as non-existent.

**4.3.5** When one compartment is flooded, with due regard for provisions of 4.3.4, main transverse bulkheads are considered not to be damaged if they have no steps more than 3 m in length.

In case these bulkheads are provided with steps more than 3 m in length, the two compartments ad-

jacent to such bulkheads shall be considered as flooded.

The extent of damage may be limited by transverse bulkheads of a side tank in case its longitudinal bulkheads are beyond the transverse extent of damage.

Where a side tank or a double bottom tank is divided by a transverse bulkhead located more than 3 m from a main transverse bulkhead, both tanks divided by such bulkhead shall be considered as flooded.

The following compartments shall be considered as flooded:

A + D, B + E, C + E + F (Fig. 4.3.5-1);

A + D + E, B + E (Fig. 4.3.5-2);

A + D, B + D + E (Fig. 4.3.5-3);

A + B + D, B + D + E (Fig. 4.3.5-4).

Where the forecastle is arranged above the fore cargo hold, subject to the condition that the forecastle bulkhead is located not more than 3 m aft from the forward bulkhead of the hold and watertightness of the stepped deck structure is ensured the bulkhead shall be considered to be continuous and not to be damaged.

**4.3.6** Where a side tank has openings into a hold, it shall be considered as communicating with the hold even where such openings are fitted with closing appliances. This provision is applicable to ships carrying liquid cargoes, except in case of sluice valves fitted in bulkheads between tanks and where the valves are controlled from above the bulkhead deck.

**4.3.7** Where pipes, ducts or tunnels are located within the assumed extent of damage, satisfactory arrangements shall be provided to preclude the possibility of progressive flooding through them to other spaces beyond the limits assumed for the calculations of the damage stability of the ship.

**4.3.8** In case of two-compartment flooding the requirements of 4.3.1 to 4.3.4, 4.3.6 and 4.3.7 shall be met.

#### 4.4 TRIM AND STABILITY OF A SHIP IN DAMAGED CONDITION

**4.4.1** The metacentric height of the ship in the damaged condition prior to taking measures for the increase thereof shall be positive.

**4.4.2** The angle of heel due to unsymmetrical flooding prior to the beginning of the equalization of the ship shall not exceed  $15^\circ$ . If no part of the deck immerses, the increase of heel up to  $17^\circ$  may be allowed.

**4.4.3** The final damage waterline having regard to heel and trim prior to the beginning of the equalization of the ship shall not be above the lower edge of openings indicated in 3.3.4, through which progressive flooding may take place.

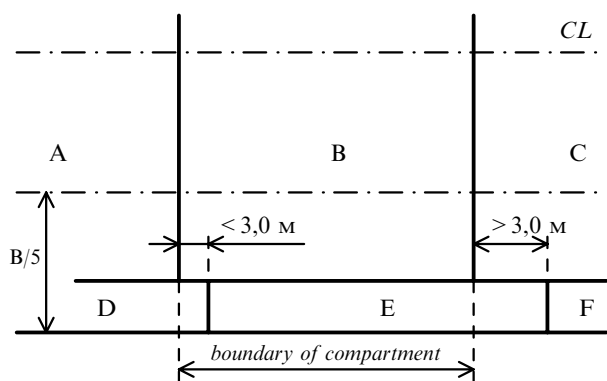


Fig. 4.3.5-1

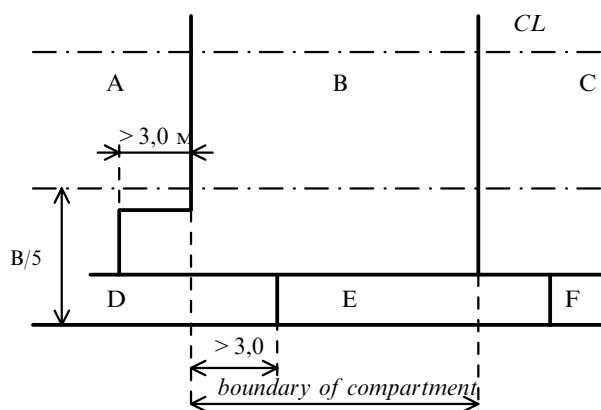


Fig. 4.3.5-4

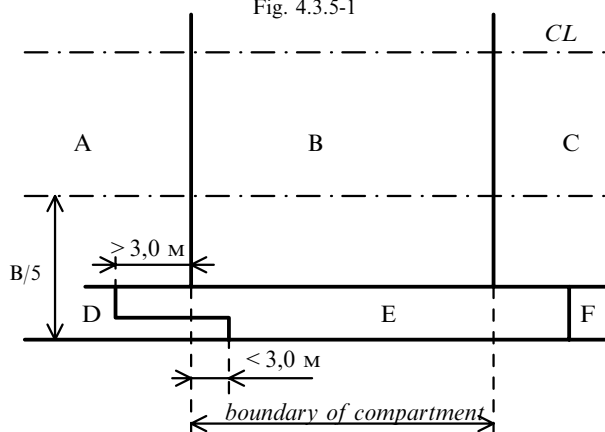


Fig. 4.3.5-2

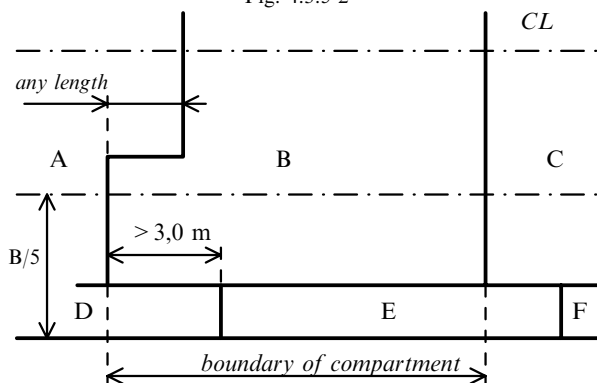


Fig. 4.3.5-3

**4.4.4** When any part of the bulkhead deck beyond the limits of the flooded compartments immerses, or the margin of damage stability is doubtful, damage stability at large angles of heel shall be investigated. It shall be shown that the value of a maximum arm of the righting lever curve of a damaged ship is not less than 0,1 m within the rated extent ( $20^\circ$ ) in association with a range of the curve with positive arms of at least  $20^\circ$ , the area of the positive portion of the curve being not less than 0,0175 m $\cdot$ rad.

## 5 REQUIREMENTS FOR SHIPS IN SERVICE

### 5.1 REQUIREMENTS FOR ROLL-ON/ROLL-OFF PASSENGER SHIPS (RO-RO PASSENGER SHIPS)

**5.1.1** Ro-ro passenger ships constructed before 1 July 1997 shall comply with the requirements of 5.1.3 not later than the date of the first periodical survey after the date of compliance prescribed below, according to the value of  $A/A_{\max}$  (ratio of the probability index  $A$  as defined in 5.1.4 to the maximum probability index  $A_{\max}$  as defined in 5.1.5):

less than 85 per cent — not later than 1 October 1998;

85 per cent or more but less than 90 per cent — not later than 1 October 2000;

90 per cent or more but less than 95 per cent — not later than 1 October 2002;

95 per cent or more but less than 97,5 per cent — not later than 1 October 2004;

97,5 per cent or more — not later than 1 October 2005.

Number of floodable compartments shall be adopted in accordance with the requirements of 3.4.1.3 and 3.4.1.4.

**5.1.2** In addition to the requirements of 5.1.1 ro-ro passenger ships certified to carry 400 persons or more shall comply with the requirements of 5.1.3.2 and 5.1.3.3, assuming the damage applied anywhere within the ship's length, not later than the date of the first periodical survey after the date of compliance prescribed in 5.1.2.1, 5.1.2.2 and 5.1.2.3 which occurs the latest:

**.1** depending on the value of  $A/A_{\max}$ :

less than 85 per cent — not later than 1 October 1998;

85 per cent or more but less than 90 per cent — not later than 1 October 2000;

90 per cent or more but less than 95 per cent — not later than 1 October 2002;

95 per cent or more but less than 97,5 per cent — not later than 1 October 2004;

97,5 per cent or more — not later than 1 October 2010;

**.2** depending on the number of persons permitted to be carried:

1500 or more — not later than 1 October 2002;

1000 or more but less than 1500 — not later than 1 October 2006;

600 or more but less than 1000 — not later than 1 October 2008;

400 or more but less than 600 — not later than 1 October 2010;

**.3** age of the ship equal or greater than 20 years (where the age of the ship means the time counted

from the date on which the keel was laid or the date on which it was at a similar stage of construction or from the date on which the ship was converted to a ro-ro passenger ship).

### 5.1.3 Requirements for damage trim and stability.

**5.1.3.1** When performing damage trim and stability calculations account shall be taken of the requirements of 3.1.1, 3.1.2, 3.1.4 to 3.1.7, 3.1.9. References to 3.2, 3.3 and 3.4 in the above paragraphs have been replaced by reference to 5.1.3.6.

**5.1.3.2** In the final stage of symmetric flooding before appropriate measures to increase metacentric height are taken the initial metacentric height of a ship in the upright condition determined by the constant displacement method shall not be less than 0,05 m.

**5.1.3.3** The statical stability curve for the final stage of flooding (after equalization, if effected) shall have a positive range not less than 15°.

Within the range stated above the area under the lever curve and the maximum lever arm of statical stability curve shall comply with the requirements of 3.4.1.10 and 3.4.1.11.

**5.1.3.4** During the intermediate stages of flooding, stability shall comply with the requirements of 3.4.1.8.

**5.1.3.5** For the purposes of damage stability calculations, the permeabilities of spaces and surfaces shall be generally assumed equal to the values to be determined from Table 5.1.3.5.

Table 5.1.3.5

Spaces	Permeability
Spaces intended for carriage of coal or stores	0,60
Accommodation spaces	0,95
Spaces occupied by machinery	0,85
Spaces intended for liquid cargoes	0 or 0,95 <sup>1</sup>
Ro-ro cargo spaces	0,90
<sup>1</sup> That value shall be taken, which results in more severe requirements.	

Higher surface permeabilities shall be assumed for those spaces which are not occupied by substantial numbers of accommodation rooms or machinery in the vicinity of the damage waterline as well as for spaces which are not generally occupied by any substantial quantities of cargo or stores.

**5.1.3.6** For the purpose of compliance with the requirements for damage trim and stability laid down in 5.1.3 the extent of damage is adopted on the basis of 3.4.1.2.



**5.1.3.7** The trim of a damaged ship shall comply with the requirements of 3.4.1.6; the equalization time necessary for the above requirements to be fulfilled shall not exceed 15 min.

**5.1.3.8** The damage waterline after the equalization of the ship and where no equalization shall be effected shall be 76 mm below the bulkhead deck.

**5.1.4** The probability index  $A$  is determined by the formula

$$A = \sum a p s. \quad (5.1.4)$$

To be summed up are the single compartments and groups of two adjacent compartments.

**5.1.4.1** For the purpose of determining the index  $A$  the ship is considered to be loaded to the deepest subdivision load line, with null or designed (if any) trim and with maximum height of centre of gravity which may occur in the ship's service.

The permeabilities are assumed in compliance with 1.6.1.1, 1.6.1.3, 1.6.2 and 1.6.5.

For ro-ro cargo spaces the permeability shall be assumed to be equal to 0,90.

**5.1.4.2** The factors  $a$  and  $p$  are determined in conformity with 2.2.4 and 2.2.5. The value of the factor  $k_v$  is assumed to be equal to 1.

**5.1.4.3** The factor  $s$  is determined by the formula

$$s = 2,58c \sqrt[4]{GZ_{\max} \psi \Omega} \quad (5.1.4.3)$$

where  $GZ_{\max}$  = the maximum positive righting lever for a damaged ship within the range of  $15^\circ$  from the position of equilibrium but not more than 0,1 m;

$\psi$  = the range of positive righting lever in degrees but not more than  $15^\circ$ ;

$\Omega$  = the positive lever arm section (m·rad) of the statical stability curve for a damaged ship, determined in conformity with 3.4.1.10, but not more than 0,015 m·rad;

$c$  = the factor equal to:

$c = 1$  if the heeling angle in the final stage of flooding  $\theta_e$  does not exceed  $7^\circ$ ;

$$c = \sqrt{\frac{20^\circ - \theta_e}{13^\circ}}, \text{ if } 7^\circ < \theta_e \leq 20^\circ;$$

$c = 0$ , if the heeling angle  $\theta_e$  exceeds  $20^\circ$ ;

$\theta_e$  = the heeling angle in the final stage of flooding (before equalization), in deg.

**5.1.4.4** Where the damage trim and stability satisfy fully the requirements of 3.4.1 the factor  $s$  shall be taken as 1.

$s$  shall be taken as zero for any case of flooding which results:

during intermediate flooding or prior to equalization, in the angle of heel in excess of  $20^\circ$  or which immerses any openings through which down-flooding might take place; or

for the final stage of flooding, except in way of the flooded compartment or compartments, in immersion of the bulkhead deck; or

in the final stage of flooding heel in excess of  $12^\circ$ ; or  $h_d$  less than 0,05 m.

**5.1.4.5** If subdivision of the ship by longitudinal watertight bulkheads is taken into account the value  $p$  is multiplied by the reduction factor  $r$  determined in compliance with 2.2.6.3 at  $k_v = 1$ .

**5.1.5** Where the value  $s < 1$  in case of flooding of any single compartment in a ship which requires the one-compartment subdivision standard (number of persons on board is less than 400) or in case of any two adjacent compartments being flooded in a ship, for which the two-compartment subdivision standard is required (number of persons on board is equal or greater than 400), provision shall be made for calculating the maximum probability index  $A_{\max 1}$  or  $A_{\max 2}$  in the same way as  $A_1$  or  $A_2$  but the value of  $s$  is assumed to be equal to 1 in case of:

flooding of every compartment in a ship which requires the one-compartment subdivision standard;

flooding of every two adjacent compartments in a ship which requires the two-compartment subdivision standard.

**5.1.6** The value  $A/A_{\max}$  is determined by the following formulae:

for the one-compartment subdivision standard

$$\frac{A}{A_{\max}} = \frac{A_1}{A_{\max 1}} \quad \text{or} \quad \frac{A}{A_{\max}} = \frac{A_1 + A_2}{A_{\max 1} + A_2}; \quad (5.1.6-1)$$

for the two-compartment subdivision standard

$$\frac{A}{A_{\max}} = \frac{A_1 + A_2}{A_{\max 1} + A_{\max 2}} \quad (5.1.6-2)$$

where  $A_1$  = a part of the value  $A$  determined in accordance with 5.1.4 for the cases where one compartment is flooded;

$A_2$  = a part of the value  $A$  determined in accordance with 5.1.4 for the cases where two adjacent compartments are flooded;

$A_{\max 1}$  = a part of the value  $A$  determined in accordance with 5.1.5 for the cases where one compartment is flooded;

$A_{\max 2}$  = a part of the value  $A$  determined in accordance with 5.1.5 for the cases where two adjacent compartments are flooded.

## 5.2 BULK CARRIERS, ORE CARRIERS AND COMBINATION CARRIERS

**5.2.1** Bulk carriers with single side shell the design of which complies with the requirements of 3.3.1.6.1, Part II «Hull», having a length  $L_1 \geq 150$  m, carrying solid bulk cargoes with a density of  $1000 \text{ kg/m}^3$  and above, constructed on July 1999 or after that date, shall comply with the requirements of 4.4 at flooding of any cargo hold under all the loading cases up to the summer load line. The bulk carrier, which forward cargo hold is confined by the outer plating or double side skin construction with a width less than 760 mm with an length  $L_1$  of 150 m and more built

before 1 July 1999 carrying hard bulk cargoes with density of  $1780 \text{ kg/m}^3$  and more, shall comply with the requirements of 4.4 while flooding the fore cargo hold in all cases of loading up to the summer load line not later than the date of survey assigned in relation to the ship age:

**.1** for ships which age at 1 July 1998 is 20 years and more, the date of the first intermediate (the second or the third annual survey) or the first special survey, which shall be carried out after 1 July 1998 is accepted, whichever is earlier;

**.2** for ships which age at 1 July 1998 is 15 years and more but less than 20 years, the date of the first special survey which shall be carried out after 1 July 1998 but not later than 1 July 2002 is accepted;

**.3** for ships which age at 1 July 1998 is less than 15 years, the date of the third special survey or the date when the ship's age becomes equal to 15 years is accepted, whichever is later.

**5.2.2** The following values of permeabilities shall be taken for the damage stability calculations:

0,90 for loaded holds;

0,95 for empty holds.

**5.2.3** The ships which don't comply with the requirements of 5.2.1 may be acquitted from this requirement provided the following conditions are met:

**.1** the programme of the fore hold annual survey is replaced by the programme approved at the full scale intermediate survey in accordance with the Section 2, Part III "Additional Surveys of Ships in Relation to Their Purpose and Hull Material" of Rules for the Classifications Surveys of Ships in Service;

**.2** the visual and audible alarm shall be fitted in the wheelhouse for signalling in case of:

flooding over two metres above the double bottom in the stern part of each cargo hold;

filling of bilge well of each hold up to the upper level.

Such signalling system shall meet the requirements of Part XI "Electrical Equipment";

**.3** the ship shall be supplied with detailed information on the effect of the phased flooding of cargo hold and detailed instructions in accordance with Section 8 of International Safety Management Code (ISM Code).

Information shall include the data and documentation stated in 1.4.6.1 and the results of damage trim and stability calculations at stage-by-stage compartment flooding under all conditions of loading to the summer load line on an even keel. When the ship meets the requirements of 4.4 at a lesser draught, the document shall contain a diagram of maximum heights of the centre of gravity of the ship (limiting moments or minimum metacentric heights) plotted with due regard to the trim and ship load. The strength of the bulkhead shall be taken into consideration. The information shall contain a summary table of calculation results with indication of critical factors and the data given in 1.4.6.1.5.

**5.2.4** The ships which are assigned with the reduced freeboard in accordance with Section 4 are considered compliant with the requirements 5.2.1.

**5.2.5** Information on compliance with the requirements of 5.2.1 to 5.2.3 shall be included in the Booklet required by 1.4.9.7, Part II "Hull".

**5.2.6** Ships built before 1 July 2004 shall meet the requirements of 3.4.12.3 to 3.4.12.5 not later than the date of the first periodical survey of a ship conducted after 1 July 2004.

**5.2.6.1** If sensors cannot be placed in the aft end of the cargo hold within a distance less than or equal to  $B/6$  from the centerline, they shall be located at both the port and starboard sides of the cargo hold.

**5.2.6.2** The upper sensor only may be fitted in cargo holds of the ships being subject to the requirement of 5.2.3; the ships not complying with the requirement of 5.2.3.2 on 1 January 2004 shall be fitted with water level detectors in cargo holds in accordance with 3.4.12.3.1 (considering 5.2.6.1).

## 6 REQUIREMENTS FOR SUBDIVISION OF SHIPS THE KEELS OF WHICH ARE LAID ON 1 JANUARY 2009 OR AFTER THAT DATE

### 6.1 GENERAL

#### 6.1.1 Application.

**6.1.1.1** The requirements of the present Section apply to design of ships the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009 and cover the following types of ships:

- .1** passenger ships;
- .2** oil tankers;
- .3** fishing vessels having the length  $L_1 \geq 100 \text{ m}$ ;
- .4** type "A" ships and type "B" ships with reduced freeboard as mentioned under 4.1.2.1 and 4.1.3.3 of Load Line Rules for Sea-Going Ships;
- .5** chemical tankers;
- .6** gas carriers;

- .7 special purpose ships;
- .8 supply vessels;
- .9 ships intended for the carriage of radioactive agents;
- .10 cargo ships having the length  $L_s \geq 80$  m not mentioned above;
- .11 dry cargo ships having the length  $L_s < 80$  m (refer to 6.1.4.9);
- .12 icebreakers having the length  $L_1 \geq 50$  m;
- .13 tugs having the length  $L_1 \geq 40$  m;
- .14 dredgers having the length  $L_1 \geq 40$  m, hopper dredgers having the length  $L_1 \geq 60$  m;
- .15 salvage ships;
- .16 drilling ships;
- .17 lightships;
- .18 ships having the ice strengthening marks **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9** in the class notation;
- .19 berth-connected ships used as floating hotels and/or having over 100 persons on board;
- .20 bulk carriers, ore and combination carriers in service, which construction date is stated in 6.5;
- .21 cargo ships having a length ( $L_1$ ) of less than 100 m other than bulk carriers, and a single cargo hold or cargo holds which are not separated by a bulkhead made watertight up to the freeboard deck (refer to 6.3.4.13).

**6.1.1.2** For ships to which the present Section is not applicable it is recommended that all measures allowed by the type and service conditions of the ship be taken to obtain the best subdivision characteristics possible.

However, if the shipowner wishes a subdivision distinguishing mark to be introduced in the class notation, the ship shall satisfy all the requirements contained in the present Section.

The applicability of the present Section to novel craft shall be determined on agreement with the Register.

**6.1.1.3** The requirements of 6.4 are applicable to type "A" ships and type "B" ships with reduced freeboard provided compliance with 4.1 of the Load Line Rules as regards the subdivision of those ships is confirmed. When making calculations required by 6.4, calculations as required by 6.2 and 6.3 may be considered.

#### **6.1.2 Definitions and explanations.**

**6.1.2.1** Definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification".

For the purpose of the present Section the following definitions and explanations have been adopted.

**Damage waterline** is the waterline of a damaged ship with one or more adjacent compartments flooded.

The depth  $D$  is the least vertical distance measured from the top of the plate keel or from the line where the inner surface of shell plating abuts upon the bar keel, to the inner line of bulkhead deck abutting to the side. In ships having rounded gunwales, this distance is measured to the point of intersection of the continued inner surfaces of bulkhead deck steel plating and the side shell plating at side, as though the gunwale were of angular design. In non-metal ships the above-said shall be referred to the outer surfaces of the deck and plating.

**Moulded depth** is measured in the same way as the depth  $D$ , but up to the top of the freeboard beam.

**Subdivision load line** is the load line of an undamaged ship, which is used in determining the subdivision of the ship.

**Trim** is the difference between the draught forward and the draught aft, where the draughts are measured at the forward and aft terminals respectively, disregarding any rake of keel.

**Subdivision length**  $L_s$  of the ship is the greatest projected moulded length of that part of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.

The ship length  $L_{ice}$  is the ship length on the waterline corresponding to the draft  $d_{ice}$ .

The ship length  $L_1$  is 96 per cent of the total length on a waterline at 85 per cent of the least moulded depth or the length from the fore side of the stem to the axis of rudder stock on that waterline if that be greater.

**Permeability index** of a space  $\mu$  is the ratio of the volume within that space, which is assumed to be occupied by water to the total volume of that space.

**Aft terminal** is the aft limit of the subdivision length.

**Forward terminal** is the forward limit of the subdivision length.

**Keel line** is a line parallel to the slope of the keel passing amidships through:

.1 the top of the keel at centreline or line of intersection of the inside of shell plating with the keel if a bar keel extends below that line, on a ship with a metal shell; or

.2 in wood and composite ships, the distance is measured from the lower edge of the keel rabbet. When the form at the lower part of the midship section is of a hollow character, or where thick garboards are fitted, the distance is measured from the point where the line of the flat of the bottom continued inward intersects the centreline amidships.

**Machinery spaces** are spaces between the watertight boundaries of a space containing the main and auxiliary propulsion machinery, including boilers, generators and electric motors primarily in-

tended for propulsion. In the case of unusual arrangements, the limits of the machinery spaces are defined on agreement with the Register.

A *midships* is at the middle of the length  $L_1$ .

*Light service draught*  $d_l$  is the service draught corresponding to the lightest anticipated loading and associated tankage, including, however, such ballast as may be necessary for stability and/or immersion. Passenger ships shall include the full complement of passengers and crew on board.

*Draught*  $d$  is the vertical distance from the keel line at mid-length to the waterline in question.

The ship draft  $d_{ice}$  is the smallest ship draft out of: a draft corresponding to the waterline serving as the upper boundary of the ice strengthening of the hull, or a draft at which the requirements for ice damage trim and stability are met, as contained in 6.3.4.10.

*Deepest subdivision draught*  $d_s$  is the waterline which corresponds to the summer load line draught of the ship.

A *compartment* is an inner space limited by the ship bottom, sides, bulkhead deck and two adjacent transverse watertight bulkheads or a peak bulkhead and an extremity.

*Bulkhead deck* in a passenger ship means the uppermost deck at any point in the subdivision length  $L_s$  to which the main bulkheads and the ship's shell are carried watertight and the lowermost deck from which passenger and crew evacuation will not be impeded by water in any stage of flooding for damage cases defined in 6.2. The bulkhead deck may be a stepped deck. In a cargo ship the freeboard deck may be taken as the bulkhead deck.

The *deepest subdivision load line* is the waterline, which corresponds to the deepest draft permitted by applicable subdivision requirements.

*Midlength* is the midpoint of the subdivision length of a ship.

*Equalization of a ship* is the process of eliminating or reducing heel and/or trim.

*Breadth*  $B$  is the greatest moulded breadth of the ship at or below the deepest subdivision draught.

*Partial subdivision draught*  $d_p$  is the light service draught plus 60 per cent of the difference between the light service draught and the deepest subdivision draught.

**6.1.2.2** In all calculated cases of flooding only one hole in the hull is assumed and only one free surface of sea water which penetrated after the accident. In this case the hole is considered to have the shape of a rectangular parallelepiped.

**6.1.2.3** All linear dimensions used in the present Section are taken in meters.

### 6.1.3 Scope of survey.

**6.1.3.1** The provisions pertaining to the procedure of classification, survey of ships under con-

struction and classification surveys, as well as the requirements for the technical documentation to be submitted for consideration by the Register are contained in General Regulations for the Classification and Other Activity and in Part II "Technical Documentation" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**6.1.3.2** For every ship meeting the requirements of the present Section, the Register shall carry out the following:

**.1** check of compliance of the structural measures taken to ensure subdivision of the ship with the requirements specified in 1.1.6 and 2.7, Part II "Hull", Section 7, Part III "Equipment, Arrangements and Outfit", Sections 2, 4, 5 and 7.1 to 7.11, 10.1, 10.2, 10.4, 12.1, Part VIII "Systems and Piping";

**.2** consideration and approval of Information on Damage Trim and Stability, Operating Manual on Water Level Detection System (refer to 6.3.4.11.4), Damage Control Plan, as well as consideration of Information on the Effect of Flooding (to be duly noted), as stipulated in 6.1.4.9;

**.3** checking of correct assignment and marking of additional load lines corresponding to subdivision load lines;

**.4** examination and approval of the computer installed on board the ship and the relevant software where it is used for assessing damage trim and stability.

### 6.1.4 General technical requirements.

**6.1.4.1** The ship subdivision shall be the most effective bearing in mind the service of the ship. The degree of subdivision shall vary proceeding from the area of navigation, ship length and number of persons on board so that the highest subdivision degree would be characteristic of ships of the greatest length engaged for the most part in the carriage of passengers and of those navigating in the Arctic and the Antarctic.

**6.1.4.2** In no case shall any subdivision load line be assigned above the deepest subdivision load line in seawater determined on the basis of the ship hull safety or in accordance with the Load Line Rules for Sea-Going Ships.

The subdivision load line assigned to the ship is marked on its sides and recorded in the documents of the Register as required by the Load Line Rules for Sea-Going Ships.

**6.1.4.3** The volumes and areas shall, in all cases, be calculated to moulded lines. The volumes and free surfaces of water which penetrates the compartments of reinforced-concrete, plastic, wood and composite ships shall be calculated to inboard hull lines.

**6.1.4.4** When determining the initial metacentric height of a ship in damaged condition, corrections for the effect of free surfaces of liquid cargoes, ship stores

and ballast water shall be taken into account in the same manner as in the case of calculating the intact stability of a ship in compliance with 1.4.7, Part IV "Stability".

When plotting static stability curves for a damaged ship, the enclosed superstructures, trunks, deckhouses, angles of flooding through openings in ship's sides, decks, hull and superstructure bulkheads considered open as well as corrections for free surfaces of liquid cargoes shall be taken into account in the same manner as in the case of plotting curves for an intact ship in compliance with 1.4.9, Part IV "Stability".

Superstructures, trunks and deckhouses which sustain damage may only be taken into account with the permeability specified in 6.1.6, or ignored. The openings in such structures leading to spaces, which are not flooded, are considered open at appropriate angles of heel only when regular weathertight means of closing are not fitted.

**6.1.4.5** When calculating damage trim and stability, account shall be taken of changes in the initial ship loading (intact ship) due to liquid cargoes being replaced by sea water in damaged tanks, taking into consideration that in the flooded tanks below the damage waterline the free surface of those cargoes disappears.

**6.1.4.6** Ships to which the present Section is applicable shall be provided with approved Information on Damage Trim and Stability with compartments flooded and with Damage Control Plan. These documents shall enable the master operating the ship, to consider the requirements concerning subdivision and to estimate the condition of the ship when compartments are flooded as well as to take measures for maintaining the damaged ship afloat.

**6.1.4.6.1** Information on Damage Trim and Stability shall include the following:

**.1** data on the ship, including its dimensions and permissible drafts on clear water and in ice conditions, its longitudinal section, deck and double-bottom plans, typical cross-sections with indication of all watertight bulkheads and enclosures with openings therein, means of their closure and drives, openings of air and ventilation pipes, as well as diagrammatic arrangement of systems necessary for the survival of the damaged ship;

**.2** information necessary to maintain the stability of an intact ship sufficient to withstand, in accordance with the requirements of the present Section, the most dangerous extent of damage; instructions on loading and ballasting the ship, including recommendations on distributing cargo in the holds, stores and ballast in a manner reasonable as regards the subdivision adopted and satisfying at the same time the requirements for the trim, stability and

strength of the ship; brief list of requirements for damage trim and stability;

**.3** diagram of the limiting gravity-centre heights of the ship (limiting moments or minimum metacentric heights) plotted taking into the account the requirements of this Section and Part IV "Stability";

**.4** list of results of symmetrical and unsymmetrical flooding calculations with data on initial and damage draught, heel, trim and metacentric height both before and after taking measures for the equalization of the ship or for improving its stability as well as measures recommended for these procedures and the period of time required. Parameters of static stability curves anticipated under the worst flooding conditions shall also be included. Where necessary, for ships with **Arc4** to **Arc9** ice strengthening, the information on the characteristics of ice unsinkability, damage trim and stability shall be indicated when sustaining design ice damage;

**.5** data on structural measures to ensure ship subdivision, instructions on the use of covers, cross flooding arrangements and emergency appliances as well as on possible consequences of flooding relating to the particular features of the ship and on advisable and prohibited actions of the crew under normal conditions of service and in case of damage involving flooding.

**6.1.4.6.2** Damage Control Plan shall be made on the scale acceptable for operation, but not less the 1:200. On passenger ships, the Plan shall be permanently exhibited on the navigating bridge. On cargo ships the Plan shall be permanently exhibited or be readily available on the navigating bridge. The Plan containing the longitudinal section, plans of decks, double bottom and transverse sections shall include:

boundaries of watertight compartments and tanks;

ballast, bilge, overflow (discharge) systems and arrangements to correct heel caused by flooding;

location of openings in watertight compartments, their closing appliances and the location of their local and remote controls, position indicators and alarms;

location of doors in the shell of the ship, position indicators, leakage detection and surveillance devices;

location of weathertight closing appliances above the bulkhead deck and on the lowest exposed weather deck, together with location of controls and position indicators, if applicable;

location of all bilge flood and ballast pumps, their control stations and valves.

**6.1.4.7** Information on Damage Trim and Stability shall be compiled on the basis of the Information on Stability. The procedure of extending the validity of the Information on Damage Trim and Stability from one ship to another is similar to that of extending the validity of Information on Stability as specified in 1.4.11.2, Part IV "Stability". Information on Damage

Trim and Stability may be incorporated in Information on Intact Stability as a separate section.

**6.1.4.8** For estimation of the ship damage trim and stability it is recommended to use the onboard computer. The associated software shall have Type Approval Certificate issued by the Register.

A computer is not equivalent to Information on Damage Trim and Stability.

**6.1.4.9** Dry cargo ships less than 80 m in length shall be provided with Information on the Effect of Flooding. This Information shall contain data and documentation listed in 6.1.4.6.1 and results of damage trim and stability calculations when engine room and every cargo space are flooded. The calculations shall be made for two draughts one of which shall be the summer load line draught. The maximum permissible position of ship's centre of gravity shall be taken according to Information on Stability. Permeabilities of cargo spaces shall be taken with regard to the cargoes intended to be carried and shall be within 0,60 to 0,90. The Information shall contain a summary table of calculation results with indication of critical factors, as well as details given in 6.1.4.6.1.5.

**6.1.4.10** Every ship shall have draught scales prominently marked at bow and stern. Where the draught scales are so placed that they are not clearly visible or where service conditions impede reading the indications of the scale the ship shall be provided with a reliable draught measurement system whereby the forward and aft draughts can be easily determined.

#### **6.1.5 Satisfactory subdivision.**

**6.1.5.1** The subdivision of a ship can be considered satisfactory as regards the present Section, if:

**.1** the attained subdivision index  $A$ , determined in accordance with 6.2.3, is not less than the required subdivision index  $R$  calculated in accordance with 6.2.2 and if, in addition, the partial indices  $A_s$ ,  $A_p$  and  $A_l$  are not less than 0,9R for passenger ships and 0,5R for cargo ships;

**.2** the attained (actual) probability ice subdivision index  $A_{ice}$  is not lower than the required probability ice subdivision index  $R_{ice}$ . The indices  $A_{ice}$  and  $R_{ice}$  shall be determined on the basis of 6.2;

**.3** the requirements under 6.1.5.1.1 are not applicable to ships for which in 6.2 there are no instructions for determining the indices  $A$  and/or  $R$ ;

**.4** damage stability is in accordance with 6.3, considering 6.3.3.2.

**6.1.5.2** A subdivision distinguishing mark is introduced in the class notation of the ship in accordance with 2.2.4, Part I "Classification" provided under all design loading conditions corresponding to the type of ship concerned its subdivision is considered satisfactory according to 6.1.5.1, damage trim and stability comply with the requirements of 6.3.3 when any single ship

compartment or any adjacent ship compartments are flooded throughout the ship's length in accordance with the introduced subdivision distinguishing mark, and the compliance of structural measures related to the subdivision of the ship with the requirements of 1.1.6 and 2.7, Part II "Hull" and in Section 7, Part III "Equipment, Arrangements and Outfit" is ensured.

When, in accordance with 6.3.4 of the present Section the number of floodable compartments is changed throughout the ship length, the lowest value shall be stated in the subdivision distinguishing conditions under which a subdivision distinguishing mark shall be introduced in the class notation can be found in 6.3.4.

#### **6.1.6 Permeability index.**

**6.1.6.1** In the calculations of damage trim and stability the permeability index of flooded space shall be assumed equal to:

**.1** 0,85 for spaces occupied by machinery, electric generating sets and processing equipment on fishing vessels and factory ships;

**.2** 0,95 for accommodation spaces and empty spaces including empty tanks;

**.3** 0,6 for the spaces intended for dry stores.

**6.1.6.2** Permeability of flooded tanks with liquid cargo or liquid stores or water ballast is determined based on the assumption that all the cargo is discharged from the tank and sea water is ingressed taking into consideration the permeability index being equal to 0,95.

**6.1.6.3** The permeability index of the spaces intended for solid cargoes is given below in the appropriate paragraphs of 6.2 to 6.5.

**6.1.6.4** The permeability index of spaces may be assumed lower than specified above only in case a special calculation is performed which is approved by the Register.

When performing such special calculations for cargo spaces including refrigerating ones, the permeability index of net cargo shall be assumed equal to 0,6, and that of the cargo in containers, trailers, roll trailers and lorries shall be assumed equal to 0,71.

**6.1.6.5** Where the arrangement of spaces or the service conditions of the ship are such that the expediency of the application of other permeability indices resulting in more severe requirements is evident, the Register is entitled to require the application of those permeability indices.

## **6.2 PROBABILITY ESTIMATION OF SUBDIVISION**

### **6.2.1 General.**

**6.2.1.1** The requirements of the present Chapter apply to cargo ships of 80 m in length  $L_s$  and upwards and to all passenger ships regardless of their length except for ships, the types of which are specified in

6.1.1.1.2 to 6.1.1.1.9, 6.1.1.1.19, 6.1.1.1.20, as well nuclear ships and nuclear floating facilities.

### 6.2.2 Required subdivision index $R$ .

**6.2.2.1** The subdivision of a ship is considered sufficient if the attained subdivision index  $A$ , determined in accordance with 6.2.3, is not less than the required subdivision index  $R$  calculated in accordance with 6.2.2.2 and if, in addition, the partial indices  $A_s$ ,  $A_p$  and  $A_l$  are not less than  $0,9R$  for passenger ships and  $0,5R$  for cargo ships.

**6.2.2.2** For all ships to which the damage stability requirements of this Section apply, the degree of subdivision to be provided shall be determined by the required subdivision index  $R$ , as follows:

**.1** in the case of cargo ships greater than 100 m in length  $L_s$ :

$$R = 1 - 128 / (L_s + 152);$$

**.2** in the case of cargo ships not less than 80 m in length  $L_s$  and not greater than 100 m in length  $L_s$ :

$$R = 1 - [1 / (1 + \frac{L_s}{100} \times \frac{R_0}{1 - R_0})]$$

where  $R_0$  = the value  $R$  as calculated in accordance with the formula in 6.2.2.1;

**.3** in the case of passenger ships:

$$R = 1 - 5000 / (L_s + 2,5N + 15255)$$

where  $N = N_1 + 2N_2$ ;

$N_1$  = number of persons for whom lifeboats are provided;

$N_2$  = number of persons (including officers and crew) the ship is permitted to carry in excess of  $N_1$ ;

**.4** where the conditions of service are such that compliance with 6.2.2.2.3 on the basis of  $N = N_1 + 2N_2$  is impracticable and where the Register considers that a suitably reduced degree of hazard exists, a lesser value of  $N$  may be taken but in no case less than  $N = N_1 + N_2$ .

### 6.2.3 Attained subdivision index $A$ .

**6.2.3.1** The attained subdivision index  $A$  is obtained by the summation of the partial indices  $A_s$ ,  $A_p$  and  $A_l$  calculated for the draughts  $d_s$ ,  $d_p$  and  $d_l$  in accordance with the following formula:

$$A = 0,4A_s + 0,4A_p + 0,2A_l. \quad (6.2.3.1-1)$$

Each partial index is a summation of contributions from all damage cases taken in consideration, using the following formula:

$$A = \sum p_i s_i \quad (6.2.3.1-2)$$

where  $i$  represents each compartment or group of compartments under consideration;

$p_i$  accounts for the probability that only the compartment or group of compartments under consideration may be flooded, disregarding any horizontal subdivision, as defined in 6.2.4;

$s_i$  accounts for the probability of survival after flooding the compartment or group of compartments under consideration, and includes the effect of any horizontal subdivision, as defined in 6.2.5.

**6.2.3.2** In the calculation of  $A$ , the level trim shall be used for the deepest subdivision draught and the partial subdivision draught. The actual service trim shall be used for the light service draught. If in any service condition, the trim variation in comparison with the calculated trim is greater than 0,5 per cent of  $L_s$ , one or more additional calculations of  $A$  are to be submitted for the same draughts but different trims so that, for all service conditions, the difference in trim in comparison with the reference trim used for one calculation will be less than 0,5 per cent of  $L_s$ .

**6.2.3.3** When determining the positive righting lever of the residual stability curve, the constant displacement method of calculation shall be used.

**6.2.3.4** The summation indicated by the above formula shall be taken over the ship's subdivision length  $L_s$  for all cases of flooding in which a single compartment or two or more adjacent compartments are involved. In the case of unsymmetrical arrangements, the calculated  $A$  value shall be the mean value obtained from calculations involving both sides. Alternatively, it shall be taken as that corresponding to the side which evidently gives the least favourable result.

**6.2.3.5** Wherever wing compartments are fitted, contribution to the summation indicated by the Formula (6.2.3.1-2) shall be taken for all cases of flooding in which wing compartments are involved. Additionally, cases of simultaneous flooding of a wing compartment or group of compartments and the adjacent inboard compartment or group of compartments, but excluding damage of transverse extent greater than one half of the ship breadth  $B$ , may be added. For the purpose of 6.2.3, transverse extent is measured inboard from ship's side, at right angle to the centreline at the level of the deepest subdivision draught.

**6.2.3.6** In the flooding calculations carried out according to the regulations, only one breach of the hull and only one free surface need to be assumed. The assumed vertical extent of damage shall extend from the baseline upwards to any watertight horizontal subdivision above the waterline or higher. However, if a lesser extent of damage will give a more severe result, such extent shall be assumed.

**6.2.3.7** If pipes, ducts or tunnels are situated within the assumed extent of damage, arrangements shall be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed flooded. However, the Register may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the ship is not impaired.

### 6.2.4 Calculation of the factor $p_i$ .

**6.2.4.1** The factor  $p_i$  for a compartment or group of compartments shall be calculated in accordance

with 6.2.4.1.1.1 and 6.2.4.1.1.2 using the following notations:

- $j$  = the aftmost damage zone number involved in the damage starting with No.1 at the stern;
- $n$  = the number of adjacent damage zones involved in the damage;
- $k$  = is the number of a particular longitudinal bulkhead as barrier for transverse penetration in a damage zone counted from shell towards the centre line. The shell has  $k = 0$ ;
- $x_1$  = the distance from the aft terminal of  $L_s$  to the aft end of the zone in question;
- $x_2$  = the distance from the aft terminal of  $L_s$  to the forward end of the zone in question;
- $b$  = the mean transverse distance in metres measured at right angles to the centreline at the deepest subdivision loadline between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor  $p_i$  and which is a tangent to, or common with, all or part of the outermost portion of the longitudinal bulkhead under consideration. This vertical plane shall be so orientated that the mean transverse distance to the shell is a maximum, but not more than twice the least distance between the plane and the shell. If the upper part of a longitudinal bulkhead is below the deepest subdivision loadline the vertical plane used for determination of  $b$  is assumed to extend upwards to the deepest subdivision waterline. In any case,  $b$  shall not be taken greater than  $B/2$ .

If the damage involves a single zone only:

$$p_i = p(x_1, x_2) [r(x_1, x_2, b_k) - r(x_1, x_2, b_{k-1})].$$

If the damage involves two adjacent zones:

$$p_i = p(x_1, x_2) [r(x_1, x_2, b_k) - r(x_1, x_2, b_{k-1})] - p(x_1, x_2) [r(x_1, x_2, b_k) - r(x_1, x_2, b_{k-1})] - p(x_1, x_2) [r(x_1, x_2, b_k) - r(x_1, x_2, b_{k-1})]$$

If the damage involves three or more adjacent zones:

$$p_i = p(x_1, x_2) [r(x_1, x_2, b_k) - r(x_1, x_2, b_{k-1})] - p(x_1, x_2) [r(x_1, x_2, b_k) - r(x_1, x_2, b_{k-1})] - p(x_1, x_2) [r(x_1, x_2, b_k) - r(x_1, x_2, b_{k-1})] + p(x_1, x_2) [r(x_1, x_2, b_k) - r(x_1, x_2, b_{k-1})]$$

where  $r(x_1, x_2, b_0) = 0$ .

**6.2.4.1.1** The factor  $p(x_1, x_2)$  shall be calculated according to the following formulae:

overall normalized max damage length:

$$J_{max} = 10/33;$$

knuckle point in the distribution:  $J_{kn} = 5/33$ ;

cumulative probability at  $J_{kn}$ :  $p_k = 11/12$ ;

maximum absolute damage length:  $l_{max} = 60$  m;

length where normalized distribution ends:

$$L^* = 260 \text{ m};$$

probability density at  $J = 0$ :

$$b_0 = 2(p_k/J_{kn} - (1-p_k)/(J_{max} - J_{kn})).$$

when  $L_s \leq L^*$ :

$$J_m = \min\{J_{max}, l_{max}/L_s\},$$

$$J_k = J_m/2 + (1 - \sqrt{1 + (1 - 2p_k)b_0J_m + 1/4b_0^2J_m^2})/b_0,$$

$$b_{12} = b_0.$$

when  $L_s > L^*$ :

$$J_m^* = \min\{J_{max}, L_{max}/L^*\},$$

$$J_k^* = J_m^*/2 + (1 - \sqrt{1 + (1 - 2p_k)b_0J_m^* + 1/4b_0^2J_m^{*2}})/b_0,$$

$$J_m = J_m^*L^*/L_s,$$

$$J_k = J_k^*L^*/L_s,$$

$$b_{12} = 2[p_k/J_k - (1-p_k)/(J_m - J_k)],$$

$$b_{11} = 4(1-p_k)/[(J_m - J_k)J_k] - 2p_k/J_k^2,$$

$$b_{21} = -2(1-p_k)/(J_m - J_k)^2,$$

$$b_{22} = -b_{21}J_m;$$

the non-dimensional damage length:

$$J = (x_2 - x_1)/L_s;$$

the normalized length of a compartment or group of compartments:

$J_n$  shall be taken as the lesser of  $J$  and  $J_m$ .

**6.2.4.1.1.1** Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:

$$J \leq J_k:$$

$$p(x_1, x_2) = p_1 = 1/6[J^2(b_{11}J + 3b_{12})],$$

$$J > J_k:$$

$$p(x_1, x_2) = p_2 = -1/3b_{11}J_k^3 + 1/2(b_{11}J - b_{12})J_k^2 + b_{12}JJ_k - 1/3b_{21}(J_n^3 - J_k^3) + 1/2(b_{12}J - b_{22})(J_n^2 - J_k^2) + b_{22}J(J_n - J_k).$$

**6.2.4.1.1.2** Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:

$$J \leq J_k:$$

$$p(x_1, x_2) = 1/2(p_1 + J),$$

$$J > J_k:$$

$$p(x_1, x_2) = 1/2(p_2 + J).$$

**6.2.4.1.1.3** Where the compartment or groups of compartments considered extends over the entire subdivision length  $L_s$ :

$$p(x_1, x_2) = 1.$$

**6.2.4.1.2** The factor  $r(x_1, x_2, b)$  shall be determined by the following formulae:

$$r(x_1, x_2, b) = 1 - (1 - C)[1 - G/p(x_1, x_2)]$$

$$\text{where } C = 12J_b(-45J_b + 4);$$

$$\text{where } J_b = b/(15B).$$

**6.2.4.1.2.1** Where the compartment or groups of compartments considered extends over the entire subdivision length  $L_s$ :

$$G = G_1 = 1/2b_{11}J_b^2 + b_{12}J_b.$$

**6.2.4.1.2.2** Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:

$$G = G_2 = -1/3b_{11}J_0^3 + 1/2(b_{11}J - b_{12})J_0^2 + b_{12}JJ_0$$

$$\text{where } J_0 = \min(J, J_b).$$

**6.2.4.1.2.3** Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:



$$G = 1/2(G_2 + G_1J).$$

### 6.2.5 Calculation of the factor $s_i$ .

**6.2.5.1** The factor  $s_i$  shall be determined for each case of assumed flooding, involving a compartment or group of compartments, in accordance with the following notations and the provisions in this regulation.

$\theta_e$  is the equilibrium heel angle in any stage of flooding, in degrees;

$\theta_v$  is the angle, in any stage of flooding, where the righting lever becomes negative, or the angle at which an opening incapable of being closed weathertight becomes submerged;

$GZ_{\max}$  is the maximum positive righting lever, in m, up to the angle  $\theta_v$ ;

*Range* is the range of positive righting levers, in deg, measured from the angle  $\theta_e$ . The positive range is to be taken up to the angle  $\theta_v$ ;

Flooding stage is any discrete step during the flooding process, including the stage before equalization (if any) until final equilibrium has been reached.

**6.2.5.1.1** The factor  $s_{i,}$  for any damage case at any initial loading condition,  $d_i$ , shall be obtained from the formula

$$s_i = \min(s_{\text{intermediate},i} \ s_{\text{final},i} \ s_{\text{mom},i})$$

where  $s_{\text{intermediate},i}$  = the probability to survive all intermediate flooding stages until the final equilibrium stage, and is calculated in accordance with 6.2.5.2;

$s_{\text{final},i}$  = the probability to survive in the final equilibrium stage of flooding. It is calculated in accordance with 6.2.5.3;

$s_{\text{mom},i}$  = the probability to survive heeling moments, and is calculated in accordance with 6.2.5.4.

**6.2.5.2** The factor  $s_{\text{intermediate},i}$  is applicable only to passenger ships (for cargo ships  $s_{\text{intermediate}}$  shall be taken as unity) and shall be taken as the least of the  $s$ -factors obtained from all flooding stages including the stage before equalization, if any, and shall be calculated as follows:

$$s_{\text{intermediate},i} = [(GZ_{\max}/0,05)(\text{Range}/7)]^{1/4}$$

where  $GZ_{\max}$  shall not be taken as more than 0,05 m and *Range* as not more than 7°.  $s_{\text{intermediate}} = 0$ , if the intermediate heel angle exceeds 15°. Where cross-flooding fittings are required, the time for equalization shall not exceed 10 min.

**6.2.5.3** The factor  $s_{\text{final},i}$  shall be obtained from the formula

$$s_{\text{final},i} = K[(GZ_{\max}/0,12)(\text{Range}/16)]^{1/4}$$

where  $GZ_{\max}$  shall not be taken as more than 0,12 m;

*Range* shall not be taken as more than 16°;

$K = 1$ ,  $\theta_e \leq \theta_{\min}$ ;

$K = 0$ ,  $\theta_e \geq \theta_{\max}$ ;

$K = \sqrt{(\theta_{\max} - \theta_e)/(\theta_{\max} - \theta_{\min})}$

otherwise,

where  $\theta_{\min}$  is 7° for passenger ships and 25° for cargo ships;  
 $\theta_{\max}$  is 15° for passenger ships and 30° for cargo ships.

**6.2.5.4** The factor  $s_{\text{mom},i}$  is applicable only to passenger ships (for cargo ships  $s_{\text{mom},i}$  shall be taken as unity) and shall be calculated at the final equilibrium from the formula

$$s_{\text{mom},i} = (GZ_{\max} - 0,04)\text{Displacement}/M_{\text{heel}}$$

where *Displacement* = the intact displacement at the subdivision draught;

$M_{\text{heel}}$  = the maximum assumed heeling moment as calculated in accordance with 6.2.5.4.1;

$s_{\text{mom},i} \leq 1$ .

**6.2.5.4.1** The heeling moment  $M_{\text{heel}}$  shall be calculated as follows:

$$M_{\text{heel}} = \max\{M_{\text{passenger}} \text{ or } M_{\text{wind}} \text{ or } M_{\text{survivalcraft}}\}.$$

**6.2.5.4.1.1**  $M_{\text{passenger}}$  is the maximum assumed heeling moment resulting from movement of passengers, and shall be obtained as follows:

$$M_{\text{passenger}} = (0,075N_p)(0,45B)$$

where  $N_p$  = the maximum number of passengers permitted to be on board in the service condition corresponding to the deepest subdivision draught under consideration;

$B$  = the beam of the ship.

Alternatively, the heeling moment may be calculated assuming the passengers are distributed with 4 persons per m<sup>2</sup> on available deck areas towards one side of the ship on the decks where muster stations are located and in such a way that they produce the most adverse heeling moment. In doing so, a weight of 75 kg per passenger shall be assumed.

**6.2.5.4.1.2**  $M_{\text{wind}}$  is the maximum assumed wind force acting in a damage situation:

$$M_{\text{wind}} = (PAZ)/9806$$

where  $P = 120 \text{ N/m}^2$ ;

$A$  = projected lateral area above waterline;

$Z$  = distance from centre of lateral projected area above waterline to  $T/2$ ;

$T$  = ship's draught,  $d_i$ .

**6.2.5.4.1.3**  $M_{\text{survivalcraft}}$  is the maximum assumed heeling moment due to the launching of all fully loaded davit-launched survival craft on one side of the ship. It shall be calculated using the following assumptions:

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;

for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken;

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;

persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment;

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.

**6.2.5.5** Unsymmetrical flooding shall be kept to a minimum consistent with the efficient arrangements. Where it is necessary to correct large angles of heel, the means adopted shall, where practicable, be self-acting, but in any case where controls to equalization devices are provided they shall be operable from above the bulkhead deck. These fittings together with their controls shall be acceptable to the Register. Suitable information concerning the use of equalization devices shall be supplied to the master of the ship.

**6.2.5.5.1** Tanks and compartments taking part in such equalization shall be fitted with air pipes or equivalent means of sufficient cross-section to ensure that the flow of water into the equalization compartments is not delayed.

**6.2.5.5.2** In all cases,  $s_i$  shall be taken as zero in those cases where the final waterline, taking into account sinkage, heel and trim, immerses:

**.1** the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of factor  $s_i$ . Such openings shall include air-pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers; and

**.2** any part of the bulkhead deck in passenger ships considered a horizontal evacuation route for compliance with Part VI "Fire Protection".

**6.2.5.5.3** The factor  $s_i$  shall be taken as zero if, taking into account sinkage, heel and trim, any of the following occur in any intermediate stage or in the final stage of flooding:

**.1** immersion of any vertical escape hatch in the bulkhead deck intended for compliance with Part VI "Fire Protection";

**.2** any controls intended for the operation of watertight doors, equalization devices, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads from above the bulkhead deck become inaccessible or inoperable;

**.3** immersion of any part of piping or ventilation ducts carried through a watertight boundary that is located within any compartment included in damage cases contributing to the attained index  $A$ , if not fitted with watertight means of closure at each boundary.

**6.2.5.5.4** However, where compartments assumed flooded due to progressive flooding are taken into account in the damage stability calculations multiple values of  $s_{intermediate,i}$  may be calculated assuming equalization in additional flooding phases.

**6.2.5.5.5** Except as provided in paragraph 6.2.5.5.3.1, openings closed by means of watertight manhole covers and flush scuttles, small watertight hatch covers, remotely operated sliding watertight doors, side scuttles of the non-opening type as well as watertight access doors and hatch covers required to be kept closed at sea need not be considered.

**6.2.5.6** Where horizontal watertight boundaries are fitted above the waterline under consideration the  $s$ -value calculated for the lower compartment or group of compartments shall be obtained by multiplying the value as determined in paragraph 6.2.5.1.1 by the reduction factor  $v_m$  according to paragraph 6.2.5.6.1, which represents the probability that the spaces above the horizontal subdivision will not be flooded.

**6.2.5.6.1** The factor  $v_m$  shall be obtained from the formula

$$v_m = v(H_{j,n,m}, d) - v(H_{j,n,m-1}, d)$$

where  $H_{j,n,m}$  = the least height above the baseline, in m, within the longitudinal range of  $x1_{(j)} \dots x2_{(j+n-1)}$  of the  $m$ th horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

$H_{j,n,m-1}$  = the least height above the baseline, in metres, within the longitudinal range of  $x1_{(j)} \dots x2_{(j+n-1)}$  of the  $(m-1)$ th horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

$j$  signifies the aft terminal of the damaged compartments under consideration;

$m$  represents each horizontal boundary counted upwards from the waterline under consideration;

$d$  = the draught in question as defined in 6.1.2;

$x1$  and  $x2$  represent the terminals of the compartment or group of compartments considered in regulation 6.2.4.

The factors  $v(H_{j,n,m}, d)$  and  $v(H_{j,n,m-1}, d)$  shall be obtained from the formulas:

$v(H, d) = 0,8(H - d)/7,8$  if  $(H_m - d)$  is less than, or equal to, 7,8 m;

$v(H, d) = 0,8 + 0,2[(H - d) - 7,8]/4,7$  in all other cases

where  $v(H_{j,n,m}, d)$  shall be taken as 1, if  $H_m$  coincides with the uppermost watertight boundary of the ship within the range  $(x1_{(j)} \dots x2_{(j+n-1)})$ , and  $v(H_{j,n,0}, d)$  shall be taken as 0.

In no case shall  $v_m$  be taken as less than zero or more than 1.

**6.2.5.6.2** In general, each contribution  $dA$  to the index  $A$  in the case of horizontal subdivisions is obtained from the formula:

$$dA = p_i[v_1 s_{\min 1} + (v_2 - v_1)s_{\min 2} + \dots + (1 - v_{m-1})s_{\min m}]$$

where  $v_m$  = the  $v$ -value calculated in accordance with 6.2.5.6.1;

$s_{\min}$  = the least  $s$ -factor for all combinations of damages obtained when the assumed damage extends from the assumed damage height  $H_m$  downwards.

### 6.2.6 Permeability.

**6.2.6.1** For the purpose of the subdivision and damage stability calculations of the regulations, the permeability of each general compartment or part of a compartment shall be as follows:

Spaces	Permeability
Appropriated to stores	0,60
Occupied by accommodation	0,95
Occupied by machinery	0,85
Void spaces	0,95
Intended for liquids	0 or 0,95 <sup>1</sup>
<sup>1</sup> Whichever results in the more severe requirement.	

**6.2.6.2** For the purpose of the subdivision and damage stability calculations of the regulations, the permeability of each cargo compartment or part of a compartment shall be as follows:

Spaces	Permeability at draught $d_s$	Permeability at draught $d_p$	Permeability at draught $d_t$
Dry cargo spaces	0,70	0,80	0,95
Container spaces	0,70	0,80	0,95
Ro-ro spaces	0,90	0,90	0,95
Cargo liquids	0,70	0,80	0,95

**6.2.6.3** Other figures for permeability may be used if substantiated by calculations.

### 6.2.7 Special requirements concerning passenger ship stability.

**6.2.7.1** A passenger ship intended to carry 400 or more persons shall have watertight subdivision abaft the collision bulkhead so that  $s_i = 1$  for the three loading conditions on which is based the calculation of the subdivision index and for a damage involving all the compartments within  $0,08L_1$  measured from the forward perpendicular.

**6.2.7.2** A passenger ship intended to carry 36 or more persons shall be capable of withstanding damage along the side shell to an extent specified in 6.2.7.3.3. Compliance with this regulation shall be achieved by demonstrating that  $s_i$ , as defined in 6.2.5, is not less than 0,9 for the three loading conditions on which is based the calculation of the subdivision index.

**6.2.7.3** The damage extent to be assumed when demonstrating compliance with 6.2.7.2, shall be dependent on both  $N$  as defined in 6.2.2, and  $L_s$  as defined in 6.1.2, such that:

**.1** the vertical extent of damage shall extend from the ship's moulded baseline to a position up to 12,5 m above the position of the deepest subdivision draught

as defined in 6.1.2, unless a lesser vertical extent of damage were to give a lower value of  $s_i$ , in which case this reduced extent shall be used;

**.2** where 400 or more persons shall be carried, a damage length of  $0,03L_s$  but not less than 3 m shall be assumed at any position along the side shell, in conjunction with a penetration inboard of  $0,1B$  but not less than 0,75 m measured inboard from the ship side, at right angle to the centreline at the level of the deepest subdivision draught;

**.3** where less than 400 persons are carried, damage length shall be assumed at any position along the shell side between transverse watertight bulkheads provided that the distance between two adjacent transverse watertight bulkheads is not less than the assumed damage length. If the distance between adjacent transverse watertight bulkheads is less than the assumed damage length, only one of these bulkheads shall be considered effective for the purpose of demonstrating compliance with 6.2.7.2;

**.4** where 36 persons are carried, a damage length of  $0,015L_s$  but not less than 3 m shall be assumed, in conjunction with a penetration inboard of  $0,05B$  but not less than 0,75 m;

**.5** where more than 36, but fewer than 400 persons are carried the values of damage length and penetration inboard, used in the determination of the assumed extent of damage, shall be obtained by linear interpolation between the values of damage length and penetration which apply for ships carrying 36 persons and 400 persons as specified in 6.2.7.3.2 and 6.2.7.3.4.

### 6.2.8 Bottom damage.

**6.2.8.1** Any part of a passenger ship or a cargo ship that is not fitted with a double bottom shall be capable of withstanding bottom damages, as specified in 6.2.8.3, in that part of the ship.

**6.2.8.2** In the case of unusual bottom arrangements in a passenger ship or a cargo ship, it shall be demonstrated that the ship is capable of withstanding bottom damages as specified in 6.2.8.3.

**6.2.8.3** Compliance with 6.2.8.1 or 6.2.8.2 shall be achieved by demonstrating that  $s_b$ , when calculated in accordance with 6.2.5, is not less than 1 for all service conditions when subject to a bottom damage assumed at any position along the ship's bottom and with an extent specified in 6.2.8.3.2 below for the affected part of the ship:

**.1** flooding of such spaces shall not render emergency power and lighting, internal communication, signals or other emergency devices inoperable in other parts of the ship;

**.2** assumed extent of damage is specified in the Table 6.2.8.3.2;

**.3** if any damage of a lesser extent than the maximum damage specified in 6.2.8.3.2 would result

Table 6.2.8.3.2

	For 0,3 $L$ from the forward perpendicular of the ship	Any other part of the ship
Longitudinal extent	$1/3 L^{2/3}$ or 14,5 m, whichever is less	$1/3 L^{2/3}$ or 14,5 m, whichever is less
Transverse extent	$B/6$ or 10 m, whichever is less	$B/6$ or 5 m, whichever is less
Vertical extent measured from the keel line	$B/20$ or 2 m, whichever is less	$B/20$ or 2 m, whichever is less

in a more severe condition, such damage shall be considered.

**6.2.8.4** In case of large lower holds in passenger ships, the Register may require an increased double bottom height of not more than  $B/10$  or 3 m, whichever is less, measured from the keel line. Alternatively, bottom damages may be calculated for these areas, in accordance with 6.2.8.3, but assuming an increased vertical extent.

### 6.3 DAMAGE TRIM AND STABILITY

#### 6.3.1 General.

**6.3.1.1** Under all loading conditions to be encountered in service and which are in agreement with the purpose of the ship (icing disregarded), the trim and stability of an intact ship shall be sufficient for satisfying damage trim and stability requirements.

**6.3.1.2** Requirements for the ship trim and stability shall be considered satisfied if, in case of damage mentioned in 6.3.2 and 6.3.4, with the number of compartments flooded as mentioned in 6.3.4, and the permeability determined in accordance with 6.1.6, calculations made in conformity with 6.3.1.3 to 6.3.1.7 indicate that the requirements of 6.3.3 and 6.3.4 are satisfied.

**6.3.1.3** Calculations to confirm compliance with the requirements of 6.3.3 and 6.3.4 as regards damage trim and stability shall be performed for such a number of loading conditions to be encountered in service and being the most unfavourable from the point of view of trim and stability (within the range of drafts up to the deepest subdivision load line and cargo distribution stipulated by the design), such distribution and extent of damage, to be determined in accordance with 6.3.2 and 6.3.4, that, proceeding from those calculations, one could assure that in all other cases the damaged ship would be in a better condition as regards damage stability, the residual freeboard, distance from the damage waterline to openings through which the ship may be flooded and heeling angles. Besides, the following shall be considered: the actual configuration of damaged compartments, their permeabilities, type of covers, whether intermediate decks, platforms, double sides, longitudinal and transverse bulkheads are provided sufficiently watertight as to render the flow of water

through the ship completely or temporarily impossible.

**6.3.1.4** Where the distance between two consecutive main transverse bulkheads is less than the longitudinal extent of design damage, the relevant compartment shall, at the discretion of the designer, be added to any of the adjacent compartments when checking damage stability. For non-passenger ships relaxation from this provision may be granted where the arrangement of the bulkhead is in agreement with the condition  $A \geq R$ .

Forepeak and afterpeak are considered to be separate compartment regardless of the length.

**6.3.1.5** Where two adjacent compartments are separated from each other by a stepped bulkhead, the bulkhead shall be held for damaged when the flooding of any of the two compartments is considered.

Where the length of the step does not exceed one frame or 0,8 m, whichever is less, or where the step is formed by floors of the double bottom, this requirement may be dispensed with in case of non-passenger ships.

**6.3.1.6** If any damage of a lesser extent than stated in 6.3.2 and 6.3.4 might result in a more severe condition as regards damage trim and stability, such a damage shall be considered when making check calculations for damage trim and stability.

**6.3.1.7** Where there are pipes, ducts or tunnels in the area of assumed damage, these shall be so designed that no water enters compartments which are considered not flooded.

**6.3.1.8** For passenger ships, the equalization time will be established on agreement with the Register proceeding from the ship type.

**6.3.1.9** The arrangements for righting the ship after damage shall be approved by the Register and shall be self-acting as far as practicable.

Where controllable cross-flooding arrangements are available, side-valve control stations shall be located above the bulkhead deck.

#### 6.3.2 Extent of design damage.

**6.3.2.1** Except cases specially provided for, including those stated in 6.3.1.6, the following extent of side damage shall be assumed when making damage trim and stability calculations to confirm compliance with 6.3.3 and 6.3.4:

**1** longitudinal extent:  $1/3 L_1^{2/3}$  or 14,5 m (whichever is less);

**2** transverse extent measured inboard of ship side at right angles to the centre line at the level of the

deepest subdivision load line:  $1/5$  of the ship breadth  $B$  or 11,5 m (whichever is the less);

**.3** vertical extent: from the base line upwards without limit.

**6.3.2.2** The requirements of 6.3.3 shall be complied with in case of simultaneous flooding of all compartments located forward of collision bulkhead.

**6.3.3 Requirements for damage trim and stability characteristics.**

**6.3.3.1** In the final stage of flooding, the initial metacentric height of a ship in the upright condition determined by the constant displacement method, shall not be less than 0,05 m before appropriate measures to increase the metacentric height are taken.

For non-passenger ships, a positive metacentric height below 0,05 m may be permitted for the upright condition in the final stage of flooding on the Registrar approval.

**6.3.3.2** For unsymmetric flooding the angle of heel shall not exceed:

20° before equalization measures and cross-flooding fittings being used;

12° after equalization measures and cross-flooding fittings being used.

**6.3.3.3** The static stability curve of a damaged ship shall have a sufficient positive lever arm section. In the final stage of flooding, cross-flooding fittings disregarded, and after the equalization of the ship, a length of positive lever arm curve, flooding angle considered, shall be ensured not less than 20°. The angle of submersion of the openings which are not equipped with watertight or weathertight covers through which water may spread to undamaged compartments may be taken as flooding angle.

The maximum lever arm shall be at least 0,1 m within this length, i.e. within the heel angle equal to the static one plus 20°.

The positive lever arm section within the said extent shall not be less than 0,0175 m-rad.

In the intermediate stages of flooding, the maximum lever arm of the static stability curve shall be at least 0,05 m, and the length of its positive section shall not be less than 7°.

**6.3.3.4** Before, during and after equalization, the damage waterline shall be at least 0,3 m or  $0,1 + (L_1 - 10)/150$  m (whichever is less) below the openings in the bulkheads, decks and sides through which progressive flooding could take place. Such openings include the outlets of air and vent pipes and those which are closed by means of weathertight doors and covers.

These do not necessarily include:

- .1** non-opening side and deck scuttles;
- .2** manholes having covers with closely space bolts;
- .3** cargo tank hatchways in tankers;

**.4** remotely controlled sliding doors, watertight doors with indication systems (except ships specified in 6.1.1.1.2, 6.1.1.1.5, 6.1.1.1.6 and 6.1.1.1.8) and access hatches normally closed at sea;

**.5** openings in subdivision bulkheads intended for the passage of vehicles during cargo handling operations which are permanently closed with strong watertight covers while at sea. Such openings are only permitted for ro-ro ships.

The position and arrangement of closures of openings shall meet the requirements of Section 7, Part III "Equipment, Arrangement and Outfit".

The location of spaces for emergency sources of electrical power shall comply with the requirements of 9.2.1, Part XI "Electrical Equipment".

**6.3.3.5** For cargo ships, immersion of the bulk-head deck and, moreover, of the weather deck is permitted.

**6.3.3.6** The requirements of 6.3.3.1 to 6.3.3.5 apply to ships specified in 6.3.4 considering the additional requirements for damage trim and stability specific for each ship type.

For ships not mentioned in 3.4 the requirements of 6.3.3.1 to 6.3.3.5 apply, if, upon the shipowner's request, the ship's class notation provides for the subdivision distinguishing mark.

**6.3.4 Additional requirements for damage trim and stability.**

**6.3.4.1** Roll-on/roll-off ships similar to passenger ships.

**6.3.4.1.1** Where vehicles accompanied by personnel of more than 12 persons including passengers (if any) shall be carried by roll-on/roll-off ships, such ships, irrespective of their length, shall be considered equal to passenger ships in respect of all relevant requirements to subdivision bearing in mind the provision of 6.3.3.4.5, if applicable according to 7.12.1.1, Part III "Equipment, Arrangements and Outfit".

**6.3.4.2** Icebreakers and fishing vessels.

**6.3.4.2.1** In Table 6.3.4.2.1 the number of compartments is indicated after the flooding of which the requirements of 6.3.3 for damage stability shall be satisfied.

Table 6.3.4.2.1

Type of ship	Length $L_1$ , in m	Number of floodable compartments
Icebreakers	50 and upwards	2
Fishing vessels	100 and upwards	1

**6.3.4.2.2** In areas where double sides are provided, ice breakers having the length  $L_1$  of 50 to 75 m may satisfy the requirements of 6.3.3 where a single compartment is flooded. The subdivision distinguishing mark  $\square$  shall be introduced in the character of classification of such ships.

**6.3.4.3** Special purpose ships.

**6.3.4.3.1** Special purpose ships having special personnel on board in excess of 200 persons shall satisfy the requirements of the present Section per-

taining to passenger ships carrying an equal number of passengers.

**6.3.4.3.2** Special purpose ships having special personnel on board in excess of 50 persons but not over 200 persons shall satisfy the requirements of 6.3.3 when a single compartment is flooded. Moreover, such ships having the length  $L_1 \geq 100$  m shall meet the requirements of 6.3.3 in the case of forward damage with the extent:

- 0,08  $L_s + 3$  m at  $L_s \leq 200$  m,
- 0,03  $L_s + 13$  m at  $200 \text{ m} < L_s \leq 267$  m
- 21 m at  $L_s > 267$  m.

In case of unsymmetrical flooding due to the forward damage the heeling angle of  $12^\circ$  is permitted.

**6.3.4.3.3** Special purpose ships having special personnel on board of 50 persons or less shall satisfy the requirements of 6.3.3 when one of the compartments is flooded, except the engine room.

**6.3.4.3.4** The requirements for the subdivision of special purpose ships having special personnel on board of 50 persons or less with the length  $L_1 \leq 50$  m and special purpose ships, which gross tonnage is below 500 shall be specially considered by the Register in each case.

**6.3.4.3.5** In the case of unsymmetrical flooding of a single compartment in special purpose ships, the heel angle after equalization shall not exceed  $7^\circ$ .

**6.3.4.4** Tugs, dredgers, salvage ships and lightships.

**6.3.4.4.1** If a single compartment is flooded, the requirements of 6.3.3 for damage trim and stability shall be satisfied for the following types of ships:

- tugs having the length  $L_1 \geq 40$  m;
- dredgers having the length  $L_1 \geq 40$  m;
- rescue ships and lightships irrespective of length;
- hopper dredgers having the length  $L_1 \geq 60$  m.

**6.3.4.4.2** Bucket dredgers shall comply with the requirements of 6.3.3 if a single compartment is flooded in way of the bucket opening. The depth of the damage is assumed equal to 0,76 m.

**3.4.4.3** Where hopper dredgers and hopper barges are concerned, damage conditions may not be considered corresponding to ship condition after spoil discharge from one side.

**6.3.4.5** Oil tankers and chemical tankers.

**6.3.4.5.1** The damage trim and stability of oil tankers and chemical tankers shall satisfy the requirements of 6.3.3 both for the case of side and bottom damage.

**6.3.4.5.2** Extent of bottom damage:

**.1** the longitudinal extent shall be  $1/3 L_1^{2/3}$  or 14,5 m (whichever is less) within  $0,3 L_1$  from the forward perpendicular and  $1/3 L_1^{2/3}$  or 5 m (whichever is less) through the rest of the ship length;

**.2** the transverse extent shall be  $B/6$  or 10 m (whichever is less) within  $0,3 L_1$  from the forward

perpendicular and  $B/6$  or 5 m (whichever is less) through the rest of the ship length;

**.3** the vertical extent, measured from the moulded line of the shell at centre line, shall be  $B/15$  or 6 m (whichever is less).

**6.3.4.5.3** In addition to 6.3.5.5.2, bottom shell damage shall be considered for oil tankers with a deadweight of 20 000 t and upwards, having touched the ground, the extent of damage being as follows:

**.1** length of  $0,6 L_1$  from the forward perpendicular for ships having a deadweight of 75000 t and upwards, and  $0,4 L_1$  from the forward perpendicular for ships having a deadweight below 75 000 t;

**.2** breadth  $B/3$  anywhere in the bottom.

**6.3.4.5.4** Damage trim and stability requirements shall be satisfied for the following locations of side and bottom damage:

**.1** oil tankers:

where the length  $L_1 > 225$  m — anywhere along the ship length;

where the length  $L_1 > 150$  but not more than 225 m — anywhere in the ship length except for the engine room when this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

where the length  $L_1 \leq 150$  m — anywhere in the ship length between consecutive transverse bulkheads except for the engine room;

where the substances of the Category C are carried under the provisions of Appendix II to MARPOL-73/78, as for chemical tankers 3;

**.2** chemical tankers:

chemical tanker 1 — anywhere along the ship length;

chemical tanker 2 having the length  $L_1$  over 150 m — anywhere along the ship length;

chemical tanker 2 having the length  $L_1 = 150$  m and below — anywhere in the ship length except for the engine room where this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

chemical tanker 3 having the length  $L_1 > 225$  m — anywhere along the ship length;

chemical tanker 3 having the length  $L_1 = 125$  to 225 m — anywhere in the ship length except for the engine room where this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

chemical tanker 3 having the length  $L_1 < 125$  m — anywhere along the ship length except for the engine room where this is located aft. Nevertheless, damage trim and stability calculations for the conditions of the engine room flooded shall be submitted to the Register for consideration.

**6.3.4.5.5** Ships which do not comply with the requirements for damage trim and stability when their engine room is flooded, as stipulated by

6.3.4.5.4.1 and 6.3.4.5.4.2, are not assigned a subdivision distinguishing mark in their character of classification.

**6.3.4.5.6** In the final stage of unsymmetric flooding before equalization measures and cross-flooding fittings being used, the angle of heel shall not exceed  $25^\circ$  or  $30^\circ$  where the bulkhead deck is not immersed). After equalization measures, the heeling angle shall not exceed  $17^\circ$ .

**6.3.4.6 Gas carriers.**

For gas carriers, the requirements of 6.3.4.5 apply except for the following details:

**.1** damage trim and stability requirements shall be satisfied when side and bottom damage is sustained as stated below:

gas carriers 1G — anywhere along the ship length;

gas carriers 2G having the length  $L_1 > 150$  m — anywhere along the ship length;

gas carriers 2G having the length  $L_1 \leq 150$  m or below — anywhere along the ship length except the engine room where this is located aft. In this case the engine room shall be considered a separate floodable compartment;

gas carriers 2PG — anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length  $L_1 \geq 125$  m — anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length  $L_1 < 125$  m — anywhere in the ship length between subdivision bulkheads except the engine room where this is located aft. However, damage trim and stability calculations for the case of the engine room being flooded shall be submitted for the consideration of the Register. No subdivision distinguishing mark shall be introduced in the character of classification if damage trim and stability requirements are not met;

**.2** the vertical extent of a bottom damage shall be assumed equal to  $B/15$  or 2 m, whichever is less.

**6.3.4.7 Drilling ships.**

With any single compartment flooded, drilling ships shall comply with the requirements of 6.3.3, unless more stringent requirements are put forward by the shipowner.

Drilling ships shall have sufficient reserve of damage stability to withstand the wind heeling moment produced by wind with a speed of 25,8 m/s (50 knots) acting from any direction. Under these conditions the final waterline after flooding shall be located below the lower edge of any opening through which the undamaged compartments may be flooded by the sea.

**6.3.4.8** Ships intended for the carriage of radioactive agents.

Damage trim and stability of ships intended for the carriage of packaged irradiated nuclear fuel,

plutonium and high-level radioactive wastes with the total radioactivity below 4000 TBq shall in each case be specially considered by the Register.

The requirements for the damage trim and stability of ships carrying packaged irradiated nuclear fuel or high-level radioactive wastes with the total radioactivity below  $2 \times 10^6$  TBq or plutonium with the total radioactivity below  $2 \times 10^5$  TBq shall be met for the case of specified damage anywhere along the ship length between the consecutive transverse bulkheads.

The requirements for damage trim and stability of the ships carrying packaged irradiated nuclear fuel or high-level radioactive wastes with the total radioactivity above  $2 \times 10^6$  TBq or plutonium with the total radioactivity  $2 \times 10^5$  TBq and above shall be met in the case of the calculated damage anywhere along the ship length.

On the Register approval the possible probability estimation of the ship subdivision may be considered being an alternative to the requirements indicated.

**6.3.4.9 Supply vessels.**

**6.3.4.9.1** The requirements of the present Section apply to all supply vessels having the length  $L_1 \leq 100$  m.

The subdivision and damage stability of supply vessels having a length over 100 m shall in each case be specially considered by the Register.

**6.3.4.9.2 The extent of damage:**

**.1** longitudinal extent shall be 3 m plus 3 per cent of the ship's length for ships with the length ( $L_1$ ) greater than 43 m. For those with length ( $L_1$ ) not greater than 43 m, 10 per cent of the ship's length;

**.2** transverse extent of damage shall be assumed as 0,76 m, measured inboard from the side of the ship perpendicularly to the centerline at the level of the summer load waterline;

**.3** vertical extent: from the underside of the cargo deck, or the continuation thereof, for the full depth of the ship.

**6.3.4.9.3** A transverse watertight bulkhead extending from the ship's side to a distance inboard of 760 mm or more measured perpendicularly to the centerline at the level of the summer load line joining longitudinal watertight bulkheads may be considered as a transverse watertight bulkhead for the purpose of the damage trim and stability calculations.

**6.3.4.9.4** Where a transverse watertight bulkhead is located within the transverse extent of assumed damage and is stepped in way of a double bottom or side tank by more than 3,0 m, the double bottom or side tanks adjacent to the stepped portion of the transverse watertight bulkhead shall be considered as damaged.

**6.3.4.9.5** In the final stage of unsymmetrical flooding the angle of heel shall not exceed  $15^\circ$  before equalization measures are taken and cross-flooding fittings are used. This angle may be increased up to  $17^\circ$  if no deck immersion occurs.

**6.3.4.9.6** Number of floodable compartments.

The damage stability requirements of 6.3.3 shall be met in the case of single compartment flooding proceeding from the extent of damage stated under 6.3.2.1.1, 6.3.2.1.3 and 6.3.4.9.2.

**6.3.4.9.7** Ships complying with the requirements of 6.3.4.9.2 only will receive no subdivision distinguishing mark in the character of classification.

**6.3.4.9.8** If preferred by the shipowner, a supply vessel may receive a subdivision distinguishing mark with the number of floodable compartments indicated in the class notation. In this case, the transverse extent of damage shall be assumed in accordance with 6.3.2.1.2. The number of compartments at the flooding of which the damage trim and stability requirements shall be met shall be determined by the shipowner.

**6.3.4.10** Ships with the ice marks **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9** in the class notation.

**6.3.4.10.1** The requirements of this paragraph apply to all ice strengthened ships of categories **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9**. The damage trim and stability requirements shall be met as far as the draught  $d_{ice}$  is concerned except for the requirement of 6.3.4.10.2.

**6.3.4.10.2** Where the extent of damage is in accordance with 6.3.2, within range of the summer load line draught assigned to the ship the damage trim and stability requirements of 6.3.3 shall be met if a single compartment is flooded in ships having the following distinguishing marks in the character of classification:

ice category marks **Arc7**, **Arc8** and **Arc9** irrespective of ship length;

ice category marks **Arc5** and **Arc6** with the ship length  $L_1 \geq 120$  m.

The subdivision distinguishing mark **I** shall be introduced in the character of classification of such ships.

**6.3.4.10.3** Ships with the ice strengthening marks for categories **Arc4**, **Arc5**, **Arc6**, **Arc7**, **Arc8** and **Arc9** (irrespective of their length) shall comply with the requirements of 6.3.3 with relevant ice damage stated in 6.3.4.10.4 and the number of floodable compartments given in 6.3.4.10.5.

Where compliance with the requirements of other chapters of this Section also testifies to 6.3.4.10 being complied with, no additional damage trim and stability calculations need be made for damage conditions mentioned under 6.3.4.10.4 and 6.3.4.10.5.

**6.3.4.10.4** For the purpose of damage trim and stability calculations, the following extent of ice damage shall be assumed:

**.1** longitudinal extent  $0,045L_{ice}$ , if the centre of damage lies within  $0,4L_{ice}$  from the forward perpendicular, and  $0,015L_{ice}$  in other areas;

**.2** damage depth 0,76 m as measured along the normal to the shell at any point in the area of assumed damage;

**.3** vertical extent  $0,2d_{ice}$ ;

**.4** location of damage from the base line to the level of  $1,2d_{ice}$  within  $L_{ice}$ .

**6.3.4.10.5** When performing damage trim and stability calculations, the number of floodable compartments shall be determined proceeding from the location of the assumed ice damage listed in Table 6.3.4.10.5.

Table 6.3.4.10.5

Nos	Type of ship and/or ice strengthening category	Location of ice damage mentioned under 6.3.4.10.4
1	Ice-strengthened ships of <b>Arc7</b> , <b>Arc8</b> and <b>Arc9</b> categories except fishing vessels	Anywhere in the ice damage area
2	Passenger ships allowed to carry over 400 passengers including the crew	Ditto
3	Special purpose ships allowed to carry over 400 passengers including the crew	—"
4	Ships intended for the carriage of radioactive agents	—"
5	Chemical tankers	—"
6	Oil tankers	—"
7	Gas carriers	—"
8	Drilling ships	—"
9	Ice-strengthened salvage ships with ice categories <b>Arc5</b> , <b>Arc6</b> , <b>Arc7</b> , <b>Arc8</b> and <b>Arc9</b>	—"
10	Ice-strengthened fishing vessels and refrigerated fish carriers with ice categories <b>Arc7</b> , <b>Arc8</b> and <b>Arc9</b>	Between watertight bulkheads, platforms, decks and plating <sup>1</sup>
11	Ice-strengthened ships with ice categories <b>Arc5</b> and <b>Arc6</b> not mentioned in 2 to 9	Between watertight bulkheads, platforms, decks and plating <sup>1</sup> . With the hull length $L_1 < 100$ m it is permitted not to comply with the requirements for damage trim and stability where engine room located aft is flooded in case of ice damage The same refers to the flooding of engine rooms of tugs less than 40 m in length irrespective of the engine room location
12	Ice-strengthened ships with ice category <b>Arc4</b> not mentioned in 2 to 9	Between watertight bulkheads, platforms, decks and plating <sup>1</sup> . With the hull length $L_1 < 125$ m it is permitted not to comply with the requirements for damage trim and stability where engine room located aft is flooded in case of ice damage. The same refers to the flooding of engine rooms of tugs less than 40 m in length irrespective of the engine room location

<sup>1</sup> Where the distance between two consecutive watertight structures is less than the extent of damage, relative adjacent compartments shall be considered a single floodable compartment when checking damage trim and stability.



**6.3.4.10.6** In all cases, irrespective of the requirements stated in items 11 and 12 of Table 6.3.4.10.5, the calculations of damage trim and stability for the case of the engine room being flooded shall be submitted for the consideration of the Register.

**6.3.4.10.7** For oil tankers, chemical tankers 2 and 3, gas carriers 2G and 3G below or equal to 150 m in length, the necessity of considering a simultaneous flooding of the engine room and an adjacent compartment shall be specially considered by the Register.

**6.3.4.10.8** Ships conforming with the requirements of 6.3.4.10.3 to 6.3.4.10.7 only will receive no subdivision distinguishing mark in the character of classification.

**6.3.4.11** Bulk carriers, ore carriers and combination carriers.

**6.3.4.11.1** Bulk carriers having the length  $L_1$  of 150 m and upwards, which carry solid bulk cargoes with density of 1000 kg/m<sup>3</sup> and above, shall meet the requirements of 6.4.4 at flooding of any cargo hold bounded by the side shell only or being double side skin construction with the width less than  $B/5$  or 11,5 m (whichever is the less) in all cases of draught up to the summer load line.

**6.3.4.11.2** When calculating damage stability the following permeabilities shall be taken:

0,90 for loaded holds;

0,95 for empty holds.

Ships assigned with the reduced freeboard in accordance with 6.4 are regarded of satisfying the requirements of 6.3.4.11.1.

Information on compliance with these requirements shall be included in the Information on Stability and Strength for the Ship Loaded with Solid Bulk Cargoes other than Grain as required by 1.4.9.7, Part II "Hull".

**6.3.4.11.3** Ships are fitted with water level detectors:

**.1** in each cargo hold, giving audible and visual alarms, one when the water level above the inner bottom in the hold reaches a height of 0,5 m high, and another at a height not less than 15 per cent of the cargo hold depth but not more than 2,0 m; it is allowed to use one detector instead of two provided its design allows to give alarm at both levels of hold flooding. The detectors are fitted in the aft end of the cargo hold as close to the centerline as practicable. If detectors cannot be placed within a distance equal to one corrugation space or one bulkhead vertical stiffener space from the centerline, they shall be located at both the port and starboard sides of the cargo hold;

**.2** in any ballast tank forward of the collision bulk-head required in 1.1.6, Part II "Hull" giving an audible and visual alarm when the liquid in the tank reaches a level not exceeding 10 per cent of tank capacity;

**.3** in any dry or void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold, giving an audible and visual alarm at a water level of 0,1 m above the deck. Such alarms need not be provided in enclosed spaces, the volume of which does not exceed 0,1 per cent of the ship's maximum displacement volume.

Detectors in cargo holds shall be protected by a robust construction from damage by cargoes or mechanical handling equipment associated with bulk carrier operations.

**6.3.4.11.4** Operating Manual on Water Level Detection System shall be provided on board the ship and shall contain the following information and operational instructions:

**.1** a description of the equipment for detection and alarm arrangements together with a listing of procedures for checking that, as far as practicable, each item of equipment is working properly during any stage of ship operation;

**.2** Type Approval Certificate for the detection system;

**.3** line diagrams of the detection and alarm system showing the positions of equipment;

**.4** installation instructions for orientation, setting, securing, protecting and testing;

**.5** list of cargoes, for which the detector protected by guard is suitable for operating in a 50 per cent seawater slurry mixture;

**.6** procedures to be followed in the event of equipment not functioning correctly;

**.7** maintenance requirements for equipment and system.

Manual shall be compiled in the language known to the ship officers, as well as in English.

**6.3.4.11.5** The Water Level Detection System shall meet the requirements of 7.10, Part XI "Electrical Equipment".

**6.3.4.12** Berth-connected ships.

**6.3.4.12.1** Damage stability requirements stated in 6.3.3 shall be complied with in the case of any single flooded compartment lying along the ship periphery and having the length not less than the length of damage given in 6.3.4.12.2.2.

**6.3.4.12.2** For the purpose of damage trim and stability calculations, the following extent of damage shall be assumed:

**.1** transverse extent measured from the inner skin at right angles to the centreline on the level of the deepest waterline permitted by the load line — 0,76 m;

**.2** longitudinal extent —  $1/6L_1^{2/3}$  or 7,2 m (whichever is less);

**.3** vertical extent in accordance with 6.3.2.1.3.

**6.3.4.12.3** No subdivision distinguishing mark will be introduced in the character of classification of berth-connected ships which comply solely with the

requirements of 6.3.4.12 and for which regard to 6.3.4.12.2 shall be taken.

**6.3.4.12.4** If the depth of waters on which the berth-connected ship floats is such that the lowermost deck accessible to passengers cannot be immersed not to mention capsizing of the ship, the requirements of this Section may be waived.

**6.3.4.13** Cargo ships of less than 100 m in length other than bulk carriers.

**6.3.4.13.1** Single hold cargo ships other than bulk carriers shall comply with the present requirements not later than the date of the first intermediate or renewal survey of the ship, whichever comes first, but, anyway, not later than 31 December 2009.

**6.3.4.13.2** Ships having a length ( $L_1$ ) of less than 80 m, or less than 100 m if constructed before 1998, and a single cargo hold below the freeboard deck or cargo holds below the freeboard deck which are not separated by at least one bulkhead made watertight up to that deck, shall be fitted in such space or spaces with water level detectors, which give an audible and visual alarm at the navigation bridge when the water level above the inner bottom in the cargo hold reaches a height of not less than 0,3 m, and another when such level reaches not more than 15 per cent of the mean depth of the cargo hold.

**6.3.4.13.3** Water level detectors shall be fitted at the aft end of the hold, or above its lowest part where the inner bottom is not parallel to the designed waterline. If detectors cannot be placed within a distance equal to one corrugation space or one bulkhead vertical stiffener space from the centerline, they shall be located at both sides of the cargo hold. Where webs or partial watertight bulkheads are fitted above the inner bottom, the Register may require the fitting of additional detectors. It is allowed to use one detector vertically instead of two provided its design allows giving alarm at both levels of hold flooding.

**6.3.4.13.4** The water level detectors need not be fitted in ships complying with the requirements of 6.3.4.11.3, or in ships having watertight side compartments each side of the cargo hold length extending vertically at least from inner bottom to freeboard deck.

**6.3.4.13.5** The water level detection system shall comply with the requirements of 7.10, Part XI "Electrical Equipment".

**6.3.4.13.6** Operating Manual on Water Level Detection System shall be provided on board the ship, which shall be developed in compliance with the requirements of 6.3.4.11.4.

#### **6.4 SPECIAL REQUIREMENTS FOR TYPE "B" SHIPS WITH REDUCED FREEBOARD AND FOR TYPE "A" SHIPS**

##### **6.4.1 General.**

**6.4.1.1** This Chapter applies to type "A" and type "B" ships specified in 6.1.1.3.

The requirements of the Section shall be fulfilled irrespective of meeting the requirements of other sections by these ships.

**6.4.1.2** The requirements are considered fulfilled where it is demonstrated by calculations that a ship being in assumed loading condition specified in 6.4.2 after the flooding of the number of compartments required by 6.4.1.3 to 6.4.1.5 caused by damages stipulated in 6.4.3 remains afloat and in a condition of equilibrium it meets the requirements of 6.4.4.

**6.4.1.3** For type "A" ships above 150 m in length ( $L_1$ ), when they are assigned a freeboard less than that of the appropriate ships of the type "B" the requirements of this Chapter shall be complied with in the case of any single compartment being flooded.

**6.4.1.4** For type "B" ships above 100 m in length ( $L_1$ ) for which the permitted reduction of tabular freeboard does not exceed 60 per cent of the difference between its values as per Tables 4.1.2.3 and 4.1.3.2 of Load Line Rules for Sea-Going Ships, the following cases of flooding shall be considered:

**.1** any single compartment with the exception of the engine room;

**.2** any single compartment including the engine room where the ship length exceeds 150 m.

**6.4.1.5** Type "B" ships, having the length  $L_1$  over 100 m, for which the permitted reduction in the tabular freeboard exceeds 60 per cent of the difference between its values as per Tables 4.1.2.3 and 4.1.3.2 of Load Line Rules for Sea-Going Ships shall be considered for the following cases of flooding:

**.1** any two adjacent compartments, except for the engine room;

**.2** any two adjacent compartments and the engine room considered separately in ships over 150 m in length.

**6.4.1.6** The following permeabilities shall be assumed in calculations required by 6.4.1.2:

0,95 for any floodable compartments and spaces, except for the engine room;

0,85 for floodable engine room.

The permeability value of 0,95 is applicable to cargo spaces and tanks as well which shall be considered full when determining the height of the ship centre of gravity in conformity with 6.4.2.3.

**6.4.1.7** In addition to the requirements of 6.4.1.4 and 6.4.1.5, ships intended for carriage of deck cargoes shall comply with the requirements of 6.2. Height of the centre of gravity used for demonstration of compliance with the requirements of 6.4.4 during the deterministic analysis of damage stability shall be equal to the height of the centre of gravity used for calculation of damage stability at probabilistic assessment at assumption of the highest loadline. The diagram of ultimate elevation of the ship centre of gravity (limiting moments or minimum metacentric heights) with deck cargo drawn taking into consideration the fulfilment of the requirements of 6.2 shall be included into the Information on Stability and Information on Damage Trim and Stability.

**6.4.2 Trim and loading condition of the ship prior to damage.**

**6.4.2.1** All cases of flooding shall be analyzed under one assumed initial loading condition of the ship, as specified in 6.4.2.2 to 6.4.2.4.

**6.4.2.2** The ship is considered to be loaded by homogeneous cargo to its summer load line draught in sea water on an even keel.

**6.4.2.3** The height of the centre of gravity of the ship shall be calculated for the following assumed loading condition:

**.1** all cargo spaces, except for those under 6.4.2.3.2, including the anticipated in service, partly filled spaces are considered to be fully loaded with dry cargo and to be 98 per cent loaded with liquid cargo;

**.2** where the ship when loaded to the summer load line is to operate with some spaces not loaded or filled with dry or liquid cargo, such spaces shall be assumed empty provided that the height of the centre of gravity of the ship, calculated with regard to empty compartments is not less than that calculated on the assumption that all the spaces are occupied with cargoes;

**.3** the amount of every type of the ship's stores and consumable liquids is taken to be equal to 50 per cent of the full capacity. Tanks, except for those under 6.4.2.4.2, are assumed to be empty or completely filled, the distribution of the stores in the tanks resulting in the highest position of the centre of gravity of the ship. The centres of gravity of the contents of the tanks mentioned in 6.4.2.4.2 are taken to be in the centres of gravity of their volumes;

**.4** loading of the ship as regards consumable liquids and ballast water shall be estimated on the basis of the following values of their density, in  $t/m^3$ :

Sea water . . . . .	1,025
Fresh water . . . . .	1,000
Fuel oil. . . . .	0,950
Diesel oil. . . . .	0,900
Lubricating oil . . . . .	0,900

**6.4.2.4** In estimating the height of the centre of gravity of the ship account shall be taken of the effect of free surfaces of liquids:

**.1** for liquid cargo, proceeding from loading specified in 6.4.2.3.1;

**.2** for consumable liquids, proceeding from the assumption that for every type of liquid at least one centreline tank or one transverse pair of tanks have free surfaces. To be taken into consideration are the tanks or the combination of tanks where the effect of free surfaces is the greatest.

It is recommended that the correction for free surfaces effect be taken into account in accordance with 1.4.7, Part IV "Stability."

**6.4.3 Extent of damage.**

**4.3.1** The vertical extent of damage shall be assumed from the base line upwards without limit.

**4.3.2** The transverse extent of damage measured inboard from the ship's side, at a right angle to the centreline at the level of the summer load waterline shall be assumed equal to one-fifth of the breadth of the ship, or 11,5 m, whichever is the less.

**6.4.3.3** If any damage of lesser extent than indicated in 6.4.3.1 and 6.4.3.2 would result in a more severe condition, such damage shall be assumed in the calculations.

**6.4.3.4** Transverse bulkheads are considered effective if the distance between them or between the transverse planes passing through the nearest portions of the stepped bulkheads is at least  $1/3L_1^{2/3}$ , or 14,5 m, whichever is the less. In case of lesser distance, one or more of these bulkheads shall be assumed as non-existent.

**6.4.3.5** When one compartment is flooded, with due regard for provisions of 6.4.3.4, main transverse bulkheads are considered not to be damaged if they have no steps more than 3 m in length.

In case these bulkheads are provided with steps more than 3 m in length, the two compartments adjacent to such bulkheads shall be considered as flooded.

The extent of damage may be limited by transverse bulkheads of a side tank in case its longitudinal bulkheads are beyond the transverse extent of damage.

Where a side tank or a double bottom tank is divided by a transverse bulkhead located more than 3 m from a main transverse bulkhead, both tanks divided by such bulkhead shall be considered as flooded.

The following compartments shall be considered as flooded:

A + D, B + E, C + E + F (Fig. 6.4.3.5-1);

A + D + E, B + E (Fig. 6.4.3.5-2);

A + D, B + D + E (Fig. 6.4.3.5-3);

A + B + D, B + D + E (Fig. 6.4.3.5-4).

Where the forecabin is arranged above the fore cargo hold, subject to the condition that the fore-

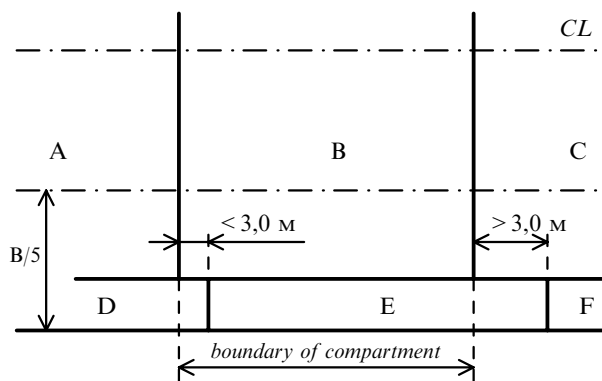


Fig. 6.4.3.5-1

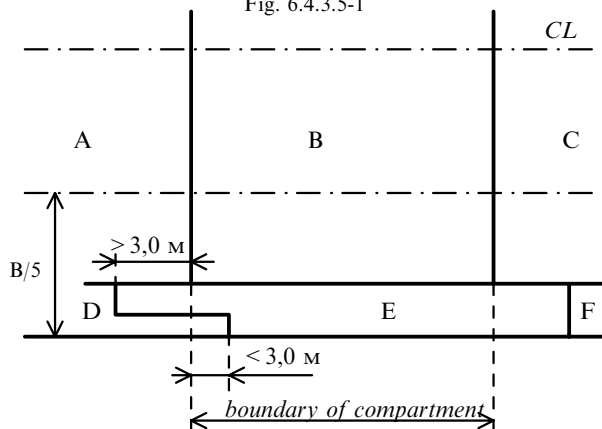


Fig. 6.4.3.5-2

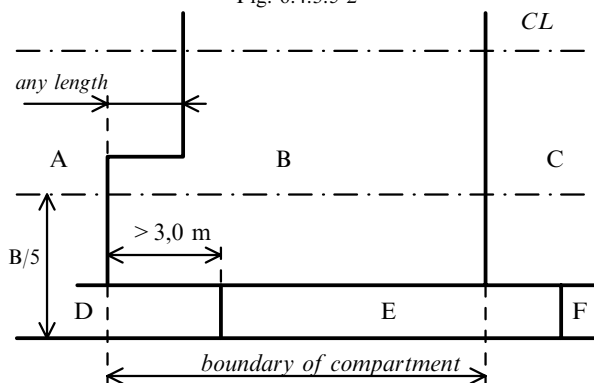


Fig. 6.4.3.5-3

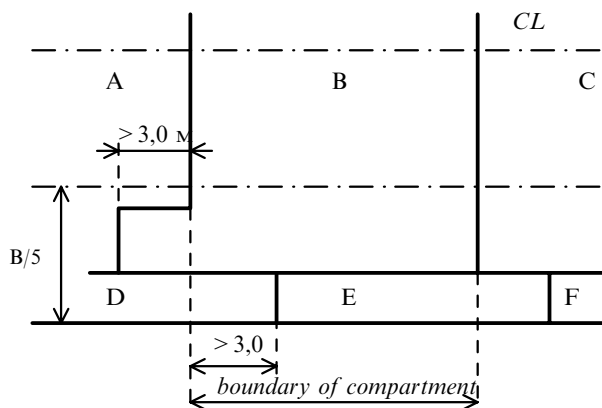


Fig. 6.4.3.5-4

castle bulkhead is located not more than 3 m aft from the forward bulkhead of the hold and watertightness of the stepped deck structure is ensured the bulkhead shall be considered to be continuous and not to be damaged.

**6.4.3.6** Where a side tank has openings into a hold, it shall be considered as communicating with the hold even where such openings are fitted with closing appliances. This provision is applicable to ships carrying liquid cargoes, except in case of sluice valves fitted in bulkheads between tanks and where the valves are controlled from above the bulkhead deck.

**6.4.3.7** Where pipes, ducts or tunnels are located within the assumed extent of damage, satisfactory arrangements shall be provided to preclude the possibility of progressive flooding through them to other spaces beyond the limits assumed for the calculations of the damage stability of the ship.

**6.4.3.8** In case of two-compartment flooding the requirements of 6.4.3.1 to 6.4.3.4, 6.4.3.6 and 6.4.3.7 shall be met.

#### 6.4.4 Trim and stability of a ship in damaged condition.

**6.4.4.1** The metacentric height of the ship in the damaged condition prior to taking measures for the increase thereof shall be positive.

**6.4.4.2** The angle of heel due to unsymmetrical flooding prior to the beginning of the equalization of the ship shall not exceed  $15^\circ$ . If no part of the deck immerses, the increase of heel up to  $17^\circ$  may be allowed.

**6.4.4.3** The final damage waterline having regard to heel and trim prior to the beginning of the equalization of the ship shall not be above the lower edge of openings indicated in 6.3.3.4, through which progressive flooding may take place.

**6.4.4.4** When any part of the bulkhead deck beyond the limits of the flooded compartments immerses, or the margin of damage stability is doubtful, damage stability at large angles of heel shall be investigated. It shall be shown that the value of a maximum arm of the righting lever curve of a damaged ship is not less than 0,1 m within the rated extent ( $20^\circ$ ) in association with a range of the curve with positive arms of at least  $20^\circ$ , the area of the positive portion of the curve being not less than  $0,0175 \text{ m}\cdot\text{rad}$ .

### 6.5 REQUIREMENTS FOR SHIPS IN SERVICE

#### 6.5.1 Bulk carriers, ore carriers and combination carriers.

**6.5.1.1** Bulk carriers with single side shell the design of which complies with the requirements of

3.3.1.6.1, Part II "Hull", having a length  $L_1 \geq 150$  m, carrying solid bulk cargoes with a density of  $1000 \text{ kg/m}^3$  and above, constructed on July 1999 or after that date, shall comply with the requirements of 6.4.4 at flooding of any cargo hold under all the loading cases up to the summer load line. The bulk carrier, which forward cargo hold is confined by the outer plating or double side skin construction with a width less than 760 mm with an length  $L_1$  of 150 m and more built before 1 July 1999 carrying hard bulk cargoes with density of  $1780 \text{ kg/m}^3$  and more, shall comply with the requirements of 6.4.4 while flooding the fore cargo hold in all cases of loading up to the summer load line not later than the date of survey assigned in relation to the ship age:

**.1** for ships which age at 1 July 1998 is 20 years and more, the date of the first intermediate (the second or the third annual survey) or the first special survey, which shall be carried out after 1 July 1998 is accepted, whichever is earlier;

**.2** for ships which age at 1 July 1998 is 15 years and more but less than 20 years, the date of the first special survey which shall be carried out after 1 July 1998 but not later than 1 July 2002 is accepted;

**.3** for ships which age at 1 July 1998 is less than 15 years, the date of the third special survey or the date when the ship's age becomes equal to 15 years is accepted, whichever is later.

**6.5.1.2** The following values of permeabilities shall be taken for the damage stability calculations:

0,90 for loaded holds;

0,95 for empty holds.

**6.5.1.3** The ships which don't comply with the requirements of 6.5.1.1 may be acquitted from this requirement provided the following conditions are met:

**.1** the programme of the fore hold annual survey is replaced by the programme approved at the full scale intermediate survey in accordance with the Section 2, Part III "Additional Surveys of Ships in Relation to Their Purpose and Hull Material" of Rules for the Classifications Surveys of Ships in Service;

**.2** the visual and audible alarm shall be fitted in the wheelhouse for signalling in case of:

flooding over two metres above the double bottom in the stern part of each cargo hold;

filling of bilge well of each hold up to the upper level.

Such signalling system shall meet the requirements of Part XI "Electrical Equipment";

**.3** the ship shall be supplied with detailed information on the effect of the phased flooding of cargo hold and detailed instructions in accordance with Section 8 of International Safety Management Code (ISM Code).

Information shall include the data and documentation stated in 6.1.4.6.1 and the results of damage trim and stability calculations at stage-by-stage compartment flooding under all conditions of loading to the summer load line on an even keel. When the ship meets the requirements of 6.4.4 at a lesser draught, the document shall contain a diagram of maximum heights of the centre of gravity of the ship (limiting moments or minimum metacentric heights) plotted with due regard to the trim and ship load. The strength of the bulkhead shall be taken into consideration. The information shall contain a summary table of calculation results with indication of critical factors and the data given in 6.1.4.6.1.5.

**6.5.1.4** The ships which are assigned with the reduced freeboard in accordance with 6.4 are considered compliant with the requirements 6.5.1.1.

**6.5.1.5** Information on compliance with the requirements of 6.5.1.1 to 6.5.1.3 shall be included in the Booklet required by 1.4.9.7, Part II "Hull".

**6.5.1.6** Ships built before 1 July 2004 shall meet the requirements of 6.3.4.11.3 to 6.3.4.11.5 not later than the date of the first periodical survey of a ship conducted after 1 July 2004.

**6.5.1.6.1** If sensors cannot be placed in the aft end of the cargo hold within a distance less than or equal to  $B/6$  from the centerline, they shall be located at both the port and starboard sides of the cargo hold.

**6.5.1.6.2** The upper sensor only may be fitted in cargo holds of the ships being subject to the requirement of 6.5.1.3; the ships not complying with the requirement of 6.5.1.3.2 on 1 January 2004 shall be fitted with water level detectors in cargo holds in accordance with 6.3.4.11.3.1 (considering 6.5.1.6.1).

## APPENDIX

**FORMULAE FOR DETERMINING THE VALUES OF  $p$   
FOR DIFFERENT COMPARTMENT ARRANGEMENTS<sup>1</sup> (refer to 2.2.6)**

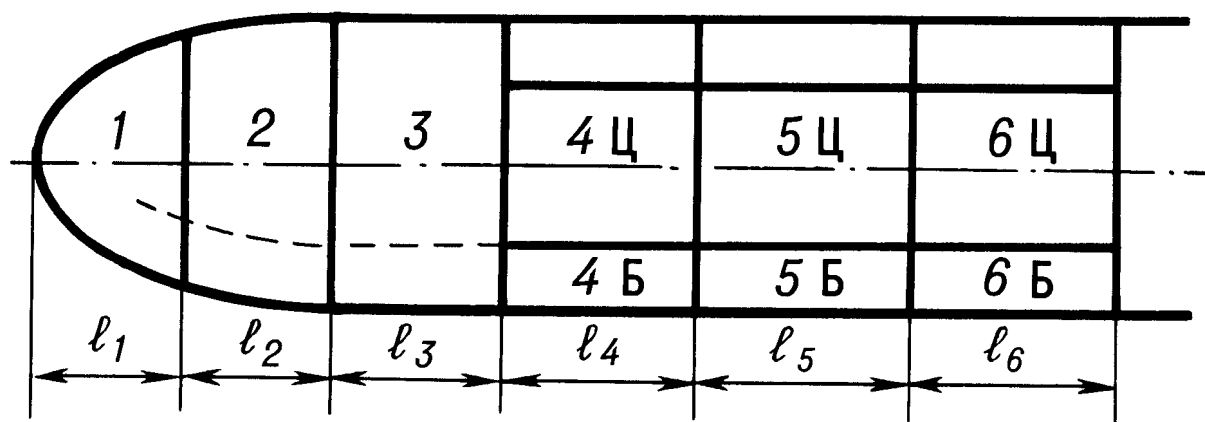


Fig. 1

Arrangement of compartments	Formula for determining the value of $p$	Distances for determining the value of $a$	
		$x_1$	$x_2$
4Б	$p_4 r_4$	$l_1 - 3$	$l_1 - 4$
4Б + 4Ц	$p_4(1 - r_4)$	$l_1 - 3$	$l_1 - 4$
3 + 4Б	$p_{34} r_{34}^* - p_3 r_3^* - p_4 r_4$	$l_1 - 2$	$l_1 - 4$
3 + 4Б + 4Ц	$p_{34}(1 - r_{34}^*) - p_3(1 - r_3^*) - p_4(1 - r_4)$	$l_1 - 2$	$l_1 - 4$
4Б + 5Б	$p_{45} r_{45} - p_4 r_4 - p_5 r_5$	$l_1 - 3$	$l_1 - 5$
4Б + 4Ц + 5Б + 5Ц	$p_{45}(1 - r_{45}) - p_4(1 - r_4) - p_5(1 - r_5)$	$l_1 - 3$	$l_1 - 5$
2 + 3 + 4Б	$p_{234} r_{234}^* - p_{23} r_{23}^* - p_{34} r_{34}^* + p_3 r_3^*$	$l_1$	$l_1 - 4$
2 + 3 + 4Б + 4Ц	$p_{234}(1 - r_{234}^*) - p_{23}(1 - r_{23}^*) - p_{34}(1 - r_{34}^*) + p_3(1 - r_3^*)$	$l_1$	$l_1 - 4$
3 + 4Б + 5Б	$p_{345} r_{345}^* - p_{34} r_{34}^* - p_{45} r_{45} + p_4 r_4$	$l_1 - 2$	$l_1 - 5$
3 + 4Б + 4Ц + 5Б + 5Ц	$p_{345}(1 - r_{345}^*) - p_{34}(1 - r_{34}^*) - p_{45}(1 - r_{45}) + p_4(1 - r_4)$	$l_1 - 2$	$l_1 - 5$
4Б + 5Б + 6Б	$p_{456} r_{456} - p_{45} r_{45} - p_{56} r_{56} + p_5 r_5$	$l_1 - 3$	$l_1 - 6$
4Б + 4Ц + 5Б + 5Ц + 6Б + 6Ц	$p_{456}(1 - r_{456}) - p_{45}(1 - r_{45}) - p_{56}(1 - r_{56}) + p_5(1 - r_5)$	$l_1 - 3$	$l_1 - 6$

<sup>1</sup>Besides Section 6.

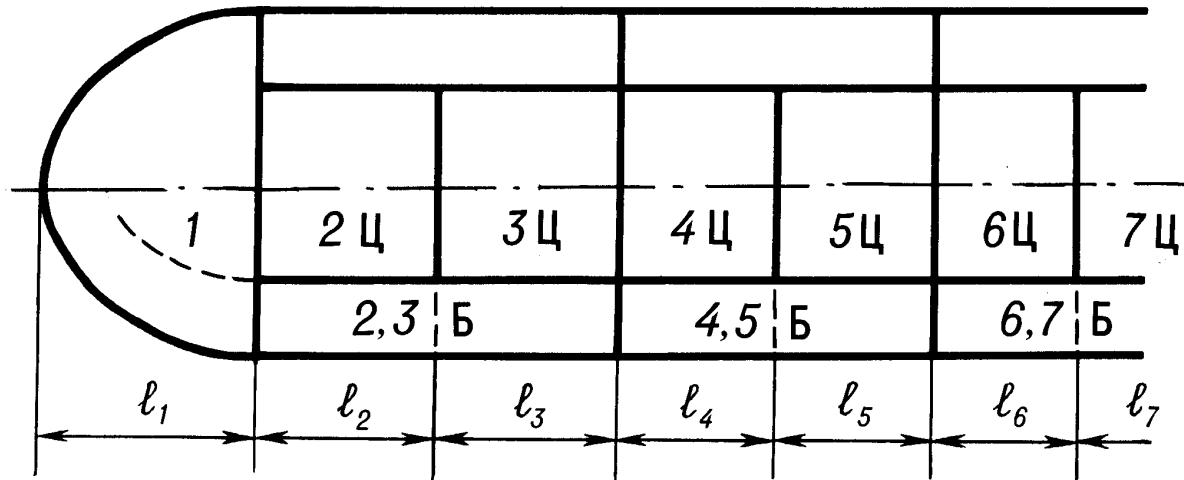


Fig. 2

1	$p_1$	0	$l_1$
2,3Б	$p_{23}r_{23}$	$l_1$	$l_1 - 3$
4,5Б	$p_{45}r_{45}$	$l_1 - 3$	$l_1 - 5$
1 + 2,3Б	$p_{123}r_{123}^* - p_1r_1^* - p_{23}r_{23}$	0	$l_1 - 3$
2,3Б + 4,5Б	$p_2 - sr_2 - s - p_{23}r_{23} - p_{45}r_{45}$	$l_1$	$l_1 - 5$
1 + 2,3Б + 4,5Б	$p_1 - sr_1 - s - p_{123}r_{123}^* - p_2 - sr_2 - s + p_{23}r_{23}$	0	$l_1 - 5$
2,3Б + 4,5Б + 6,7Б	$p_2 - sr_2 - s - p_2 - sr_2 - s - p_4 - sr_4 - s + p_{45}r_{45}$	$l_1$	$l_1 - 7$
2Ц + 2,3Б	$p_2(1 - r_2)$	$l_1$	$l_1 - 2$
3Ц + 2,3Б	$p_3(1 - r_3)$	$l_1 - 2$	$l_1 - 3$
1 + 2Ц + 2,3Б	$p_{12}(1 - r_{12}^*) - p_1(1 - r_1^*) - p_2(1 - r_2)$	0	$l_1 - 2$
2Ц + 3Ц + 2,3Б	$p_{23}(1 - r_{23}) - p_2(1 - r_2) - p_3(1 - r_3)$	$l_1$	$l_1 - 3$
3Ц + 4Ц + 2,3Б + 4,5Б	$p_{34}(1 - r_{34}) - p_3(1 - r_3) - p_4(1 - r_4)$	$l_1 - 2$	$l_1 - 4$
1 + 2Ц + 3Ц + 2,3Б	$p_{123}(1 - r_{123}^*) - p_{12}(1 - r_{12}^*) - p_{23}(1 - r_{23}) + p_2(1 - r_2)$	0	$l_1 - 3$
2Ц + 3Ц + 4Ц + 2,3Б + 4,5Б	$p_{234}(1 - r_{234}) - p_{23}(1 - r_{23}) - p_{34}(1 - r_{34}) + p_3(1 - r_3)$	$l_1$	$l_1 - 4$

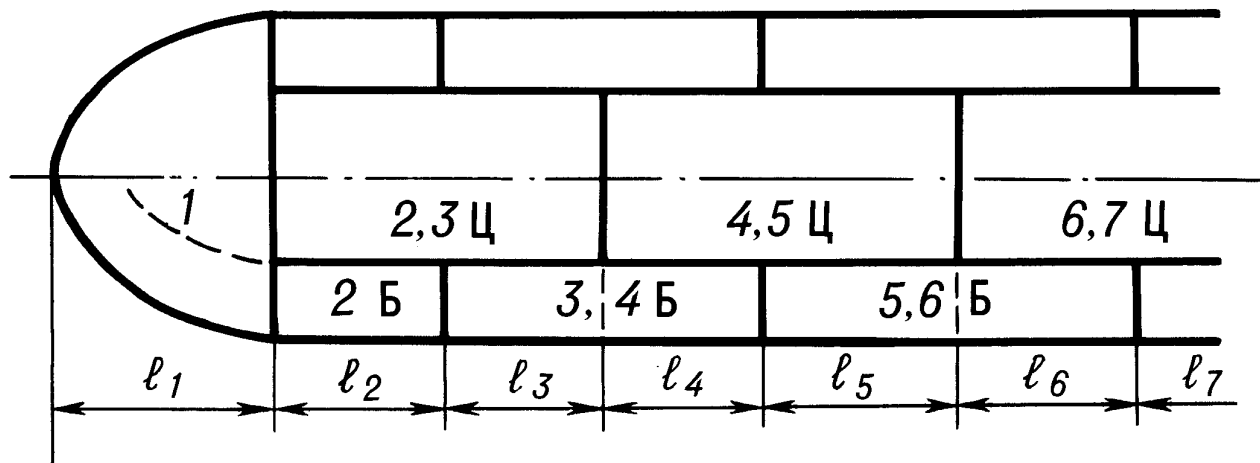


Fig. 3

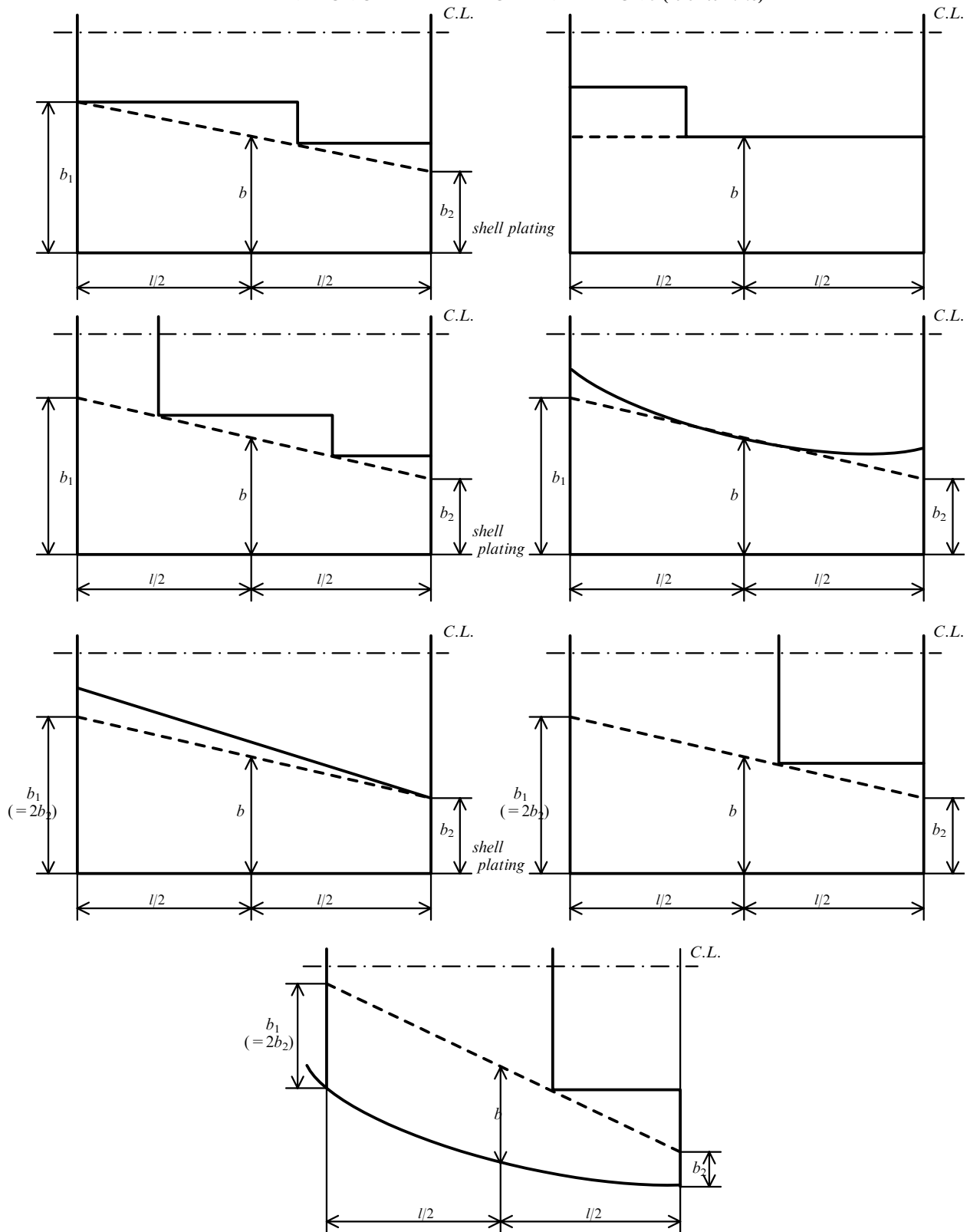
1 2Б 3,4Б	$p_1$ $p_2 r_2$ $p_{34} r_{34}$	0 $l_1$ $l_1 - 2$	$l_1$ $l_1 - 2$ $l_1 - 4$
1 + 2Б 2Б + 3,4Б	$p_{12} r_{12}^* - p_1 r_1^* - p_2 r_2$ $p_{234} r_{234} - p_2 r_2 - p_{34} r_{34}$	0 $l_1$	$l_1 - 2$ $l_1 - 4$
1 + 2Б + 3,4Б	$p_1 - 4 r_1^* - 4 - p_{12} r_{12}^* - p_{234} r_{234} + p_2 r_2$	0	$l_1 - 4$
2Б + 3,4Б + 5,6Б	$p_2 - 6 r_2 - 6 - p_{234} r_{234} - p_3 - 6 r_3 - 6 + p_{34} r_{34}$	$l_1$	$l_1 - 6$
2,3Ц + 2Б 2,3Ц + 3,4Б 4,5Ц + 3,4Б	$p_2(1 - r_2)$ $p_3(1 - r_3)$ $p_4(1 - r_4)$	$l_1$ $l_1 - 2$ $l_1 - 3$	$l_{12}$ $l_1 - 3$ $l_1 - 4$
1 + 2,3Ц + 2Б 1 + 2,3Ц + 2Б + 3,4Б 2,3Ц + 4,5Ц + 3,4Б 2,3Ц + 4,5Ц + 2Б + 3,4Б 2,3Ц + 4,5Ц + 3,4Б + 5,6Б	$p_{12}(1 - r_{12}^*) - p_1(1 - r_1^*) - p_2(1 - r_2)$ $p_{123}(1 - r_{123}^*) - p_{12}(1 - r_{12}^*) - p_{23}(1 - r_{23}) + p_2(1 - r_2)$ $p_{34}(1 - r_{34}) - p_3(1 - r_3) - p_4(1 - r_4)$ $p_{24}(1 - r_{24}) - p_2(1 - r_2) - p_{34}(1 - r_{34})$ $p_{35}(1 - r_{35}) - p_{34}(1 - r_{34}) - p_{45}(1 - r_{45}) + p_4(1 - r_4)$	0 0 $l_1 - 2$ $l_1$ $l_1 - 2$	$l_{12}$ $l_1 - 3$ $l_1 - 4$ $l_1 - 4$ $l_1 - 5$
2,3Ц + 4,5Ц + 2Б + 3,4Б + 5,6Б	$p_2 - 5(1 - r_2 - s) - p_{234}(1 - r_{234}) - p_{345}(1 - r_{345}) + p_{34}(1 - r_{34})$	$l_1$	$l_1 - 5$

Notes: 1. When determining the probability values of  $r^*$ , it shall be assumed that in compartments 1 (Figs 2 and 3), 2 and 3 (Fig. 1) an inner side is available being a continuation of the existing one.

2. The compartment arrangements to be found in the Table shall be considered flooded when determining the values of  $s$ .

3. In the tables:  $l_1 - 2 = l_1 + l_2$   
 $l_1 - 3 = l_1 + l_2 + l_3$   
 $\dots$   
 $l_1 - 7 = l_1 + l_2 + l_3 + l_4 + l_5 + l_6 + l_7$



DETERMINATION OF THE DEPTH OF PENETRATION  $b$  (refer to 2.2.6)

If  $r$  is calculated for a group of two or more compartments, the value of  $b$  is the same for all compartments of this group, and it is equal to the least  $b$  value in this group:

$$b = \min(b_1, b_2, \dots, b_n)$$

where  $n$  = the number of side compartments comprising this group;  
 $b_1, b_2, \dots, b_n$  = is the mean value of  $b$  for individual side compartments forming this group.

# PART VI. FIRE PROTECTION

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## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The requirements of the present Part of the Rules apply to ship's structural fire protection, fire extinguishing systems and fire detection and alarm systems, as well as fire-fighting equipment and outfit.

**1.1.2** The fire protection requirements relating to the structural items of the ship hull, machinery and parts thereof, electrical equipment, pumping and piping, ship's arrangements, fuel oil and lubricating oil tanks, construction and location of boilers, refrigerating plants, ship's spaces, etc. are set out in the relevant parts of the Rules.

### 1.2 DEFINITIONS AND EXPLANATIONS

**1.2.1** The definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification".

The following definitions have been adopted in this Part of the Rules.

**Cabin balcony** is an open deck space which is provided for exclusive use of the occupants of single cabin and has direct access from such a cabin.

**Flammable liquids** are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (e.g. paints, varnishes, lacquers, etc.) which give off flammable vapours at or below 61 °C closed cup test.

**Structural fire protection** is a complex of the passive means of structural fire protection intended for:

- prevention of fire;
- containment of flame and smoke spreading throughout the ship;
- creation of conditions for safe evacuation of people from the ship's spaces and from the ship, as well as for effective fire extinction.

**A standard fire test** is a test in which the relevant specimens are exposed in a test furnace to temperatures corresponding approximately to the time-temperature curve. The test methods shall comply with Fire Test Procedures Code.

**Fire Safety Systems Code** means International Code for Fire Safety Systems, as adopted by the IMO Maritime Safety Committee by Resolution MSC.98(73).

**Fire Test Procedures Code** means International Code for Application of Fire Test Pro-

cedures, as adopted by the IMO Maritime Safety Committee by Resolution MSC.61(67).

**Foam expansion ratio** is the ratio of the volume of foam produced to the volume of the mixture of water and foam-making concentrate required.

**Continuous "B" class ceilings or linings** are those "B" class ceilings or linings which terminate at an "A" or "B" class division.

**Lower flammable limit (LFL)** is minimum concentration of oil gases and vapours in air capable of igniting from a source of ignition and propagating combustion in the mixture.

**Fire-fighting equipment and systems** are those active means of fire protection which are intended for fire extinction and containment of fire spreading throughout the ship.

**Adjacent compartments or spaces** are those compartments or spaces which are separated from one another by a bulkhead, deck, platform, or any other fixed division without openings or with openings provided with means of closure.

Compartments or spaces continuous to one another at the corners only are not considered as adjacent.

Compartments and spaces separated from one another by removable divisions (i.e. those removable under normal service conditions) or having openings not fitted with means of closing, in the bulkhead or deck that separates them, are considered as one single space.

**Primary deck covering** is the first layer of a floor construction, which is applied directly on top of the deck plating and is inclusive of any primary covering, corrosion-resistant compound or adhesive, which is necessary to provide protection or adhesion to the deck plating. Other layers of a floor construction, which are applied directly on top of the deck plating, constitute floor coverings.

**Protected space** is a space equipped with one of the fire extinguishing systems or with an automatic fire detection system.

**Fire control station** is a control station where items of fire detection and alarm systems or control of fire extinguishing systems are centralized.

**Rooms containing furniture and furnishings of restricted fire risk** for the purpose of application on ships carrying more than 36 persons are the rooms (whether cabins, public spaces, offices or other types of accommodation referred to in 1.5.2) in which:

all furniture, such as desks, wardrobes, dressing tables, bureaux, dressers, is constructed entirely of

approved non-combustible materials, except that a combustible veneer not exceeding 2 mm in thickness may be used on the working surface of such articles;

all free-standing furniture, such as chairs, sofas, tables, is constructed with frames of non-combustible materials;

all draperies, curtains and other suspended textile materials have qualities of resistance to the flame spread not inferior to those of wool of mass 0,8 kg/m<sup>2</sup>, this being determined in accordance with Fire Test Procedures Code;

all floor coverings have low flame spread characteristics;

all exposed surfaces of bulkheads, linings and ceilings have low flame spread characteristics;

all upholstered furniture has qualities of resistance to ignition and flame spread, this being determined in accordance with Fire Test Procedures Code;

all bedding components have qualities of resistance to ignition and flame spread, this being determined in accordance with Fire Test Procedures Code.

**Rated volume of a protected space** is the gross volume of a space bounded by watertight or gastight bulkheads and decks with the deduction for the volume occupied by main machinery reduction gear, auxiliaries, boilers, condensers, evaporators, tanks, ventilation and exhaust gas piping.

**Sauna** is a hot room with temperatures normally varying between (usually 80 to 120 °C) where the heat is provided by a hot surface (e.g. by electrically-heated oven). The hot room may also include the space where the oven is located and adjacent bathrooms.

**Water-screen systems** are systems which create a water barrier in the form of sufficiently thick curtain of water fed through spray nozzles. Such systems are fitted where the use of "A" class divisions is impracticable.

**Water drenching systems** are those systems which supply water onto vertical or horizontal ship's structures.

**Fixed fire extinguishing systems** are those systems which are intended to supply fire extinguishing medium to the protected spaces or directly therein and structurally fixed to the ship's hull.

**A system equivalent to a deck foam system for cargo tanks** is a system which shall be capable of extinguishing spill fires, precluding ignition of spilled oil not yet ignited and fire extinction in ruptured tanks.

**Fire-fighting outfit** is portable fire-fighting equipment (apparatus, appliances, consumable materials) intended for:

fire extinction;

ensuring effective fire-fighting actions of the crew;

ensuring operation of fire extinguishing systems.

**Combustible medium** is flammable liquids; flammable gases, compressed, liquefied or dissolved under pressure; solid combustible materials and substances, including cargoes, fuel, finishing materials, equipment, insulation, furniture.

**Steel or other 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 fire exposure during a standard fire test (e.g., aluminum alloy with appropriate insulation).

**Crude oil** means any oil occurring naturally in the earth whether or not treated to render it suitable for transportation and includes crude oil from which certain distillate fractions may have been removed and crude oil to which certain distillate fractions may have been added.

**Flash point** is the temperature in degrees Celsius (closed cup test), at which liquid will give off enough flammable vapors to be ignited as determined by an approved flash point apparatus.

**Motor vehicle without fuel in its tanks** is motor vehicle, motor bike, truck, tractor, etc., powered with an internal combustion engine and having empty fuel system and fuel tanks, as well as both battery leads disconnected from the accumulator.

**Surface extinction** is cooling, wetting or restriction of oxygen access to burning surfaces.

**Smothering** is filling of a protected space with a medium not supporting combustion.

**Fuel oil units** refer to definition given in 1.2, Part VII "Machinery Installations".

**Central control station (CCS)** is a control station where the following control and indicator functions are centralized:

fixed fire detection and alarm systems;

automatic sprinkler system, fire detection and alarm systems, as well as remote starting controls of other fire extinguishing systems;

fire door indicator panels;

fire door closures;

watertight door indicator panels;

watertight door closures;

ventilation fans;

general/fire alarms;

ship communication systems including telephones;

microphones for public address systems.

**Continuously manned central control station** in the context of the present Part is a central control station, which is continuously manned by a responsible member of the crew (refer to Section 4).

### 1.3 SCOPE OF SURVEY

**1.3.1** General regulations for the classification, survey of ships under construction and classification surveys, as well as the requirements for the documentation to be submitted to the Register for consideration are set out in General Regulations for the Classification and Other Activity and in Part I "Classification".

**1.3.2** Subject to the Register survey during construction of a ship are: structural fire protection, materials used for the interior finishing of ship's spaces, as regards fire hazardous properties thereof, fire extinguishing, fire detection and alarm systems subject to the provisions of the present Part.

As regards fire-fighting outfit, it shall only be checked for correct location and for complete availability in accordance with the requirements of the present Part.

**1.3.3** The following shall be submitted to the Register for approval of active fire-fighting means and passive means of structural fire protection according to the requirements of the present Part:

**.1** documents on fire tests run by competent bodies, confirming the efficiency of newly applied fire extinguishing medium with the recommended standards on composition and application rates, as well as information on storage life and conditions;

**.2** reports of the recognized laboratories on the fire tests of "A" and "B" class fire-fighting divisions, closures of openings and passages (cutouts) in such divisions ("A" and "B" class doors included);

**.3** drawings of fire-fighting divisions together with the protocols of the recognized laboratories on tests, which confirm their compliance with "A" and "B" class divisions;

**.4** reports of the recognized laboratories on tests of the fire hazardous material features (refer to 1.6);

**.5** drawings for individual standard assemblies (equipment) of fire extinguishing systems and fire-fighting outfit;

**.6** required calculations, which confirm the fulfillment of the requirements of the present Part.

### 1.4 FIRE PLANS

**1.4.1** At the main fire control station, wheelhouse or in conspicuous positions in corridors and lobbies of any ship, there shall be exhibited general arrangement plans clearly showing the following for each deck:

**.1** location of control stations;

**.2** arrangement of fire-resisting and fire-retarding divisions;

**.3** spaces protected by the fire detection and alarm system;

**.4** spaces protected by fixed fire extinguishing systems with indication of the location of instruments and fittings for their control and also the disposition of fire hydrants;

**.5** means of access to different compartments, decks, etc., with indication of escape routes, corridors and doors;

**.6** ventilation system including the controls of fans and showing the disposition of dampers and the identification numbers of the fans serving the groups of spaces, fenced off by fire-resistant boundaries.

**.7** arrangement of fire fighting outfit;

**.8** location of the documents referred to in 1.4.6;

**.9** location of emergency escape breathing devices specified in 5.1.23.

**1.4.2** In lieu of the plans, information specified in 1.4.1 may be set out in a booklet, a copy of which shall be supplied to each officer, and one copy at all times shall be available on board in an accessible position.

**1.4.3** A duplicate set of the plans or the booklet protected against marine environment shall be permanently stowed outside the deckhouse in a weathertight enclosure painted red and marked as indicated in Fig. 1.4.3-1 in compliance with IMO MSC/Circ.451.

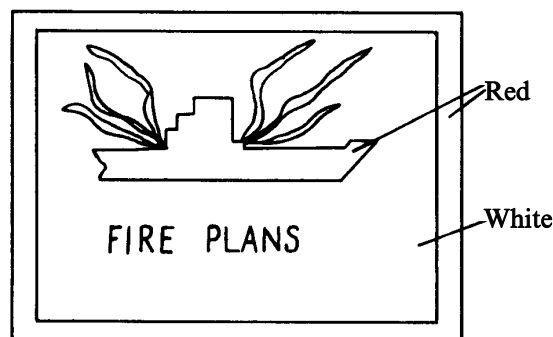


Fig. 1.4.3-1

The enclosure shall be capable of being easily opened, be readily available to the shoreside fire-fighting personnel, be located in a well-illuminated position, if possible including illumination from an emergency source.

In oil tankers, chemical tankers and gas carriers the enclosure of fire control plans shall not be located on exterior bulkheads of superstructures which face cargo area and the surfaces within 3 m from them along the side.

If the enclosure is not adjacent to the gangway, there shall be guide signs as indicated in Fig. 1.4.3-2 showing the way thereto. The dimensions of the signs shall be not less than 300 × 400 mm.

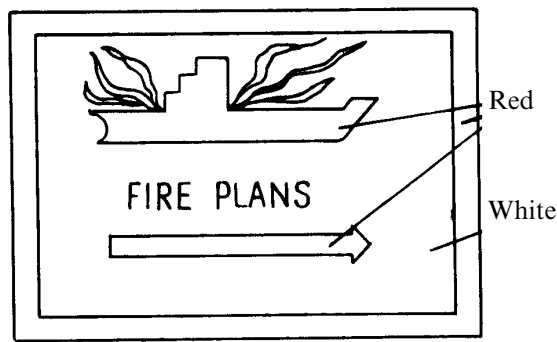


Fig. 1.4.3-2

In cargo ships of less than 150 gross tonnage the duplicate set or the booklet may be omitted.

**1.4.4** Description in such plans and booklets shall be in the state language and in the English/French language. The symbols for items listed in 1.4.1 shall be in agreement with IMO Resolution A.952(23) "Graphical Symbols for Fire Control Plans".

For ships not engaged on international voyages, translation into English or French is not required.

The graphical symbols shall be coloured.

**1.4.5** All alterations in the fire protection of a ship shall be entered in the ship's documents stated in 1.4.1 and 1.4.2.

**1.4.6** To be kept in a separate file in an accessible position are technical instructions for maintenance and use of all ship's installations for extinction and containment of fire.

**1.4.7** In passenger ships carrying more than 36 passengers, plans and booklets shall provide information regarding fire protection, fire detection and fire extinction in accordance with 1.4.1 and considering IMO Resolution A.756(18).

## 1.5 CATEGORIES OF SHIP'S SPACES

### 1.5.1 Control stations:

**.1** spaces in which the ship's radio or main navigational equipment (in particular: steering stand, compass, radar and direction finding equipment), or the emergency power source, (including accumulator batteries regardless of their capacity, according to Part XI "Electrical Equipment"), or in which items of fire detection and alarm systems or control of fire extinguishing systems are centralized. Steering gear room containing its emergency control is not considered as a control station. If in the present Part there are no specific requirements for the centralization within a control station of major components of the fixed fire extinguishing systems, then such major

components may be placed in spaces, which are not considered as control stations;

**.2** control stations (refer to 1.5.1.1), which may also be considered as machinery spaces, such as emergency diesel generators rooms;

**.3** spaces containing equipment for the control of submersion, emersion and heeling;

**.4** control stations for fire and rescue operations (refer to 6.6.2).

### 1.5.2 Accommodation spaces:

**.1** spaces used as cabins, corridors, offices, medical rooms, cinema halls, games and entertainment halls, barbers shops, pantries which are not used for taking meals and do not contain equipment for cooking hot meals (however such pantries may have the following appliances: coffee machines, toasters, dish washing machines, microwave ovens, induction heaters and similar appliances each consuming not more than 5 kW; electric stoves and kitchen stoves for food heating consuming not more than 2 kW and having a surface temperature of not more than 150 °C), and other similar spaces;

**.2** public spaces: the accommodation spaces used as halls, dining rooms, lounges and similar permanently enclosed spaces;

**.3** sanitary spaces: the public spaces used as shower-rooms, bathrooms, toilets, small laundries, indoor swimming pools, etc.

### 1.5.3 Service spaces:

**.1** service spaces used as galleys (spaces containing electric stoves and kitchen stoves with a capacity of more than 5 kW), pantries containing equipment for cooking hot meals (such pantries may have the following appliances: coffee machines, toasters, microwave ovens, induction heaters and similar appliances each consuming not more than 5 kW; electric stoves and kitchen stoves for food heating consuming up to 5 kW), various workshops not forming part of machinery spaces and similar spaces as well as trunks leading to such spaces;

**.2** service spaces used as storerooms:

**.2.1** storerooms for explosives;

**.2.2** storerooms for flammable materials and substances: paint lockers, spaces for flammable liquids, flammable liquefied and compressed gases, sheltered garages, fuel distribution systems, etc.;

**.2.3** storerooms other than mentioned in 1.5.3.2.1 and 1.5.3.2.2;

**.2.4** working spaces defined in 1.5.8;

**.3** cargo control rooms (refer to definitions in 1.2, Part VII "Machinery Installations").

### 1.5.4 Cargo spaces:

**.1** cargo tanks intended for the carriage of liquids in bulk, slop tanks included;

**.2** spaces for dry cargoes other than ship stores: dry cargo and refrigerated cargo holds and 'tween-

decks, including those intended also for carriage of containers and portable tanks, dangerous goods in packaged form or in bulk, motor vehicles without fuel in their tanks; storage spaces for ready produce, utilizable refuse, fishing equipment, packages, etc., as well as produce discharge trunks, cargo lifts and access trunks leading to such spaces;

**.3** ro-ro cargo spaces not normally subdivided in any way and extending to either a substantial length or the entire length of the ship, spaces in which motor vehicles with fuel in their tanks for their own propulsion, and/or goods packaged (in tare or in bulk, on rail or road cars, vehicles (including road or rail tanks), trailers, containers, pallets, demountable tanks or similar enlarged units, or other tanks) are normally loaded and unloaded in a horizontal direction. Such spaces are divided into:

**.3.1** closed ro-ro cargo spaces which are not spaces specified in 1.5.4.3.2 and 1.5.4.5;

**.3.2** open ro-ro cargo spaces either open at both ends, or open at one and provided with adequate natural ventilation effective over their entire length through permanent openings in the side plating or deckhead or from above while the total square of openings shall be at least 10 per cent of the square of side plating of spaces;

**.4** vehicle spaces intended for carriage of motor vehicles with fuel in their tanks for their own propulsion, which divide into:

**.4.1** enclosed spaces, for vehicles which are not open spaces for vehicles neither weather decks;

**.4.2** open vehicle spaces, open similar to 1.5.4.3.2;

**.5** weather deck is a deck fully open for environmental exposure from above and at least from two sides.

**1.5.5 Machinery spaces** — refer to definition of 1.2, Part VII "Machinery Installations".

**1.5.6 Machinery spaces of category A** — refer to definition given in 1.2, Part VII "Machinery Installations".

**1.5.7 Pump rooms on tankers and combination carriers:**

**.1** cargo pump rooms where cargo pumps are located as well as exits and trunks leading to such spaces; pump rooms adjacent to cargo tanks and bilge tanks (refer to 2.4.7);

**.2** pump rooms where pumps transporting water and liquid fuel are located.

**1.5.8 Working spaces** are spaces on special purpose ships, which are neither machinery spaces nor part of them such as workshops, laboratories and other similar spaces, as well as trunks leading to such spaces, where:

**.1** fuel oil or flammable liquids are used or combustible materials are processed;

**.2** neither flammable liquids are used, nor combustible materials are processed.

Working spaces shall comply with the requirements of the present Part for service spaces if not specified otherwise.

**1.5.9 Special category spaces** are enclosed spaces located above or below the bulkhead deck into and out of which motor vehicles can be driven under their own propulsion and to which passengers have access. These spaces may be located on more than one deck if total overall clear height for the motor vehicles does not exceed 10 m.

**1.5.10 Special electrical spaces** — refer to 1.2, Part XI "Electrical Equipment".

#### 1.6 SUBDIVISION AND TESTING OF MATERIALS AND PRODUCTS ACCORDING TO THE FIRE TEST PROCEDURES CODE

**1.6.1** The Fire Test Procedures Code is applied to materials and products subject to testing and assessment in accordance with the provisions of the Code and approved by the Register, as required by the Rules.

**1.6.2** Where reference to the Fire Test Procedures Code is made in the text of any requirement of the present Rules, it means that the material or product shall be tested in compliance with an applicable fire test procedure or procedures, stipulated by the Code, except cases specified by the same Code.

**1.6.3** In accordance with applicable parts of Annex 1 to the Fire Test Procedures Code materials and products shall be tested mentioned in the present Rules as:

**.1** non-combustible materials (refer to 2.1.1.5, 2.1.2, 2.2.2.5 and 2.3.4). Non-combustible material is a material, which neither burns nor gives off flammable vapors in the amount sufficient for self-ignition when heated to 750 °C approximately. Any other material is a combustible material. However, products made only of glass, concrete, ceramics, natural stone, masonry units, common metals and metal alloys are considered being non-combustible and may be installed without testing;

**.2** not generating excessive quantities of smoke and toxic products (refer to 2.1.1.7 and 2.1.2.6) or not hazardous as regards generation of toxic or explosive products at elevated temperatures (refer to 2.1.1.6);

**.3** "A" or "B" class divisions, such as: decks, bulkheads, doors, continuous ceilings and linings, windows, fire dampers, places of piping and cabling passage (refer to 2.1.2 and 2.1.3);

**.4** fire doors control systems capable of operating in case of fire (refer to 2.2.4.1.15);

**.5** low flame-spread surfaces (refer to 2.1.1.5, 2.1.1.8, 2.1.2.6 and 2.1.2.8). Low flame-spread means that the surface restricts the spread of flame to a sufficient extent;

**.6** not readily ignitable primary deck coverings (refer to 2.1.1.6);

**.7** draperies, curtains and other vertically supported textile materials, which meet the requirements as regards flame spread resistance not inferior to those of wool having a mass of 0,8 kg/m<sup>2</sup> (refer to 2.1.1.9);

**.8** upholstered furniture meeting the requirements as regards ignition and flame-spread resistance (refer to 2.1.1.9);

**.9** bedding components (blankets, covers, pillows, mattresses), which meet the requirements as regards ignition and flame-spread resistance (refer to 2.1.1.9).

**1.6.4** When testing and approving the materials and products in accordance with the Fire Test Procedures Code additional requirements specified in the appropriate parts of Annex 1 to the Fire Test Procedures Code.

## 1.7 ALTERNATIVE DESIGN AND ARRANGEMENTS

### 1.7.1 General.

**1.7.1.1** Fire safety design and arrangements may deviate from the requirements of the present Part, provided, that the design and arrangements meet the fire safety objectives and the functional requirements.

**1.7.1.2** If the design and arrangements deviate from the prescriptive requirements of the present Part, engineering analysis, evaluation and approval of the alternative design and arrangements shall be carried out in accordance with the requirements of the present Chapter.

### 1.7.2 Engineering analysis.

**1.7.2.1** The engineering analysis submitted to the Register shall be prepared based on the Guidelines on Alternative Design and Arrangements for Fire Safety (refer to MSC/Circ.1002), and shall include, as a minimum, the following elements:

**.1** determination of the ship type and space(s) concerned;

**.2** identification of prescriptive requirement(s) with which the ship or the space(s) will not comply;

**.3** identification of the fire and explosion hazards of the ship or the space(s) concerned including:

**.3.1** identification of the possible ignition sources;

**.3.2** identification of the potential for the spread of fire of each space concerned;

**.3.3** identification of the smoke and toxic products generation potential for each space concerned;

**.3.4** identification of the potential for the spread of fire, smoke or of toxic products generation from the space(s) concerned to other spaces;

**.4** determination of the required fire safety performance criteria for the ships or the space(s) concerned addressed by the prescriptive requirement(s), which shall:

**.4.1** be based on the fire safety objectives and on the functional requirements of the present Part;

**.4.2** provide a degree of safety not less than that achieved by using the prescriptive requirements;

**.4.3** be quantifiable and measurable;

**.5** detailed description of the alternative design and arrangements, including a list of the assumptions used in the design and any proposed operational restrictions or conditions;

**.6** technical justification demonstrating that the alternative design and arrangements meet the required fire safety performance criteria.

### 1.7.3 Evaluation of the alternative design and arrangements.

**1.7.3.1** The engineering analysis required in 1.7.2 shall be evaluated and approved by the Register taking into account the Guidelines developed by the IMO.

**1.7.3.2** A copy of the documentation, as approved by the Register, indicating that the alternative design and arrangements comply with the requirements of the present Chapter shall be carried on board a ship.

### 1.7.4 Re-evaluation due to change of conditions.

**1.7.4.1** If the assumptions and operational restrictions that were stipulated in the alternative design and arrangements are changed, the engineering analysis shall be carried out again under the changed condition and shall be approved by the Register.

## 2 STRUCTURAL FIRE PROTECTION

### 2.1 GENERAL

#### 2.1.1 Requirements for materials.

**2.1.1.1** The hull, superstructures, structural bulkheads decks and deckhouses shall be manufactured of steel or other equivalent material. For the purpose of using the definition of steel or other equivalent material, given in 1.2.1, "applicable fire exposure" shall correspond to the standards of fire

integrity and insulation, specified in the appropriate bulkheads and decks fire integrity tables. For example, if for such divisions as decks or side and end bulkheads of deckhouses fire integrity equal to "B-0" is allowed, then "applicable fire exposure" shall be equal to half an hour.

If aluminum alloys or glass-reinforced plastics are used, the requirements of 2.1.1.3 or 2.1.1.12 shall be met, respectively.

The use of materials other than those mentioned above for manufacture of hull, superstructures, structural bulkheads, decks and deckhouses, shall be subject to special consideration by the Register in each particular case with regards to the purpose and the size of ship.

**2.1.1.2** Casings and crowns of machinery spaces of category A shall be of steel and insulated as required by Tables 2.3.3-1 and 2.4.2-1 as appropriate.

**2.1.1.3** If any part of the division is manufactured of aluminum alloys, the following requirements shall be complied with:

**.1** parts of "A" or "B" class divisions, made of aluminum alloy, except the divisions, which are not load-bearing, shall be insulated so, that the temperature of the structural core of the specimen does not rise more than 200 °C above the ambient temperature at any time during the applicable fire exposure at the standard fire test;

**.2** special attention shall be given to insulation of aluminum alloy components of columns, stanchions and other structural members required to support lifeboat and life raft stowage, launching and embarkation areas and "A" and "B" class divisions to ensure that:

**2.1** such members required to support lifeboat and life raft stowage, launching and embarkation areas and "A" type divisions comply with the temperature rise limitation requirement, as specified in 2.1.1.3.1, at the end of an hour;

**2.2** such members required to support "B" class divisions comply with the temperature rise limitation requirement, as specified in 2.1.1.3, at the end of half an hour.

**2.1.1.4** In accommodation spaces, service spaces and control stations of all types of ships the total mass of combustible materials of each enclosed space shall be calculated based on the following formula:

$$M_{rel} = M_t / S \quad (2.1.1.4)$$

where  $M_{rel}$  = the total mass of combustible materials per unit area of the space, kg/m<sup>2</sup>;

$M_t$  = the total mass of combustible materials of the space, kg;

$S$  = the floor area of the space, m<sup>2</sup>.

The following combustible materials shall be included to the calculations:

**.1** construction materials as cables insulation, plastic pipes, veneers and combustible materials permitted to be used according to the present Part;

**.2** outfitting, which may be installed during construction or provided by the shipowner or crew, including furniture, bedding components and electrical appliances.

Maximum values for the total mass of combustible materials per unit area ( $M_{rel}$ ), kg/m<sup>2</sup>, shall not exceed the values specified in Table 2.1.1.4. Space categories shall correspond to the ones specified in 2.2.1.3, 2.2.1.5, 2.3.3 or 2.4.2, depending on the ship type.

**2.1.1.5** Insulation materials shall be non-combustible, except for use in cargo spaces, postal and baggage storerooms and refrigerated storerooms of service spaces. Vapor barriers and adhesives used in conjunction with insulation, as well as insulation of piping fittings of cooling systems and piping of cooling water of the conditioning systems may be combustible, but they shall be kept to the minimum as far as practicable, while their exposed surfaces shall be low flame-spread.

Insulating materials shall not contain asbestos, along with that, the Regulation 3-5 of IMO Resolution MSC.194(80) shall be taken into consideration.

In the spaces where oily products may be present the insulation surface shall be oily vapors-impermeable, which may be provided by coating insulation with metallic film or glass cloth vapor-impermeable and having reliable joint sealing.

**2.1.1.6** Primary deck coverings, if applied within accommodation and service spaces and control stations or on cabin balconies of passenger ships constructed on or after 1 July 2008 shall be of an approved material which is neither non-flammable, nor will not give rise to toxic or explosive hazards at elevated temperatures, this being determined in accordance with Fire Test Procedures Code.

Where according to 2.1.1.8 a floor covering is required to be low flame-spread; all layers shall comply with the requirement of 1.6.3.5. If the floor covering has a multilayer construction, the tests shall be conducted for each layer or combinations of some layers of such covering. At that, the Register approval is applicable to the tested combinations of layers. When a primary deck covering is also the exposed surface (refer to 2.1.1.8), it shall comply with

Table 2.1.1.4

Ship type Space category	Passenger ship carrying more, than 36 passengers	Passenger ship carrying not more, than 36 passengers	Cargo ships
Stairways, corridors	5	5	5
Control stations	5	5	5
Accommodation spaces	15 – minor fire risk, 35 – moderate and greater fire risk	35	35
Service spaces surrounded by "A" class divisions	45	45	45



the requirements of 1.6.3.5. However, primary deck covering, which comply with the requirements of 1.6.3.6, are considered as complying with the requirements of 1.6.3.5 for floor coverings. Primer or similar thin film of paint on deck plating need not comply with the requirements of 1.6.3.6.

On passenger ships constructed on or after 1 July 2008, primary deck coverings on cabin balconies shall not give rise to smoke, toxic or explosive hazards at elevated temperatures, this being determined in accordance with the Fire Test Procedures Code.

**2.1.1.7** Paints, varnishes and other finishings used on exposed surfaces inside service and accommodation spaces, control stations and stairways enclosures shall not generate excessive quantity of smoke and toxic vapours, this being determined in accordance with Fire Test Procedures Code.

This requirement applies to the finish materials of bulkheads, decks, floor coverings, linings and ceilings, but is not applicable to cables insulation, plastic piping and furniture.

Finish materials and primary deck coverings (refer to 2.1.1.6) with total thermal emission of not more than 0,2 MJ and maximum value of thermal emission factor not more than 1,0 kW (both values are determined in accordance with the IMO Resolution A.653(16)), and are considered as complying with the requirements of 1.6.3.2 without tests.

In oil tankers and oil recovery vessels the use of aluminium paints in cargo oil tanks, cofferdams, pump rooms, in way of cargo tank decks and in other places where explosive vapours can accumulate, is not permitted.

On passenger ships constructed on or after 1 July 2008, paints, varnishes and other finishes used on exposed surfaces of cabin balconies, excluding natural hard wood decking systems, shall not be capable of producing excessive quantities of smoke and toxic products, this being determined in accordance with the Fire Test Procedures Code.

**2.1.1.8** In accordance with Fire Test Procedures Code the following surface shall have low flame spread characteristics:

**.1** on passenger ships:

**.1.1** exposed surfaces in corridors and stairway enclosures, as well as bulkheads and plating, ceiling linings in accommodation and service spaces (except saunas) and control stations;

**.1.2** surfaces and grounds in concealed and inaccessible spaces in accommodation and service spaces and control stations;

**.2** on cargo ships with gross tonnage more than 500:

**.2.1** exposed surfaces in corridors and stairway enclosures and of ceilings in accommodation and service spaces (except saunas) and control stations;

**.2.2** surfaces and grounds in concealed and inaccessible spaces in accommodation and service spaces and control stations;

**.3** glues and sealants used in the "A" and "B" class divisions;

**.4** exposed surfaces of cabin balconies, except for natural hard wood decking systems.

The above requirements apply to finish materials of bulkheads, decks, floor coverings, linings and ceilings, but is not applicable to plastic piping, electrical cables and furniture.

**2.1.1.9** On passenger ships carrying more than 36 passengers in accommodation spaces, the furniture and furnishings of which constitute restricted fire risk, upholstered furniture, bedding components, draperies and curtains and other vertically supported textile materials shall be satisfactorily tested in compliance with the Fire Test Procedures Code (refer to 1.6.3.7 to 1.6.3.9). For other types of ships, the said requirements are recommended only.

**2.1.1.10** On passenger ships, "A", "B" and "C" class divisions in accommodation and service spaces and cabin balconies, which are faced with combustible materials, facings, mouldings, decorations and veneers shall comply with the requirements of the present paragraph and 2.1.1.6 to 2.1.1.8. However, traditional wooden benches and wooden linings of bulkheads and ceilings are allowed in saunas and such materials may not be taken into calculation required by the paragraph.

On cargo ships, non-combustible bulkheads, ceilings and linings fitted in accommodation and service spaces may be faced with combustible materials, facings, mouldings, decorations and veneers provided such spaces are bounded by non-combustible bulkheads, ceilings and linings in accordance with the requirements of the present paragraph and 2.1.1.6 to 2.1.1.8.

Combustible materials used on the surfaces and linings shall have calorific value not exceeding 45 MJ/m<sup>2</sup> taking into consideration their thickness. Requirements of this article are not applicable to the surfaces of furniture fixed to linings or bulkheads.

Calorific value  $Q$ , in MJ/m<sup>2</sup>, taking into consideration the thickness of covering material, is determined by the formula

$$Q = Q_g p s \quad (2.1.1.10)$$

where  $Q_g$  = the maximum specific heat of combustion determined oil in accordance with ISO 1716 "Construction Materials. Determination of the Calorific Potential", in MJ/kg;

$p$  = the density of material, in kg/m<sup>3</sup>;

$s$  = the thickness of material, in m.

Where combustible materials are used in accordance with the present paragraph, they shall comply with the following requirements:

.1 the total volume of combustible facings, mouldings, decorations and veneers in any accommodation or service spaces shall not exceed a volume equivalent to 2,5 mm veneer of the combined area of the walls and ceiling linings. The furniture fixed to linings, bulkheads or decks may be not included into the calculation of the total volume of combustible materials;

.2 in case of ships fitted with an automatic sprinkler system complying with the provisions of Fire Safety Systems Code, the above volume may include some combustible materials used for erection of "C" class divisions.

On cargo ships of 500 gross tonnage and more and on non-self-propelled ships without regard of their gross tonnage, it is permissible to fit non-combustible bulkheads, ceilings and linings with a combustible covering at most 2 mm thick instead of compliance with the above requirements, except corridors, stairway enclosures as well as control stations where thickness of combustible covering shall not exceed 1,5 mm.

However, the provisions of sub-paragraphs 2.1.1.10.1 and 2.1.1.10.2 need not be applied to cabin balconies.

**2.1.1.11** All waste receptacles shall be constructed of non-combustible materials with no openings in the sides and bottom.

Containers constructed of combustible materials may be used in galleys, pantries, bars, garbage handling or storage spaces and incinerator rooms provided they are intended purely for the carriage of wet waste, glass bottles or metal cans and are suitably marked.

**2.1.1.12** When structures of a ship or lifeboat are made of glass-reinforced plastic in compliance with the requirements of Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats", fire-retardant properties and fire integrity of such structures are tested in accordance with the procedure specified in MSC/Circ.1006.

### 2.1.2 Fire-fighting divisions.

**2.1.2.1** "A" class divisions are those divisions which are formed by bulkheads or decks complying with the following requirements:

.1 they shall be constructed of steel or other equivalent material;

.2 they shall have respective stiffening elements;

.3 they shall be so constructed as to be capable of preventing the passage of smoke and flame up to the end of the 60-min standard fire test;

.4 they shall be so insulated with approved non-combustible material that the average temperature of 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.

Depending on the time during which the above-indicated temperature rise is ensured in the course of the standard fire test, the following symbols are given to divisions: "A-60" — during 60 min.; "A-30" — during 30 min.; "A" — during 15 min.; "A-0" — during 0 min.

**2.1.2.2** When approving the structural fire protection the danger of heat transfer through joints and ends of insulation shall be taken into account. Insulation of steel and aluminium decks and bulkheads shall extend for at least 450 mm beyond boundaries of structures forming the given space. If a space is divided by the "A" class deck or bulkhead with an insulation of different size, then an insulation of greater size shall extend over the deck and bulkhead for at least 450 mm from the less insulated structure.

Measures taken to prevent heat transfer through joints and ends of insulation of decks and bulkheads are shown in Figs. 2.1.2.2-1 and 2.1.2.2-2. The Register may approve some other variants of such measures, provided the efficacy of the proposed structure is verified by the results of tests conducted in accordance with the Fire Test Procedures Code.

Where the lower part of insulation is cut off to provide drainage, the structure shall comply with Fig. 2.1.2.2-3.

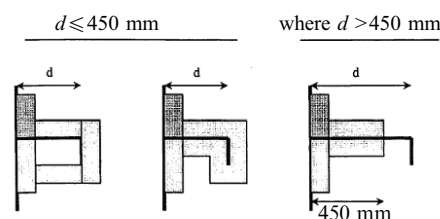


Fig. 2.1.2.2-1

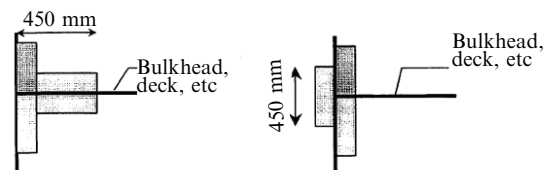


Fig. 2.1.2.2-2

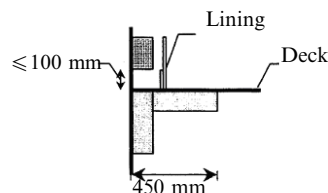


Fig. 2.1.2.2-3

*Note: d — height of the stiffener at the longitudinal member.*

**2.1.2.3** Lightweight (honeycomb and other) structures made of steel or other equivalent material may be used as internal divisions of "A" class in the

accommodation and service spaces, provided they are not load-bearing structures and successfully passed prescribed tests in accordance with the Fire Test Procedures Code. Such lightweight structures shall not be used as the components of the main fire protection zones and stairways enclosures in passenger ships.

**2.1.2.4** The following elements may be fitted without tests:

**.1** "A-0" class bulkheads, if made of steel and having the dimensions not less than the following:

plate thickness – 4 mm;

stiffeners  $60 \times 60 \times 5$  mm located at a distance of 600 mm from each other or having similar construction;

**.2** "A-0" class decks if made of steel and having the dimensions not less than the following:

plate thickness – 4 mm;

stiffeners  $95 \times 65 \times 7$  mm located at a distance of 600 mm from each other or having similar construction.

**2.1.2.5** "B" class divisions are those divisions which are formed by bulkheads, decks, ceilings or linings which comply with the following requirements:

**.1** they are made of approved non-combustible materials.

Use of combustible veneer is permitted (refer to 2.1.1.8 and 2.1.1.10);

**.2** divisions shall be so constructed as to remain capable of preventing the passage of flame up to the end of the 30-minute standard fire test;

**.3** divisions shall have an insulation value such that the average temperature on the unexposed side during the fire test will not rise more than  $140^\circ\text{C}$  above the original temperature, nor will the temperature at any one point, including any joint, rise more than  $225^\circ\text{C}$  above the original temperature when either side is exposed to the fire test.

According to the time during which the above-mentioned temperature rise is ensured in the course of the standard fire test, the following symbols are given to divisions: "B-30" — during 30 min.; "B-15" — during 15 min.; "B-0" — during 0 min.

**2.1.2.6** Materials used in the "A" and "B" class divisions, which according to the present Part shall have particular characteristics (be non-combustible, low flame-spread or not generating excessive quantities of smoke and toxic agents), shall comply with the requirements of the Fire Test Procedures Code (refer to 1.6.3.1, 1.6.3.2 and 1.6.3.5).

**2.1.2.7** Continuous "B" class ceilings and linings with the relevant decks or bulkheads may be considered as fully or partially ensuring insulation and fire integrity of structures, as required by the respective fire integrity tables.

**2.1.2.8** "C" class divisions are the divisions made of approved non-combustible materials. They do not need meet any requirements relative to the passage of smoke and flame or the limiting of temperature rise. It is not required that gluing materials in these structures be non-combustible, however, these materials shall be low flame-spread.

**2.1.2.9** Divisions consisting of non-combustible core and combustible veneers may be accepted as a "B" or "C" class divisions, provided that the non-combustible core is tested and complies with the requirements of 1.6.3.1, and the "B" class division is tested and complies with the requirements of 2.1.2.4, and the veneers, if applicable, are tested and comply with the requirements of 1.6.3.2 and 1.6.3.5.

### **2.1.3 Closures of openings in fire-fighting divisions.**

**2.1.3.1** Fire integrity of doors shall be equal to fire integrity of the divisions where they are installed, which is determined in accordance with the Fire Test Procedures Code. Doors and doorframes in "A" class divisions shall be made of steel or other equivalent material. Doors in "B" class divisions shall be non-combustible.

**2.1.3.2** The doors designed in compliance with the requirements of 7.5.2 and 7.12, Part III "Equipment, Arrangements and Outfit" and fitted according to 7.12 of the above mentioned Part, and, in certain cases (e.g., for providing gastightness), if specially agreed with the Register, may be fitted in "A" class bulkheads. Watertight doors may be not insulated and they do not require fire tests if fitted below the bulkhead deck.

Doors, which are installed above the bulkhead deck subject to fire integrity and water tightness requirements, shall be tested in accordance with the Fire Test Procedures Code.

**2.1.3.3** If the "A" class divisions are penetrated, then such penetrations (cutouts) shall be tested in accordance with the Fire Test Procedures Code, considering the provisions of 2.2.1.4. The requirements of 12.2.3 and 12.2.12, Part VIII "Systems and Piping" are applied to ventilation ducts. Tests may not be conducted if the pipes penetrations are made of steel or other equivalent material with a thickness of 3 mm or greater and a length of not less than 900 mm (preferably 450 mm at each side of the division) and do not have any openings. Such penetrations shall be insulated similar to the division itself.

**2.1.3.4** If "B" class divisions are penetrated for the passage of electric cables, pipes, ducts, trunks, etc., or for the fitting of the ventilation terminals, lighting fixtures and similar devices, arrangements shall be provided to ensure fire integrity of a division. Ventilation ducts shall comply with the requirements of 12.2.5, Part VIII "Systems and Piping". Pipes other than steel or copper that penetrate "B" class divisions shall be protected by the following:

**.1** fire tested penetration device, adequate to the fire integrity of the division penetrated and the type of pipes used; or

**.2** steel sleeve, having a thickness of not less than 1,8 mm and a length of not less than 900 mm for pipe diameters of 150 mm or greater and not less than 600 mm for pipe diameters of less than 150 mm (preferably equally divided at each side of the division). Pipes shall be connected to the ends of the sleeve by flanges or couplings; or the clearance between the sleeve and the pipe shall not exceed 2,5 mm; or any clearance between the pipe and the sleeve shall be made tight by means of non-combustible or other suitable material.

**2.1.3.5** Uninsulated metallic pipes penetrating "A" or "B" class divisions shall be made of materials having a melting temperature exceeding 950 °C for "A-0" class divisions and 850 °C for "B-0" class divisions.

**2.1.3.6** In ships other than passenger ships carrying more than 36 passengers external boundaries, which shall be made of steel or other equivalent material, may be penetrated for the fitting of windows and side scuttles, provided there is no requirement in the present Part for such boundaries to be of "A" class. In such boundaries, which are not required to be of "A" class, doors on agreement with the Register may be made of materials the ventilation ducts than the ones of the boundary.

**2.1.3.7** Balancing openings or ducts between two enclosed spaces are prohibited except for the openings permitted by 2.2.4.3 and 2.3.8.

#### **2.1.4 Measures for prevention of spread of fire and smoke.**

**2.1.4.1** For machinery spaces provision shall be made to control the opening and closing of skylights, arrangements for closing openings in funnels, which normally ensure exhaust ventilation as well as closing of ventilation flaps.

The controls shall be located outside the serviced space where they would not be isolated in case of fire in the space.

**2.1.4.2** For the protection of openings in the boundaries of A category machinery spaces the following measures shall be taken:

**.1** the number of skylights, doors, ventilation openings, openings in funnels to permit exhaust ventilation and other openings shall be reduced to a minimum required for ventilation, as well as proper and safe operation of ship;

**.2** skylights shall be made of steel and shall have no glass panels;

**.3** provision shall be made to control the closing of power operated doors or actuating release mechanism of doors other than watertight power operated doors. The controls shall be located outside the

serviced space where they would not be isolated in case of fire in the space;

**.4** windows shall not be fitted in machinery spaces boundaries. However, this does not preclude the use of glass in control stations within the machinery spaces;

**.5** in passenger ships the requirements of 2.2.4.1 shall be met additionally.

Skylights of cargo pump rooms, specified in 1.5.7.1, shall be made of steel and shall be closed from a position located outside the pump room.

**2.1.4.3** In accommodation and service spaces, as well as in control stations stairways and lift trunks shall be protected in the following way:

**.1** in cargo ships stairways which penetrate only a single deck shall be protected at least at one level by at least "B-0" class divisions and self-closing doors. Lifts which penetrate only a single deck shall be surrounded by "A-0" class divisions with steel doors at both levels. Stairways and lift trunks which penetrate more than a single deck shall be surrounded by at least "A-0" class divisions and protected by self-closing doors at all levels. Stairway enclosures may be arranged so as to allow to go from one stair to a superimposed stair within such enclosure (Fig. 2.1.4.3.1-1), or to enclose the stairs only with doors at each end of the stair (Fig. 2.1.4.3.1-2), or to enclose the stairs only in combination with fully closed steel stairs and doors fitted at the end of each stair (Fig. 2.1.4.3.1-3);

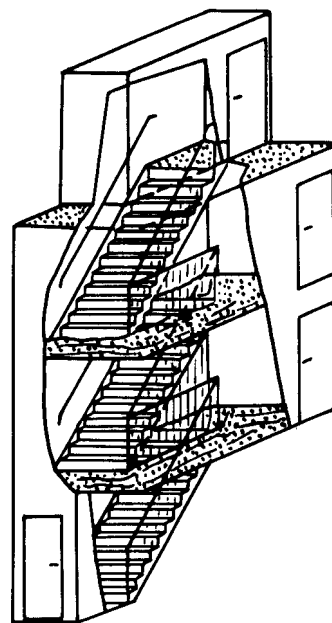


Fig. 2.1.4.3.1-1

**.2** on ships having accommodation for 12 persons or less, where stairways penetrate more than a single deck and where there are at least two escapes direct to

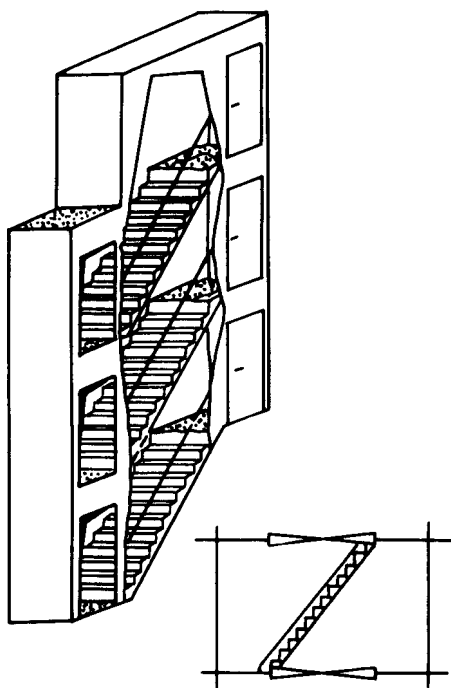


Fig. 2.1.4.3.1-2

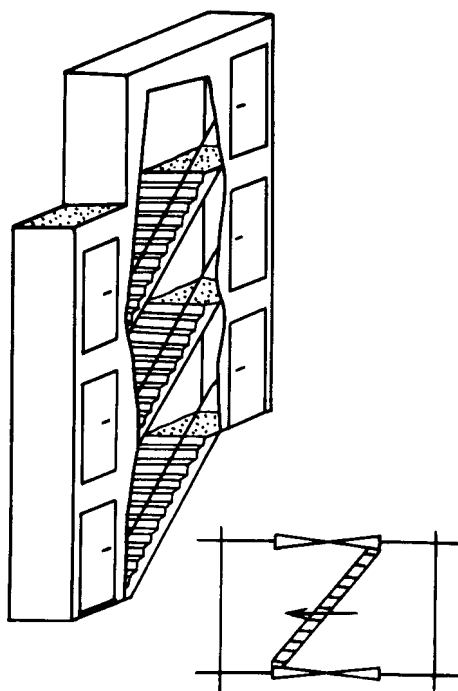


Fig. 2.1.4.3.1-3

the open deck at every accommodation level, stairways and lift trunks may be protected by "B-0" class divisions;

.3 in passenger ships the stairways and lift trunks shall be protected in compliance with 2.2.2.4;

.4 the construction of stairways shall comply with the requirements of 8.5.4, Part III "Equipment, Arrangements and Outfit".

**2.1.4.4** Air spaces enclosed behind ceilings, pannelings, or linings shall be divided by close-fitting draught stops spaced not more than 14 m apart.

In the vertical direction, such air spaces, including those behind linings or stairways, trunks, etc. shall be closed at each deck.

**2.1.4.5** In machinery spaces from which two stairways are provided in accordance with 4.5, Part VII "Machinery Installations" one of them shall be protected by enclosure along its whole length meeting requirement 2.2.1.3 category (2) or requirements 2.2.1.5, 2.3.3 or 2.4.2 category (4) as appropriate. Self-closing fire doors of the same type of fire integrity shall be fitted in the enclosure.

Stairways shall be arranged to avoid transfer of heat to the enclosure through uninsulated fixing points.

**2.1.4.6** In addition to watertight door separating the machinery space of category A from the shaft tunnel, from the side of the latter a light steel fire-screen door shall be fitted to be operated from each side.

**2.1.4.7** Permanent openings in the side shell, ends and ceiling of enclosed spaces for the carriage of vehicles, enclosed ro-ro spaces, as well as special category spaces shall be so situated that a fire in these spaces does not endanger stowage areas and embarkation stations for lifeboats and liferafts, accommodation spaces, service spaces and control stations in superstructures and deckhouses above the mentioned spaces.

#### **2.1.5 Additional requirements to spaces of separate categories.**

In addition to the requirements of Section 2, the following requirements to structural fire protection shall be complied with.

**2.1.5.1** Saunas shall comply with the following requirements:

.1 the perimeter of the sauna shall be of "A-60" class boundaries except spaces inside of the perimeter and spaces of categories (5), (9) and (10) as specified in 2.2.1.3, or spaces of categories (5), (7) and (10) as specified in 2.2.1.5.1, 2.3.3 or 2.4.2, depending on the purpose of ship;

.2 saunas may include changing rooms, showers and toilets. Bathrooms with direct access to saunas may be considered as part of them. In such cases, the door between sauna and the bathroom need not comply with fire safety requirements;

.3 the traditional wooden lining on the bulkheads and ceiling are permitted in the sauna. The ceiling

above the oven shall be lined with non-combustible plate with an air gap of at least 30 mm. The distance from the hot surfaces to combustible materials shall be at least 500 mm or the combustible materials shall be protected (e.g., by a non-combustible plate with an air gap of at least 30 mm);

**.4** the traditional wooden benches are permitted in saunas;

**.5** the sauna door shall have no locks and open outwards by pushing;

**.6** electrically heated ovens shall be provided with a timer and meet the requirements of Section 15, Part XI "Electrical Equipment", while cables and wires shall meet the requirements of 16.8 of the same Part.

**2.1.5.2** Galleys shall comply with the following requirements:

**.1** galleys utilizing sources of power other than electricity shall not be adjacent to storerooms for flammable materials and substances or to fuel oil and lubricating oil tanks;

**.2** galley decks shall be covered with ceramic tiles or similar non-combustible covering;

**.3** exhaust ventilation ducts from galley ranges shall meet the requirements of 12.2.7 or 12.3.6, Part VIII "Systems and Piping".

**2.1.5.3** Storerooms for flammable materials and substances shall comply with the following requirements:

**.1** storerooms for flammable materials shall not be generally situated in common with accommodation spaces in superstructure or deckhouse. Access to the storerooms shall be provided from the open deck directly or through a corridor and/or a stairway leading only to these storerooms;

**.2** in cargo ships of less than 300 gross tonnage storerooms may be arranged in way of the accommodation spaces, but not adjacent thereto. Where provision of a separate storeroom for

flammable liquids is impeded, it is permissible to keep such liquids in steel ventilated

lockers or cases. The lockers or cases shall not be adjacent to accommodation spaces. The doors of such lockers or cases shall open outwards;

**.3** all electrical equipment of the storeroom shall be explosion proof in compliance with 2.9, Part I "Electrical Equipment".

**2.1.5.4** Spaces for electric and gas welding operations shall comply with the following requirements:

**.1** the spaces shall be separated from adjacent spaces by "A-60" class divisions;

**.2** spaces shall have direct access from the open deck; the doors shall open outwards and be fitted with locks;

**.3** location and arrangement of such spaces in oil tankers is subject to special consideration by the Register;

**.4** oxygen and acetylene cylinders for electric and gas welding operations shall be kept in separate storerooms, complying with the following requirements:

**.4.1** acetylene cylinders storeroom shall be independent of the oxygen cylinder storeroom;

**.4.2** storerooms shall not be located below accommodation spaces and control stations or be adjacent to them. Besides, storerooms shall not be adjacent to machinery spaces of category A, galleys, storerooms for flammable materials and substances and other fire risk spaces, as well as to fuel oil and lubricating oil tanks;

**.4.3** divisions separating the storerooms from adjacent spaces shall be of "A-60" class;

**.4.4** such spaces shall have direct access from the open deck, the doors shall open outwards and be fitted with locks providing their reliable closure to prevent unauthorized access;

**.4.5** the warning plates: "Danger of explosion!" and "No smoking!" shall be provided on the storerooms doors.

**2.1.5.5** Cargo spaces specified in 1.5.4.3, 1.5.4.4 and 1.5.9, in which motor vehicles with fuel in their tanks are carried, shall comply with the following requirements:

**.1** entrances to the cargo spaces from accommodation, machinery and special electrical spaces shall be equipped with self-closing permanently closed doors. The coamings height of these doors shall not be less than 450 mm;

**.2** warning plates prohibiting smoking shall be provided near the entrances to the cargo spaces;

**.3** the cargo spaces shall comply with the requirements of 12.6, Part VIII "Systems and Piping" and 19.3, Part XI "Electrical Equipment".

**2.1.5.6** A portion of open deck recessed into a deck structure, machinery casing, deck house, etc, used for the exclusive storage of gas bottles shall comply with the following requirements:

**.1** such a recess shall have an unobstructed opening, except for small appurtenant structures, such as opening corner radii, small sills, pillars, etc. The opening may be provided with grating walls and doors;

**.2** the depth of such a recess shall not be greater than 1 m;

**.3** a portion of the open deck complying with the requirements of 2.1.5.6.1 and 2.1.5.6.2, is considered as open deck in applying Tables 2.2.1.3-1, 2.2.1.3-2, 2.2.1.5-1, 2.2.1.5-2, 2.3.3-1, 2.3.3-2, 2.4.2-1, 2.4.2-2.

**2.1.5.7** Fan rooms serving engine rooms shall meet the following requirements:

**.1** a fan room solely serving the engine room or multiple spaces containing an engine room may be treated as machinery space having little or no fire

risk, in this case boundaries between the fan room and engine room casing shall be of "A-0" fire integrity;

.2 a fan room solely serving the engine room may be considered as part of the engine room, in this case the requirements for fire integrity of the horizontal boundary between fan room and engine room need not apply;

.3 for both of the cases described above, for any space(s) adjacent to the fan room superstructure, the fire integrity of the separating bulkhead(s) shall meet the applicable fire integrity requirements contained in the present Rules.

## 2.2 PASSENGER SHIPS

### 2.2.1 General.

2.2.1.1 The requirements of this Chapter are additional to those set out in 2.1.

2.2.1.2 For ships carrying more than 36 passengers, the hull, superstructure and deckhouses shall be divided into main vertical zones by "A-60" class divisions. Steps and recesses shall be kept to a minimum, but where they are necessary they shall also be "A-60" class divisions. Where a class 2.2.1.3 (5), 2.2.1.3 (9) or 2.2.1.3 (10) space is on one side of the division the class may be reduced to "A-0".

For ships carrying not more than 36 passengers, the hull, superstructure and deckhouses in way of accommodation and service spaces shall be divided into main vertical zones by "A" class divisions. These divisions shall have insulation values in accordance with Tables 2.2.1.5-1 and 2.2.1.5-2.

As far as practicable, the bulkheads forming the boundaries of the main vertical zones above the bulkhead deck shall be in line with watertight subdivision bulkheads situated immediately below the bulkhead deck. The length and width of main vertical zones may be extended to a maximum of 48 m in order to bring the ends of main vertical zones to coincide with subdivision watertight bulkheads or in order to accommodate a large public space extending for the whole length of the main vertical zone provided that the total area of the main vertical zone is not greater than 1600 m<sup>2</sup> on any deck.

If a stairway serves two main vertical zones, then maximum length of one main vertical zone shall be measured from the far side of the main vertical zone stairway enclosure. In this case, all boundaries of the stairway enclosure are to be insulated as main vertical zone bulkheads and access doors leading to the stairway are to be provided from these zones (refer to Figs. 2.2.1.2-1 to 2.2.1.2-4). However, the stairway is not to be included in calculating size of the main

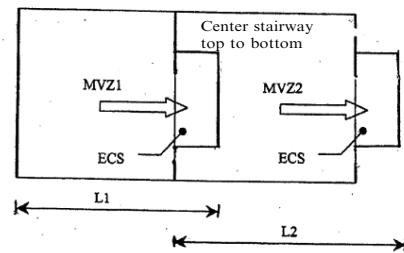


Fig. 2.2.1.2-1 ECS serves one MVZ

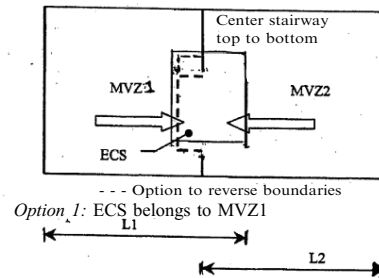


Fig. 2.2.1.2-2 ECS serves two MVZ

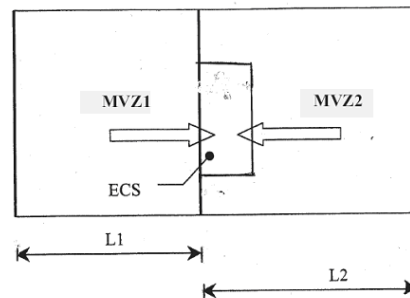


Fig. 2.2.1.2-3 ECS serves two MVZ (ECS belongs to MVZ2)

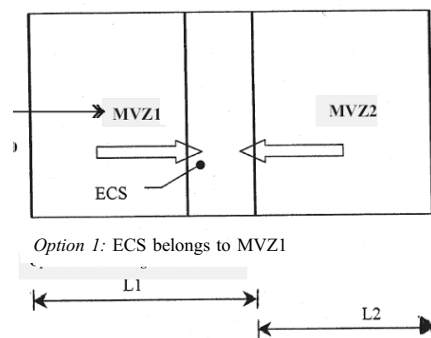


Fig. 2.2.1.2-4 ECS serves two MVZ

Notes:

MVZ: Main vertical zone

ECS: Escape stairway

→ : Direction of escape

vertical zone if it is treated as its own main vertical zone.

Bulkheads forming the boundaries of main vertical zones shall extend from deck to deck and to the shell or other boundaries.

Where the main vertical zone is divided by horizontal "A" class divisions into horizontal zones for the purpose of providing an appropriate barrier between sprinklered and non-sprinklered zones of the ship, the divisions shall extend between adjacent main vertical zone bulkheads and to the shell or exterior boundaries of the ship and shall be insulated in accordance with the fire insulation classes given in Table 2.2.1.5-2.

On ships designed for special purposes, such as automobile or railroad car ferries, where the provision of main vertical zone bulkheads would defeat the purpose for which the ship is intended, equivalent means for controlling and limiting a fire, such as water screens complying with the requirements of 3.5, shall be provided. Service spaces and storerooms if they are not protected in compliance with the applicable requirements shall not be located on decks of ships specified in 1.5.4.3.

**2.2.1.3** The minimum fire integrity of all bulkheads and decks separating adjacent spaces in ships carrying 36 passengers and more shall be as prescribed in Tables 2.2.1.3-1 and 2.2.1.3-2.

For the purpose of determining the class of structures between adjacent spaces, such spaces are classified according to their fire risk as follows.

(1) Control stations — spaces accommodating emergency sources of electrical power and lighting; wheelhouse and navigation room; spaces accommodating ship radio equipment; fire stations; main machinery control station if it is located outside the space accommodating such machinery; spaces accommodating centralized fire alarm system; spaces accommodating central control stations and emergency loud speaking system equipment.

(2) Stairways: interior stairways, lifts, fully enclosed trunks for evacuation and escalators for passengers and crew (except those, which are fully located in machinery spaces) and their enclosures.

A stairway which is enclosed at only one level shall be regarded as part of the space from which it is not separated by a fire door.

(3) Corridors:

corridors and lobbies for passengers and crew.

(4) Evacuation stations and external escape routes; survival craft stowage area; open deck spaces and enclosed promenades forming lifeboat and liferaft embarkation and launching stations; muster stations, internal and external; external stairs and open decks used for escape routes; the ship's side to the waterline in the lightest seagoing condition, su-

perstructure and deckhouse sides situated below and adjacent to the liferaft's and evacuation slide's embarkation areas.

(5) Open deck spaces:

open deck spaces and enclosed promenades clear of lifeboat and liferaft embarkation and launching stations. To be considered in this category, enclosed promenades shall have no fire risk. This means that furnishings shall be restricted to deck furniture. In addition, such places shall be naturally ventilated by permanent openings;

air spaces (spaces outside superstructures and deckhouses).

(6) Accommodation spaces of minor fire risk: cabins, offices, dispensaries and public spaces containing furniture and furnishings of restricted fire risk and having a deck area of less than 50 m<sup>2</sup> (refer to 1.2).

(7) Accommodation spaces of moderate fire risk: accommodation spaces as in category (6) containing furniture and furnishings other than of restricted fire risk; public spaces containing furniture and furnishings of restricted fire risk and having a deck area of 50 m<sup>2</sup> and greater;

isolated lockers and small storerooms in accommodation spaces having areas less than 4 m<sup>2</sup> (in which flammable liquids are not stowed), sales shops;

cleaning gear lockers, laboratories (in which flammable liquids are not stowed); drying rooms (having a deck area of 4 m<sup>2</sup> or less); diet kitchens (containing no open flame);

specie rooms;

motion picture projection rooms and film rooms;

drug-stores;

operating rooms;

spaces accommodating electrical distribution boards with an area less than 4 m<sup>2</sup>.

(8) Accommodation spaces of greater fire risk: public spaces containing furniture and furnishings of other than restricted fire risk and having a deck area of 50 m<sup>2</sup> and greater;

barber shops, beauty parlours and saunas.

(9) Sanitary and similar spaces:

communal sanitary facilities, showers, baths, water closets, etc.;

small laundry rooms;

indoor swimming pool area;

isolated serving pantries containing no cooking appliances in accommodation spaces.

Individual sanitary spaces shall be considered a portion of the spaces in which they are located.

(10) Tanks, voids and auxiliary machinery spaces having little or no fire risk:

water tanks forming part of the ship's structure; voids and cofferdams;

auxiliary machinery spaces which do not contain machinery having a pressure lubrication system and



Table 2.2.1.3-1

**Bulkheads not bounding either main vertical zones or horizontal zones**

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Control stations	(1)	B-0 <sup>1</sup>	A-0	A-0	A-0	A-0	A-60	A-60	A-60	A-0	A-0	A-60	A-60	A-60	A-60
Stairways	(2)		A-0 <sup>1</sup>	A-0	A-0	A-0	A-0	A-15	A-15	A-0 <sup>3</sup>	A-0	A-15	A-30	A-15	A-30
Corridors	(3)			B-15	A-60	A-0	B-15	B-15	B-15	B-15	A-0	A-15	A-30	A-0	A-30
Evacuation stations and external escape routes	(4)					A-0	A-60 <sup>2</sup>	A-60 <sup>2</sup>	A-60 <sup>2</sup>	A-0	A-0	A-60 <sup>2</sup>	A-60 <sup>2</sup>	A-60 <sup>2</sup>	A-60 <sup>2</sup>
Open deck spaces	(5)					—	A-0 <sup>4</sup>	A-0 <sup>4</sup>	A-0 <sup>4</sup>	A-0 <sup>4</sup>	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of minor fire risk	(6)						B-0	B-0	B-0	C	A-0	A-0	A-30	A-0	A-30
Accommodation spaces of moderate fire risk	(7)							B-0	B-0	C	A-0	A-15	A-60	A-15	A-60
Accommodation spaces of greater fire risk	(8)								B-0	C	A-0	A-30	A-60	A-15	A-60
Sanitary and similar spaces	(9)									C	A-0	A-0	A-0	A-0	A-0
Tanks, voids and auxiliary machinery spaces having minor or no fire risk	(10)										A-0 <sup>1</sup>	A-0	A-0	A-0	A-0
Auxiliary machinery spaces, cargo spaces, special category spaces, <sup>5</sup> cargo and other oil tanks and other similar spaces of moderate fire risk	(11)											A-0 <sup>1</sup>	A-0	A-0	A-15
Machinery spaces and main galleys	(12)												A-0 <sup>1</sup>	A-0	A-60
Storerooms, workshops, pantries, etc.	(13)													A-0 <sup>1</sup>	A-0
Other spaces in which flammable liquids are stored	(14)														A-30

<sup>1</sup>If adjacent spaces marked with footnote 1 have the same fire integrity, it is not necessary to divide such spaces with a bulkhead or deck. For instance for spaces of category (12) it is not necessary to divide a galley and buffets which are part thereof with bulkheads provided the bulkheads and buffet decks have the same fire resistance equal to that of structures bordering the galley. However, it is necessary to erect a bulkhead between the galley and machinery space although both spaces have the same category (12).

<sup>2</sup>The ship's side, to the waterline in the lightest seagoing condition, superstructure and deckhouse sides situated below and adjacent to the liferafts and evacuation slides may be reduced to "A-30" class.

<sup>3</sup>Where public toilets are installed completely within the stairway enclosure, the public toilet bulkhead within the stairway enclosure can be of "B" class fire integrity.

<sup>4</sup>Where spaces of categories (6), (7), (8) and (9) are located completely within the outer perimeter of the muster station, the bulkheads of these spaces are allowed to be of "B-0" class fire integrity. Control positions for audio, video and light installations may be considered as part of the muster station.

<sup>5</sup>Where fuel oil tanks are located under a special category space, the fire integrity of the separating deck may be reduced to "A-0" class.

Notes: 1. In respect of category (5) spaces, it is subject to the special consideration by the Register whether the insulation values in Table 2.2.1.3-1 shall apply to ends of deckhouses and superstructures, and whether the insulation values in Table 2.2.1.3-2 shall apply to weather decks. In no case shall the requirements of category (5) of Tables 2.2.1.3-1 to 2.2.1.3-2 necessitate enclosure of spaces which in the opinion of the Register need not be enclosed.

2. Where, due to any particular structural arrangements in the ship, difficulty is experienced in determining from the tables the minimum fire integrity value of any divisions, such values are subject to the special consideration by the Register.

3. Where the contents and use of a space are such that there is a doubt as to its classification, it shall be treated as a space within the relevant category having the most stringent boundary requirements.

4. Notwithstanding the provisions of 2.2.2 there are no special requirements for material or fire integrity of boundaries where only a dash appears in the tables.

5. Small enclosed spaces inside the room are treated as separate spaces if square of doorways to adjacent spaces is less than 30 per cent of openings (doorways). Fire integrity of bulkheads and decks surrounding such spaces shall comply with the requirements set forth in tables of the paragraph of the Rules.

where storage of combustibles is prohibited, such as: ventilation and air-conditioning rooms; windlass room; steering gear room; spaces accommodating stabilizer equipment; electrical propulsion motor room; rooms containing section switchboards and purely electrical equipment, except oil transformers (with capacity over 10 kVA); shaft alleys and pipe

tunnels; spaces for pumps and refrigeration machinery (not handling or using flammable liquids);

closed trunks serving the spaces listed above;

other closed trunks such as pipe and cable trunks.

(11) Auxiliary machinery spaces, cargo spaces, cargo and other oil tanks and other similar spaces of moderate fire risk:

Table 2.2.1.3-2

## Decks not forming steps in main vertical zones nor bounding horizontal zones

Spaces below		Spaces above													
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Control stations	(1)	A-30	A-30	A-15	A-0	A-0	A-0	A-15	A-30	A-0	A-0	A-0	A-60	A-0	A-60
Stairways	(2)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-30	A-0	A-30
Corridors	(3)	A-15	A-0	A-0 <sup>1</sup>	A-60	A-0	B-0	A-15	A-15	A-0	A-0	A-15	A-30	A-0	A-30
Evacuation stations and external escape routes	(4)	A-0	A-0	A-0	A-0	—	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Open deck spaces	(5)	A-0	A-0	A-0	A-0	—	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of minor fire risk	(6)	A-60	A-15	A-0	A-60	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of moderate fire risk	(7)	A-60	A-15	A-15	A-60	A-0	A-15	A-15	A-15	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of greater fire risk	(8)	A-60	A-15	A-15	A-60	A-0	A-0	A-15	A-30	A-0	A-0	A-0	A-0	A-0	A-0
Sanitary and similar spaces	(9)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Tanks, voids and auxiliary machinery spaces having minor or no fire risk	(10)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0 <sup>1</sup>	A-0	A-0	A-0	A-0
Auxiliary machinery spaces, cargo spaces, special category spaces, cargo and other oil tanks and other similar spaces of moderate fire risk	(11)	A-60	A-60	A-60	A-60	A-0	A-0	A-15	A-30	A-0	A-0	A-0 <sup>1</sup>	A-0	A-0	A-30
Machinery spaces and main galleys	(12)	A-60	A-60	A-60	A-60	A-0	A-60	A-60	A-60	A-0	A-0	A-30	A-30 <sup>1</sup>	A-0	A-60
Storerooms, workshops, pantries, etc.	(13)	A-60	A-30	A-15	A-60	A-0	A-15	A-30	A-30	A-0	A-0	A-0	A-0	A-0	A-0
Other spaces in which flammable liquids are stored	(14)	A-60	A-60	A-60	A-60	A-0	A-30	A-60	A-60	A-0	A-0	A-0	A-0	A-0	A-0

<sup>1</sup>Refer to footnote <sup>1</sup> to Table 2.2.1.3-1.

Note. Refer to notes to Table 2.2.1.3-1.

cargo oil tanks;  
 cargo holds, trunkways and hatchways;  
 refrigerated chambers;  
 fuel oil tanks (where installed in a separate space with no machinery);  
 shaft alleys and pipe tunnels allowing storage of combustibles;  
 auxiliary machinery spaces as in category (10) which contain machinery having a pressure lubrication system or where storage of combustibles is permitted;  
 fuel oil filling stations;  
 spaces containing turbine and reciprocating steam engine driven auxiliary generators and small internal combustion engines up to 110 kW driving generators, sprinkler, drencher or fire pumps, bilge pumps, etc.;  
 closed trunks serving the spaces listed above;  
 spaces accommodating oil transformers (with capacity over 10 kVA).  
 (12) Machinery spaces and main galleys:  
 engine and boiler rooms (other than electric propulsion motor rooms);  
 auxiliary machinery spaces other than those in categories (10) and (11) which contain internal com-

bustion machinery or other oil-burning, heating or pumping units;  
 main galleys and annexes;  
 trunks and casings to the spaces listed above.  
 (13) Storerooms, workshops, pantries, etc.:  
 main pantries, not annexed to galleys;  
 main laundry;  
 large drying rooms (having a deck area of more than 4 m<sup>2</sup>);  
 miscellaneous stores;  
 mail and baggage rooms;  
 garbage rooms;  
 workshops (not part of machinery spaces, galleys, etc.);  
 lockers and storerooms having areas of more than 4 m<sup>2</sup> and not having provisions for the storage of flammable liquids.  
 (14) Other spaces in which flammable liquids are stowed:  
 paint rooms;  
 storerooms containing flammable liquids (including dyes, medicines, etc.);  
 laboratories (in which flammable liquids are stowed).

**2.2.1.4** On ships carrying not more than 36 passengers, where a space is protected by an automatic sprinkler system or fitted with a continuous "B" class ceiling, openings in decks not forming steps in main vertical zones nor bounding horizontal zones shall be closed reasonably tight and such decks shall meet the "A" class requirements.

**2.2.1.5** The minimum fire integrity of all bulkheads and decks separating adjacent spaces in ships carrying not more than 36 passengers shall be as prescribed in Tables 2.2.1.5-1 and 2.2.1.5-2 with regard to the following:

**.1** for determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (I) to (II) below:

(I) control stations: spaces accommodating emergency sources of electrical power and lighting; wheelhouse and navigation room; spaces accommodating ship radio equipment; fire stations; main machinery control station if it is located outside machinery spaces; spaces accommodating centralized fire alarm system;

(2) corridors and lobbies;

(3) accommodation spaces as defined in 1.5.2, except corridors;

(4) stairways:

interior stairways, lifts, totally enclosed emergency escape exits trunks and escalators (other than those wholly contained within machinery spaces) and enclosures thereto.

In this connexion, a stairway which is enclosed only at one level shall be regarded as part of the space from which it is not separated by a fire door;

(5) service spaces (low risk):

lockers and storerooms not having provisions for the storage of flammable liquids and having areas less than 4 m<sup>2</sup>, drying rooms and laundries, spaces accommodating electrical distribution boards with an area less than 4 m<sup>2</sup>;

(6) machinery spaces of category A:

spaces as defined in 1.2, Part VII "Machinery Installations";

(7) other machinery spaces:

machinery spaces excluding spaces referred to in (6) and spaces accommodating electrical equipment (automatic telephone stations, spaces for air conditioning ducts);

(8) cargo spaces: all spaces, which are not special category spaces used for the carriage of cargo (including cargo tanks for oily products), as well as ventilation and hatch trunks servicing such spaces;

(9) service spaces (high risk): galleys, pantries containing appliances for hot food preparation, paint rooms, lockers and storerooms with an area of 4 m<sup>2</sup>

and over, spaces for storage of flammable liquids, saunas, workshops and similar spaces, which are not part of machinery spaces;

(10) open decks:

open deck spaces and enclosed promenades having no fire risk. To be considered in this category, enclosed promenades shall have no fire risk. This means that furnishings shall be restricted to deck furniture. In addition, such spaces shall be naturally ventilated by means of permanent openings;

air spaces (spaces outside superstructures and deckhouses).

(11) special category spaces as defined in 1.5.9 and ro-ro spaces in compliance with 1.5.4.3;

**.2** the doors from the cabins to individual sanitary spaces may be of combustible materials.

## **2.2.2 Accommodation and service spaces within a main vertical zone.**

**2.2.2.1** For ships carrying more than 36 passengers all bulkheads which are not required to be "A" class divisions shall be "B" class or "C" class divisions as prescribed in Table 2.2.1.3-1.

For ships carrying not more than 36 passengers all bulkheads within accommodation and service spaces which are not required to be "A" class divisions shall be "B" class or "C" class divisions as prescribed in Table 2.2.1.5-1.

All such divisions may be faced with combustible materials in accordance with the provisions of 2.1.1.10.

**2.2.2.2** For ships carrying not more than 36 passengers all corridor bulkheads where not required to be "A" class divisions shall be "B" class divisions which shall extend from deck to deck except:

**.1** when continuous "B" class ceilings or linings are fitted on both sides of the bulkhead, the portion of the bulkhead behind the continuous ceiling or lining shall be of material which, in thickness and composition, is acceptable in the construction of "B" class divisions but which shall be required to meet "B" class integrity standards only in so far as is reasonable and practicable in the opinion of the Register;

**.2** on ships equipped with an automatic sprinkler system complying with the provisions of Fire Safety Systems Code, corridor bulkheads may end by the corridor ceilings provided that such bulkheads and ceilings are of "B" class in accordance with 2.2.1.5. All doors and door frames in such bulkheads shall be made of non-combustible materials and they shall have the same fire integrity as the bulkhead in which they are fitted.

**2.2.2.3** Bulkheads required to be "B" class divisions, except corridor bulkheads required by 2.2.2.2, shall extend from deck to deck and to the shell or other boundaries unless the continuous "B" class ceilings or linings, having at least the same fire in-

Table 2.2.1.5-1

## Fire integrity of bulkheads separating adjacent spaces

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations	(1)	A-0 <sup>1</sup>	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*	A-60
Corridors and lobbies	(2)		C <sup>2</sup>	B-0 <sup>2</sup>	A-0 <sup>5</sup> B-0 <sup>2</sup>	B-0 <sup>2</sup>	A-60	A-0	A-0	A-15 A-0 <sup>3</sup>	*	A-15
Accommodation spaces	(3)			C <sup>2</sup>	A-0 <sup>5</sup> B-0 <sup>2</sup>	B-0 <sup>2</sup>	A-60	A-0	A-0	A-15 A-0 <sup>3</sup>	*	A-30 A-0 <sup>3</sup>
Stairways	(4)				A-0 <sup>5</sup> B-0 <sup>2</sup>	A-0 <sup>5</sup> B-0 <sup>2</sup>	A-60	A-0	A-0	A-15 A-0 <sup>3</sup>	*	A-15
Service spaces (low risk)	(5)					C <sup>2</sup>	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A	(6)						*	A-0	A-0	A-60	*	A-60
Other machinery spaces	(7)							A-0 <sup>4</sup>	A-0	A-0	*	A-0
Cargo spaces	(8)								*	A-0	*	A-0
Service spaces (high risk)	(9)									A-0 <sup>4</sup>	*	A-30
Open decks	(10)										—	A-0
Special category spaces	(11)											A-0

<sup>1</sup> Bulkheads separating the wheelhouse and chartroom from each other may be "B-0" class.  
<sup>2</sup> "B-0" or "C" class bulkheads, where appearing in the table as main fire-fighting bulkheads required by 2.2.1.2 shall be read as "A-0" class.  
<sup>3</sup> Where each of the adjacent spaces is protected by an automatic sprinkler system, the lower of the two values given in the tables may be used.  
<sup>4</sup> Where the spaces are used for the same purpose, no divisions may be fitted between them.  
<sup>5</sup> For clarification of the applicable fire integrity standard, refer to 2.2.2.1, 2.2.2.2 and 2.2.2.4.

Notes: 1. Where an asterisk appears in the tables the division shall be of steel or equivalent material, but is not required to be of "A" class. However, if in the deck except for the decks in a space of category (10), there are penetrations for electric cables, piping and ventilation ducts, such penetrations shall be flame and smoke tight. Divisions between control stations (emergency generators) and open decks may have air intake openings without closing appliances, except cases when fixed gas fire-fighting system is installed.  
 2. Refer to Note 3 and 5 to Table 2.2.1.3-1.

Table 2.2.1.5-2

## Fire integrity of decks separating adjacent spaces

Spaces below		Spaces above										
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0	*	A-30
Corridors and lobbies	(2)	A-0	*	*	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Accommodation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30 A-0 <sup>1</sup>
Stairways	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	A-0	*	A-0
Service spaces (low risk)	(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A	(6)	A-60	A-60	A-60	A-60	A-60	*	A-60 <sup>2</sup>	A-30	A-60	*	A-60
Other machinery spaces	(7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*	A-0
Cargo spaces	(8)	A-60	A-0	A-0	A-0	A-0	A-0	A-0	*	A-0	*	A-0
Service spaces (high risk)	(9)	A-60	A-30 A-0 <sup>1</sup>	A-30 A-0 <sup>1</sup>	A-30 A-0 <sup>1</sup>	A-0	A-60	A-0	A-0	A-0	*	A-30
Open decks	(10)	*	*	*	*	*	*	*	*	*	—	A-0
Special category spaces	(11)	A-60	A-15	A-30 A-0 <sup>1</sup>	A-15	A-0	A-30	A-0	A-0	A-30	A-0	A-0

<sup>1</sup> Refer to footnote 3 to Table 2.2.1.5-1.  
<sup>2</sup> Where other machinery spaces of category (7) are the spaces of low fire risk, i.e. they do not contain machinery operating in fuel oil or having a pressure lubrication systems, "A-0" class divisions are permitted.

Notes: 1. Refer to Note 1 to Table 2.2.1.5-1. Where the requirements of 2.2.1.2 are applicable, an asterisk means "A-0" class, except categories (8) and (10).  
2. Refer to Note 3 and 5 to Table 2.2.1.3-1.

tegrity as the adjacent bulkhead, are fitted on both sides of it, in which case the bulkhead may terminate at the continuous ceiling or lining. If an air gap between the cabins results in an opening in the continuous "B-15" class ceiling, the bulkheads on both sides of the air gap shall be of "B-15" class.

**2.2.2.4** Stairways in accommodation and service spaces shall be protected as follows:

Stairways and lifts shall be protected in the following way:

**.1** stairways shall be enclosed by "A" class divisions with positive closing appliances of all openings, except that a stairway connecting only two decks need not be enclosed, provided the integrity of the deck is ensured by proper bulkheads or self-closing doors. When a stairway is enclosed in 'tween deck, then this enclosure shall be protected in compliance with Tables 2.2.1.3-2 or 2.2.1.5-2;

**.2** stairways in public spaces may not have enclosures, provided they are located wholly within the public space;

**.3** lift trunks shall be so fitted as to prevent the penetration of smoke and flame from one 'tween-deck compartment to another and shall be provided with closing appliances to prevent draught and smoke penetration. Lifts machinery located within stairways enclosure shall be arranged in a separate space, surrounded by steel boundaries, except that small passages for lift cables are permitted. Lifts, which open into spaces other, than corridors, public spaces, special category spaces, stairways and external spaces shall not open (stop) into stairways serving as the means of escape;

**.4** stairway enclosures shall have direct communications with the corridors and be of sufficient area to comply with 8.5.4.2, Part III "Equipment, Arrangements and Outfit". Within the perimeter of such stairway, enclosures, only public toilets, lockers of non-combustible material providing storage for safety equipment and open information counters are permitted. Only public spaces, corridors, public toilets, special category spaces, other escape stairways required by Part III "Equipment, Arrangements and Outfit" and external areas are permitted to have direct access to these stairway enclosures;

**.5** one of the means of escape from a watertight compartment or a main fire vertical zone as required in 8.5.2.1, Part III "Equipment, Arrangements and Outfit" shall consist of enclosed stairways which provide a continuous shelter according to the requirements of 2.2.1.3 or 2.2.1.5.

**.6** protection of escape routes from the stairways enclosures to the life boats and life rafts embarkation stations shall be provided either directly, or by protected interior passageways, having fire integrity and insulation values for the stairways enclosures as

specified by Tables 2.2.1.3-1, 2.2.1.3-2, 2.2.1.5-1, 2.2.1.5-2, as applicable;

**.7** on passenger ships constructed on or after 1 July 2008, non-load bearing partial bulkheads which separate adjacent cabin balconies shall be capable of being opened by the crew from each side for the purpose of fighting fires.

**2.2.2.5** In all spaces, except for refrigerated provision storerooms, cargo spaces, mail baggage cabins and saunas, the ceilings, bulkheads, linings, draught stops and grounds shall be made of non-combustible materials.

Partial bulkheads or decks used to subdivide a space for utility or artistic treatment shall also be of non-combustible materials.

**2.2.2.6** In the case of ships fitted with an automatic sprinkler system, combustible materials used for erection of "C" class divisions may be added to the total volume of combustible materials mentioned in 2.1.1.10.

**2.2.2.7** The construction of ceiling and bulkheading shall be such that it will be possible, without impairing the efficiency of the fire protection, for the fire patrols to detect any smoke originating in concealed and inaccessible places, except where there is no risk of fire originating in such places.

**2.2.2.8** The furniture in stairway enclosures shall consist of seats only. It shall be fixed to six seats on each deck in each stairway enclosure, be of restricted fire risk determined in accordance with Fire Test Procedures Code and shall not create obstacles for passengers at the routes of escape. The Register may permit additional seating in the main reception area within the stairway enclosure if it is fixed, non-combustible and do not create obstacles for passengers at the routes of escape. The furniture shall not be permitted in passenger and crew corridors forming escape routes in cabin areas. In addition to the above lockers of non-combustible material, providing storage for fire-fighting equipment and life-saving appliances required by the present Rules may be permitted. Drinking water automation devices and ice cube machines may be permitted in corridors provided they are properly fixed and do not restrict the width of the escape routes. This applies as well to decorative flower or plant arrangements, statues or other objects of art such as painting and tapestries in corridors and stairways enclosures.

**2.2.2.9** Linings, ceilings and partial bulkheads used to screen or to separate adjacent cabin balconies shall be of non-combustible materials. Cabin balconies on passenger ships constructed before 1 July 2008 shall comply with the requirements of this paragraph by the first survey after 1 July 2008.

**2.2.2.10** Furniture and furnishings on cabin balconies of passenger ships.

Rooms containing furniture and furnishings of restricted fire risk, for the purpose of containment of fire in the place of origin, as mentioned in IMO Resolution MSC.99(73), are those rooms (whether cabins, public spaces, offices or other types of accommodation) in which:

**.1** case furniture such as desks, wardrobes, dressing tables, bureaux, dressers, are constructed entirely of approved non-combustible materials, except that a combustible veneer not exceeding 2 mm may be used on the working surface of such articles;

**.2** free-standing furniture such as chairs, sofas, tables, are constructed with frames of non-combustible materials;

**.3** draperies, curtains and other suspended textile materials have qualities of resistance to the propagation of flames not inferior to those of wool having a mass of 0,8 kg/m<sup>2</sup>, this being determined in accordance with the Fire Test Procedures Code;

**.4** 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** bedding components have qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code.

**2.2.2.11** On passenger ships, furniture and furnishings on cabin balconies shall comply with 2.2.2.10 unless such balconies are protected by a fixed pressure water-spraying and fixed fire detection and fire alarm systems complying with the requirements of 3.4.1.1 and 4.2.1.2.7.

Passenger ships constructed before 1 July 2008, shall comply with the requirements of this paragraph by the first survey after 1 July 2008.

### **2.2.3 Motor vehicles spaces, ro-ro spaces, special category spaces.**

**2.2.3.1** When the special category spaces cannot be protected by main vertical fire zones, their protection shall be ensured by subdivision into horizontal zones. These zones may cover more than one deck, but their overall height calculated as a sum of distances between adjacent decks without regard of framing height shall not exceed 10 m.

Fire doors and passages (cutouts) in decks and bulkheads of "A" class, forming boundaries, which separate horizontal areas from each other as well as the remain part of the ship shall meet the requirements applicable to fire doors and penetrations (cutouts) in horizontal areas (refer to 2.2.4).

**2.2.3.2** In ships carrying more than 36 passengers the boundary bulkheads and decks of special category spaces shall be "A-60" class. However, where a category 2.2.1.3 (5), 2.2.1.3 (9) or 2.2.1.3 (10) space is on one side of the division the class may be reduced

to "A-0". If fuel oil tanks are located under special category spaces, the fire integrity of decks between such spaces may be of "A-0" class.

In ships carrying not more than 36 passengers the boundary bulkheads of special category spaces shall be as required for category (II) spaces in 2.2.1.5-1 and the horizontal boundaries as required for category (II) spaces in Table 2.2.1.5-2.

In passenger ships carrying not more than 36 passengers, the bulkheads and decks forming boundaries of enclosed and open ro-ro spaces shall have fire integrity required for spaces of category (8) according to 2.2.1.5-1, while the horizontal boundaries shall have fire integrity required for spaces of category (8) according to 2.2.1.5-2.

**2.2.3.3** Indicators shall be provided on the navigating bridge which shall indicate when any fire door of special category spaces is closed.

**2.2.3.4** Special category spaces shall have means of escape leading to the lifeboat and liferaft embarkation places complying with the requirements of 8.5.1, 8.5.2.3, Part III "Equipment, Arrangements and Outfit" as well as the requirements of 2.1.4.7 and 2.2.2.4.1 of this Part.

One of escape routes from machinery spaces where the crew is normally engaged shall not have a direct access to the special category spaces.

### **2.2.4 Doors, windows and sidescuttles.**

**2.2.4.1** Except hatches between the cargo spaces, special category spaces, storerooms and baggage rooms, as well as between such spaces and open decks, all openings shall be provided with permanent closing appliances, having at least such fire integrity as the divisions, in which they are fitted.

Construction of doors and doorframes in the bulkheads of "A" class with locking devices shall provide the same fire integrity and smoke and flame tightness as the bulkheads, in which those doors are fitted as determined in compliance with the Fire Test Procedures Codes. Each door fitted in "A" class division shall be capable of being opened and closed manually from both sides of the bulkhead by one person only.

Fire doors in main vertical bulkheads, galley boundaries and stairway enclosures other than power-operated watertight doors and those which are normally locked, 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;

**.2** 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 ship in the upright position. The approximate uniform rate of closure for sliding fire doors shall be no more

than 0,2 m/s and no less than 0,1 m/s from the beginning of their movement with the ship in the upright position;

**.3** the doors shall be capable of remote release from the continuously manned main machinery control room, either simultaneously or in groups and shall be capable of release also individually from a position at both sides of the door. Release switches shall have an on-off function to prevent automatic resetting of the system;

**.4** hold-back hooks not subject to main fire control station release are prohibited;

**.5** a door closed remotely from the main fire 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;

**.6** indication shall be provided at the fire door indicator panel in the continuously manned main fire control station whether each of the remote-released doors is closed;

**.7** the release mechanism shall be so designed that the door will automatically close in case of disruption of the control system or main source of power;

**.8** 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 electrical power at least ten times (fully opened and closed) using the local controls;

**.9** disruption of the control system or main source of electrical power of one door shall not impair the safe functioning of other doors;

**.10** remote-released sliding or power-operated doors shall be equipped with an alarm that sounds for at least 5 s but no more than 10 s after the door is released from the main fire control station and before the door begins to move and continues sounding until the door is completely closed;

**.11** a door designed to re-open upon contacting an object in its path shall re-open not more than 1 m far from the point of contact;

**.12** 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 control system;

**.13** doors giving direct access to special category spaces which are power-operated and automatically closed need not be equipped with the alarms and remote-release mechanisms required in 2.4.4.1.3 and 2.4.4.1.10;

**.14** the components of the local control system shall be accessible for maintenance and adjusting; and

**.15** 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 Fire Test Procedures Code. This system shall satisfy the following requirements:

the control system shall be able to operate the door at the temperature of at least 200 °C for at least 60 min, served by the power supply;

the power supply for all other doors not subject to fire shall not be impaired;

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.

**2.2.4.2** Except watertight doors, weathertight doors (semi watertight doors), doors leading to the open decks, and doors required to be adequately gastight, all "A" class doors located in stairways, public spaces and main vertical zone bulkheads in escape routes shall be equipped with a self-closing hose port of material, construction and fire integrity which is equivalent to the door into which it is fitted, and shall be a 150 cm<sup>2</sup> clear opening with the door closed and shall be inset into the lower edge of the door, opposite the door hinges, or in the case of sliding doors, nearest the opening.

**2.2.4.3** Doors and doorframes in "B" class divisions and their locking devices shall ensure the same fire integrity as the divisions where they are installed in accordance with the Fire Test Procedures Code, except that ventilation openings may be permitted in the lower portion of such doors. If such ventilation openings are located in the door or under it, their total net area shall not exceed 0,05 m<sup>2</sup>. Alternatively, pressure-balancing ventilation duct made of non-combustible material is allowed to be arranged between the cabin and the corridor, and located below sanitary room if an area of its cross section does not exceed 0,05 m<sup>2</sup>. All such openings shall be fitted with grills made of non-combustible material. Cabin doors in "B" class divisions shall be of the self-closing type and shall have no hold-backs.

**2.2.4.4** Windows facing life-saving appliances, embarkation and muster areas, external stairs and open decks used for escape routes, and windows situated below liferaft and escape slide embarkation areas shall have the fire integrity as required in Table 2.2.1.3-1. Where automatic dedicated sprinkler heads are provided for windows, "A-0" class windows may be accepted as equivalent. Sprinklers shall be located above windows in addition to sprinklers of ceilings; alternatively this may be sprinklers of ceilings fitted in such manner that a window is protected by water flow with a feed of at least 5 l/min·m<sup>2</sup>, the square of a window shall be included into calculation of the area covered by the sprinkler. Windows located in the ship's side below the lifeboat embarkation areas shall have the fire integrity at least equal to "A-0" class.



All windows and side scuttles in bulkheads within accommodation and service spaces, and control stations, except those subject to provisions of 2.2.4.5 and 2.2.4.8, shall be fitted so as to ensure that fire integrity of the bulkheads they are fitted in is not impaired, which is determined in accordance with the Fire Test Procedures Code. Despite the requirements of Tables 2.2.1.3-1, 2.2.1.3-2, 2.2.1.5-1 and 2.2.1.5-2, windows and side scuttles in the outer bulkheads of accommodation spaces, service spaces and control stations shall have frames made of steel or other equivalent material and meet the requirements of 7.2.2.4, Part III "Equipment, Arrangements and Outfit".

**2.2.4.5** The requirements for "A" class fire integrity of ship external boundaries do not apply to glassed bulkheads, windows and side scuttles, provided that 2.2.4.4 does not contain the requirement that such boundaries shall be of "A" class. The requirements for "A" class fire integrity of the outer boundaries of a ship shall not apply to exterior doors, except for those in superstructures and deckhouses facing life-saving appliances, embarkation and external muster station areas, external stairs and open decks used for escape routes. Stairway enclosure doors need not meet this requirement.

**2.2.4.6** In passenger ships carrying not more than 36 passengers, it is allowed to use combustible materials for manufacture of doors separating cabins from internal individual sanitary spaces such as showers.

**2.2.4.7** Doors to machinery spaces of category A, other than power-operated watertight doors shall be arranged to ensure their positive closing by power operated closings arrangements or by fitting self-closing doors capable of being closed with an angle of inclination of up to 3,5° opposite to the door closure and equipped with locking device and remotely controlled release mechanism. Doors for the emergency escape trunks may not to be equipped with locking devices and remotely controlled release mechanisms.

Doors closure controls, required by 2.1.4.2.3, shall be located in one place or centralized at possibly less number of places. These places shall have free access from the open deck.

**2.2.4.8** The requirements for "B" class fire integrity of ship external boundaries do not apply to glassed bulkheads, windows and side scuttles. Such requirements for "B" class fire integrity do not apply to exterior doors in superstructures and deckhouses.

## 2.3 CARGO SHIPS

**2.3.1** The requirements of this Chapter are additional to those set out in 2.1 and apply to cargo ships of 500 gross tonnage and upwards.

**2.3.2** In way of accommodation and service spaces and control stations one of the following methods of protection shall be adopted:

*Method IC:* construction of internal subdivision bulkheads of non-combustible "B" or "C" class divisions, generally without installation in the accommodation and service spaces of the automatic sprinkler fire extinguishing system and fire detection systems;

*Method IIC:* the fitting of an automatic sprinkler system and fire alarm system in all spaces in which fire might be expected to originate, generally with no restriction on the type of internal bulkheads; or

*Method IIIC:* the fitting of a fixed fire detection and fire alarm system of approved type complying with requirements of 4.1 and 4.2 in spaces where fire might develop, generally with no restriction on the class of internal subdivision bulkheads, except that in no case shall the area of any accommodation space bounded by "A" or "B" class division exceeds 50 m<sup>2</sup>. Consideration may be given by the Register to increasing this area for public spaces.

The requirements on using non-combustible materials for the construction and insulation of bulkheads bounding machinery spaces, control stations, service spaces, etc, as well as protection of above mentioned trunks and stairways enclosures are common for all three methods described above.

**2.3.3** The minimum fire integrity of the bulkheads and decks separating adjacent spaces shall be as prescribed in Tables 2.3.3-1 and 2.3.3-2.

For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, the spaces are classified according to their fire risk as follows:

(1) control stations: spaces accommodating emergency sources of electrical power and lighting; wheel-house and navigation room; spaces accommodating ship radio equipment; fire stations; main machinery control station if it is located outside machinery space; spaces accommodating centralized fire alarm system;

(2) corridors and lobbies;

(3) accommodation spaces in accordance with 1.5.2, except corridors;

(4) stairways:

interior stairways, lifts, totally enclosed emergency escape trunks and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto.

A stairway which is enclosed only at one level shall be regarded as part of the space from which it is not separated by a fire door;

(5) service spaces (low risk):

storerooms not having provisions for the storage

Fire integrity of bulkheads separating adjacent spaces

Table 2.3.3-1

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations	(1)	A-0 <sup>1</sup>	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*	A-60
Corridors and lobbies	(2)		C	B-0	A-0 <sup>2</sup> B-0	B-0	A-60	A-0	A-0	A-0	*	A-30
Accommodation spaces	(3)			C <sup>3,4</sup>	A-0 <sup>2</sup> B-0	B-0	A-60	A-0	A-0	A-0	*	A-30
Stairways	(4)				A-0 <sup>2</sup> B-0	A-0 <sup>2</sup> B-0	A-60	A-0	A-0	A-0	*	A-30
Service spaces (low risk)	(5)					C	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A	(6)						*	A-0	A-0 <sup>5</sup>	A-60	*	A-60 <sup>6</sup>
Other machinery spaces	(7)							A-0 <sup>7</sup>	A-0	A-0	*	A-0
Cargo spaces	(8)								*	A-0	*	A-0
Service spaces (high risk)	(9)									A-0 <sup>7</sup>	*	A-30
Open decks	(10)										—	A-0
Ro-ro cargo spaces and spaces for motor vehicles	(11)											* <sup>8</sup>

<sup>1</sup>Bulkheads separating the wheelhouse, chartroom and radio room from each other may be "B-0" class.  
<sup>2</sup>For clarification as to which applies, refer to 2.1.4.3.  
<sup>3</sup>Doors separating cabins from individual sanitary accommodation may be constructed of combustible materials in method IC fire protection. No special requirements are imposed upon bulkheads in methods IIC and IIIC.  
<sup>4</sup>In case of method IIIC bulkheads of "B-0" class shall be provided between spaces or groups of spaces of 50 m<sup>2</sup> and over in area.  
<sup>5</sup>For cargo spaces intended for carriage of dangerous goods refer to 2.8.10.  
<sup>6</sup>"A-0" class may be used if no dangerous goods are intended to be carried.  
<sup>7</sup>Where spaces are used for the same purpose, divisions between them need not be fitted.  
<sup>8</sup>Openings in bulkheads and decks shall be closed reasonably gastight.

Notes: 1. Where an asterisk appears in the tables the division shall be of steel or equivalent but is not required to be of "A" class. However, if in the deck except for the decks in a space of category (10), there are penetrations for electric cables, piping and ventilation ducts, such penetrations shall be flame and smoke tight. Divisions between control stations (emergency generators) and open decks may have air intake openings without closing appliances, except cases when fixed gas fire-fighting system is installed.  
 2. Refer to Note 5 to Table 2.2.1.3-1.

Table 2.3.3-2

## Fire integrity of decks separating adjacent spaces

Spaces below		Spaces above										
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0	*	A-60
Corridors and lobbies	(2)	A-0	*	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30
Accommodation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30
Stairways	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	A-0	*	A-30
Service spaces (low risk)	(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A	(6)	A-60	A-60	A-60	A-60	A-60	*	A-60 <sup>1</sup>	A-30	A-60	*	A-60
Other machinery spaces	(7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*	A-0
Cargo spaces	(8)	A-60	A-0	A-0	A-0	A-0	A-0	A-0	*	A-0	*	A-0
Service spaces (high risk)	(9)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0 <sup>2</sup>	*	A-30
Open decks	(10)	*	*	*	*	*	*	*	*	*	—	*
Ro-ro cargo spaces and vehicle spaces	(11)	A-60	A-30	A-30	A-30	A-0	A-60	A-0	A-0	A-30	*	* <sup>3</sup>

<sup>1</sup> Where other machinery spaces of category (7) are the spaces of low fire risk, i.e. they do not contain machinery operating on fuel oil or having a pressure lubrication systems, "A-0" class divisions are permitted.  
<sup>2</sup> Refer to footnote 7 to Table 2.3.3-1.  
<sup>3</sup> Refer to footnote 8 to Table 2.3.3-1.  
 Notes: 1. Refer to Note 1 to Table 2.3.3-1.  
           2. Refer to Note 5 to Table 2.2.1.3-1.

of flammable liquids and having areas less than 4 m<sup>2</sup>, drying rooms, laundries and refrigerated provision storerooms insulated with non-combustible materials; spaces accommodating electrical distribution boards having an area of less than 4 m<sup>2</sup>;

(6) machinery spaces of category A:

spaces as defined in 1.2, Part VII "Machinery Installations";

(7) other machinery spaces:

machinery spaces excluding those specified in (6) and spaces accommodating electrical equipment (automatic telephone stations, spaces for air conditioning ducts);

(8) cargo spaces:

all spaces used for carriage of cargoes (including cargo tanks for oily products) as well as trunkways and hatchways to such spaces;

(9) service spaces (greater fire risk): galleys and pantries containing appliances for hot food preparation, saunas, paint lockers and storerooms with an area of 4 m<sup>2</sup> and over, spaces for storage of flammable liquids, workshops and similar spaces, which are not part of machinery spaces; refrigerated provision storerooms insulated with combustible materials;

(10) open decks:

open deck spaces and enclosed promenades having no fire risk. This means that their furnishings shall be restricted to deck furniture. In addition, such spaces shall be naturally ventilated by permanent openings:

air spaces (spaces outside superstructures and deckhouses);

(11) ro-ro cargo spaces and motor vehicles spaces as defined in 1.5.4.3 and 1.5.4.4.

**2.3.4** Linings, ceilings, draught stops and their associated grounds shall be made of non-combustible materials:

in accommodation and service spaces, and in control stations, if protection method IC is used;

in corridors and stairway enclosures serving accommodation and service spaces, and control stations, if protection methods IIC and IIIC are used.

**2.3.5** Within accommodation and service spaces bulkheads not required to be "A" or "B" class divisions shall be:

**.1** at least "C" class division in method IC fire protection;

**.2** not subject to any restrictions, except in cases where "C" class bulkheads are required in accordance with Table 2.3.3-1 in method IIC fire protection;

**.3** not subject to any restrictions except that in no case shall the area of any accommodation space or spaces bounded by "A" or "B" class divisions exceed 50 m<sup>2</sup> (except in cases where "C" class bulkheads are required in accordance with Table 2.3.3-1), in method IIIC fire protection.

Consideration may be given by the Register to increasing this area for public spaces.

If the IC method of protection has been used while ship construction, application of combustible materials may be allowed for doors separating cabins from internal sanitary spaces such as showers.

**2.3.6** The doors installed in the bulkheads bounding machinery spaces of category A shall be self-closing and adequately gastight.

**2.3.7** The doors required to be self-closing shall not be equipped with locking devices. However, locking devices may be used equipped with remotely controlled release mechanisms.

**2.3.8** In the corridor bulkheads ventilation openings may be permitted in and under the doors of cabins and public spaces. Ventilation openings are also permitted in "B" class doors leading to sanitary rooms, studies, pantries, lockers and storerooms. Except for the permitted below, openings shall be provided in the lower portion of such doors only. If such ventilation opening is located in or under the door, the total net area of such opening shall not exceed 0,05 m<sup>2</sup>. Alternatively, balancing duct made of non-combustible material and located below sanitary room is allowed to be arranged between the cabin and the corridor if an area of its cross section does not exceed 0,05 m<sup>2</sup>. Ventilation openings except the ones located under the door shall be fitted with grills made of non-combustible material.

**2.3.9** All bulkheads required to be "B" class divisions within accommodation spaces, shall extend from deck to deck and to the hull shell or other boundaries. However, if the continuous "B" class ceilings or linings are fitted on both sides of the bulkhead the bulkhead may terminate at the continuous ceiling or lining.

**2.3.10** For the purpose of application of the requirements of 2.1.1.7, 2.1.1.8 and 2.1.1.10 it is necessary to follow Fig. 2.3.10 and Tables 2.3.10-1 and 2.3.10-2. Table 2.3.10-1 is used for the method IC, Table 2.3.10-2 is used for the methods IIC and IIIC.

## 2.4 OIL TANKERS

**2.4.1** The requirements of this Chapter are additional to those set out in 2.1 and 2.3 (except for 2.3.3) when only method IC fire protection is adopted and apply to oil tankers and combination carriers of 500 gross tonnage and upwards.

**2.4.2** The minimum fire integrity of bulkheads and decks separating adjacent spaces shall be as prescribed in Tables 2.4.2-1 and 2.4.2-2 with regard to the following.

For determining the appropriate fire integrity standards to be applied to divisions between adjacent

Table 2.3.10-1

No.	Requirements to materials Structural member	Non-combustibility (refer to 2.3.4)	Non-combustibility (refer to 2.1.1.5)	Low flame-spread (refer to 2.1.1.8)	Total volume of combustible materials (refer to 2.1.1.10.1)	Calorific value (refer to 2.1.1.10)	Smoke generation (refer to 2.1.1.7)	Hardened combustibility (refer to 2.1.1.6)
1	Moldings				×			
2	Panels	×						
3	Painted surfaces, linings, textiles, films			×	×	×	×	
4	Painted surfaces, linings, textiles, films			×	×	×	×	
5	Decorations				×		×	
6	Painted surfaces, linings, textiles, films				×	×	×	
7	Plinth							
8	Insulation				×			
9	Surfaces and paints in concealed and inaccessible places		×	×				
10	Draught prevention seals	×		×				
11	Furring	×		×				
12	Linings	×						
13	Primary deck covering						×	×
14	Floor covering			×			×	
15	Scuttle frame	×						
16	Scuttle frame surface			×	×	×	×	
17	Scuttle frame surface in concealed and inaccessible places			×				
18	Ceiling panel	×						

Notes:

- Vapor barriers used for coating of the cooling systems piping (refer to 2.1.1.5) may be combustible, provided they are low flame-spread.
- Applied to paints, varnishes and other coatings.
- In corridors and stairways enclosures only.

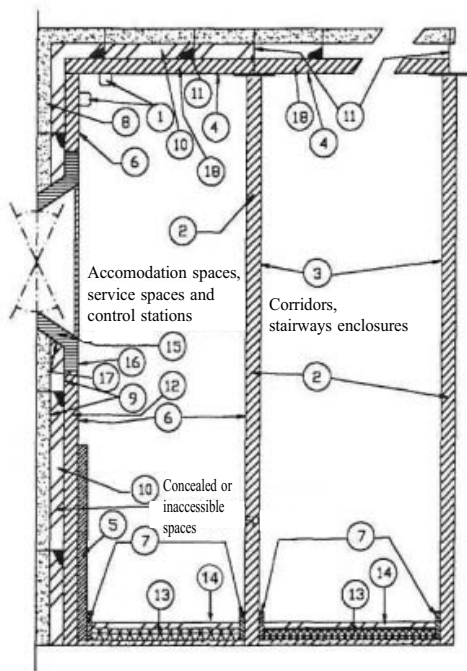


Fig. 2.3.10 Structural members

spaces, the spaces are classified according to their fire risk as follows:

(1) control stations: spaces accommodating emergency sources of electrical power and lighting;

wheelhouse and navigation room; spaces accommodating ship radio equipment; fire stations; main machinery control station if it is located outside machinery space; spaces accommodating centralized fire alarm system;

(2) corridors and lobbies;

(3) accommodation spaces as defined in 1.5.2, except corridors;

(4) stairways:

interior stairways, lifts, totally enclosed emergency escape trunks and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto.

A stairway which is enclosed only at one level shall be regarded as part of the space from which it is separated by a fire door;

(5) service spaces (low risk):

storerooms having areas less than 4 m<sup>2</sup> and not having provisions for the storage of flammable liquids, drying rooms, laundries and refrigerated provision storerooms insulated with non-combustible materials; spaces accommodating electrical distribution boards having an area of less than 4 m<sup>2</sup>;

(6) machinery spaces of category A:

spaces as defined in 1.2, Part VII "Machinery Installations";

(7) other machinery spaces:

Table 2.3.10-2

No.	Requirements to materials Structural member	Non-combustibility (refer to 2.3.4)	Non-combustibility (refer to 2.1.1.5)	Low flame-spread (refer to 2.1.1.8)	Total volume of combustible materials (refer to 2.1.1.10.1)	Calorific value (refer to 2.1.1.10)	Smoke generation (refer to 2.1.1.7)	Hardened combustibility (refer to 2.1.1.6)
1	Moldings				×			
2	Panels	×						
3	Painted surfaces, linings, textiles, films			×	×	×	×	
4	Painted surfaces, linings, textiles, films			×	×	×	×	
5	Decorations				×		×	
6	Painted surfaces, linings, textiles, films				×	×	×	
7	Plinth				×			
8	Insulation		×					
9	Surfaces and paints in concealed and inaccessible places			×				
10	Draught prevention seals	×						
11	Furring	×		×				
12	Linings	×						
13	Primary deck covering						×	×
14	Floor covering			×			×	
15	Scuttle frame	×						
16	Scuttle frame surface			×	×	×	×	
17	Scuttle frame surface in concealed and inaccessible places			×				
18	Ceiling panel	×						

Notes:

1. Vapor barriers used for coating of the cooling systems piping (refer to 2.1.1.5) may be combustible, provided they are low flame-spread.
2. When combustible materials are fitted on non-combustible bulkheads, ceilings and linings in accommodation and service spaces.
3. Applied to such accommodation and service spaces, which are bounded by non-combustible bulkheads, ceilings and linings.
4. Only in corridors and stairways enclosures servicing accommodation and service spaces and control stations.
5. Applied to paints, varnishes and other coatings.
6. In corridors and stairways enclosures only.

machinery spaces excluding spaces referred to in (6) and spaces accommodating electrical equipment (automatic telephone stations, spaces for air conditioning ducts);

(8) cargo pump rooms as defined in 1.5.7.1;

(9) service spaces (greater fire risk): galleys and pantries containing appliances for hot food preparation, saunas, paint lockers and storerooms with an area of 4 m<sup>2</sup> and over, spaces for storage of flammable liquids, workshops and similar spaces, which are not part of machinery spaces; refrigerated provision storerooms insulated with combustible materials;

(10) open decks:

open deck spaces and enclosed promenades having no fire risk. This means that their furnishings shall be restricted to deck furniture. In addition, such spaces shall be naturally ventilated by permanent openings.

air spaces (spaces outside superstructures and deckhouses);

**2.4.3** Exterior boundaries of superstructures and deckhouses enclosing accommodation and including any overhanging decks which support such accommodation, shall be constructed of steel and be "A-60" class for the whole of the portions which face the

cargo area and on the outward sides for a distance of 3 m from the end boundary facing the cargo area.

The distance of 3 m shall be measured horizontally and parallel to the centre plane of the ship from the boundary facing the cargo area at the each deck level. The insulation above shall be provided up to the underside of navigating bridge deck.

Lower part of the navigating bridge facing the cargo area shall be "A-60" class.

**2.4.4** Arrangement of openings shall meet the requirements of 2.4.4.1 to 2.4.4.3.

**2.4.4.1** Except as permitted in 2.4.4.2, access doors, air inlets and openings to accommodation spaces, service spaces, control stations and machinery spaces shall not face the cargo area. They shall be located on the transverse bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse at the distance of at least 4 per cent of the ship length but not less than 3 m from the end of the superstructure or deckhouse facing the cargo area. However, this distance need not exceed 5 m.

Access to forecabin spaces containing sources of ignition may be permitted through doors facing cargo area provided the doors are located outside ha-

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations	(1)	A-0 <sup>1</sup>	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*
Corridors and lobbies	(2)			B-0	A-0 B-0 <sup>2</sup>	B-0	A-60	A-0	A-60	A-0	*
Accommodation spaces	(3)		C	C	A-0 B-0 <sup>2</sup>	B-0	A-60	A-0	A-60	A-0	*
Stairways and lifts	(4)				A-0 B-0 <sup>2</sup>	A-0 B-0 <sup>2</sup>	A-60	A-0	A-60	A-0	*
Service spaces (low risk)	(5)					C	A-60	A-0	A-60	A-0	*
Machinery spaces of category A	(6)						*	A-0	A-0 <sup>3</sup>	A-60	*
Other machinery spaces	(7)							A-0 <sup>4</sup>	A-0	A-0	*
Cargo pump rooms	(8)								*	A-60	*
Service spaces (high risk)	(9)									A-0 <sup>4</sup>	*
Open decks	(10)										—

<sup>1</sup>Bulkheads separating the wheelhouse, chartroom and radio room from each other may be "B-0" class.  
<sup>2</sup>For clarification as to which applies, refer to 2.1.4.3.  
<sup>3</sup>Where bulkheads and decks are penetrated by cargo pump shafts, electric cables, etc. refer to 2.4.8.  
<sup>4</sup>Where spaces are used for the same purpose, divisions between them need not be fitted.

Notes : 1. Where an asterisk appears in the tables the division shall be of steel or other equivalent material but is not required to be of "A" class. However, if in the deck except for the decks in a space of category (10), there are penetrations for electric cables, piping and ventilation ducts, such penetrations shall be flame and smoke tight. Divisions between control stations (emergency generators) and open decks may have air intake openings without closing appliances, except cases when fixed gas fire-fighting system is installed.  
 2. Refer to Note 5 to Table 2.2.1.3-1.

Table 2.4.2-2

## Fire integrity of decks separating adjacent spaces

Spaces below		Spaces above									
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	—	A-0	*
Corridors and lobbies	(2)	A-0	*	*	A-0	*	A-60	A-0	—	A-0	*
Accommodation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	—	A-0	*
Stairways and lifts	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	—	A-0	*
Service spaces (low risk)	(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	—	A-0	*
Machinery spaces of category A	(6)	A-60	A-60	A-60	A-60	A-60	*	A-60 <sup>1</sup>	A-0	A-60	*
Other machinery spaces	(7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*
Cargo pump rooms	(8)	—	—	—	—	—	A-0 <sup>2</sup>	A-0	*	—	*
Service spaces (high risk)	(9)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	—	A-0 <sup>3</sup>	*
Open decks	(10)	*	*	*	*	*	*	*	*	*	*

<sup>1</sup>Where other machinery spaces of category (7) are the spaces of low fire risk, i.e. they do not contain machinery operating on fuel oil or having a pressure lubrication systems, "A-0" class divisions are permitted.  
<sup>2</sup> Refer to footnote 3 to Table 2.4.2-1.  
<sup>3</sup> Refer to footnote 4 to Table 2.4.2-1.  
Notes: 1. Refer to Note 1 to Table 2.4.2-1.  
2. Refer to Note 5 to Table 2.2.1.3-1.



zardous areas (refer to 19.2, Part XI "Electrical Equipment").

**2.4.4.2** The Register may permit access doors in superstructures or deckhouses on transverse bulkheads facing the cargo area or on side bulkheads within 5 m (distance specified in 2.4.4.1), to cargo control rooms and to such service spaces as provision rooms, lockers and storerooms, provided they do not give direct or indirect access to any another space containing or providing for accommodation, control stations or service spaces such as galleys, pantries or workshops or similar spaces containing sources of vapour ignition. Boundaries of such space shall be of "A-60" class except for boundary facing the cargo area. Within the limits specified in 2.4.4.1 it is allowed to fit bolted plates for the removal of machinery. Wheelhouse doors and windows may be located within the limits specified in 2.4.4.1, so long as they are designed to ensure that the wheelhouse can be made rapidly and efficiently gas and vapour tight.

**2.4.4.3** The Register may permit access to a deck foam system room where foam tanks and control station are located within the distances specified in 2.4.4.1 provided the requirements of 2.4.4.2 are fulfilled and the door is located flush with a bulkhead.

**2.4.5** Windows and sidescuttles facing the cargo area and located on the sides of superstructures and deckhouses within the limits specified in 2.4.4.1 shall be of the fixed (non-opening) lights. Such windows and sidescuttles, except wheelhouse window, shall be of "A-60" class.

Except that "A-0" class standard is acceptable for windows and sidescuttles outside the limit specified in 2.4.4.1.

**2.4.6** The Register may permit a navigation position to be fitted above the cargo area where this is for navigation purposes only, and it shall be separated from the cargo tank deck by means of an open space with a height of at least 2 m. The fire protection of such a navigation position shall be as required for control stations in 2.4.2 and other provisions, as applicable, of this Part.

Where the control station is on the forecastle deck or in the forward part of the ship equipped with a fore cargo gear, an emergency exit shall be provided to ensure safe escape in case of fire.

**2.4.7** Machinery spaces shall be positioned aft of cargo tanks and slop tanks; they shall also be situated aft of pump rooms and cofferdams, but not necessarily aft of the fuel oil tanks. Any machinery space shall be isolated from cargo tanks and slop tanks by cofferdams, pump rooms, fuel oil tanks, or ballast tanks.

Pump rooms containing pumps and their accessories for ballasting those spaces situated adjacent to cargo tanks and slop tanks, and pumps for fuel oil

transfer may be used for isolation of machinery spaces from cargo tanks and slop tanks provided that such pump rooms have the same safety standard as that required for cargo pump rooms. The lower portion of the pump room bulkhead may be recessed into machinery spaces of category A to accommodate pumps. The deck head of the recess may be not more than one third of the moulded depth above the keel. In ships of not more than 25000 t deadweight, for reasons of access and satisfactory piping arrangements and on agreement with the Register, the deck head of the recess may be at a level of up to one half of the moulded depth above the keel.

A cargo tank or a slop tank adjoining machinery spaces by a corner shall be isolated therefrom by a corner cofferdam.

The design and dimensions of cofferdams shall comply with the requirements of 2.7.5.2, Part II "Hull".

Corner cofferdams inaccessible for inspection shall be fitted with suitable media.

No cargoes or wastes shall be stowed in cofferdams.

Void space or ballast water tank protecting fuel oil tank as shown in Fig. 2.4.7, need not be considered as a cargo area even though they have a cruciform contact with the cargo oil tank or slop tank. The void space protecting fuel oil tank is not considered as a cofferdam required above. Void spaces may be located as shown in Fig. 2.4.7 even though they have a cruciform contact with the slop tank.

**2.4.8** Pump rooms shall be closed in by gastight bulkheads.

Permanent approved gastight lighting enclosures may be installed in bulkheads and decks separating pump rooms from other spaces. These enclosures are intended for lighting of pump rooms provided that they are sufficiently durable and that fire integrity and gas-tightness of the bulkhead or deck is preserved.

**2.4.9** Control stations, cargo control stations, accommodation and service spaces (except for isolated cargo handling gear lockers) shall be positioned aft of all cargo tanks, slop tanks and spaces isolating cargo or slop tanks from machinery spaces, but not necessarily aft of the fuel oil tanks and ballast tanks, and shall be arranged in such a way that a single failure to a deck or bulkhead shall not permit the entry of gas or fumes from the cargo tanks into any of the above spaces. The recess provided in accordance with 2.4.7 may be disregarded when determining the location of the said spaces.

Enclosed smoking rooms shall be provided within the accommodation area. These spaces shall be formed by "B-15" class divisions, and facings shall

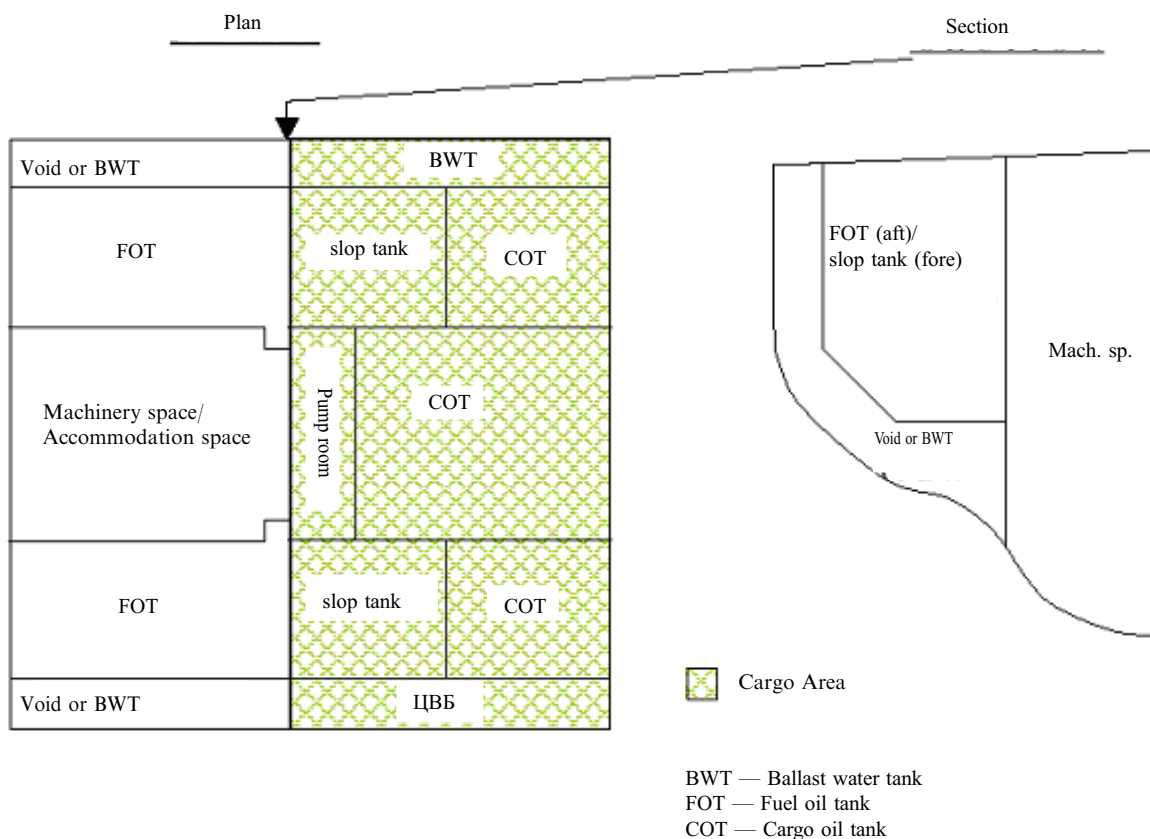


Fig. 2.4.7

be made of materials having low flame spread characteristics.

**2.4.10** Where deemed necessary and on agreement with the Register, control stations, cargo control rooms, accommodation and service spaces may be positioned forward of the cargo tanks, slop tanks and spaces which isolate cargo tanks and slop tanks from machinery spaces but not necessarily forward of fuel oil tanks or ballast tanks. Machinery spaces other than category A may be permitted forward of the cargo tanks and slop tanks provided they are isolated from the cargo tanks and slop tanks by cofferdams, pump rooms, fuel oil tanks or ballast tanks.

All of the above-mentioned spaces shall be subject to an equivalent standard of safety and appropriate availability of fire-fighting arrangements. Control stations, cargo control rooms, accommodation and service spaces shall be arranged in such a way that a single failure of a deck or a bulkhead shall not permit the entry of gas or fumes from the cargo tanks into such spaces. In addition, where deemed necessary for the safety of navigation of the ship, machinery spaces containing internal combustion engines not being main propulsion machinery having

output greater than 375 kW may be located forward of the cargo area.

Paint lockers, regardless of their use shall not be positioned above the tanks and spaces as determined in 2.4.9.

**2.4.11** No access holes to fuel oil tanks located in the double bottom below cargo tanks are permitted in cargo tanks and in the machinery space.

**2.4.12** Means shall be provided to keep deck spills away from the accommodation and service spaces. This may be accomplished by provision of a permanent continuous coaming of a height at least 300 mm from side to side. Similar measures and arrangements shall be provided for stern loading.

**2.4.13** Manholes, openings for cleaning cargo tanks and other openings shall not be arranged in completely enclosed or in semi-enclosed spaces.

**2.4.14** The following requirements shall be also met in combination carriers:

**.1** the slop tanks shall be surrounded by cofferdams, except where the boundaries of the slop tanks are the hull, main cargo deck, cargo pump room bulkhead or fuel oil bunker tank. These cofferdams shall not be open to a double bottom, pipe tunnel, pump room or other enclosed space, as well as they shall not be used

for carriage of cargo or ballast and they need not be connected with cargo or ballast systems.

Means shall be provided for filling the cofferdams with water and draining them.

Where the boundary of the slop tank is the cargo pump room bulkhead, the pump room shall not be open to the double bottom, pipe tunnel or other enclosed space. However, openings provided with gas-tight bolted covers may be permitted;

**.2** hatches and tank cleaning openings to slop tanks shall be only permitted on the open deck; they shall be fitted with closing arrangements, except where they consist of bolted plates with bolts at watertight spacing. Closing arrangements shall be fitted with securing devices controlled by responsible person out of ship officers;

**.3** arrangement of openings for cargo handling operations in decks and bulkheads separating the spaces for the carriage of oil and oil products from the spaces not intended or fitted for their carriage is permitted only provided equivalent tightness for oil products and their vapours is ensured;

**.4** detailed instructions shall be exhibited on board, covering safety measures to be taken during loading or unloading of the ship and when dry cargoes are carried with oil product residues in the slop tanks.

**2.4.15** Where the electrochemical protection is fitted on the ship it shall comply with the following requirements:

**.1** where the electrochemical protection of structures or their elements is fitted, anodes can be made of zinc, magnesium or aluminium alloys as well as of steel;

**.2** magnesium alloy anodes used for protection of unpainted elements of structures made of light metals shall be shielded by blinds which do not conduct electricity.

Additional painting shall be applied where magnesium alloy anodes are used on the suspended steel and aluminium structures;

**.3** magnesium alloy anodes and electrochemical protection systems with superimposed current are not permitted in oil cargo tanks and tanks adjacent to them of ships carrying oil products.

Use of magnesium alloy anodes in other places of possible concentration of combustible compounds is allowed upon the Register approval;

**.4** aluminium alloy anodes are only permitted in cargo tanks and tanks adjacent to cargo tanks of ships carrying oil products in locations where the potential energy does not exceed 275 J. The height of the anode shall be measured from the bottom of the tank to the centre of the anode, and its weight shall be taken as the weight of the anode as fitted, including the fitting devices and inserts.

However, where aluminium alloy anodes are located on horizontal surfaces such as bulkhead girders and stringers not less than 1 m wide and fitted with an upstanding flange or face flat projecting not less than 75 mm above the horizontal surface, the height of the anode may be measured from the surface.

Aluminium alloy anodes shall not be located under tank hatches or openings (in order to avoid any metal parts falling on the fitted anodes), unless protected by adjacent structure;

**.5** the anodes shall have steel covers and these shall be sufficiently rigid to avoid resonance in the anode support and be designed so that they retain the anode even when it is wasted. Anodes shall be fitted with delimiters from sides and bottom made of the material which does not spark while contact with the anode. The steel inserts shall be attached to the structure by means of a continuous weld of adequate section. Alternatively they may be attached to separate supports by bolting, provided a minimum of two bolts with locknuts are used.

However, the ways of attachment are subject to special consideration by the Register.

The supports at each end of an anode shall not be attached to separate items which are likely to move independently.

### 3 FIRE-FIGHTING EQUIPMENT AND SYSTEMS

#### 3.1 GENERAL

##### 3.1.1 General.

**3.1.1.1** The requirements of this Section are applicable to all fire-fighting equipment and systems fitted in sea-going ships for the purpose of fire protection of the ship concerned.

Where provision is made in a ship for extra fire extinguishing systems in addition to those prescribed by this Section, such systems shall also comply with the requirements set out below, to an extent approved by the Register.

During design and manufacture of fire extinguishing systems requirements of Fire Safety Systems Code and Sections 1 — 5, Part VIII "Systems and Piping" shall be complied with.

**3.1.1.2** Fire-fighting equipment and systems shall be so constructed that they will be efficient and readily available for operation under all service conditions (refer to 2.3.1, Part VII "Machinery Installations").

**3.1.1.3** Containers and pressure vessels used in fire extinguishing systems shall meet the requirements set forth in 6.4, Part X "Boilers, Heat Exchangers and Pressure Vessels".

**3.1.1.4** The use of a fire extinguishing medium which either by itself or under expected conditions of use gives off toxic gases in such quantities as to endanger the persons shall not be permitted. It is prohibited to install in ships new fire extinguishing plants utilizing halon 1211, halon 1301 halon 2402, as well as perfluoridecarbons.

##### 3.1.2 Fire extinguishing systems.

**3.1.2.1** In addition to the water fire main system and in accordance with the purpose for which they are intended, all ship's spaces shall be protected by one of the fixed fire extinguishing systems according to Table 3.1.2.1, unless expressly provided otherwise.

The Register may consider the use of other equivalent systems, ensuring equivalent protection.

Fitting of the equivalent fire extinguishing system approved by the Register and complying with the requirements of IMO MSC/Circ.848 is allowed in category A machinery spaces and pump rooms specified in 1.5.7.1 instead of the carbon dioxide smothering system, while fitting of water mist fire extinguishing system approved by the Register according to MSC/Circ.668, MSC/Circ.728 and MSC/Circ.1165 is allowed instead of water-spraying system.

For protection of spaces specified in 1.5.4.3, 1.5.4.4 and 1.5.9, the Register may permit the use of fixed fire extinguishing system other than prescribed

by Table 3.1.2.1, if the full-scale test in conditions simulating spilled petroleum burning in the said space will prove that alternative system is not less effective in fire fighting (refer to MSC/Circ.914).

**3.1.2.2** Calculation of the required amount of the extinguishing medium shall be made for each protected space. The maximum calculation values shall be taken for the amount of stored extinguishing medium.

Fire extinguishing system shall be fitted with valves normally closed for transfer of fire extinguishing medium to the appropriate space.

Where two or more adjacent spaces presenting different degrees of fire risk are not separated by gastight or watertight bulkheads or decks, or where fuel oil can flow from one space into another and the possibility of such flowing is not eliminated structurally, the choice of extinguishing medium and, consequently, of a fire extinguishing system shall be made to comply with the requirements for the fire protection of the space which affords the greatest fire risk, and the calculation of the required amount of extinguishing medium and the rate of application shall be made on the basis of the total area or volume, respectively, of all spaces thus communicating.

**3.1.2.3** Where a fixed gas fire extinguishing system is used, the openings through which air may penetrate to or gas may escape from a protected space shall be capable of being closed from outside the protected space. Watertight and gastight doors in the bulkhead separating adjacent machinery spaces may be considered as closures of openings in such bulkhead only where they are of a self-closing type or operated remotely and the fire extinction stations, from which the extinguishing medium may be discharged, are provided with the signalling of the fully closed doors. In the absence of such signalling, the calculation of the required amount and the rate of discharge of extinguishing medium shall be based on the requirement of providing for the total volume (area) of the adjacent spaces.

**3.1.2.4** In multi-deck ships, one 'tweendeck is considered as separated from another 'tweendeck or hold by a gastight deck, provided the cargo hatchways, other hatchways and openings in this deck are closed with watertight or gastight steel hatch closures and covers, while watertight stops are fitted where the deck is pierced in way of the framing. In the absence of such closures and stops, the spaces shall be considered as communicating, and the extinguishing medium calculation shall be made on the basis of the total volume of the spaces.

Table 3.1.2.1

Nos	Description of spaces	Fixed fire extinguishing systems								
		Sprinkler	Pressure water-spraying	Water-screen	Drenching	Foam fire extinguishing	Carbon dioxide smothering	Inert gas	Dry powder	Aerosol
1	Control stations listed in 1.5.1.1	<sup>1</sup>								
2	Control stations listed in 1.5.1.2 <sup>2</sup>		+			+	+			+
3	Accommodation spaces listed in 1.5.2.1 and 1.5.2.2	<sup>1</sup>								
4	Service spaces listed in 1.5.3.1, 1.5.3.2.3 and 1.5.3.2.4	<sup>1</sup>								
5	Storerooms listed in 1.5.3.2.1				+					
6	Storerooms listed in 1.5.3.2.3 <sup>3</sup>	<sup>1</sup>	+			<sup>4</sup>	+		+	<sup>5</sup>
7	Cargo spaces listed in 1.5.4.3, 1.5.4.4		+	<sup>6</sup>		<sup>8</sup>	<sup>9</sup>	<sup>9</sup>		
8	Tanks for petroleum products, refer to 1.5.4.1					+				
9	Cargo spaces, refer to 1.5.4.2 <sup>7,10</sup>		<sup>11,12</sup>			<sup>4</sup>	+	+		
10	Machinery spaces of category A <sup>2,13</sup> , hangers and spaces where refuelling and hanger facilities are located		+			<sup>8</sup>	+			+
11	Silencers of internal combustion engines, exhaust gas boilers and in smoke uptakes of steam boilers, regenerators of gas turbine installations <sup>15</sup> and exhaust ventilation ducts galley ranges <sup>19</sup>		+				+			
12	Unattended machinery spaces containing propulsion electric motors, steam engines or steam turbines having power output not less than 375 kW		<sup>14</sup>			<sup>8</sup>	+			
13	Pump rooms listed in 1.5.7.1		+			<sup>8</sup>	<sup>16</sup>			<sup>5</sup>
14	Working spaces listed in 1.5.8.1		+			<sup>8</sup>	+			+
15	Fire zones of category A machinery spaces				<sup>17</sup>					
16	Special category spaces listed in 1.5.9		+							
17	Cargo tank deck in gas carriers and cargo piping and cargo manifolds								+	
18	Rooms for separators, etc. and other spaces specified in 4.2.7, Part VII "Machinery Installations"		+			<sup>8</sup>	+			+
19	Scavenge spaces of the crosshead type internal combustion engines (refer to 2.2.4, Part IX "Machinery")						+			
20	Area of forward and aft loading/unloading arrangements in oil tankers, helidecks					+				
21	Chain stoppers and cargo hose connections on oil tankers accommodated to mooring at point berths carried out to sea and fitted up with a forward cargo gear		+							
22	Corridors and stairways	<sup>18</sup>								

<sup>1</sup>Automatic sprinkler system shall be installed:

In passenger ships carrying more than 36 passengers in control stations, accommodation and service spaces including corridors and stairways. Alternatively, control stations, where water may damage essential equipment may be fitted with an approved fixed fire extinguishing system of another type (refer to 1.5.1.2). The system may not be fitted in spaces of minor or no fire risk as void spaces, public toilets, carbon dioxide cylinder rooms and similar spaces;

in passenger ships carrying not more than 36 passengers (where fixed smoke detection alarm system is fitted only in corridors, stairways and escape routes within accommodation spaces) in accommodation and service spaces and if the Register deems it necessary, in control stations (refer to 1.5.1.2), except in spaces of minor or no fire risk as void spaces, sanitary rooms, etc;

in cargo ships where method IIC is adopted in accommodation spaces, galleys and other service spaces, except spaces of minor or no fire risk as void spaces, sanitary rooms, etc.

<sup>2</sup> For glass-reinforced plastic ships specified in 2.9 a carbon dioxide smothering system shall be used. Where the capacity of emergency diesel-generator is lower than 375 kW, the control station space may be protected by portable fire extinguishers according to Table 5.1.2.

<sup>3</sup> Paint lockers and storerooms for flammable liquids, liquefied and compressed gases need not be fitted with a fixed fire extinguishing system, if the area of each storage space is not more than 4 m<sup>2</sup> (refer to 3.1.3.4). Spaces for storage of cargo specimen located in the tanker cargo area may not be fitted with fire extinguishing system.

<sup>4</sup> A system using medium expansion foam with expansion ratio of about 100:1 shall be used, except for the hangars for helicopters and enclosed garages where a system with foam expansion ratio about 1000:1 shall be employed.

<sup>5</sup> Explosion-proof aerosol generators shall be installed.

<sup>6</sup> Water screens are used in addition to the systems specified in cols 4, 7 and 10 in cases indicated in 2.2.1.2.

<sup>7</sup> A foam fire extinguishing system shall not be used for the protection of cargo spaces of container ships.

<sup>8</sup> A system using foam with expansion ratio of about 1000:1 shall be used, provided that foam concentrate is applicable for fire extinction of the cargoes carried.

<sup>9</sup> A carbon dioxide smothering system or inert gas fire extinguishing system may be installed only in the cargo spaces, which may be closed tightly from a location outside the said spaces. Refer also to 3.1.2.13.

<sup>10</sup> On agreement with the Register spaces for general cargoes except dangerous goods may not be fitted with fixed fire extinguishing systems in the following cases:

in passenger ships engaged in short voyages;

in passenger ships of less than 1000 gross tonnage, provided the ship is fitted with portable fire-fighting equipment for cargo spaces, as well as with steel hatch covers and effective closing appliances of all ventilating and other openings leading to cargo spaces;

in cargo ships of less than 2000 gross tonnage constructed or intended only for the carriage of ore, coal, grain, green timber, non-combustible cargoes and cargoes of minor fire risk (refer to Table 1 MSC/Circ.1146), provided the ship is fitted with steel hatch covers and effective closing appliances of all ventilating and other openings leading to cargo spaces;

in cargo spaces are carried only such cargoes, for which fixed gas fire extinguishing system is not efficient (refer to Table 2 of MSC/Circ.1146), provided the requirement of 7.2.5.2 is fulfilled.

<sup>11</sup> Only in fish meal spaces.

<sup>12</sup> Spaces for the carriage of Class 1 dangerous goods, except 1.4S, in addition to the smothering system shall be protected according to 7.2.5.3.

<sup>13</sup> Where an auxiliary oil-fired boiler or boilers as well as incinerators operating on fuel oil situated inside the machinery space is (are) not isolated from the rest of the space by gastight enclosure bulkheads and platforms, the machinery space shall be fitted with one of the above fire extinguishing systems, this system being capable of protecting the entire space, even where this machinery space does not contain any other oil-fired equipment or machinery, besides the above boilers.

<sup>14</sup> Pressure water-spraying system may be used only for spaces where steam turbines or steam engines are of enclosed type.

<sup>15</sup> Installation of one of the above systems is compulsory for all ships carrying flammable liquids and ships that serve them, all ships carrying readily flammable dry cargoes, irrespective of their gross tonnage, and for all other ships with a total power of main and auxiliary machinery more than 740 kW.

<sup>16</sup> A warning notice shall be provided at the carbon dioxide smothering system controls stating that because of ignition hazard caused by electrostatic discharges the system shall be used only for fire extinguishing but not for inerting purposes.

<sup>17</sup> Refer to 3.12.

<sup>18</sup> The sprinkler system is compulsory only on passenger ships carrying more than 36 passengers.

<sup>19</sup> In passenger ships carrying not more than 36 passengers and in cargo ships is required when ducts pass through some spaces located in way of accommodation spaces.

**3.1.2.5** Where a space protected by means of carbon dioxide smothering system and aerosol fire extinguishing system contains air reservoirs the required quantity of extinguishing medium shall be calculated on the basis of the designed volume of the protected space plus the excess of the free volume of the compressed air. If arrangements are made for discharging the compressed air outside the protected space, by means of relief valves and fuses provided on the air reservoirs then an increase of the quantity of carbon dioxide in the carbon dioxide smothering systems need not be provided and the volume of the air in the air receivers in the aerosol fire extinguishing systems while assessment of the quantity of the aerosol generating compound may be not considered (refer to 3.11.1.3).

**3.1.2.6** In order to prevent excessive pressure in spaces protected by fire smothering systems, due to discharge of extinguishing medium, such spaces shall be fitted with breather valves, where necessary, or other available means (e.g. air pipes or ventilation ducts) shall be used.

**3.1.2.7** Spaces for fuel oil units (refer to item 18 of Table 3.1.2.1) enclosed inside engine rooms may have either an independent fire extinguishing system or they may be protected by the fire extinguishing system of the engine room.

**3.1.2.8** Whatever a fixed fire extinguishing system is specified in Table 3.1.2.1 for boiler spaces of oil tankers in which crude oil or clops are used for boilers, provision shall be made for 135 l capacity foam extinguisher in compliance with 5.1.10 or an equivalent foam unit both equipped with fixed foam generators capable of delivering foam to the boiler fronts and to trap under burners, valves and connections. This fire extinguisher (unit) shall be remote operated from outside the boiler room.

**3.1.2.9** The systems shall be so arranged as to provide the delivery of extinguishing medium to the entire space protected, including the enclosed portions thereof (e.g. control stations, workshops, etc. in machinery spaces).

**3.1.2.10** The use of steam may be permitted by the Register depending on the particular case as an addition to the required fire extinguishing medium; the boiler or boilers available for supplying steam shall have an evaporation of at least 1,0 kg of steam per hour for each 0,75 m<sup>3</sup> of the gross volume of the largest space so protected.

**3.1.2.11** Where gas, which is a gaseous product of oil fuel combustion, is used as a fire extinguishing medium, the systems using it for protection of machinery and cargo spaces shall comply with the Fire Safety Systems Code.

**3.1.2.12** Liquid cargoes with the flash point above 60 °C other than oil products or liquid cargoes

liable to the requirements of IMO Code on Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk are treated as those with low fire risk and requiring no fixed foam fire extinguishing system.

**3.1.2.13** For protection of cargo spaces fitted with partially weathertight hatchway covers on board containerships (refer to IMO MSC/Circ.1087), the requirements of Section 2 of the above Circular shall serve as a guide when calculating the amount of carbon dioxide in the carbon dioxide fire extinguishing systems. If the clear gaps between hatchway covers exceed 50 mm, fixed pressure water-spraying system shall be fitted in the cargo spaces.

**3.1.2.14** Deep-fat cooking equipment shall be fitted with an automatic or manual fire extinguishing system tested according to the international standard ISO 15371 "Fire Extinguishing Systems for Protection of Galley Deep-Fat Cooking Equipment". Controls for manual operation of the fire extinguishing system shall be clearly labeled. When actuating this system the following shall be provided:

**1** automatic shutdown of electrical power supply to the deep-fat cooking equipment;

**2** the alarms giving warning of actuation of this system in a galley where deep fat cooking equipment is fitted.

Deep-fat cooking equipment shall be equipped with main and auxiliary thermostats with individual failure warning systems.

### **3.1.3 Arrangement and equipment of fire extinction stations.**

**3.1.3.1** Mechanical equipment, such as foam mixers, reservoirs, cylinders or vessels containing extinguishing medium or compressed air, inert gas generators, or high expansion foam generators, refrigerating plants, etc., as well as the starting controls of all fire extinguishing systems, except for the water fire main system, shall be arranged as a rule in fire extinction stations outside the protected spaces. Spaces for storage of fire extinguishing medium located below deck or having no access from the open deck shall be provided with mechanical ventilation system in compliance with 12.9.1, Part VIII "Systems and Piping".

The storage rooms for fixed gas fire extinguishing systems of fire extinction stations shall be used for no other purpose.

Pumps, other than those servicing the fire main, required for the water supply to fire extinguishing systems, their sources of power and controls shall be fitted outside the space or spaces protected by such systems and shall be so arranged as to prevent failure of any system in case of fire in the space or spaces protected.

**3.1.3.2** Fire extinction stations shall comply with the following requirements:

**.1** any entrance to the fire extinction stations shall be, as a rule, from the open deck and shall be independent of the protected space. If the station 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.

The means of controlling the fixed fire extinguishing system shall be readily accessible and shall be grouped in as few locations as possible at positions not likely to be cut off by a fire in the protected space;

**.2** stations shall not be arranged forward of the collision bulkhead;

**.3** bulkheads and decks (including doors and other means of closing any opening therein), which form the boundaries between them and adjacent enclosed spaces shall be gastight. Such storage rooms for fire extinguishing medium shall be considered as fire control stations when applying fire integrity tables;

**.4** the spaces housing stations shall be protected by heat insulation and shall be fitted with heating, if it is essential for normal operation of the station that positive temperature is maintained therein. The temperature in the spaces housing carbon dioxide extinction stations shall not exceed 45 °C;

**.5** air temperature in the station shall be controlled by means of thermometer so fitted therein that its readings are visible both from inside the station and, through a scuttle, from outside the station; in case of remote control of temperature limit the scuttle need not be required;

**.6** fire extinction stations for cargo spaces shall be provided with telephone or other means of communication with the main fire control station and with the machinery space, if operation of the fire extinction station is dependent on the equipment located in the machinery space;

**.7** entrance doors shall be opened outwards and kept permanently locked and one set of keys for the locks shall be kept in a closed case with a glazed door located near the lock;

**.8** all valves and other arrangements of the station shall be provided with nameplates identifying them with the spaces whose protection is controlled by the individual valves or arrangements. In addition, a schematic plan of the fire extinguishing system showing the controls and the spaces protected, as well as brief instructions for starting and operating the system shall be displayed in a conspicuous position within the station.

**3.1.3.3** In ships of less than 150 gross tonnage where arranging a fire extinction station outside the protected space is hardly feasible, as well as in special cases in ships under 500 gross tonnage where the volume of individual protected spaces does not exceed

100 m<sup>3</sup>, reservoirs with fire extinguishing medium and pressure vessels may be fitted within a protected space on condition that such stations are provided with efficient remote control for immediately putting the system from outside the protected space; the remote starting control position shall be distinctly indicated and provided with lighting both from the general lighting and from the emergency lighting circuit.

**3.1.3.4** For lockers of a deck area of less than 4 m<sup>2</sup>, which do not give access to accommodation spaces carbon dioxide portable fire extinguisher providing a minimum volume of free gas to 40 per cent of the gross space volume, may be accepted in lieu of fixed fire extinguishing systems. The inlet port shall be arranged in a locker bulkhead to allow discharge of extinguishing medium without entry into the protected space. This portable fire extinguisher shall be stowed adjacent to the port. Alternatively, a port or hose connection may be provided to facilitate the use of fire main water.

**3.1.3.5** In passenger ships controls for any required fire extinguishing system for machinery spaces and the controls specified in 2.1.4.1, 2.1.4.2.3, as well as in 12.2.11 and 13.1.3, Part VIII "Systems and Piping" shall be located together or shall be grouped in as few places as possible. A safe access to these places from the open deck shall be provided.

**3.1.3.6** Requirements for distribution of fire extinguishing medium bottles of equivalent fixed gas fire extinguishing systems.

Fire extinguishing medium bottles stored in a protected space shall be distributed throughout the space with bottles or groups of bottles located in at least six separate locations. Duplicate power release lines shall be arranged to release all bottles simultaneously. The release lines shall be so arranged that in the event of damage to any power release line, five sixth of the fire extinguishing gas can still be discharged. The bottle valves are considered to be part of the release lines and a single failure shall include also failure of the bottle valve.

For systems that need less than six cylinders (using the smallest bottles available), the total amount of extinguishing gas on the bottles shall be such that in the event of a single failure to one of the release lines (including bottle valve), five sixth of the fire extinguishing gas can still be discharged. This may be achieved by for instance using more extinguishing gas than required so that if one bottle is not discharging due to a single fault, the remaining bottles will discharge the minimum five sixth of the required amount of gas. This can be achieved with minimum two bottles. However, NOAEL values calculated at the highest expected engine room temperature are not to be exceeded when discharging the total amount of extinguishing gas simultaneously.



Systems that can not comply with the above, for instance systems using only one bottle located inside the protected space, can not be accepted. Such systems shall be designed with the bottle(s) located outside the protected space, in a dedicated room in compliance with 3.1.3.2.

**3.1.3.7** Fire-extinguishing medium protecting the cargo holds may be stored in a room located

forward the cargo holds, but aft of the collision bulkhead, provided that both the local manual release mechanism and remote control(s) for the release of the media are fitted, and the latter is of robust construction or so protected as to remain operable in case of fire in the protected spaces. The remote controls shall be placed in the accommodation area in order to facilitate their ready accessibility by the crew. The capability to release different quantities of fire-extinguishing medium into different cargo holds so protected shall be included in the remote release arrangement.

#### **3.1.4 Pipes and fittings.**

**3.1.4.1** Pipes shall be so laid as to comply with the following requirements:

**.1** extinguishing medium shall be supplied to each protected space through a separate pipeline, with shut-off fittings provided thereon in the fire extinction station.

This requirement does not apply to the foam extinguishing systems intended to deliver foam from outside the cargo tanks by means of monitors and portable air-foam nozzles or foam generators producing average expansion foam;

**.2** where a cargo space provided with the pipes of a fire smothering system is periodically used for accommodation of passengers or special personnel, an additional closing arrangement shall be fitted to the pipes which shall be located in the fire extinction station behind the fire extinguishing medium discharge valve for the space in question;

**.3** laying the pipes of fire extinguishing systems through spaces containing fuel oil and lubricating oil shall not be permitted.

Pipes of fire extinguishing systems, shall not be laid through refrigerated spaces;

**.4** gas fire extinguishing systems may pass through accommodation spaces, provided they have sufficient wall thickness, and their gas tightness after installation on board a ship is tested by test pressure of not less, than 5 N/mm<sup>2</sup>. Besides, pipelines running through the accommodation spaces shall be connected by welding only and shall not have condensate drainage openings or other openings within such spaces;

**.5** all fire extinguishing systems shall be so designed as to permit periodical checks in operation.

Systems fitted with pipes and nozzles for supply of fire extinguishing medium shall have arrangements for checking them in operation using compressed air.

A non-return shut-off valve shall be fitted on the pipeline supplying compressed air to the manifold of the fire smothering station;

**.6** gaskets and flexible joints used in fire extinguishing systems shall be made of non-combustible materials resistant to the effect of the extinguishing medium, and marine environment.

**3.1.4.2** Pipes shall be made of steel.

Copper, copper-and-nickel or other bimetallic pipes (one of the layers being steel or copper) may be used as equivalent to steel pipes.

Carbon steel pipes shall have anti-corrosive coating both inside and outside.

The fittings of fire extinguishing systems, including sprinklers and sprayers, shall be made of materials resistant to the fire extinguishing medium and to marine environment. Nozzles and sprinklers shall be of type approved by the Register and tested in compliance with applicable provisions of MSC/Circ.668 and MSC/Circ.728 or the IMO Resolution A.800(19) as applicable.

#### **3.1.5 Starting of systems.**

**3.1.5.1** A system shall be put into operation without any supplementary change-over at the station and shall operate quickly and efficiently under all service conditions, including those when the temperature is below zero and during a fire.

**3.1.5.2** The possibility of spontaneous starting of a fire extinguishing system shall be excluded under any service conditions, including the effect of such factors as pitching and rolling, shaking and vibration.

**3.1.5.3** Release mechanisms shall be so arranged, and if necessary so protected, that a free access to them is provided and their mechanical damage is precluded.

**3.1.5.4** Arrangements shall be provided for the attachment of seals to the starting devices of the system.

**3.1.5.5** Irrespective of remote control provision the system shall be capable of being manually started directly at the fire extinction station, and the pump — at the place of its location.

**3.1.5.6** Remote control system (by air, nitrogen, carbon dioxide, etc.) shall be provided with two cylinders, gas quantity in each of them being sufficient for a single start.

**3.1.5.7** Where provision is made for mechanical devices in the remote starting system, their valves shall be controlled with the help of hand wheel or levers to be positively connected to the valve stems or spindles.

**3.1.5.8** Automatic discharge of fire extinguishing medium is not permitted except for cases stipulated by 3.3, 3.6.3 and 3.11.2.7.

### 3.2 WATER FIRE MAIN SYSTEM

#### 3.2.1 Number and capacity of fire pumps.

**3.2.1.1** In ships other than those referred to in 3.2.1.6, provision shall be made for pumps, fire mains, hydrants and hoses complying as applicable with the requirements of this Chapter.

The number of fixed independently driven fire pumps and the minimum pressure at all hydrants at water delivery through any adjacent hydrants by two pumps simultaneously of the quantity of water specified in 3.2.5.1 shall be not less than those specified in Table 3.2.1.1, the length of hoses complying with the requirements of 5.1.4, and the nozzle outlet diameters complying with 5.1.5.

Table 3.2.1.1

Gross tonnage	Passenger ships		Other ships	
	Number of pumps	Minimum pressure at hydrants, in MPa	Number of pumps	Minimum pressure at hydrants, in MPa
Under 500	2	0,30	1	0,20
500 to 1000	2	0,30	2	0,25
1000 to 4000	2	0,30	2	0,25
4000 to 6000	3	0,40	2	0,25
6000 and upwards	3	0,40	2	0,27
<b>Notes:</b> 1. The number of pumps indicated above does not include the emergency fire pump, if fitted. 2. The maximum pressure at any hydrant shall not exceed pressure, at which the effective control of a fire hose can be demonstrated.				

For ships of restricted areas of navigation, which are not engaged in international voyages (except for passenger ships) and have a gross tonnage under 2000, the requirement of Table 3.2.1.1 concerning the number of pumps may be waived subject to a special agreement with the Register.

On floating cranes with a gross tonnage under 2000, one fire pump may be installed.

The pressure developed by the fire pumps shall be sufficient to ensure the operation of other fire extinguishing systems using water (e.g., for pressure water spraying, froth extinguishing, etc.) and supplied from the same fire pumps.

**3.2.1.2** Passenger ships of less than 1000 gross tonnage and cargo ships of 2000 gross tonnage and over shall be provided with an emergency fire pump of a capacity not less than 25 m<sup>3</sup>/h and cargo ships of less than 2000 gross tonnage shall be provided with an emergency fire pump of a capacity not less than 15 m<sup>3</sup>/h independently driven, if fire in any single compartment may render all main fire pumps or their sources of power inoperable. Source of power and sea connection shall be located outside spaces in which

the main fire pumps or their sources of power are installed (refer also to 3.2.4.2 and 3.2.5.8).

For self-propelled ships of less than 500 gross tonnage, except passenger ships, the provision of an emergency fire pump is subject to special consideration by the Register. A diesel motor pump complying with the requirements of 5.1.17 may be used as such a pump.

**3.2.1.3** Emergency fire pump, if fitted, shall meet the requirements of 3.2.4.

**3.2.1.4** In addition to the provisions of 3.2.1.2 in passenger ships of less than 1000 gross tonnage and in cargo ships the emergency fire pump shall be also fitted in the following cases:

**1** the two main fire pumps, their sea suctions and the fuel supply or source of power for each pump are situated within compartments separated at least by "A-0" class divisions, so that a fire in any one compartment will not render both fire pumps inoperable;

**2** one main fire pumps is located in a compartment having more than one bulkhead or deck adjacent to the compartment containing the other main fire pump.

**3.2.1.5** The total capacity of fixed fire pumps, except for an emergency pump, if any, with the pressure at any hydrant not less than that specified in Table 3.2.1.1, shall ensure discharge of water for fire fighting in a quantity, in m<sup>3</sup>/h, not less than

$$Q = km^2 \quad (3.2.1.5)$$

where  $m = 1,68\sqrt{L(B+D+25)}$ ;

$L$  = length of the ship (refer to 1.1.3, Part II "Hull"), in m, excluding the length of the spoil hopper, if no tanks and other storages for combustible materials are installed therein, in hopper dredgers and hopper barges;

$B$  = moulded breadth, in m;

$D$  = depth to the bulkhead deck amidships, in m;

$k$  = coefficient equal to:

0,016 for passenger ships having subdivision index  $R$  equal to, or more than, 0,5;

0,012 for passenger ships having subdivision index  $R$  less than 0,5;

0,008 for all other ships;

$R$  = subdivision index determined in accordance with 2.3, Part V "Subdivision".

In all cases for passenger ships and cargo ships of more than 500 gross tonnage the required fire pumps shall provide the following water supply for fire-fighting purposes at the pressure specified in Table 3.2.1.1:

**1** in passenger ships – not less than two thirds of the quantity sucked from the holds by bilge pumps;

**2** in cargo ships – not less than four thirds of the quantity sucked from the holds of the same size passenger ship by each independent bilge pump according to the requirements of 7.1, Part VIII "Systems and Piping".

For catamarans and similar ships, the total capacity of fire pumps shall be determined as twice the capacity value for one hull.

**3.2.1.6** The fixed water fire main system need not be installed in ships with the crew of less than 3 members.

**3.2.1.7** In all ships other than passenger ships the total capacity of fire pumps need not exceed 180 m<sup>3</sup>/h, unless a larger capacity is required in order to ensure the simultaneous operation of other systems using water.

**3.2.1.8** The capacity, pressure head and number of fire pumps for floating docks shall be chosen in accordance with the quantity of water required by the largest cargo ship which the dock can carry, for the operation of the water fire main system.

On non-self-contained floating docks receiving water for the water fire main system from the shore the emergency fire pump need not be installed.

**3.2.1.9** Each fixed fire pump except of emergency shall be capable of supplying at least two jets of water required by 3.2.6.2.

**3.2.1.10** The capacity of each fixed pump, other than an emergency pump, shall not be less than 80 per cent of the total required capacity divided by the required number of fire pumps, but in any case not less than 25 m<sup>3</sup>/h.

If the number of fire pumps exceeds the required number, the feed of the additional pumps shall be at least 24 m<sup>3</sup>/h and it shall be sufficient to support at least two nozzles in accordance with 3.2.6.2.

**3.2.1.11** If other fire extinguishing systems using water supplied by fixed fire pumps are provided in ships, the capacity of these pumps shall be sufficient for the operation of the water fire main system having the capacity not less than 50 per cent determined by the Formula (3.2.1.5) and for parallel operation of one of the other systems requiring the largest quantity of water. In the case concerned the quantity of water for the water fire main system shall be sufficient for delivering at least two jets of water through largest nozzles used in the ships, but more than six jets and more than 90 m<sup>3</sup>/h for cargo ships are not required. Possible increase of water discharge through each hydrant due to the pressure rise in the pipes required for the operation of the other fire extinguishing systems shall be taken into consideration.

The quantity of water for fire extinguishing systems, other than for the water fire main system, shall be determined in accordance with the requirements in 3.3.2.2, 3.4.2, 3.5.2 (within one main vertical zone), 3.6.5 and 3.7.

### **3.2.2 Location of fire pumps.**

**3.2.2.1** In passenger ships of 1000 gross tonnage and upwards, sea valves, fire pumps and associated sources of power shall be so located as to ensure that a fire in any one compartment will not render all pumps simultaneously inoperative.

**3.2.2.2** In catamarans and similar ships, for which not less than two pumps are required in com-

pliance with Table 3.2.1.1, it is recommended that one pump be fitted in each hull.

In this case, water supply by each pump to the water fire main of any hull of the ship shall be ensured.

### **3.2.3 Basic requirements for fire pumps.**

**3.2.3.1** In all self-propelled ships, fixed fire pumps shall generally have an independent mechanical drive.

In cargo ships between 300 and 1000 gross tonnage, one of the pumps shall have an independent drive.

In cargo ships of less than 300 gross tonnage with the main propulsion machinery of power output less than 220 kW and in passenger ships of less than 150 gross tonnage with the main propulsion machinery of power output less than 220 kW, as well as in dynamically supported craft the pumps driven from the main engine may be used provided that the propulsion unit (engine-shaft-propeller) is so designed as to permit of fire pump operation when the ship is not under way.

On agreement with the Register, a V-belt drive from the main engine to the pump may be permitted in above ships, provided that transmission of torque is ensured even when one of the belts is broken.

**3.2.3.2** Fixed fire pumps including an emergency pump may be used for other shipboard services, if the ship is provided with at least two independently driven pumps, one of which is at all times kept readily available for its direct purpose.

Where in conformity with Table 3.2.1.1 only one fire pump is fitted, it may be used for other purposes requiring short-time consumption of water (flushing out of decks, hawse pipes etc.).

A fire pump may be used for emergency drainage of machinery spaces.

**3.2.3.3** In cargo ships where other pumps, such as general service, bilge, ballast, and etc., are fitted in a machinery space, provision shall be made to ensure that at least one of these pumps, having the capacity and pressure required by 3.2.1.11 and Table 3.2.1.1, is capable to supply water to the fire main. However, if the ship is equipped with the required number of fire pumps of necessary capacity and pressure, then it is sufficient to have a connection of the general service pump with water fire main system. Such pumps shall meet the requirements of 3.2.3.2 and 3.2.3.4.

**3.2.3.4** Pumps and piping intended for fire-fighting purposes shall not be used for the pumping of oil and other flammable liquids, nor as ballast pumps for tanks used for alternate carriage of fuel oil and water ballast.

**3.2.3.5** Fire pumps shall be fitted with a pressure gauge on the discharge side.

Pumps capable of developing in the fire main hydrants and hoses a pressure exceeding the permissible value shall be provided with relief valves set to operate at a pressure not more than 10 per cent in

excess of the fire main working pressure, and having the pipes to discharge water into the suction main. Location and adjustment of these valves shall prevent excessive pressure in any part of the fire main.

**3.2.3.6** Fixed fire pumps and their sea valves shall be located below the light-draught waterline of the ship.

A fixed emergency pump shall be installed in compliance with 3.2.4.

Fire pumps installed outside machinery spaces of category A shall have an independent sea valve in each compartment in which they are located.

In the case of ice ships, at least one of the pumps shall be connected with the heated ice box (refer to 4.3.1.2, Part VIII "Systems and Piping").

**3.2.3.7** All pumps, including the emergency pump, shall be placed in spaces with positive temperature.

**3.2.3.8** On passenger ships of 1000 gross tonnage and over and on all passenger ships with periodically unattended machinery spaces containing fire pumps, the water fire main system shall constantly be under pressure providing immediate the supply of at least one effective water jet from any of fire hydrants and automatic start of one of the required fire pumps at a drop of pressure.

On passenger ships of less than 1000 gross tonnage, the water fire main system shall enable the automatic and remote start-up of at least one fire pump from the navigating bridge. If the pump starts automatically or if the bottom valve can not be opened from location where the pump is remotely started, the bottom valve shall always be kept open.

**3.2.3.9** In cargo ships with a periodically unattended machinery space containing fire pumps or when only one person is required on watch provision shall be made for remote starting of one of the main fire pumps from the navigating bridge and from fire station if available and for immediate water supply in the fire main without additional opening of the valves in the pump room. At the location of such arrangement a water pressure indicator shall be installed.

Where water fire main system is under pressure as required in 3.2.3.8, remote starting need not be provided.

On the ships of less than 1600 gross tonnage, fulfilment of this requirement may not be provided, if starting arrangement of the fire pump in machinery space is easily accessible.

**3.2.4 Fixed emergency fire pump.**

**3.2.4.1** The emergency pump shall be driven by a diesel engine or an electric motor supplied with power from the emergency source of power.

**3.2.4.2** The pump, its sources of power and sea valves shall be so located as not to be rendered inoperative by a fire within the spaces where the main fire pumps are located.

The emergency fire pump, its seawater inlet, piping suction, delivery pipes and isolating valves shall be located outside the machinery space. If such arrangement can not be made, the sea chest may be fitted in the machinery space, if the valve is remotely controlled in the same compartment as the emergency fire pump, and the suction pipe is as short as practicable. Short lengths of suction or discharge piping may penetrate the machinery space, provided they are enclosed in a substantial steel casing or insulated to "A-60" class. They shall be welded except for flange connection to the sea valve and they shall have thickness not less than 11 mm.

Location of the pump and its drive shall allow free access to them for maintenance and repair.

**3.2.4.3** Where the pump is located above the lowest possible waterline, efficient arrangements shall be made for self-priming.

Under all conditions of heel, trim, pitch and roll, likely to be encountered in the ship service, the total suction head and the net positive suction head shall provide the fulfilment of the requirement of 3.2.4.6.

The design conditions for fulfilment of these requirements are as follows:

heel and trim data given in Table 2.3.1-1, Part VII "Machinery Installations". If the ship length exceeds 100 m, the trim may be taken as  $500/L$  where  $L$  is the ship's length (refer to 1.1.3, Part II "Hull");

loading condition of the ship without cargo or ballast water, with 10 per cent stores and fuel remaining (heel and trim not taken into account).

The ship in ballast entering or leaving the dry dock may not be considered as a ship in operation.

**3.2.4.4** The space containing the fire pump shall not be contiguous to the boundaries of machinery spaces of category A or those spaces containing main fire pumps. Where this is not practicable, the common bulkhead between the two spaces shall comply with the requirements of Table 2.3.3-1 for control stations.

When a single access to the emergency fire pump room is through another space adjoining a machinery space of category A or the spaces containing the main fire pumps, "A-60" class boundary is required between that other space and the machinery space of category A or the spaces containing the main fire pumps.

No direct access shall be permitted between the machinery space and the space containing the emergency fire pump and its source of power. When this is impracticable, an arrangement may be accepted where the access is by means of an air-lock where the door to the machinery space shall be made to "A-60" class and the second door shall be made at least of steel, each of the doors being self-closing and gas-tight, or through a watertight door capable of being

operated from a space remote from the machinery space and the space containing the emergency fire pump and unlikely to be cut off in the event of fire in those spaces. In such cases a second means of access to the space containing the emergency fire pump and its source of power shall be provided.

No hold-back hooks are permitted for the above doors.

**3.2.4.5** Any diesel driven source of power supplying the emergency fire pump shall be easily started manually in cold condition at a temperature up to 0 °C. If this source of power is installed in unheated space, it shall be fitted with electrical means of cooling water or lubricating oil heating, which ensure its quick start. If manual start of this source of power is practically impossible, then on agreement with the Register starting arrangements or other compressed air, hydraulically or electrically driven starting mechanisms shall be used. These mechanisms shall be such as to provide starting of the source of power at least six times during half an hour and, at least twice during the first 10 min.

Service fuel tank for the pump drive shall contain fuel sufficient to ensure the pump operation at full load for not less than three hours. Besides, outside the machinery space of category fuel stores shall be available sufficient to ensure the pump operation at full load for additional 15 hours.

**3.2.4.6** The capacity of the emergency fire pump shall be sufficient for the simultaneous operation of at least two fire hose nozzles of the largest size adopted in the ship, at a pressure in compliance with the requirements of Table 3.2.1.1, and shall be not less than 40 per cent of the total capacity of the fire pumps and in any case taking into account 3.2.1.2.

**3.2.4.7** If the emergency fire pump is the main supply of water for any fixed fire extinguishing system provided to protect the space where the main fire pumps are located, the pump shall have the capacity for this system and, in addition, the capacity required by 3.2.4.6.

### **3.2.5 Piping.**

**3.2.5.1** The diameters of the fire main and water service pipes shall be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously. In cargo ships the diameter need only be sufficient for the discharge of 140 m<sup>3</sup>/h.

In ships of 500 gross tonnage and upwards and floating cranes (refer to 3.2.5.6) the pipes of the fire main shall be rated at a working pressure of at least 1 MPa.

**3.2.5.2** To prevent freezing, the pipelines of the water fire main system extended to open decks or non-heated spaces shall be provided with shut-off fittings mounted in heated spaces, and with water drainage arrangements.

**3.2.5.3** Each fire pump shall be fitted with shut-off valves on the suction and discharge pipes.

The use of slide valves on the suction pipe is permitted.

In ships of 500 gross tonnage and upwards the valves on the discharge side of the pumps shall be of a non-return shut-off type.

**3.2.5.4** In oil tankers, the fire main shall comply with the following supplementary requirements:

**.1** on the main pipe where it is led out of the poop and in easily accessible places on the cargo oil tank deck, cut-off valves shall be fitted at the interval of not more than 40 m. Each of such valves shall be provided with an information plate to indicate that the valve shall be kept permanently open under normal service conditions;

**.2** before each cut-off valve on the fire main there shall be fitted twin fire hydrants of 70 mm diameter so located that they are equally spaced, over the length of the ship and the fulfilment of the requirements of 3.2.6.2 is ensured;

**.3** before the cut-off valve fitted in the poop there shall be a branch pipe on either side, led out from the fire main to the forward part of the poop deck; the diameter of each branch pipe shall be sufficient for supplying water through two fire hoses connected to two hydrants fitted at the end of each branch; in ships of 1000 gross tonnage and upwards the diameter of each hydrant provided shall be about 70 mm, and in ships of less gross tonnage this diameter shall be about 50 mm.

Where fire pumps are fitted forward of the cargo tanks, two more similar pipes branching from the fire main of the same diameter as above shall be provided on the after part of the forecastle deck, a cut-off valve being fitted on the fire main within the erection, after the branches.

**3.2.5.5** On catamarans and similar ships, each hull shall be provided with a water fire main system including water hydrants, hoses and nozzles.

**3.2.5.6** On all ships of 500 gross tonnage and upwards, and on floating cranes facilities shall be available on the open deck enabling an international shore connection to be used on either side of the ship (refer to 5.1.18).

**3.2.5.7** Isolating valves to separate the piping within the machinery space of category A containing the fire pump (or pumps) from the main outside it shall be fitted in machinery space water supply pipes in easily accessible positions (outside the machinery space).

The fire main shall be so arranged that when the isolating valves are shut all the hydrants on the ship, except those fitted in the piping separated from water supply, can be supplied with water by another fire pump located outside the machinery space.

Short lengths of the emergency fire pump suction and discharge piping may be permitted to penetrate the machinery space if it is impracticable to route it externally provided that the integrity of the fire main is maintained by the closure of the piping in a substantial steel casing.

### **3.2.6 Fire hydrants.**

**3.2.6.1** Each fire hydrant shall have a shut-off valve and a standard quick-acting coupling. Hydrants fitted on open decks shall also have quick-acting plugs, or equivalent device.

**3.2.6.2** The number and arrangement of fire hydrants shall ensure at least the delivery of two water jets from different hydrants, one of the jets being delivered through a hose of standard length as stipulated under 5.1.4.1, to any area of the ship which is generally accessible to passengers and crew during the voyage and to any part of any cargo space that is empty, ro-ro cargo space and for special-category spaces – to any part of the space through standard length hoses. In the latter case, two jets shall be delivered to any part of the space through standard length hoses. Besides, such hydrants shall be located near entrance to the protected spaces. In passenger ships the number and location of fire hydrants in the accommodation, service and machinery spaces shall be such that this requirement may be complied with when all watertight doors and all doors in main vertical zones are closed.

On open decks for containers two jets of water shall be delivered onto each accessible vertical side of the container by standard length hoses.

**3.2.6.3** The distance between fire hydrants is recommended to be not more than 20 m in spaces and 30 m on weather decks.

**3.2.6.4** Fire hydrants shall not be placed at the ends of dead-end corridors, in special electrical spaces or closed or rarely attended spaces.

**3.2.6.5** In ships, carrying deck cargoes fire hydrants shall be located to ensure easy access, while the pipes shall be located to avoid being damaged by cargo.

**3.2.6.6** In machinery space of category A at least two hydrants shall be provided. For ships of less than 500 gross tonnage only one such hydrant is permitted.

**3.2.6.7** In all ships there shall be fitted a fire hydrant located in the forward part of the propeller shaft tunnels.

**3.2.6.8** All fire hydrants shall be painted red.

**3.2.6.9** In passenger ships two fire hydrants shall be provided in the shaft tunnel, being one of the means of escape, in the proximity to the machinery space of category A.

Where some other space is used as a means of escape, two fire hydrants shall be provided therein at

the entrance to the machinery space of category A. Provision of 3.2.6.7 need not be met in this case.

## **3.3 SPRINKLER SYSTEM**

### **3.3.1 General.**

**3.3.1.1** The sprinkler system shall be of the wet pipe type but small exposed sections may be of the dry pipe type where in the opinion of the Register this is a necessary precaution. Any parts of the system which may be subjected to freezing temperature in service shall be suitably protected against freezing.

**3.3.1.2** A sprinkler system shall be automatically set in operation at temperatures in the protected space rising to the values indicated in 3.3.4.2.

**3.3.1.3** The automatic sprinkler system shall be kept charged at the necessary pressure and shall have provision for a continuous supply of water as required in the present Chapter.

**3.3.1.4** The air cylinder, compressor, pump and the pipes of the sprinkler system, except for the piping connecting the sprinkler system to the water fire main system, shall be independent of all other systems.

**3.3.1.5** A sprinkler pump and a pressure tank shall be arranged outside the protected space, at an adequate distance from the machinery spaces of category A. A gauge indicating the pressure in the system shall be provided at each section stop valve and at a central station.

**3.3.1.6** Means shall be provided for testing the automatic operation of the sprinkler pump on reduction of pressure in the system.

**3.3.1.7** When sprinkler systems equivalent to the systems specified in the present Chapter are used, they shall be approved by the Register according to the Guidelines adopted by the IMO Resolution A.800(19). When approving such systems special consideration shall be given to the fulfillment of the requirements of 3.3.1.1 to 3.3.1.3, 3.3.1.6, 3.3.2.1, 3.3.4.1, 3.3.5.1 and 3.3.5.2.

### **3.3.2 Sprinkler pumps.**

**3.3.2.1** An independent power pump shall be provided solely for the purpose of continuing automatically the discharge of water from the sprinklers. The pump shall be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted.

**3.3.2.2** The pump and piping system shall be capable of maintaining the necessary pressure at the level of the highest sprinkler to ensure a continuous flow rate of water sufficient for the simultaneous coverage of the minimum floor area of 280 m<sup>2</sup> at the application rate specified in 3.3.4.1.

For application to a ship with a total protected area of less than 280 m<sup>2</sup>, the Register may specify the appropriate area for sizing of pumps and supply components.

**3.3.2.3** The pump shall be fitted on the delivery side with a test valve with a short open-ended discharge pipe. The effective area through the valve and pipe shall be adequate to permit the release of the required pump output while maintaining the pressure in the system specified in 3.3.3.2.

**3.3.2.4** The sea inlet to the pump shall wherever possible be in the space containing the pump and shall be so arranged that when the ship is afloat it will not be necessary to shut off the supply of sea water to the pump for any purpose other than the inspection or repair of the pump.

**3.3.2.5** Provision shall be made for connection of the main supply piping with the ship's fire main. A lockable non-return shut-off valve shall be fitted at the connection concerned.

**3.3.2.6** There shall be not less than two sources of power for the pumps. Where the sources of power are electrical, the pump shall be supplied according to 4.3.1.5, 19.1.1.1, 19.1.1.2 and 19.1.2.1.7, Part XI "Electrical Equipment".

One of the sources of power for the pump may be an internal combustion engine which shall be so situated (besides compliance with the instructions of 3.3.1.5) that a fire in any protected space will not affect the air supply to the machinery.

### **3.3.3 Pressure tank.**

**3.3.3.1** The pressure tank shall be fitted with:

- .1 an automatic pressure maintaining device;
- .2 glass gauge;
- .3 a relief valve;
- .4 a pressure gauge.

**3.3.3.2** The pressure tank shall contain a standing charge of fresh water equivalent to the volume of water which would be discharged in one minute by the sprinkler pump.

The volume of the pressure tank shall be equal to at least twice that of the charge of water specified above.

Arrangements shall be made for maintaining such air pressure in the tank as to ensure that where the perennial supply of fresh water in the tank has been used the pressure in that tank is not less than a working pressure at the sprinkler plus a hydrostatic pressure from the tank bottom to the highest sprinkler.

Suitable means of replenishing the air under pressure and of replenishing the fresh water charge in the tank shall be provided. Means shall be also provided to prevent the passage of sea water into the tank.

**3.3.3.3** Pneumatic pressure tanks shall comply with the requirements for pressure vessels set out in

Part X "Boilers, Heat Exchangers and Pressure Vessels".

### **3.3.4 Sprinklers.**

**3.3.4.1** Sprinklers shall be placed in an overhead position and spaced in a suitable pattern to maintain an average application rate of not less than 5 l/min per 1 m<sup>2</sup> over the horizontal area of the protected space.

The Register may permit the use of other application rate depending on structural features of the protected space.

While protecting windows by sprinklers, the requirements of 2.2.4.4 shall be met.

**3.3.4.2** The sprinklers shall be resistant to corrosion by marine atmosphere. In accommodation and service spaces the sprinklers shall come into operation within the temperature range from 68 to 79 °C, except that in locations such as drying rooms where high ambient temperatures might be expected, the operation temperature may be increased by not more than 30 °C above the maximum deckhead temperature. In saunas, provision shall be made for empty sprinkler systems with the upper operating limit of 140 °C. Refrigerated chambers may be fitted with dry pipe sprinkler systems.

### **3.3.5 Control valves.**

**3.3.5.1** Each section of sprinklers shall include means for giving a visual and audible alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. Such alarm systems shall be such as to indicate if any fault occurs in the system. Such units shall indicate in which section served by the system a fire has occurred and shall be centralised on the navigating bridge or in the continuously manned central control station and, in addition, visible and audible alarms from the unit shall also be placed in a position other than on the aforementioned spaces to ensure that the indication of fire is immediately received by the crew.

**3.3.5.2** Switches shall be provided at one of the indicating positions referred to in 3.3.5.1 which will enable the alarm and the indicators for each section of sprinklers to be tested. A list or plan shall be displayed at each indicating unit showing the spaces covered and the location of the zone in respect of each section. Suitable instructions for testing and maintenance shall be available.

**3.3.5.3** A test valve shall be provided for testing the automatic alarm for each section of sprinklers by a discharge of water equivalent to the operation of one sprinkler. The test valve for each section shall be situated near the stop valve for that section.

### **3.3.6 Pipes.**

**3.3.6.1** Sprinklers shall be grouped into separate sections, each of them shall contain not more than

200 sprinklers. In passenger ships, any section of sprinklers shall not serve more than two decks and shall not be situated in more than one main vertical zone. However, the Register may permit such section of sprinklers to serve more than two deck or be situated in more than one main vertical zone, provided it shall not reduce, on the Register opinion, the fire protection of the ship.

**3.3.6.2** Provision shall be made in each section for purging the pipes with compressed air and flushing them with fresh water.

**3.3.6.3** Each section of sprinklers shall be capable of being isolated by one stop valve only after which a gauge shall be provided.

The stop valve in each section shall be readily accessible in a location outside of the associated section or in cabinets within stairway enclosures. The valve's location shall be clearly and permanently indicated.

Measures shall be taken to preclude unauthorized persons from operating the shut-off valves.

**3.3.6.4** The suction pipes of the pumps feeding a sprinkler system shall be fitted with filters.

**3.3.6.5** The diameters of the pipes of a sprinkler system shall be such as to ensure the operation of sprinklers at the water pressure and the rate of discharge specified in 3.3.2.2 and 3.3.4.1.

**3.3.6.6** The pipelines of the sprinkler system shall be fitted with non-return shut-off valves preventing sea water from penetrating into the pressure tank and the leakage of water from the tanks and the system.

#### 3.4 PRESSURE WATER-SPRAYING SYSTEM

**3.4.1** In machinery spaces of category A as well as in pump rooms specified in 1.5.7 pressure water-spraying system shall be supplied from an independent pump which shall be automatically put into action by a pressure drop in the system and from the fire main. A non-return shut-off valve shall be fitted on the connection line with the fire main.

In cargo spaces specified in 1.5.4.3 and 1.5.4.4 and in special category spaces (refer to 1.5.9) the pressure water-spraying system shall comply with the requirements of IMO Resolution A.123(V) "Recommendation on Fixed Fire Extinguishing Systems for Special Category Spaces". Such system shall protect all portions of any deck and sites for vehicles in the specified spaces, shall have manual control and pressure gauge at every distribution box with clear marking indicating protected spaces, as well as suitable maintenance and service instructions located at the valves section. Considering a substantial loss of stability, which may occur due to large concentration

of water on decks of specified spaces during system operation, measures shall be provided as stipulated in 7.6.12, Part VIII "Systems and Piping".

In spaces where flammable liquids are stored the system may be supplied only from the fire main.

Where high-pressure water-spraying system is used, the necessity for the reserve supply for such system shall be determined in each case on agreement with the Register, the rate of water supply shall be provided not less than specified in 3.4.2.1.

A fixed pressure water-spraying fire-extinguishing system complying with the provisions of the Fire Safety Systems Code shall be installed on cabin balconies of ships to which the requirement of 2.2.2.11 applies, where furniture and furnishings on such balconies are not as defined in 2.2.2.10.

The pressure finely disintegrated water-spraying systems in machinery spaces and cargo pump-rooms, referred to in 1.5.7.1, shall be submitted to the Register for approval in accordance with the "Revised Test Method for Equivalent Water-Based Fire-Extinguishing Systems for Machinery Spaces of Category A and Cargo Pump-Rooms" (refer to IMO MSC/Circ.1165 with regard to the amendments introduced by MSC.1/Circ.1237).

**3.4.2** The number and arrangement of the nozzles shall be such as to ensure an effective average distribution of water in the spaces to be protected of not less than:

- .1** 5 l/min per 1 m<sup>2</sup> of the horizontal area over which fuel oil is likely to spread or cargo space area;
- .2** 1,5 l/min per 1 m<sup>2</sup> of the largest horizontal cross-sectional area of the fish meal hold.

In cargo, working and special spaces, where the system may be divided into sections, the pump shall be capable of supplying two sections of the total length of at least 40 m.

**3.4.3** In machinery spaces of category A of ships specified in 1.5.7 the pressure water-spraying system shall be kept charged under the required pressure up to the valves on the distribution pipes. The pump supplying the water for the system shall be put automatically into action by a pressure drop in the system.

**3.4.4** Filters preventing the system and spray nozzles from becoming clogged shall be fitted on the suction pipe of the pump supplying the system and on the connection pipe with the fire main.

**3.4.5** Distribution valves shall be placed in easily accessible positions outside the protected spaces so as not to be readily cut off by a fire in the protected space.

Provision shall be made in the protected spaces, where people are permanently present, for remote control of distribution valves from these spaces.

**3.4.6** Spray nozzles shall be placed in the protected spaces as follows:

- .1** underneath the ceiling of the space;



**.2** above equipment and machinery using fuel oil or other flammable liquids and other fire hazardous objects;

**.3** above bilges, double bottom floor coverings and other surfaces over which fuel oil or flammable liquids are likely to spread;

**.4** above stacks of fish meal bags.

The spray nozzles shall be so disposed in the protected space that the area covered by one nozzle will overlap that covered by adjacent nozzles.

**3.4.7** Pump of the system providing protection of category A machinery spaces and pump rooms shall ensure a supply of water at the required pressure to all sections of the system in any compartment to be protected. The pump and its controls shall be installed outside the spaces to be protected.

The pump may be driven by independent internal combustion machinery which shall be so situated that a fire in the protected space will not affect the air supply to the machinery. If the pump is electrically driven from the emergency generator, the generator shall comply with the requirements of Section 9, Part XI "Electrical Equipment".

**3.4.8** Average rate of water supply specified in 3.4.2, shall be increased for the following spaces:

**.1** 20 l/min per 1 m<sup>2</sup> for boilers frontal parts and surfaces, fuel oil units, centrifugal separator (other than bilge water separators), and fuel filters;

**.2** 10 l/min per 1 m<sup>2</sup> for pipelines of heated fuel located near the exhaust pipes or similar heated surfaces of main and auxiliary diesel engines.

**3.4.9** Water-mist fire-extinguishing systems for Category A machinery spaces and cargo pump-rooms shall be approved by the Register based on the IMO MSC/Circ.1165.

**3.4.10** Fixed pressure water-spraying fire-extinguishing systems for cabin balconies shall be approved by the Register based on the IMO Resolution MSC.217(82).

### 3.5 WATER-SCREEN SYSTEM

**3.5.1** The present Rules provide for the use of the water-screen system in the following cases:

**.1** in special purpose ships where, subject to special agreement with the Register, water screens are permitted in lieu of "A" class divisions, in accordance with 2.2.1.2;

**.2** for protection of vertical surfaces of ships hull in compliance with 6.6.6.

**3.5.2** The design capacity of the pumps supplying the water-screen system shall be sufficient to provide at least 70 l/min per linear metre of the screen length.

### 3.6 DRENCHING SYSTEM

**3.6.1** The present Rules provide for the use of the water drenching system for drenching the racks of magazines (refer to 6.2.2.18 and Table 3.1.2.1).

**3.6.2** The drenching system shall be fed from the fire main. The pumps and associated sources of power shall be placed outside the space protected.

**3.6.3** The system shall be started from outside the space.

It is recommended that the system shall be put into action at a temperature rise in the space above admissible.

**3.6.4** The drenching system of magazines and the pressure water-spraying system of the cargo spaces fitted for the carriage of explosives may be used for their flooding in emergency.

**3.6.5** The capacity of the pumps supplying the system shall be sufficient to ensure the following rates of water discharge for drenching magazine racks, 24 l/min per 1 m<sup>2</sup> of the total magazine floor area.

### 3.7 FOAM FIRE EXTINGUISHING SYSTEM

#### 3.7.1 General.

**3.7.1.1** The foam fire extinguishing systems shall be capable to produce air mechanical foam for the use as an extinguishing medium depending on the foam expansion ratio:

of low expansion ratio (about 10:1);

of medium expansion ratio (between 50:1 and 150:1);

of high expansion ratio (about 1000:1).

Foam fire extinguishing systems may include units separately producing, but simultaneously supplying low expansion ratio foam and medium expansion ratio foam (combination foam).

**3.7.1.2** Use shall be made of foam concentrate of types approved by the Register (refer to 1.3.3.1).

A foam concentrate for generating low expansion and medium expansion foam shall be capable of being used both with fresh water and sea water.

**3.7.1.3** The capacity of foam fire extinguishing systems and the quantity of a foam concentrate shall be calculated depending on the foam expansion ratio, the rate of application of solution and operation time of the system given in Table 3.7.1.3 and in 3.7.2.1.

**3.7.1.4** Tanks for the storage of foam concentrate shall be fitted with arrangements for filling and draining, a device for watching the level of the liquid and a manhole for cleaning and inspecting. The tanks shall be of sufficient capacity to contain the full required amount of foam concentrate.

Table 3.7.1.3

Spaces	Rate of solution supply, in l/min·m <sup>2</sup> , with the foam expansion ratio			Rated time of continuous operation, in min
	10:1	100:1 <sup>1</sup>	1000:1	
Cargo oil tanks and cargo tank deck	$\begin{cases} 6^2 \\ 0,6 \\ 3 \\ 6^3 \end{cases}$	6 <sup>3</sup>	—	20 <sup>4</sup> /30
Tanks for oil products with a flash point 60°C and above (fuel oil tanks)	—	4,5 <sup>3</sup>	—	20
Dry cargo holds	—	4 <sup>3</sup>	—	45
Machinery spaces and other spaces whose equipment is oil-fired	—	—	1 <sup>3</sup>	— <sup>5</sup>
Paint lockers, storerooms for flammable liquids, flammable liquefied and compressed gases	—	4,5 <sup>3</sup>	—	20
Hangars for helicopters, enclosed garages, as well as spaces listed in 1.5.4.3 and 1.5.8.1	—	—	— <sup>6</sup>	45
<sup>1</sup> The solution supply rates apply to combination-foam production as well. <sup>2</sup> The rate of solution supply shall not be less than the greatest of the following: .1 6 l/min per square metre of the horizontal sectional area of the single tank having the largest such area; .2 0,6 l/min per square metre of cargo tanks deck area, where cargo tanks deck area means the maximum breadth of the ship multiplied by the total longitudinal extent of the cargo tank spaces; .3 3 l/min per square metre of the area protected by the largest monitor, such area being entirely forward of the monitor but not less than 1250 l/min. <sup>3</sup> For the area of the largest horizontal section of the largest protected space. <sup>4</sup> Sufficient foam concentrate shall be supplied to ensure at least 20 min of foam generation in oil tankers fitted with an inert gas system and 30 minutes in oil tankers not fitted with an inert gas system using largest rate of solution supply stipulated in Note 1. <sup>5</sup> Sufficient foam concentrate shall be supplied to ensure foam generation in the volume equal to 5-fold volume of the largest protected space. Foam expansion ratios shall not exceed 1000:1. <sup>6</sup> The rate of solution supply shall be sufficient for filling of the protected space volume during 15 min.				

If no excessive pressure is required to be created in tanks during the system operation, non-return valves shall be fitted between such tanks and the fire main.

Where a foam concentrate using fresh water is utilized in the high expansion foam system, at fire extinction station there shall be a foam concentrate sufficient for at least single foam fill up of the protected space of the largest volume. The remainder of the water may be supplied from ship's storage tanks. Equipment (pumps, fittings, etc.) necessary for supplying fresh water to the tank shall be arranged outside the protected space, be fed from the emergency diesel-generator and have a capacity sufficient to ensure continuous operation of the system as required in Table 3.7.1.3.

**3.7.1.5** The mixers for making aqueous solution of a foam concentrate of the required concentration shall be of an approved type. The mixers shall ensure operation of simultaneously used foam nozzles and/or foam generators.

**3.7.1.6** The main control station of the fixed deck system shall be located in the fire extinction station outside the cargo spaces in the vicinity of accommodation spaces and be easily accessible and ensure control of the system in the event of fire in protected areas. Sampling device for measurement of the percentage of foam concentrate in a solution shall be fitted at the fire extinction station on the fire main at a maximum distance from mixers, the pressure gauge shall be fitted on the pipe supplying water to the system.

The main equipment of the deck system (tanks with a foam concentrate, pumps, mixers, etc) may be located in the engine room.

**3.7.1.7** Upon special agreement with Register the use of the deck main for the foam fire extinguishing and water fire main systems is allowed, whereas demonstrated that the foam nozzles can be effectively operated by one person when foam is supplied at a pressure required for monitors. Additional foam concentrate shall be provided for 2 nozzles operation during the period of time according to Table 3.7.1.3.

### **3.7.2 Fixed deck systems.**

**3.7.2.1** The expansion ratio of the foam generated by the system shall not generally be greater than 12:1. If the system generates actually low expansion foam with expansion ratio slightly in excess of 12:1, the quantity of the foam solution shall be calculated as for the system with foam expansion ratio 12:1. Where the system generates the foam with expansion ratio somewhat below 12:1, the quantity of the foam solution shall be proportionally increased.

The system shall be capable of discharging through fixed discharge outlets in no more than 5 min, a quantity of foam sufficient to produce an effective foam blanket over the largest single area over which fuel oil is liable to spread.

Where medium expansion ratio foam is used in oil tankers, the amount of the foam concentrate shall be not less than the rated quantity and sufficient for the operation of the rated number of the foam generators and one monitor during 10 min.

**3.7.2.2** On oil tankers foam shall be supplied by means of monitors and foam applicators (refer to 5.1.6 and 5.1.19) to the entire cargo deck area and to any cargo tank whose deck was ruptured. The number and location of the foam main hydrants shall be such as to ensure foam supply to any part of the cargo tanks deck from at least two portable foam generators or manual air-foam nozzles.

**3.7.2.3** At least 50 per cent of the foam solution supply rate required in .1 and .2 of footnote 2 to Table 3.7.1.3 shall be delivered from each monitor.

On ships of less than 4000 t deadweight only portable foam generators or hand applicators may be employed. However, in such a case the capacity of each generator or applicator according to 5.1.19 or applicator according to 5.1.6.1 shall be at least 25 per cent of the foam solution supply rate required in .1 and .2 of footnote 2 to Table 3.7.1.3.

**3.7.2.4** The number and position of monitors shall be such as to comply with 3.7.2.2, 3.7.2.6 and 3.7.2.8. The solution-delivering capacity of any monitor shall not be less than indicated in .3 of footnote 2 to Table 3.7.1.3.

**3.7.2.5** It is recommended that a monitor shall be provided with a changing-over device for alternate supply of water and foam. Pipes branching from the fire main and foam solution supply piping shall be connected to the changing-over device.

In lieu of the changing-over device suitably interlocked shut-off valves may be fitted.

**3.7.2.6** The distance from the monitor to the farthest extremity of the protected area forward of that monitor shall be not more than 75 per cent of the monitor throw in still air conditions.

**3.7.2.7** The foam fire main in easily accessible places of the cargo deck shall be fitted with cut-off sluice or disc valves spaced 30 m apart. Next to each of such valves there shall be provided an information plate to indicate that the valve shall be kept permanently open under normal service conditions.

Before each cut-off valve fitted on the foam piping there shall be twin fire hydrants, 70 mm in inside diameter, for coupling thereto fire hoses with air-foam nozzles located at such distance that the requirements of 3.2.6.2 are met.

Branches from the fire main and foam piping to the monitors shall also be fitted before the cut-off valves.

Where medium expansion foam is used, twin fire hydrants shall be substituted by valve chests with a number of fire hydrants equal to 50 per cent of the required number of foam generators.

**3.7.2.8** In oil tankers, each foam fire extinction station shall be provided with a shut-off device located on the foam fire main before it extends beyond the boundaries of the station.

Before the shut-off device there shall be a branch led out to the forward part of the poop deck, both starboard and port, to monitors and twin fire hydrant, about 70 mm in inside diameter, for coupling thereto fire hoses with air-foam nozzles. For oil tankers of less than 4000 t deadweight, it is sufficient to provide only branch pipes to the said fire hydrants.

Where medium expansion foam is used, twin fire hydrants shall be substituted by valve chests with a number of fire hydrants equal to 50 per cent of the required number of foam generators.

**3.7.2.9** Foam fire extinguishing system for dry cargo spaces shall meet the following requirements:

**.1** a shut-off valve shall be fitted where the foam fire main is led out to the open deck;

**.2** provision shall be made for valve chests with fire hydrants to be fitted on the foam fire main on both sides. The distance between the valve chests of either side shall not exceed 40 m. The number of fire hydrants in each valve chest shall be equal to 50 per cent of the required number of foam generators.

**3.7.2.10** If a ship is provided with a fixed low and/or medium expansion foam system, there shall be provided branches from solution pipe line to entrances from the upper deck to machinery spaces as also to the fuel oil filling positions. Each branch shall be fitted with two hydrants for coupling thereto fire hoses with air-foam nozzles or foam generators.

**3.7.2.11** In ships where medium expansion mechanical foam is used, solution piping shall be connected to fire main to provide for the possibility of application of such foam for extinction of fires in accommodation and service spaces through the fire main. For this purpose provision shall be made for an appropriate number of portable foam generators at hydrants in accommodation and service spaces.

**3.7.2.12** The foam shall be delivered to the helideck the area of which is limited by the length of the operated helicopters from monitors or foam generators capable of delivering foam to all parts of the helideck in all weather conditions in which helicopters can operate. The system shall be capable of delivering a discharge rate specified in Table 3.7.2.12 for at least five minutes.

Table 3.7.2.12

Helicopter overall length, m	Discharge rate of foam solution, in l/min
up to but not including 15	250
from 15 up to but not including 24	500
from 24 up to but not including 35	800

**3.7.2.13** Instead of monitors and foam generators, permanent or portable combination foam units may be used respectively.

### 3.7.3 High expansion foam system.

**3.7.3.1** In spaces protected by a high expansion foam system provision shall be made in the upper part, opposite to foam delivery, for openings to discharge air during foam supply. Such openings shall be generally arranged beyond positions 1 and 2 as stipulated in 7.1.4, Part III "Equipment, Arrangements and Outfit". Where the outlets are otherwise arranged, they shall meet the requirements of 7.7 of the said Part.

**3.7.3.2** The cross-sectional area of the foam ducts shall be not less than that of foam generator orifices. Foam pipes shall be so laid that the head loss therein is minimized and discharge orifices shall be so located that there are no obstructions for free foam discharge into the protected space.

**3.7.3.3** A foam generator shall be of a design approved by the Register, ensuring the production of high expansion mechanical foam from the aqueous solution of foam concentrate of an approved type.

**3.7.3.4** A generator discharge orifice or foam duct at the place of its coming out beyond the station shall be provided with a closing device. This device shall open automatically concurrent with the foam discharge.

A manual control and position indicators "closed", "open" shall be provided.

**3.7.3.5** A special changing-over device shall be provided to discharge the foam to the protected space or to the open deck while putting the system to test. This device shall always be in a position to direct the foam discharge to the protected space and shall have an appliance for sealing in such position.

**3.7.3.6** Where the area of the protected space is more than 400 m<sup>2</sup>, at least two foam generators shall be provided discharging the foam to the zones of the protected space, far distant from each other.

**3.7.3.7** Equipment essential for the operation of the foam generators shall be supplied from the main and emergency sources of electrical power in accordance with the requirements of 4.3.1, 9.3 and 19.1.2, Part XI "Electrical Equipment".

## 3.8 CARBON DIOXIDE SMOTHERING SYSTEM

### 3.8.1 General.

**3.8.1.1** The amount of carbon dioxide, in kg, shall be determined by the formula

$$G = 1,79 V \varphi \quad (3.8.1.1)$$

where  $V$  = rated volume of the protected space, in m<sup>3</sup>;

- $\varphi$  = factor equal to:
- 0,3 for dry cargo holds and other spaces, except those indicated below;
  - 0,35 for machinery spaces, the rated volume of which is determined with regard to the full volume of casings;
  - 0,4 for machinery spaces, the rated volume of which is determined without any regard to the volume of casings from the level at which the horizontal area of the casings is equal to, or less than, 40 per cent of the horizontal cross sectional area of the space itself measured in the middle between the floor covering of the inner bottom and the trunk bottom and store-rooms specified in 1.5.3.2.2 (refer also to footnote 3 to Table 3.1.2.1);
  - 0,45 for spaces for the carriage of vehicles and ro-ro spaces, which are not special category spaces and may be closed tight from a position outside the spaces.

For machinery spaces such value of the factor  $\varphi$  shall be taken which results in a greater value  $G$ . In ships of less than 2000 tons gross tonnage, except for passenger ships, factors 0,35 and 0,4 may be reduced to 0,3 and 0,35, respectively, if two or more machinery spaces, which are not fully separated from each other, are considered as forming one space.

**3.8.1.2** Where a carbon dioxide smothering piping is used as a smoke detection one, the carbon dioxide distributing manifold may be placed together with the CO<sub>2</sub> release controls for each space protected by the smoke detection system near its detecting units. However, it is recommended that the provision of such manifold shall not preclude the possibility of discharging CO<sub>2</sub> into any of the protected spaces directly from the fire extinction station, if two or more machinery spaces, which are not fully separated from each other, are considered as forming one space.

**3.8.1.3** The total cross-sectional area of manifolds and the cross-section of the distributing manifold shall be not more than the sum of the cross-sections of the cylinder valves simultaneously opening for the largest by volume protected space (for high-pressure systems) and not more than the cross-section of the tank discharge valve (for low-pressure systems).

**3.8.1.4** The cross-sections of distributing pipes for individual protected spaces shall be not more than the sum of the cross-sections of cylinder discharge valves simultaneously opening for the space concerned (for high-pressure system) or not more than the cross-section of the tank discharge valve (for low-pressure systems). The sum of the cross-sections of the discharge pipes shall not exceed the cross-section of the supply pipe except where the calculated pressure drop in any pipe cross section is not less than 1 MPa.

**3.8.1.5** The supply of 85 per cent of the rated amount of carbon dioxide within not more than 2 min shall be ensured for machinery spaces.

The supply of 2/3 of the rated amount of carbon dioxide within not more than 10 min shall be ensured for spaces specified in 1.5.4.3.1 and 1.5.4.4.1.

**3.8.1.6** The thickness of pipe walls shall be calculated in accordance with 2.3, Part VIII "Systems and Piping"; in this case, the design pressure  $p$  is assumed as equal to the design pressure of cylinders and tankers according to 3.8.2.1 and 3.8.3.1 and shall be not less than the values specified in Table 2.3.8 of the above Part.

**3.8.1.7** Carbon dioxide shall be supplied to the protected spaces through nozzles arranged in the upper part of these spaces. The piping for the distribution of fire-extinguishing medium shall be arranged and discharge nozzles so positioned that a uniform distribution of the medium is obtained. Where the floor plates of the machinery spaces of category A are placed higher than one metre above the tank top, a number of nozzles (about 15 per cent of the total number) shall be fitted in the upper portion of the space below the plates.

**3.8.1.8** The total sectional area of the outlets of the nozzles of the space concerned shall not exceed 85 per cent of the total cross-section of the distributing piping.

**3.8.1.9** Perforated pipes may be used instead of nozzles in silencers, exhaust-gas boilers and smoke stacks. The total area of pipe perforations shall be by 10 per cent less than the pipe cross-section.

**3.8.1.10** In addition to the alarms required by 4.3.4, signal whistles operated by the released carbon dioxide pressure shall be fitted on pipes laid in the spaces listed in 4.3.1.

**3.8.1.11** The sealing materials for the valves and flexible hoses shall be usable at low temperatures down to  $-60^{\circ}\text{C}$ .

**3.8.1.12** In piping sections where valve arrangements introduce sections of closed piping, such sections shall be fitted with a pressure relief valve and the outlet of the valve shall be led to open deck.

**3.8.1.13** All discharge piping, fittings and nozzles in the protected spaces shall be constructed of materials having a melting temperature which exceeds  $925^{\circ}\text{C}$ . The piping and associated equipment shall be adequately supported.

**3.8.1.14** A fitting shall be installed in the discharge piping to permit the air testing.

### **3.8.2 High-pressure system.**

**3.8.2.1** The number of cylinders for storing liquid carbon dioxide shall be provided depending on the filling ratio (amount of carbon dioxide per 1 l of cylinder capacity) which is not to be more than 0,675 kg/l at the design cylinder pressure 12,5 MPa and over and not more than 0,75 kg/l at the cylinder design pressure 15 MPa and over.

When filling cylinders, deviation of not more than by  $\pm 0,5$  kg from the rated amount per cylinder is permitted.

In cases specified in 3.1.3.3 and 3.8.5 the filling ratio shall be reduced by 0,075 kg/l against the above values.

**3.8.2.2** The cylinders shall be placed vertically in rows on the pads which may be made of wood and shall be accessible for inspection and checking of the amount of carbon dioxide contained therein. Each cylinder shall be marked with its ordinal number.

Pilot cylinders shall be fitted in the fire extinction station and be coated with a distinguished paint.

**3.8.2.3** A pipe connecting a cylinder with a manifold shall be as a rule seamless and made of red copper. But use of special flexible hoses made of approved materials is permitted.

A non-return valve shall be fitted on the pipe connecting the cylinder and the manifold.

Arrangement of the manifolds shall provide their complete draining.

**3.8.2.4** A manifold of the carbon dioxide extinction station shall be fitted with a pressure gauge graduated to a value at least 1 MPa in excess of the hydraulic test pressure of the carbon dioxide cylinders. The value of the pressure gauge scale division shall not exceed 0,5 MPa.

**3.8.2.5** A carbon dioxide extinction station shall have arrangements for weighing the cylinders or measuring the level of liquid therein.

**3.8.2.6** Valves of cylinders.

**3.8.2.6.1** The valve shall have protective devices complying with the following requirements:

protective diaphragms shall break at a pressure rise in the cylinders up to  $(1,3 \pm 0,1)p$ , in MPa (where  $p$  is design pressure of the cylinder). For valves with slotted diaphragms which are additionally fitted with protective diaphragms the breaking pressure of slotted diaphragms shall be at least 1 MPa more than the highest value of the protective diaphragm breaking pressure;

there shall be provided a checking device to indicate that the protective device has operated.

**3.8.2.6.2** Where the lever type device is used to open the valve this device shall ensure the full opening of the valve by turning the lever to an angle not more than 90° and shall permit the valves to be opened individually or by groups.

**3.8.2.6.3** The cylinder valves shall be fitted with scarfed pipes cut short at 5 to 15 mm from the cylinder bottom; the inside diameter of the said valve pipes and of the pipes connecting the cylinder valves with a manifold shall be not less than 10 mm.

**3.8.2.6.4** If the design of the valves of pilot cylinders differs from that of the valves of all other cylinders, they shall be coated with a paint of another colour and have the inscription "starting".

**3.8.2.7** The gas from the protective devices of cylinders shall be discharged:

**.1** to the atmosphere beyond the boundaries of the station through a separate pipe provided with an audible alarm at the outlet;

**.2** to the distribution manifold where provision shall be made for:

two pipes, one of which is open-ended and fitted with a shut-off valve, and the other is provided with a protective diaphragm;

a signalling device to indicate the presence of pressure in the manifold whose readings shall be transmitted to the space where watch keepers are present all the time.

In this case, a checking device to indicate that the protective device has operated is not required for the valves.

**3.8.3 Low pressure system.**

**3.8.3.1** The rated amount of liquid carbon dioxide shall be stored in tank (tanks) at the working pressure of about 1,8 to 2,2 MPa which is ensured by maintaining a temperature of about  $-18^{\circ}\text{C}$ .

The normal liquid charge in the container shall be limited to provide sufficient vapour space to allow for expansion of the liquid under the maximum storage temperatures than can be obtained corresponding to the setting of the pressure relief valves but shall not exceed 95 per cent of the volumetric capacity of the container.

**3.8.3.2** A tank shall be served by two self-contained refrigerating plants, each consisting of one compressor, a condenser and a cooling battery.

The refrigerating capacity and the automatic control of each unit shall be so as to maintain the required temperature under conditions of continuous operation during 24 h at sea temperatures up to  $32^{\circ}\text{C}$  and ambient air temperatures up to  $45^{\circ}\text{C}$ .

When one of the plants is rendered inoperative, the other shall be automatically brought into operation.

Cooling batteries shall be separate for each plant or common, but they shall consist of not less than two isolated sections, each having a surface designed for full output.

In other respects, a refrigerating plant shall meet the requirements of Part XII "Refrigerating Plants" for unclassified plants (except for 3.3, 3.4, 3.5 and 6.2.6), as well as those of 2.1.1, 2.3.11, 2.3.12 and 7.2.2 for classed plants.

The system control devices and the refrigerating plants shall be located within the same room where the pressure vessels are stored.

**3.8.3.3** A tank shall be fitted with:

branches with shut-off valves for filling the tank;  
a discharge pipe;

a device for direct monitoring of liquid carbon dioxide level, mounted on the tank;

two relief valves with discharge pipes laid to the open air and arranged so as to provide disconnection of any of them with the remaining one connected with the container;

a pressure gauge;

high (not more than setting of the relief valve) and low (not less than 1,8 MPa) pressure;

lowest acceptable level alarm device.

The setting of each relief valve shall be at least  $1,1 - 1,2p$ , and its throughput shall be such that pressure in the tank with the valve fully open may not exceed  $1,35p$  (here  $p$  is working pressure in the tank, in MPa).

The value of the design pressure of the tank shall be assumed equal to the greatest lifting pressure of a relief valve.

**3.8.3.4** If fitted outside the tank, the level gauge pipe of the device for remote monitoring of the level of liquid shall be shut off with two valves (open throughout the period of operation) and provided with one control hydrant only, nominally filled (100 per cent). The pipe and the control hydrant shall be thermally insulated.

**3.8.3.5** If the system serves more than one space, means for control of discharge quantities of CO<sub>2</sub> shall be provided, e.g. automatic timer or accurate level indicators located at the control position(s). It shall be also possible to regulate the discharge manually.

**3.8.3.6** The tank and pipes led therefrom and permanently filled with carbon dioxide shall be provided with heat insulation preventing operation of the relief valve within 24 hours after the installation is de-energized, at the ambient temperature of 45 °C and initial pressure equal to the starting pressure of the refrigerating plant.

**3.8.3.7** Material for a tank shall meet the requirements of 3.3, Part XIII "Materials". Welds shall be radiographed as required for class II in Table 3.3.2-2, Part XIV "Welding".

**3.8.3.8** Safety relief devices shall be provided in each section of pipe that may be isolated by block valves and in which there could be a build-up of pressure in excess of the design pressure of any of the components.

**3.8.3.9** The alarm system shall give visual and audible alarm signals:

- when the maximum (not higher than the setting of the relief valve) and minimum (not less than 18 bar) pressure is reached in the tank;

- when the level of liquid carbon dioxide in the tank is reduced to the minimum acceptable level;

- in case of refrigerating plant failure;

- when the discharge of carbon dioxide begins.

The alarm signals shall be given at the main fire control station and in engineers' cabins.

#### **3.8.4 Release control.**

**3.8.4.1** Controls of systems protecting those spaces, which are normally manned, shall comply with the requirements of 3.8.4.2.

**3.8.4.2** At the position from which the system is remotely started, an alarm shall be provided for gas discharge from its storage containers and for gas release into a protected space (for gas pressure in front of and after the starting shut-off valve).

Two separate controls shall be provided for releasing carbon dioxide into the protected space and to ensure the activities 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 space. Positive means shall be provided so that both controls can only be operated in that order.

The two controls shall be located inside a release box clearly identified for the particular space. If the box containing the controls shall be locked, a key to the box should be in a break-glass type enclosure conspicuously located adjacent to the box.

**3.8.4.3** The pipes supplying carbon dioxide from pilot cylinders to servomotors shall be fitted with shut-off valves interlocked with a device opening pilot cylinders.

**3.8.4.4** In low pressure systems, release of carbon dioxide shall be manual. Where an automatic control system is provided to supply rated amount of carbon dioxide to protected spaces, manual regulation of gas supply shall also be provided.

Where the system serves more than one spaces, facilities shall be provided to control the amount of released carbon dioxide such as an automatic flow-meter or a precision level indicator located at the control station(s).

#### **3.8.5 Local carbon dioxide fire extinction stations.**

In well-founded cases local stations with not more than five cylinders (not more than 125 kg of carbon dioxide) may be permitted for certain protected spaces.

In a machinery space carbon dioxide cylinders may be placed for fire protection of crankcases and silencers of internal combustion engines, of smoke stacks and other enclosed compartments.

### **3.9 INERT GASES EXTINCTION SYSTEM**

**3.9.1** Gas used as a fire extinguishing medium shall be a gaseous product of fuel combustion, in which the content of oxygen, carbon dioxide, corrosive substances and any other solid combustible particles shall be kept to a permissible minimum.

**3.9.2** The capacity of the system shall be as follows:

- .1** for protection of machinery spaces – protection shall be ensured equivalent to that provided by the carbon dioxide fire smothering system;

- .2** for cargo spaces — the gas quantity shall be sufficient for receiving during 72 h of the free gas volume equal to, at least, 25 per cent gross volume of the largest protected spaces.

**3.9.3** The arrangement of the distribution pipeline and location of the discharge nozzles shall ensure the uniform distribution of fire extinguishing gas.

### **3.10 DRY POWDER SYSTEM**

#### **3.10.1 General.**

**3.10.1.1** An extinguishing powder approved by the Register for this purpose shall be used in the dry powder system.

**3.10.1.2** Nitrogen or other inert gas approved by the Register for this purpose shall be used as a propellant gas.

**3.10.1.3** The system shall consist of:

powder installations that contain dry powder containers, propellant gas cylinders and a distribution manifold;

hose stations;

pipes and fittings for bringing the system into action and powder supply to the hose stations.

**3.10.1.4** Provision shall be made for a remote release of the system from any hose station.

The system shall be brought into action in not more than 30 s after the opening of the release cylinder at the remotest hose station operating from the powder installation concerned.

#### **3.10.2 Quantity of dry powder and propellant gas. Capacity and number of nozzles.**

**3.10.2.1** A rated quantity of dry powder shall be stored in each container of the powder installation to provide a minimum 45 continuous discharge time at rated consumption for all attached monitors and hand hose lines.

**3.10.2.2** Each nozzle shall be capable of discharge at a rate not less than 3,5 kg/s, the powder throw range being not less than 8 m. In determining a maximum distance of coverage of each hand hose line the length of its hose shall be taken into account.

The capacity of each fixed monitor shall be at least 10 kg/s, maximum distance of coverage for monitors having a capacity 10, 25 and 45 kg/s shall be 10, 30 and 40 m, respectively.

**3.10.2.3** The number of hand hose lines and monitors shall provide the delivery of the dry chemical powder to any part of the cargo tank deck and cargo piping from two hand hose lines or a combination monitor/hand hose line.

At least one hand hose line or monitor shall be located aft of the cargo area.

**3.10.2.4** In gas carriers one monitor shall be provided in the cargo area to protect cargo manifold and capable of discharge locally and remotely.

**3.10.2.5** Dry powder fire extinguishing system for the protection of spaces stipulated in 1.5.3.2.2, shall

ensure the delivery of not less than 0,5 kg powder/m<sup>3</sup> for not more than 10 s.

**3.10.2.6** The quantity of the propellant gas shall provide for a single entire release of the dry powder from the powder container.

#### **3.10.3 Powder fire extinction stations.**

**3.10.3.1** The powder fire extinction stations shall be positioned aft of the cargo tank area.

Where the length of the cargo tank deck exceeds 150 m, one powder fire extinction station may be located thereon.

**3.10.3.2** The dry powder system shall consist of at least two self-contained station and in gas carriers with a cargo capacity of less than 1000 m<sup>3</sup> only one such station may be fitted.

**3.10.3.3** Ships fitted with bow or stern cargo loading and discharge manifold shall be provided with an additional dry powder fire extinction station complete with at least one monitor and one hand hose line.

**3.10.3.4** Where a fire extinction station has two or more hose stations, an independent pipe with release valves shall ensure proper dry powder delivery from the manifold to each station.

The powder fire extinction station shall provide for independent and simultaneous operation of all those stations.

#### **3.10.4 Hose station.**

**3.10.4.1** Each hose station shall consist of remote-release cylinders with a non-kinkable hand hose line not more than 33 m in length or of a monitor.

**3.10.4.2** All hose station equipment, other than a monitor, shall be stored in a watertight box or cabinet.

**3.10.4.3** Each nozzle shall be fitted with an on/off operation and discharge device.

**3.10.4.4** The cross-section of the nozzle shall be equal to that of the fire hose line or less than that by not more than 50 per cent.

**3.10.4.5** Release cylinders shall be provided with pressure gauges.

**3.10.4.6** Instructions on putting the system into action shall be available at the hose station.

#### **3.10.5 Dry powder containers, pipes and fittings.**

**3.10.5.1** Provision shall be made in the container for a dry powder discharge pipe cut short at about 100 mm from the bottom.

**3.10.5.2** A device shall be provided in the lower part of the container for gas flow into the container preventing the powder from flowing back into the gas pipe.

**3.10.5.3** The filling ratio of the containers shall be taken equal to not more than 0,95.

**3.10.5.4** Pipes and fittings shall have no contractions and abrupt expansions of cross-section.

**3.10.5.5** The cross-sectional area of the manifold in the powder installation shall be not less than the



total area of the pipes connected thereto for simultaneous discharge of dry powder or shall be not more than twice that area.

**3.10.5.6** Provision shall be made on the distribution manifold for an arrangement for purging the pipes after use.

**3.10.5.7** A bending radius of the dry powder pipe shall be not less than 10 pipe diameters.

**3.10.5.8** The dry powder shall be discharged into the spaces indicated in 1.5.3.2.2 through nozzles. Their construction, arrangement and number shall provide for uniform spraying of powder in the entire volume of the space. The pressure at the remotest nozzle shall be taken at least equal to a minimum pressure necessary for effective spraying of powder.

### 3.11 AEROSOL FIRE EXTINGUISHING SYSTEM<sup>1</sup>

#### 3.11.1 General.

**3.11.1.1** The fire extinguishing aerosol (which is produced while combustion of solid fuel aerosol generating compounds) generators used in the aerosol fire extinguishing systems shall be of the type approved by the Register.

**3.11.1.2** The aerosol fire extinguishing system shall include:

- generators of fire extinguishing aerosol;
- remote control device;
- predischARGE alarms;
- cables.

**3.11.1.3** Design mass of the aerosol generating agent, in kg, shall be determined by the formula

$$G = (V + \sum_{j=1}^n V_{arj} \cdot P_{arj} \cdot P_a^{-1}) \cdot k \cdot q \quad (3.11.1.3)$$

where  $V$  = design volume of the protected space, in m<sup>3</sup>;  
 $V_{arj}$  = volume of the  $j$ -th air receiver, in m<sup>3</sup>, refer to 3.1.2.5;  
 $n$  = number of air receivers in the protected space;  
 $j$  = serial number of air receiver;  
 $P_{arj}$  = working pressure in the  $j$ -th air receiver, in MPa;  
 $P_a$  = atmospheric pressure, in MPa;  
 $q$  = normative fire extinguishing capacity of aerosol, in kg/m<sup>3</sup>;  
 $k$  = factor of safety equal to 1,5.

**3.11.1.4** Normative fire extinguishing concentration of aerosol depends on the type of generator and usually doesn't exceed 0,2 kg/m<sup>3</sup>.

**3.11.1.5** The following measures shall be taken at system actuation:

automatic activation of the emergency alarm systems in the protected space in accordance with the requirements of 4.3;

automatic disconnection of ventilation in the protected space; automatic shutdown of the electric

drives of oil burner units of boilers and incinerators if they are located in the protected spaces.

**3.11.1.6** For machinery spaces, emergency diesel generator and other spaces where liquid fuel or combustible liquids are used, the generator's working regime (feed of design quantity of aerosol) shall not exceed 2 min.

**3.11.1.7** Arrangement of generators in the protected space shall ensure equal distribution of fire extinguishing aerosol. If there are shadow zones formed by equipment and boundaries fire extinguishing aerosol shall be fed directly to the shadow zones.

**3.11.1.8** When generators are installed, they shall be oriented so that (keeping due note of 3.11.2.2 requirements) jets of fire extinguishing aerosol do not cause thermal action on the ways of evacuation, ship equipment, cables, emergency lighting, emergency alarm system, fuel oil and lubricating oil tanks and pipes.

#### 3.11.2 Fire extinguishing aerosol generators.

**3.11.2.1** Fire extinguishing aerosol generator consists of a casing, which contains an aerosol generating agent, starting device, electrical connection, devices for mounting to the ship structures. Casing of the generator shall be fitted with the arrangement (nozzle) for the release of an aerosol.

**3.11.2.2** Each type of generator shall have information about the distance (along the aerosol jet) from its exit out of the generator to the end of the thermal zone with a temperature + 70 °C.

**3.11.2.3** Time from the start up of the generator until operating duty shall not exceed 10 s (refer to 3.11.1.6).

**3.11.2.4** Time of operating duty shall not be less than 20 s (refer to 3.11.1.6).

**3.11.2.5** Design number of generators (pieces) can be determined by the formula

$$N = G/m \quad (3.11.2.5)$$

where  $G$  = design mass of aerosol generating agent, in kg;  
 $M$  = mass of a charge in one generator, in kg.

**3.11.2.6** Casing of generator, its foundation and details fastening it to the foundation shall be made of non-combustible materials.

**3.11.2.7** Generators shall be fitted with arrangements for automatic (spontaneous) starting, if the ambient temperature exceeds 250 °C.

#### 3.11.3 The fire extinguishing remote control device.

**3.11.3.1** The remote control device shall comply with Section 2, Part XI "Electrical Equipment".

**3.11.3.2** The remote control device shall enable distant starting of all generators protecting the space. The start-up of generators by groups is permitted proceeding from their number and provided the requirements of 3.11.1.6 and 3.11.2.3 are met.

<sup>1</sup>Refer also to IMO MSC/Circ.1007 "Guidelines for the Approval of Fixed Aerosol Fire Extinguishing Systems".

**3.11.3.3** If several spaces are protected by the remote control device, it shall enable divided start-up of generators in each space.

**3.12.3.4** There shall be two sources of power supply — main and auxiliary — for the remote control device.

**3.11.3.5** The remote control device shall enable automatic control of the running order of starting circuits (for instance, disconnection, fault to frame etc.) and signalling of the fault on the front panel.

**3.11.4 Local stations of the aerosol fire extinguishing.**

Local stations with one or two generators and the starting arrangement may be fitted near entrance to the space (without remote control device) in justified cases.

**3.11.5 Cabling.**

**3.11.5.1** Cabling shall comply with the requirements of Section 16, Part XI "Electrical Equipment".

**3.11.5.2** Starting cables shall be shielded and the shield shall be grounded.

**3.12 FIXED LOCAL APPLICATION FIRE EXTINGUISHING SYSTEMS FOR USE IN MACHINERY SPACES**

**3.12.1** Fixed local application fire extinguishing systems shall be fitted on passenger ships of 500 gross tonnage and above and on cargo ships of 2000 gross tonnage and above.

**3.12.2** Machinery spaces of category A above 500 m<sup>3</sup> in volume shall, in addition to the fixed fire extinguishing system required in Table 3.1.2.1, be protected by an approved type of fixed water-based or equivalent local application fire extinguishing system complying with the requirements of IMO Guidelines (refer to MSC/Circ. 913)<sup>1</sup>. In the case of periodically unattended machinery spaces the fire extinguishing system shall have both automatic and manual release capabilities. In the case of continuously manned machinery spaces the fire extinguishing system is only required to have a manual release capability.

Where automatic release is provided the availability of manual release is obligatory.

The manual release shall be activated from a machinery control station or another corresponding place.

The automatic release shall be activated by fire detection system, indicating fire risk areas. Besides it shall be so designed as to prevent accidental release of the local application fire extinguishing system.

**3.12.3** Fixed local application fire extinguishing systems are to protect fire risk areas of the following machinery and equipment (without the necessity of engine shutdown, personnel evacuation, or sealing of the spaces):

**.1** main internal combustion engines and diesel generators;

**.2** incinerators;

**.3** purifiers for heated fuel oil;

**.4** boiler fronts (where nozzles are fitted);

**.5** inert gas generators, specified in 3.9.9;

**.6** fuel heaters.

In multi-engine installations, at least two sections shall be arranged.

**3.12.4** The activation of any local application fire extinguishing system shall give a visual and a distinct audible alarm in the protected space in the main machinery control room and in the wheelhouse. The alarm, which may be monotone, shall indicate the specific system activated. The system alarm requirements, described within this paragraph are in addition to, and not in lieu of, the detection and fire alarm systems required elsewhere in this Part.

**3.12.5** Electrical equipment of the system and its release alarm shall comply with the requirements of 7.13, Part XI "Electrical Equipment".

**3.12.6** Any installation of nozzles on board a ship shall reflect the arrangement successfully tested in accordance with the IMO Guidelines (MSC/Circ.913). A specific arrangement of nozzles may be accepted by the Register provided such arrangement additionally passes fire tests in accordance with the IMO Guidelines.

**3.13 TESTING OF FIRE EXTINGUISHING SYSTEMS**

**3.13.1** Fire extinguishing systems shall be tested in compliance with Table 3.13.1.

**3.13.2** The operational testing of the systems shall be conducted in conformity with Register — approved programs to verify their serviceability, operation of release devices, and where prototype ships are concerned, to confirm the stipulated time for the fire extinguishing medium discharge into the protected space.

On prototype ships, a test discharge of the rated amount of carbon dioxide into one of the protected spaces is required for high-pressure carbon dioxide systems.

The test discharge may be omitted if reasonable substantiations are submitted to the Register.

<sup>1</sup> Refer to IMO Resolutions Pertaining to the RS Activity, No. 3, 2000.

Table 3.13.1

Nos	Systems and assemblies to be tested	Hydraulic test pressure	
		in shop	on board ship
<b>1</b>	Foam and water fire extinguishing systems (refer also to Section 20, Part VIII "Systems and Piping"):	—	In action
	.1 pipes	—	$1p$
	.2 pipes of sprinkler system	$1,5p$	$1p$ (by air)
<b>2</b>	Pipes of dry powder system		
<b>3</b>	Carbon dioxide systems		
<b>3.1</b>	High-pressure systems:		
	.1 pipes from cylinders to release control valves; transit pipe lines passing through spaces (refer to 3.1.4.1.4)	—	$1,5p$
	.2 pipes from release control valves to nozzles and pipes from safety devices	—	5 MPa
<b>3.2</b>	Low-pressure systems:		
	.1 pipes from tank to release control valves	—	$1,5p$
	.2 pipes from release control valves to nozzles and pipes from safety devices	—	$1p$
<b>4</b>	Pipes and scrubber of the inert gas system	—	$1p$ (by air)
<b>5</b>	Pneumatic pipes	—	$1,5p$
<b>6</b>	Cylinders, containers and tanks:		
	.1 operating under pressure, including cylinders without valves	$1,5p$	—
	.2 operating without pressure	By filling up to the top of the air pipe	In assembly with system
	.3 cylinders with screwed-in valves	$1p$ (by air)	—
<b>7</b>	Fittings	$1,5p$ , but not less than 0,2 MPa	—
<p>Notes:</p> <p>1. <math>p</math> is the maximum working pressure in the system, and for carbon dioxide <math>p</math> is a design pressure of a cylinder or a tank, in MPa.</p> <p>2. Fittings in assembly shall be tested for the tightness of closing by a pressure of at least <math>1,25p</math>, the valves of carbon dioxide cylinders — by the highest breaking pressure of protective diaphragms according to 3.8.2.6.1.</p> <p>3. The systems shall be tested in assembly on board ship upon completion of all erection work.</p> <p>4. Pipes specified in 3.1.1 and 3.2.1, after being tested by a pressure of <math>1,5p</math>, may be tested on board by an air pressure of <math>1p</math>.</p> <p>5. Pipes of the water fire main system in ships of 500 gross tonnage and upwards (refer to 3.2.5.1) shall be tested by a pressure of at least 1,0 MPa.</p>			

## 4 FIRE DETECTION AND ALARM SYSTEMS

### 4.1 GENERAL

**4.1.1** All items of electrical equipment, devices, feeders and wiring of fire detection and alarm systems shall fully comply with 7.5 and 7.6, Part XI "Electrical Equipment" and Fire Safety Systems Code.

**4.1.2** Passenger ships carrying more than 36 passengers shall have the detection alarms for the systems required by 4.2.1.2 centralized in a continuously manned main machinery control room. In addition, controls for remote closing of the fire doors and shutting down the ventilation fans shall be centralized in the same location. The ventilation fans shall be capable of reactivation by the crew at the continuously manned control station. The control panels in the main machinery control room shall be capable of indicating open or closed position of fire doors, on or off status of the detectors, alarm and fans.

**4.1.3** Fire detection and alarm system shall not be used for any other purpose, except for closing fire doors from the switchboard and other similar purposes (refer to 3.12.2). Where fire doors are at the same time watertight doors (refer to 7.12, Part III "Equipment, Arrangements and Outfit") they are not to be automatically closed upon operation of fire alarms.

### 4.2 FIRE DETECTION SYSTEMS

#### 4.2.1 Fixed fire detection and fire alarm systems.

**4.2.1.1** The fixed fire detection and fire alarm system shall be installed to protect:

**.1** accommodation and service spaces and control stations (refer to 4.2.1.2);

**.2** Category A machinery spaces periodically unattended and Category A machinery spaces in which installation of automatic and remote control systems and equipment has been approved by the Register instead of continuous manning of the space and the main propulsion plant and associated machinery including main sources of power are provided to a variable degree with automatic or remote control and permanently under supervision of the watch-keeping staff at the control station;

**.3** cargo spaces in which packaged dangerous goods are carried (refer to 7.2.7) as well as cargo spaces which are inaccessible, on passenger ships, except cases when the ship is engaged in voyages of so short duration, that application of this requirement will be unsuitable;

**.4** spaces for carriage of vehicles, special category spaces and ro-ro spaces (refer to 4.2.1.3). The fire detection and fire alarm system shall not be installed on weather decks used for the carriage of vehicles with fuel in their tanks;

**.5** cabin balconies of passenger ships. The fixed fire detection and fire alarm systems for cabin balconies shall be approved in accordance with MSC.1/Circ.1242.

On agreement with the Register, cargo ships of less than 500 gross tonnage need not be provided with the fixed fire detection and fire alarm system.

**4.2.1.2** When protecting accommodation and service spaces and control stations the following shall be provided:

**.1** smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces as specified in 4.2.1.2.2 to 4.2.1.2.4. Consideration shall be given to installation of special smoke detectors in ventilation ducts;

**.2** in passenger ships carrying more than 36 passengers the fixed fire detection and fire alarm system shall be so installed and arranged as to detect the presence of smoke in service spaces, control stations and accommodation spaces including corridors, stairways and escape routes within accommodation spaces. There is no need to install smoke detectors in private bathrooms and galleys. There are no need to install the fixed fire detection and fire alarm system in low fire risk spaces or spaces with no fire risk such as void spaces, public toilets, CO<sub>2</sub> storerooms and similar spaces. For refrigerated chambers and similar spaces where steam is produced such as saunas and laundries, heat detectors shall be installed. Moreover, an automatic sprinkler system shall be installed (refer to Table 3.1.2.1);

**.3** in passenger ships carrying not more than 36 passengers, there shall be installed throughout each separate vertical or horizontal zone, in all accommodation and service spaces, and where the Register considers it necessary, in control stations, except spaces posing no substantial fire risk such as void spaces, sanitary spaces, etc., either:

**.3.1** a fixed fire detection and fire alarm system so installed and arranged as to detect the presence of fire in such spaces and provide smoke detection in corridors, stairways and escape routes within accommodation spaces; or

**.3.2** a fixed fire detection and fire alarm system so installed and arranged as to detect the presence of smoke in corridors, stairways and escape routes within the accommodation spaces if there is an au-

automatic sprinkler system so arranged as to protect such spaces (refer to Table 3.1.2.1);

**.3.3** a fixed fire detection and fire alarm system complying with the provisions of the Fire Safety Systems Code shall be installed on cabin balconies of ships to which the requirement of 2.2.2.11 applies, when furniture and furnishings on such balconies are not as defined in 2.2.2.10;

**.3.4** the fixed fire detection and fire alarm system shall be capable of remotely and individually identifying each detector and manually operated call point. A section of fire detectors and manually operated call points shall not be situated in more than one main vertical zone;

**.4** the entire main vertical zone containing atrium (i.e. public spaces including three or more weather decks) shall be protected over the entire area by the smoke detection system;

**.5** in cargo ships accommodation and service spaces and control stations depending on a protection method are protected by a fixed fire detection and fire alarm system and/or by an automatic sprinkler system and fire alarm and detection system as follows:

**.5.1** when method IC is used: a fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces;

**.5.2** when method IIC is used: a fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces. In addition, an automatic sprinkler system shall be so installed and arranged as to protect accommodation spaces, galleys and other service spaces (refer to Table 3.1.2.1);

**.5.3** when method IIIC is used: a fixed fire detection and fire alarm system shall be so installed and arranged as to detect the presence of fire in all accommodation and service spaces, providing smoke detection in corridors, stairways and escape routes within accommodation spaces, except spaces posing no substantial fire risk such as void spaces, sanitary spaces, etc. However there is no need to provide fixed fire detection and fire alarm system in service spaces built away from the accommodation block;

**.6** if the fixed fire detection and fire alarm system is required for protection of spaces other than spaces specified in 4.2.1.2,1, at least one detector complying with the requirements of the International Code for Fire Safety Systems shall be installed in each such space.

**4.2.1.3** The fire detection and fire alarm system installed in spaces intended for the carriage of vehicles, special category spaces and in ro-ro spaces

shall provide early detection of fire. The type of automatic detectors and arrangement thereof shall be determined with consideration of effect of ventilation and other appropriate factors. After installation, the system shall be tested under normal ventilation conditions to determine the average time of its responding. The fire detection and fire alarm system may not be fitted in special category spaces if an effective watching in the form of continuous fire watch is maintained in the spaces throughout the voyage.

**4.2.1.4** 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 on the overhead shall be a minimum distance of 0,5 m away from bulkheads, except corridors, lockers and stairways. The maximum spacing of detectors shall be in accordance with Table 4.2.1.4.

Table 4.2.1.4

Type of detector	Maximum floor area per detector, in m <sup>2</sup>	Maximum distance apart between centres, in m	Maximum distance away from bulkheads, in m
Heat	37	9	4,5
Smoke	74	11	5,5

The Register may permit departures from the requirements of Table 4.2.1.4 based upon characteristics obtained during tests and agreed with the Register.

When heat-pulse detectors are used in machinery spaces, the deck area served by one detector shall be 50 m<sup>2</sup>, and distance between centres is to be not more than 6 m.

**4.2.1.5** A sample extraction smoke detection system of a type approved by the Register and meeting the requirements of 4.2.1.6 may be provided in cargo spaces specified in 4.2.1.1.3 and 4.2.1.1.4, except spaces specified in 1.5.4.3.2, 1.5.4.4.2 and 1.5.9.

**4.2.1.6** Smoke detection system operating on the basis of air sampling from spaces shall comply with the following additional requirements:

**.1** the system shall be capable of continuous operation at all times. Systems operating on a sequential scanning principle may be permitted on agreement with the Register provided that interval (*I*) between two scanings of the same space does not exceed 120 s and provides time (*T*) mentioned in 4.2.1.6.10. With an allowance of 20 per cent the interval (*I*) is determined by the formula:

$$I = 1,2 \times T \times N$$

where *N* = the number of scanning points;

**.2** the sampling pipe arrangements shall be such that the location of the fire can be readily identified;

**.3** the system shall be constructed and installed so as to prevent the leakage of any toxic or flammable substances or fire extinguishing media into any accommodation and service space, control station or machinery space, as well as to avoid the possibility of ignition of flammable gas-air mixture;

**.4** at least one smoke accumulator shall be located in every enclosed space for which smoke detection is required. However, where a space is designed to carry oil or refrigerated cargo, or other cargoes for which a smoke sampling system is required, means may be provided to isolate the smoke accumulators in such compartments on agreement with the Register;

**.5** smoke accumulators shall be located for optimum performance and shall be spaced so that no part of the overhead deck area is more than 12 m measured horizontally from an accumulator.

Where systems are used in spaces which may be mechanically ventilated, the position of the smoke accumulators shall be considered having regard to the effects of ventilation.

Smoke accumulators shall be positioned where impact or physical damage is unlikely to occur;

**.6** not more than four accumulators shall be connected to each sampling point;

**.7** smoke accumulators from more than one enclosed space shall not be connected to the same sampling point;

**.8** sampling pipes shall be self-draining and protected from impact or damage during cargo operations;

**.9** the sensing unit shall operate before the smoke density within the sensing chamber exceeds 6,65 per cent obscuration per metre;

**.10** at least two sample extraction fans, duplicating one another, shall be provided.

The fans shall be of sufficient capacity to operate with the normal conditions of ventilation in the protected area;

The fans, depending on capacity and length of piping, shall provide time ( $T$ ) of total system operation delay not more than 15 s;

**.11** the switchboard shall have means permitting observation of smoke in the individual sampling pipe;

**.12** means shall be provided to monitor the airflow through the sampling pipes so designed as to ensure equal quantities are extracted from each interconnected accumulator;

**.13** sampling pipes shall be a minimum of 12 mm inside diameter. Where the pipes are used in conjunction with fixed gas fire extinguishing systems, the minimum size of pipe shall be sufficient to permit the fire extinguishing medium to be discharged within the appropriate time;

**.14** sampling pipes shall be provided with arrangement for periodically purging with compressed air;

**.15** the control panel shall be located on the navigating bridge or in the main fire control station. Clear information shall be displayed on or adjacent to the control panel about the spaces covered;

**.16** provision shall be made for testing for correct operation and restoring to normal surveillance without the renewal of any component;

**.17** detection of smoke or other combustion products shall initiate visual and audible fire signals at the control panel and navigating bridge or in continuously manned control station;

**.18** power supplies necessary for the system operation shall be monitored loss of power. The loss of power shall initiate a visual and audible fault signal at the control panel and navigating bridge which shall be distinct from a fire signal (refer also to 7.5.4, Part XI "Electrical Equipment");

**.19** provision shall be made for suitable instructions and spare parts necessary for testing and maintenance of the system.

**4.2.1.7** Provision shall be made for checking the operation of detectors by means of devices supplying hot air of particular temperature or by using smoke or aerosol having the relevant range of density or particle sizes, or by applying other conditions inherent in a fire to which the automatic detector shall respond.

#### **4.2.2 Manual alarms.**

**4.2.2.1** Manual fire alarms shall be provided in the ships which in compliance with 4.2.1.1 are equipped with fixed fire detection system.

**4.2.2.2** Manually operated call points shall be installed throughout the accommodation spaces, service spaces and control stations considering the requirements of 4.2.1.2.3.4. One manually operated call point shall be located at each exit.

**4.2.2.3** The buttons shall be easily accessible in corridors on each deck and located so that any part of the corridor is located not far than 20 m from the button.

**4.2.2.4** In special category spaces the manual call points shall be installed so that no part of the space is more than 20 m from the call point and one call point shall be installed close to each exits from such spaces.

**4.2.2.5** All buttons of manual fire alarms shall be painted red and adequately illuminated both in normal and emergency conditions. The button shall be protected with glass.

**4.2.2.6** Any required fixed fire detection and fire alarm system with manually operated call points shall be capable of immediate operation at all times.

#### **4.2.3 Protection of unattended machinery spaces.**

**4.2.3.1** Unattended machinery spaces of category A, as well as heated air ducts and main boiler uptakes, essential auxiliary boilers with a steam capacity over 3 t/h and boilers with thermal liquids (including ex-

haust gas boilers) in such spaces shall be provided with an automatic fire alarm and fire detection system (refer also to 2.2.4, Part IX "Machinery").

#### 4.3 FIRE WARNING ALARMS

**4.3.1** Automatic alarms to warn that the fire extinguishing medium is released shall be provided in the spaces attended by crew members on their duties or accessible to them under normal service conditions, fitted with doors or access hatches for this purpose, including closed roll-on/roll-off cargo spaces and holds in container-ships carrying thermal containers. In other cargo spaces, as well as in small spaces (compressor rooms, paint and lamp lockers, etc), no fire warning alarms are required.

**4.3.2** The signal warning of putting a total flooding system into action shall be given only within the space into which the extinguishing medium is to be discharged.

Means of audible alarm actuation shall be so arranged that the alarm can be heard throughout the protected space with all machinery in operation and

be distinct from other audible alarms through adjustment of sound pressure or pattern.

**4.3.3** Control of fire warning alarms shall be interlocked both with the local and remote control stations of the fire extinguishing system so as to ensure its automatic start into operation at opening the doors of any locker containing starting devices.

Besides there shall be provided an automatic delay (not less than 20 s) in discharging the fire extinguishing medium in the protected space from the starting of fire warning alarm for the personnel to be able to leave the space before the fire extinguishing medium is discharged.

**4.3.4** The signal shall be clear, distinct and readily audible in a noisy space, and shall be of a tone distinct from all other signals. In addition to the audible signal, there shall be a visible signal: "Gas! Go away!" and for the spaces protected by the aerosol fire extinguishing systems — "Aerosol! Go away!".

**4.3.5** Audible alarm in the cargo pump room of oil tankers shall be:

pneumatic, operated by dry and clean air; or

electrically-operated, intrinsically safe; or

electrically-operated, the electric actuating mechanism being located outside the pump room.

## 5 FIRE-FIGHTING OUTFIT, SPARE PARTS AND TOOLS

#### 5.1 FIRE-FIGHTING OUTFIT

**5.1.1** Items of fire-fighting outfit shall comply with Fire Safety Systems Code and be of approved type and ready for use at any time.

Fire-fighting outfit shall be located in a readily accessible place.

In passenger ships the location of fire-fighting outfit shall be marked by photoluminescent material or by lighting. Such photoluminescent markers or lighting shall meet the requirements of 8.5.5, Part III "Equipment, Arrangements and Outfit" and International Code for Fire Safety Systems.

**5.1.2** Depending on the purpose and size of the ship the standards for supplying portable fire-fighting appliances, apparatus and consumable materials shall be in compliance with Table 5.1.2. The ships below shall be provided with extra items of outfit in addition to those mentioned in Table 5.1.2, as follows: ships carrying dangerous goods — in conformity with 2.8.8 and 2.8.9, oil recovery ships — in conformity with 2.11.18 to 2.11.20, ships with helicopter decks — in conformity with 2.1.10.11 as well as ships with the marks **FF** and **FFWS** in the class notation in accordance with 2.13.13.

**5.1.3** The couplings of all portable items of outfit (fire hoses, fire hose nozzles, portable foam gen-

erators, etc.) shall be of the standard quick-acting type and size adopted for the given ship. All couplings and items of outfit shall be made of a material resistant to marine environment.

Items of fire-fighting outfit installed in the dangerous areas, rooms and spaces as well as on the open decks of oil tankers and oil recovery vessels, gas carriers and chemical tankers shall be of type preventing spark formation. Aluminium alloys may be used for hose couplings and nozzles except weather decks of oil tankers and chemical tankers.

**5.1.4** Fire hoses shall comply with the following requirements:

**.1** shall have a length not less than 10 m, but not more than:

**.1.1** 15 m in machinery spaces;

**.1.2** 20 m in spaces other than those specified in 5.1.4.1.1 and on weather decks;

**.1.3** 25 m on weather decks of ships with maximum breadth more than 30 m.

In any case the fire hose length shall be sufficient to deliver a jet of water to any of the spaces where their use may be required;

**.2** they shall be made of approved materials resistant to wear and destruction by microorganisms (rotting);

**.3** fire hoses in assembly with nozzles shall be stowed at hydrants or on open places on reels or in

Table 5.1.2

Nos	Description of items of outfit	Number of items of outfit to be available in each ship
1	Fire hoses with couplings (refer to 5.1.4): .1 for water .2 for foam solution	In accordance with the number of hydrants fitted on board ship. In accordance with the number of fire hydrants to which foam solution is supplied from fixed foam fire extinguishing system. If the size of the water hoses required by 1.1 is suitable for handling foam solution, such hoses may be taken into account to complete the number of hoses to be coupled to the hydrants fitted on the upper decks.
2	Fire hose nozzles: .1 dual-purpose nozzles for producing a compact and a sprayed jet (refer to 5.1.5) .2 air-foam nozzles (refer to 5.1.6)  .3 foam extension pipes (refer to 5.1.7) .4 portable foam generators or portable combination-foam production units (refer to 5.1.19) .5 extension pipes (refer to 5.1.7)	In accordance with the number of hydrants fitted on board ship. In accordance with the number of hydrants whereto foam solution is supplied from fixed foam fire extinguishing system, but not less than 4. In accordance with the number of air-foam nozzles for fire extinction in cargo tanks of oil tankers. Twice the rated number of foam generators.  50 per cent of the number of portable foam generators or combination-foam production units intended for fire extinction in the cargo tanks of oil tankers.
3	Portable foam set (refer to 5.1.8)	1 In machinery spaces at least one set in spaces containing internal combustion engines and one set in each boiler room or externally close to the entrance to the boiler room. 2 For fuel oil storage tanks (except for double bottom tanks), 1 set for each space adjacent to the walls or decks of the tanks. Where the walls of the tanks are adjacent to machinery spaces of category A, the sets contained in the latter spaces may be regarded as sets required for protecting the fuel oil storage tanks. 3 In each fuel distributing station and each cargo hose room, 1 set. 4 In working spaces referred to in 1.5.8.1, 1 set per fire hydrant fitted, but not more than 3 sets are required for each space. A space of less than 150 m <sup>2</sup> need not have more than 1 set. 5 In ships with spaces specified in 1.5.4.3, 1.5.4.4 and 1.5.9 not less than two sets for use in these spaces and additionally one set in each such space if vehicles with fuel in their tanks for self propulsion are carried therein. There is no need to provide sets for weather decks used for the carriage of vehicles with fuel in their tanks, as well as for cargo spaces used for the carriage of vehicles with fuel in their tanks which are loaded in open or closed containers. 6 On open deck of container ships, 2 sets.
4	Portable foam fire extinguishers, dry powder fire extinguishers and carbon dioxide fire extinguishers (refer to 5.1.9). The use of dry powder fire extinguishers is permitted in all spaces instead of foam and carbon dioxide fire extinguishers	Ships of gross tonnage 1000 and above shall have at least 5 portable fire extinguishers. The minimum number of fire extinguishers at control stations, accommodation and service spaces shall be determined on the basis of 2 fire extinguishers for every 30 m or part thereof, of the deck length on which such spaces are situated, but not less than the number required in accordance with the following provisions: 1 Control stations: 1.1 1 foam fire extinguisher for each space, 1 fire extinguisher being permitted to be fitted in the corridor for a group of small spaces with a total area of up to 50 m <sup>2</sup> , provided that the entrances to the spaces are adjacent and situated in the same corridor. Not required in unattended spaces of ships of less than 300 gross tonnage; 1.2 1 carbon dioxide fire extinguisher for each space or group of spaces (as specified in 4.1.1 of this Table) containing electrical or radio equipment, as also for chart houses and chart compartments; 1.3 1 foam fire extinguisher for each space containing an emergency diesel-generator or a fire diesel-driven pump 2 Accommodation and service spaces: 2.1 for every 30 m, or part thereof, of the length of the corridors communicating with accommodation and service spaces, 1 foam fire extinguisher; 2.2 for every 100 m <sup>2</sup> , or part thereof, of area of public spaces, 1 foam fire extinguisher. For spaces less than 15 m <sup>2</sup> in area fire extinguishers fitted near them may be used;



Table 5.1.2 — continued

Nos	Description of items of outfit	Number of items of outfit to be available in each ship
		<p><b>2.3</b> in galleys and bakeries with oil-fired equipment, 1 foam fire extinguisher for each space;  <b>2.4</b> in galleys and bakeries with electrical, steam, coal- or gas-fired equipment, having the area of more than 50 m<sup>2</sup>, 1 foam or carbon dioxide fire extinguisher;  <b>2.5</b> in other domestic service spaces, 1 foam fire extinguisher (where fire extinguishers are available in the corridor, at the entrance to the space, provision of fire extinguishers within the space is not compulsory);  <b>2.6</b> in each stairway enclosure and in each lobby, 1 foam fire extinguisher;  <b>2.7</b> in storerooms for readily flammable (refer also to 3.1.3.4) and combustible materials, 1 foam fire extinguisher for each space. Where the storeroom area is less than 50 m<sup>2</sup>, the fire extinguishers may be kept in the corridor in close vicinity of the entrance to the space concerned or group of small spaces (with a total area not more than 50 m<sup>2</sup>).</p> <p>In addition to the above number of fire extinguishers, within the other ship's spaces the number of fire extinguishers shall be determined as follows.</p> <p><b>3</b> In machinery spaces containing internal combustion engines the portable foam fire extinguishers shall be located within 10 m from any point of the space. Each such space shall contain not less than 2 fire extinguishers.</p> <p><b>4</b> In machinery spaces containing oil-fired boilers — two foam fire extinguishers nearby each boiler front. If oil-fired units are located in this space — two additional foam fire extinguishers.</p> <p><b>5</b> In machinery spaces containing steam turbines or enclosed steam engines the number of fire extinguishers is determined in accordance with 4.3. However, such fire extinguishers shall not be required in addition to those specified in 4.4.</p> <p><b>6</b> In spaces containing electric machinery or equipment:</p> <p><b>6.1</b> 1 carbon dioxide fire extinguisher, for spaces containing main internal combustion or steam machinery, if the total power of the main machinery is less than 740 kW;  <b>6.2</b> 2 carbon dioxide fire extinguishers, for spaces containing main internal combustion or steam machinery, if the total power of the main machinery is equal to, or more than, 740 kW;  1 carbon dioxide fire extinguisher for each electric generator or group of generators, the total power being 500 to 1000 kW;  1 carbon dioxide fire extinguisher for each space or group (not more than three) of small spaces containing auxiliary machinery with electrical drives and for special electrical spaces.</p> <p>The carbon dioxide fire extinguishers required by this sub-item shall be provided in the above spaces whether or not provision is made for foam extinguishers required by other sub-items of this Table.</p> <p><b>7</b> In separate spaces containing switchboards, 2 carbon dioxide fire extinguishers per space.  In space having an area of 15 m<sup>2</sup>, 1 carbon dioxide fire extinguisher, near the entrance to the space.</p> <p><b>8</b> At the entrance to accumulator battery rooms, other than those for radio stations and emergency lighting, 1 carbon dioxide fire extinguisher per space.</p> <p><b>9</b> In compartments for auxiliary machinery, 1 foam fire extinguisher, when the space area is 50 m<sup>2</sup> and more, otherwise the fire extinguisher placed near the entrance to such space may be sufficient.</p> <p><b>10</b> For oil fuel tanks, other than those of double bottom, not less than 2 foam fire extinguishers in each space adjacent to the walls or decks of the tanks. If such adjacent spaces are already provided with fire extinguishers, no additional fire extinguishers are required.</p> <p><b>11</b> In pump rooms, fuel distributing stations, petrol pipe line trunks, cargo hose spaces: 1 foam fire extinguisher for every 30 m<sup>2</sup> for floor area.</p> <p><b>12</b> In working spaces, 2 foam fire extinguishers, if the space area is under 100 m<sup>2</sup>, plus 1 foam fire extinguisher for every 250 m<sup>2</sup> or part thereof, if the space area is more than 100 m<sup>2</sup>.</p> <p><b>13</b> In welding shops and in storerooms for welding equipment, 1 foam fire extinguisher and one carbon dioxide fire extinguisher per space.</p>

Nos	Description of items of outfit	Number of items of outfit to be available in each ship
5	Foam fire extinguishers of at least 45 l capacity or at least 16 kg carbon dioxide or dry powder fire extinguishers (refer to 5.1.10 and 5.1.11)	<p><b>14</b> In special category spaces, cargo spaces for motor vehicles with fuel in their tanks and in ro-ro cargo spaces on each deck, 1 fire extinguisher for each 20 m of deck length on both sides. At entrances to such spaces from accommodation and machinery spaces, 1 foam fire extinguisher. There is no need to provide additional fire extinguishers for weather decks used for the carriage of vehicles with fuel in their tanks, as well as for cargo spaces used for the carriage of vehicles with fuel in their tanks which are loaded in open or closed containers.</p> <p><b>1</b> In machinery spaces containing internal combustion engines in number according to 5.1.10.4; <b>2</b> In machinery spaces containing steam turbines or enclosed steam engines in number according to 5.1.10.4, however such fire extinguishers are not required if the space is protected by a fixed fire extinguishing system according to Table 3.1.2.1; <b>3</b> In the working spaces, referred to in 1.5.8.1 1 fire extinguisher mentioned in 5.1.11 for every 300 m<sup>2</sup> or part thereof, of each working space (bounded by watertight and gastight bulkheads). <b>4</b> In spaces containing electric generators or propulsion motors with the total power output being 1000 to 5000 kW, 1 fire extinguisher according to 5.1.11 for each space. <b>5</b> In separate spaces containing electric switchboards if the switchboard length is more than 5 m and the space is not protected by means of a fire smothering system, 1 fire extinguisher mentioned in 5.1.11 for a space.</p>
6	Foam fire extinguishers, at least 136 l capacity, or at least 45 kg carbon dioxide fire extinguishers or dry powder fire extinguishers (refer to 5.1.10 and 5.1.11)	<p><b>1</b> In machinery spaces containing oil fuel units as well as oil-fired boilers — one fire extinguisher per each space. In boiler rooms with domestic boilers of less than 175 kW the fire extinguisher is not required. <b>2</b> In spaces containing electric generators and propulsion motors with the total power output 5000 kW and over, 1 fire extinguisher according to 5.1.11 for a space. Three fire extinguishers in accordance with item 5 of this Table may be used instead of one fire extinguisher prescribed by this item.</p>
7	Metal receptacles containing sand or sawdust (refer to 5.1.12)	<p>1 receptacle in each firing space in each boiler room with oil-fired boilers, and each space containing a part of the fuel oil unit, as well as near lamp and paint lockers, fuel filling and distributing positions and in other fire hazardous areas where fuel oil or other flammable liquids are liable to spread (except for machinery spaces). 1 receptacle containing sand or dry sawdust impregnated with soda may be replaced by 1 portable foam fire extinguisher.</p>
8	Blankets (refer to 5.1.13)	<p><b>1</b> 1 blanket for every 40 m, or part thereof, of open deck length of oil tankers and passenger ships. <b>2</b> In all other ships not referred to in 8.1 of this Table, 1 blanket, if the ship is from 300 to 1000 gross tonnage, and 2 blankets, if the ship is of 1000 gross tonnage and upwards. <b>3</b> In machinery spaces of category A in ships of more than 300 gross tonnage, 1 blanket for each space. <b>4</b> In working spaces indicated in 1.5.8.1, 1 blanket for each space.</p>
9	Sets of fire fighting tools (refer to 5.1.14)	<p>For ships of less than 2000 gross tonnage, 1 set. For ships of 2000 to 4000 gross tonnage, 2 sets. For ships of 4000 to 10000 gross tonnage, 3 sets. For ships of 10000 gross tonnage and upwards, 4 sets.</p>
10	Fireman's outfit (refer to 5.1.15)	<p><b>.1</b> In passenger ships, 2 sets and additionally for every 80 m, or part thereof, of the total length of all accommodation and service spaces on the deck they are situated, or if there are more than one such deck on the deck with the maximum total length of the above spaces 2 sets in accordance with 5.1.15 and 2 sets of personal outfit in accordance with 5.1.15.1.1, 5.1.15.1.2 and 5.1.15.1.3. In passenger ships carrying more than 36 passengers, two additional fireman's outfits shall be provided for each main vertical zone. However, for stairway enclosures which constitute individual main vertical zones and for the main vertical zones in the fore or aft end of the ship, which do not contain spaces of categories (6), (7), (8) or (12) (refer to 2.2.1.3), no additional fireman's outfits are required.</p>

Table 5.1.2 — continued

Nos	Description of items of outfit	Number of items of outfit to be available in each ship
<b>11</b> <b>12</b> <b>13</b> <b>14</b> <b>15</b>	Portable electric or pneumatic drills (refer to 5.1.16) Portable fire motor-pumps <sup>1</sup> complete with suction and delivery hoses and fire hose nozzles (refer to 5.1.17) International shore connection (refer to 5.1.18) Foam concentrate Gas analyzers (refer to 5.1.22): .1 for vapours of flammable liquids and gases  .2 for oxygen content <b>16</b> Fog applicator (refer to 5.1.20)  <b>17</b> Fire buckets (refer to 5.1.21) <b>18</b> Emergency Escape Breathing Devices (EEBD) (refer to 5.1.23)	<b>2</b> In oil tankers and combination carriers of 500 gross tonnage and upwards, 4 sets. <b>3</b> In cargo ships of 500 gross tonnage and upwards, 2 sets. <b>4</b> In ships with helicopter decks an additional fireman's outfit shall be provided according to 2.1.10.7. In all ships of 4000 gross tonnage and upwards, 1 drill per ship. <b>1</b> In ships where the fixed water fire main system is not fitted according to 3.2.1.6, 1 pc per ship. <b>2</b> Where no fixed emergency fire pump is fitted (refer to 3.2.1.2), 1 motor-pump per ship. In all ships of 500 gross tonnage and upwards, and on the floating cranes, 1 set. Full amount of foam concentrate required by 3.7.  In ships carrying motor vehicles with fuel oil (other than diesel oil) in their tanks and in ships with spaces specified in 1.5.4.3.1, 1.5.4.4.1 and 1.5.9, 1 pc. In oil tankers and combination carriers, 2 pcs. In oil tankers fitted with inert gas system — 2 portable gas analyzers capable to operate in the inert gas atmosphere in addition to the above. Calibration devices for gas analyzers shall be provided in oil tankers and combination carriers. In oil tankers and combination carriers, 2 pcs. <b>1</b> In passenger ships carrying more than 36 passengers: in each machinery space of category A, 2 pcs; <b>2</b> In passenger ships carrying more than 36 passengers: for each pair of breathing apparatuses (refer to 5.1.15.2), 1 pc; <b>3</b> In each space for the carriage of vehicles, ro-ro spaces and special category spaces intended for the carriage of vehicles with fuel in their tanks for self propulsion, 2 pcs. There is no need to provide applicators for weather decks used for the carriage of vehicles with fuel in their tanks as well as for cargo spaces used for the carriage of vehicles with fuel in their tanks which are loaded in open or closed containers. In ships having no water fire main system, 3 buckets. <b>.1</b> within accommodation spaces; <b>.1.1</b> in cargo ships, 2 pcs; <b>.1.2</b> in passenger ships, 2 pcs in each main vertical zone. In passenger ships carrying more than 36 passengers, in addition to those required, two additional EEBD shall be provided in each main vertical zone. This requirement is not applied to stairway enclosures comprising separate main vertical zones and to main vertical zones at both ends of a ship which do not have spaces of categories (6), (7), (8) or (12) specified in 2.2.1.3; <b>.2</b> in machinery spaces EEBD shall be located at easily visible places, which can be easily accessed in case of fire. The location of EEBD shall take into account the arrangement of the equipment and the number of persons usually manning the space: <b>.2.1</b> in machinery spaces of category A containing internal combustion engines used for main propulsion; <b>.2.1.1</b> in the central control station, if located within the machinery space, 1 pc; <b>.2.1.2</b> in workshop area, 1 pc. If there is a direct exit from the workshops, not entering the engine room, an EEBD is not required; <b>.2.1.3</b> close to ladder constituting the means of escape from machinery space (refer to 4.5.5.2 and 4.5.10.2, Part VII "Machinery Installations"), 1 pc at each deck or platform; <b>.2.2</b> in machinery spaces of category A other than those specified in 18.2.1, 1 pc, as a minimum, located in accordance with 18.2.1.3; <b>.2.3</b> in other machinery spaces, the necessity, number and location of EEBD shall be determined on agreement with the Register; <b>.3</b> provision shall be made for two spare EEBD for passenger ships and one spare EEBD for cargo ships.

<sup>1</sup>In non-propelled oil tankers, the motor-pump shall be replaced by a portable hand pump of at least 6 m<sup>3</sup>/h capacity with a nozzle 10 mm in diameter and a nozzle pressure of at least 0,20 MPa. The pump shall be provided with two suction hoses, each 4 m long, fitted with a non-return valve, two delivery hoses, each 20 m long, and a hose nozzle of dual-purpose type with an outlet 10 mm in diameter.

baskets. On open decks they shall be kept in spray-proof ventilated lockers or enclosures. The lockers and enclosures shall be marked with letters "FH" (fire hydrant) painted red;

**.4** in passenger ships, there shall be provided at least one fire hose for each of the hydrants and these hoses shall be used only for fire fighting or testing at fire drills and surveys. Additionally, in inner spaces in passenger ships carrying more than 36 passengers fire hoses shall be connected to hydrants at all times;

**.5** on cargo ships:

**.5.1** of 1000 and more gross tonnage, the number of fire hoses is determined one fire hose per each 30 m of length and one spare fire hose, but not less than five hoses per ship. This number doesn't include any hoses required for machinery or boiler spaces. The Register may require to increase number of hoses in order to ensure sufficient number of hoses and their accessibility at any time, considering the type of ship and character of voyages made by the ship. A ship carrying dangerous goods shall be equipped with three additional hoses and nozzles in excess of those required above;

**.5.2** of less than 1000 gross tonnage, the number of fire hoses is calculated in accordance with 5.1.4.5.1. However, the number of hoses shall be not less than three.

**5.1.5** Standard nozzle sizes shall be 12, 16 and 19 mm or close thereto.

Nozzles sizes greater than 12 mm need not be used in accommodation, service and working spaces. In ships under 150 gross tonnage nozzles having 10 mm in diameter are permitted to be used. For machinery spaces and exterior locations, the nozzle size shall be such as to obtain maximum discharge possible from two jets at the pressure at each hydrant mentioned in Table 3.2.1.1 from the smallest pump, but nozzles sizes greater than 19 mm need not be used.

Nozzles shall be of an approved dual-purpose type with a shut-off device. Fire hose nozzles made of plastic type material, e.g. polycarbonate, are considered acceptable provided capacity and serviceability are documented and the nozzles are found suitable for the marine environment.

**5.1.6** Air-foam nozzles for delivery of low-expansion foam (refer to 3.7) from fixed fire extinguishing system shall comply with the following requirements:

**.1** on cargo tank deck of oil tankers each nozzle shall be capable of delivering 400 l/min of foam, in this case, the length of jet delivered by the fire hose at still-air shall be not less than 15 m (refer also to 3.7.2.3);

**.2** in ship's spaces each nozzle shall be capable of delivering at least 2 m<sup>3</sup>/min of foam.

**5.1.7** Foam extension pipes with a hook-shaped bell-mouth at the end (for low-expansion foam) and

extension pipes fitted with light supports at the middle (for medium-expansion foam) shall be of about 4 m in length.

An extended air-foam nozzle having a hook-shaped bell-mouth may be used in addition to the usual air-foam nozzle instead of a foam extension pipe.

#### **5.1.8 Portable foam applicators.**

**5.1.8.1** A portable foam applicator unit shall consist of a foam nozzle/branch pipe, either of a self-inducing type or in combination with a separate inductor, capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 l of foam concentrate and at least one spare tank of foam concentrate of the same capacity.

**5.1.8.2** The nozzle/branch pipe and inductor shall be capable of producing effective foam suitable for extinguishing an oil fire, at a foam solution flow rate of at least 200 l/min at the nominal pressure in the fire main.

**5.1.8.3** The foam concentrate shall be approved by the Register based on IMO MSC/Circ.582/Corr.1.

**5.1.8.4** The values of the foam expansion and drainage time of the foam produced by the portable foam applicator unit shall not differ more than  $\pm 10$  per cent of that determined in IMO MSC/Circ.582/Corr.1.

**5.1.8.5** The portable foam applicator unit shall be designed to withstand clogging, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered on ships.

**5.1.8.6** The portable foam applicator units shall be located near hydrants.

**5.1.9** Portable fire extinguishers shall be of type and design approved by the Register taking into account the IMO Guidelines (refer to Resolution A.951(23)) and shall comply with the following requirements:

**.1** no fire extinguishing medium shall be used which, either by itself or under anticipated conditions of application, would give off toxic gases in amounts dangerous to human health;

**.2** fire extinguishers shall have safety devices preventing the pressure therein to rise above permissible limits;

**.3** for 100 per cent of the first ten fire extinguishers and 50 per cent of the remaining fire extinguishers capable of being recharged onboard shall be provided with spare chargers. A total of not more than 60 spare charges are required. Instructions for recharging shall be available on board;

**.4** for fire extinguishers which cannot be recharged onboard, additional portable fire extinguishers of the same quantity, type, capacity and number, as determined in 5.1.9.3 above, shall be provided in lieu of spare charges;

**.5** fire extinguishers shall be mounted in special brackets of quick-detachable type at places easily

visible and accessible in case of fire, and in such a way that their serviceability is not impaired by the weather, vibration and other external factors.

They shall be located at the height of not more than 1,5 m from deck and not closer than 1,5 m from sources of heat;

**.6** one of the portable fire extinguishers intended for use in any space shall be stowed close to the entrance to that space;

**.7** each powder or carbon dioxide fire extinguisher shall have capacity not less than 5 kg, and each foam fire extinguisher — not less than 9 l.

Mass of any portable fire extinguisher shall not exceed 23 kg. Portable fire extinguishers shall have efficiency, which, in compliance with the recognized international or national standard, is at least equivalent to the efficiency of a 9-litre wetting agent fire extinguisher, which is determined when extinguishing model fire seat of A class, rating 2A;

**.8** powder fire extinguishers shall be selected with regard for the purpose of the powder extinguishing medium;

**.9** in the machinery spaces fire extinguishers shall be so located that an extinguisher is not more than 10 m walking distance from any point in the space;

**.10** carbon dioxide fire extinguishers shall not be located in accommodation spaces. In control stations and other spaces containing electrical or electronic equipment or facilities required for ship safety, fire extinguishers shall be provided, charged with the fire extinguishing medium, which does not conduct electricity and does not cause harm to equipment and facilities;

**.11** portable fire extinguishers shall be provided with a visual indication of discharge;

**.12** casing and other components of the fire extinguishers subject to internal pressure shall be tested by hydraulic pressure:

2,7 times exceeding the maximum working pressure, but not less than 5,5 MPa for the low pressure fire extinguishers (with working pressure not more than 2,5 MPa at environmental temperature of 20 °C);

determined in accordance with recognized national standard on safety of pressure vessels – for high pressure fire extinguishers (with working pressure more than 2,5 MPa at environmental temperature of 20 °C);

**.13** fire extinguishers shall be suitable for operation under exposure to ambient temperatures according to Table 2.3.1-2, Part VII "Machinery Installations" with due regard for the materials used and maximum degree of filling established by the manufacturer. The degree of filling for carbon dioxide fire extinguishers shall not exceed 0,75 kg/l;

**.14** materials used for the manufacture of fire extinguishers, which can be exposed to marine environment during operation shall be selected with consideration for their compatibility;

**.15** each fire extinguisher shall be clearly marked with at least the following information:

**.15.1** manufacturer;

**.15.2** types of fire for which the fire extinguisher is suitable and its fire-extinguishing capability (i.e. capability to extinguish a model fire seat under certain conditions);

**.15.3** type and nominal quantity of extinguishing medium with which the fire extinguisher is charged;

**.15.4** information on the Register approval;

**.15.5** instruction on actuating the fire extinguisher in the form of several pictograms with explanatory note in the language understandable to potential user, in general case, in Russian and in English;

**.15.6** year of manufacture;

**.15.7** range of temperatures within which the fire extinguisher is operable;

**.15.8** test pressure.

**5.1.10** Foam fire extinguishers of at least 45 and 135 l shall meet the following requirements:

**.1** fire extinguishers shall be located within the protected space, in regular fixed places near the exits.

Only fresh water shall be used for charging the fire extinguishers;

**.2** the air for an air-foam extinguisher shall be kept in a cylinder provided solely for that particular extinguisher. The quantity of air in the cylinder shall be at least 25 per cent in excess of the rated amount. The air cylinder shall be fitted with a pressure gauge;

**.3** fire extinguishers having capacity of not less than 135 l shall be provided with hoses wound on reels and provide access to any place of boiler room;

**.4** location of 45-litre fire extinguishers (or their equivalents) in machinery spaces, specified in 5.1, 5.2 and 5.6 of Table 5.1.2, shall ensure the delivery of the fire extinguishing medium to any part of the fuel system, to pressure lubricating systems, drives casings covering turbine parts lubricated under pressure, engines and associated drives and other fire risk equipment. In cargo ships a fire extinguisher having a capacity of 45 l (or equivalent) may be located outside the space for which it is intended.

**5.1.11** Carbon dioxide or dry powder fire extinguishers of at least 16 and 45 kg shall meet the following requirements:

**.1** carbon dioxide fire extinguishers shall not be used in spaces of such volume that the complete discharge of the carbon dioxide contained in the cylinders is liable to cause concentration of carbon dioxide in excess of 5 per cent;

**.2** an extinguishing medium shall be delivered to any part of the protected space through fire hoses of 10 to 15 m in length and through pipes if necessary;

**.3** fire extinguishers shall be placed near the exits in the spaces and shall be protected against mechanical damage.

**5.1.12** Metal receptacles containing sand or dry sawdust impregnated with soda shall comply with the following requirements:

**.1** the capacity of the receptacles shall be at least 0,1 m<sup>3</sup>;

**.2** each receptacle shall be provided with a readily opening watertight cover, a scoop and a device for holding the cover in the open position.

**5.1.13** Fire smothering blankets shall comply with the following requirements:

**.1** they shall be sufficiently stout and durable;

**.2** as a rule, they are to be made of non-combustible material; clean unraised thick felt may be used;

**.3** blankets shall be stowed in special cases or lockers;

**.4** they shall have an area of at least 3 m<sup>2</sup> and be similar to a square or circle in shape.

**5.1.14** Complete sets of fire fighting tools shall comply with the following requirements:

**.1** one complete set shall include one fire axe and one light-weight fire crowbar;

**.2** the sets of fire fighting tools shall be stowed on regular boards. The fastening of the tools shall permit of ready availability of the tools for use;

**.3** in ships for the carriage of motor vehicles with fuel (other than diesel oil) in their tanks one set of tools shall be placed near the exits from the accommodation and machinery spaces to cargo spaces.

**5.1.15** The fireman's outfit shall include:

**.1** personal outfit consisting of:

**.1.1** protective clothing made of a material capable of protecting the fireman's skin against the heat radiated by the fire, against burns and against scalding by steam; the outside surface shall be waterproof; tarpaulin and polyvinylchloride clothes are not allowed for the outer material of fireman outfit. The type of the top material shall be approved by the competent body;

**.1.2** boots and mittens of rubber or of some other dielectric material;

**.1.3** a rigid helmet ensuring effective protection against impacts;

**.1.4** a portable safe manual lantern with a minimum burning period of 3 h.

In ships carrying dangerous goods, in oil tankers and other ships having cargo spaces and spaces where a flammable gas, vapour or dust/air mixture is present or may arise, provision shall be made for explosion-proof lamps with explosion group 1Exd or

1Exp. The explosion group and temperature class shall be consistent with the category of the cargo carried. For example, they are 1Exd IIAT3 and 1Exp IIT3 for oil, kerosene and a number of gasoline;

**.1.5** a fire axe with a helve made of hard wood; if the helve is made of some other material, it shall be insulated with some suitable dielectric material;

**.2** a self-contained compressed air-operated breathing apparatus, the volume of air contained in the cylinders of which shall be at least 1200 l or other self-contained breathing apparatus which is to be capable of functioning for at least 30 min.

Each breathing apparatus shall be provided with a flexible fire resisting lifeline, not less than 30 m in length. The lifeline shall be subjected to a test by static load of 3,5 kN for 5 min and withstand this load without damage. The lifeline shall be fastened to the harness of the apparatus or to a separate belt by means of a snaphook to preclude spontaneous separation of the line from the apparatus.

Provision shall be made for two spare charges or two spare breathing apparatuses per each required self-contained breathing apparatus. All air cylinders for the apparatus shall be interchangeable.

Passenger ships carrying not more than 36 passengers and cargo ships equipped with properly installed devices for complete recharge of air cylinders by clean air may have only one spare charge for each breathing apparatus or one spare breathing apparatus per each required self-contained breathing apparatus.

In passenger ships carrying more than 36 passengers, two spare charges or two spare breathing apparatus shall be provided per each required self-contained breathing apparatus;

**.3** fireman's outfit and personal equipment shall be ready for use and stored in readily accessible locations that are permanently and clearly marked and where more than one fireman's outfit or more than one set of personal equipment is carried on board they shall be stored in widely separated places. In passenger ships at least two fireman's outfits and, in addition, one set of personal equipment shall be available at any such place. At least two fireman's outfits shall be stored in each main vertical zone.

**5.1.16** Portable electric drills shall be provided with an electric cable of sufficient length. The use of pneumatic drills instead of electric ones is permitted. The electric or pneumatic drills specified in item 11 of Table 5.1.2 may be reckoned in the number of the items prescribed for other types of ship's outfit.

**5.1.17** Portable diesel fire motor-pumps shall comply with the following requirements:

**.1** the pump shall ensure simultaneous operation of at least two fire hose nozzles with an outlet diameter of at least 12 mm at a pump discharge pressure of at least 0,2 MPa and at vacuum in suction piping

not less than 0,05 MPa; centrifugal pumps shall be fitted with a self-priming device;

.2 the pump motor shall be capable of being readily started either by hand or by special starters both at above-zero and below-zero ambient temperatures. The motor shall be provided with a quantity of fuel to ensure the operation of the pump for 1,5 h without refuelling; the ship shall carry an additional reserve of fuel for refuelling;

.3 each motor-pump shall be provided with suction hoses, to a total length of 8 m, fitted with a suction strainer and a non-return valve, two delivery hoses, each 10 m long, two dual purpose fire hose nozzles with an outlet diameter of at least 12 mm and a branch coupling for connecting two hoses;

.4 the dimensions and type of coupling for the delivery hoses and nozzles shall correspond to those used in the fixed water fire extinguishing systems fitted in the ship;

.5 the motor-pumps shall be provided with tools and accessories in compliance with the manufacturer's specification;

.6 motor-pumps for use in ships navigating under northern latitudes shall be placed in heated spaces, together with the suction and delivery hoses and nozzles.

**5.1.18** The international shore connection (Fig. 5.1.18) for water supply from shore shall be in accordance with the following specification:

outside diameter of flange — 178 mm;

inside diameter of flange — 64 mm;

bolt circle diameter — 132 mm;

holes — 4 equispaced holes 19 mm diameter equidistantly placed, slotted to the flange periphery;

flange thickness — at least 14,5 mm;

bolts — 4 pcs, each 16 mm in diameter and 50 mm in length;

bolt nuts — 4 pcs, 16 mm in diameter;

washers for bolts — 8 pcs.

On one side the shore connection shall have a flat-faced flange with dimensions as above, and on the other a quick-acting coupling which shall correspond to the ship's hydrants and hoses both in dimensions and design.

The shore connection, gasket, bolts and nuts shall be made of materials suitable for 1,0 MPa.

The shore connection complete with gasket, four bolts, four nuts and eight washers shall be stowed together with other items of fire fighting outfit in an easily accessible position.

**5.1.19** Portable medium expansion mechanical foam generators and portable combination-foam production units shall comply with the following requirements:

.1 concentrate solution discharge at a pressure of 0,6 MPa, not less than 360 l/min (refer also to 3.7.2.2);

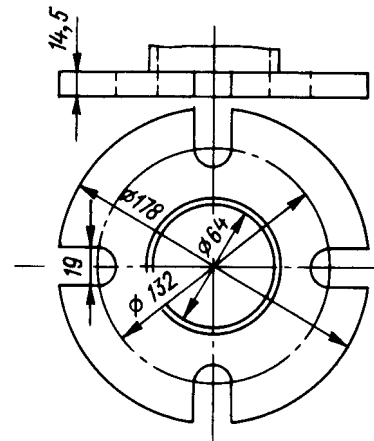


Fig. 5.1.18  
International shore connection (ship)

.2 foam jet range, at least 8 m;

.3 rated number of foam generators/units shall be determined by the formula

$$N = Q/q \quad (5.1.19.3)$$

where  $Q$  = solution capacity of the system, in l/min;

$q$  = solution capacity of a foam generator/unit, in l/min.

50 per cent of the foam generators/units and extension pipes required by items 2.4 and 2.5 of Table 5.1.2 shall be placed in the poop, the remainder, in the forecastle and midship superstructure, if any.

**5.1.20** For applicator shall consist of L-shaped pipe with long side of about 2 m fitted for connection to fire hoses and short side of about 0,25 m equipped with fixed nozzle for producing water for or fitted for connecting water-spraying nozzle.

These applicators shall be located near the fire hydrants and those for breathing apparatus near the latter.

**5.1.21** Fire buckets shall be provided with the hemp rope of sufficient length and shall be stowed on the open decks in easily accessible places. The buckets shall be painted red and bear inscription "fire".

**5.1.22** In tankers and combination carriers provision shall be made for use of gas analyzers with gas sampling pipes as specified in 9.14.2, Part VIII "Systems and Piping".

**5.1.23** In all passenger and cargo ships of 500 gross tonnage and over provision shall be made for emergency escape breathing devices (EEBD) of a Register-approved type which shall be only used for emergency escape from a compartment with a hazardous atmosphere. EEBD shall not be used by crew for fighting fires, entering oxygen deficient void spaces or tanks. In such cases a self-contained breathing apparatus specified in 5.1.15.2 shall be used.

EEBD shall meet the following requirements:

**.1** EEBD shall provide service duration of at least 10 min;

**.2** EEBD shall protect eyes, nose and mouth during escape and consist of a helmet fully covering head, neck and may cover portions of the shoulders, or a mask fully covering the face so as to form a complete seal around the eyes, nose and mouth, which is secured by suitable means. The helmets and masks shall be manufactured of flame resistant materials and include a clear window for viewing;

**.3** an inactivated EEBD shall be carried hands-free;

**.4** EEBD shall be designed so that to enable quick and easy dressing. Brief instructions or diagrams clearly illustrating their use shall be clearly printed on each EEBD.

An EEBD, when stored, shall be suitably protected from weather exposure.

Maintenance requirements, manufacturer's trade-mark and serial number, shelf life and date of manufacture shall be printed on each EEBD. EEBD intended for training shall have appropriate distinct marking.

The number and location of EEBD shall be indicated on fire control plans (refer to 1.4).

## 5.2 SPARE PARTS AND TOOLS

**5.2.1** A ship shall carry spare parts and tools, the number of which shall be not less than that specified in Table 5.2.1. The quantities prescribed in the Table apply to fixed fire extinguishing systems only.

**5.2.2** The spare parts and tools for the systems shall be kept in the fire extinction stations.

Spare parts shall be suitably marked.

Table 5.2.1

Nos	Description of spare parts and tools	Number per ship
<b>1</b>	Water fire main system:	
	.1 a fire hose of each length and diameter fitted complete with couplings	1 pc of each
	.2 connection couplings for each size fitted (if the ship is provided with hydrants of various diameters)	2 pcs
	.3 quick-acting couplings (hose couplings)	2 pcs (of each diameter)
	.4 quick-acting couplings (hose couplings) for ships of 4000 gross tonnage and upwards	4 pcs (of each diameter)
	.5 rubber rings for packing of joints between couplings, hoses and apparatuses	5 per cent of total number, but not less than 10 pcs
	.6 hose clamps	4 pcs (for ships of less than 300 gross tonnage, as many as the number of hoses, but not more than 4) according to the number of hydrants.
	.7 wrenches for engaging or disengaging couplings (where nozzles are fitted by means of a special wrench)	
	.8 fire hydrant of each size fitted, in assembly	1 pc of each size
	.9 handwheel to fire hydrant of each size fitted	1 pc of each size
	.10 valve disks with packing rings to fire hydrants of each size fitted	1 pc of each size
<b>2</b>	Sprinkler system:	
	.1 sprinkler heads, in assembly	The number of spare sprinkler heads shall be determined proceeding from their type and number already fitted on board: 6 – for systems having less than 300 heads; 12 – for systems having 300 to 1000 heads; 24 – for systems having more than 1000 heads
	.2 wrenches for sprinkler heads (where heads are fitted by means of a special wrench)	1 pc per section
	.3 parts for control valve	1 set, according to delivery specification
<b>3</b>	Pressure water-spraying, water-screen, drenching systems:	
	.1 spray nozzles of various types fitted in the system	5 per cent of total number of spray nozzles fitted
	.2 wrench for spray nozzles (where nozzles are fitted by means of a special wrench)	1 pc
<b>4</b>	Foam fire extinguishing system:	
	.1 hydrant of each size fitted, in assembly	1 pc
	.2 fixed air-foam nozzle or foam generator	1 pc
	.3 gauge glasses for tanks	1 pc
	.4 rubber rings for joints	10 pcs
<b>5</b>	Carbon dioxide smothering system:	
	.1 cylinder valves, assembled; for the number of cylinders:	
	below 50	1 pc
	50 to 100	2 pcs
	100 and over	3 pcs
	.2 wrenches for assembling and disassembling cylinder valves and other special valves	1 set per station
	.3 plugs to be fitted on pipes leading from cylinder valves, when cylinders are removed	25 per cent of the number of cylinders



Table 5.2.1 - continued

Nos	Description of spare parts and tools	Number per ship
	.4 protective diaphragms	In accordance with the number of cylinders
	.5 thrust bushes and washers for protective devices	10 per cent of the number of cylinders
	.6 non-return valves	5 per cent of total number, but not less than 1 pc
	.7 discharge nozzles of each type and size fitted	2 pcs
	.8 scales for weighing cylinders or carbon dioxide level gauge	1 pc
	.9 parts of tank carbon dioxide contents gauges	In accordance with delivery specification
6	Inert gas smothering system:	
	.1 control valve (sluice valve) for admitting inert gas into protected spaces	1 pc
	.2 parts for automatic control	In accordance with delivery specification
7	Dry powder system:	
	.1 parts of release arrangements for hand hose lines and monitors	1 set of each
	.2 nozzles of each type and size	1 — 2 pcs
	.3 wrenches for assembling and disassembling valves, hand hose lines, nozzles	1 set
8	Aerosol system:	
	.1 generator of fire extinguishing aerosol	One generator of each type used
9	Miscellaneous items, for all systems:	
	.1 instruments and gauges: pressure gauges, vacuum gauges, thermometers of each type fitted in systems	1 pc of each
	.2 adequate quantity of packing material for onboard repairs	1 set
	.3 fuses for automatic closing of fire doors and dampers	In accordance with number of doors and dampers thus controlled
	.4 spare parts for pumps, fans, compressors and engines serving fire extinguishing systems	In accordance with Section 5, Part VII "Machinery Installations"
	.5 spare parts for electrical equipment of fire extinguishing systems	In accordance with Section 21, Part XI "Electrical Equipment"

## 6 REQUIREMENTS FOR FIRE PROTECTION OF SPECIAL PURPOSE SHIPS AND SPECIAL FACILITIES ON SHIPS

### 6.1 SHIPS EQUIPPED WITH HELIDECKS

**6.1.1** The requirements of the present Chapter are additional to the requirements of Sections 1 to 5 and are applicable to helideck as well as to the helicopter refueling and hangar facilities

Helideck is a purpose-built helicopter landing area including all structures, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

**6.1.2** Helidecks shall be of steel or other equivalent material. If the helideck forms the ceiling of a deckhouse or superstructure it shall be of "A-60" class.

**6.1.3** The Register may permit aluminium or other low-melting metal construction not equivalent to steel, provided the following:

**.1** if a console platform is fitted on board the ship, after each fire on the ship or on the platform, the platform shall undergo a structural analysis to determine its fitness for further use;

**.2** if a platform is located above the deckhouse or similar structure, the following conditions shall be satisfied:

**.2.1** the deckhouse top and bulkheads below the platform shall have no openings;

**.2.2** windows below the platform shall be provided with steel covers;

**.2.3** after each fire on the platform or in close proximity, the platform shall undergo a structural analysis to determine its fitness for further use.

**6.1.4** A helideck shall be provided with both main and emergency means of escape and with access for fire-fighting and rescue personnel. These shall be located as far apart from each other as practicable and preferably on opposite sides of the helideck.

**6.1.5** Landing and helicopter refuelling areas shall be clearly marked and provided with coamings to prevent fuel oil leakage from spreading. The drainage facilities in way of helidecks shall be of steel and shall lead directly overboard independent of any other system and shall be designed so that drainage does not fall on any part of the ship.

**6.1.6** Helideck shall be protected by a fixed foam fire extinguishing system according to item 20 of Table 3.1.2.1 with characteristics specified in 3.7.2.12. The foam concentrate shall be suitable for use with seawater and meet the requirements not interior to those which are adopted by the International Civil Aviation Organization.

**6.1.7** In close proximity to the helideck the following fire-fighting outfit shall be provided and stored near the means of access to that helideck:

**.1** at least two dry powder fire extinguishers having a total capacity not less than 45 kg;

**.2** carbon dioxide fire extinguishers having a total capacity not less than 18 kg or equivalent;

**.3** at least two nozzles of an approved dual-purpose type with hoses sufficient to reach any part of the helideck;

**.4** two sets of fireman's outfit in addition to the those required by item 10 of Table 5.1.2;

**.5** at least the following equipment stored to provide its immediate use and protection from weather exposure:

adjustable wrench;

blanket;

cutter with a 60 cm handle;

hook, hinge or fire-hook;

hacksaw, heavy duty, complete with 6 spare blades;

ladder;

lifeline 5 mm diameter and 15 m in length;

pliers, side cutting;

set of screwdrivers;

harness knife complete with sheath.

**6.1.8** Structural fire protection, fixed fire extinguishing systems and fire detection and alarm systems and fire-fighting outfit for hangars and spaces where helicopter refuelling and maintenance facilities are located shall be similar to those of category A machinery spaces.

**6.1.9** The boundary structures of helicopter hangar shall be constructed of steel.

**6.1.10** The ventilation system of hangars and spaces where helicopter refuelling and maintenance facilities are located shall meet the requirements of 12.11, Part VIII "Systems and Piping".

**6.1.11** Electrical equipment and electric wiring of hangars and spaces where helicopter refuelling and maintenance facilities are located shall comply with the requirements of 2.9, Part XI "Electrical Equipment".

**6.1.12** "NO SMOKING!" signs shall be displayed at appropriate locations in hangars and spaces where helicopter refuelling and maintenance facilities are located.

**6.1.13** All the equipment used in refuelling operations shall be effectively earthed. All the equipment, arrangements, machinery and deck coverings shall be manufactured and installed so as to prevent spark formation.

**6.1.14** Tanks used for storage of helicopter fuel shall be located on weather deck in especially designed area which shall be:

**.1** as remote as practicable from accommodation and machinery spaces, escape routes and embarkation

stations as well as from locations containing sources of ignition;

**.2** isolated from areas containing sources of vapour ignition.

**6.1.15** Tanks used for the storage of helicopter fuel and associated equipment shall be protected against mechanical damage and from a fire in an adjacent space or area. Tanks shall be protected against direct sunrays.

**6.1.16** When equipping tanks for the storage of helicopter fuel with facilities for their emergency jettisoning precautions shall be taken to prevent the tank jettisoned from impact against ship's structures.

**6.1.17** Where portable storage tanks are used, their construction as well as the mounting and securing arrangements shall be designed considering the tank purpose and possibility of inspections. Electric grounding of the tank shall be provided.

**6.1.18** The helicopter refuelling facilities shall meet the requirements of 13.13, Part VIII "Systems and Piping".

**6.1.19** Helicopter facilities shall be provided with an operation manual, including equipment description, a checklist of inspections, requirements for safety measures and equipment maintenance procedures. This manual shall also include the procedures and precautions to be followed during helicopter refuelling operations developed in accordance with recognized safe practices.

## 6.2 SPECIAL PURPOSE SHIPS

### 6.2.1 General

**6.2.1.1** The fire protection of special purpose ships shall be arranged depending on the special personnel carried on board:

**.1** up to 50 persons – similar to that of cargo ships of more than 500 gross tonnage;

**.2** from 50 up to 200 persons – similar to that of passenger ships carrying not more than 36 passengers;

**.3** more than 200 persons – similar to that of passenger ships carrying more than 36 passengers.

**6.2.1.2** Fire protection of working spaces specified in 1.5.8 shall be arranged with due regard for the purpose of the working space and equipment located therein. As a rule the fire protection of working spaces shall be arranged similar to that of service spaces specified in 1.5.3.

### 6.2.2 Storerooms for explosives (magazines).

**6.2.2.1** In special purpose ships the arrangement of storerooms for explosives (magazines) may be permitted. The magazines shall be of the following types:

**.1** integral magazines forming an integral part of the ship;

**.2** independent magazines that are non-integral, portable magazines with a capacity of 3 m<sup>3</sup> or greater;

**.3** magazine boxes that are non-integral, portable magazines with a capacity of less than 3 m<sup>3</sup>.

**6.2.2.2** Integral magazines shall be located in the forward or after portion of the ship and be located not less than one watertight space apart from the propeller shaft, propeller and rudder. They shall not be located below accommodation spaces, control stations and be adjacent to them.

**6.2.2.3** Integral magazines shall not be adjacent to machinery spaces of category A, galleys and other dangerous spaces. If it is necessary to locate the magazine in proximity to these areas, a cofferdam of at least 0,6 m shall be provided separating two spaces. Such a cofferdam shall not be used for stowage and shall be provided with ventilation. One of the bulkheads forming the cofferdam shall be of "A-15" class, if it is adjacent to machinery space of category A it shall be "A-30" class.

**6.2.2.4** Access to integral magazines shall preferably be from the weather deck, but in no case through spaces specified in 6.2.2.2 and 6.2.2.3.

**6.2.2.5** Independent magazines and magazine boxes shall be located on a weather deck in a location protected from direct impact of the sea. The location shall provide sufficient protection against warm air and hazardous vapours being emitted from galleys, pump rooms, etc. Due regard shall be paid to possible risk of subjecting certain explosives to radio emissions.

**6.2.2.6** Magazine boxes shall be located on a weather deck at least 0,1 m from the deck and any deckhouse and in a position suitable for jettisoning the contents.

**6.2.2.7** Bulkheads and decks bounding integral magazines shall be of watertight construction of "A-15" class. If the spaces adjacent to the magazines contain no combustible materials the construction may be of "A-0" class. Insulation shall be provided to prevent condensation of moisture.

**6.2.2.8** Piping of fresh or salt water and drainage systems and piping of systems installed in the magazines themselves may be routed through magazines. Piping of other systems shall be permitted only if they are enclosed in a watertight trunk.

**6.2.2.9** The magazines shall be provided with means to ensure their effective closing and to prevent unauthorized access.

**6.2.2.10** Racks, supports and other means shall be installed, the construction and capacity of which shall provide safe stowage of explosives in their approved containers with minimum dunnage and to

prevent them from shifting and falling when the ship is rolling.

The upper rack shall not be located higher than 1,8 m above the deck. The racks shall have holes for water flowing from the upper to the lower racks during operation of the drenching system.

**6.2.2.11** Decks of magazines shall be covered with a permanent non-slip, non-sparking covering.

**6.2.2.12** A free volume of the magazine, when loaded, shall be at least 70 per cent of the entire magazine volume. Not more than 100 kg of explosives or 1000 detonators shall be placed for each 1 m<sup>2</sup>.

**6.2.2.13** Integral magazines shall be provided with natural or mechanical ventilation fitted with flame arresters sufficient to maintain the magazine temperature not higher than 38 °C.

**6.2.2.14** Independent magazines shall have watertight metal construction insulated with non-combustible materials on the inside as a construction of "A-15" class.

**6.2.2.15** An independent magazine shall bear a label indicating mass in light condition and maximum permissible mass of explosives.

**6.2.2.16** Independent magazines shall be provided with efficient natural ventilation fitted with flame arresters.

**6.2.2.17** Magazines shall be fitted with automatic heat detectors operating at temperatures rising above 40 °C. An appropriate visible and audible alarms actuated by this detector shall be provided in the wheelhouse and in the chief mate's cabin.

**6.2.2.18** Integral and independent magazines shall be fitted with drenching systems in accordance with 3.6. The controls shall be clearly marked with indication of their purpose.

**6.2.2.19** Magazines shall be fitted with scuppers. The scupper pipes shall be provided with valves which shall be kept permanently closed under normal service conditions. The valves shall be controlled from outside the magazines.

**6.2.2.20** Integral and independent magazines shall be clearly marked:

"The space is a magazine";

"Open lights and flame shall be kept away";

"The magazine door shall be locked";

"Matches and lighters shall be removed prior to entering";

"Do not lift with contents" (in case of independent magazines).

**6.2.2.21** Magazine boxes shall have watertight metal construction with walls and lids not less than 3 mm thick. Boxes exposed to sunrays shall be protected with solar screens.

**6.2.2.22** Magazine boxes shall be clearly labeled:

"The container is a magazine box";

"Open lights and flame shall be kept away";

"The box shall be locked".

**6.2.2.23** Electrical equipment in magazines shall comply with the requirements of 19.4.3, Part XI "Electrical Equipment" and other applicable requirements of the above Part.

**6.2.2.24** Detonators shall be stowed separately from other explosives.

**6.2.2.25** Charging of cartridges and other preparatory operations for using explosives shall be made in charging rooms which shall be specially provided for that purpose. Charging rooms shall be arranged in steel enclosures and located on the weather deck apart from control stations, accommodation and service spaces. Bulkheads, decks and equipment of the charging rooms shall be faced with non-sparking materials.

### 6.3 OIL TANKERS (> 60 °C)

**6.3.1** The fire protection of oil tankers (> 60 °C) shall be similar to that of cargo ships having regard of the following:

**.1** a fixed deck foam fire extinguishing system complying with the requirements of 3.7 shall be fitted;

**.2** the water fire main system shall additionally meet the requirements of 3.2.5.4;

**.3** two additional sets of fireman's outfit in accordance with item 10.2 of Table 5.1.2 shall be provided.

**6.3.2** In addition to the requirements of 6.3.1 the following shall be provided:

**.1** cargo tanks shall not be adjacent to accommodation spaces;

**.2** air intakes and other openings leading to accommodation spaces shall not be faced to cargo area. Entrance doors in bulkheads of superstructures and deckhouses facing cargo area may be installed only in cases if they do not lead to accommodation spaces;

**.3** a continuous coaming not less than 150 mm high extending from side to side shall be fitted on the upper deck at a distance of about 2 m from a superstructure where accommodation and service spaces are arranged;

**.4** machinery spaces of category A shall be in general arranged aft beyond cargo and slop tank area.

**6.3.3** Where cargo heating arrangements are fitted, provision shall be made to prevent cargo from heating up to the temperature which is not less than 15 °C lower than the flash temperature.

### 6.4 OIL RECOVERY SHIPS AND BILGE WATER REMOVING SHIPS

**6.4.1** The fire protection of oil recovery ships shall be similar to that of oil tankers and in addition meet the requirements of 6.4.4 to 6.4.10.

**6.4.2** The fire protection of oil recovery ships (> 60 °C) shall be similar to that of oil tankers (> 60 °C) and in addition meet the requirements of 6.4.4 and 6.4.10.

**6.4.3** The fire protection of bilge water removing ships shall be similar to that of oil tankers (> 60 °C) and in addition meet the requirements of 6.4.10.

**6.4.4** The hull, superstructures, structural bulkheads, decks and deckhouses shall be manufactured of steel. The use of aluminium alloys for this purpose is not permitted.

**6.4.5** The spaces intended for removable equipment which is used for oil recovery shall meet the following requirements:

**.1** fire integrity of their structures shall meet the requirements of 2.4.2 for service spaces of category (9);

**.2** they shall be protected by fire extinguishing system according to item 6 of Table 3.1.2.1;

**.3** may be regarded as cofferdams specified in 2.4.7.

**6.4.6** The ship shall be provided with a fixed drenching system for drenching of ship's outside surfaces with the following rate of water discharge:

**.1** 10 l/min per 1 m of superstructure outside walls length;

**.2** 2,5 l/min per 1 m<sup>2</sup> of cargo area horizontal surface.

The drenching system specified in 6.4.6.2 may not be installed if the fixed deck foam fire extinguishing system ensures effective cooling by water of the entire surface of cargo area with the use of monitors remotely controlled from the navigating bridge.

**6.4.7** The water fire main system and drenching and foam fire extinguishing systems specified in 6.4.6 shall use sea water coming only from sea openings arranged in ship's bottom.

**6.4.8** Remote starting of fire pumps, fixed fire extinguishing systems for machinery space of category A and drenching systems specified in 6.4.6 shall be provided from navigating bridge.

**6.4.9** The high expansion foam system shall not be used for protection of machinery spaces and spaces specified in 6.4.5.

**6.4.10** The ship shall be provided with a fixed or portable oil flashpoint tester.

**6.4.11** For small ships of up to 1000 t deadweight periodically engaged in recovery of oil products at the

sea surface, the fixed automatic system for atmosphere monitoring may be replaced, on agreement with the Register, by a monitoring system with portable analyzers specified in item 15.1 of Table 5.1.2. Atmosphere monitoring shall be applied during the whole period of stay of the ship within oil spot in locations specified in 9.14.5, Part VIII "Systems and Piping".

## 6.5 BERTH-CONNECTED SHIPS

**6.5.1** The fire protection of berth-connected ships used as floating hotels and hostels shall be designed depending on the number of persons who sojourn therein:

**.1** up to 50 persons – similar to that of cargo ships of more than 500 gross tonnage;

**.2** from 50 up to 200 persons – similar to that of passenger ships carrying not more than 36 passengers;

**.3** more than 200 persons – similar to that of passenger ships carrying more than 36 passengers.

**6.5.2** The fire protection of floating docks, power plants, workshops and floating warehouses shall be similar to that of cargo ships of more than 500 gross tonnage. If a special personnel of 50 persons and more is carried on these ships, the fire protection shall comply with the requirements of 6.5.1.2 or 6.5.1.3.

**6.5.3** For berth-connected ships operating at shore quay wall the Register may revise the requirements specified in 6.5.1 and 6.5.2, taking into account operating conditions of the ship and its fire protection determined by the ship designer on agreement with the customer.

## 6.6 SHIPS HAVING A DISTINGUISHING MARK OF PROVISION WITH MEANS FOR FIRE-FIGHTING ABOARD OTHER SHIPS

**6.6.1** The fire protection of oil tankers having a distinguishing mark of provision with means for fire-fighting aboard other ships shall be designed in similar manner to other ships with due regard for the following:

**.1** hull, superstructures, deckhouses and decks shall be made of steel;

**.2** structural fire protection shall be made in compliance with the IC method.

**6.6.2** Ships shall be provided with a fire and rescue operations control station. The control station shall be placed so that the ship structures do not impair, as far as practicable, the vision of the water around the ship.

**6.6.3** The ships shall have:

special systems and equipment, the minimum number of which is indicated in Tables 6.6.3-1 and 6.6.3-2;

Table 6.6.3-1

Special systems	Distinguishing mark in the class notation				
	FF1	FF1WS	FF2	FF2WS	FF3WS
Water-screen system <sup>1</sup>	—	+	—	+	+
Drenching system <sup>1</sup>	—	+	—	+	+
Water fire main system	+	+	+	+	+ <sup>2</sup>
Foam fire extinguishing system	+	+	+	+	+
Dry powder system	+ <sup>3</sup>	+ <sup>3</sup>	+ <sup>3</sup>	+ <sup>3</sup>	+ <sup>3</sup>
Bilge system <sup>4</sup>	+	+	+	+	—
<sup>1</sup> Refer to 6.6.6.6.					
<sup>2</sup> Refer to 6.6.8.2.					
<sup>3</sup> Refer to 6.6.10.1.					
<sup>4</sup> Refer to 7.1.10, Part VIII "Systems and Piping".					

Table 6.6.3-2

Special equipment	Distinguishing mark in the class notation		
	FF1 FF1WS	FF2 FF2WS	FF3WS
Pumps, in pcs	2 — 4	2 — 3	1
Monitors:			
water monitors, in pcs	4	3	2
with supply rate of each monitor, in m <sup>3</sup> /hour	2500	1200	100 <sup>1</sup> /500/1000
jet range, in m	150	120	80 <sup>1</sup> /100/420
foam monitors, in pcs	2	— <sup>2</sup>	— <sup>2</sup>
Dry powder monitors <sup>3</sup> , in pcs	1	1	1
Distribution valve manifolds, in pcs	4	4	2
<sup>1</sup> The smaller value is for ships referred to in 6.6.8.2.			
<sup>2</sup> A necessity in installation and characteristics to be indicated by the customer in accordance with the requirements of 6.6.9.2.			
<sup>3</sup> For ships referred to in 6.6.10.1.			

items of fire-fighting outfit in compliance with 6.6.11.1;

additional bilge arrangements (systems) in accordance with 7.1.10 and 13.7.7, Part VIII "Systems and Piping";

additional internal service communications in compliance with 7.2.2, Part XI "Electrical Equipment".

**6.6.4** Special systems installed on board ships for fire-fighting on other objects and for their own protection (water-screen, drenching, water fire main, foam fire extinguishing, dry powder systems) shall also comply with the requirements of Section 3 of this Part and Sections 2, 4, 5, Part VIII "Systems and Piping".

Where special systems other than specified in this Section of the Rules are installed, they shall comply with the requirements of the Rules to the extent agreed with the Register in each particular case.

**6.6.5** The equipment of special systems (pumps, fittings, monitors) may be remote-controlled from the fire and rescue operations control station.

Air-operated and hydraulic control systems shall be supplied from two independent sources of power.

Electrically driven items shall comply with the requirements of 5.1 to 5.3, Part XI "Electrical Equipment".

**6.6.6** Water-screen system.

**6.6.6.1** In ships having distinguishing marks **FF1WS**, **FF2WS** and **FF3WS** in the class notation outer vertical hull surfaces, including superstructures and deckhouses, shall be protected with the water-screen system.

The water-screen system shall totally cover the ship and not impede visibility from the wheelhouse, fire and rescue operations control stations and manually operated monitor platforms.

**6.6.6.2** Doors and side scuttles of ships having distinguishing marks **FF1** or **FF2** in the class notation, which are not fitted with the above system, shall comply with the requirements of 7.2.1.10, Part III "Equipment, Arrangements and Outfit".

**6.6.6.3** The capacity and pressure of pumps serving the system shall be sufficient to supply water through spray nozzles at a rate indicated in 3.5.2.

**6.6.6.4** Where the system is subdivided into sections, manual operation shall be provided from the place of their installation in spite of the provision of the remote control.

**6.6.6.5** The water-screen system shall protect also the manually operated monitor platforms; the system shall be put into operation directly at each monitor.

**6.6.6.6** The ship shall be fitted with water-screen system in combination with the drenching or pressure water-spraying system or one of these two systems provided they are capable to ensure adequate protection of all the outer surfaces of the ship. In any case the letters "WS" shall be retained in class notation.

**6.6.7 Drenching and pressure water-spraying systems**

**6.6.7.1** The drenching and pressure water-spraying systems in ships having distinguishing marks **FF1WS**, **FF2WS** or **FF3WS** in the class notation shall protect outer vertical surfaces of the hull, superstructures and deckhouses as well as horizontal surfaces of the hull where it is appropriate with regard to 6.6.6.6.

**6.6.7.2** The rate of water discharge to the protected surface shall be at least 10 l/min per 1 m of the tier length where the drenching system is applied and 10 l/min per 1 m<sup>2</sup> of the protected surface where the pressure water-spraying system is applied. Intensity of water discharge may be reduced to 5 l/min provided the protected surfaces are of "A- 60" class.

**6.6.7.3** For protection of superstructures and deckhouses the sections of the system shall be ar-

ranged on each tier; the arrangement of spray nozzles shall ensure uniform discharge of water onto the protected outer surface.

Where the system is subdivided into sections, the requirements of 6.6.6.4 shall be met.

**6.6.8 Special water fire extinguishing system**

**6.6.8.1** The system is generally intended for water supply to water monitors, distribution valve manifolds, as well as for supply of water-screen and pressure water-spraying systems. The system may be used for pumping out the water from compartments of a ship in distress (refer to 7.1.10, Part VIII "Systems and Piping").

The requirements for installation of pumps, laying of pipes, water intake arrangements, fittings and tests shall comply with the provisions of the present Part and Part VIII "Systems and Piping" as far as they are applicable and reasonable with regard to the requirements given below.

**6.6.8.2** The special water fire extinguishing system in ships having distinguishing marks **FF1**, **FF1WS**, **FF2** or **FF2WS** in the class notation shall be independent.

In ships having distinguishing mark **FF3WS** in the class notation the ship water fire main system may be used as part of the special water fire extinguishing system.

**6.6.8.3** Availability of remote starting and control of the system shall not prevent starting of the pumps, control of monitors and fittings from the place of their installation (refer to Section 5, Part XI "Electrical Equipment").

Remote-controlled fittings shall have devices for their opening/closing during the time allowing to prevent water hammers.

**6.6.8.4** Provision shall be made for operation of pumps without overheating in case of no or small supply of water to consumers.

**6.6.8.5** The number of monitors shall be not less than that indicated in Table 6.6.3-2 and their arrangement shall:

provide supply of water from each monitor to both sides of the ship;

prevent water from being discharged to the ship's own deck and its equipment;

provide the water jet range in accordance with Table 6.6.3-2.

**6.6.8.6** Each monitor shall have an independent connection to the main of the system.

**6.6.8.7** Distribution valve manifolds shall be arranged on the weather deck. The number of valves on the manifold shall be determined by the designer upon agreement with the customer.

**6.6.8.8** The capacity of the pumps shall be calculated so that water can be simultaneously delivered to monitors, the number of which shall comply with

Table 6.6.3-2 depending on the distinguishing mark in the class notation.

**6.6.9 Special foam fire extinguishing system.**

**6.6.9.1** The special foam fire extinguishing system shall be provided in ships having distinguishing marks of provision with means for fire-fighting aboard other ships.

The system may use totally or partly the equipment of the special water fire extinguishing system (pumps, pipes, monitors). The number and type of the equipment of the foam fire extinguishing system shall be determined by the designer on agreement with the customer.

**6.6.9.2** Ships with distinguishing marks **FF2**, **FF2WS** or **FF3WS** in the class notation may have the system fitted with air-foam nozzles, foam generators or combination foam units, in this case foam monitors may be omitted.

**6.6.9.3** Ships with distinguishing marks **FF1** or **FF1WS** in the class notation shall be fitted with foam monitors or foam nozzles for monitors of the special water fire extinguishing system. The number of foam monitors shall be not less than that indicated in Table 6.6.3-2; the requirements for their installation shall be in line with those for monitors of the special water fire extinguishing system.

**6.6.9.4** The reserve of foam concentrate shall be calculated on the basis of the operating time of a specified number of foam generators or one monitor during at least 30 min.

**6.6.9.5** The type of foam concentrate shall be chosen with regard for water salinity in the prescribed ship service area, and class of liquids, materials or goods the concentrate is intended to extinguish (oil and petroleum products, alcohols, ketons, aldehydes, etc.).

**6.6.10 Special dry powder system.**

**6.6.10.1** The system shall be generally installed on ships servicing the operation area of gas carriers and chemical tankers.

**6.6.10.2** Applicable requirements of 3.10 also cover the special dry powder system.

**6.6.10.3** The powder rate through the monitor shall be not less than 40 kg/s.

The monitor shall be placed on a special platform fitted with devices for remote starting of the system (refer to 6.6.6.5).

**6.6.10.4** The quantity of the extinguishing powder shall be determined by the designer on agreement with the customer.

**6.6.11 Fire-fighting outfit.**

**6.6.11.1** In addition to the fire-fighting outfit specified in Table 5.1.2, the following outfit shall be provided on board ships:

- fireman's outfits;
- fire hoses;
- dual-purpose manual fire nozzles;
- portable air-foam nozzles, foam generators or combination foam units;
- international shore connections;
- complete sets of fire-fighting tools;
- gas analyzers for flammable vapours and gases;
- induced-draught fans.

The number and composition of the additional fire-fighting outfit and spare parts thereto shall be determined by the designer on agreement with the customer.

**6.6.11.2** Additional fire-fighting outfit shall be kept in special storerooms.

Part of the fire-fighting outfit (hoses, hand nozzles, foam generators, air-foam nozzles, hose wrenches) may be placed at the fire stations near each distribution valve manifold.

**6.6.11.3** For charging cylinders of self-contained compressed air breathing apparatus ships shall be provided with compressors approved by competent authorities.

The capacity and the number of simultaneously charged cylinders shall be specified by the customer. There shall be at least four charged cylinders on board the ship. The need for a compressor to be provided on board ship may be specially considered by the Register depending on the main purpose of the ship and number of crew.

**6.6.11.4** Ships shall have two searchlights in accordance with 9.2.12, Part III "Equipment, Arrangements and Outfit".

## 7 SPECIAL REQUIREMENTS FOR SHIPS CARRYING PACKAGED DANGEROUS GOODS AND DANGEROUS GOODS IN BULK

### 7.1 GENERAL

**7.1.1** The requirements of the present Section are aimed at providing additional safety measures in respect of ships carrying packaged dangerous goods and dangerous goods in bulk.

**7.1.2** For the purpose of the present Section, the following additional definitions and abbreviations have been adopted.

High-level radioactive wastes mean liquid wastes resulting from the operation of the first stage extraction system or the concentrated wastes from subsequent extraction stages, in a facility for re-processing irradiated fuel, or solids into which such liquid wastes have been converted.

INF cargo means packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes carried as cargo in accordance with Class 7 of the IMDG Code.

IMDG Code means the International Maritime Dangerous Goods Code adopted by the IMO Resolution MSC.122(75), as amended.

BC Code means the Code of Safe Practice for Solid Bulk Cargoes adopted by IMO Resolution A.434 (XI), as amended.

INF Code means the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships adopted by IMO Resolution MSC.88(71), as amended.

Dangerous goods mean substances, materials and products covered by the IMDG Code.

Dangerous goods in bulk mean any materials other than liquid or gas, consisting of mixture of particles, granules or larger pieces of material, generally homogenous, covered by the IMDG Code, and which are loaded directly into cargo spaces without the use of any intermediate package, including the same materials loaded into shipborne barges.

Irradiated nuclear fuel means material containing uranium, thorium and/or plutonium isotopes which has been used to maintain a self-sustaining nuclear chain reaction.

Plutonium means the resultant mixture of isotopes of that material extracted from irradiated nuclear fuel from reprocessing.

Package means cargo container established by the IMDG Code.

### 7.2 SHIPS CARRYING PACKAGED DANGEROUS GOODS OR DANGEROUS GOODS IN BULK

**7.2.1** The requirements of the present Chapter apply to the following types of ships and cargo spaces:

**.1** ships and cargo spaces not specially designed for the carriage of freight containers but intended for the carriage of packaged dangerous goods including goods in freight containers and portable tanks;

**.2** purpose-built container ships and cargo spaces intended for the carriage of dangerous goods in freight containers and portable tanks (refer to 8.4.8, Part III "Equipment, Arrangements and Outfit");

**.3** ro-ro ships and ro-ro cargo spaces, spaces for vehicles and special category spaces intended for the carriage of dangerous goods. A ro-ro cargo space completely open from above and on both sides may be treated as the weather deck;

**.4** ships and cargo spaces intended for the carriage of dangerous goods in bulk;

**.5** ships and cargo spaces intended for the carriage of dangerous goods other than liquids and gases in bulk in shipborne barges.

**7.2.2** Cargo ships of less than 500 gross tonnage shall comply with the requirements of the present Chapter; however, these requirements may be reduced by the Register with an appropriate note in the Certificate of Compliance of the Ship Carrying Dangerous Goods with the Special Requirements, issued by the Register.

**7.2.3** In addition to the requirements of the present Chapter, the applicable provisions of the IMDG Code and BC Code shall be complied with. The carriage of dangerous goods is prohibited in all ships except in accordance with the provisions of the IMDG Code.

**7.2.4** Depending on the modes of carriage of dangerous goods in ships and cargo spaces specified in 7.2.1 the requirements of Table 7.2.4-1 shall apply; depending on the class of dangerous goods carried in bulk the requirements of Table 7.2.4-2 shall apply; depending on the class of dangerous goods other than those carried in bulk the requirements of Table 7.2.4-3 shall apply.

**7.2.5 The following additional measures shall be taken to ensure supply of water:**

**.1** the water fire main system shall ensure immediate availability of water supply at the required pressure either by permanent pressurization in the



Table 7.2.4-1

Ships and cargo spaces Requirements of paragraphs	Weather deck of ships and cargo spaces listed in 7.2.1.1 to 7.2.1.5	Ships not specifically designed (refer to 7.2.1.1)	Container cargo spaces (refer to 7.2.1.2)	Closed cargo spaces as given in 1.5.4.3.1 <sup>1</sup> (refer to 7.2.1.3)	Open cargo spaces as given in 1.5.4.3.2 (refer to 7.2.1.3)	Ships for the carriage of solid dangerous goods in bulk (refer to 7.2.1.4)	Shipborne barges (refer to 7.2.1.5)
7.2.5.1	+	+	+	+	+	For application of the requirements of 7.2 to different classes of dangerous goods, refer to Table 7.2.4-2	+
7.2.5.2	+	+	+	+	+		—
7.2.5.3	—	+	+	+	+		+
7.2.5.4	—	+	+	+	+		+
7.2.6	—	+	+	+	+		+ <sup>3</sup>
7.2.7	—	+	+	+	—		+ <sup>3</sup>
7.2.8.1	—	+	+ <sup>2</sup>	+	—		+ <sup>3</sup>
7.2.8.2	—	+	+ <sup>2</sup>	+	—		+ <sup>3</sup>
7.2.9	—	+	+	+	—		—
7.2.10.1	+	+	+	+	+		—
7.2.10.2	+	+	+	+	+		—
7.2.11	+	+	—	—	+		—
7.2.12	+	+	+ <sup>4</sup>	+	+		—
7.2.13	—	—	—	+ <sup>5</sup>	+		—
7.2.14	—	—	—	+	—		—
7.2.15	—	—	—	+	—		—

<sup>1</sup> Special category spaces shall be treated as closed ro-ro cargo spaces when dangerous goods are carried.

<sup>2</sup> This requirement is not applicable to carriage of dangerous goods of classes 4 and 5.1 in 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 the purpose of this requirement a portable tank is a closed freight container.

<sup>3</sup> In special cases where the barges are capable of containing flammable vapours or alternatively if they are capable of discharging flammable vapours to a safe space outside the barge carrier compartment by means of ventilation ducts connected to the barges, these requirements may be reduced or waived, which is subject to special consideration by the Register.

<sup>4</sup> Applicable to decks only.

<sup>5</sup> Applies only to closed cargo spaces as given in 1.5.4.3.1, not capable of being sealed.

Note: Wherever + 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 2.8.2-3, except as indicated in the footnotes.

Table 7.2.4-2

Class of dangerous goods Requirements of paragraphs	4.1	4.2	4.3 <sup>1</sup>	5.1	6.1	8	9
7.2.5.1	+	+	—	+	—	—	+
7.2.5.2	+	+	—	+	—	—	+
7.2.6	+	+ <sup>2</sup>	+	+ <sup>3</sup>	—	—	+ <sup>3</sup>
7.2.7	—	+ <sup>2</sup>	+	—	—	—	—
7.2.8.1	+ <sup>4</sup>	+ <sup>2</sup>	+	+ <sup>2, 4</sup>	—	—	+ <sup>2, 4</sup>
7.2.8.2	+	+	+	+	+	+	+
7.2.10	+	+	+	+	+	+	+
7.2.12	+	+	+	+ <sup>2</sup>	—	—	+ <sup>5</sup>

<sup>1</sup> The hazards of substances in this class which may be carried in bulk are such that special consideration shall be given to the construction and equipment of the ship involved in addition to meeting the requirements of this table.

<sup>2</sup> Only applicable to oilcake containing solvent extractions, ammonium nitrate and ammonium nitrate fertilizers.

<sup>3</sup> Only applicable to ammonium nitrate and ammonium nitrate fertilizers. However, the degree of protection in accordance with the standards contained in the International Electrotechnical Commission, publication 79 — Electrical Apparatus for Explosive Gas Atmospheres, is sufficient.

<sup>4</sup> Only suitable wire mesh guards are required.

<sup>5</sup> The requirements of BC Code are sufficient.

fire main or by suitably placed remote starting arrangements for the fire pumps from the locations referred to in 3.2.3.9;

.2 the water fire main system shall ensure the delivery of the quantity of water capable of supplying four nozzles with applicators provided on board under the pressure as specified in 3.2.1.1 to any part

of the cargo space when empty. Upon agreement with the Register, this amount of water may be applied by equivalent means. The number and arrangement of fire hydrants shall be such that at least two water jets out of four required can be delivered through fire hoses of standard length to any part of the empty cargo space and that all the four jets can be delivered

Table 7.2.4-3

Class of dangerous goods Requirements of paragraphs	1.1 to 1.6	1.4S	2.1	2.2	2.3	3		4.1	4.2	4.3	5.1	5.2 <sup>5</sup>	6.1				8				9
						liquids (≤23 °C) <sup>6</sup>	liquids (>23 ≤61 °C) <sup>6</sup>						liquids	liquids (≤23 °C) <sup>6</sup>	liquids (>23 ≤61 °C) <sup>6</sup>	solids	liquids	liquids (≤23 °C) <sup>6</sup>	liquids (>23 ≤61 °C) <sup>6</sup>	solids	
7.2.5.1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
7.2.5.2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—
7.2.5.3	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7.2.5.4	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7.2.6	+	—	+	—	—	+	—	—	—	—	—	—	—	+	—	—	—	+	—	—	—
7.2.7	+	+	+	+	+	+	+	+	+	+	+	—	+	+	+	+	+	+	+	+	—
7.2.8.1	—	—	+	—	+	+	—	+ <sup>1</sup>	+ <sup>1</sup>	+	+ <sup>1</sup>	—	—	+	+	+ <sup>1</sup>	—	+	+	—	+ <sup>1</sup>
7.2.8.2	—	—	+	—	—	+	—	—	—	—	—	—	—	+	+	—	—	+	+	—	—
7.2.9	—	—	—	—	—	+	—	—	—	—	—	—	+	+	+	—	—	+	—	—	—
7.2.10	—	—	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+ <sup>2</sup>
7.2.11	—	—	—	—	—	+	+	+	+	+	+	—	—	+	+	—	—	+	+	—	—
7.2.12	+ <sup>3</sup>	—	+	+	+	+	+	+	+	+	+ <sup>4</sup>	—	—	+	+	—	—	+	+	—	—
7.2.13	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
7.2.14	+	+	+	+	+	+	+	+	+	+	+	+ <sup>5</sup>	+	+	+	+	+	+	+	+	+
7.2.15	+	+	+	+	+	+	+	+	+	+	+	+ <sup>5</sup>	+	+	+	+	+	+	+	+	+

<sup>1</sup> When "mechanically-ventilated" spaces are required by IMDG Code.

<sup>2</sup> As appropriate to the goods being carried.

<sup>3</sup> Cargoes stow 3 m horizontally away from the machinery space boundaries which shall be "A-60" class in all cases.

<sup>4</sup> Refer to IMDG Code.

<sup>5</sup> Stowage of class 5.2 dangerous goods under deck or in enclosed ro-ro spaces is prohibited.

<sup>6</sup> Refer to the flashpoint.

through hoses of standard length to any part of cargo ro-ro space;

**.3** the water fire main system shall effectively cool a cargo space by a pressure water-spraying system with a rate of water supply specified in 3.4.2.1 or by flooding (refer to 3.6.4).

Hoses capable to ensure the delivery of the required quantity of water may be used for this purpose in small spaces and in small areas of larger cargo spaces on agreement with the Register.

The drainage and pumping arrangements shall be such as to prevent the build-up of free surfaces as specified in 7.14.2, Part VIII "Systems and Piping". If this is impossible a calculation shall be made to prove that the ship with the cargo space flooded with water complies with the requirements of Sections 2 and 3, Part V "Subdivision";

**.4** in lieu of compliance with the requirements of 7.2.5.3 the high expansion foam system may be used in accordance with 3.7.3 using a supply rate and time of continuous supply according to Table 3.7.1.3 for machinery or by other special suitable extinguishing media;

**.5** the total required quantity of water shall satisfy the requirements of 7.2.5.2 and 7.2.5.3, if applicable, simultaneously calculated for the largest designated cargo space. The requirements of 7.2.5.2 shall be met by the total capacity of the main fire pumps not including the capacity of the emergency fire pump, if fitted. If a drencher system is used to satisfy the requirements of 7.2.5.3, the drencher pump shall also be taken into account in this total capacity calculation;

**.6** the pressure water-spraying system required in accordance with 9.2, 9.3 and 9.4 of the MSC/Circ.608/Rev.1 "Interim Guidelines for Open-Top Containerships" also satisfies the requirements for dangerous goods. The quantity of water required to fire fighting in the largest cargo space shall be capable to ensure simultaneous operation of the pressure water-spraying system and four jets from fire nozzles.

**7.2.6** Electrical equipment shall comply with the requirements of 2.9.2, 2.9.3, 2.9.9, 2.9.10, 2.9.12, 16.8.1.6, 16.8.4.5, 16.8.6.1 and 19.11, Part XI "Electrical Equipment".

Any other equipment which may constitute a source of ignition of flammable gases, vapours and dust shall not be permitted in cargo spaces.

**7.2.7** Ro-ro cargo spaces shall be fitted with a fixed fire detection and fire alarm system complying with the requirements of 4.2.1. All other types of cargo spaces shall be fitted either with a fixed fire detection and fire alarm system complying with the requirements of 4.2.1 or sample extraction smoke detection system complying with the requirements of

4.2.1.6. If a sample extraction smoke detection system is fitted, particular attention shall be given to the requirements of 4.2.1.6.3 to prevent leakage of toxic smoke into areas where people stay.

**7.2.8** Ventilation of cargo spaces shall comply with the following requirements of Part VIII "Systems and Piping":

**.1** arrangement of the ventilation system, with the requirements of 12.1.7, 12.1.8, 12.7.1, 12.7.3 and 12.7.5. For bulk cargoes of class 4.3 and oil-cake containing oil extracting solvents, additionally with the requirements of 12.7.7;

**.2** construction of ventilation fans, with the requirements of 12.7.4;

**.3** natural ventilation system in compliance with the requirements of 12.7.2 shall be provided in enclosed cargo spaces intended for the carriage of dangerous goods in bulk unless not fitted with mechanical ventilation.

**7.2.9** The bilge system of cargo spaces shall comply with the requirements of 7.14.1, 7.14.4 to 7.14.9, Part VIII "Systems and Piping".

**7.2.10** Ships shall be provided with the following outfit:

**.1** four full sets protective clothing resistant to chemical exposure and intended for use in emergency situations. The protective clothing shall cover all skin so that no part of the body is unprotected and, subject to cargo characteristics, shall meet the recommendations of IMDG Code or BC Code;

**.2** at least two self-contained breathing apparatus in addition to those required by item 10 of Table 5.1.2. Two spare charges suitable for the use with the breathing apparatus shall be provided for each apparatus in addition to those required for the fireman's outfit (refer to 5.1.15.2).

**7.2.11** Portable fire extinguishers with a total capacity of at least 12 kg of dry powder or equivalent shall be provided for cargo spaces. These extinguishers shall be in addition to any portable fire extinguishers required by the present Part.

**7.2.12** Bulkheads forming boundaries between cargo spaces and machinery spaces of category A shall be of "A-60" class, unless dangerous goods are stowed at least 3 m horizontally away from such bulkheads. Other boundaries between such spaces shall be of "A-60" class.

When a cargo space is partially located above the machinery space of category A and bounding structures do not have the required insulation, such cargo space is unfit for carriage of dangerous goods. The same refers to areas of bare weather deck located above the machinery space of category A.

**7.2.13** Each open ro-ro space having a deck above it and each space considered to be a closed ro-ro space not capable of being sealed shall be fitted

with an approved manually operated fixed pressure water-spraying system which shall protect all parts of any deck and vehicle platform in such space. The Register may permit the use of any other fixed fire extinguishing system that has been shown by full-scale tests to be not less effective (refer to 1.3.3). However, the drainage and pumping arrangements shall be such as to prevent free surfaces as specified in 7.14.2, Part VIII "Systems and Piping". If this is impossible, a calculation shall be made to prove that the ship with flooded cargo space meets the requirements of Sections 2 and 3, Part V "Subdivision".

**7.2.14** In ships having ro-ro spaces, subdivision shall be provided between a closed ro-ro space and an adjacent open ro-ro space. The subdivision shall be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such subdivision need not be provided if the ro-ro space is considered to be a closed cargo space over its entire length and shall fully comply with the relevant special requirements of the present Chapter.

**7.2.15** In ships having ro-ro spaces, subdivision shall be provided between a closed ro-ro space and the adjacent weather deck. The subdivision shall be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such subdivision need not be provided if the arrangements of the closed ro-ro spaces are in accordance with the requirements for the carriage of dangerous goods on the adjacent weather deck.

**7.2.16** Cargo spaces in ships other than ro-ro ships shall not be adjacent to accommodation and service spaces, except service spaces of low fire risk referred to in 1.5.3.2.3.

**7.2.17** Hatch covers of dry-cargo holds shall comply with the requirements of 7.10.8.6, Part III "Equipment, Arrangements and Outfit".

### **7.3 SHIPS CARRYING PACKAGED IRRADIATED NUCLEAR FUEL, PLUTONIUM AND HIGH-LEVEL RADIOACTIVE WASTES (INF CARGO)**

**7.3.1** The requirements of the present Chapter are based on the provisions of the INF Code and apply to all ships regardless of their date of build and size, including cargo ships of less than 500 gross tonnage, engaged in the carriage of INF cargo.

**7.3.2** For the purpose of the present Chapter, ships carrying INF cargo are assigned to the following three classes, depending on the total activity of INF cargo which is carried on board.

Class **INF1** ship is a ship, having certificate to carry INF cargo with an aggregate activity less than 4000 TBq.

Class **INF2** ship is a ship, having certificate to carry irradiated nuclear fuel or high-level radioactive wastes with an aggregate activity less than 2 106 TBq and ship which is certified to carry plutonium with an aggregate activity less than 2 105 TBq.

Class **INF3** ship is a ship, having certificate to carry irradiated nuclear fuel or high-level radioactive wastes and ship which is certified to carry plutonium with no restriction of the maximum aggregate activity of the materials.

The compliance of the ship with the requirements of this Chapter shall be certified by the appropriate distinguishing mark added to the class notation in accordance with 2.2.13, Part I "Classification" and by the International Certificate of Fitness for Carriage of INF Cargo issued by the Register.

**7.3.3** In addition to the requirements of the present Chapter, the applicable provisions of the IMDG Code shall be complied with.

**7.3.4** The INF cargo which is required to be carried on Class **INF3** ships shall not be carried on passenger ships.

**7.3.5** The damage trim and stability shall comply with the requirements of 3.4.9, Part V "Subdivision".

**7.3.6** In addition to the requirements of the present Part, the ship shall be fitted with a fixed pressure water-spraying system to protect cargo spaces which shall ensure the rate of water discharge as indicated in 3.4.2.1. In Class **INF1** ships the pressure water-spraying system need not be installed provided the requirements of 7.2.5.1 and 7.2.5.2 are complied with.

**7.3.7** In Class **INF3** ships accommodation spaces, service spaces, control stations and machinery spaces of category A shall be fitted forward or aft of the cargo spaces, due regard being paid to the overall safety of the ship.

**7.3.8** The cargo spaces of the ship shall be fitted with temperature control systems complying with the requirements of 12.7.8, Part VIII "Systems and Piping".

**7.3.9** The ship hull structure shall comply with the requirements of Part II "Hull".

**7.3.10** Permanent devices shall be provided to secure packages of INF cargo within the cargo spaces. The devices shall meet the requirements of the Guidelines for the Development of the Cargo Securing Manual.

**7.3.11** The electrical equipment of systems and arrangements referred to in 7.3.6 and 7.3.8 shall comply with the requirements of Part XI "Electrical Equipment".

The requirements for the emergency source of electrical power to supply these systems are set forth in Section 9, Part XI "Electrical Equipment".

**7.3.12** Depending upon the characteristics of the INF cargo to be carried and upon the design of the ship, additional arrangements and equipment for radiological protection meeting the requirements of the competent state authorities on radiological safety shall, if necessary, be provided.

**7.3.13** Every ship shall carry on board an approved shipboard emergency plan based on the Guidelines for Developing Shipboard Emergency

Plans for Ships Carrying Materials Subject to the INF Code adopted by IMO Resolution A.854(20).

**7.3.14** Every ship shall carry on board equipment (individual personnel protection outfit, apparatus, etc.) for use in emergency. The type and amount of such equipment depend upon the INF cargo to be carried and is specified by the shipboard emergency plan referred to in 7.3.13.

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