RUSSIAN MARITIME REGISTER OF SHIPPING

RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

ND No. 2-020101-174-E

RULE CHANGE NOTICE

ENTERS INTO FORCE:

01.07.2024

St. Petersburg
2024

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

The present Rule Change Notice to the Rules for the Classification and Construction of Sea-Going Ships (hereinafter — RCN) has been approved in accordance with the established approval procedure and contains information on amendments and additions, except for editorial amendments. RCN amendments come into force on 1 July 2024 (excluding earlier approved amendments of an urgent matter, published by the Circular Letters and Urgent Rule Change Notices after entering into force of the previous version of the Rules for the Classification and Construction of Sea-Going Ships, specified in the Revision History and highlighted in yellow).

REVISION HISTORY

PART I. CLASSIFICATION

Item	Applicability	Description	Remarks
Para 1.1.1	Terminology	New definitions "Offshore industrial activities" and "Industrial personnel" have been introduced	IMO resolutions MSC.521(106) and MSC.527(106)
Para 1.2.4	Area of application of the Rules	Cargo ships carrying the industrial personnel have been included in the area of application of the Rules	IMO resolutions MSC.521(106) и MSC.527(106)
Para 2.2.3.1	Ships under construction and in service Ice Navigation Ship Certificate	Requirements that the conditions for safe operation of a ship in ice do not depend on the ice class mark of the ship have been specified	
Para 2.2.3.1.3	Characteristics of ice conditions	Definition "medium first-year ice" has been introduced	
Table 2.2.3.3.2	Ships under construction and in service Description of ice classes	Division of ice classes into arctic and non-arctic has been canceled. Information on the Ice Navigation Ship Certificate. Description of ice classes has been amended taking into account the definitions in the Sea Ice Nomenclature of the World Meteorological Organization	
Para 2.2.3.3.3	Ships under construction and in service	Requirements that are no longer relevant have been deleted	
Para 2.2.6.5	Sea-going ships Class notation of a ship	Requirements for assignment of distinguishing automation marks **AUT1-ICS**, **AUT2-ICS** or **AUT3-ICS** have been specified	

Item	Applicability	Description	Remarks
Para 2.2.60 (new)	Ships with an equipment length of 135 m and above Anchor arrangement	New para containing requirements for assignment of distinguishing mark **ADUW** to ships intended for anchoring in deep and unsheltered water has been introduced	
Para 2.2.62 (new)	Cargo ships carrying the industrial personnel	New para containing requirements for assignment of distinguishing marks **IPS1(N)** and **IPS2(N)** has been introduced	IMO resolutions MSC.521(106) and MSC.527(106)
Para 2.2.63 (new)	Cargo ships carrying special personnel (special purpose ships)	New para containing requirements for assignment of distinguishing marks **SPS1(N)** and **SPS2(N)** has been introduced	In connection with the deletion of descriptive notation **Special purpose ship**
Para 2.4.1	Standby vessels and salvage ships Classification Certificate	Reference to para 13.2.4.1.5 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" containing requirement for an entry to be made in the Classification Certificate regarding the number of survivors for which the ship is intended to carry, has been introduced	
Table 2.5, item 2.36 (new)	Ships with an equipment length of 135 m and above Anchor arrangement	New item 2.36 containing description and conditions for assignment of distinguishing mark **ADUW** has been introduced	
Table 2.5, item 2.38 (new)	Cargo ships carrying the industrial personnel	Description of new distinguishing marks **IPS1(N)** and **IPS2(N)** has been introduced	
Table 2.5, item 2.39 (new)	Cargo ships carrying special personnel	Description of new distinguishing marks **SPS1(N)** and **SPS2(N)** has been introduced	

Item	Applicability	Description	Remarks
Table 2.5, Section 3, item 3.1	Cargo ships carrying special personnel	Descriptive notation **Special purpose ship** has been deleted	Requirements have been transferred to new item 2.39 of Table 2.5
Para 3.2.3.30 (new)	Ships Towing and mooring arrangements	Requirements for submission of the Towing and Mooring Arrangements Plan within the design documentation on arrangements, equipment and outfit have been introduced	**Entry-into-force date: 21.05.2024** (Urgent Rule Change Notice No. 311-05-2011 of 21.05.2024)
Para 3.2.8.1.5	Sea-going ships Technical documentation	Requirements for design documentation regarding diagrams of power supply for automation systems have been specified	
Paras 3.2.8.2.1 — 3.2.8.2.27	Sea-going ships Technical documentation	The list of design documentation on individual automation systems, consoles and control and monitoring switchboards has been updated. New paras 3.2.8.2.3 — 3.2.8.2.8 containing requirements for the documentation on computer-based systems of categories I, II and III have been introduced. Existing paras 3.2.8.2.3 — 3.2.8.2.21 have been renumbered 3.2.8.2.9 — 3.2.8.2.27 accordingly	IACS UR E22 (Rev. 3 June 2023)
Para 3.2.10.1.3	Ships under construction Technical documentation	Requirements for the development and submission of documentation have been introduced	IMO resolution MEPC.364(79)

Item	Applicability	Description	Remarks
Para 3.2.10.1.15	Sea-going ships Design documentation Documentation on electrical equipment Calculation of the expected total harmonic distortions (non-sinusoidality)	References to the calculation have been unified throughout the text of the para. New remark regarding the possibility of non-performing calculation has been introduced	In accordance with Part XI "Electrical Equipment" of the RS Rules/C
Para 3.2.11.1.3	Ships under construction Technical documentation Arrangements and equipment for the prevention of pollution from ships	Text has been updated due to transfer of some requirements to new para 3.2.11.1.11	
Para 3.2.11.1.11 (new)	Ships under construction Technical documentation Arrangements and equipment for the prevention of pollution from ships	New para has been introduced containing requirements for sewage holding tanks and garbage receptacles transferred from 3.2.11.1.3	
Para 3.2.17.8.28 (new)	Design documentation Ships equipped for using gas as fuel	List of documentation required for assignment of distinguishing mark **GFS** has been supplemented by Fuel Handling Manual	

Item	Applicability	Description	Remarks
Para 3.2.17.10	Technical documentation required for assignment of distinguishing mark **IWS** (in-water survey)	A list of technical documentation required for assignment of distinguishing mark **IWS** (in-water survey) has been amended	Requirements have been transferred from Chapter 12.2 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the RS Rules/C

Item	Applicability	Description	Remarks
Para 3.2.17.15	Ship's passenger and crew spaces including accommodation spaces (cabins, corridors, offices, hospitals, lounges, mess rooms, shopping rooms, sanitary spaces, games, recreation and entertainment rooms, and other similar spaces), navigation bridge, main machinery control room and other spaces where the continuous or prolonged presence of persons is required for normal operational conditions Measurements of indoor climate, noise level and sanitary vibration level	Distinguishing marks specifying noise and sanitary vibration levels have been introduced. Technical documentation necessary for confirmation of distinguishing marks specifying indoor climate, noise level and sanitary vibration level has been introduced	Requirements for noise level do not apply to ships specified in 18.2.1.2 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the RS Rules/C. Requirements for sanitary vibration level do not apply to ships specified in 18.2.1.3 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the RS Rules/C
Para 3.2.17.24 (new)	Container ships and ships designed for the carriage of containers Technical documentation Additional fire-fighting equipment and outfit for container ships	New para has been introduced containing the list of design documentation for assignment of distinguishing marks **ACFP(P)**, **ACFP(S)**, **ACFP(S,F)** to a ship the special equipment of which ensures effective fire fighting in way of cargo holds and container stowage decks	Transferred from Section 29 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the RS Rules/C

Item	Applicability	Description	Remarks
Para 3.2.17.25 (new)	Container ships and ships designed for the carriage of containers Technical documentation Additional refrigeration equipment for the carried containers	New para has been introduced containing the list of design documentation for assignment of distinguishing marks **RC-C**, **RC-A**, **RC-IA** or **RC-E** to a ship the special equipment of which ensures refrigeration of carried containers	Transferred from Section 30 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the RS Rules/C
Para 3.2.17.26 (new)	Offshore supply vessels carrying limited amount of hazardous and noxious liquid substances in bulk	New para has been introduced containing the list of design documentation for assignment of distinguishing mark **HNLS** (Hazardous and Noxious Liquid Substances) to a ship	Transferred from Section 31 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the RS Rules/C
Para 3.2.17.27 (new)	Offshore supply vessels with special equipment for well stimulation in oil and gas fields installed on board, or specially prepared for installation of such equipment	New para has been introduced containing the list of design documentation for assignment of distinguishing marks **WSV1** (well stimulation vessel type 1) or **WSV2** (well stimulation vessel type 2) to a ship	Transferred from Section 32 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the RS Rules/C
Para 3.2.17.28 (new)	Cargo ships carrying the industrial personnel	List of documentation relating to personnel transfer appliance has been introduced	IMO resolutions MSC.521(106) and MSC.527(106)

PART II. HULL

Item	Applicability	Description	Remarks
Para 1.6.5.7 (new)	Ships of 90 m in length and above, of unrestricted area of navigation Buckling strength of hull structural members	New para has been introduced containing requirements, allowing for the possibility of using an alternative methodology of buckling strength check	IACS UR S35 (Feb 2023)
Para 2.4.5.6 (new)	Special purpose ships Requirements for double bottom	New para containing requirements for double bottom structure of special purpose ships has been introduced	
Para 2.12.4.4	Ships Hull End bulkheads of superstructures and deckhouses	Para has been amended considering new revision of IACS UR S3, allowing for a reduction in the minimum thicknesses of end bulkheads of superstructures and deckhouses for ships of less than 65 m in length	IACS UR S3 (Rev.2 June 2023)
Para 3.1.3.8	Ships with large deck openings Loads on container securing arrangements	Design mass values for containers have been deleted	
Appendix 1	Ships Testing procedures of watertight compartments	Appendix has been amended considering new revision of IACS UR S14	IACS UR S14 (Rev.7 Dec 2022) **Entry-into-force date: 01.01.2024** (Circular Letter No. 311-05-1988c of 28.12.2023)

PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT

Item	Applicability	Description	Remarks
Para 1.4.2	Ships Mooring arrangement and towing arrangement	Requirements for the content of the Towing and Mooring Arrangements Plan have been amended	**Entry-into-force date: 21.05.2024** (Urgent Rule Change Notice No. 311-05-2011 of 25.05.2024)
Para 3.1.3	Ships Anchor arrangement	Basic weather conditions have been added to apply the requirements of 3.1, and the requirement regarding alternative calculation for ships of length less than 90 m has also been added	IACS UR A1 (Rev. 7 Corr.1 Sep 2021) IACS UI A1 (Rev. 7 Corr.1 Sep 2021)
Para 3.2.2	Tugs Anchoring equipment	Requirements for provision with anchors of tugs under 45 m in length have been introduced	IACS UR A1 (Rev.8 June 2023)
Para 3.2.3	Dredgers Anchoring equipment	Requirements for selection of anchoring equipment for dredgers with unusual design of the underwater part of the hull have been introduced	IACS UR A1 (Rev.8 June 2023)
Para 3.2.5	Ships with an equipment length of 135 m and above Anchor arrangement	Requirements for ships intended for anchoring in deep and unsheltered water have been specified	For assignment of distinguishing mark **ADUW** IACS Rec. No.10 (Rev.5 June 2023)
Paras 3.4.7 — 3.4.9	Ships Anchor chains and wire ropes	Requirements for the use of wire ropes in place of chain cables have been amended	IACS UR A1 (Rev.8 June 2023)

Item	Applicability	Description	Remarks
Para 4.1.1	Ships Mooring arrangement	Requirements relating to towing and mooring arrangement design and availability of the towing and mooring arrangements plan on board the ship have been added	IMO resolution MSC.474(102) **Entry-into-force date: 01.01.2024** (Circular Letter No. 311-05-1981c of 14.12.2023)
	Ships Mooring arrangement	The area of application and the requirements for storage of information have been specified	**Entry-into-force date: 21.05.2024** (Urgent Rule Change Notice No. 311-05-2011 of 25.05.2024) IACS UI SC 212 (Rev.1 Nov 2023 Complete Revision)
Para 4.1.2	Ships Mooring arrangement	Requirements relating to definition of mooring equipment have been added	IACS Rec.No.10 (Rev.5 June 2023)
Para 4.1.6 (deleted)	Ships Mooring lines	Requirements for non-metallic lines have been deleted	IACS Rec.No.10 (Rev.5 June 2023)
Para 4.2.1	Ships Mooring lines	Requirements for minimum diameter of non-metallic ropes have been deleted	IACS Rec.No.10 (Rev.5 June 2023)
Para 4.2.2	Ships Mooring lines	Requirements for the number of wires and fibre cores in wire ropes have been deleted	

Item	Applicability	Description	Remarks
Para 4.5.2	Ships Mooring arrangement and towing arrangement	Requirements for the Towing and Mooring Arrangements Plan have been amended	**Entry-into-force date: 21.05.2024** (Urgent Rule Change Notice No. 311-05-2011 of 25.05.2024) IACS UI SC 212 (Rev.1 Nov 2023 Complete Revision)
Para 4.5.3 (new)	Ships of 3000 gross tonnage and above Mooring arrangement	Additional requirements for the Towing and Mooring Arrangements Plan have been introduced. Existing para 4.5.3 has been renumbered 4.5.4	**Entry-into-force date: 21.05.2024** (Urgent Rule Change Notice No. 311-05-2011 of 25.05.2024) IACS UI SC 212 (Rev.1 Nov 2023 Complete Revision)
Para 7.7.2.1	Container ships Small hatches on the exposed fore deck	Instructions on the applicability of the requirements have been introduced	IACS UR S26 (Rev.5 May 2023)
Paras 8.6.9 and 8.6.10	Oil tankers, chemical tankers, gas carriers and NLS tankers Access to the ship's bow	Requirements formulation has been corrected	IACS UI SC138 (Corr.1 Feb 2023) and LL50 Rev.6 (June 2021)
Appendices 2 and 3 (new)	Ships Mooring arrangement Anchor arrangement	Calculation methodologies have been introduced	IACS Rec.No.10 (Rev.5 June 2023)

PART V. SUBDIVISION

Item	Applicability	Description	Remarks
Para 1.1.1.7	Area of application of the Part	Ships carrying more than 12 persons of industrial personnel have been included in the area of application of the Part	
Para 1.1.4 (deleted)	Cargo ships of L_1 ≥80 m in length Passenger ships Probability estimation of subdivision	Excessive information on the applicability of the requirements has been deleted. Para 1.1.5 has been renumbered 1.1.4	**Entry-into-force date: 18.03.2024** (Urgent Rule Change Notice No. 311-05-2003 of 18.03.2024)
Para 1.1.4 (renumbered)	Cargo ships of L_1 ≥80 m in length Probability estimation of subdivision	Excessive information on the applicability of the requirements has been deleted	**Entry-into-force date: 18.03.2024** (Urgent Rule Change Notice No. 311-05-2003 of 18.03.2024)
Para 2.5.4.1.1	Passenger ships Probability estimation of subdivision	Alternative requirements for calculation of the maximum allowable heeling moment due to passengers crowding have been introduced	IMO resolution MSC.421(98) **Entry-into-force date: 18.03.2024** (Urgent Rule Change Notice No. 311-05-2003 of 18.03.2024)

Item	Applicability	Description	Remarks
Para 2.5.5.3.4 (new)	Passenger ships Probability estimation of subdivision	New para containing requirements for calculation of factor s_i at any intermediate stage of flooding for passenger ships has been introduced	IMO resolution MSC.474(102) **Entry-into-force date: 18.03.2024** (Urgent Rule Change Notice No. 311-05-2003 of 18.03.2024)
Para 2.5.5.5	Cargo ships of L_1 ≥80 m in length Passenger ships Probability estimation of subdivision	Reference to the requirements for openings in watertight subdivision bulkheads and their closing appliances has been introduced	IMO resolution MSC.474(102) **Entry-into-force date: 18.03.2024** (Urgent Rule Change Notice No. 311-05-2003 of 18.03.2024)
Para 3.3.4.5	Chemical tankers Damage trim and stability characteristics Openings and covers	The applicability of the requirements has been extended to chemical tankers	IMO resolutions MSC.526(106), MEPC.345(78)
Para 3.4.3.1	Special purpose ships Additional requirements for damage trim and stability	Scope of application of the requirements of the para has been extended to ships carrying more than 12 persons of industrial personnel	

PART VI. FIRE PROTECTION

Item	Applicability	Description	Remarks
Para 2.1.1.7	Ships Accommodation and service spaces, control stations, stairway enclosures, cabin balconies Finish materials of bulkheads, decks, floor coverings, linings and ceilings, except for cables insulation, plastic piping and furniture Primary deck coverings	Possible omission has been specified of the tests for determination of calorific value in accordance with ISO 1716 upon test results in accordance with the requirements of Part 5 of the FTP Code based on the provisions of para 2.3, Annex 2 to the FTP Code	Para 2.3, Annex 2 to the FTP Code
Para 2.1.3.3	Ships Pipe penetrations Type approval of pipe penetrations	Applicability has been specified of regulation II-1/13.2.3 of SOLAS-74, as amended regarding fire integrity and water tightness tests of pipe penetrations where heat-sensitive materials are used	IACS UI SC299 (July 2023)
Para 2.1.5.4.3	Ships The acetylene cylinder storerooms and the oxygen cylinder storerooms Boundaries	New requirement has been introduced for separation of the storerooms by gastight divisions	
Para 2.1.5.9	Ships Incinerators and waste stowage spaces Fire protection of incinerators and waste stowage spaces	Special requirements for fire protection of incinerators and waste stowage spaces implemented by IMO resolution MEPC.244(66) and contradicting provisions of Chapter II-2 of SOLAS-74, as amended have been deleted	IMO resolution MEPC.368(79)
Para 2.2.6.1	Passenger ships having length L_{LL}, as defined in 1.1.3 of Part II "Hull", of 120 m or more or having three or more main vertical zones	Reference to para 1.2.1 of the Load Line Rules for Sea-Going Ships has been replaced by reference to para 1.1.3 of Part II "Hull" of the Rules RS/C	

Item	Applicability	Description	Remarks
Para 2.2.7.1	Passenger ships having length L_{LL}, as defined in 1.1.3 of Part II "Hull", of 120 m or more or having three or more main vertical zones	Reference to para 1.2.1 of the Load Line Rules for Sea-Going Ships has been replaced by reference to para 1.1.3 of Part II "Hull" of the Rules RS/C	
Para 3.1.1.4	Ships Fire extinguishing media Foam concentrates	Prohibition of use and storage of foam concentrates containing PFOS in compliance with the requirements of IMO resolution MSC.532(107)	**Entry-into-force date:** 01.01.2026
Para 3.3.3.2	Ships other than passenger ships having length L_{LL} of 120 m or more or having three or more main vertical zones Pressure tank Ship's compressed air system	Types of ships have been specified where the ship's compressed air system for automatic pressure maintenance may be used	
Para 3.8.1.10 (deleted)	Ships Carbon dioxide smothering system Ro-ro spaces, container holds equipped with integral reefer containers, spaces accessible by doors or hatches, and other spaces in which personnel normally work or to which they have access Means for automatically giving audible and visual warning of the release of fire-extinguishing medium Signal whistles	Obsolete requirement for additional fitting of signal whistles for giving warning of the release of fire extinguishing medium has been deleted. Paras 3.8.1.11 — 3.8.1.14 and references thereto are renumbered 3.8.1.10 — 3.8.1.13, accordingly	
Para 3.8.2.6.1	Ships High-pressure carbon dioxide smothering system Protective diaphragms of valves of carbon dioxide cylinders	Obsolete requirement has been deleted due to practical non-use of valves of carbon dioxide cylinders with two types of diaphragms	

Item	Applicability	Description	Remarks
Para 4.1.2	Ships Fire detection and alarm systems Automatic fire detector	The definition "Automatic fire detector" has been supplemented by the possible fire factors causing actuation of automatic fire detectors. Transfer from para 4.2.1.2.4 to avoid redundancy	
Para 4.1.3	Passenger and cargo ships Fire detection and alarm systems Indicating unit of fixed fire detection and fire alarm systems	Requirements for fire detection and alarm system have been specified	IMO resolution MSC.484(103)
Para 4.2.1.2.4 (deleted)	Ships Fire detection and fire alarm systems Automatic fire detector	Transfer of requirements to para 4.1.2. Paras 4.2.1.2.5 — 4.2.1.2.7 and references thereto have been renumbered 4.2.1.2.4 — 4.2.1.2.6, accordingly	
Para 4.3.1	Ships Fire warning alarm Automatically-activated warning alarm of the release of fire-extinguishing medium	Spaces with only a local release need not be provided with warning alarm have been specified	
Para 4.3.2	Ships Fire warning alarm Automatically-activated warning alarm of the release of fire-extinguishing medium	Wording has been specified regarding the pattern of signals given by warning alarm of the release of fire-extinguishing medium in the protected space and spaces indicated in 4.3.4	
Para 4.3.4	Ships Fire warning alarm Automatically-activated warning alarm of the release of fire-extinguishing medium	Redundancy of requirements in the first paragraph of para 4.3.2 has been deleted	

Item	Applicability	Description	Remarks
Para 5.1.9.10	Ships Galley, control stations (wheelhouse, emergency diesel generators room), special electrical spaces Portable carbon dioxide fire extinguishers	New requirement has been introduced for safe capacity of portable carbon dioxide fire extinguishers considering volume of spaces, which they are intended to protect	
Para 5.1.15	Ships Fireman's outfit	Para has been completely revised to amend the structure of requirements and avoid incorrect interpretation of requirements	
Para 6.2.1.1.2	Special purpose ships carrying more than 60, but not more than 240 persons Fire protection	The need to meet excessive requirements has been excluded	IMO Circular MSC.1/Circ.1422 **Entry-into-force date: 23.04.2024** (Urgent Rule Change Notice No. 311-05-2007 of 23.04.2024)
Chapter 6.6	Ships equipped for fire fighting aboard other ships and having relevant distinguishing marks **FF1**, **FF1WS**, **FF2**, **FF2WS**, **FF3**, **FF3WS**	Chapter has been renamed	

Item	Applicability	Description	Remarks
Para 6.6.8.8	Ships equipped for fire fighting aboard other ships and having relevant distinguishing marks **FF1**, **FF1WS**, **FF2**, **FF2WS**, **FF3**, **FF3WS** Special water fire extinguishing system	List of equipment to be considered when calculating the pump capacity has been specified. Requirements have been introduced for fitting the shut-off valves between the system pipelines intended for water supply to water monitors and spray nozzles. Requirement has been introduced for non-mandatory application of para 3.4.4 regarding fitting of the filters preventing the system and spray nozzles from becoming clogged for special independent water fire extinguishing systems not being part of the water fire extinguishing system	
Chapter 6.7	Container ships and other ships designed to carry containers on or above the weather deck	In the heading, the other ships have been added designed to carry containers on or above the weather deck according to scope of application of paras 6.7.1 — 6.7.3	
Para 6.7.5	Container ships and other ships designed to carry containers on or above the weather deck Main fire pumps, fire main and water service pipes	Requirements have been specified for the total capacity of the main fire pumps, as well as for diameter of the fire main and water service pipes excluding references to the requirements of paras 3.2.1.7 and 3.2.5.1	
Para 6.7.6	Container ships and other ships designed to carry containers on or above the weather deck Main fire pumps, mobile water monitors, fire hoses	Requirements have been specified for supply of two jets of water by the fire hoses in case where the mobile water monitors are supplied by the main fire pumps.	Regulation II-2/10.7.3.2.3 of SOLAS-74, as amended

Item	Applicability	Description	Remarks
Para 6.7.7	Container ships and other ships designed to carry containers on or above the weather deck Main fire pumps	Requirements for the minimum total capacity of the main fire pumps has been deleted due to specified requirements in paras 6.7.5 and 6.7.6	

PART VIII. SYSTEMS AND PIPING

Item	Applicability	Description	Remarks
Paras 11.4.2.3, 11.4.2.4, 11.4.2.10, 11.4.2.18	Ships under construction Systems for reducing NO_x emission Storage tank for chemical treatment fluids	Wording of the requirements has been brought in compliance with the IACS requirements	IACS UR M81 (Rev.1 July 2023)
Para 11.4.4 (new)	Ships under construction Systems for reducing NO_x emission Storage tank for chemical treatment fluids	Requirements for overboard discharge from exhaust gas cleaning system using chemicals	IACS UR M81 (Rev.1 July 2023)
Para 12.1.11	Ships under construction Ventilation system Short ducts not exceeding 2 m in length and with a free cross-sectional area not exceeding 0,02 m^2	Requirements have been specified for performance of fire tests in compliance with the FTP Code for short ventilation ducts made of non-combustible material other than steel	IACS UI SC264 (Corr.1 Dec 2023)
Para 13.8.1	Ships Fuel oil system Fuel oil supply to internal combustion engines	Additional requirements have been introduced for fuel oil supplied to the main and auxiliary engines	IACS UI SC123 (Rev.5 July 2023)

PART IX. MACHINERY

Item	Applicability	Description	Remarks
Table1.2.3.1-3	Dual Fuel ICE Relief Devices Documents	Reference for the applicable requirements of Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships has been introduced	IACS UR M82 (Mar 2023)
Appendix IV, Section 2	ICE Crankshafts Calculations of crankshaft acceptability	The formula for acceptability factor has been amended according to the latest revision of IACS UR M53	IACS UR M53 (Rev.5 May 2023)
Para 9.7.1	Dual Fuel ICE Relief Devices	Reference to the applicable requirements of Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships has been introduced	IACS UR M82 (Mar 2023)

PART XI. ELECTRICAL EQUIPMENT

Item	Applicability	Description	Remarks
Para 1.2.1	Sea-going ships Electrical equipment Electromagnetic compatibility	Additional definitions "harmonic filter" and "electromagnetic compatibility" have been introduced	
Para 2.2.1.2.2	Sea-going ships Electrical equipment Electromagnetic compatibility	Determination of voltage curve harmonic components in supply circuits has been specified	

Item	Applicability	Description	Remarks
Para 2.2.1.3	Sea-going ships Electrical equipment Electromagnetic compatibility	Additional requirements for total harmonic distortion have been introduced	
Para 2.2.1.4	Sea-going ships Electrical equipment Electromagnetic compatibility	Determination of radio interference from equipment in the power supply circuits has been specified	
Para 2.2.2.3	Sea-going ships Electrical equipment Power cables	Requirements for earthing of power cable metal armour and sheath have been specified	
Para 2.2.2.5	Sea-going ships Electrical equipment Cable products	Requirements for cable separation and earthing of cable braids/sheaths have been introduced	
Para 2.2.2.9	Sea-going ships Electrical equipment Cable products	Requirements for phase cores of cables for a. c. wiring have been introduced	
Para 2.9.3	Safe-type electrical equipment Log and depth-sounder devices	Reference to the applicable requirements for installation of depth-sounder oscillators and associated cables on gas carriers has been introduced, references to the applicable requirements of the Rules for the Equipment of Sea-Going Ships have been updated	IMO Resolution MSC.370(93)
Para 4.6.7.1	Fishing vessels Switchboard and switchgear Passageways in front of the switchboards	Types of ships where reduction in width of passageways is allowed have been specified	Instructive Letter No. 311-05-1978instr dated 24.11.2023

Item	Applicability	Description	Remarks
Chapter 4.7 (new)	Sea-going ships Electrical equipment System of electrical power distribution	Requirements for harmonic distortion of systems of electrical power distribution containing harmonic filters have been introduced	
Para 6.8.2	Sea-going ships Navigation lights Power supply of the navigation lights switchboard	References to paras in Part XI of the RS Rules/C containing requirements for power supply of the navigation lights switchboard by two feeders from the main switchboard and emergency switchboard have been introduced	
Chapter 12.2	Sea-going ships Power semiconductor units Parameters of voltage deviation and distortion	Chapter has been renamed	
Para 12.2.1	Sea-going ships Power semiconductor units Parameters of voltage deviation and distortion	Requirements for total harmonic distortion and changes in voltage and frequency have been introduced	
Para 12.2.3 (new)	Sea-going ships Power semiconductor units Parameters of voltage deviation and distortion	Requirements for electrical distribution devices of ship power plant fitted with harmonic filter have been introduced	
Para 12.2.4 (new)	Sea-going ships Power semiconductor units Parameters of voltage distortion	Requirements for change of total harmonic distortion have been introduced	
Para 12.2.5 (new)	Sea-going ships Power semiconductor units Parameters of voltage distortion	Requirement has been introduced regarding level of voltage between phase and ship's hull	

Item	Applicability	Description	Remarks
Para 17.5.3	Sea-going ships Electric propulsion plants Electromagnetic compatibility	Requirement for total harmonic distortion has been introduced	
Para 17.11.1	Sea-going ships Electric propulsion plants Protection arrangements for harmonic filters	Definition of total harmonic distortion of voltage curve has been specified	
Para 17.11.7 (new)	Sea-going ships Electric propulsion plants Protection arrangements for harmonic filters	Requirements for electrical distribution systems fitted with harmonic filters have been introduced	
Para 23.8.3	Sea-going ships Electric propulsion plants systems of electrical power distribution for direct current Protection of power filters against over-currents and short-circuit currents	Definition of total harmonic distortion has been specified	
Section 23, Appendix 1, para 2.1	Sea-going ships Electric propulsion plants systems of electrical power distribution for direct current Protection of power filters against over-currents and short-circuit currents	Definition of total harmonic distortion has been specified	

PART XII. REFRIGERATING PLANTS

Item	Applicability	Description	Remarks
Para 8.1.1	Insulation of the refrigerated cargo spaces Steelwork of ship's hull	Requirement for approval of the insulating materials has been excluded	

PART XIII. MATERIALS

Item	Applicability	Description	Remarks
Para 2.2.11.1	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Test method for brittle crack arrest toughness K_{ca} has been deleted. This method has been replaced by the reference to ISO 20064:2019	IACS UR W31 (Rev.3 Mar 2023)
Para 2.2.11.2	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Method of test series for obtaining K_{ca} at a specific temperature has been deleted. This method has been replaced by the reference to ISO 20064:2019	IACS UR W31 (Rev.3 Mar 2023)
Para 2.2.11.3 (deleted)	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Para 2.2.11.3 has been deleted. Double tension type arrest test has been deleted. Existing para 2.2.11.4 with paras and references thereto has been renumbered 2.2.11.3	IACS UR W31 (Rev.3 Mar 2023)
Para 2.2.11.3 (renumbered)	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Through the text methods, references to testing methods contained in 2.2.11.1 and deleted para 2.2.11.3 have been replaced by the references to ISO 20064:2019	IACS UR W31 (Rev.3 Mar 2023)

Item	Applicability	Description	Remarks
Table 3.19.2.2.2	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Reference to new para 3.19.3.3 has been introduced regulating small-scale tests when obtaining the manufacturer recognition of BCA steels	IACS UR W31 (Rev.3 Mar 2023)
Para 3.19.3.1.2.1	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Requirements have been introduced regarding the fact that the products subject to testing shall be of the maximum thickness. The para number has been corrected	IACS UR W31 (Rev.3 Mar 2023)
Para 3.19.3.1.2.2.2.1	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	References to standards JIS and CB/T have been replaced by the reference to ISO	IACS UR W31 (Rev.3 Mar 2023)
Para 3.19.3.2.3.1.1	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Extent of test results for lower steel grade in the same strength level and the strength level immediately below has been deleted. Requirements have been specified regarding the fact that the products subject to testing shall be of the maximum thickness	IACS UR W31 (Rev.3 Mar 2023)
Para 3.19.3.2.3.3.4	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Possibility of additional test to avoid brittle crack has been specified	IACS UR W31 (Rev.3 Mar 2023)

Item	Applicability	Description	Remarks
Para 3.19.3.2.6	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Requirements for BCA manufactuing records of BCA steels for the Certificate of Recognition for Manufacturer renewal have been specified	IACS UR W31 (Rev.3 Mar 2023)
Para 3.19.3.3 (new)	Container ships Steel plates with thickness from 50 to 100 mm Steels YP36, YP40 and YP47 with brittle crack arrest (BCA) properties	Procedure for small-scale tests for manufacture recognition of BCA steels has been introduced	IACS UR W31 (Rev.3 Mar 2023)

PART XIV. WELDING

Item	Applicability	Description	Remarks
Table 3.3.4	Ships Non-destructive testing Welded joints of piping	Requirements for the scope of testing have been supplemented considering current international requirements	IACS UR P2 (Rev.2 Nov 2001)

PART XV. AUTOMATION

Item	Applicability	Description	Remarks
Section 7	Sea-going ships Automation equipment Computers and computer-based systems	The Section contents have been revised following the requirements of IACS UR E22 (Rev. 3 June 2023) with regard to the programmable electronic systems and components	

PART XVII. DISTINGUISHING MARKS AND DESCRIPTIVE NOTATIONS IN THE CLASS NOTATION SPECIFYING STRUCTURAL AND OPERATIONAL PARTICULARS OF SHIPS

Item	Applicability	Description	Remarks
Table 1.2.12.4	Polar class ships Requirements for selecting materials	Requirements have been specified for selecting a steel grade for the hull structures: grade F of mild steel (MS) is deleted for Material Class III in the range of thickness 35<t≤50 mm (polar classes PC1 — PC3) and 45<t≤50 mm (polar classes PC4 and PC5), due to inapplicability	IACS UR I2 (Rev.4)
Chapter 1.3	Polar class ships Main machinery Steering gear Essential auxiliary systems	Requirements have been detailed for analyses of the design ice loads and the design parameters of propulsion elements. Requirements have been introduced for the steering systems of all polar class ships and icebreakers	IACS UR I3 Rev. 2 (Jan 2023)
Para 9.5.4.11	Ships equipped for using gases as fuel Fuel pipes passing outside the machinery spaces	Scope of application of the requirements of the para is limited to the pipes intended for gas fuel in a gaseous state	IMO resolution MSC.458(101) **Entry-into-force date: 27.02.2024** (Urgent Rule Change Notice No. 311-05-1996 of 27.02.2024)

Item	Applicability	Description	Remarks
Para 9.5.4.12 (new)	Ships equipped for using gases as fuel Fuel pipes passing outside the machinery spaces	Requirements for protection of liquefied gas fuel pipes and leakage detection within secondary enclosure of such pipes has been introduced	IMO resolution MSC.458(101)) **Entry-into-force date: 27.02.2024** (Urgent Rule Change Notice No. 311-05-1996 of 27.02.2024)
Para 9.5.5.1	Ships equipped for using gases as fuel Fuel system Gas fuel piping	Requirements for flange connections have been introduced	IACS UI GF19 (Dec 2023) IMO circular MSC.1/Circ.1670
Para 9.6.1.1	Ships equipped for using gases as fuel Internal combustion engines Exhaust gas system	Requirements have been introduced for equipping the exhaust gas system of internal combustion engines with explosion relief systems	IMO resolution MSC.458(101)) **Entry-into-force date: 27.02.2024** (Urgent Rule Change Notice No. 311-05-1996 of 27.02.2024)
Para 9.7.2.2	Ships equipped for using gases as fuel Structural fire protection Fuel storage hold spaces	Conditions have been introduced under which a fuel storage hold space with the type C tank may be considered as a cofferdam in relation to the structural fire protection	IMO resolution MSC.458(101)) **Entry-into-force date: 27.02.2024** (Urgent Rule Change Notice No. 311-05-1996 of 27.02.2024)
Para 11.5.2	LNG bunkering ship Additional cargo transfer equipment Fire protection	Requirements for fire protection of additional cargo transfer equipment have been introduced	IACS UI GC39 (Sep 2023) IMO circular MSC.1/Circ.1668

Item	Applicability	Description	Remarks
Paras 13.2.3.11 and 13.2.3.12	Standby vessels and salvage ships Life-saving appliances	Para 13.2.3.11 has been deleted as containing a requirement that duplicates the one of existing para 13.2.4.4. Existing para 13.2.3.12 and references thereto have been renumbered 13.2.3.11	
Paras 13.2.4.1.1 — 13.2.4.1.6	Standby vessels and salvage ships Life-saving appliances	Para 13.2.4.1.1 has been deleted due to the loss of relevance of the requirement contained therein regarding means of rescue. Existing paras 13.2.4.1.2 — 13.2.4.1.6 and references thereto have been renumbered 13.2.4.1.1 — 13.2.4.1.5 accordingly	
Para 13.2.4.1.5 (renumbered)	Standby vessels and salvage ships Life-saving appliances	Para has been supplemented with the requirement for an entry in the Classification Certificate	
Para 19.2.4.8 (new)	Double acting ships (the distinguishing mark **DAS** in the class notation) Azimuth thrusters	Requirements to regulate loads on the supporting structures for azimuth thrusters have been introduced	
Section 34 (new)	Cargo ships carrying the industrial personnel	New Section has been introduced with requirements for ships carrying the industrial personnel	IMO resolutions MSC.521(106) and MSC.527(106)

PART XX. ADDITIONAL REQUIREMENTS FOR YACHTS

Item	Applicability	Description	Remarks
Para 5.2.1	Equipment, arrangements and outfit of yachts	The scope of application has been specified	

Item	Applicability	Description	Remarks
Para 5.2.4 (new)	Yachts not carrying more than 12 passengers Doorways and access to stairways	Requirements to the closures have been introduced	

PART I. CLASSIFICATION

1 GENERAL

1.1 DEFINITIONS AND EXPLANATIONS

Para 1.1.1. Before the definition "Crew boat" **new definitions "Offshore industrial activities"** and **"Industrial personnel"** are introduced reading as follows:

"Offshore industrial activities mean the construction, maintenance, operation, repair (servicing) and/or decommissioning of offshore installations, but not limited to, exploration and exploitation of resources by the renewable or hydrocarbon energy sectors, aquaculture, ocean mining or similar activities.

Industrial personnel (IP) means all persons transported and/or accommodated on board for the purpose of offshore industrial activities performed on board other ships and/or offshore installations. The total number of industrial personnel is determined as the aggregated number of industrial personnel, special personnel and passengers carried on board, where the number of passengers shall not exceed 12.".

1.2 APPLICATION

Para 1.2.4 is amended as follows:

"1.2.4 These Rules apply to cargo ships carrying special personnel (special purpose ships) as well as cargo ships carrying the industrial personnel. ~~of not less than 500 gross tonnage. On agreement with the Register, the requirements of these Rules may also apply as far as reasonable and practicable to special purpose ships of less than 500 gross tonnage.~~".

2 CLASS OF A SHIP

2.2 CLASS NOTATION OF A SHIP. MANDATORY AND OPTIONAL DISTINGUISHING MARKS AND DESCRIPTIVE NOTATIONS IN THE CLASS NOTATION ASSIGNED BY RUSSIAN MARITIME REGISTER OF SHIPPING

Para 2.2.3.1. The **last paragraph** is amended as follows:

"Recommendations for operation of a ship in ice may be determined by the Register at the request of the shipowner for the purpose of issuing the Ice Navigation Ship Certificate and Ice Safety Passport specifying the conditions for safe operation of a ship in ice depending on the ~~ice class mark (including ships without an ice class assigned),~~ ship's specific design features, ice conditions and icebreaker support.".

Para 2.2.3.1.3 is amended as follows:

"**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 — 6, where most of the floes do not touch each other;

close floating ice is ice of concentration 7 — 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;

multi-year ice is ice of thickness more than 3,0 m, which has survived at least two summers' melt;

second-year ice is ice of thickness from 2,0 to 3,0 m, which has survived only one summer's melt;

first-year ice is ice of thickness from 0,3 to 2,0 m, of not more than one winter's growth;

medium first-year ice is first-year ice of thickness from 70 to 120 cm;

ice cake is any relatively flat piece of sea ice less than 20 m across.".

Table 2.2.3.3.2 is amended as follows:

"Table 2.2.3.3.2

Ice class	Description
Arc9	Year-round operation in~~ all areas of the oceans~~ ice without restrictions
Arc8	~~In summer/autumn navigation — voyage in all areas of the World Ocean. In winter/spring navigation in Arctic — voyage in close floating second-year ice up to 2,5 m thickness and in freezing non-arctic seas without restrictions~~Voyage in second-year ice up to 2,5 m thickness
Arc7	~~In summer/autumn navigation — voyage in all areas of the World Ocean. In winter/spring navigation in Arctic — voyage in close floating first year ice up to 2,1 m thickness and in freezing non arctic seas without restrictions~~Voyage in second-year ice up to 2,1 m thickness
Arc6	~~In summer/autumn navigation in Arctic — voyage in open floating first-year ice up to 1,5 m thickness. In winter/spring navigation in Arctic — voyage in open floating first-year ice up to 1,3 m thickness. Year-round voyage in freezing non-arctic seas~~Voyage in medium first-year ice up to 1,5 m thickness
Arc5	~~In summer/autumn navigation in Arctic — voyage in open floating first-year ice up to 1,2 m thickness. In winter/spring navigation in Arctic — voyage in open floating first-year ice up to 0,9 m thickness. Year-round voyage in freezing non-arctic seas~~Voyage in medium first-year ice up to 1,2 m thickness
Arc4	~~In summer/autumn navigation in Arctic — voyage in open floating first-year ice up to 0,9 m thickness. In winter/spring navigation in Arctic — voyage in open floating first-year ice up to 0,7 m thickness. Year-round voyage in freezing non-arctic seas in light ice conditions~~Voyage in medium first-year ice up to 0,9 m thickness
Ice3	~~Regular voyage in open floating ice-cake ice of non-arctic seas up to 0,7 m thickness~~Voyage in open floating ice-cake ice up to 0,7 m thickness
Ice2	~~Regular voyage in open floating ice-cake ice of non-arctic seas up to 0,5 m thickness~~Voyage in open floating ice-cake ice up to 0,5 m thickness
Ice1	~~Episodical voyage in open floating ice-cake ice of non-arctic seas up to 0,4 m thickness~~Voyage in open floating ice-cake ice up to 0,4 m thickness

Notes: 1. ~~The possibility of operation of a vessel in a particular area is determined depending on the season, current weather conditions, actual ice conditions, presence of assistance for navigation in ice and this is the responsibility of the shipowner~~Permissible ice conditions for ship operation may be indicated by the Register in the Ice Navigation Ship Certificate and Ice Safety Passport specifying the conditions for safe operation of a ship in ice taking into account ship's specific design features, ice conditions, icebreaker support etc. disregarding the ice class mark (including ships without an ice class assigned), In any case, the shipowner independently determines safe operating modes depending on the actual ice conditions.

2. For ships having distinguishing mark **DAS** in~~ class symbol~~ the class notation, ice conditions are assigned on the basis of the descriptions of ice classes.

".

Para 2.2.3.3.3. The **second paragraph** is deleted.

Para 2.2.6.5 is amended as follows:

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

New para 2.2.60 is introduced reading as follows:

"**2.2.60 Distinguishing mark ADUW for ships with an equipment length of 135 m and above intended for anchoring in deep and unsheltered water.**

Ships intended for anchoring in deep and unsheltered water and meeting the requirements of 3.2.5 of Part III "Equipment, Arrangements and Outfit", the distinguishing mark **ADUW** (Anchoring in Deep and Unsheltered Water) may be added to the character of classification.".

New paras 2.2.62 and 2.2.63 are introduced reading as follows:

"**2.2.62 Distinguishing marks IPS1(N) and IPS2(N) for cargo ships carrying industrial personnel.**

For cargo ships complying with the requirements of Section 34 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships", one of the following distinguishing marks may be added to the character of classification:

IPS1(N) — assigned to cargo ships of 500 gross tonnage and upwards;

IPS2(N) — assigned to cargo ships below 500 gross tonnage,

where **IPS** stands for an industrial personnel ship; instead of **N**, the aggregated number of industrial personnel, special personnel and passengers shall be indicated, with the number of passengers not exceeding 12. Cargo ships carrying in total not more than 12 persons of industrial personnel, special personnel and passengers, shall comply with the requirements of these Rules and, if/where applicable, the Rules for the Equipment of Sea-Going Ships for cargo ships without assignment of distinguishing marks.

2.2.63 Distinguishing marks IPS1(N) and IPS2(N) for cargo ships carrying special personnel.

For ships carrying special personnel (special purpose ships), one of the following distinguishing marks may be added to the character of classification:

SPS1(N) — assigned to cargo ships of 500 gross tonnage and upwards, complying with the requirements of these Rules for cargo ships as well as with the additional requirements listed in Table 2.5;

SPS2(N) — assigned to cargo ships below 500 gross tonnage, complying with the requirements of these Rules for cargo ships as well as with the additional requirements listed in Table 2.5,

where **SPS** stands for a special purpose ship; instead of **N**, the total number of special personnel and passengers shall be indicated, with the number of passengers not exceeding 12. Cargo ships carrying in total not more than 12 persons of special personnel and passengers, shall comply with the requirements of these Rules and, if/where applicable, the Rules for the Equipment of Sea-Going Ships for cargo ships without assignment of distinguishing marks.".

2.4 ADDITIONAL ENTRIES IN THE CLASSIFICATION CERTIFICATE

Para 2.4.1 is amended as follows:

"**2.4.1** When complying with definite requirements of the RS 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 Section "Other characteristics" of the Classification Certificate stating, for example, that the ship is equipped for occasional loading/unloading of cargoes in a horizontal direction — by a roll-on/roll-off; the ship is suitable for escort operations, towing and serving oil tankers and/or oil recovery ships; the ship may operate in oil harbour water areas; the ship may occasionally carry bulk cargoes; the ship may carry heavy bulk cargoes (with indication of bulk cargo density), and other entries stipulated by the RS rules (refer also to 1.1.4.8, 1.1.5.1, 1.1.5.2, 3.3.1.5, 3.10.4.1 and 3.12.1.4.3 of Part II "Hull", 1.1.1.2, 1.1.1.3, 1.1.1.6, 1.1.3.1, 2.4.3, 10.3.2.1, 10.5.3.2, 13.2.4.1.5 and 13.3.10.3 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of these Rules; 2.2.3.1, 3.2.4.1 and 4.2.3.2 of Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships).".

2.5 SUMMARY INFORMATION ON DISTINGUISHING MARKS AND DESCRIPTIVE NOTATIONS IN THE CLASS NOTATION OF A SHIP

Table 2.5. **New item 2.36** is introduced reading as follows:

"2.36 ADUW — distinguishing mark for ships with an equipment length of 135 m and above intended for anchoring in deep and unsheltered water

Distinguishing mark	Brief description	Reference to additional RS requirements for the distinguishing mark
ADUW	The distinguishing mark is assigned to ships with an equipment length of 135 m and above intended for anchoring in deep and unsheltered water	**Rules for the Classification and Construction of Sea-Going Ships** Part I "Classification", 2.2.60 Part III "Equipment, Arrangements and Outfit", 3.2.5

".

Table 2.5. **New items 2.38 and 2.39** are introduced reading as follows:

"2.38 IPS1(N) and IPS2(N) — distinguishing marks for cargo ships carrying the industrial personnel

Distinguishing mark	Brief description	Reference to additional RS requirements for the distinguishing mark
IPS1(N) **IPS2(N)**	Assigned to cargo ships carrying the industrial personnel and complying with the RS requirements depending on the gross tonnage	**Rules for the Classification and Construction of Sea-Going Ships** Part I "Classification", 2.2.62 Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships", Section 34

2.39 SPS1(N) and SPS2(N) — distinguishing marks for cargo ships carrying special personnel

Distinguishing mark	Brief description	Reference to additional RS requirements for the distinguishing mark
SPS1(N) **SPS2(N)**	Assigned to cargo ships accommodating and carrying special personnel (special purpose ships). The following ship types are included: research, expedition, hydrographic, training ships, whale factory ships, fish factory ships and ships processing other living resources of the sea, not engaged in catching, salvage ships, cable laying vessels, seismic survey ships, diving support ships, pipe laying vessels, floating cranes and crane ships	**Rules for the Classification and Construction of Sea-Going Ships** Part I "Classification", 1.1.1, 2.2.63. Part II "Hull", 2.4.5.6; Part III "Equipment, Arrangements and Outfit", 2.1.10, 2.9.5, 7.12.5, 8.5.2.1, 8.5.2.2, 8.5.3.1, 8.5.3.7, 8.5.4.2, 8.5.5, 9.2.2, Appendix 1; Part IV "Stability", 3.6; Part V "Subdivision", 1.1.1.7, 3.4.3; Part VI "Fire Protection", Section 1, 2.1, 2.2 or 2.3, Sections 3 — 5, 6.2, 8.14; Part VII "Machinery Installations", 4.3.2, 4.5.10 — 4.5.13, 7.4.7.2, 7.4.8.2; Part VIII "Systems and Piping", 5.1.2, 7.1.2, 7.1.3, 7.1.4, 7.1.5, 7.1.6, 7.3.6, 12.2, 12.3; Part IX "Machinery", 7.1.1, 7.1.5; Part XI "Electrical Equipment", 7.3.1.11, 19.4; **Rules for the Equipment of Sea-Going Ships** (if applicable) Part II "Life-Saving Appliances", 5.2

".

Table 2.5. In **Section 3** the phrase ", for example: **Cable laying vessel Special purpose ship**" is deleted from the **preamble**.

Table 2.5. In **item 3.1** the heading and the table for descriptive notation **Special purpose ship** are deleted.

3 TECHNICAL DOCUMENTATION

3.2 DESIGN DOCUMENTATION

New para 3.2.3.30 is introduced reading as follows:

"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.30	Towing and Mooring Arrangements Plan	A	●		●	

".

Para 3.2.8.1.5 is amended as follows:

"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.5	Diagrams of power supply for automation systems: alarm and monitoring systems (AMS), ~~centralized monitoring systems and~~ integrated ~~control~~ systems ~~and AMS~~, remote automated control systems for main machinery and propellers, automation systems of auxiliary engines and electric power plant, automation systems of boiler plant, automation systems of compressor plants, automation system of bilge and ballast systems, remote level indicating systems	A	●	●	●	

".

Paras 3.2.8.2.1 and 3.2.8.2.2 are amended as follows:

"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.1	Functional diagrams of AMS, ~~centralized monitoring systems,~~ computer-based systems and integrated ~~control~~ systems ~~and AMS, including diagrams of power supply~~	A	●			Computer-based systems specified in 3.2.8.2.1 — 3.2.8.2.27 shall be interpreted as systems within the area of application of Section 7 of Part XV "Automation"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.2	Technical documentation on ~~alarm and monitoring systems (~~AMS~~)~~, ~~centralized monitoring systems,~~ computer-based systems and integrated ~~control~~ systems ~~and AMS~~, including functional diagrams, ~~face~~ front panels of consoles and ~~control and monitoring~~ switchboards with indication of all devices~~, diagrams of power supply~~	A			●	

".

New paras 3.2.8.2.3 — 3.2.8.2.8 are introduced reading as follows:

"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.3	Quality plan for suppliers of computer-based systems of categories II and III	FI	●		●	Submitted upon request
.4	List of computer-based system categorizations	A	●		●	Submitted upon request
.5	Risk assessment report for computer-based systems of categories I, II and III	A	●		●	Submitted upon request
.6	Architecture of computer-based systems of categories I, II and III	FI	●		●	Submitted upon request
.7	Program of acceptance tests of computer-based systems of categories II and III conducted on board the ship in accordance with 7.9.5.3.6 of Part XV "Automation"	A	●		●	
.8	Program of integration tests of integrated systems of categories II and III conducted on board the ship in accordance with 7.9.5.3.7 of Part XV "Automation"	A	●		●	

".

Existing paras 3.2.8.2.3 — 3.2.8.2.21 are renumbered **3.2.8.2.9 — 3.2.8.2.27** accordingly.

Existing para 3.2.8.2.3 is amended as follows:

"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.~~3~~9	Technical documentation on remote automated control system for main engines and propellers~~:~~, including functional diagrams, ~~remote automated control~~ front panels of consoles ~~panels~~ with indication of all devices~~, diagrams of power supply of remote automated control~~	A	●		●	

".

Existing para 3.2.8.2.9 is amended as follows:

"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.~~9~~15	Diagrams of electric connections for automation systems and equipment: ~~alarm and monitoring systems (~~AMS~~)~~, ~~centralized monitoring systems and~~ integrated ~~control~~ systems ~~and AMS~~, remote automated control systems for main machinery and propellers, automation system of auxiliary engines and electric power plant, automation system of boiler plant, automation system of compressor plants, automation system of bilge and ballast systems, remote level indicating systems (with indication of cable types and places of installation of ~~all system elements and devices~~ devices and system elements)	A		●	●	

".

Para 3.2.10.1.3 is amended as follows:

"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.3	Calculation results of necessary output of the ship's electric power plant to ensure the operating conditions specified in 3.1.5 of Part XI "Electrical Equipment", substantiation of the choice of the number and power output of generators, as well as calculation of capacity of emergency sources of electrical power	AG	●		●	Where the data obtained from the calculation is used for the purposes of calculating ship's energy efficiency design index (EEDI) or energy efficiency existing ship index (EEXI), the calculation shall be developed and submitted in accordance with Appendix 2 to IMO Resolution MEPC.364(79)

".

Para 3.2.10.1.15 is replaced by the following text:

"

.15	Results of calculation of the expected total harmonic distortions (non-sinusoidality) for different parts of the ship mains when using power semiconductor units, as well as the total harmonic distortion (non-sinusoidality) calculation results following the harmonic filters failure during their installation in the ship's electrical distribution system	AG	●		●	It is allowed not to perform the calculation for ships on which the total power of semiconductor converters does not exceed 20 % of the total power generated by the main sources of electrical power

".

Para 3.2.11.1.3 is amended as follows:

"

.3	Calculation of required capacity of oil residue (sludge) holding tanks, oily bilge water holding tanks and their arrangement plans~~, as well as calculation of capacity of sewage holding tanks and garbage receptacles~~	AG	●		●	

".

New para 3.2.11.1.11 is introduced reading as follows:

"

.11	Calculation of capacity of sewage holding tanks and garbage receptacles	FI	●		●	

".

Para 3.2.17.8. Table is supplemented by **new para 3.2.17.8.28** reading as follows:

"

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.28	Fuel Handling Manual	AG	●		●	

".

Para 3.2.17.10 is amended as follows:

"3.2.17.10 IWS.

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
~~.1~~	~~Drawing of the marking on the side and bottom plating to identify the tanks~~	~~A~~	~~●~~	~~●~~	~~●~~	
.1	In-water survey plan, containing the following items (as applicable):	A	●	●	●	Information listed in 3.2.17.10.1.1 — 3.2.17.10.1.10 may be submitted by separate documents
.1.1	arrangements plan of sea inlets and bottom and side valves in the underwater hull					
.1.2	fore part and aft part structures plans					
.1.3	bilge keels details/arrangements					
.1.4	rudder and steering gear plan					
.1.5	propeller plan, including blades numbers for each blade identification					
.1.6	arrangement of cathodic protection system					
.1.7	procedure for measurement of clearances for rudder bearings and pintles afloat					
.1.8	procedure for measurement of shaft sagging afloat					
.1.9	procedure for measurement of clearances for AMSS					
.1.10	drawing of the marking on the side and bottom plating to identify the tanks					

".

Para 3.2.17.15 is amended as follows:

"3.2.17.15 COMF(C), (N – 1 or 2, or 3), (N – S), (V – 1 or 2, or 3).

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.1	Heat balance calculation	~~FI~~AG	●		●	For assignment of distinguishing mark **COMF(C)** to a ship
.2	Measurement program	A		●	●	For assignment of distinguishing marks **COMF(C)**, **(N – 1 or 2, or 3)**, **(N – S)**, **(V – 1 or 2, or 3)** to a ship

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.3	Measurement results	FI		●	●	For assignment of distinguishing marks **COMF(C)**, **(N – 1 or 2, or 3)**, **(N – S)**, **(V – 1 or 2, or 3)** to a ship

".

New para 3.2.17.24 is introduced reading as follows:

"3.2.17.24 ACFP(P), ACFP(S), ACFP(S,F).

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.1	Arrangement diagrams of fire-fighting equipment	A	●	●	●	For assignment of distinguishing marks **ACFP(P)**, **ACFP(S)** or **ACFP(S,F)** to a ship
.2	List of fire-fighting equipment	AG	●	●	●	For assignment of distinguishing marks **ACFP(P)**, **ACFP(S)** or **ACFP(S,F)** to a ship
.3	Diagrams of ventilation systems showing the location of fire dampers, closures of ventilation ducts and ventilation openings in cargo holds	A	●	●	●	For assignment of distinguishing marks **ACFP(S)** or **ACFP(S,F)**
.4	Diagram of fire alarm system	A	●	●	●	For assignment of distinguishing marks **ACFP(S)** or **ACFP(S,F)** to a ship
.5	Calculations of fire extinguishing and flooding systems	AG	●		●	For assignment of distinguishing marks **ACFP(S)** or **ACFP(S,F)** to a ship
.6	Diagrams of fire extinguishing and flooding systems	A	●		●	For assignment of distinguishing marks **ACFP(S)** or **ACFP(S,F)** to a ship
.7	Cargo hold flooding control booklet	AG	●		●	For assignment of distinguishing mark **ACFP(S,F)** to a ship
.8	Stability and damage stability calculations showing that the ship complies with the requirements set out in Sections 2 and 3 of Part V "Subdivision" taking into account possible flooding of cargo holds	AG	●		●	
.9	Calculations of longitudinal and local strength of ship hull showing that the ship complies with the requirements in 3.1 of Part II "Hull" and Part XVIII "Additional Requirements for Structures of Container Ships and Ships, Dedicated Primarily to Carry their Load in Containers", taking into account possible flooding of cargo holds	AG	●		●	

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.10	Functional diagram of alarm and monitoring system activated when water is detected in the hold and upon reaching the design water level at flooding	A	●	●	●	

".

New para 3.2.17.25 is introduced reading as follows:

"3.2.17.25 RC-C, RC-A, RC-IA, RC-E.

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.1	Circuit diagrams of refrigerant systems	A	●	●	●	
.2	Diagrams of ventilation systems and system for supply of cooled air to the containers with indication of arrangement of fire dampers, closures of ventilation ducts and openings in cargo holds	A	●	●	●	

".

New para 3.2.17.26 is introduced reading as follows:

"3.2.17.26 HNLS.

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.1	Information regarding loading arrangement of deck cargoes, weights and their centres of gravity	AG	●	●	●	
.2	Lashing arrangement of deck cargoes	A	●	●	●	
.3	Details of integral liquid cargo tanks including vents and/or overflows height and location	A	●	●	●	
.4	Details of independent liquid and/or dry cargo tanks	A	●	●	●	
.5	Details of independent tank supports and fastening arrangements	A		●	●	
.6	Piping diagrams of liquid cargo transfer systems	A	●	●	●	
.7	Piping diagrams of dry bulk cargo transfer systems	A	●	●	●	
.8	Ventilation diagrams of liquid cargoes	A	●	●	●	
.9	Stability calculation	AG	●		●	
.10	Calculation of damage trim and stability	AG	●		●	
.11	Stability Booklet	AG		●	●	
.12	Damage Stability Booklet	AG		●	●	

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.13	General arrangement of cargo areas (refer to 31.1.27 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships")	A	●	●	●	
.14	General arrangement of hazardous areas	A	●	●	●	
.15	General arrangement of cargo tanks with adjacent cofferdams	A	●	●	●	
.16	Full particulars of the intended cargo or cargoes and its properties	FI	●	●	●	
.17	Cargo hatches and other openings to cargo tanks	A	●	●	●	
.18	Doors, hatches and other openings to pump rooms and other hazardous spaces	A	●	●	●	
.19	Ventilation ducts and openings to pump room and other hazardous spaces	A	●	●	●	
.20	Doors, air locks, hatches and other openings to non-hazardous spaces adjacent to cargo area	A	●	●	●	
.21	Cargo pipes with loading and discharging connections for dry bulk cargoes	A	●	●	●	
.22	Vent pipes for cargo tanks	A	●	●	●	
.23	Cargo piping system including drawings showing details such as expansion elements and flange connections	A	●	●	●	
.24	Bilge piping systems in pump room, cofferdams, and pipe tunnels within the cargo area	A	●	●	●	
.25	Cargo heating systems	A	●	●	●	
.26	Procedures and calculations of cooling down, loading and unloading operations	FI	●	●	●	
.27	Drawings of pressure vacuum valves or high velocity vent valves, their details and installation, relevant calculations of their relieving capacity	A	●	●	●	
.28	Arrangement and capacity of ventilation system in the cargo area	A	●	●	●	
.29	Drawings of fan rotating parts and casings	A	●	●	●	
.30	Portable ventilators	FI	●	●	●	
.31	Arrangement of inert gas supply if applicable	A	●	●	●	
.32	Drawings showing location of all electrical equipment in hazardous areas	A	●	●	●	
.33	List of certified safe equipment	FI	●	●	●	
.34	One-line diagram for intrinsically safe circuits and data	A	●	●	●	
.35	Maintenance manual for electrical installations in hazardous areas	AG	●	●	●	
.36	Arrangement and specifications of fixed fire extinguishing systems	A	●		●	
.37	Diagrams of fire detection and fire alarm systems, diagrams of gas detection and alarm systems	A	●	●	●	
.38	Cargo tank level gauging system	A	●	●	●	
.39	Cargo tank overflow protection system	A	●	●	●	
.40	Cargo valves and pump control and monitoring system	A	●	●	●	

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.41	Inert gas control and monitoring system if applicable	A	●	●	●	

".

New para 3.2.17.27 is introduced reading as follows:

"3.2.17.27 WSV1, WSV2.

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.1	General arrangement plan of the vessel	FI	●	●	●	
.2	General arrangement plan of well stimulation equipment including hazardous area/zone classification and chemical storage area definition, as well as decontamination and eye-washing facilities, and personnel protective equipment location	A	●	●	●	
.3	Structural fire protection	A	●	●	●	
.4	Tank Plan or Capacity Plan, or table with centres of gravity and tank free surface corrections	AG	●	●	●	
.5	Body Lines plan or Offset Table	AG	●	●	●	
.6	Hydrostatic curves or table	AG	●	●	●	
.7	Cross curves of stability	AG	●	●	●	
.8	Arrangement of all integral and independent tanks, including supports and stays of independent tanks	A	●	●	●	
.9	Structural drawings of acid tanks including vent arrangements, information on non-destructive testing of welds, strength and tightness testing, and specification of protective linings	A	●	●	●	
.10	Documentation for liquid nitrogen tanks	A	●	●	●	
.11	Pumping arrangement including diagrams of piping for acid, nitrogen and liquid additives, details of flange connections and pipe clamping/securing as well as specification and data on high pressure flexible hoses with end connections	A	●	●	●	
.12	Arrangement of mechanical ventilation of closed and semi-closed spaces containing acid tanks, pipes, pumps, mixers and blenders	A	●	●	●	
.13	Drawings showing location of all electrical equipment in areas containing installations for uninhibited acid	A	●	●	●	
.14	Electrical diagrams of well stimulation systems including single line diagram for intrinsically safe circuits, control and monitoring systems for cargo tank level gauging,	A	●	●	●	

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
	overflow protection and emergency shutdown, as well as indication equipment for hydrogen, hydrogen chloride and oxygen					
.15	List of safe type electrical equipment together with certificates and references to specific diagrams and/or plans	AG	●	●	●	
.16	Calculations demonstrating the adequacy of the vessel's stability	AG	●	●	●	
.17	Calculations demonstrating adequacy of propulsion power required for the vessel to maintain station during well stimulation operations	AG	●	●	●	
.18	Stress analysis of supporting structure in way of flexible hose storage reel(s)	AG	●	●	●	
.19	Stress analysis of liquid nitrogen piping and heat exchangers	AG	●	●	●	
.20	Personnel protective equipment scope and types	AG	●	●	●	

".

New para 3.2.17.28 is introduced reading as follows:

"3.2.17.28 IPS1(N), IPS2(N).

The complete list of documentation is given in 1.4 "Technical Documentation" of the Rules for the Cargo-Handling Gear of Sea-Going Ships.

No.	Description of documentation	Stamp	TD	DD	PAD	Remarks
.1	Specification (Explanatory Note) for personnel transfer appliance	FI	●		●	
.2	General arrangement plans of personnel transfer appliance with indication of its principal characteristics (dimensions, materials, capacity, lifting/lowering speed, etc.)	A	●		●	
.3	Analysis of risks related to the use of personnel transfer appliance	AG	●		●	

".

PART II. HULL

1 DESIGN PRINCIPLES

1.6 REQUIREMENTS FOR SCANTLINGS OF HULL STRUCTURAL MEMBERS

Para 1.6.5.7 is introduced reading as follows:

"**1.6.5.7** For ships of 90 m in length and above, of unrestricted area of navigation, the buckling strength of hull structural members shall be checked either in accordance with 1.6.5.1 — 1.6.5.6 or in accordance with IACS UR S35.".

2 GENERAL REQUIREMENTS FOR HULL STRUCTURES

2.4 DOUBLE BOTTOM

New para 2.4.5.6 is introduced reading as follows:

"**2.4.5.6** The double bottom of special purpose ships of 500 gross tonnage and above shall meet the requirements for double bottom of passenger ships.".

2.12 SUPERSTRUCTURES, DECKHOUSES AND QUARTER DECKS

Para 2.12.4.4 is amended as follows:

"**2.12.4.4** In any case, the plate $s_{\min}$, in mm, of superstructure end bulkheads, sides and end bulkheads of deckhouses shall not be less than:
for the lowest tier

$$s_{\min} = (5 + 0{,}01L)\sqrt{\eta}; \qquad (2.12.4.4\text{-}1)$$

for other tiers

$$s_{\min} = (4 + 0{,}01L)\sqrt{\eta} \qquad (2.12.4.4\text{-}2)$$

where η 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 < 50 m, and to 3 mm for ships of length L < 20 m. ~~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.~~ For ships of length L < 65 m, the minimum plate thickness of end bulkheads of superstructures and deckhouses may be reduced to 5 mm for the lowest tier and for other tiers — to 4 mm."

3 REQUIREMENTS FOR STRUCTURES OF SHIPS OF SPECIAL DESIGN

3.1 SHIPS WITH LARGE DECK OPENINGS

Para 3.1.3.8 is amended as follows:

"**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

$p = 1{,}0$ kPa.".

Appendix 1 is replaced by the following text:

"APPENDIX 1

TESTING PROCEDURES OF WATERTIGHT COMPARTMENTS

Part A — Ships Covered by SOLAS (SOLAS Ships)

1 GENERAL

1.1 These test procedures shall confirm the watertightness of tanks ~~and~~, watertight boundaries and the structural adequacy of tanks which ~~consist~~ form part of the watertight subdivisions[*] of ships. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of ships during new construction and those relevant to major conversions or major repairs[†] shall be confirmed by these test procedures prior to the delivery of the ship.

1.2 Testing procedures of watertight compartments for SOLAS ships (including bulk carriers and oil tankers covered by the Common Structural Rules (hereinafter referred to as "the CSR BC and OT")), shall be carried out in accordance with Part A of this Appendix, unless:

a) the shipyard provides documentary evidence of the shipowner's agreement to a request to the Administration for an exemption from the application of SOLAS Chapter II-1, regulation 11, or for an equivalency agreeing that the content of Part B is equivalent to SOLAS Chapter II-1, regulation 11; and

b) the above-mentioned exemption/equivalency has been granted by the responsible Administration.

[*] Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

[†] Major repair means a repair affecting structural integrity.

2 APPLICATION

2.1 All gravity tanks* and other boundaries required to be watertight or weathertight shall be tested in accordance with this Appendix and proven to be tight and structurally adequate as follows:

gravity tanks for their tightness and structural adequacy;

watertight boundaries other than tank boundaries for their watertightness; and weathertight boundaries for their weathertightness.

2.2 The testing of cargo containment systems of liquefied gas carriers shall be in accordance with the testing requirements in 4.21 — 4.26 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and standards deemed appropriate by the Register.

2.3 The testing of structures not listed in Table 4.1-1 or 4.1-2 shall be specially considered.

3 TEST TYPES AND DEFINITIONS

3.1 The following two types of tests are specified in this Appendix:

Structural test is a test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test;

Leak test is a test to verify the tightness of a boundary. Unless a specific test is indicated, this may be a hydrostatic/hydropneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries, as indicated by Footnote 9 of Table 4.1-1.

3.2 Definition of each type of test is given in Table 3.2.

Table 3.2

Hydrostatic test: (Leak and structural)	A test wherein a space is filled with a liquid to a specified head
Hydropneumatic test: (Leak and structural)	A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air
Hose test: (Leak)	A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side
Air tests: (Leak)	A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as compressed air fillet weld tests and vacuum box tests
Compressed air fillet weld test: (Leak)	An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds
Vacuum box test: (Leak)	A box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks
Ultrasonic test: (Leak)	A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques
Penetration test: (Leak)	A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e. dye penetrant test)

3.3 The "top of the overflow" is defined as being the top of any overflow system which is used to prevent overfilling of a tank. Such system can be an overflow pipe, air pipe, intermediate tank. For gravity tanks (i.e. sewage, grey water and similar tanks, not filled with pumps) the top of the overflow shall be taken as the highest point of the filling line.

Gauging devices are not considered equivalent to an overflow system with the exception of fuel oil overflow tanks not intended to hold fuel which have been fitted with a level alarm.

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* Gravity tank means a tank that is subject to vapour pressure not greater than 70 kPa.

Where a tank is fitted with multiple means of preventing overfilling, the decision on which overflow system to be used for determining the test head shall be based on the highest point to which the liquid may rise in service.

4 TEST PROCEDURES

4.1 General.

Tests shall be carried out in the presence of the RS surveyor at a stage sufficiently close to the completion of work with all hatches, doors, windows, etc., installed and all penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints. Specific test requirements are given in 4.4, Tables 4.1-1 and 4.1-2. For the timing of the application of coating and the provision of safe access to joints, refer to 4.5, 4.6 and Table 4.1-3.

Table 4.1-1

Test requirements for tanks and boundaries

Nos.	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
1	Double bottom tanks[1]	Leak and structural[2]	The greater of: top of the overflow[10]; or to 2,4 m above top of tank[3]; or to bulkhead deck	
2	Double bottom voids[4]	Leak	Refer to 4.4.4 ~~through~~ — 4.4.6, as applicable	Including pump room double bottom and bunker tank protection double hull required by MARPOL Annex I
3	Double side tanks	Leak and structural[2]	The greater of: top of the overflow[10], to 2,4 m above top of tank[3]; or to bulkhead deck	
4	Double side voids	Leak	Refer to 4.4.4 ~~through~~ — 4.4.6, as applicable	
5	Deep tanks other than those listed elsewhere in this table	Leak and structural[2]	The greater of: top of the overflow[10]; or to 2,4 m above top of tank[3]	
6	Cargo oil tanks	Leak and structural[2]	The greater of: top of the overflow[10]; or to 2,4 m above top of tank[3]; or to top of tank[3] plus ~~setting of any~~ the design vapour pressure ~~relief valve~~	
7	Ballast hold of bulk carriers	Leak and structural[2]	Top of cargo hatch coaming	
8	Peak tanks	Leak and structural[2]	The greater of: top of the overflow[10]; or to 2,4 m above top of tank[3]	After peak to be tested after installation of stern tube
9	**.1** Fore peak spaces with equipment	Leak	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	
	.2 Fore peak voids	Leak	To bulkhead deck	
	.3 Aft peak spaces with equipment	Leak	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	
	.4 Aft peak voids	Leak	Refer to 4.4.4 ~~through~~ — 4.4.6, as applicable	After peak to be tested after installation of stern tube
10	Cofferdams	Leak	Refer to 4.4.4 ~~through~~ — 4.4.6, as applicable	
11	**.1** Watertight bulkheads	Leak[6]	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable7	

Nos.	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
	.2 Superstructure end bulkheads	Leak	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	
12	Watertight doors below freeboard or bulkhead deck	Leak[7, 8]	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	
13	Double plate rudder blades	Leak	Refer to 4.4.4 ~~through~~ — 4.4.6, as applicable	
14	Shaft tunnels clear of deep tanks	Leak[9]	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	
15	Shell doors	Leak[9]	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	
16	Weathertight hatch covers and closing appliances	Leak[7, 9]	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	Hatch covers closed by tarpaulins and battens excluded
17	Dual purpose tanks/dry cargo hatch covers	Leak[7, 9]	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	In addition to structural test in item 6 or 7
18	Chain lockers	Leak and structural[2]	Top of chain pipe	
19	Lubricating oil sump. tanks and other similar tanks/spaces under main engines	Leak[5]	Refer to 4.4.3 ~~through~~ — 4.4.6, as applicable	
20	Ballast ducts	Leak and structural[2]	The greater of: ballast pump maximum pressure; or setting of any pressure relief valve	
21	Fuel oil tanks	Leak and structural[2]	The greater of: top of the overflow[10]; or to 2,4 m above top of tank[3]; or to top of tank[3] plus ~~setting of any~~ the design vapour pressure ~~relief valves~~; or to bulkhead deck	
~~**22**~~	~~Sea chests and ice boxes~~	~~Leak and structural[1, 2, 9]~~	~~The greater of: head to 1,25 m depthwise; or equal to blow system pressure~~	~~When testing ice boxes fitted with steam heating system, the test head shall not be less than the heating system design pressure.~~ ~~Where air pipes are led through ice boxes and sea chests, the tests are carried out by applying the hydraulic head to top of the overflow~~
22	Fuel oil overflow tanks not intended to hold fue	Leak and structural[2]	The greater of: top of the overflow[10]; or to 2,4 m above top of tank[3]; or to bulkhead deck	

Nos.	Tank or boundary to be tested	Test type	Test head or pressure	Remarks

1 Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4.
2 Refer to 4.2.2.
3 The top of a tank is the deck forming the top of the tank, excluding any hatchways.
4 Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/11.2 and II-1/9.4 respectively, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex I, Chapter 3, Part A regulation 12 and Chapter 4, Part A, regulation 22 respectively.
5 Where lubricating oil sump tanks and other similar spaces under main engines intended to hold liquid form part of the watertight subdivision of the ship, they shall be tested as per the requirements of item 5 "Deep tanks other than those listed elsewhere" in this table.
6 A "Leak and structural test", refer to 4.2.2 shall be carried out for a representative cargo hold if intended for in-port ballasting. The filling level requirement for testing cargo holds intended for in-port ballasting shall be the maximum loading that will occur in-port as indicated in the Loading Manual.
7 As an alternative to the hose testing, other testing methods listed in 4.4.7 ~~through~~ — 4.4.9 may be applicable subject to adequacy of such testing methods being verified. Refer to SOLAS regulation II-I/11.1. For watertight bulkheads (refer to 11.1) alternatives to the hose testing may only be used where a hose test is not practicable.
8 Where water tightness of a watertight door has not been confirmed by prototype test, testing by filling watertight spaces with water shall be carried out. Refer to SOLAS regulation II-1/16.2 and IMO circular ~~MSC/Circ.1176~~ MSC.1/Circ.1572/Rev.1.
9 Hose test may also be considered as a medium of the test. Refer to 3.2.
10 Refer to 3.3.

Table 4.1-2

Additional test requirements for special service ships/tanks

Nos.	Type of ship/tank	Structures to be tested	Type of test	Test head or pressure	Remarks
1	Liquefied gas carriers	Integral tanks	Leak and structural	Refer to IACS UR GI	
		Hull structure supporting membrane or semimembrane tanks	Refer to IACS UR GI	Refer to IACS UR GI	
		Independent tanks type A	Refer to IACS UR GI	Refer to IACS UR GI	
		Independent tanks type B	Refer to IACS UR GI	Refer to IACS UR G1	
		Independent tanks type C	Refer to IACS UR G2	Refer to IACS UR G2	
2	Edible liquid tanks	Independent tanks	Leak and structural[1]	The greater of: top of the overflow[3]; or to 0,9 m above top of tank[2]	
3	Chemical tankers	Integral or independent cargo tanks	Leak and structural[1]	The greater of: to 2.4 m above top of tank[2]; or to top of tank[2] plus ~~setting of any~~ the design vapour pressure ~~relief valve~~	Where a cargo tanks is designed for the carriage of cargoes with specific gravities larger than 1,0, ~~an appropriate additional head shall be considered~~ refer to 4.4.1

1 Refer to 4.2.2.
2 Top of tank is deck forming the top of the tank excluding any hatchways.
3 Refer to 3.3.

Table 4.1-3

Application of leak test, coating and provision of safe access for type of welded joints

Type of welded joints		Leak test	Coating[1]		Safe access[2]	
			Before leak test	After leak test but before structural test	Leak test	Structural test
Butt	Automatic	Not required	Allowed[3]	N/A	Not required	Not required
	Manual or semi-automatic[4]	Required	Not allowed	Allowed	Required	Not required
Fillet	Boundary including penetrations	Required	Not allowed	Allowed	Required	Not required

[1] Coating refers to internal (tank/hold coating), where applied, and external (shell/deck) painting. It does not refer to shop primer.
[2] Temporary means of access for verification of the leak test.
[3] The condition applies provided that the welds have been carefully inspected visually to the satisfaction of the RS surveyor.
[4] Flux core arc welding (FCAW) semiautomatic butt welds need not be tested provided that careful visual inspections show continuous uniform weld profile shape, free from repairs, and the results of NDT show no significant defects.

4.2 Structural test procedures.

4.2.1 Type and time of test.

Where a structural test is specified in Table 4.1-1 or 4.1-2, a hydrostatic test in accordance with 4.4.1 will be acceptable. Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with 4.4.2 may be accepted instead.

A hydrostatic test or hydropneumatic test for the confirmation of structural adequacy may be carried out while the ship is afloat, provided the results of a leak test are confirmed to be satisfactory before the ship is afloat.

Alternative equivalent tank testing procedures may be considered for tanks which are constructed from composite materials based on the recommendations of the composite manufacturer.

4.2.2 Testing schedule for new construction or major structural conversion.

4.2.2.1 Tanks which are intended to hold liquids, and which form part of the watertight subdivision of the ship[*], hall be tested for tightness and structural strength as indicated in Table 4.1-1 and 4.1-2.

4.2.2.2 The tank boundaries shall be tested from at least one side. The tanks for structural test shall be selected so that all representative structural members are tested for the expected tension and compression.

4.2.2.3 The watertight boundaries of spaces other than tanks for structural testing maybe exempted, provided that the watertightness of boundaries of exempted spaces is verified by leak tests and inspections. Structural testing may not be exempt and the requirements for structural testing of tanks in 4.2.2.1 — 4.2.2.2 shall apply, for ballast holds, chain lockers and a representative cargo hold if intended for in-port ballasting.

4.2.2.4 Tanks which do not form part of the watertight subdivision of the ship[†]~~, as well as sea chests and ice boxes~~ may be exempted from structural testing provided that the watertightness of boundaries of exempted spaces is verified by leak tests and by a careful visual examination of welded connections, supported where necessary by means such as a dye penetrant test or ultrasonic leak test or the equivalent.

[*] Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

[†] Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

4.3 Leak test procedures.

For the leak tests specified in Table 4.1-1, tank air tests, compressed air fillet weld tests, vacuum box tests in accordance with 4.4.4 ~~through~~ — 4.4.6, or their combination, will be acceptable. Hydrostatic or hydropneumatic tests may also be accepted as leak tests provided that 4.5, 4.6 and 4.7 are complied with. Hose tests will also be acceptable for such locations as specified in Table 4.1-1, Footnote 9, in accordance with 4.4.3.

The application of the leak test for each type of welded joint is specified in Table 4.1-3.

Air tests of joints may be carried out in the block stage provided that all work on the block that may affect the tightness of a joint is completed before the test. Refer also to 4.5.1 for the application of final coatings and 4.6 for the safe access to joints and the summary in Table 4.1-3.

4.4 Tests methods.

4.4.1 Hydrostatic test.

Unless another liquid is approved, hydrostatic tests shall consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in Table 4.1-1 or 4.1-2. Refer also to 4.7.

In cases where a tank is designed for cargo densities greater than sea water and testing is with fresh water or sea water, the testing pressure height shall simulate the actual loading for those greater cargo densities as far as practicable~~.~~, but the test pressure shall not exceed the maximum design internal pressure at the top of tank.

All external surfaces of the tested space shall be examined for structural distortion, bulging and buckling, other related damage and leaks.

4.4.2 Hydropneumatic test.

Hydropneumatic tests, where approved, shall be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, will simulate the actual loading as far as practicable. The requirements and recommendations for tank air tests in 4.4.4 will also apply to hydropneumatic tests. Refer also to 4.7.

All external surfaces of the tested space shall be examined for structural distortion, bulging and buckling, other related damage and leaks.

4.4.3 Hose test.

Hose tests shall be carried out with the pressure in the hose nozzle maintained at least at $2 \cdot 10^5$ Pa during the test. The nozzle shall have a minimum inside diameter of 12 mm and be at a perpendicular distance from the joint not exceeding 1,5 m. The water jet shall impinge directly upon the weld.

Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where necessary by means such as a dye penetrant test or ultrasonic leak test or the equivalent.

4.4.4 Tank air test.

All boundary welds, erection joints and penetrations, including pipe connections, shall be examined in accordance with the approved procedure and under a stabilized pressure differential above atmospheric pressure not less than $0{,}15 \cdot 10^5$ Pa, with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.

A U-tube with a height sufficient to hold a head of water corresponding to the required test pressure shall be arranged. The cross sectional area of the U-tube shall not be less than that of the pipe supplying air to the tank. Instead of using a U-tube, two calibrated pressure gauges may be acceptable to verify required test pressure. Arrangements involving the use of two calibrated pressure gauges to verify the required test pressure may be accepted taking into account the provisions in F5.1 and F7.4 of IACS recommendation No. 140 "Recommendation for Safe Precautions during Survey and Testing of Pressurized Systems".

A double inspection shall be made of tested welds. The first ~~is to~~ shall be immediately upon applying the leak indication solution; the second shall be after approximately four or five minutes in order to detect those smaller leaks which may take time to appear.

4.4.5 Compressed air fillet weld test.

In this air test, compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges shall be arranged so that an air pressure of at least $0{,}15 \cdot 10^5$ Pa can be verified at each end of all passages within the portion being tested.

Note. Where a leak test is required for fabrication involving partial penetration welds, a compressed air test shall also be applied in the same manner as to fillet weld where the root face is large, i.e. 6 — 8 mm.

4.4.6 Vacuum box test.

A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of $0{,}20 \cdot 10^5$ — $0{,}26 \cdot 10^5$ Pa inside the box.

4.4.7 Ultrasonic test.

An ultrasonic echoes transmitter shall be arranged inside of a compartment and a receiver shall be arranged on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver in order to detect an ultrasonic leak indication. A location where sound is detectable by the receiver indicates a leakage in the sealing of the compartment.

4.4.8 Penetration test.

A test of butt welds or other weld joints uses the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement. If no liquid is detected on the opposite sides of the boundaries after expiration of a definite period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

4.4.9 Other tests.

Other methods of testing may be considered by the Register upon submission of full particulars prior to the commencement of testing.

4.5 Application of coating.

4.5.1 Final coating.

For butt joints welded by an automatic process, the final coating may be applied any time before the completion of a leak test of spaces bounded by the joints, provided that the welds have been carefully inspected visually to the satisfaction of the RS surveyor.

RS surveyors reserve the right to require a leak test prior to the application of the final coating over automatic erection butt welds.

For all other joints, the final coating shall be applied after the completion of the leak test of the joint. Refer also to Table 4.1-3.

4.5.2 Temporary coating.

Any temporary coating which may conceal defects or leaks shall be applied at the time as specified for the final coating (refer to 4.5.1). This requirement does not apply to shop primer.

4.6 Safe access to joints.

For leak tests, safe access to all joints under examination shall be provided. Refer also to Table 4.1-3.

4.7 Hydrostatic or hydropneumatic tightness test.

In cases where the hydrostatic or hydropneumatic tests are applied instead of a specific leak test, examined boundaries shall be dew-free, otherwise small leaks are not visible.".

Part B — ~~Ships Not Covered by SOLAS (Non-SOLAS Ships) and Ships Granted SOLAS Exemption/Equivalent (~~SOLAS ~~Exemption~~Exempt/Equivalent Ships~~)~~

1 GENERAL

1.1 These test procedures shall confirm the watertightness of tanks~~ and~~, watertight boundaries and the structural adequacy of tanks which ~~consist~~ form part of the watertight subdivisions[*] of ships. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of ships during new construction and those relevant to major conversions or major repairs[†] shall be confirmed by these test procedures prior to the delivery of the ship.

1.2 Testing procedures of watertight compartments shall be carried out in accordance with Part B of this Appendix for ~~non-SOLAS ships and~~ those SOLAS ships (including CSR BC and OT) for which:

a) the shipyard provides documentary evidence of the shipowner's agreement to a request to the Administration for an exemption from the application of SOLAS Chapter II-1, regulation 11, or for an equivalency agreeing that the content of Part B is equivalent to SOLAS Chapter II-1, regulation 11; and

b) the above-mentioned exemption/equivalency has been granted by the responsible Administration.

2 APPLICATION

2.1 Testing procedures shall be carried out in accordance with the requirements of Part A of this Appendix in association with the alternative procedures for 4.2.2 ~~and alternative test requirements for Table 4.1-1,~~ of Part A.

2.2 The tank boundaries shall be tested from at least one side. The tanks for structural test shall be selected so that all representative structural members are tested for the expected tension and compression.

2.3 Structural tests shall be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localised differences determined to be acceptable by the ~~attending~~ RS surveyor) on each ship provided all other tanks are tested for leaks by an air test. The acceptance of leak testing using an air test instead of a structural test does not apply to cargo space boundaries adjacent to other compartments in tankers and combination carriers or to the boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships.

2.4 Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

2.5 For tanks which are less than 2 m^3 in volume, structural testing may be replaced by leak testing.

2.~~5~~6 Where the structural adequacy of the tanks and spaces of a ~~vessel~~ ship were verified by the structural testing required ~~in~~ by either Table 4.1-1 of Part A~~ of this Appendix~~ or 2.3 of Part B, subsequent ships in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

.1 watertightness of boundaries of all tanks ~~is~~ and spaces are verified by leak tests and thorough inspections are carried out;

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[*] Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

[†] Major repair means a repair affecting structural integrity.

.2 structural testing is carried out for at least one tank or space of each type among all tanks/spaces of each sister ship;

.3 additional tanks and spaces may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the ~~attending~~ RS surveyor.

For cargo space boundaries adjacent to other compartments in tankers and combination carriers or boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships, ~~the provisions of 2.5.2 of Part B of this Appendix shall apply in lieu of 2.3 of Part B~~ structural tests shall be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localised differences determined to be acceptable by the RS surveyor) on each ship provided all other tanks are tested for leaks by an air test.

2.~~6~~7 Sister ships built (i.e. keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with 2.~~5~~6 of Part B of this Appendix, provided that:

.1 general workmanship has been maintained (i.e. there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by the Register); and

.2 an NDT plan is implemented and evaluated by the Register for the tanks not subject to structural tests. Shipbuilding quality standards for the hull structure during new construction shall be reviewed and agreed during the kick-off meeting. ~~Structural fabrication shall be carried out in accordance with IACS recommendation 47 "Shipbuilding and Repair Quality Standard", or a recognised fabrication standard which has been accepted by the Register prior to the commencement of fabrication/construction.~~ The work shall be carried out in accordance with the RS rules and under the RS technical supervision.

Part C — Ships Not Covered by SOLAS (Non-SOLAS Ships)

1 GENERAL

1.1 These test procedures shall confirm the watertightness of tanks, watertight boundaries and the structural adequacy of tanks which form part of the watertight subdivisions[*] of ships. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of ships during new construction and those relevant to major conversions or major repairs[†] shall be confirmed by these test procedures prior to the delivery of the ship.

1.2 Testing procedures of watertight compartments shall be carried out in accordance with Part C of this Appendix for non-SOLAS ships.

2 APPLICATION

2.1 Testing procedures shall be carried out in accordance with the requirements of Part A of this Appendix in association with the following alternative procedures for 4.2.2 of Part A.

2.2 The tank boundaries shall be tested from at least one side. The tanks for structural test shall be selected so that all representative structural members are tested for the expected tension and compression.

[*] Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter II-1.

[†] Major repair means a repair affecting structural integrity.

2.3 The requirements given in Table 4.1-1 of Part A to structurally test tanks to 2.4 m above the top of the tank do not apply. Instead, the minimum test pressure for structural testing shall be taken as $0{,}3D + 0{,}76$ m above the top of the tank where the top of the tank is the deck forming the top of the tank, excluding any hatchways and D is the depth of the ship. The minimum test pressure need not be taken greater than 2,4 m above the top of the tank.

2.4 Structural tests shall be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localised differences determined to be acceptable by the RS surveyor) on each ship provided all other tanks are tested for leaks by an air test. The acceptance of leak testing using an air test instead of a structural test does not apply to cargo space boundaries adjacent to other compartments in tankers and combination carriers or the boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships.

2.5 Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

2.6 For tanks which are less than 2 m^3 in volume, structural testing may be replaced by leak testing.

2.7 Where the structural adequacy of the tanks and spaces of a ship were verified by the structural testing required by either Part A or 2.4 of Part C, subsequent ships in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

.1 water-tightness of boundaries of all tanks and spaces are verified by leak tests and thorough inspections are carried;

.2 structural testing is carried out for at least one tank or space among all tanks/spaces of each sister ship;

.3 additional tanks and spaces may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the RS surveyor.

For cargo space boundaries adjacent to other compartments in tankers and combination carriers or boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships, structural tests shall be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localised differences determined to be acceptable by the RS surveyor) on each ship provided all other tanks are tested for leaks by an air test.

2.8 Sister ships built (i.e. keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with 2.7 of Part C of this Appendix, provided that:

.1 general workmanship has been maintained (i.e. there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by the Register); and

.2 an NDT plan is implemented and evaluated by the Register for the tanks not subject to structural tests. Shipbuilding quality standards for the hull structure during new construction shall be reviewed and agreed during the kick-off meeting. The work shall be carried out in accordance with the RS rules and under the RS technical supervision.".

PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT

1 GENERAL

1.4 GENERAL

Para 1.4.2 is amended as follows:

"**1.4.2** Towing and ~~m~~Mooring ~~a~~Arrangements ~~p~~Plan containing the ~~relevant~~ ~~ship-specific~~ information in accordance with 4.5 shall be submitted to the Register for approval and be available on board for the guidance of the master. ~~The information provided on the plan in respect of shipboard 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.~~".

3 ANCHOR ARRANGEMENT

3.1 GENERAL

Para 3.1.3 is replaced by the following text:

"**3.1.3** For all ships other than fishing vessels, the anchoring equipment shall be selected from Table 3.1.3-1, for fishing vessels — from Table 3.1.3-2. For fishing vessels, when Equipment Number exceeds 720, the anchoring equipment shall be selected from Table 3.1.3-1.

The Equipment Number is determined in compliance with 3.2 for ships of unrestricted service and of restricted area of navigation **R1**, and is reduced:

by 15 % for ships of restricted areas of navigation **R2**, **R2-RSN**, **R2-RSN(4,5)** and **R3-RSN**;

by 25 % for ships of restricted area navigation **R3**, taking into account of the provisions specified in 3.1.4, 3.3.1, 3.3.2, 3.4.1, 3.4.2 and 3.4.3.

The Equipment Number EN formulae for anchoring equipment is based on an assumed maximum current speed of 2,5 m/s, maximum wind speed of 25 m/s and a minimum scope of chain cable of 6, the scope being the ratio between length of chain paid out and water depth. For ships with an equipment length (refer to Note 4 of 3.2.1) greater than 135 m, alternatively the required anchoring equipment can be considered applicable to a maximum current speed of 1,54 m/s, a maximum wind speed of 11 m/s and waves with maximum significant height of 2 m.

For ships of length less than 90 m, alternative methodology using direct force calculation for anchoring equipment described in Appendix 3 may be used.".

Tables 3.1.3-1 and **3.1.3-2** remain unamended.

3.2 EQUIPMENT NUMBER

Para 3.2.2 is supplemented by the following text:

"For tugs under 45 m in length intended for towing service only, one anchor may be used onboard provided that the second anchor and its relevant chain cable are stored and held readily available to be installed. The place of stowage is determined by the shipowner.".

Para 3.2.3 is supplemented by the following text:

"Dredgers with unusual design of the underwater part of the hull are not covered by alternative methodology using direct force calculation for anchoring equipment described in Appendix 3.".

Paras 3.2.5 and 3.2.5.1 are replaced by the following text:

"**3.2.5** For ships with an equipment length of ~~not less than~~ 135 m and above, intended to anchor in deep and unsheltered water~~, as well as to anchor in water~~ with depth up to 120 m, current with up to 1,54 m/s, wind with up to 14 m/s and waves with significant height of up to 3 m (0,75·$h_{3\%}$), the anchoring equipment shall be selected according to 3.2.5.1 — 3.2.5.3.".

3.4 CHAIN CABLES AND ROPES FOR BOWER ANCHORS

Paras 3.4.7 — 3.4.9 are replaced by the following text:

"**3.4.7** Wire rope may be used in place of chain cable on ships:

of less than 90 m in length and which may require an anchor for emergency purposes, i.e., not intended to use their anchor in normal anchorage conditions; or

with the anchoring equipment used for positioning with a minimum of 4 points anchoring, e.g., for a cable laying vessel or a pipe laying vessel.

3.4.8 Use of wire rope is subject to the following conditions:

the length of the wire rope shall be equal to 1,5 times the corresponding length of chain cable as given in Table 3.1.3-1 or 3.1.3-2, and its strength shall be equal to that of chain cable of grade 1 as given in Table 3.1.3-1 or 3.1.3-2;

the anchor weight shall be increased by 25 % compared to that as given in Table 3.1.3-1 or 3.1.3-2;

a short length of chain cable shall be fitted between the wire rope and anchor having a length of 12,5 m or the distance between anchor in stowed position and winch, whichever is less;

all surfaces being in contact with the wire rope shall be rounded with a radius of not less than 10 times the wire rope diameter (including stem);

wire rope shall be selected to fit for purpose based on the manufacturer's documentation and shall be provided with guidance for maintenance and inspection. In all other respects, the wire ropes for anchors shall meet the requirements of 3.15 of Part XIII "Materials".

3.4.9 In ships of less than 40 m in length of restricted area of navigation, as well as in fishing vessels with Equipment Number up to 980, regardless of their length, the use of wire ropes may be accepted in place of chain cables, taking account of the requirements of 3.4.8.".

4 MOORING ARRANGEMENT

4.1 GENERAL

Para 4.1.1 is replaced by the following text:

"**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 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships (for European Inland Waterways).

For shipboard fittings not selected from an industry standard accepted (approved) by the Register, the corrosion addition t_c and the wear allowance t_w, given in 4.3.5, respectively, ~~shall~~ should be considered.

Mooring arrangement shall be designed and selected, including lines, based on IMO circular MSC.1/Circ.1619 taking into account occupational safety and safe mooring of the ship[1]. Ship-specific information in accordance with 4.5 shall be provided and kept onboard.

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[1] Ships of less than 3000 gross tonnage shall comply with the requirement as far as reasonably practicable.".

Para 4.1.1 is amended as follows:

"**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. Mooring arrangement including lines, equipment and machinery shall meet the requirements of this Section.

For shipborne barges the mooring arrangement shall comply with the requirements of Section 4 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships (for European Inland Waterways).

For shipboard fittings not selected from an industry standard accepted (approved) by the Register, the corrosion addition t_c and the wear allowance t_w, given in 4.3.5, respectively, should be considered.

Mooring arrangement shall be designed and selected, including lines, based on IMO circular MSC.1/Circ.1619 taking into account occupational safety and safe mooring of the ship[1]. Ship-specific information in accordance with 4.5 shall be provided in the Towing and Mooring Arrangements Plan and kept onboard during the ship's service life.

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[1] Ships of less than 3000 gross tonnage shall comply with the requirement as far as reasonably practicable.".

Para 4.1.2 is amended as follows:

"**4.1.2** For all ships other than fishing vessels, the number, length and minimum breaking strength of mooring lines shall be as recommended values given in Table 3.1.3-1, and for fishing values — in Table 3.1.3-2. For fishing vessels, when Equipment Number exceeds 720, the number, length and minimum breaking strength of mooring lines, given as recommended values, shall be selected from Table 3.1.3-1 based on Equipment Number determined in compliance with 3.2.

As an alternative to 4.1.3, the minimum recommendation for mooring lines may be determined by direct mooring analysis in line with the procedure given in Appendix 2.

The designer should consider verifying the adequacy of mooring lines based on assessments carried out for the individual mooring arrangement, expected shore-side mooring facilities and design environmental conditions for the berth.

The definition of line design break force ($LDBF$) is the minimum force at which a new, dry, spliced mooring line will break at. This is for all synthetic cordage material.

This value is declared by the manufacturer on each line's mooring line certificate and is stated on a manufacturer's line data sheet. $LDBF$ shall be 100 — 105 % of the ship design minimum breaking load (MBL_{SD}) defined in accordance with 4.1.3.1.

The $LDBF$ for nylon (polyamide) mooring lines should be specified as break tested wet, because nylon lines change strength characteristics once exposed to water and generally do not fully dry to their original construction state.".

Para 4.1.6 is deleted.

4.2 MOORING LINES

Para 4.2.1 is amended as follows:

"**4.2.1** Mooring lines may be of steel wire, natural fibre or synthetic fibre construction or of a mixture of wire and fibre.

~~Notwithstanding the breaking strength recommendations given in Tables 3.1.3-1 or 3.1.3-2, no fibre rope shall be less than 20 mm in diameter.~~

For synthetic fibre ropes it is recommended to use lines with reduced risk of recoil (snap-back) to mitigate the risk of injuries or fatalities in the case of breaking mooring lines.".

Para 4.2.2 is amended as follows:

"**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 s~~Steel wire ropes shall meet the requirements of 3.15 of Part XIII "Materials".".

4.5 TOWING AND MOORING ARRANGEMENTS PLAN

Para 4.5.2 is amended as follows:

"**4.5.2** ~~Information provided on the plan~~ The Towing and Mooring Arrangements Plan (hereinafter referred to as "the Plan") shall ~~include~~ provide the following information in respect of each shipboard fitting intended for mooring and towing purposes:

location on the ship;

fitting type;

SWL/TOW;

the maximum brake holding load (for ships of less than 3000 gross tonnage);

purpose (mooring/harbour towing/other towing);

manner of applying towing or mooring line load including limiting fleet angles i.e. angle of change in direction of a line at the fitting.

Furthermore, information provided on the pPlan shall include:

the arrangement of mooring lines showing number of lines (N);

the ship design minimum breaking load (MBL_{SD});technical specification document of the mooring lines:

minimum diameter D of each fitting in contact with the mooring lines;

line design break force ($LDBF$) of the mooring lines (which shall be within the range 100 — 105 % of MBL_{SD});

properties of mooring lines related to $LDBF$ (refer to 4.1.2);

the acceptable diameter of the fitting in contact with the mooring lines D in relation to the mooring line diameter d (D/d ratio) for all fittings of the mooring arrangement, as well as a warning that the wear rate of lines may be higher for lower diameter D;

N o t e . Where the acceptable minimum bend radius requirements for a particular mooring line are not achievable, the service life of the line may be less than that stated by the manufacturer and therefore the line may need to be replaced before the end of the service life recommended by the manufacturer.

the acceptable environmental conditions as given in the current version of IACS recommendation No. 10 (Rev.4 Sep 2020) (the document is available at the IACS website: www.iacs.org.uk), for the recommended ship design minimum breaking load for ships with Equipment Number $EN > 2000$:

30 s mean wind speed from any direction (v_W or v_W^* according to the current version of IACS recommendation No. 10 (Rev.4 Sep 2020) (the document is available at the IACS website: www.iacs.org.uk));

maximum current speed acting on bow or stern (±10°).;

for ships of 3000 gross tonnage and above, the additional information listed in 4.5.3 shall be submitted by the designer.".

New para 4.5.3 is introduced reading as follows:

"**4.5.3** For ships of 3000 gross tonnage and above, the following shall be provided by the designer in addition to the information specified under 4.5.2:

the confirmation of compliance of the mooring arrangement with the requirements of this Section. If deviations are not found, then this shall be stated explicitly in the document;

the confirmation that the mooring maximum brake holding load of the winches is less than 100 % of (MBL_{SD}). The winches shall be fitted with brakes that allow for the reliable setting of the brake rendering load; and

N o t e . The selection of mooring lines should take into account the compatibility of the MBL_{SD} of mooring lines and the brake capacity of the mooring winches installed on board. To avoid overload on mooring winches, fittings and mooring lines, consideration should be given to select mooring winches with brake capacity of less than the ship design minimum breaking load of the mooring line or with adjustable brake capacity.

The document shall provide the information on the deviations, if any, in relation to the following:

straight line lead from the mooring winch to the chocks, fairleads, rollers;

unobstructed aerial view of the mooring operations and berth arrangements planned to be used;

protection of winch operators from hazards associated with mooring operations;

unobstructed access to the equipment and fittings;

exposure of the shipboard personnel to lines under tension through snap-back or sudden movements of mooring lines;

minimizing the need for manual handling of towing and mooring lines.

The document with the description of deviations shall include justification for such deviations and suitable safety measures for the shipboard personnel to avoid the risks and hazards associated with mooring operations.".

Existing para 4.5.3 is renumbered **4.5.4**.

7 OPENINGS IN HULL, SUPERSTRUCTURES AND DECKHOUSES AND THEIR CLOSING APPLIANCES

7.7 COMPANION HATCHES, SKYLIGHTS AND VENTILATING TRUNKS

Para 7.7.2.1 is supplemented by the following text:

"Requirements of 7.7.2 of this Part do not apply to small hatches on container ships giving access to a cargo hold which comply with the requirements of 3.2.14 of the Guidelines on Application of Provisions of the International Convention on Load Lines (LL-66/88) except the requirements of 3.2.14.4 and 3.2.14.5. Such hatch covers are considered non-weathertight. For scantlings of small hatches, the requirements of 7.7.2.2 — 7.7.2.4 of this Part may be applied instead of requirements of 3.2.14.6 of the Guidelines on Application of Provisions of the International Convention on Load Lines (LL-66/88).".

8 ARRANGEMENT AND EQUIPMENT OF SHIP'S SPACES. OTHER ARRANGEMENTS AND EQUIPMENT

8.6 GUARD RAILS, BULWARK AND GANGWAYS

Paras 8.6.9 and 8.6.10 are amended as follows:

"**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.~~ Oil tankers, chemical tankers, gas carriers and NLS tankers shall be fitted in such a way as to provide safe access to the ship's bow. Therewith, the following shall be ensured:

.1 a well lighted and ventilated under-deck passageway (clear opening 0,8 m wide, 2,0 m high) as close as practicable to the freeboard deck, connecting and providing access to the locations in question;

.2 a permanent and efficiently constructed gangway fitted at or above the level of the superstructure deck on or as near as practicable to the centreline of the ship:

located so as not to hinder easy access across the working areas of the deck;

providing a continuous platform at least 1,0 m in width (for ships with a length of less than 100 m — not less than 0,6 m);

constructed of fire resistant and non-slip material;

fitted with guard rails extending on each side throughout its length; guard rails shall be at least 1,0 m high with courses as required by 8.6.5 of this Part and supported by stanchions spaced not more than 1,5 m. Guard rails shall meet the requirements of 3.5.5.2 of Part II "Hull";

provided with a foot stop on each side;

having openings, with ladders where appropriate, to and from the deck. Openings shall not be more than 40 m apart;

having shelters of substantial construction set in way of the gangway at intervals not exceeding 45 m if the length of the exposed deck to be traversed exceeds 70 m. Every such shelter shall be capable of accommodating at least one person and be so constructed as to afford weather protection on the forward, port and starboard sides;

.3 a permanent and efficiently constructed walkway fitted at freeboard deck level on or as near as practicable to the centreline of the ship having the same specifications as those for a permanent gangway listed in 8.6.9.2 except for foot-stops.

Where necessary, alternative transverse locations may be the following:

fitted at or near centreline of the ship or on hatchways at or near centreline of the ship;

fitted on each side of the hatchways as near to the centreline as practicable.

~~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 of 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 non slip material.~~

The plating may be manufactured of fibre-reinforced plastic provided it complies with the requirements of 6.9 of Part XIII "Materials".

~~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.".

Existing Appendix is assigned **number 1**.

New Appendices 2 and 3 are introduced reading as follows:

"APPENDIX 2

DIRECT MOORING ANALYSIS

1 General.

As an alternative to selection of mooring equipment, direct mooring analysis may be performed to determine the necessary mooring restraint, i.e. number and strength of mooring lines. Direct analyses allow to optimize mooring equipment and arrangement for the individual ship and the port mooring facilities typical for the considered ship type and size.

2 Documentation.

The calculations shall be documented in a report. The report shall include all assumptions made in calculations for the finally chosen mooring equipment, including lines, and its arrangement, reflected in the mooring arrangement plan as required by Section 4 of this Part.

3 Analysis methodology.

Three dimensional quasi-static calculations should be performed to determine the acting mooring line forces. As a minimum, loads from wind and current should be accounted for in the analysis. Geometrical and material nonlinearities of mooring lines and fenders or breasting dolphins should be considered. An iterative calculation procedure should be applied to arrive at a converged solution with forces acting on mooring lines and on fenders or breasting dolphins being in equilibrium with forces and moments applied to the ship.

4 Environmental conditions.

Mooring line forces should be calculated for environmental conditions given in 4.1.3 of this Part. Additional loads, e.g. wave loads or cross currents, or increased wind and current loads may be considered for certain ship types or for specific ports intended to be regularly called.

5 Direct assessment of mooring forces and determination of the necessary number and strength of mooring lines comprise the following steps.

5.1 Determination of port mooring facilities representative for the considered ship type and size.

Characteristics of port mooring facilities have strong influence on the resulting mooring line forces. Mooring analysis should be performed for port mooring facilities representative for the considered ship type and size, i.e. type of berth, type and arrangement of hooks/bollards, type and arrangement of fenders or breasting dolphins and height of pier above waterline.

Fenders or breasting dolphins in many cases may not affect the critical mooring line loads. Hence, initially, generic fender or dolphin arrangements and infinitely stiff load-deformation characteristics may be considered. If no fender or dolphin loads occur for load cases yielding the critical mooring line loads, more specific fender or dolphin arrangements and characteristics may be omitted.

If there are substantially different port mooring facilities typically encountered by the considered ship type, additional calculations shall be performed to consider these variations.

5.2 Determination of shipboard mooring equipment and arrangement.

The mooring equipment and arrangement need to be chosen for the mooring analysis, i.e. location of mooring decks and location of mooring winches and fairleads. As a starting point, mooring equipment for the number of lines as determined according to 4.1.3.2 of this Part may be chosen.

5.3 Determination of mooring line type(s) to be used.

The mooring analysis should apply the mooring line type(s) intended to be supplied with the ship. The geometrical and material nonlinearities of the mooring lines should be considered by the mooring analysis. Load-deflection characteristics of mooring lines can be taken from data sheets of rope manufacturers. If given, characteristics of the broken-in ropes should be applied.

To achieve a good distribution of mooring line forces, mooring line type and characteristics shall be at least same for lines in the same service, e.g. for head and stern lines, breast lines and spring lines. For very stiff mooring lines, e.g. made of steel or high modulus synthetic fibers, the use of elastic tails should be considered to enhance the elasticity in the mooring system and taken into account for the mooring analysis.

5.4 Determination of mooring layout(s) to be assessed.

For the assessment of forces acting on mooring lines, a realistic mooring layout needs to be assumed, i.e. for each mooring line it needs to be determined from which bollard or winch, along which path, through which fairlead it is led and to which shoreside hook or bollard it is connected. Inboard parts of the mooring lines (between fairlead and shipboard fixation point) contribute to the elongation behavior of the line and shall be included in the analysis.

The maximum number of lines connected to one shore mooring point needs to be limited to not load the shore side mooring points unrealistically high. For multi-purpose piers the number of lines per shore bollard shall be limited to three. For other types of berths, the number of mooring lines per shore mooring point is also limited, e.g., by the available number of hooks. Reasonable assumptions shall be made based on typical berth types encountered by the considered ship type.

Alternative mooring layouts should also be assessed, considering possible and reasonable options to moor the ship to the assumed port mooring facilities. Also, a different position of the ship relative to the shoreside mooring bollards/hooks should be assessed to find the critical mooring line loads for the normal operation of the ship. Alternative mooring layouts may not apply to e.g. tankers, LNG carriers or ferries if typically moored in the same position relative to the shoreside mooring facilities.

5.5 Determination of ship loading condition(s) to be assessed.

Mooring line forces should be calculated for loading conditions given in в 4.1.3 of this Part.

5.6 Selection or determination of wind and current drag coefficients.

To calculate the wind and current forces and moments acting on the ship, wind and current drag coefficients are needed for the considered ship type, size and loading condition. Drag coefficients shall be as specific as possible for the considered ship and loading conditions.

There are different sources for drag coefficients. Some industry standards provide drag coefficients for tankers and LNG carriers which can be applied. Due to the similarity of hull forms and superstructures, these coefficients may also be used for bulk carriers and ore carriers. For other ship types drag coefficients may be taken from the literature, if available, or can be determined by CFD calculations or model tests. CFD calculations shall be justified with suitable validation and sensitivity studies.

There are some effects that can influence the drag coefficients, i.e. blockage (limited under keel clearance, solid quay walls), ship draft and wind shielding by solid quays and buildings or cargo stored on quays (e.g. container stacks). Effects from blockage and ship draft can only be accounted for by appropriate coefficients. Drag coefficient should be chosen or determined for realistic water depth to draft ratios and for the considered ship draft(s). Some industry guidelines provide current drag coefficients for ballast and loaded draft conditions and for different water depth to draught ratios. Wind shielding effects are typically not considered by the wind drag coefficients. The effect of wind shielding of solid quays may be considered by an equivalent reduction of the lateral wind area of the ship. Shielding by buildings or cargo stored on quays should not be considered as their presence is imponderable.

5.7 Determination of wind and current forces and moments.

Wind and current forces and moments can be calculated for the given environmental conditions with the geometrical particulars of the considered ship and the selected drag coefficients. Usually, the forces in longitudinal and transversal directions as well as the moment about the vertical ship axis (yaw) are calculated.

Wind forces and moments should be calculated for all directions in intervals of preferably 15°, but not more than 30°. Current forces and moments should be calculated for selected directions as per 4.1.3 of this Part. For ships regularly moored to non-solid piers or jetties, cross current may need to be considered in addition.

5.8 Computation of forces acting on all mooring line.

For all considered scenarios and all combinations of applied environmental conditions, the maximum mooring line force shall be determined for groups of lines in the same service.

In case of all lines are intended to be attached to winches, brake rendering can be considered to better distribute line loads among all lines in a group of lines in the same service. Then, the average mooring line force of a group of lines may be determined and taken as mooring line force used to determine the necessary strength of the mooring lines according to 5.9.

5.9 Determination of necessary strength of mooring lines.

The necessary strength of mooring lines, i.e., the ship design minimum breaking load (MBL_{SD}), results from the calculated maximum mooring line force ($F_{L,max}$) divided by the work load limit (WLL) factor of mooring lines. The WLL factor and the resulting MBL_{SD} for different mooring line materials are shown in Table 5.9.

Table 5.9

Mooring line material	WLL factor	MBL_{SD}
Steel wire	0,55	$1{,}82 \cdot F_{L,max}$
Synthetic fibers	0,5	$2{,}0 \cdot F_{L,max}$

Preferably, all lines supplied to the ship should have the same characteristics and strength to avoid confusion of lines. However, for significantly different maximum calculated line loads, lines in different service may also have different strength and characteristics, e.g. for head and stern lines other than for spring lines.

5.10 If strength of mooring lines should be altered, modify steps 5.2, 5.3 and/or 5.4 with or without changing the number of mooring lines and repeat steps 5.8 and 5.9.

APPENDIX 3

DIRECT FORCE CALCULATION FOR ANCHORING EQUIPMENT

1 General.

As an alternative to selection of anchoring equipment, direct force calculation may be performed to determine the necessary anchoring equipment for monohull ships with length less than 90 m.

2 Total force F_{EN}.

The total force (static + dynamic) F_{EN}, in kN, induced by wind and current acting on monohull in anchoring condition may be calculated as follows:

$$F_{EN} = 2(F_{SLPH} + F_{SH} + F_{SS}) \quad (2)$$

where F_{SLPH} = static force on wetted part of the hull due to current, as defined in 2.1 of this Appendix;
F_{SH} = static force on hull due to wind, as defined in 2.2 of this Appendix;
F_{SS} = static force on superstructures due to wind, as defined 2.3 of this Appendix.

2.1 Static force on wetted part of the hull F_{SLPH}.

The theoretical static force induced by current applied on the wetted part of the hull, in kN, is defined according to the following formula:

$$F_{SLPH} = \frac{1}{2}\rho C_f S_m V_c^2 10^{-3} \quad (2.1)$$

where ρ = water density, equal to 1025 kg/m^3;
C_f = coefficient equal to:

$$C_f = (1+k)\frac{0{,}075}{(logR_e - 2)^2}$$

where $R_e = \frac{(V_c L_{WL})}{1{,}054 \cdot 10^{-6}}$;
k = coefficient equal to:

$$k = 0{,}017 + 20\frac{c_{bWL}}{L_{WL}^2 T^{-0{,}5} B_{WL}^{-1{,}5}};$$

c_{bWL} = block coefficient at waterline:

$$c_{bWL} = \frac{\Delta}{1{,}025 L_{WL} B_{WL} T};$$

Δ = moulded displacement at waterline, in m^3;
S_m = total wetted surface of the part of the hull under draught, in m^2. The value of S_m shall be given by the designer. When this value is not available, S_m may be taken equal to $6\Delta^{2/3}$;
V_C = speed of the current, in m/s.

2.2 Static force on hull F_{SH}

The theoretical static force induced by wind applied on the upper part of the hull, in kN, is defined according to the following formula:

$$F_{SH} = \frac{1}{2}\rho(C_{hfr}S_{hfr} + 0{,}02S_{hlat})V_W^2 10^{-3}, \quad (2.2)$$

where ρ = air density, equal to 1,22 kg/m^3;
V_W = speed of the wind, in m/s, as defined in 3.1.3 of this Part;
S_{hfr} = front surface of hull and bulwark if any, in m^2, projected on a vertical plane of the ship situated aft of the aft end of the ship and perpendicular to the longitudinal axis of the ship;
S_{hlat} = partial lateral surface of one single side of the hull and bulwark if any, in m^2, through the overall length of the ship, projected on a vertical plane parallel to the longitudinal axis of the ship and delimited according to Fig. 2.2 of this Appendix;
C_{hfr} = $0{,}8\sin\alpha$, with α defined in Fig. 2.2 of this Appendix.

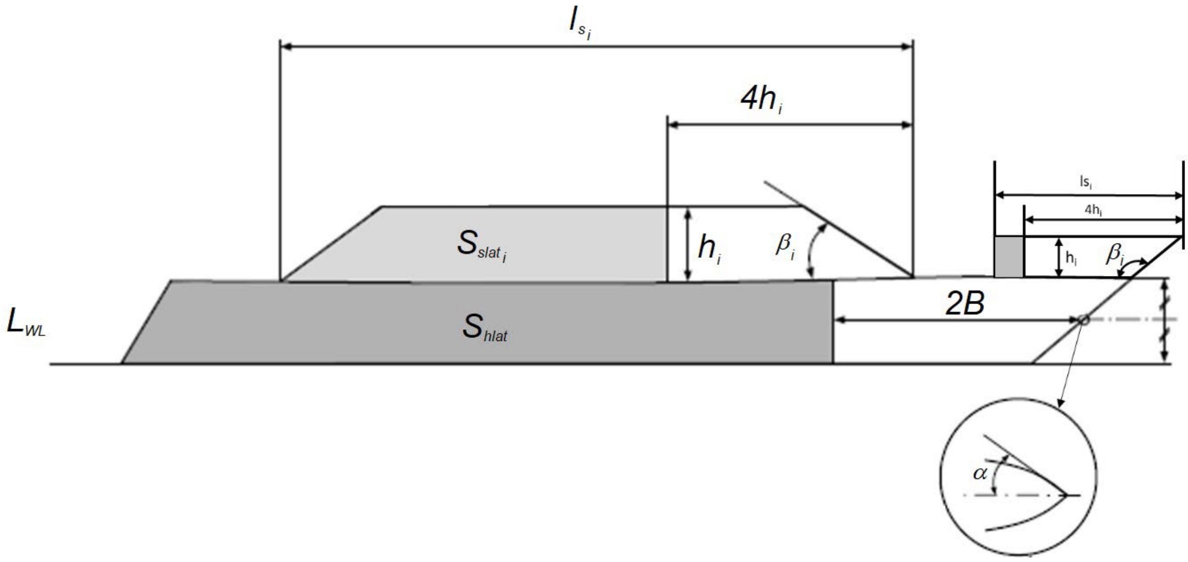


Fig. 2.2
B is the breadth of the hull, in m

U p p e r p a r t o f t h e h u l l is the part extending from side to side to the uppermost continuous deck extending over the ship length.

2.3 Static forces F_{SS} on superstructures and deckhouses.

2.3.1 General case.

The theoretical static force induced by wind applied on the superstructures and deckhouses, in kN, is defined as the sum of the forces applied to each superstructure and deckhouse tier according to the following formula:

$$F_{SS} = \frac{1}{2}\rho\sum(C_{sfr_i}S_{sfr_i} + 0{,}08S_{slat_i})\,V_W^2 10^{-3} \quad (2.3.1)$$

where ρ = air density, equal to 1,22 kg/m^3;
V_W = speed of the wind, in m/s, as defined in 2.2 of this Appendix;
S_{sfr_i} = front surface of tier i (superstructure or deckhouse, including bulwark if any), m^2, projected on a vertical plane of the ship situated aft of the aft end of the ship and perpendicular to the longitudinal axis of the ship;

S_{slat_i} = partial lateral surface of one single side of tier i (superstructure or deckhouse, including bulwark if any), in m^2, projected on a vertical plane parallel to the longitudinal axis of the ship and delimited according to Fig. 2.2 of this Appendix.
When $4h_i \geq l_{si}$, S_{slat_i} is to be taken equal to 0;

C_{sfr_i} = $0{,}8 \sin \beta_i$, with β_i defined in Fig. 2.2 of this Appendix without being greater than 90°.

2.3.2 Superstructures in the forward part of the ship.

When superstructures are located in the front of the hull with front and side walls of superstructures in the continuity of the side shell, the static force induced by wind applied on these superstructures, in kN, is defined as the sum of the forces applied to each superstructure tier according to the following formula:

$$F_{SS} = \frac{1}{2} \rho \sum (C_{hfr_i} S_{hfr_i} + 0{,}08 S_{slat_i}) V_W^2 10^{-3} \qquad (2.3.2)$$

where S_{hfr_i} = front surface of tier i of the superstructure, m^2, projected on a vertical plane of the ship situated aft of the aft end of the ship and perpendicular to the longitudinal axis of the ship;

C_{hfr_i} = $0{,}8 \sin \alpha_s$, with α_s as defined for α in Fig. 2.2 of this Appendix and measured at mid height of the superstructure tier located in the front of the hull;

ρ, V_W, S_{slat_i} = as defined in 2.3.1 of this Appendix.

The static force shall be added to the static force calculated for the other superstructures and deckhouses according to 2.3.1 of this Appendix.

3 Anchor weight.

The individual mass of anchor, in kg, shall be at least equal to:

for ordinary anchor: $P = (F_{EN}/7) * 10^2$;

for high holding power anchor: $P = (F_{EN}/10) * 10^2$;

for super high holding power: $P = (F_{EN}/15) * 10^2$.

4 Chain cable.

4.1 Stud link chain cable scantling.

Chain cable diameters are to be selected from Table 5 of IACS UR A1, based on the minimum breaking load BL and proof load PL of steel grades, in kN, calculated according to the following formulae:

for steel Grade 1:

$BL = 6F_{EN}$;

$PL = 0{,}7BL$;

for steel Grade 2:

$BL = 6{,}8F_{EN}$;

$PL = 0{,}7BL$;

for steel Grade 3:

$BL = 7{,}5F_{EN}$;

$PL = 0{,}7BL$.

The chain cable scantling shall be consistent with the mass of the associated anchor. In case the anchor on board is heavier by more than 7 % from the mass calculated in Section 3 of this Appendix, the value of F_{EN} to take into account in the present Article for the calculation of BL and PL shall be deduced from the actual mass of the anchor according to the formulae in Section 3 of this Appendix.

4.2 Length of individual chain cable.
The length of chain cable L_{cc}, in m, linked to each anchor shall be at least equal to:
when $P < 180$
$L_{cc} = 30\ In(P) - 42$

where P = anchor weight, in kg, defined in Section 3 of this Appendix for an ordinary anchor according to the considered case;

when $P \geq 180$
L_{cc} to be selected according to Table 3.1.3-1 of this Part.".

PART V. SUBDIVISION

1 GENERAL

1.1 APPLICATION

Para 1.1.1.7 is amended as follows:

"**.7** special purpose ships and ships carrying more than 12 persons of industrial personnel;".

Para 1.1.4 is deleted. **Para 1.1.5** is renumbered **1.1.4**.

Renumbered para 1.1.4 is amended as follows:

"**1.1.4** ~~Where~~ For ~~an~~ existing cargo ships covered after conversion by the ~~provisions of SOLAS 74/78~~ requirements of 2.1~~is subject to any conversion~~, and where such conversion ~~which~~ affects the level of subdivision~~ of that ship~~, it shall be demonstrated that the A/R ratio calculated for the ship after such conversion is not less than the A/R ratio calculated for the ship before the conversion. However, in those cases where the ship's A/R ratio before conversion is equal to or greater than unity, it is only necessary to demonstrate that the ship after such conversion has an A value, which is not less than R, calculated for the ship after conversion.~~ A definition of the term "existing cargo ship" in the context of the above interpretation means a cargo ship constructed before 1 February 1992, regardless of the length and a ship constructed before 1 July 1998 of 100 m in length or less.~~".

2 PROBABILITY ESTIMATION OF SUBDIVISION

2.5 CALCULATION OF THE FACTOR s_i

Para 2.5.4.1.1 is supplemented by the following **new paragraph**:

"Alternatively, the heeling moment may be calculated assuming the passengers are distributed with 4 persons per square metre 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.".

New para 2.5.5.3.4 is introduced reading as follows:

"**.4** at any intermediate stage of flooding, for passenger ships, 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.".

Para 2.5.5.5 is amended as follows:

"**2.5.5.5** Except as provided in 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 watertight hatch covers required to be kept closed at sea in accordance with 7.12 and 7.15 of Part III "Equipment, Arrangement and Outfit" need not be considered.".

3 DAMAGE TRIM AND STABILITY

3.3 REQUIREMENTS FOR DAMAGE TRIM AND STABILITY CHARACTERISTICS

Para 3.3.4.5 is amended as follows:

"**.5** hinged watertight access doors with open/closed indication locally and at the navigation bridge, of the quick-acting or single-action type that are normally closed at sea, hinged watertight doors that are permanently closed at sea (except ships specified in ~~1.1.1.5 and~~ 1.1.1.8);".

3.4 ADDITIONAL REQUIREMENTS FOR DAMAGE TRIM AND STABILITY

Para 3.4.3.1 is amended as follows:

"**3.4.3.1** Special purpose ships and ships carrying more than 12 persons of industrial personnel shall comply with the requirements of Section 2 related to passenger ships, and special and industrial personnel shall be considered as passengers. Where the abovementioned ships ~~is~~ are certified to carry less than 240 persons, the requirements of 2.7 are not applicable.".

PART VI. FIRE PROTECTION

2 STRUCTURAL FIRE PROTECTION

2.1 GENERAL

Para 2.1.1.7. **The third paragraph** is amended as follows:

"Finish materials and primary deck coverings (refer to 2.1.1.6) with the total heat release not more than 0,2 MJ and peak heat release rate not more than 1,0 kW (both values are determined in accordance with Part 5 of the FTP Code) are considered as complying with the requirements of 1.6.3.2 without tests and meeting the requirement of 2.1.1.10 of the maximum gross calorific value (not more than 45 MJ/m^2 with regard to their thickness) without tests in accordance to standard ISO 1716.".

Para 2.1.3.3. **The last paragraph** is amended as follows:

"Type approval of pipe penetrations ~~and cable transits~~ where heat-sensitive materials are used and which are subject to fire integrity and water tightness requirements and which are designed to be fitted in bulkheads and decks of passenger ships and special purpose ships, which fire protection shall be arranged equivalent to that of passenger ships, shall include a prototype test of watertightness in accordance with the procedure specified in Appendix 1 to Section 4, Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships. Fire tests and tests of watertightness for such penetrations and transits designed to be fitted in bulkheads and decks of cargo ships and special purpose ships, which fire protection shall be arranged equivalent to that of cargo ships may be performed independently of each other.".

Para 2.1.5.4.3 is amended as follows:

"**.3** divisions separating the storerooms from adjacent spaces shall be of "A-60" class. The acetylene cylinder storerooms and the oxygen cylinder storerooms shall be separated by the gastight divisions;".

Para 2.1.5.9 is amended as follows:

"**2.1.5.9** Incinerators and waste stowage spaces.
As regards structure, equipment and insulation, the incinerator rooms shall be considered as category "A" machinery spaces; waste stowage spaces, garbage grinding and compacting spaces — as service spaces. ~~The following is subject to consideration:~~
~~**.1** requirements for structural fire protection in compliance with 2.2.1.3, 2.2.1.5, 2.3.3, 2.4.2 and 2.6.3 may not be applied, if the spaces are arranged aft as far as practicable; at least 3 m from entrances, air inlets or openings to accommodations, service spaces and control stations, not less than 5 m measured horizontally from the nearest hazardous area or vent outlet from a hazardous area; not less than 2 m shall separate the incinerator and the waste material stowage area, unless physically separated by a structural fire barrier;~~
~~**.2** in case the spaces are located on weather deck, they shall be accessible with two means of fire extinguishment; either fire hoses or fire extinguishers in compliance with para 5, Table 5.1.2; fire monitors, or fixed fire-extinguishing system.~~".

2.2 PASSENGER SHIPS

Para 2.2.6.1 is amended as follows:

"**2.2.6.1** Passenger ships having length L_{LL}, as defined in ~~1.2.1 of Load Line Rules for Sea-Going Ships~~ 1.1.3 of Part II "Hull", of 120 m or more or having three or more main vertical zones, shall comply with the requirements of 2.2.6 in order to meet functional requirements and performance standards for safe areas in case of casualty that does not exceed the casualty threshold.".

Para 2.2.7.1 is replaced by the following text:

"**2.2.7.1** Passenger ships having length L_{LL}, as defined in ~~1.2.1 of Load Line Rules for Sea-Going Ships~~ 1.1.3 of Part II "Hull", of 120 m or more, or having three or more main vertical zones shall comply with the requirements of 2.2.7 to provide the systems operability if the casualty threshold is exceeded.".

3 FIRE-FIGHTING EQUIPMENT AND SYSTEMS

3.1 GENERAL

Para 3.1.1.4 is amended as follows:

"**3.1.1.4** The use of a fire extinguishing medi~~um~~a which either by ~~itself~~themselves or under expected conditions of use give~~s~~ 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 и halon 2402, as well as perfluorocarbons.

On ships contracted for construction on or after 01.01.2026, use and storage of foam concentrates containing perfluorooctane sulfonic acid (PFOS) shall be prohibited.".

3.3 SPRINKLER SYSTEM

Para 3.3.3.2. **The last paragraph** is amended as follows:

"~~The~~On the ships other than passenger ships specified in 2.2.6 and 2.2.7, the ship's compressed air system may be used for automatic pressure maintenance in the pressure tank, provided the requirements of 16.1.6, Part VIII "Systems and Piping" are met.".

3.8 CARBON DIOXIDE SMOTHERING SYSTEM

Para 3.8.1.10 and references thereto are deleted.

Paras 3.8.1.11 — 3.8.1.14 and references thereto are renumbered **3.8.1.10 — 3.8.1.13**, accordingly.

Para 3.8.2.6.1 is amended as follows:

"**3.8.2.6.1** The valves shall have protective devices complying with the following requirements:

protective diaphragms shall break at a pressure rise in the cylinders up to (1,3 ± 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.".

4 FIRE DETECTION AND ALARM SYSTEMS

4.1 GENERAL

Para 4.1.2. **The definition "Automatic fire detector"** is amended as follows:

"Automatic fire detector is a fire detector responding to one or several fire factors.

Depending on the mode of data exchange with the fire alarm control and indicating equipment, the automatic fire detectors are divided into threshold and analogue.

Depending on a type of the monitored fire signature, the automatic fire detectors are divided into:

heat detectors;
smoke detectors;
flame detectors;
gas detectors;
combination detectors.

The automatic fire detectors may be operated by heat, smoke or other products of combustion, flame or any combination of these factors. Detectors operated by other factors may be considered by the Register, provided that they are no less sensitive than the above detectors.".

Para 4.1.3 is amended as follows:

"**4.1.3** In passenger ships, the control panel shall be located in the onboard safety centre. An indicating unit that is capable of individually identifying each detector that has been activated or manually operated call point shall be located on the navigation bridge.

In cargo ships, the control panel shall be located on the navigation bridge or in the fire control station. In cargo ships, an indicating unit shall be located on the navigation bridge if the control panel is located in the fire control station. A space in which a cargo control console is installed, but does not serve as a dedicated cargo control room (e.g. ship's office, machinery control room), shall be regarded as a cargo control room, and therefore be provided with an additional indicating unit.

Clear information shall be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

In cargo ships and on passenger cabin balconies, indicating units shall, as a minimum, denote the section in which a detector has activated or manually operated call point has operated.

In cargo ships and on passenger ship cabin balconies, where an individually identifiable system is fitted, notwithstanding the provisions in 7.5.5 of Part XI "Electrical Equipment", isolator modules need not be provided at each fire detector if the system is arranged in such a way that the number and location of individually identifiable fire detectors rendered ineffective due to a fault would not be larger than an equivalent section in a section identifiable system arranged in accordance with 7.5.11 and 20.1.1.6.2 of Part XI "Electrical Equipment".

~~In addition~~ On the passenger ships carrying more than 36 passengers, controls for remote closing of the fire doors and shutting down the ventilation fans shall be additionally centralized at the continuously manned central control station. The ventilation fans shall be capable of reactivation by the crew at the continuously manned control station. The control panels in the central control station shall be capable of indicating open or closed position of fire doors, on or off status of the detectors, alarm and fans.".

4.2 FIRE DETECTION AND FIRE ALARM SYSTEMS

Para 4.2.1.2.4 and references thereto are deleted.

Paras 4.2.1.2.5 — 4.2.1.2.7 and references thereto are renumbered **4.2.1.2.4 — 4.2.1.2.6**, accordingly.

4.3 FIRE WARNING ALARMS

Para 4.3.1 is amended as follows:

4.3.1 Means shall be provided for automatically giving audible and visual warning of the release of fire-extinguishing medium into any ro-ro spaces, container holds equipped with integral reefer containers, spaces accessible by doors or hatches, and other spaces in which personnel normally work or to which they have access.

Conventional cargo spaces and small spaces (such as compressor room, paint locker, etc.) with only a local release need not be provided with such an alarm.".

Para 4.3.2 is amended as follows:

"**4.3.2** The audible and visual signal warning of putting a total flooding system into action shall be given only within the space into which the extinguishing medium shall be discharged.

Means of audible alarm actuation shall be so arranged that the ~~alarms~~ signals can be heard throughout the protected space with all machinery in operation ~~and~~. These signals shall be distinct from other audible alarms through adjustment of sound pressure or pattern (tone).".

Para 4.3.4 is amended as follows:

"**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 spaces protected by the gas fire extinguishing system in addition to the ~~audible signal~~ above mentioned alarm, there shall be a visible signal (visible alarm panel): "Gas! Go away!" and for the spaces protected by the aerosol fire extinguishing system~~s~~ — "Aerosol! Go away!".".

5 FIRE-FIGHTING OUTFIT, SPARE PARTS AND TOOLS

5.1 FIRE-FIGHTING OUTFIT

Para 5.1.9.10 is amended as follows:

"**.10** carbon dioxide fire extinguishers shall not be located in accommodation spaces.

Capacity of the portable carbon dioxide fire extinguishers located at galleys, control stations (wheelhouse, emergency diesel generators room) and special electrical spaces shall be sufficient to (limited to) provide not more than 1 kg of carbon dioxide (CO_2) per 15 m^3 of the volume of spaces, which they are intended to protect.

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;".

Para 5.1.15 is replaced by the following text:

"**5.1.15** The fireman's outfit shall include the personal outfit specified in 5.1.15.1.1 — 5.1.15.1.5, be provided with the self-contained breathing apparatuses according to 5.1.15.2 with the means for recharging self-breathing apparatus cylinders according to 5.1.15.4, be provided with the two-way portable radiotelephone apparatuses according to 5.1.15.3 and be kept according to 5.1.15.5.

5.1.15.1 The personal outfit shall consist of the following:

.1 protective clothing of material approved by the competent bodies to protect the skin from the heat radiating from the fire and from burns and scalding by steam. The outer surface shall be water-resistant; tarpaulin and polyvinylchloride clothes are not allowed for the outer material of the fireman's outfit;

.2 boots and mittens of rubber or of some other dielectric material;

.3 a rigid helmet ensuring effective protection against impacts;

.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 explosionproof 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 gasolines;

.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;

5.1.15.2 The breathing apparatus shall be the self-contained compressed air-operated breathing apparatus, the volume of air contained in the cylinders of which shall be not less than 1200 l or other self-contained breathing apparatus which shall be capable of functioning for not less than 30 min. Compressed air breathing apparatus shall be fitted with an audible alarm and a visual or other device which will alert the user before the volume of the air in the cylinder has been reduced to not less than 200 l.

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 statical 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 snap hook in such a way as 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 suitably located means for fully recharging breathing 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 apparatuses.

In passenger ships carrying more than 36 passengers, two spare charges or two spare breathing apparatuses shall be provided per each required self-contained breathing apparatuses.

Passenger ships carrying more than 36 passengers shall be fitted with a suitably located means for fully recharging breathing air cylinders, free from contamination.

For fire drills, all ships shall be provided with an onboard means of recharging breathing apparatus cylinders or a suitable number of spare cylinders — not less than one set of cylinders for each mandatory breathing apparatus, unless additional spare cylinders are required by the shipboard safety management system (SMS). No additional cylinders are required for fire drills for breathing apparatus sets required by Section 7 of this Part, the IMSBC Code, the IBC Code or the IGC Code.

5.1.15.3 The two-way portable radiotelephone apparatus shall be of an explosion-proof type or intrinsically safe type suitable for use in zone 1 hazardous areas as defined in IEC 60079 in the quantity of two pieces for each fire party. The minimum requirements in respect to the apparatus group and temperature class of portable apparatuses shall be consistent with the most restrictive requirements for the hazardous area zone on board which is accessible to fire party.

5.1.15.4 The means for recharging the self-contained breathing apparatus cylinders shall be the following:

.1 breathing air compressors supplied from the main and emergency switchboards, or independently driven, with a minimum capacity of 60 l/min per required breathing apparatus, not to exceed 420 l/min; or

.2 self-contained high-pressure storage systems of suitable pressure to recharge the breathing apparatus used on board, with a capacity not less than 1200 l per required breathing apparatus, not to exceed 50 000 l of free air.

5.1.15.5 Location of the fireman's outfit on board the ship shall comply with the following requirements:

.1 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;

.2 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.".

6 REQUIREMENTS FOR FIRE PROTECTION OF SPECIAL PURPOSE SHIPS AND SPECIAL FACILITIES ON SHIPS

6.2 SPECIAL PURPOSE SHIPS

Para 6.2.1.1.2 is amended as follows:

"**.2** more than 60, but not more than 240 persons — equivalent to that of passenger ships carrying not more than 36 passengers<u>, except for the need to meet the requirements in 2.2.6 and 2.2.7</u>;".

6.6 SHIPS HAVING A DISTINGUISHING MARK FOR A SHIP CARRYING EQUIPMENT FOR FIRE FIGHTING ABOARD OTHER SHIPS

Chapter is renamed as follows:

"**6.6 SHIPS EQUIPPED FOR FIRE FIGHTING ABOARD OTHER SHIPS AND HAVING RELEVANT DISTINGUISHING MARKS FF1, FF1WS, FF2, FF2WS, FF3, FF3WS**".

Para 6.6.8.8 is amended as follows:

"**6.6.8.8** The capacity of the pumps shall be calculated so that water can be simultaneously delivered to <u>the</u> monitors, the number of which shall comply with Table 6.6.3-2, ~~depending on the distinguishing mark in the class notation.~~ <u>all nozzles of the water-screen and</u>

water-spraying systems (refer to 6.6.6.6) under the required pressure, as well as the required number of fire hoses connected to valve chests.

A connection with shut-off valve shall be fitted between the fire main for the monitors and the main pipeline for the water spraying system allowing for separate as well as simultaneous operation of both the fire fighting water monitors and the water spray system.

For the special independent water fire extinguishing systems (refer to 6.6.8.2), the requirements of 3.4.4 need not apply.".

6.7 CONTAINER SHIPS AND SHIPS DESIGNED TO CARRY CONTAINERS ON OR ABOVE THE WEATHER DECK

Chapter is renamed as follows:

"**6.7 CONTAINER SHIPS AND OTHER SHIPS DESIGNED TO CARRY CONTAINERS ON OR ABOVE THE WEATHER DECK**".

Paras 6.7.5 — 6.7.7 are amended as follows:

"**6.7.5** In cases where the mobile water monitors are supplied by separate pumps and piping system, the total capacity of the main fire pumps need not exceed 180 m^3/h according to 3.2.1.7, and the diameter of the fire main and water service pipes need only be sufficient for the discharge of 140 m^3/h.

6.7.6 In cases where the mobile water monitors are supplied by the main fire pumps, the total capacity of the main fire pumps and the pipework diameter shall be sufficient for simultaneously supplying both the~~ required number of fire hoses and~~ mobile water monitors and two jets of water by the fire hoses under the required pressure.~~ However, the total capacity shall not be less than the following values, whichever is smaller:~~

~~**.1** required under 3.2.1.5.2;~~

~~**.2** 180 m^3/h.~~

6.7.7 In cases where the mobile water monitors and the water spraying system required for carriage of dangerous goods by 7.2.5.3, are supplied by the main fire pumps, the total capacity of the main fire pumps and the pipework diameter need only be sufficient to supply whichever of the following is the greater:

.1 the mobile water monitors and ~~the~~ four fire hoses with the nozzles required by 7.2.5.2; or

.2 ~~the~~ four fire hoses with the nozzles required by 7.2.5.2 and the water spraying system required by 7.2.5.3.

~~The total capacity, however, shall not be less than 6.7.6.1 or 6.7.6.2, whichever is smaller.~~".

PART VIII. SYSTEMS AND PIPING

11 EXHAUST GAS SYSTEM

11.4 SYSTEMS FOR REDUCING NO_X EMISSIONS

Para 11.4.2.3 is amended as follows:

"**.3** if a storage tank for chemical treatment fluids is installed in a closed compartment, the area shall be served by an effective mechanical ventilation system of extraction type providing not less than 6 air changes per hour which is independent from the ventilation system of ~~accommodation, service spaces, or control stations~~ other spaces. The ventilation system shall be capable of being controlled from outside the compartment. A warning notice requiring the use of such ventilation before entering the compartment shall be provided outside the compartment adjacent to each point of entry;".

Para 11.4.2.4 is amended as follows:

"**.4** storage tank for chemical treatment fluids may be located within the engine room. In this case, the requirements of 11.4.2.3 shall be complied with, except that a separate ventilation system is not required when the general ventilation system for the space ~~providing not less than 6 air changes per hour~~ is arranged so as to provide an effective movement of air in the vicinity of the storage tank and is maintained in operation continuously except when the storage tank is empty and has been thoroughly ventilated;".

Para 11.4.2.10 is amended as follows:

"**.10** storage tanks ~~and~~ for chemical treatment fluids, pipes/piping systems and drip trays ~~which transfer undiluted chemical treatment fluids~~ shall be of steel or other equivalent material with a melting point above 925 °C;".

Para 11.4.2.18 is amended as follows:

"**.18** storage tanks for chemical treatment fluids shall be arranged so that they can be safely emptied of the fluids and ventilated by means of portable or permanent systems.".

New para 11.4.4 is introduced reading as follows:

"**11.4.4** Requirement for water discharge from exhaust gas cleaning system:
.1 overboard discharge system shall not be interconnected to other systems;
.2 overboard discharges shall not lead to the location area of the ship propulsion features, such as thrusters, propellers;
.3 location of overboard discharges shall prevent any discharge water onto survival craft during abandonment;
.4 piping material for the discharge water pipeline shall be selected based on the conveyed medium;
.5 adequate arrangements shall be provided to prevent contact corrosion due to the use of different metals according to the requirements in 1.4.3;
.6 in case the welded branch pipe is fitted between the outboard discharge valve and the shell plating, it shall be made according to 4.3.2.10 and protective coating shall be applied thereon according to 1.4.3. The thickness of the branch pipe shall be not less than the following:
12 mm when the branch pipe is made of corrosion-resistant steel;
15 mm when the branch pipe is made of ordinary steel, the inside surface is covered with protective coating and an electrically-insulating connection is fitted at the point of contact of different metals.".

12 VENTILATION SYSTEM

12.1 GENERAL REQUIREMENTS FOR VENTILATION SYSTEMS

Para 12.1.11 is amended as follows:

"**12.1.11** Ventilation ducts, including single and double wall ducts, shall be of steel or equivalent material except flexible elements of short length not exceeding 600 mm used for connecting fans to the ducting in air-conditioning rooms.

Unless expressly provided otherwise in 12.1.21, any other material used in the construction of ducts, including insulation, shall ~~also~~ be non-combustible. However, short ducts, not generally exceeding 2 m in length and with a free cross-sectional area not exceeding 0,02 m^2 ~~need not~~ may be made of non-combustible material other than steel ~~or equivalent material~~ and may be considered equivalent to a ventilation duct made of steel, subject to the following conditions:

.1 ~~the~~ ducts ~~shall be made of non-combustible material,~~ have passed the fire test in accordance with Part 3 of Annex 1 to the FTP Code as non-load bearing structures for 30 min following the requirements for testing "B" class divisions and membranes with which the ducts may be faced internally and externally ~~with membranes~~ ~~having~~have low flame-spread characteristics and, in each case, a calorific value not exceeding 45 MJ/m^2 of their surface area ~~for the~~ considering its thickness ~~used~~;

.2 the duct~~s~~ ~~are~~is only used at the end of the ventilation device; ~~and~~

.3 the duct~~s~~ ~~are~~is not situated less than 600 mm, measured along the duct, from an opening in an "A" or "B" class division, including continuous "B" class ceiling;

.4 flexible components of combustible material with length not exceeding 600 mm may be used for connection of fans to the ducting in air conditioning room.".

13 FUEL OIL SYSTEM

13.8 FUEL OIL SUPPLY TO INTERNAL COMBUSTION ENGINES

Para 13.8.1. **The last but one paragraph** is amended as follows:

"The schemes shown on Fig. 13.8.1-1*b* and Fig. 13.8.1-2*b* are applied only in cases when arrangements and systems are used providing a quick switch from one fuel oil grade to another and capable of operating on two fuel oil grades at sea under all normal operating conditions. Any fuel oil, which requires post service tank heating to achieve the required injection viscosity is not regarded in this context as diesel fuel oil.".

PART IX. MACHINERY

1 GENERAL

Table 1.2.3.1-3 is supplemented by **new item 13** and **new footnote 5**:

"

13	Relief devices for combustion air inlet manifold[5]
[1] taking into account the design features of the engine, the Register may request the provision of additional documentation;	

2 for information;
3 required for DF engine;
4 required for GF engine.
5 refer to Section 3 of Appendix 12 to Section 5, Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships.

".

2 INTERNAL COMBUSTION ENGINES

APPENDIX IV

GUIDANCE FOR EVALUATION OF FATIGUE TESTS (REFER TO IACS UR M53)

4. FULL-SCALE TESTING

Para 4.3 is amended to read as follows:

"**4.3 Use of results and crankshaft acceptability**

In order to combine the bending and torsion fatigue strength test results in calculation of crankshaft acceptability (refer to 2.4.11 of this Part), the Gough-Pollard approach and the maximum principal equivalent stress formulation can be applied for the following cases:

~~As for~~ At the crankpin fillet ~~diameter~~:

~~$$Q = \left(\sqrt{(\sigma_{BH}/\sigma_{DWCT})^2 + (\tau_{BH}/\tau_{DWCT})^2}\right)^{-1}$$~~

$$Q = \left(\sqrt{((\sigma_{BH} + \sigma_{add})/\sigma_{DWCT})^2 + (\tau_{BH}/\tau_{DWCT})^2}\right)^{-1},$$

where:

σ_{DWCT} is bending test fatigue strength

τ_{DWCT} is torsion test fatigue strength.

As for the crankpin oil bore:

$$Q = \frac{\sigma_{DWOT}}{\sigma_v};$$

$$\sigma_v = \frac{1}{3}\,\sigma_{BO}\left[1 + 2\sqrt{1 + \frac{9}{4}\left(\frac{\sigma_{TO}}{\sigma_{BO}}\right)^2}\right],$$

where σ_{DWOT} is fatigue strength by means of largest principal stress from torsion testing.

~~As for~~ At the journal fillet ~~diameter~~:

~~$$Q = \left(\sqrt{(\sigma_{BG}/\sigma_{DWJT})^2 + (\tau_G/\tau_{DWJT})^2}\right)^{-1}$$~~

$$Q = \left(\sqrt{((\sigma_{BG} + \sigma_{add})/\sigma_{DWJT})^2 + (\tau_G/\tau_{DWJT})^2}\right)^{-1}$$

where:

σ_{DWJT} is bending test fatigue strength

τ_{DWJT} is torsion test fatigue strength.

For other parameters refer to in 2.4.4.3, 2.4.5.2 and 2.4.7

If increase in fatigue strength due to surface treatment is considered to be similar between the above cases, it is sufficient to test only the most critical locations according to the calculation where surface treatment has not been taken into account.".

9 GAS INTERNAL COMBUSTION ENGINES

Para 9.7.1 is amended to read as follows:

"**9.7.1** Intake piping and supercharging air receivers as well as exhaust gas collectors shall be fitted with safety valves or other protective devices considering the requirements of Appendix 12 to Section 5 of Part IV "Technical supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships. For engines operating on gas with a maximum working gas pressure of not more than 1,0 MPa, the use of other design solutions is allowed provided that proving calculations or experimental data are provided.".

PART XI. ELECTRICAL EQUIPMENT

1 GENERAL

1.2 DEFINITIONS AND EXPLANATIONS

Para 1.2.1. After the definition "Not readily ignitable electrically insulating material" **new definition "Harmonic filter"** is introduced reading as follows:

"Harmonic filter is a group of capacitors, reactors, resistors, measuring and protective devices connected to each other without commutation units for harmonic filtration and designed to enhance the power quality in the a. c. mains (section of mains).".

After definition "Electrical installation of low power" **new definition "Electromagnetic compatibility"** is introduced reading as follows:

"Electromagnetic compatibility is the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.".

2 GENERAL REQUIREMENTS

2.2 ELECTROMAGNETIC COMPATIBILITY

Para 2.2.1.2.2 is amended as follows:

"**.2** harmonic components of voltage curve in supply circuits in accordance with the higher harmonics voltage curve components diagram for ship mains to be found in Fig. 2.2.1.2.2 on a logarithmic scale;

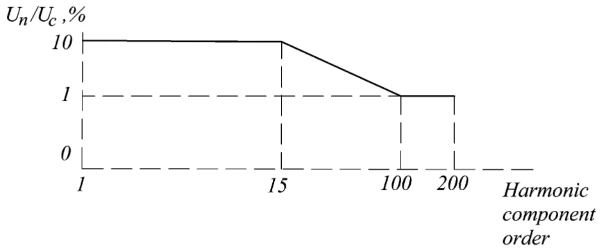


Fig. 2.2.1.2.2
Diagram of higher harmonic voltage curve components for ship mains".

Para 2.2.1.3 is amended as follows:

"**2.2.1.3** The total harmonic distortion shall not exceed 8 % and shall be determined by the formula

$$K_u = \sqrt{\sum_{k=2}^{40} \left(\frac{U_{p,k}}{U_{p,1}}\right)^2} \cdot 100\ \%, \quad (2.2.1.3\text{-}1)$$

where $U_{p,k}$ — mean square value of *k* harmonic subgroup voltage;
k — harmonic component order.

$$U_{p,k} = \sqrt{U_k^2 + \sum_{h=-1}^{h=+1} U_{c,k+h}^2}\ , \text{B} \quad (2.2.1.3\text{-}2)$$

where U_k — mean square voltage value of k harmonic component;
$U_{c,k}$ — mean square value of spectral component adjacent to *k* harmonic component;
h — spectral component order.

The value of K_u is specified for the complete electrical power system of a ship.

Any voltage harmonics of the same order shall not exceed 5 %.

For circuits of electric propulsion plants not directly connected to ship's general consumers (no electrical or electromagnetic connection is available) the total harmonic distortion shall not exceed 10 %. If K_u exceeds 10 %, electrical equipment provided for operation with such distortions shall be used.

Busbars with K_u > 8 % may be used for power supply to powerful sources of voltage curve harmonic components and to electrical equipment not sensitive to such harmonic components, provided that the busbars are connected to the main busbars through isolating devices (refer to 2.2.2.2) or electrical equipment provided for operation with such distortions shall be used.

When the specified value of the total harmonic distortion is exceeded, all electrical equipment connected to this section of the mains shall be designed for such excess, which shall be supported by the documentation.

When designing the ship with total harmonic distortion exceeding the specified value (8 % or 10 %) the following negative factors shall be considered:

additional thermal losses in electrical machines, transformers, distribution systems and control devices;

additional thermal losses in capacitors;

resonant processes in the supply mains;

disfunctioning of control devices and systems sensitive (susceptible) to distortions;

decrease in accuracy of electrical measuring devices and sensibility of protective equipment;

interferences to the electrical equipment, for example, regulators, communication and control systems, radio equipment and navigational systems.".

Para 2.2.1.4 is amended as follows:

"**2.2.1.4** The ~~intensity~~ levels of ~~radio~~ the caused interference from equipment in the power supply circuits shall not exceed the following values within the frequency bands given below:

for the equipment installed on open deck and navigation bridge:
10 — 150 kHz — 96 – 50 dBµV~~/m~~;
150 — 350 kHz — 60 –50 dBµV~~/m~~;
350 kHz — 30 MHz — 50 dBµV~~/m~~;
for the equipment installed in machinery and other enclosed spaces:
10 — 150 kHz — 120 – 69 dBµV~~/m~~;
150 — 500 kHz — 79 dBµV~~/m~~;
500 kHz — 30 MHz — 73 dBµV~~/m~~.

Artificial mains network and quasi-peak measuring receiver shall be used for measuring the ~~intensity~~ level of ~~radio~~ the caused interference. The receiver bandwidth when measurements are taken within the frequency band from 10 to 150 kHz shall be 200 Hz and within the frequency band from 150 kHz to 30 MHz — 9 kHz.".

Para 2.2.2.3 is amended as follows:

"**2.2.2.3** Power cable ~~screens or~~ metal armour or sheath shall be ~~connected~~ earthed to the metal casing of relevant equipment ~~and shall be earthed~~ as frequently as possible, at each end as a minimum. The end subcircuits may be earthed only from the supply side.".

Para 2.2.2.5 is amended as follows:

"**2.2.2.5** Continuous screening shall be ensured, and for this purpose cable screens shall be connected to equipment casings, and it shall also be ensured in cable branch boxes and cable distribution boxes, and in way of cable penetrations through bulkheads.

All separation of cables and braiding shall be performed inside casings. If the space does not allow such arrangement, cable braiding/screens may be connected to the earth in a protected non-corrosive environment under the casing. Cable braids/sheaths shall remain of sufficient length to have the possibility to be laid inside the casing, thus, to increase the EMC effect.".

Para 2.2.2.9 is amended as follows:

"**2.2.2.9** Cable of the same group may be laid in the same cable run provided interference-sensitive equipment is not influenced by the difference in the levels of signals conveyed. Where cable lengths laid in parallel are in excess of 1 m, the cables (cable runs) of different groups shall be laid at least 0,1 m apart and their intersections shall be effected at right angles. The radar installation and echo sounder cables mentioned in 2.2.2.8.5 shall either be double-screened or, if they are coaxial, laid inside a metal pipe. The outer screen shall be earthed, as well as the principal screen of the cable.

Where meeting the requirements for separate installation is not possible, cables of high degree of screening shall be used or cables shall be laid inside metal pipes or conduits.

All phase cores of cables for a.c. wiring shall be arranged in the same sheath in order to avoid overheating from induction during use of multi-core cables.

Where the requirements of the equipment manufacturer regarding installation of cables connected to this equipment are available, these cables shall be laid in compliance with the requirements of the equipment manufacturer.".

2.9 SAFE-TYPE ELECTRICAL EQUIPMENT

Para 2.9.3 is amended as follows:

"**2.9.3** In dangerous spaces and zones, only safe type electrical equipment may be installed, the protection level of which corresponds to the category and group of the most dangerous gas mixture:

.1 paint lockers — sub-group IIB, temperature class T3 (refer also to 2.9.16);

.2 storerooms for cylinders with flammable gases — sub-group IIC, temperature class T2;

.3 battery compartments — sub-group IIC, temperature class T1;

.4 spaces which enclose tanks, machinery and piping for inflammable liquids having a flash point 60 °C and below — sub-group IIB, temperature class T3.

Depth-sounder oscillators and associated cables shall be installed in compliance with the requirements of ~~3.7.4~~ 3.3.1 and ~~3.8.3~~ 3.5.1, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships, and on gas carriers — 2.2.3.2, Part VII "Electrical Equipment" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk, ventilator motors shall be installed in spaces adapted for the carriage of dangerous cargoes ~~in compliance with~~ and shall meet the requirements of 12.7.4, Part VIII "Systems and Piping".".

4 DISTRIBUTION OF ELECTRICAL POWER

4.6 SWITCHBOARD AND SWITCHGEAR

Para 4.6.7.1 is amended as follows:

"**4.6.7.1** In front of the main, emergency and other switchboards, a passageway shall be provided not less than 1000 mm wide for switchboards 3 m long and over. In front of the main and emergency switchboards, a passageway shall be provided not less than 800 mm wide for switchboards up to 3 m long and on ships of less than 500 gross tonnage and fishing vessels in case of insufficient space, the passageway shall be at least 600 mm wide.

If withdrawable arrangements are provided in front of the main and emergency switchboards, the free space in the passageway shall be not less than 400 mm wide from the most protruding parts of this arrangement in completely withdrawn position.

In any case, if opening swing panels are located in front of the switchboard, the width of the passageway shall be sufficient for switchboard maintenance with the panel at a fully open position.".

New Chapter 4.7 is introduced reading as follows:

"4.7 HARMONIC DISTORTION FOR SHIP ELECTRICAL DISTRIBUTION SYSTEMS INCLUDING HARMONIC FILTERS

4.7.1 Measurement of total harmonic distortion for a ship including harmonic filters.

4.7.1.1 The ships where harmonic filters are installed on main busbars of electrical distribution system, shall be fitted with facilities to continuously monitor the voltage curve total harmonic distortion experienced on the main busbar as well as alert the crew should the level of voltage curve total harmonic distortion exceed the acceptable limits.

Where the engine room is provided with automation systems, this reading shall be logged electronically, otherwise it shall be recorded in the engine log book for future inspection by the RS surveyor.

4.7.2 Mitigation of the effects of harmonic filter failure on a ship's operation.

4.7.2.1 Where the electrical distribution system on board a ship includes harmonic filters, the system integrator of the distribution system (or ship's designer) shall show, by calculation, the effect of a failure of a harmonic filter on the level of total harmonic distortion experienced. This information shall be documented in a form of the report included in the ship operational documentation.

In case of filter failure, a possibility shall be provided to continue safe operation of electrical power system and electric propulsion plant with required limitations. Operational limitations shall be specified in the report and relevant operational documents.

The system integrator of the distribution system (or ship's designer) shall provide the ship owner with guidance documenting permitted modes of operation of the electrical power system and electric propulsion plant in case of harmonic failure. The report shall contain calculation values of voltage curve total harmonic distortion within the limits accepted by the requirements of 2.2.1.3 during normal operation as well as following the failure of harmonic filters (at any combination of failures).

The methodical recommendations on measurement of voltage curve total harmonic distortion are given in Appendix 10 to Section 10 of the Guidelines on Technical Supervision of Ships under Construction.

4.7.3 Protection arrangements for harmonic filters.

4.7.3.1 Arrangements shall be provided to alert the crew in the event of activation of the protection of a harmonic filter circuit.

A harmonic filter shall be arranged as a three phase unit with individual protection of each phase at least against overload, overvoltage and short circuit. The activation of the protection arrangement in a single phase shall result in automatic disconnection of the complete filter. Additionally, there shall be installed a current unbalance detection system independent of the overcurrent protection alerting the crew in case of current unbalance.

Consideration shall be given to additional protection for the individual capacitor element as e.g. relief valve or overpressure disconnector in order to protect against damage from rupturing or bulging. This consideration shall take into account the type of capacitors used. In addition, provision shall be made to disconnect capacitor batteries if input protective filter devices are actuated.".

6 LIGHTING

6.8 NAVIGATION LIGHTS

Para 6.8.2 is amended as follows:

"**6.8.2** The navigation lights switchboard shall be supplied by two independent feeders:

.1 one feeder from the main switchboard ~~through the emergency switchboard~~ in accordance with 4.3.1.11;

.2 the second feeder from ~~the nearest distribution board, which is not supplied from~~ the emergency switchboard in accordance with 9.3.1.2.

It is permitted to install the navigation lights control devices in the integrated bridge control console and taking the power in accordance with 4.5.2.

Where the main source of power of the ship is an accumulator battery and the main switchboard is installed in the wheelhouse, the navigation lights may be controlled directly from the main switchboard.".

12 POWER SEMICONDUCTOR UNITS

Chapter 12.2 is renamed reading as follows:

"**12.2 PERMISSIBLE PARAMETERS OF VOLTAGE DEVIATION AND DISTORTION**".

Para 12.2.1 is amended as follows:

"**12.2.1** ~~The total harmonic distortion in the ship mains depending upon the operation of the power semiconductor units shall not exceed the values specified in 2.2.1.3.~~ Operation of semiconductor units (including any related transformers, chokes, capacitors and filters) shall not lead to increase of total harmonic distortion in the ship mains above the values specified in 2.2.1.3 and changes in voltage and frequency exceeding values given in 2.1.3.1.".

New paras 12.2.3 — 12.2.5 are introduced reading as follows:

"**12.2.3** For ships where harmonic filters are installed on main busbars of electrical distribution system, requirements of 4.7 shall be met.

12.2.4 Changes of total harmonic distortion resulting from short-term deviations of power parameters in transition modes (direct start of electric drive, etc.) within the limits specified in 2.1.3.1 shall not lead to failures and shut-down of electrical equipment.

12.2.5 Increased voltage level between phase and ship's hull resulting from operation of semiconductor converters shall not lead to failures and incorrect operation of ship's equipment, means of automation, navigation, communication, etc. In order to decrease the voltage level between phase and ship's hull and to avoid loop formation where in-phase voltage is available, ferromagnetic rings for cables, filters, isolation transformers, etc. may be applied.".

17 ELECTRIC PROPULSION PLANTS

17.5 ELECTROMAGNETIC COMPATIBILITY (EMC)

Para 17.5.3 is amended as follows:

"**17.5.3** If a total voltage curve harmonic distortion value in supply circuits of ship's general consumers of ~~10~~ 8 % is exceeded when operating the propulsion plant, ~~the appropriate filtering and interference-free operation of any consumers shall be ensured~~ measures shall be taken to decrease K_u to the acceptable level specified in 2.2.1.3.".

17.11 PROTECTION ARRANGEMENTS FOR HARMONIC FILTERS

Para 17.11.1 is amended as follows:

"**17.11.1** A harmonic filter maintaining voltage curve harmonic ~~distantion~~ distortion ~~levels~~ values within acceptable limit shall be arranged as a three phase unit with individual protection of each phase on the main switchboard busbars at any step of propulsion.".

New para 17.11.7 is amended as follows:

"**17.11.7** For ships where harmonic filters are installed on main busbars of electrical distribution system, of propulsion plants, the requirements of 4.7 shall be met.".

23 SPECIAL REQUIREMENTS FOR ELECTRICAL EQUIPMENT OF SHIP'S ELECTRIC POWER SYSTEM WITH ELECTRICAL POWER DISTRIBUTION FOR DIRECT CURRENT

23.8 ELECTRIC PROPULSION PLANTS

Para 23.8.3 is amended as follows:

"**23.8.3** Circuits of each individual filter maintaining voltage curve harmonic distortion ~~levels~~ values within acceptable limits shall be protected against over-currents and short-circuit currents. When designing power filters, the possibility of integrating into the circuits of additional elements to reduce current contribution from capacitors and their variability in short-circuit conditions of external circuits. Integrity of fuses in filter circuits shall be monitored. In case of any fuse burnout, an alarm warning system shall be activated.".

APPENDIX 1 (RECOMMENDED)

PROCEDURE FOR CALCULATING SHORT-CIRCUIT CURRENTS IN SHIP'S ELECTRIC POWER SYSTEMS WITH ELECTRICAL POWER DISTRIBUTION FOR DIRECT CURRENT

2 POWER SYSTEM MAIN CURRENT DIAGRAMS

The fourth paragraph of para 2.1 is amended as follows:

"These systems have local areas with d.c. power distribution. D.c. switchboards are supplied via rectifiers and power transformers. Most often, triple-wound voltage transformers with two output windings shifted by 30 el. deg. are used for power supply of the d.c. switchboard. An uncontrolled bridge semiconductor rectifier is connected to each secondary winding. Such connection of the uncontrolled rectifier enhances the power quality in the ship's a.c. mains and reduces a voltage ~~non-sinusoidality ratio~~ curve harmonic components.".

PART XII. REFRIGERATING PLANTS

8 INSULATION

8.1 INSULATION OF THE REFRIGERATED SPACES

Para 8.1.1 is amended as follows:

"**8.1.1** All steelwork of ship's hull inside the refrigerated cargo spaces shall be ~~efficiently~~ insulated. ~~The applied insulating materials shall be of a type approved by the Register and shall also comply with the requirements of the properly authorized Sanitary Inspection Authorities.~~".

PART XIII MATERIALS

2 PROCEDURES OF TESTING

2.2 TESTING PROCEDURES FOR METALS

Para 2.2.11.1 is replaced by the following text:

"**2.2.11.1** Test method for Brittle Crack Arrest Toughness, K_{ca}.
2.2.11.1.1 Scope.
ISO 20064:2019 provides a test method for the determination of brittle crack arrest toughness of steel by using wide plates with a temperature gradient.

Requirements of 2.2.11.1 cover the test procedures for Brittle Crack Arrest Toughness K_{ca} of steel using fracture mechanics and determination method of at a specific temperature which are specified in ISO 20064:2019. Additionally, these requirements specify the evaluation method of K_{ca} of test plate. They are applicable to hull structural steels with the thickness over 50 mm and not greater than 100 mm in accordance with 3.2 and 3.19.

2.2.11.1.2 Test procedures.

The test procedures including testing equipment, test specimens, test methods, determination of arrest toughness, reporting of test results, etc. shall be in accordance with ISO 20064:2019. As a method for initiating a brittle crack, a secondary loading mechanism can be used in accordance with Annex D of ISO 20064:2019, except that the first sentence in Annex B 2.4 of ISO 20064:2019 is revised to "Obtain the value {$K_{ca}/[K_0$ *exp(-cT_{caK})]} for each data point".".

Para 2.2.11.2 is amended as follows:

"**2.2.11.2** ~~Method for obtaining~~ Determination of K_{ca} at a specific temperature and the evaluation.

2.2.11.2.1 ~~General~~ Method.

The ~~present requirements method apply to the~~ method for conducting multiple tests ~~specified in 2.2.11.1~~ to obtain K_{ca} value at a specific temperature T_d shall be in accordance with Annex B of ISO 20064:2009.

~~**2.2.11.2.2** Method.~~

~~A number of experimental data show dependency of K_{ca} on arrest temperature, as expressed by Formula (2.2.11.2.2), where T_K (K) (= T (°C) + 273), c and $K0$ are constants.~~

$$K_{ca} = K_0 exp\left(\frac{c}{T_K}\right) \qquad (2.2.11.2.2)$$

~~The arrest toughness at a required temperature T_D (K) can be obtained by following the procedures below:~~

~~**.1** obtain at least four valid K_{ca} data to comply with the Rules.~~

~~**.2** approximating log K_{ca} by a linear expression of 1/TK, determine the coefficients log K_0 and c for the data described above by using the least square method~~

$$logK_{ca} = logK_0 + c\frac{1}{T_K}; \qquad (2.2.11.2.2.2)$$

~~**.3** obtain the value of (K_{ca} /K_0)·exp(c/T_K) for each data item. When the number of data outside the range of 0,85 through 1,15 is not exceeded, the least square method used in 2.2.11.2.2.2 is considered valid. Here is an integer obtained by rounding down the value of (number of all data divided by 6). If this condition is not met, conduct additional tests to add at least two data and apply the procedure in 2.2.11.2.2.2 to the data.~~

~~**.4** the value of K_0 exp(c/TD) is defined as the estimated value of K_{ca} at T_d. The estimated value for the temperature corresponding to a specific value of K_{ca} can be obtained from T_K = c/log(K_{ca}/K_0). If the condition specified in 2.2.11.2.2.3 is not met, these estimated values are treated as reference values.~~

2.2.11.2.~~3~~2 Evaluation.

The straight-line approximation of arrhenius plot for valid K_{ca} data by interpolation method ~~are to~~ shall comply with either the following 2.2.11.2.2.1 and 2.2.11.2.2.2.

2.2.11.2.~~3~~2.1 The evaluation temperature of K_{ca} (i.e. –10 °C) is located between the upper and lower limits of the arrest temperature, with the K_{ca} corresponding to the evaluation temperature not lower than the required K_{ca} (e.g. 6,000 N/mm$^{3/2}$ or 8,000 N/mm $^{3/2}$), as shown in Fig. 2.2.11.2.~~3~~2.1.

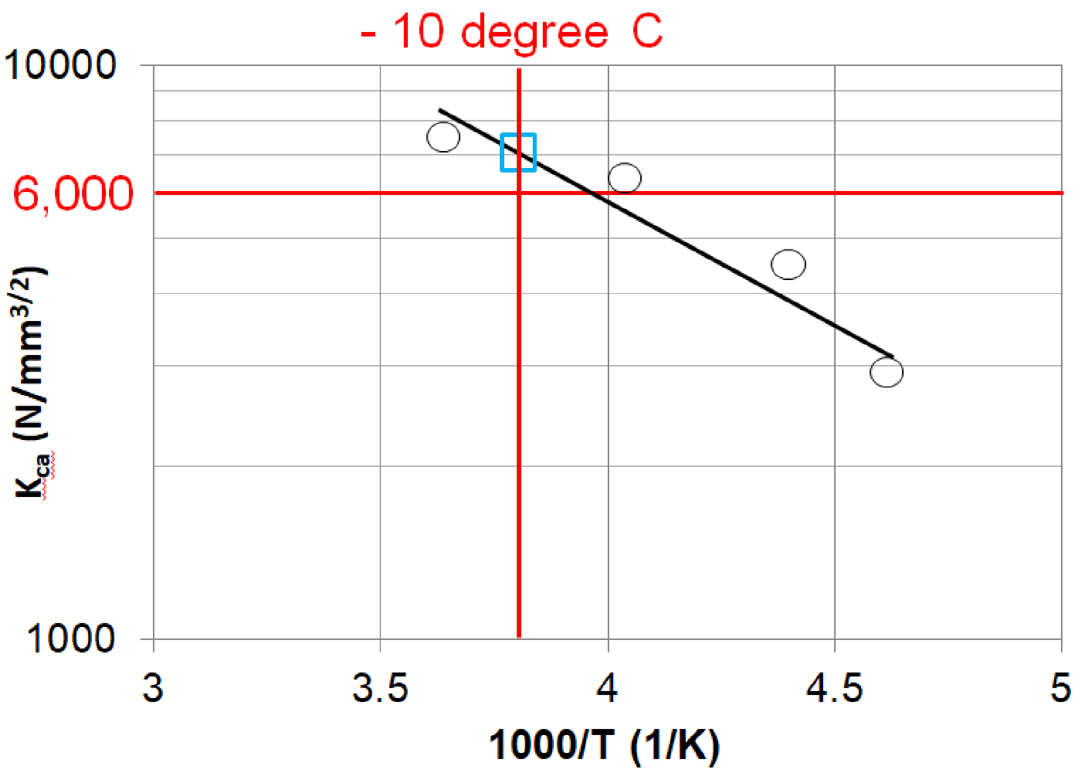


Fig. 2.2.11.2.32.1 Example for evaluation of K_{ca} at temperature –10 °C

2.2.11.2.32.2 The temperature corresponding to the required K_{ca} (e.g. 6,000 N/mm$^{3/2}$ or 8,000 N/mm$^{3/2}$) is located between the upper and lower limits of the arrest temperature, with the temperature corresponding to the required K_{ca} not higher than the evaluation temperature (i.e. –10 °C), as shown in Fig. 2.2.11.2.32.2.

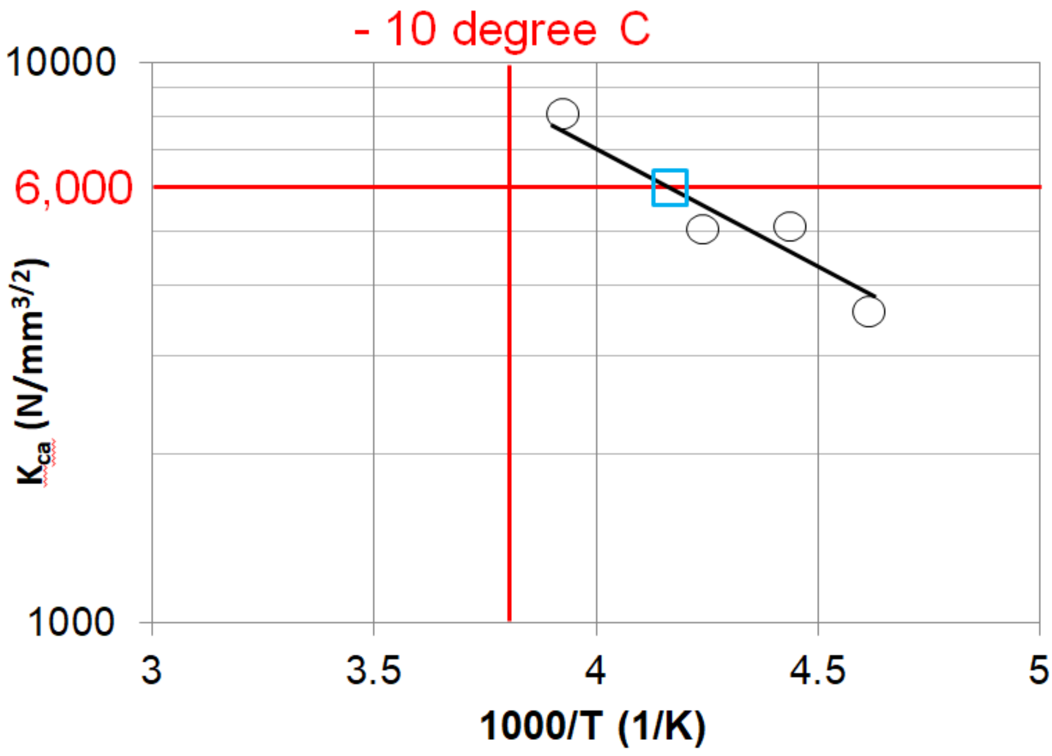


Fig. 2.2.11.2.~~3~~2.2 Example for evaluation of temperature corresponding to the required K_{ca}

If requirements of 2.2.11.2.~~3~~2 are not satisfied, conduct additional tests to satisfy this condition.".

Para 2.2.11.3 is deleted. **Existing para 2.2.11.4** (with paras and references thereto) is renumbered **2.2.11.3**.

Renumbered para 2.2.11.3 is amended as follows:

"**2.2.11.3** Requirements for undertaking isothermal Crack Arrest Temperature (*CAT*) test.
2.2.11.3.1 Scope of application.
2.2.11.3.1.1 Provisions of 2.2.11.3 shall be applied according to the scope defined in 3.19.
2.2.11.3.1.2 Provisions of 2.2.11.3 specify the requirements for test procedures and test conditions when using the isothermal crack arrest test to determine a valid test result under isothermal conditions and in order to establish the crack arrest temperature (*CAT*). The requirements of 2.2.11.3 are applicable to steels with thickness over 50 mm and not greater than 100 mm.
2.2.11.3.1.3 This method uses an isothermal temperature in the test specimen being evaluated. Unless otherwise specified in 2.2.11.3, the other test parameters shall be in accordance with ~~2.2.11.1~~ ISO 20064:2009.
2.2.11.3.1.4 Table 3.19.2.2.2 gives the relevant requirements for the brittle crack arrest property described by the crack arrest temperature (*CAT*).
2.2.11.3.1.5 The manufacturer shall submit the test procedure to the Register for review prior to testing.

2.2.11.3.2 Symbols and their significance.

2.2.11.3.2.1 Requirements of Table 2.2.11.3.2.1 supplement those of ~~Table 2.2.11.1.2~~ ISO 20064:2009 with specific symbols for the isothermal test.

Table 2.2.11.3.2.1

Nomenclature supplementary to ~~Table 2.2.11.1.2~~ ISO 20064:2009

Symbol	Unit	Significance
t	mm	Test specimen thickness
L	mm	Test specimen length
W	mm	Test specimen width
a_{MN}	mm	Machined notch length on specimen edge
L_{SG}	mm	Side groove length on side surface from the specimen edge. L_{SG} is defined as a groove length with constant depth except a curved section in depth at side groove end
d_{SG}	mm	Side groove depth in section with constant depth
L_{EB}-min	mm	Minimum length between specimen edge and electron beam re-melting zone front
$L_{EB-s1,\,-s2}$	mm	Length between specimen edge and electron beam re-melting zone front appeared on both specimen side surfaces
L_{LTG}	mm	Local temperature gradient zone length for brittle crack runway
a_{arrest}	mm	Arrested crack length
T_{target}	°C	Target test temperature
T_{test}	°C	Defined test temperature
T_{arrest}	°C	Target test temperature at which valid brittle crack arrest behavior is observed
σ	N/mm²	Applied test stress at cross section of $W \times t$
SMYS	N/mm²	Specified minimum yield strength of the tested steel grade to be approved
CAT	°C	Crack arrest temperature, the lowest temperature, T_{arrest}, at which running brittle crack is arrested

2.2.11.3.3 Testing equipment.

2.2.11.3.3.1 The test equipment to be used shall be of the hydraulic type of sufficient capacity to provide a tensile load equivalent to 2/3 of *SMYS* of the steel grade to be approved.

2.2.11.3.3.2 The temperature control system shall be equipped to maintain the temperature in the specified region of the specimen within ±2 °C from T_{target}.

2.2.11.3.3.3 Methods for initiating the brittle crack may be of drop weight type, air gun type or double tension tab plate type.

2.2.11.3.3.4 The detailed requirements for testing equipment are specified in ~~2.2.11.1.3~~ ISO 20064:2009.

2.2.11.3.4 Test specimens.

2.2.11.3.4.1 Impact type crack initiation.

2.2.11.3.4.1.1 Test specimens shall be in accordance with ~~2.2.11.1.4~~ ISO 20064:2009, unless otherwise specified.

2.2.11.3.4.1.2 Specimen dimensions are shown in Fig. 2.2.11.3.4.1.2. The test specimen width, *W,* shall be 50 mm. The test specimen length, *L*, shall be equal to or greater than 500 mm.

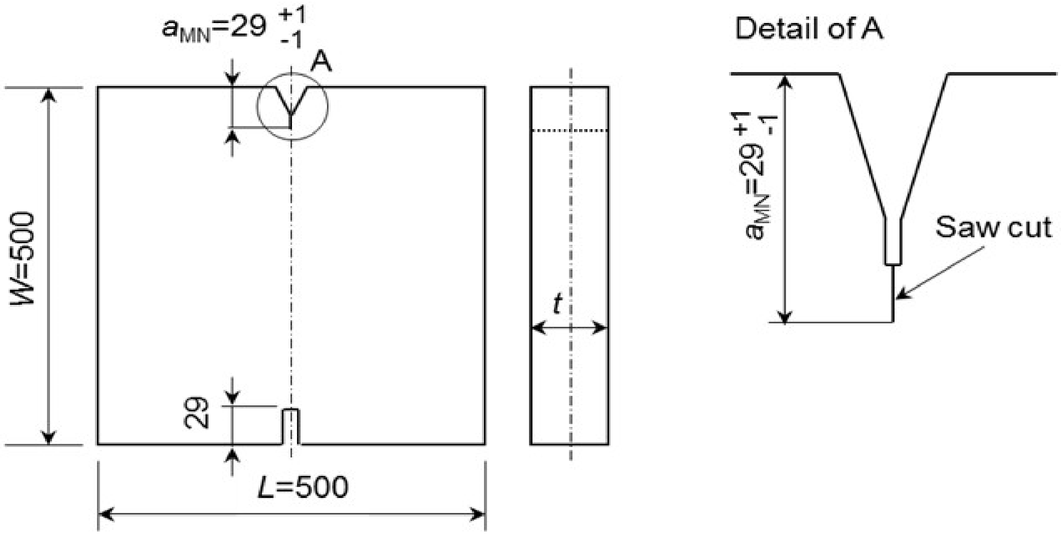


Fig. 2.2.11.3.4.1.2 Test specimen dimensions for an impact type specimen

N o t e . Saw cut notch radius may be machined in the range 0,1 mm *R* and 1 mm *R* in order to control a brittle crack initiation at test.

2.2.11.3.4.1.3 V-shape notch for brittle crack initiation is machined on the specimen edge of the impact side. The whole machined notch length shall be equal to 29 mm with a tolerance range of ± 1 mm.

2.2.11.3.4.1.4 Requirements for side grooves are described in 2.2.11.3.4.4.

2.2.11.3.4.2 Double tension type crack initiation

2.2.11.3.4.2.1 Reference shall be made to ~~2.2.11.3~~ Annex D to ISO 20064:2009 for the shape and sizes in secondary loading tab and secondary loading method for brittle crack initiation.

2.2.11.3.4.2.2 In a double tension type test, the secondary loading tab plate may be subject to further cooling to enhance an easy brittle crack initiation.

2.2.11.3.4.3 Embrittled zone setting.

2.2.11.3.4.3.1 An embrittled zone shall be applied to ensure the initiation of a running brittle crack. Either Electron Beam Welding (EBW) or Local Temperature Gradient (LTG) may be adopted to facilitate the embrittled zone.

2.2.11.3.4.3.2 In EBW embrittlement, electron beam welding is applied along the expected initial crack propagation path, which is the center line of the specimen in front of the machined V-notch.

2.2.11.3.4.3.3 The complete penetration through the specimen thickness is required along the embrittled zone. One side EBW penetration is preferable, but dual sides EB penetration may be also adopted when the EBW power is not enough to achieve the complete penetration by one side EBW.

2.2.11.3.4.3.4 The EBW embrittlement is recommended to be prepared before specimen contour machining.

2.2.11.3.4.3.5 In EBW embrittlement, zone shall be of an appropriate quality.

N o t e . EBW occasionally behaves in an un-stable manner at start and end points. EBW line is recommended to start from the embrittled zone tip side to the specimen edge with an increasing power control or go/return manner at start point to keep the stable EBW.

2.2.11.3.4.3.6 In LTG system, the specified local temperature gradient between machined notch tip and isothermal test region is regulated after isothermal temperature control. LTG temperature control is to be achieved just before brittle crack initiation, nevertheless the steady temperature gradient through the thickness shall be ensured.

2.2.11.3.4.4 Side grooves.

2.2.11.3.4.4.1 Side grooves on side surface can be machined along the embrittled zone to keep brittle crack propagation straight. Side grooves shall be machined in the specified cases as specified in this section.

2.2.11.3.4.4.2 In EBW embrittlement, side grooves are not necessarily mandatory. Use of EBW avoids the shear lips. However, when shear lips are evident on the fractured specimen, e.g. shear lips over 1 mm in thickness in either side then side grooves shall be machined to suppress the shear lips.

2.2.11.3.4.4.3 In LTG embrittlement, side grooves are mandatory. Side grooves with the same shape and size shall be machined on both side surfaces.

2.2.11.3.4.4.4 The length of side groove, *LSG* shall be no shorter than the sum of the required embrittled zone length~~ of 150 mm~~.

2.2.11.3.4.4.5 When side grooves would be introduced, the side groove depth, the tip radius and the open angle are not regulated, but are adequately selected in order to avoid any shear lips over 1 mm thickness in either side. An example of side groove dimensions is shown in Fig. 2.2.11.3.4.4.5.

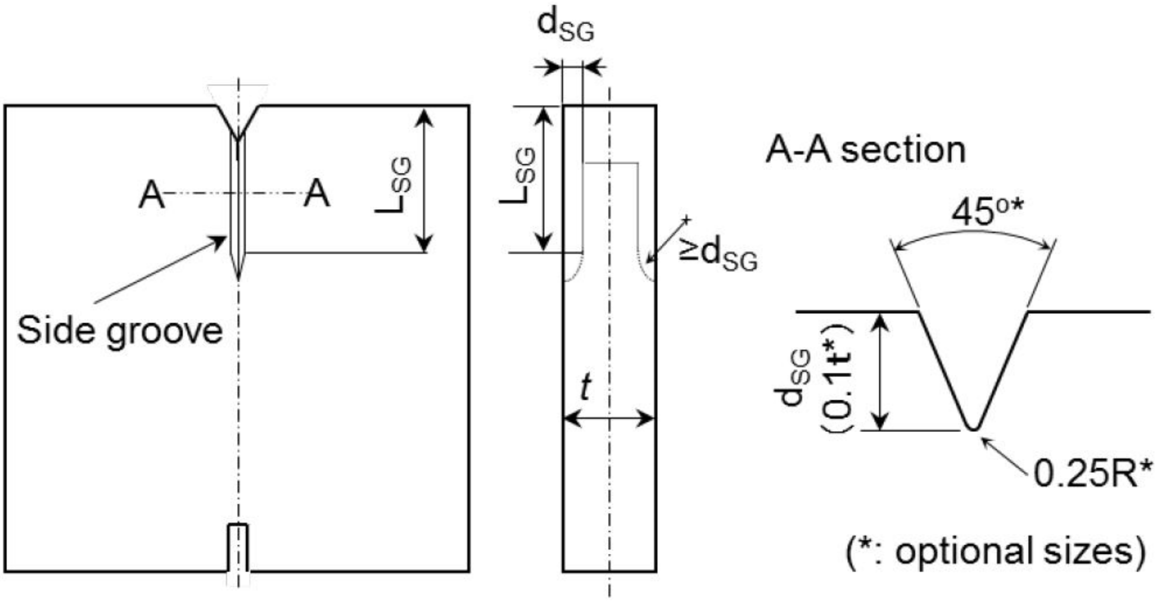


Fig. 2.2.11.3.4.4.5 Side groove configuration and dimensions

2.2.11.3.4.4.6 Side groove end shall be machined to make a groove depth gradually shallow with a curvature larger than or equal to groove depth, d_{SG}. Side groove length, L_{sg} is defined as a groove length with constant depth except a curved section in depth at side groove end

2.2.11.3.4.5 Nominal length of embrittled zone.

2.2.11.3.4.5.1 The length of embrittled zone shall be ~~nominally equal to~~ at least 150 mm ~~in both systems of EBW and LTG~~.

2.2.11.3.4.5.2 EBW zone length is regulated by three measurements on the fracture surface after test (as shown in Fig. 2.2.11.3.4.5.2), L_{EB}-min between specimen edge and EBW front line, EBW, $L_{EB\text{–}s1}$ and $L_{EB\text{–}s2}$.

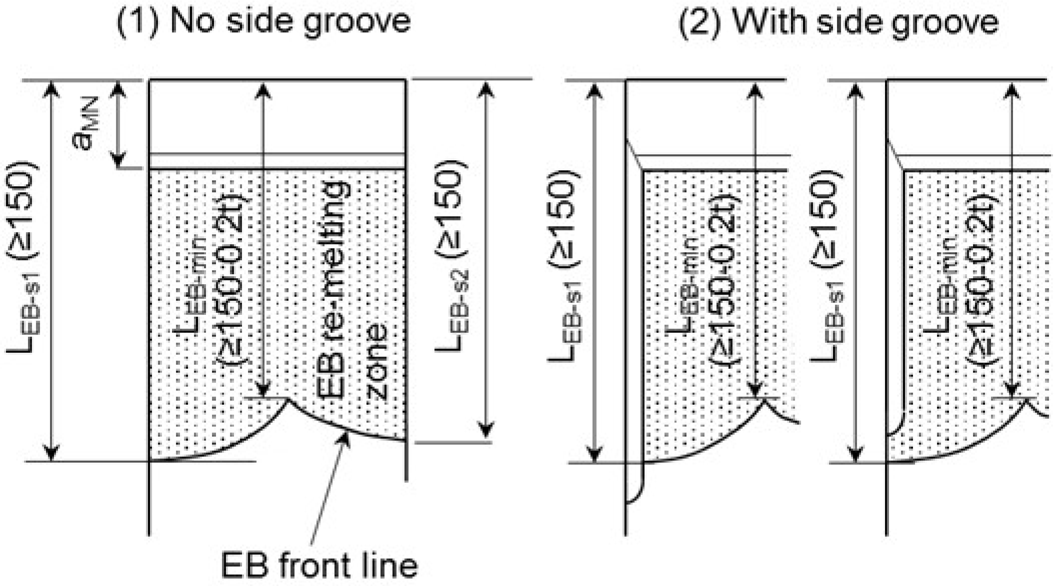


Fig. 2.2.11.3.4.5.2 Definition of EBW length

2.2.11.3.4.5.3 The minimum length between specimen edge and EBW front line, L_{EB}-min shall no smaller than 150 mm. However, it may be acceptable even if L_{EB}-min is no smaller than 150 mm – 0,2*t*, where *t* is specimen thickness. When L_{EB}-min is smaller than 150 mm, a temperature safety margin shall be considered into T_{test} (refer to 2.2.11.3.8.1.2).

2.2.11.3.4.5.4 The other two are the lengths between specimen edge and EBW front appeared on both side surfaces, as denoted with $L_{EB\text{–}s1}$ and $L_{EB\text{–}s2}$. Both of $L_{EB\text{–}s1}$ *and* $L_{EB\text{–}s2}$ shall be no smaller than 150 mm.

2.2.11.3.4.5.5 In LTG system, LLTG shall be set as 150 mm and over.

2.2.11.3.4.6 Tab plate / pin chuck details and welding of test specimen to tab plates.

2.2.11.3.4.6.1 The configuration and size of tab plates and pin chucks shall comply with those specified in ~~2.2.11.1.4.2~~ ISO 20064:2009. The welding distortion in the integrated specimen shall be also within the requirements of ~~2.2.11.1.4.3~~ ISO 20064:2009.

2.2.11.3.5 Test method.

2.2.11.3.5.1 Preloading.

2.2.11.3.5.1.1 Preloading at room temperature may be applied to avoid unexpected brittle crack initiation at test. The applied load value shall be no greater than the test stress. Preloading can be applied at higher temperature than ambient temperature when brittle crack initiation is expected at preloading process. The specimen shall not be subjected to temperature higher than 100 °C.

2.2.11.3.5.2 Temperature measurement and control.

2.2.11.3.5.2.1 Temperature control plan showing the number and position of thermocouples shall be in accordance with 2.2.11.3.5.2.

2.2.11.3.5.2.2 Thermocouples shall be attached to both sides of the test specimen at a maximum interval of 50 mm in the whole width and in the longitudinal direction at the test specimen center position (0,5*W*) within the range of ± 100 mm from the centerline in the longitudinal direction (refer to Fig. 2.2.11.3.5.2.2).

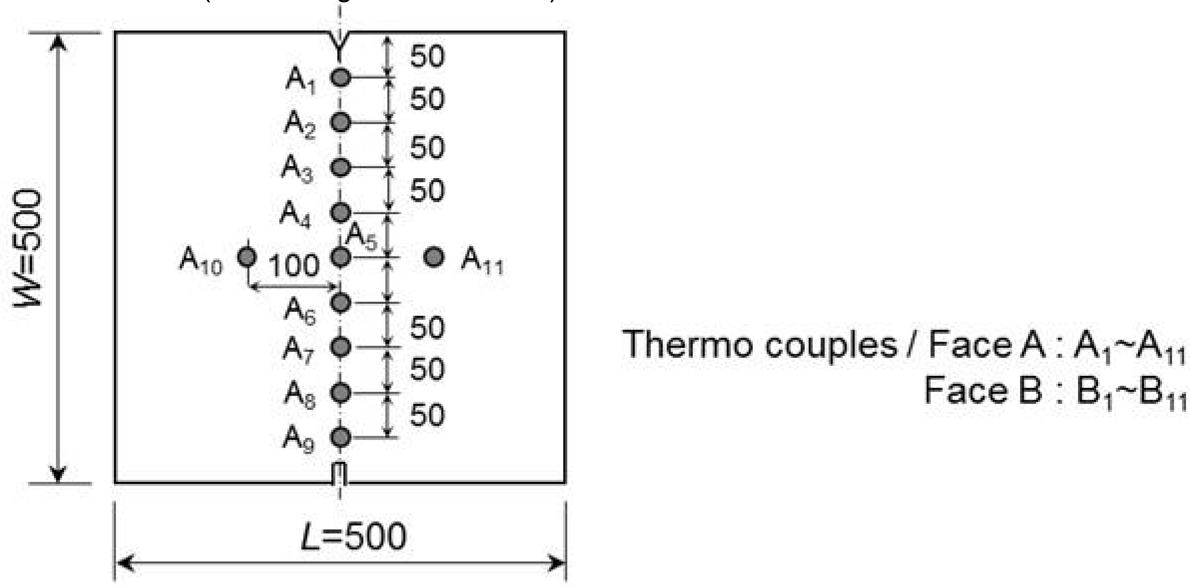


Fig. 2.2.11.3.5.2.2 Locations of temperature measurement

2.2.11.3.5.2.3 EBW embrittlement.

2.2.11.3.5.2.3.1 The temperatures of the thermocouples across the range of 0,3*W* ~ 0,7*W* in both width and longitudinal directions shall be controlled within ± 2 °C of the target test temperature, T_{target}.

2.2.11.3.5.2.3.2 When all measured temperatures across the range of 0,3*W* ~ 0,7*W* have reached T_{target}, steady temperature control shall be kept at least for 10 + 0,1*t* (mm) minutes to ensure a uniform temperature distribution into mid-thickness prior to applying test load.

2.2.11.3.5.2.3.3 The machined notch tip may be locally cooled to easily initiate brittle crack. Nevertheless, the local cooling shall not disturb the steady temperature control across the range of 0,3*W* ~ 0,7*W*.

2.2.11.3.5.2.4 For LTG embrittlement.

2.2.11.3.5.2.4.1 In LTG system, in addition to the temperature measurements shown in Fig. 2.2.11.3.5.2.2, the additional temperature measurement at the machine notch tip, A_0 and B_0 is required. Thermocouples positions within LTG zone are shown in Fig. 2.2.11.3.5.2.4.1.

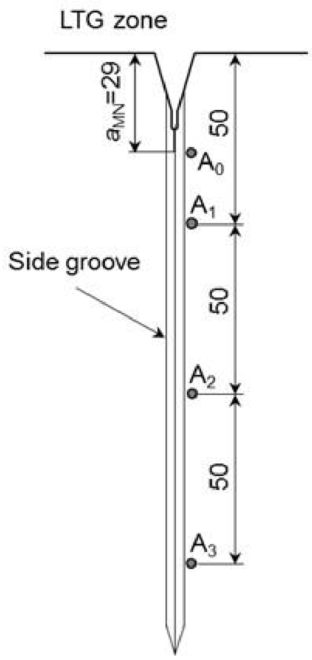


Fig. 2.2.11.3.5.2.4.1 Detail of LTG zone and additional thermocouple A_0

2.2.11.3.5.2.4.2 The temperatures of the thermocouples across the range of 0,3*W* ~ 0,7*W* in both width and longitudinal directions shall be controlled within ± 2°C of the target test temperature, T_{target}. However, the temperature measurement at 0,3*W* (location of A_3 and B_3) shall be in accordance with 2.2.11.3.5.2.4.6.

2.2.11.3.5.2.4.3 Once the all measured temperatures across the range of 0,3W ~ 0,7W have reached T_{target}, steady temperature control shall be kept at least for 10 + 0,1*t* min to ensure a uniform temperature distribution into mid-thickness, then the test load is applied.

2.2.11.3.5.2.4.4 LTG is controlled by local cooling around the machined notch tip. LTG profile shall be recorded by the temperature measurements from A_0 to A_3 shown in Fig. 2.2.11.3.5.2.4.4.

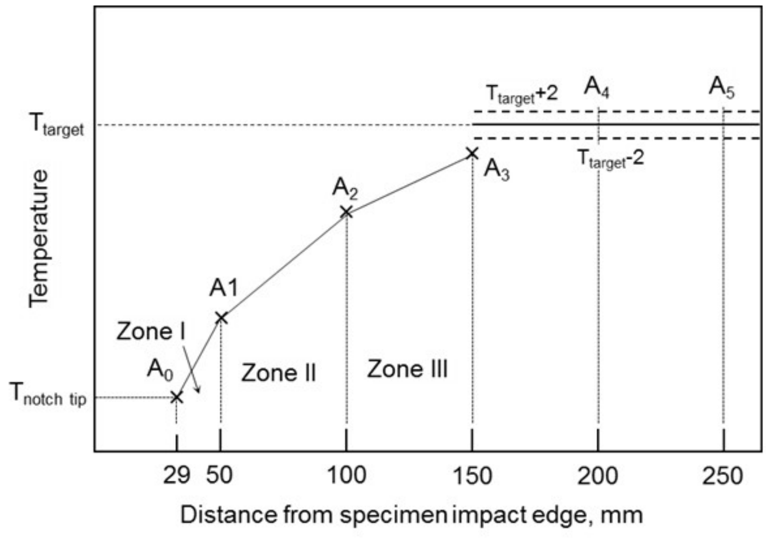


Fig. 2.2.11.3.5.2.4.4 Schematic profile of the temperature gradient in the LTG zone

2.2.11.3.5.2.4.5 LTG zone is established by temperature gradients in three zones: Zone I, Zone II and Zone III. The acceptable range for each temperature gradient is listed in Table 2.2.11.3.5.2.4.5.

Table 2.2.11.3.5.2.4.5

Acceptable LTG range

Zone	Location from edge	Acceptable range of temperature gradient
Zone I	29 mm — 50 mm	2,00 °C/mm — 2,30 °C/mm
Zone II	50 mm — 100 mm	0,25 °C/mm — 0,60 °C/mm
Zone III[1]	100 mm —150 mm	0,10 °C/mm — 0,20 °C/mm

[1] The Zone III arrangement is mandatory.

2.2.11.3.5.2.4.6 ~~Two t~~Temperature measurements at A_2;B_2 and A_3;B_3 shall satisfy the following requirements:

T at A_3, T at B_3 < T_{target} – 2 °C;

T at A_2 < T at A_3 – 5 °C;

T at B_2 < T at B_3 – 5 °C.

2.2.11.3.5.2.4.7 No requirements for T at A_0 and T at A_1 temperatures when T at A_3 and T at A_2 satisfy the requirements above. Face B is the same.

2.2.11.3.5.2.4.8 The temperatures from A_0;B_0 to A_3;B_3 shall be decided at test planning stage. Table 2.2.11.3.5.2.4.5 gives the recommended temperature gradients in three zones: Zone I, Zone II and Zone III in LTG zone.

2.2.11.3.5.2.4.9 The temperature profile in LTG zone mentioned above shall be ensured after holding time at least for 10 + 0,1t min to ensure a uniform temperature distribution into mid-thickness before brittle crack initiation.

2.2.11.3.5.2.4.10 The acceptance of LTG in the test shall be decided from Table 2.2.11.3.5.2.4.5 based on the measured temperatures from A_0 to A_3.

2.2.11.3.5.2.5 Double tension type crack initiation specimen.

2.2.11.3.5.2.5.1 Temperature control and holding time at steady state shall be the same as specified in 2.2.11.3.5.2.3 or in 2.2.11.3.5.2.4 according to the method specified.

2.2.11.3.5.3 Loading and brittle crack initiation.

2.2.11.3.5.3.1 Prior to testing, a target test temperature (T_{target}) shall be selected.

2.2.11.3.5.3.2 Test procedures shall be in accordance with ~~2.2.11.1.6~~ ISO 20064:2019 except that the applied stress shall be 2/3 of SMYS of the steel grade.

2.2.11.3.5.3.3 The test load shall be held at the test target load or higher for a minimum of 30 s prior to crack initiation.

2.2.11.3.5.3.4 Brittle crack may be initiated by impact or secondary tab plate tension after all of the temperature measurements and the applied force are recorded.

2.2.11.3.6 Measurements after test and test validation judgment.

2.2.11.3.6.1 Brittle crack initiation and validation.

2.2.11.3.6.1.1 If brittle crack spontaneously initiates before the test force is achieved or the specified hold time at the test force is not achieved, the test shall be invalid.

2.2.11.3.6.1.2 If brittle crack spontaneously initiates without impact or secondary tab tension but after the specified time at the test force is achieved, the test is considered as a valid initiation. The following validation judgments of crack path and fracture appearance shall be examined.

2.2.11.3.6.2 Crack path examination and validation.

2.2.11.3.6.2.1 When brittle crack path in embrittled zone deviates from EBW line or side groove in LTG system due to crack deflection and/or crack branching, the test shall be considered as invalid.

2.2.11.3.6.2.2 All of the crack path from embrittled zone end shall be within the range shown in Fig. 2.2.11.3.6.2.2. If not, the test shall be considered as invalid.

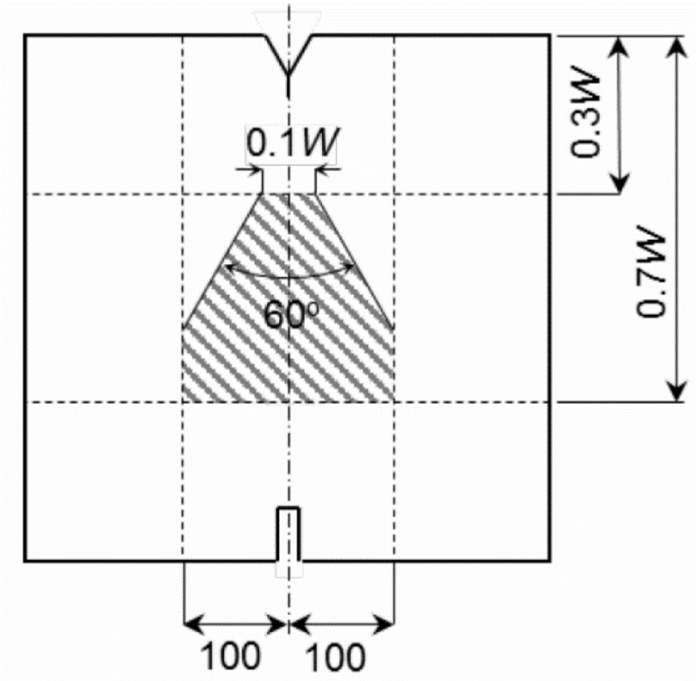


Fig. 2.2.11.3.6.2.2 Allowable range of main crack propagation path

2.2.11.3.6.3 Fracture surface examination, crack length measurement and their validation.

2.2.11.3.6.3.1 Fracture surface shall be observed and examined. The crack "initiation" and "propagation" shall be checked for validity and judgments recorded. The crack "arrest" positions shall be measured and recorded.

2.2.11.3.6.3.2 When crack initiation trigger point is clearly detected at side groove root, other than the V-notch tip, the test shall be invalid.

2.2.11.3.6.3.3 In EBW embrittlement setting, EBW zone length is quantified by three measurements of $L_{EB\text{-}s1}$, $L_{EB\text{-}s2}$ and L_{EB}-min, which are defined in 2.2.11.3.4.5. When either or both of $L_{EB\text{-}s1}$, $L_{EB\text{-}s2}$ are smaller than 150 mm, the test shall be invalid. When L_{EB}-min is smaller than 150 mm – 0,2*t*, the test shall be invalid.

2.2.11.3.6.3.4 When the shear lip with thickness over 1 mm in either side near side surfaces of embrittled zone are visibly observed independent of the specimens with or without side grooves, the test shall be invalid.

2.2.11.3.6.3.5 In EBW embrittlement setting, the penetration of brittle crack beyond the EBW front line shall be visually examined. When any brittle fracture appearance area continued from the EB front line is not detected, the test shall be invalid.

2.2.11.3.6.3.6 The weld defects in EBW embrittled zone shall be visually examined. If detected, it shall be quantified. A projecting length of defect on the thickness line through EBW weld region along brittle crack path shall be measured, and the total occupation ratio of the projected defect part to the total thickness is defined as defect line fraction (refer to Fig. 2.2.11.3.6.3.6). When the defects line fraction is larger than 10%, the test shall be invalid.

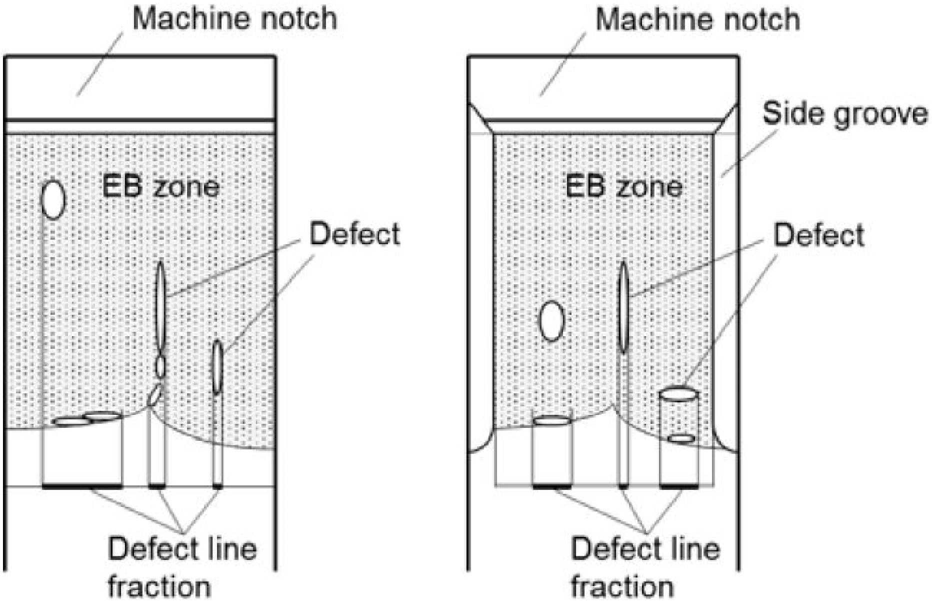


Fig. 2.2.11.3.6.3.6 Counting procedure of defect line fraction

2.2.11.3.6.3.7 In EBW embrittlement by dual sides' penetration, a gap on embrittled zone fracture surface, which is induced by miss meeting of dual fusion lines, is visibly detected at an overlapped line of dual side penetration, the test shall be invalid.

2.2.11.3.7 Judgment of "arrest" or "propagate".

2.2.11.3.7.1 The final test judgment of "arrest", "propagate" or "invalid" is determined by the requirements of 2.2.11.3.7.

2.2.11.3.7.2 If initiated brittle crack is arrested and the tested specimen is not broken into two pieces, the fracture surfaces shall be exposed with the procedures specified in ~~2.2.11.1.6.3 and 2.2.11.1.6.4~~ ISO 20064:2019.

2.2.11.3.7.3 When the specimen was not broken into two pieces during testing, the arrested crack length, a_{arrest} shall be measured on the fractured surfaces. The length from the specimen edge of impact side to the arrested crack tip (the longest position) is defined as a_{arrest}.

2.2.11.3.7.4 For LTG and EBW, a_{arrest} shall be greater than L_{LTG} and $L_{EB\text{-}s1}$, $L_{EB\text{-}s2}$ or L_{EB}-min. If not, the test shall be considered as invalid.

2.2.11.3.7.5 Even when the specimen was broken into two pieces during testing, it can be considered as "arrest" when brittle crack re-initiation is clearly evident. Even in the fracture surface all occupied by brittle fracture, when a part of brittle crack surface from embrittled zone is continuously surrounded by thin ductile tear line, the test can be judged as re-initiation behavior. If so, the maximum crack length of the part surrounded tear line can be measured as a_{arrest}. If re-initiation is not visibly evident, the test is judged as "propagate".

2.2.11.3.7.6 The test is judged as "a_{arrest}" when the value of a_{arrest} is no greater than 0,7*W*. If not, the test is judged as "propagate".

2.2.11.3.8 T_{test}, T_{arrest} and *CAT* determination

2.2.11.3.8.1 T_{test} determination.

2.2.11.3.8.1.1 It shall be ensured on the thermocouple measured record that all temperature measurements across the range of 0,3*W* ~ 0,7*W* in both width and longitudinal direction are in the range of T_{target} ±2 °C at brittle crack initiation. If not, the test shall be invalid. However, the temperature measurement at 0,3*W* (location of A_3 and B_3) in LTG system shall be exempted from this requirement.

2.2.11.3.8.1.2 If L_{EB}-min in EBW embrittlement is no smaller than 150 mm, T_{test} can be defined to equal with T_{target}. If not, T_{test} shall be equaled with T_{target} + 5 °C.

2.2.11.3.8.1.3 In LTG embrittlement, T_{test} can be equated with T_{target}.

2.2.11.3.8.1.4 The final arrest judgment at T_{test} is concluded by at least two tests at the same test condition which are judged as "arrest".

2.2.11.3.8.2 T_{arrest} determination.

2.2.11.3.8.2.1 When at least repeated two "arrest" tests appear at the same T_{target}, brittle crack arrest behaviour at T_{target} will be decided ($T_{arrest} = T_{target}$). When a "propagate" test result is included in the multiple test results at the same T_{target}, the T_{target} cannot to be decided as T_{arrest}.

2.2.11.3.8.3 *CAT* determination.

2.2.11.3.8.3.1 When CAT is determined, one "propagate" test is needed in addition to two "arrest" tests. The target test temperature, T_{target} for "propagate" test is recommended to select 5 °C lower than T_{arrest}. The minimum temperature of T_{arrest} is determined as *CAT*.

2.2.11.3.8.3.2 With only the "arrest" tests, without "propagation" test, it is decided only that *CAT* is lower than T_{test} in the two "arrest" tests, i.e. not deterministic CAT.

2.2.11.3.9 Reporting.

The following items shall be reported:

.1 test material: grade and thickness;

.2 test machine capacity;

.3 test specimen dimensions: thickness *t*; width *W* and length *L*; notch details and length a_{MN}, side groove details if machined;

.4 embrittled zone type: EBW or LTG embrittlement;

.5 integrated specimen dimensions: Tab plate thickness, tab plate width, integrated specimen unit length including the tab plates, and distance between the loading pins, angular distortion and linear misalignment;

.6 brittle crack trigger information: impact type or double tension. If impact type, drop weight type or air gun type, and applied impact energy;

.7 test conditions; applied load; preload stress, test stress;

judgments for preload stress limit, hold time requirement under steady test stress;

.8 test temperature: complete temperature records with thermocouple positions for measured temperatures (figure and/or table) and target test temperature;

judgments for temperature scatter limit in isothermal region;

judgment for local temperature gradient requirements and holding time requirement after steady local temperature gradient before brittle crack trigger, if LTG system is used;

.9 crack path and fracture surface: tested specimen photos showing fracture surfaces on both sides and crack path side view; mark at "embrittled zone tip" and "arrest" positions;

judgment for crack path requirement;

judgment for cleavage trigger location (whether side groove edge or V-notch edge);

.10 embrittled zone information.

When EBW is used: L_{EB-s1}, L_{EB-s2} and L_{EB}-min:

judgment for shear lip thickness requirement;

judgment whether brittle fracture appearance area continues from the EBW front line;

judgment for EBW defects requirement;

judgment for EBW lengths, L_{EB-s1}, L_{EB-s2} and L_{EB}-min requirements.

When LTG is used: L_{LTG}.

Judgment for shear lip thickness requirement;

test results:

when the specimen did not break into two pieces after brittle crack trigger, arrested crack length a_{arrest};

when the specimen broke into two pieces after brittle crack trigger,

If there is brittle crack re-initiation, arrested crack length a_{arrest}:

judgement for a_{arrest} in the valid range ($0,3W < a_{arrest} \leq 0,7W$);
final judgement either "arrest", "propagate" or "invalid";
.11 dynamic measurement results: history of crack propagation velocity, and strain change at pin chucks, if needed.
2.2.11.3.10 Use of test for material qualification testing.
Where required, the method can also be used for determining the lowest temperature at which a steel can arrest a running brittle crack (the determined *CAT*) as the material property characteristic in accordance with 2.2.11.3.8.3.".

3 STEEL AND CAST IRON

3.19 YP47 STEELS AND BRITTLE CRACK ARREST STEELS

Table 3.19.2.2.2 is amended as follows:

"Table 3.19.2.2.2

Requirements for properties for brittle crack arrest steels BCA

Steel grade index[1]	Thickness range (mm)	Brittle crack arrest properties[2, 3]	
		Brittle Crack Arrest Toughness K_{ca} at –10 °C N/mm$^{3/2}$[4]	Crack Arrest Temperature CAT (°C)[5]
BCA1	$50 < t \leq 100$	6000	–10 or below
BCA2	$80 < t \leq 100$[6]	8000	[7]

[1] BCA1 or BCA2 index shall be affixed to the steel grade designation (e.g. PCEH40BCA1, PCEH47BCA1, PCE47BCA2).
[2] Brittle crack arrest properties shall be verified by either the brittle crack arrest toughness K_{ca} or crack arrest temperature (*CAT*).
[3] Where small-scale ~~alternative~~ tests are used for product testing (batch release testing), these test methods shall be approved by the Register in accordance with 3.19.3.3.
[4] K_{ca} value shall be obtained by the brittle crack arrest test specified in 2.2.11.1.
[5] *CAT* shall be obtained by the test method specified in 2.2.11.3.
[6] Steel with thicknesses of 80 mm or lower may be approved by the Register.
[7] Criterion of *CAT* for brittle crack arrest steels corresponding to K_{ca} = 8000 N/mm$^{3/2}$ shall be approved by the Register.

".

Para 3.19.3.1.2.1 is amended as follows:

"**3.19.3.1.2.1** Scope of testing.
~~**3.19.3.1.3.1**~~ Regarding YP47, unless otherwise specified, the requirements shall be applicable to the scope of initial surveys equally along with the shipbuilding steels of other grades.
The products for testing shall represent the maximum thickness for approval. If the target chemical composition changes with the thickness, the maximum thickness for each specified chemical composition specification shall be tested.".

Para 3.19.3.1.2.2.2.1 is amended as follows:

"**.1** Y-groove weld cracking test (Hydrogen crack test).
The test method shall be in accordance with recognized national standards such as ~~JIS Z 3158-2016 or CB/T 4364-2013~~ ISO 17642-2:2005. Acceptance criteria shall be tentatively in accordance with the Register's practice;".

Para 3.19.3.2.3.1.1 is amended as follows:

"**3.19.3.2.3.1.1** The extent of the test program is specified in 3.19.3.2.3.
If the manufacturing process and mechanism to ensure the brittle crack arrest properties for the steels intended for approval are same, provisions of 2.2.2, Part III "Technical Supervision for the Manufacture of Materials" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships shall be complied with for the extent of the approval tests. For YP steels with brittle crack arrest properties, 2.2.2.3.1.3 and 2.2.2.3.1.4, Part III "Technical Supervision for the Manufacture of Materials" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships shall not be applied.
The products for testing shall represent the maximum thickness for approval. If the target chemical composition changes with the thickness, the maximum thickness for each specified chemical composition specification shall be tested.".

Para 3.19.3.2.3.3.4 is amended as follows:

"**3.19.3.2.3.3.4** The test specimens and repeat test specimens shall be taken from the same steel plate. Where the brittle crack arrest properties are evaluated by K_{ca}, and the brittle crack arrest test result fails to meet the requirements, further brittle crack arrest tests may be carried out. In this case, the judgment of acceptance shall be made on the arrest toughness value K_{ca} of all test specimens (results of the initial test, failed tests and additional tests shall be included in the testing report).".

Para 3.19.3.2.6 is amended as follows:

"**3.19.3.2.6** The Certificate of Recognition for Manufacturer renewal.
The manufacturer shall also submit to RS actual manufacturing records of the approved brittle crack arrest steels within the term of validity of the manufacturing approval certificate in addition to that specified in 2.1.4, Part III "Technical Supervision for the Manufacture of Materials" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships.

N o t e . Chemical composition, mechanical properties, brittle crack arrest properties (e.g. brittle crack arrest test results or small-scale ~~alternative~~ test results) and nominal thickness shall be described in the form of histogram or statistics.".

New para 3.19.3.3 is introduced reading as follows:

"**3.19.3.3** Manufacturing Approval Scheme of small-scale test methods for Brittle Crack Arrest steels.
3.19.3.3.1 Scope.

3.19.3.3.1.1 These requirements specify the approval scheme of small-scale test methods which are used for product testing (batch release testing) of brittle crack arrest steels specified in Table 3.19.2.2.2.

3.19.3.3.1.2 Unless otherwise specified in 3.19.3, this scheme shall be followed.

3.19.3.3.2 Approval application.

3.19.3.3.2.1 Documents to be submitted:

.1 application for approval of small-scale test procedure specification;

.2 small-scale test procedure specification including the following items at least:
applicable material grades, thickness range, deoxidation practice, heat treatment, etc.;
types and methods of small-scale tests;
sampling positions in plate thickness direction and final rolling direction of test specimens;
size and dimension of test specimens;
number of test specimens;
test conditions, such as test temperature;
acceptance criterion;
example of format of test report;
example of product inspection certificate including small-scale test results;
handling of the products when small-scale test results do not satisfy the criterion;

.3 mechanism of achieving the brittle crack arrest properties of brittle crack arrest steels;

.4 technical background for enabling the evaluation of brittle crack arrest properties by small-scale test methods considering the mechanism specified in 3.19.3.3.2.1.3;

.5 procedure of the evaluation for the brittle crack arrest properties of brittle crack arrest steels by small-scale test results;

.6 data records which validate the correlation between small-scale test results and the large brittle crack arrest test results of brittle crack arrest steels whose number can satisfy the requirement for minimum data number given in 3.19.3.3.3.3;

.7 proposed test plan for approval.

3.19.3.3.2.2 Small-scale test procedure specification shall be prepared in accordance with 3.19.3.3.3.

3.19.3.3.2.3 Where the manufacturer proposes to change any part of the approved small-scale test procedure specification, then the manufacturer shall submit to the Register the documents which can cover all items specified in 3.19.3.3.2.1.

3.19.3.3.2.4 The documents confirming the reason for the change shall be submitted to identify the impact of those changes on the existing procedure, and the proposed actions to address any such impacts.

3.19.3.3.3 Establishment of procedure specification for small-scale testing.

3.19.3.3.3.1 General.

3.19.3.3.3.1.1 Small-scale test methods shall be determined based on the manufacturer's own technical philosophy with regard to achieving the brittle crack arrest properties of brittle crack arrest steels. Furthermore, description of an appropriate correlation between large-scale brittle crack arrest properties and small-scale test results shall be required, and the acceptance criterion of the small-scale test shall be determined, based on the following:
mechanism of achieving the suitable brittle crack arrest properties;
sampling position and direction;
frequency of sampling;
small-scale test methodology;
demonstrated correlation between brittle crack arrest test results and small-scale test results;
derivation of small-scale testing acceptance criterion based on the statistical analysis.

3.19.3.3.3.1.2 The manufacturer shall prepare the small-scale test procedure specification in accordance with 3.19.3.3.3.2 — 3.19.3.3.3.5.

3.19.3.3.3.2 Types and methods of testing.

3.19.3.3.3.2.1 Types, methods, dimension and positions as well as direction of test specimens, etc. of small-scale tests shall be specified by the manufacturer, and approved in accordance with these provisions.

3.19.3.3.3.2.2 The test method shall reproduce the crack initiation, propagation and arrest feature by such as the following test method:

combination of test methods, e.g. NDT drop weight test and V-notch Charpy impact test;

one test method, e.g. press-notch Charpy impact test or side-section drop weight test.

3.19.3.3.3.2.3 In general, brittle crack arrest properties of brittle crack arrest steels shall be predicted using a regression equation on the relationship between small-scale test result (e.g. transition temperature obtained by small-scale tests) and large-scale brittle crack arrest test result (e.g. K_{ca} or temperature corresponding to the specific brittle crack arrest properties). Other approaches can be used subject to the approval of the Register.

Tables 3.19.3.3.3.2.3-1, 3.19.3.3.3.2.3-2 and 3.19.3.3.3.2.3-3 give the examples of small-scale test methods.

Table 3.19.3.3.3.2.3-1

Example of small-scale test method using NDT drop weight test and V-notch Charpy impact test

Test type	NDT drop weight and V-notch Charpy impact test
Standard	ASTM E208:2020 and ISO 148-1:2016
Sampling positions	NDT drop weight test: at surface V-notch charpy impact test: ¼ of thickness
Length direction of test specimen	Parallel to the final rolling direction of test plate
Regression equation	$T_{Kca} = \alpha \cdot (NDT + 10) + \beta \cdot vTrs + 153(t-5)^{\frac{1}{13}} - 170{,}5$ where T_{Kca} — temperature at K_{ca} of 6000 N/mm$^{3/2}$ and of 8000 N/mm$^{3/2}$ (°C); *NDT* — Nil-ductility transition temperature (°C); *vTrs* — transition temperature of the absorbed energy (°C); α, β[1] — constant
[1] α and β are determined by comparing small-scale test results with brittle crack arrest test results.	

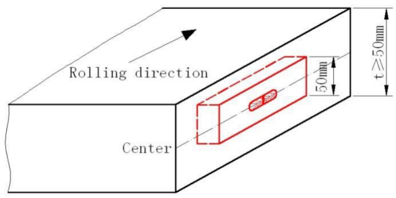
Table 3.19.3.3.3.2.3-2

Example of small-scale test method using NDT drop weight test and V-notch Charpy impact test

Test type	Pressed-notch Charpy impact test
Standard	Dimension, shape, introducing method of notch: manufacturer's proposal, Others: ISO 148-1:2016
Sampling position	½ of thickness
Length direction of test specimen	Parallel to the final rolling direction of test plate
Regression equation	$T_{Kca} = \alpha\, {}_{p}T_{E\gamma J} + \beta$ where T_{Kca}— temperature at K_{ca} of 6000 N/mm$^{3/2}$ and of 8000 N/mm$^{3/2}$ (°C); $pT_{E\gamma J}$ — test temperature at absorbed energy of γ(J), (°C); α, β[1] — constant; γ[1] — absorbed energy at brittle fracture surface ratio of δ[1] (%), (J)
[1] α, β, γ and δ are determined by comparing small-scale test results with brittle crack arrest test results.	

Table 3.19.3.3.3.2.3-3

Example of small-scale test method using side-section drop weight test

Test type	Side-section drop weight test
Standard	Dimension: P-2 type of ASTM E 208 2020
Sampling position of test specimens	½ of thickness and side-section 
Length direction of test specimen	Parallel to the final rolling direction of test plate
Regression equation	$T_{Kca} = \alpha + \beta \cdot T_{NDT}^{side} + \gamma \cdot t^{1,5}$ T_{Kca} — temperature at K_{ca} of 6000 N/mm$^{3/2}$ and of 8000 N/mm$^{3/2}$ (°C); T_{NDT}^{side} — Nil-ductility transition temperature obtained by side-section drop weight test, (°C); *t* — thickness α, β, γ[1]— constant
[1] α, β, γ shall be determined by comparing small-scale test results with brittle crack arrest test results	

3.19.3.3.3.2.4 For determination of test methods, the manufacturer shall confirm the applicability of these test methods to their brittle crack arrest steels theoretically taking into account the methodology of test methods, their own mechanism of achieving the brittle crack arrest properties, and sampling positions of test specimens (refer to 3.19.3.3.3.1.1). Then, the manufacturer shall also submit the technical background for determination of small-scale test methods to the Register as given in 3.19.3.3.2.1.

3.19.3.3.3.3 Testing data.

3.19.3.3.3.3.1 Selection of test plates.

3.19.3.3.3.3.1.1 Brittle crack arrest tests and small-scale tests shall be conducted for each material grade (including all indices) of brittle crack arrest steels in accordance with 3.19.3.3.3.3.

3.19.3.3.3.3.1.2 Brittle crack arrest tests and small-scale tests shall be carried out on at least 12 test plates, in accordance with 3.19.3.3.3.3.1.3, by which these test results can reliably estimate brittle crack arrest properties of brittle crack arrest steels.

N o t e . "One test plate" means "the rolled product from a single slab or ingot if this is rolled directly into plates".

3.19.3.3.3.3.1.3 In order to ensure appropriate correlation between small-scale test results and brittle crack arrest properties with various manufacturing conditions of steel plates, the steel plates shall be representative for each combination of thickness range and heat sample to include:

the intended maximum and minimum plate thickness;

different heats chosen for each thickness.

Furthermore, the above test plates shall include a fixed number of steel plate(s) whose brittle crack arrest properties (i.e. brittle crack arrest test results) do not comply with the requirements specified in Table 3.19.2.2.2. Such a number shall be at least one, but not exceeding one quarter of all test plates. Manufacturing process of these test plates can be different (or intentionally altered from the approved manufacturing process) from that of the brittle crack arrest steels to which the small-scale test method is applied. It is recommended that the strength grade of these test plates (non-compliant with the relevant requirements of brittle crack arrest properties) are similar to that of the brittle crack arrest steels.

Where the manufacturer has requested approval for only a single thickness, the thickness of test plates can be only a single thickness. In this case, at least four steel plates for each combination of thickness (single thickness) and heats (three different heats) shall be used, and the applicable thickness of the small-scale test is only that single thickness condition.

3.19.3.3.3.3.1.4 Brittle crack arrest steels used for the approval test of manufacturing process of these steels (and its approval test results) can also be used as the test plates specified in 3.19.3.3.3.3.1.3.

3.19.3.3.3.3.1.5 Brittle crack arrest test specimens and small-scale test specimens shall be taken from the same test plate.

3.19.3.3.3.3.1.6 A decrease of the total of the indicated number of test plates may be accepted by the Register in the following (a) or (b) cases:

(a) when the manufacturer applies a small-scale test procedure specification to multiple material grades, and the manufacturing process and mechanism to ensure the brittle crack arrest properties of these different material grades are the same;

(b) when a small-scale test procedure specification is already approved by the Register for one or some material grades, and the manufacturer applies similar small-scale test procedure specification to the other material grade(s), and the manufacturing process and mechanism to ensure the brittle crack arrest properties of these different material grades are same.

3.19.3.3.3.3.2.1 Brittle crack arrest tests shall be carried out for each test plate in accordance with 3.19.3.2.3.3.

3.19.3.3.3.3.2.2 Where brittle crack arrest tests are carried out for evaluation of K_{ca}, K_{ca} at a specific temperature shall be obtained in accordance with 2.2.11.2.

3.19.3.3.3.3.2.3 Where brittle crack arrest tests are carried out for evaluation of *CAT*, deterministic (actual) *CAT* shall be obtained in accordance with 2.2.11.3.8.3.

3.19.3.3.3.3.3 Small-scale tests.

3.19.3.3.3.3.3.1 Small-scale tests shall be carried out in accordance with small-scale test procedure specification to be approved for each test plate.

3.19.3.3.3.3.3.2 In general, the test specimens of small-scale tests shall be taken with their longitudinal axis parallel to the final rolling direction of the test plates.

3.19.3.3.3.3.3.3 The test specimens of small-scale tests shall be taken from the specified positions in plate thickness direction of the test plates, as given in 3.19.3.3.3.2.3.

3.19.3.3.3.4 Validation of correlation.

3.19.3.3.3.4.1 A regression equation on the relationship between brittle crack arrest property obtained from brittle crack arrest test and single or multiple small-scale test results is to be established. For brittle crack arrest properties, a specific temperature (e.g. $T_{Kca6000}$ in BRCA1, $T_{Kca8000}$ in BCA2 or *CAT*) of the K_{ca} value at –10 °C may be used.

3.19.3.3.3.4.2 The validity of the regression equation shall be examined to predict brittle crack arrest properties with enough accuracy. The correlation in brittle crack arrest properties between the calculated values from small-scale tests and the brittle crack arrest test results shall be assured by using the value of twice the standard deviation (2σ). When using temperature for brittle crack arrest property, 2σ shall not be greater than 20 °C. In other cases (e.g. K_{ca} value at –10°C), an upper limit of 2σ shall be established with the agreement of the Register.

N o t e . Calculation procedure of the standard deviation (σ) is given as follows:

$$\sigma = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(y_i - x_i)^2}$$

where n — number of test plates;
y_i — brittle crack arrest property obtained from brittle crack arrest test for one test plate;
x_i — brittle crack arrest property estimated from small-scale tests for one test plate.

3.19.3.3.3.5 Acceptance criterion.

3.19.3.3.3.5.1 Acceptance criterion of brittle crack arrest steels by the small-scale tests shall be proposed by the manufacturer based on the regression equation which is assured in the correlation with brittle crack arrest properties in 3.19.3.3.3.4 above. The criterion shall be determined so that regression equation can predict brittle crack arrest properties on safety side, considering the scatter of brittle crack arrest properties from the predicted value by the regression equation.

3.19.3.3.3.5.2 Unless otherwise agreed by the Register, an acceptance criterion of small-scale tests shall be determined by following procedures:

.1 for correlation by means of temperature:

.1.1 the required temperature (refer to Fig. 3.19.3.3.3.3.5.2.1) is obtained by subtracting 2σ (℃) from the brittle crack arrest steel specification in Table 3.19.2.2.2, that is – 0-2σ (℃), where 2σ is given in 3.19.3.3.3.4.2.

$T_{Kca6000}$ and $T_{Kca8000}$ in Fig. 3.19.3.3.3.3.5.2.1 are the temperatures at which the K_{ca} value of steel plates equals 6000 N/mm$^{3/2}$ and 8000 N/mm$^{3/2}$, respectively;

.1.2 the temperature predicted from the small-scale test results through the regression equation shall be no higher than the value of –10 – 2σ (℃);

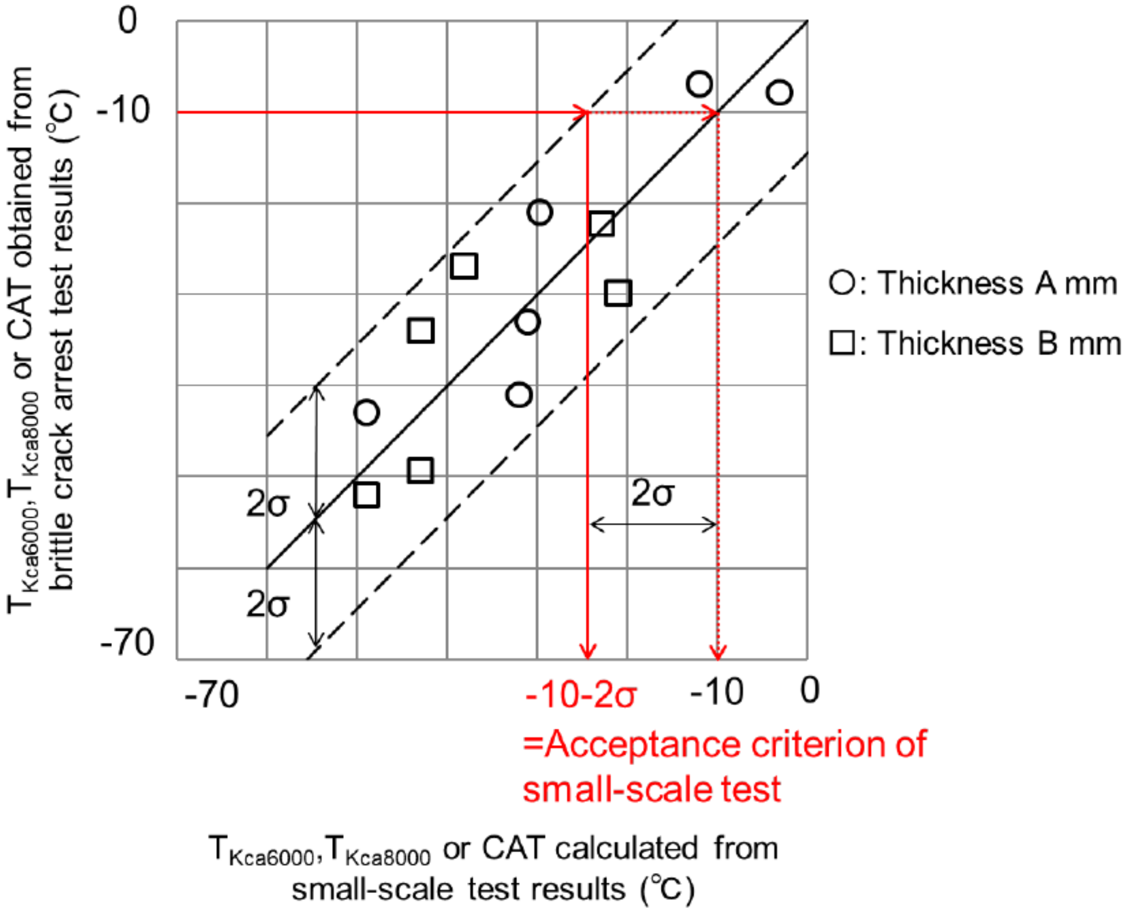


Fig. 3.19.3.3.3.3.5.2.1
Example for determination of acceptance criterion of small-scale test for correlation by means of temperature
(N o t e . This is only a schematic and may not represent the actual data obtained)

.2 for correlation by means of brittle crack arrest toughness (K_{ca}):

.2.1 the required K_{ca} (refer to Fig. 19.3.3.3.3.5.2.1) is obtained by adding 2σ (N/mm$^{3/2}$) to the brittle crack arrest steel specification in Table 3.19.2.2.2, that is either 6000+2σ (N/mm$^{3/2}$) in BCA1, where 8000+2σ (N/mm$^{3/2}$) in BCA2, where 2σ is given in 3.19.3.3.3.3.4.2;

.2.2 The K_{ca} value predicted from the small-scale test results through the regression equation shall be no smaller than the value of 6000+2σ(N/mm$^{3/2}$) for BCA1 or 8000+2σ(N/mm$^{3/2}$) for BCA2.

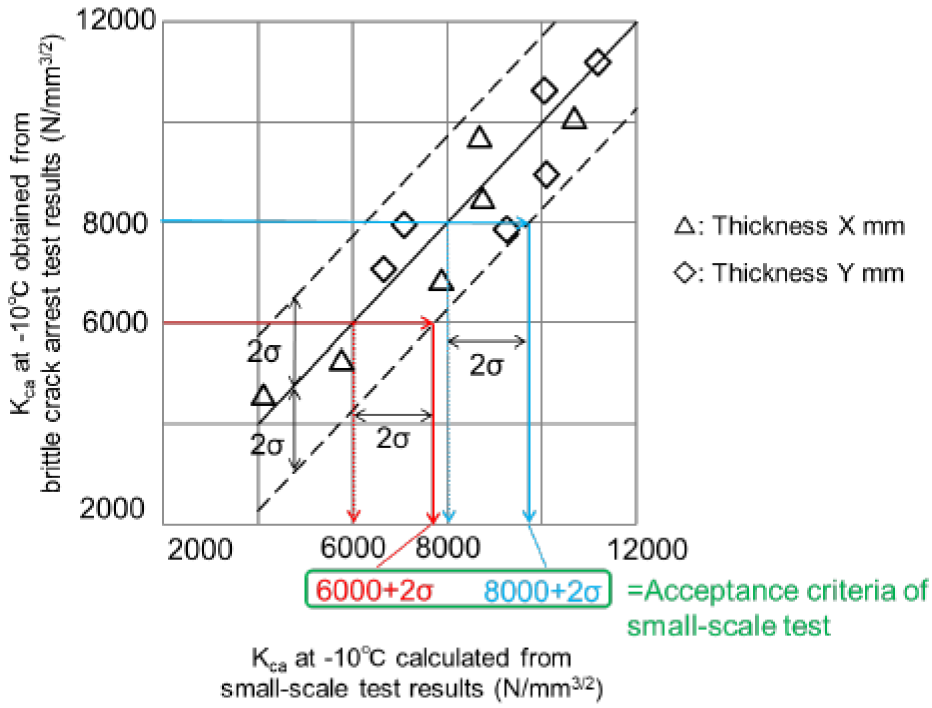


Fig. 3.19.3.3.3.3.5.2.2
Example for determination of acceptance criteria of small-scale tests for correlation by means of brittle crack arrest toughness (Kca)
(Note: This is only a schematic and may not represent the actual data obtained)

3.19.3.3.4 Approval Test.

3.19.3.3.4.1 General.

3.19.3.3.4.1.1 In order to confirm the validity of the submitted technical documents specified in 3.19.3.3.2.1, approval tests shall be carried out.

3.19.3.3.4.1.2 Approval test plan shall be approved by the Register prior to testing.

3.19.3.3.4.1.3 Considering the contents of the submitted technical documents specified in 3.19.3.3.2.1, the Register may require additional tests in the following cases:

.1 when the Register determines that the number of brittle crack arrest tests or small-scale tests is too few to adequately confirm the validity of the acceptance criterion of small-scale tests (refer to 3.19.3.3.3.3.1);

.2 when the Register determines that the testing data obtained for setting the acceptance criterion of small-scale tests varies too widely (refer to 3.19.3.3.3.4.2), or that the data is clustered producing a biased correlation curve;

.3 when the Register determines that the validity of brittle crack arrest test results or small-scale test results for setting the acceptance criterion of small-scale tests is insufficient, or has some flaws during tests and/or for test results (refer to 3.19.3.3.3.3.2 and 3.19.3.3.3.3.3).

3.19.3.3.4.2 Extent of the approval tests.

3.19.3.3.4.2.1 Extent of the approval tests shall be in accordance with 3.19.3.1.2.1 and 3.19.3.2.3.1.

3.19.3.3.4.3 Type of tests.

3.19.3.3.4.3.1 Brittle crack arrest tests.

3.19.3.3.4.3.1.1 Brittle crack arrest tests shall be carried out in accordance with 3.19.3.2.3.3.

3.19.3.3.4.3.1.2 Where brittle crack arrest tests are carried out for evaluation of K_{ca}, K_{ca} at a specific temperature ($T_{Kca6000}$ and $T_{Kca8000}$) shall be obtained in accordance with 2.2.11.2.

3.19.3.3.4.3.1.3 Where brittle crack arrest tests are carried out for evaluation of *CAT*, deterministic *CAT* shall be obtained in accordance with 2.2.11.3.8.3.

3.19.3.3.4.3.2 Small-scale tests.

3.19.3.3.4.3.2.1 Small-scale tests shall be carried out in accordance with 3.19.3.3.3.3.3.

3.19.3.3.5 Results.

3.19.3.3.5.1 Results of test items and the procedures shall comply with the test program approved by the Register.

3.19.3.3.5.2 Brittle crack arrest test results.

The manufacturer shall submit to the Register the brittle crack arrest test reports in accordance with 2.2.11.1 for K_{ca} and 2.2.11.3 for CAT.

3.19.3.3.5.3 Small-scale test results.

The manufacturer shall submit to the Register the small-scale test reports in accordance with the example of format of test reports submitted as specified in 3.19.3.3.2.1.2.

3.19.3.3.6 Approval.

Upon satisfactory completion of the survey and tests, and satisfactory confirmation of the submitted technical documents, the approval for small-scale test procedure specification is granted by the Register.".

PART XIV WELDING

3 TESTING OF WELDED JOINTS

3.3 SCOPE OF NON-DESTRUCTIVE TESTING

Table 3.3.4 is amended as follows:

"Table 3.3.4

Class of piping	Outer diameter of pipe, mm	Scope of welded joint testing as percentage of total weld length			
		Butt joints		Fillet joints (with flanges)	
		visual[1]	radiographic or ultrasonic[2]	visual[1]	dye penetrant or magnetic particle[3]
I	≤ 75	100	10[24]	100	10[24]
	>75		100		100
II	≤ 100		Random		Random
	>100		10[24]		10[24]
III	Любой		Random		Random

[1] In case of doubts in the results of visual testing, dye penetrant or magnetic particle testing may be carried out.
[2] For pipe thickness of 8 mm and above.
[3] Depending on the method applicable to the piping base material.
[24] But not less than one welded joint made by a particular welder.

PART XV. AUTOMATION

Section 7 is replaced by the following text:

"7 COMPUTERS AND COMPUTER-BASED SYSTEMS

7.1 APPLICATION

7.1.1 The requirements of this Section apply to computers and computer-based systems used for monitoring, control, alarm, safety or intercom functions on board a ship (requirements thereto are set forth in Sections 2 to 6 of this Part and in Section 7, Part XI "Electrical Equipment") as well as unattended operation of the ship's machinery installation.

Ships fitted with such automation systems may be assigned, in accordance with 2.2.6, Part I "Classification", one of the following distinguishing automation marks in the class notation:

.1 **AUT1-C**, **AUT2-C** or **AUT3-C** — where automation of the machinery installation is based on computers or programmable logic controllers;

.2 **AUT1-ICS**, **AUT2-ICS** or **AUT3-ICS** — where computer-based systems are combined into a network forming a common integrated system.

7.1.2 These requirements shall not apply to navigation systems, radio communication systems, and ship loading instruments/stability computers.

7.2 DEFINITIONS AND EXPLANATIONS

Black-box description is a description of a system's functionality, behavior and performance as observed from outside the system in question.

Black-box testing methods is a verification of the functioning, performance and reliability of a system, subsystem or a component by only manipulating the input data and observing the output data. This process does not require any expertise of the system's internal operation and focuses only on the observable behavior of the system/component under test to achieve the desired level of verification.

Computer is a programmable electronic device for storing and processing data in the digital form, making calculations or performing control. A computer may be a monoblock or may consist of several interconnected units.

Computer-based system (CBS) is a programmable electronic device, or interoperable set of programmable electronic devices, organized to achieve one or more specified purposes such as collection, processing, maintenance, use, sharing, dissemination, or disposition of information. CBSs onboard include IT and OT systems. A CBS may be a combination of subsystems connected via network. Onboard CBSs may be connected directly or via public means of communications (e.g. Internet) to ashore CBSs, other ships' CBSs and/or other facilities.

Failure mode description is a document describing the effects due to failures in the system, not failures in the equipment supported by the system. The following aspects shall be covered:

list of failures, which are subject to assessment with description of the system response to each of the above failures;

comments to the consequence of each of these failures.

Integrated automation system is a system, which integrates a range of interacting systems, subsystems, and/or equipment organized to perform one or more essential functions. An integrated system is typically a combination of computer-based systems with redundant architecture interfaced to enable ship's monitoring and control, as well as the centralized access to sensor-derived data.

Interface is a transfer point, at which information is exchanged. Examples of interface include: input/output interface used for interconnection with sensors and actuators; man-machine interface, e.g. monitors, keyboards, tracker-balls, etc. used for communication between the operator and the computer; communications interface used to enable serial communications/networking with other computers or peripherals.

Monitor is an electronic device for representing data.

Node is a point of interconnection to a data communication link.

Owner is an organization or a person, which orders the ship in the construction phase or which owns or manages the ship in service.

Parametrization is a process to configure and tune system and software functionality by changing parameters. It does not usually require computer programming and is normally done by the system supplier or a service provider, not the operator or end-user.

Peripheral is a device performing an auxiliary action in the system, e.g. printer, data storage device, etc.

Programmable logic controller (PLC) is a programmable electronic device designed as a stand-alone functional unit and intended to perform functions relevant to control and monitoring of ship's machinery and processes.

Quality plan is a document containing information on the requirements prescribed by the quality management system to be applied for the specific computer-based system and/or software, the minimum scope of which is specified in 7.9.5.2.1.

Robustness is the ability to respond to abnormal inputs and conditions.

Service supplier is a person or a company, not related to the Register, who at the request of an equipment manufacturer, shipyard, ship’s owner or other client acts in connection with inspection work and provides services for a ship or a mobile offshore unit such as measurements, tests or maintenance of safety systems and equipment, the results of which are used by surveyors of the Register in making decisions affecting classification or statutory certification and services.

Simulation tests are the monitoring, control, or safety system testing, where the equipment under control is partly or fully replaced with simulation tools, or where parts of the communication network and lines are replaced with simulation tools.

Software is programs, data and documentation associated with the operation of a computer-based system.

Software master files are the computer files that constitutes the original source of the software.

Software-structure is an overview of how the different software components interact and is commonly referred to as the software architecture, or software hierarchy. The system hierarchy diagram is illustrated at fig.1.

Subsystem is an identifiable part of a system, which may perform a specific function or set of functions.

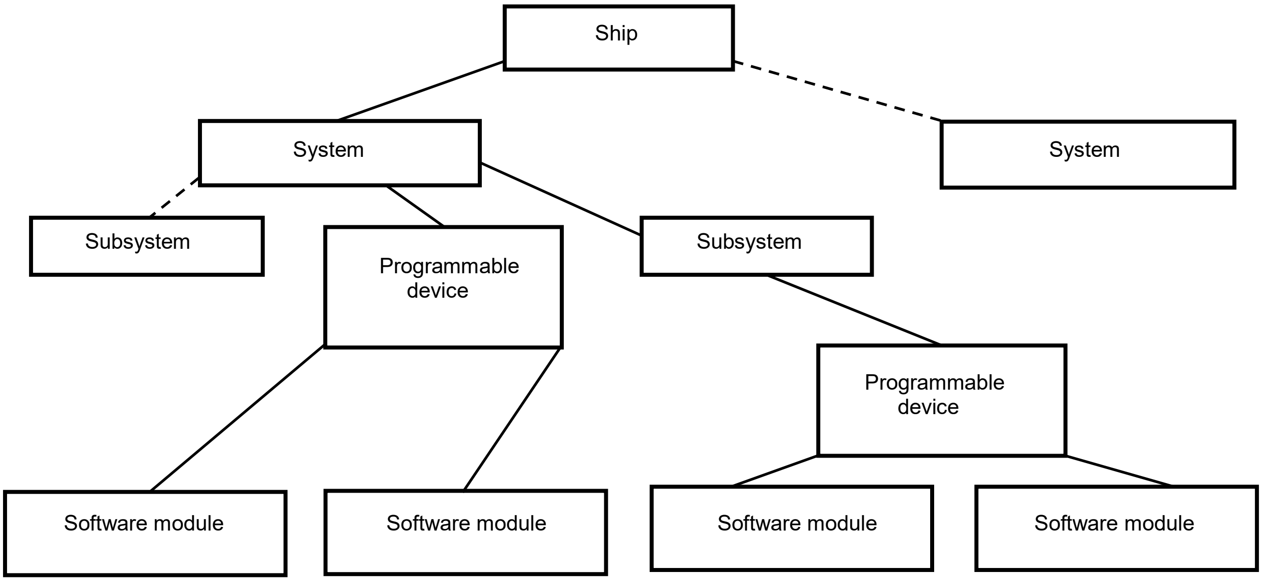
Supplier is any organization or a person that is a contracted or a subcontracted provider of services, system components, or software.

System is a combination of components, equipment and logic, which has a defined purpose, functionality, and performance. In the context of these Rules, a specific system is delivered by one system supplier.

Systems integrator is a single organization or a person coordinating interaction between suppliers of systems and subsystems on all stages of life cycle of CBS in order to integrate them into a verified ship-wide system of systems and to provide proper operation and maintenance of the CBS. During the design and delivery phases, the shipyard is the default systems integrator; during operations phase, the owner is the default systems integrator.

System of systems is a system, which is made up of several systems. In the context of these Rules, the system of systems encompasses all monitoring, control and safety systems delivered from the shipyard as a part of a ship.

System supplier is an organization or a person that is contracted or a subcontracted provider of system components or software under the coordination of the systems integrator.



Note: Non-developed branches of the diagram are shown with dashed lines

Fig. 1
System hierarchy diagram

7.3 ABBREVIATIONS

FAT	—	Factory acceptance test.
FMEA	—	Failure mode and effect analysis.
IT	—	Information technology.
OT	—	Operational technology.
PMS	—	Planned maintenance system.
SAT	—	System acceptance test.
SOST	—	System of systems test.
SSLS	—	Ship software logging system.

7.4 GENERAL REQUIREMENTS FOR THE DESIGN OF COMPUTER-BASED SYSTEMS

7.4.1 Computer-based systems shall fulfil the functional requirements of the system under control for all operating conditions including emergency conditions, taking into account the following:

danger to persons;

environmental impact;

damage to equipment;

usability;
operability of non-computer devices and systems.

7.4.2 If process times for functions of the system are shorter than the reaction times of the operator and therefore damage cannot be prevented by manual intervention, means of automatic intervention shall be provided.

7.4.3 A computer-based system shall have sufficient capability to:
perform necessary autonomous operations;
accept operator (user) commands;
inform the operator (user) correctly under all operating conditions including emergency.

7.4.4 System capability shall provide adequate response times for all functions, taking into consideration the maximum load and maximum number of simultaneous tasks, including network communication speed, under normal and abnormal process conditions.

7.4.5 Computer-based systems shall be designed in such a way that they can be used without special previous knowledge, otherwise appropriate assistance shall be provided for the user.

7.5 HARDWARE REQUIREMENTS

7.5.1 Hardware shall function reliably in conditions normally encountered in ships as specified in 2.1.

7.5.2 The design of the hardware shall ensure easy access to interchangeable parts for repairs and maintenance.

7.5.3 Each replaceable part shall be simple to replace and shall be constructed for easy and safe handling. All replaceable parts shall be arranged in such a way that it is not possible to connect them incorrectly or to use incorrect replacements. Where this is not practicable, the replaceable parts shall be clearly marked.

7.6 REQUIREMENTS FOR THE CONFIGURATION OF COMPUTER-BASED SYSTEMS

7.6.1 General.

7.6.1.1 The hardware and software shall be of modular, hierarchical design in order to maximize the fault tolerance of the system.

7.6.1.2 The selection of the computer equipment shall be consistent with safe operation of the system under control.

7.6.2 Self-test.

Computer-based systems shall have self-test capability to monitor for correct operation and alarm shall be given for an abnormal condition.

7.6.3 Power supply.

7.6.3.1 The sources of power supply shall be monitored for failure and shall give an alarm in the event of abnormal condition.

7.6.3.2 Program and data held in the system shall be protected from corruption by loss of power.

7.6.3.3 Redundant systems shall be selectively fed and separately protected against short circuits and overloads.

7.6.4 Installation.

7.6.4.1 Equipment and its associated cabling shall be installed in such a way as to minimize electromagnetic interference between the equipment concerned and other equipment on board.

7.6.4.2 Cables used for data communication shall be of adequate mechanical strength, suitably supported and also protected from mechanical damage.

7.6.5 Data communication links.

7.6.5.1 The data communication link shall be continuously self-checking, for detecting failures on the link itself and data communication failure on nodes and shall give an alarm in the event of abnormal condition.

7.6.5.2 When the same data communication link is used for two or more essential functions, this link shall be redundant. Redundant data communication links shall be routed with as much separation as practical.

7.6.5.3 Switching between redundant links shall not disturb data communication or continuous operation of functions. An automatic switching alarm signal shall be transmitted.

7.6.5.4 To ensure that data can be exchanged between various systems, standardized interfaces shall be used.

7.6.6 Fail-to-safe principle.

7.6.6.1 In the event of a failure of a computer-based system, systems under control shall automatically revert to the least hazardous condition.

7.6.6.2 The failure and restarting of computer-based systems shall not cause processes to enter undefined or critical states.

7.6.6.3 Control, alarm and safety functions shall be arranged such that a single failure will not affect more than one of these functions.

7.6.7 Integration of systems.

7.6.7.1 Operation with an integrated system shall be at least as effective as it would be with individual, stand-alone equipment. Where multifunction displays and controls are used they shall be duplicated and interchangeable.

7.6.7.2 Failure of one part (individual module, equipment or subsystem) of the integrated system shall not affect the functionality of other parts, except for those functions directly dependent upon information from the defective part.

7.6.7.3 A complete failure in connectivity between parts shall not affect their independent functionality.

7.6.7.4 An alternative means of operation, independent of the integration, shall be available for all essential functions.

7.6.7.5 When systems under control are required to be duplicated and in separate compartments this shall be also applied to computer-based systems used for control and monitoring.

7.7 USER INTERFACE

7.7.1 General.

7.7.1.1 Computer-based systems shall be designed for ease of handling and user-friendliness and shall follow ergonomic principles.

7.7.1.2 The operational status of a computer-based system (on, off, non-failed, failed, etc.) shall be easily recognizable.

7.7.1.3 A user manual shall be provided. The user guide shall describe for example:

function keys;

menu displays;

computer-guided dialogue steps, etc.

7.7.1.4 An alarm shall be displayed at relevant operator stations for failure or shutdown of a subsystem.

7.7.2 Input devices.

7.7.2.1 Input devices shall have clearly definable functions, be reliable in use and operate safely under all conditions. The acknowledgement of the instruction given shall be recognizable.

7.7.2.2 Dedicated function keys shall be provided for frequently recurring commands and for commands, which shall be available for rapid execution. If multiple functions are assigned to keys, it shall be possible to recognize, which of the assigned functions is active.

7.7.2.3 Control panels on the bridge shall be provided with separate lighting. The level of lighting and the brightness of visual display units shall be controllable.

7.7.2.4 Where equipment operations or functions may be changed via keyboards access to such operations shall be provided for authorized personnel only.

7.7.2.5 If operation of a key is able to cause dangerous operating conditions, measures shall be taken to prevent the instruction in question from being executed by a single action such as:

use of a special key lock;

use of two or more keys.

7.7.2.6 Conflicting control interventions shall be prevented by means of interlocks or warnings. The active control status shall be recognizable.

7.7.2.7 The operation of input devices shall be logical and correspond to the direction of action of the controlled equipment.

7.7.3 Output devices.

7.7.3.1 The size, colour and density of text and graphic information displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all operational lighting conditions. The brightness and contrast shall be capable of being adjusted to the prevailing ambient conditions in order to enable the information to be normally recognized.

7.7.3.2 Information shall be displayed in a logical priority.

7.7.3.3 If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.

7.7.4 Graphical user interface.

7.7.4.1 Information shall be presented clearly and intelligibly according to its functional significance and association. Screen contents shall be logically structured and their representation shall be restricted to the data, which is directly relevant for the operator.

7.7.4.2 When using general purpose graphical user interfaces, only the functions necessary for the respective process shall be available.

7.7.4.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

7.7.4.4 All display and control functions in control stations operated by the same operators shall adopt a consistent user interface. Particular attention shall be paid to symbols, colours, controls, information priorities and layout.

7.8 TRAINING

7.8.1 Training shall be provided at a level required to effectively operate and maintain computer-based systems and shall cover normal, abnormal and emergency conditions. The user interface for training shall correspond with the real system.

7.8.2 Documentation shall be provided to support the training and shall be available for repeated use on board during maintenance of computer-based systems.

7.8.3 Where a training mode is incorporated in a computer-based system it shall be clearly indicated when such a training mode is active.

7.8.4 Whilst in the training mode the operation of the system shall not be impaired, and neither any system alarms nor indications be inhibited.

7.9 PROGRAMMABLE ELECTRONIC SYSTEMS AND COMPONENTS THEREOF

7.9.1 Scope.
These requirements shall apply to design, construction, commissioning and maintenance of computer-based systems where they depend on software for the proper achievement of their functions.
7.9.2 General.
7.9.2.1 Programmable electronic systems shall fulfill the requirements of the system under control for all operating conditions, taking into account danger to persons, environmental impact, damage to ship as well as equipment, usability of programmable electronic systems and operability of non-computer devices and systems.
7.9.2.2 When systems or their devices and components other than provided by these Rules are applied, an engineering analysis carried out in accordance with a relevant international or national standard and proving the equivalent effectiveness of the specified systems, devices and components with regard to those determined in these Rules in accordance with 1.3.4 of the General Regulations for the Classification and Other Activity, shall be obligatory submitted to the Register.
7.9.3 Applicable standards.
7.9.3.1 The following standards may be used for the development of hardware/software of computer-based systems:
IEC 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems;
ISO/IEC 12207:2017 Systems and software engineering — Software life cycle processes;
ISO 9001:2015 Quality Management Systems — Requirements;
ISO/IEC 90003:2018 Software engineering — Guidelines for the application of ISO 9001:2015 to computer software;
IEC 60092-504:2016 Electrical installations in ships — Part 504: Special features — Control and instrumentation;
ISO/IEC 25000:2014 Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE;
ISO/IEC 25041:2012 Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Evaluation guide for developers, acquirers and independent evaluators;
IEC 61511:2016 Functional safety — Safety instrumented systems for the process industry sector;
ISO/IEC 15288:2015 Systems and software engineering — System life cycle process;
ISO 90007:2017 Quality management — Guidelines for configuration management;
ISO 24060:2021 Ships and marine technology — Ship software logging system for operational technology.
The list of applicable standards shall not be limited to those mentioned above. Other industry standards, both international and domestic, may also be considered.
7.9.4 System categories.
7.9.4.1 Computer-based systems shall be divided into three categories, as specified in Table 7.9.4.1, based on the potential severity of consequences if the system serving a particular function fails.

Table 7.9.4.1

System categories

Category	Failure effects	System functionality
I	Systems, failure of which will not lead to dangerous situations for human safety, safety of the ship and/or threat to the environment	Monitoring, informational and administrative functions
II	Systems, failure of which could eventually lead to dangerous situations for human safety, safety of the ship and/or threat to the environment	Ship alarm, monitoring and control functions which are necessary to maintain the ship in its normal operational and habitable conditions
III	Systems, failure of which could immediately lead to dangerous or catastrophic situations for human safety, safety of the ship and/or threat to the environment	Control functions for maintaining the ship's propulsion and steering; Ship safety functions

Notes: 1. Consideration shall be given to the effects immediately caused by such a failure, not to indirect effects.

2. The appropriate redundancy shall not be considered when categorizing a system.

7.9.4.2 Category I systems are normally not subject to verification by the Register, as failure of these systems shall not lead to dangerous situations. However, information pertinent to category I systems shall be submitted on demand to determine the correct category or ensure that they do not influence the operation of systems in category II and category III.

7.9.4.3 The category of a system shall always be evaluated in the context of the specific ship in question; thus, the categorization of a system may vary from one ship to the next. This means that the examples of categories given in Table 7.9.4.2 are for guidance only. For determining the categorization of systems for a specific ship, you shall be guided by the requirements of 7.9.5.3.3.

Table 7.9.4.2

Examples of the categorization of systems

System category	Examples
I	Fuel monitoring system; Maintenance support system; Diagnostics and troubleshooting system; Closed circuit television; Cabin security system; Entertainment system; Fish detection system
II	Fuel oil treatment system; Alarm monitoring and safety systems for propulsion and auxiliary machinery; Inert gas system; Control, monitoring and safety system for cargo containment system

System category	Examples
III	Propulsion control system; Steering gear control system; Electric power system; Dynamic positioning system (IMO classes 2 and 3)

7.9.5 Requirements for development and certification of computer-based system.

7.9.5.1 General requirements.

7.9.5.1.1 Life cycle approach, with appropriate standards in use.

A global top-down approach shall be undertaken in the design and development of both hardware and software and the integration in subsystems, systems, and system of systems, spanning the complete system lifecycle. This approach shall be based on the standards as listed herein or other standards recognized by the Register.

This shall be verified by the Register as a part of the quality management system verification described in 7.9.5.1.2.

7.9.5.1.2 Quality management system.

Systems integrators and system suppliers shall, in the development of computer-based systems for Category II and Category III, comply to a recognized quality standard such as ISO 9001; also incorporating principles of IEC/ISO 90003.

The quality management system shall as a minimum include the following topics, which are applicable for both Category II and Category III systems (see Table 7.9.5.1.2).

Table 7.9.5.1.2

Quality management system

Area		Role	
No.	Topic	System supplier	Systems integrator
1	Responsibilities and competency of the staff	x	x
2	The complete lifecycle of delivered software and of associated hardware	x	x
3	Specific procedure for unique identification of a computer-based system, it's components and versions	x	
4	Creation and update of the ship's system architecture		x
5	Organization set in place for acquisition of software and related hardware from suppliers	x	x
6	Organization set in place for software code writing and verification	x	
7	Organization set in place for system validation before integration in the ship	x	

Area		Role	
No.	Topic	System supplier	Systems integrator
8	Specific procedure for conducting and approving of systems at FAT and SAT	x	x
9	Creation and update of system documentation	x	
10	Specific procedure for software modification and installation on board the ship, including interactions with shipyard and owner	x	x
11	Specific procedures for verification of software code	x	
12	Procedures for integrating systems with other systems and testing of the system of systems for the ship	x	x
13	Procedures for managing changes to software and configurations before FAT	x	
14	Procedures for managing and documenting changes to software and configurations after FAT	x	x
15	Checkpoints for the organization's own follow-up of adherence to the quality management system	x	x

The quality management system may be verified by two alternative means:

.1 the Register confirms that the quality management system is certified as compliant to a recognized standard by an organization with accreditation under a national accreditation scheme;

.2 the Register confirms compliance to a standard through a specific assessment of the quality management system. The documentation requirements shall be defined per case.

7.9.5.2 Requirements for the system supplier.

7.9.5.2.1 Compliance with a quality plan.

The system supplier shall document that the quality management system is applied for the design, construction, delivery, and maintenance of the specific system to be delivered.

All applicable items described in 7.9.5.1.2 (for the system supplier role) shall be demonstrated to exist and being followed, as relevant.

Category I: no documentation required.

Categories II and III: the quality plan shall be available during survey (FAT) or submitted for information on demand (FI).

7.9.5.2.2 Unique identification of systems and software.

A method for unique identification of a system, its different software components and different revisions of the same software component shall be applied. The method shall be applied throughout the lifecycle of the system and the software.

See also 7.9.7.1 for related technical requirements on the system in question.

The documentation of the method is typically a part of the quality management system, see 7.9.5.1.2.

Category I: no verification required.

Categories II and III: application of the identification system is verified as a part of the FAT (see 7.9.5.2.7) and SAT (see 7.9.5.3.6).

7.9.5.2.3 System description.

The system's specification and design shall be determined and documented in the system description. In addition to serve as a specification for the detailed design and implementation, the purpose of the system description is to document that the entire system delivery is according to the specifications and in compliance with applicable rules and regulations.

The system description shall contain information of the following:

.1 purpose and main functions, including any safety aspects;

.2 system category as defined;

.3 key performance characteristics;

.4 compliance with the technical requirements and the Register rules;

.5 user interfaces/mimics;

.6 communication and interface aspects:

identification and description of interfaces to other ship's systems;

.7 hardware-arrangement related aspects:

network-architecture/topology, including all network components like switches, routers, gateways, firewalls, etc.;

internal structure with regards to all interfaces and hardware nodes in the system (e.g. operator stations, displays, computers, programmable devices, sensors, actuators, I/O modules, etc.);

I/O allocation (mapping of field devices to channel, communication link, hardware unit, logic function);

power supply arrangement;

failure mode description.

The information listed above may be presented as several different documents or as several sections of a single document.

Category I: the system description documentation shall be submitted for information on demand (FI).

Categories II and III: the system description documentation shall be submitted for approval (A).

7.9.5.2.4 Environmental compliance of hardware components.

Evidence of environmental type testing according to the requirements of Section 12, Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships regarding the hardware elements included in the system and subsystems shall be submitted to the Register.

Category I: this requirement is not mandatory. Reference to Type approval certificate (CTO) or other evidence of type testing shall be submitted for information on demand (FI), see 7.9.4.2.

Categories II and III: reference to Type approval certificate (CTO) or other evidence of type testing shall be submitted for information (FI).

7.9.5.2.5 Software code creation, parameterization, and testing.

The software created, changed, or configured for the delivery project shall be developed and have the quality assurance activities assessed according to the selected standard(s) as described in the quality plan.

The quality assurance activities may be performed on several levels of the software structure and shall include both custom-made software and configured components (e.g. software libraries) as appropriate.

The verification of the software shall as a minimum verify the following aspects based on black-box methods:

.1 correctness, completeness and consistency of any parameterization and configuration of software components;
.2 intended functionality;
.3 intended robustness.
For components in systems of Category II and III, the scope, purpose, and results of all performed reviews, analyses, tests, and other verification activities shall be documented in test reports.
Some of the methods utilized in this activity are sometimes referred to as "software unit test" or "developer test" and may also include verification methods like code-reviews and static- or dynamic code analysis.
Category I: no documentation required.
Categories II and III: software test reports shall be submitted for information on demand (FI).
7.9.5.2.6 Internal system testing before FAT.
The system shall as far as practicable be tested before the FAT. The main purpose of the system test is for the system supplier to verify that the entire system delivery is according to the specifications, approved documentation and in compliance with applicable rules and regulations; and further, that the system is completed and ready for the FAT.
The testing shall at least verify the following aspects of the system:
.1 functionality;
.2 effect of faults and failures (including diagnostic functions, detection, alerts response);
.3 performance;
.4 integration between software and hardware components;
.5 human-machine interfaces;
.6 interfaces to other systems.
Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response.
Some of the testing may be performed by utilizing simulators and replica hardware.
The test environment shall be documented, including a description of any simulators, emulators, test-stubs, test-management tools, or other tools affecting the test environment and its limitations.
Test cases and test results shall be documented in test programs and test reports respectively.
Category I: no documentation required.
Categories II and III: internal system test report shall be made available during FAT or submitted on demand (FI).
7.9.5.2.7 Factory acceptance testing (FAT) before installation on board.
A factory acceptance test (FAT) shall be arranged for the system in question. The main purpose of the FAT is to demonstrate to the Register that the system is completed and compliant with applicable classification rules, thus enabling issuance of a Register Certificate for the system.
The FAT test program shall cover a representative selection of the test items from the internal system test (see 7.9.5.2.6), including normal system functionality and response to failures.
For Category II and III systems, network testing to verify the network resilience requirements of 7.9.7.2.1 shall be performed. If agreed by all parties, the network testing may be performed as a part of the system test onboard the ship.
The FAT shall as a rule be performed with the project specific software operating on the actual hardware components to be installed on board, with necessary means for simulation of functions and failure responses, however other solutions such as replica hardware or simulated hardware (emulators) may be agreed with the Register.

For each test-case, it shall be noted if the test passed or failed, and the test results be documented in a test report. The test report shall also contain a list of the software (including software versions) that were installed in the system when the test was executed.

For complex systems, there may be a large difference in scope between the "Internal system testing before FAT" activity (see 7.9.5.2.6) and the FAT, while for some systems the scope may be identical.

Category I: no FAT required.

Categories II and III: the FAT program shall be approved (A) before the test is executed. The FAT execution shall be witnessed by the Register. The FAT report shall be submitted for information (FI).

Additional FAT documentation including e.g., user manuals and internal system test report shall be made available during FAT or submitted for information on demand (FI).

7.9.5.2.8 Secure and controlled software installation on the ship.

The initial installation and subsequent updates of the software components of the system shall be done according to the change management procedure, which has been agreed between the system supplier and the systems integrator.

The change management procedure shall comply with the requirements of 7.9.6.

Cyber security measures shall comply with the requirements of Part XXI "Cyber Resilience".

Category I: no verification required.

Categories II and III: the change management procedure shall be submitted for information on demand (FI).

7.9.5.3 Requirements for the systems integrator.

7.9.5.3.1 For the purposes of this Section, the shipyard is considered as the systems integrator in the development and delivery phase unless another organization or a person is explicitly appointed by the shipyard.

7.9.5.3.2 Compliance with a quality plan.

The systems integrator shall document that the quality management system is applied for the installation, integration, completion, and maintenance of the systems to be installed on board. All applicable items described in 7.9.5.1.2 (for the systems integrator role) shall be demonstrated to exist and being followed, as relevant.

Category I: no documentation required.

Categories II and III: the quality plan shall be made available during survey (at SAT/SOST) or submitted for information on demand (FI).

7.9.5.3.3 Determining the category of the system in question.

For each system delivery to a particular ship, it shall be decided which category the system falls under based on the failure effects of the system (see 7.9.4). The category for a specific system shall be conveyed to the relevant system supplier. The Register may decide that a risk-assessment is needed to verify the proper system category.

Category I, II and III: the category for the different systems shall be documented and submitted for approval on demand (A).

7.9.5.3.4 Risk assessment of the system.

If demanded by the Register, a risk assessment of a specific system in context of the specific ship in question shall be performed and documented in order to determine the applicable category for the system.

IEC/ISO31010 "Risk management — Risk assessment techniques" may be used as guidance in order to determine method of risk assessment.

Categories I, II and III: the risk assessment report shall be submitted for approval on demand (A).

7.9.5.3.5 Define the ship's system-architecture.

The system of systems (SoS) shall be specified and documented. This architecture specification provides the basis for category determination and development of the different integrated systems by allocating functionality to individual systems and by identifying the main interfaces between the systems. It shall also serve as a basis for the testing of the integrated systems on the ship level (see 7.9.5.3.7).

The ship's system architecture shall at least contain description of:

.1 overview of the total systems architecture (the system of systems);

.2 each system's purpose and main functionality;

.3 communication and interface aspects between different systems.

Refer to the requirements of Section 2, Part XXI "Cyber Resilience" for diagram of security zones and conduits.

Categories I, II, and III: the ship's system architecture shall be submitted for information on demand (FI).

7.9.5.3.6 System acceptance test (SAT) onboard the ship.

A system acceptance test shall be arranged onboard the ship. The main purpose of the system acceptance test (SAT) is to verify the system functionality, after installation and integration with the applicable machinery/electrical/process systems on board including possible interfaces with other control and monitoring systems.

For each test-case, it shall be noted if the test passed or failed, and the test-results be documented in a test report. The test report shall also contain a list of the software (including software versions) that were installed in the system when the test was executed.

Category I: no verification required.

Categories II and III: the SAT program shall be submitted for approval (A) before the test is executed.

The SAT execution shall be witnessed by the Register. The SAT report shall be submitted for information (FI).

7.9.5.3.7 Testing of integrated systems on ship's level (SOST).

Integration tests shall be conducted after installation and integration of the different systems in its final environment on board. The purpose of the tests is to verify the functionality of the complete installation (system of systems) including all interfaces and inter-dependencies in compliance with requirements and specifications.

The testing shall at least verify the following aspects of the system of systems:

.1 the overall functionality of the interacting systems as a whole;

.2 failure response between systems;

.3 performance;

.4 human-machine interfaces;

.5 interfaces between the different systems.

For complex systems there may be a large difference in scope between the "System acceptance test (SAT) onboard the ship" activity (see 7.9.5.3.6) and the SOST, while for some systems the scope may be overlapping or identical. It is possible to combine the two activities into one when the test scope is similar.

Category I: not required.

Categories II and III: the SOST program shall submitted for approval (A) before the test is executed.

The SOST execution shall be witnessed by the Register. The SOST report shall be submitted for information (FI).

7.9.5.3.8 The change management.

The systems integrator shall follow procedures for the change management to the system as described in 7.9.6.

Category I: no documentation requirements.

Categories II and III: the change management procedure shall be submitted for information on demand (FI).

7.9.6 Requirements for maintenance of computer-based systems.

7.9.6.1 Requirements for the ship owner.

7.9.6.1.1 For the purposes of these Rules, the ship owner is considered to be the systems integrator in the operations phase unless another organization or a person is explicitly appointed by the owner.

Accordingly, the Register shall in a timely manner be informed by the owner about the appointed systems integrator which is responsible for implementing any changes to the systems in conjunction with system supplier(s).

7.9.6.2 Requirements for the systems integrator.

7.9.6.2.1 The change management.

The systems integrator shall ensure that necessary procedures for software and hardware change management exist on board, and that any software modification/upgrade are performed according to the procedure(s). For details about the change management, see 7.9.7.

Changes to computer-based systems in the operational phase shall be recorded.

The records shall contain information about the relevant software versions and other relevant information as described in 7.9.7.9.

Category I: no documentation requirements.

Categories II and III: see 7.9.7.12.

7.9.6.3 Requirements for the system supplier.

7.9.6.3.1 The change management.

The system supplier shall follow procedures for maintenance of the system including procedures for the change management as described in 7.9.7.

Category I: no documentation required.

Categories II and III: see 7.9.7.12.

7.9.6.3.2 Testing of changes before installation onboard.

The system supplier shall make sure that the planned changes to a system have passed relevant in-house tests before the change is made to systems on board.

Category I: no documentation requirements.

Categories II and III: see 7.9.7.12.

7.9.7 The change management.

7.9.7.1 General.

Requirements for the change management throughout the lifecycle of a computer-based system. Different procedures for the change management may be defined for specific phases in a system's lifecycle as the different phases typically involve different stakeholders. The Register's verification is described in 7.9.7.12.

7.9.7.2 Documented change management procedures.

The organization in question shall have defined and documented change management procedures applicable for the computer-based system in question covering both hardware and software. After FAT, the system supplier shall manage all changes to the system in accordance with the procedure. Examples could be qualification of new versions of acquired software, new hardware, modified control logic, changes to configurable parameters.

The procedure(s) shall at least describe the activities listed in 7.9.7.3 — 7.9.7.9. The outcome of the impact analysis in 7.9.7.8 will determine to what extent the activities in 7.9.7.3 — 7.9.7.12 shall be performed. Change records (see 7.9.7.9) shall always be produced.

7.9.7.3 Agreement between relevant stakeholders.

The change management process shall be coordinated and agreed between the relevant stakeholders along the different stages of the lifecycle of the computer-based system.

Typically, the change management shall address at least three different stages:

.1 development and internal verification before FAT, with involvement of the system supplier and subsuppliers;

.2 from FAT to handover of the ship to the owner, with involvement of the system supplier, the systems integrator, the Register, and the owner;

.3 in operation, with involvement of the system supplier, service suppliers, the owner, and the Register.

7.9.7.4 The change management of approved software.

If changes are required for a system after it has been approved by applicable stakeholders (typically, by the systems integrator and the Register at FAT) the modifications shall follow the defined change management procedures.

7.9.7.5 Unique identification of system and software versions.

The system supplier shall make sure that each system and software version is uniquely identifiable, see 7.9.5.2.2.

7.9.7.6 Handling of software master files.

There shall be defined mechanisms for handling of the files that constitutes the master files for a software component. Authorities of the personnel shall be clearly defined along with the tools and mechanisms used to ensure the integrity of the master files.

7.9.7.7 Backup and restoration of onboard software.

It shall be clearly defined how to perform backup and restoration of the software components of a computer-based system onboard the ship.

7.9.7.8 Impact analysis before a change is made.

Before a change to the system is made, an impact analysis shall be performed in order to:

.1 determine the criticality of the change;

.2 determine the impact on existing documentation;

.3 determine the needed verification and test activities;

.4 determine the need to inform other stakeholders about the change;

.5 determine the need to obtain approval from other stakeholders (e.g. the Register and/or the owner) before the change is made.

7.9.7.9 Rollback in case of failed software changes.

When maintenance includes installation of new versions of the software in the system, it shall be possible to perform a rollback of the software to the previous installed version with the purpose of returning the system to a known, stable state.

Rollbacks shall be documented and analyzed to find and eliminate the root cause.

7.9.7.10 Verification and validation of system changes.

To the largest degree practically possible, modifications shall be verified before being installed onboard. After installation, the modification(s) shall be verified onboard according to a documented verification program containing:

.1 verification that the new functionalities and/or improvements have had the intended effect;

.2 regression test to verify that the modification has had no negative effects on functionality or capabilities that was not expected to be affected.

7.9.7.9 The change records.

Changes to systems and software shall be documented in the change records to allow for visibility and traceability of the changes. The change records shall contain at least the following items:

.1 the purpose for a change;

.2 a description of the changes and modifications;

.3 the main conclusions from the impact analysis (see 7.9.7.8);

.4 the identity and version of any new system or software version(s) (see 7.9.7.5);

.5 test reports or tests summaries (see 7.9.7.10).

Documentation of the changes to software may be recorded in the planned maintenance system (PMS), in a software registry or equivalent.

7.9.7.12 Verification of the change management by the Register.

7.9.7.12.1 In operation (ship in service) phase.

The verification by the Register regarding the change management in operation is generally performed during the annual survey of the ship. Procedures for the change management and relevant change records (see 7.9.7.9) shall be made available at the time of survey.

In the cases where a change requires approval from the Register up front, the relevant procedures and documentation for the change in question may be verified at that time.

7.9.7.12.2 During newbuilding.

The verification of the change management in the newbuilding phase is divided into two:

procedures are verified as a part of the verification of the quality management system (see 7.9.5.1.2);

project-specific implementation of the procedures is verified during FAT (see 7.9.5.2.7) and after FAT (see 7.9.7.12.1).

7.9.8 Technical requirements for computer-based systems

The below-mentioned are technical requirements for computer-based systems. The compliance to these requirements shall be documented in the design documentation (see 7.9.5.2.3) and verified through the verification activities described in this Section.

7.9.8.1 Reporting of system, software identification, and version.

7.9.8.1.1 System identification.

The system shall provide means to identify its name, version, identifier, and manufacturer. It is recommended that the system can automatically report the status of its software to a ship software logging system (SSLS) as specified in the international standard ISO 24060.

7.9.8.2 Data links.

7.9.8.2.1 General requirements for Category II and III systems.

Loss of a data link shall be specifically addressed in the risk assessment analysis/FMEA (see 7.9.5.2.3).

.1 a single failure in a data link shall not cause loss of ship's functions of Category III. Any effect of such failures shall meet the principle of fail-to-safe for the ship's function(s) being served;

.2 for ship's functions of Category II and III, any loss of functionality in the remote-control system shall be compensated for by local/manual means;

.3 data links shall have means to prevent or cope with excessive communication rates;

.4 data links shall be self-checking, detecting failures or performance issues on the link itself and data communication failures on nodes connected to the link;

.5 detected failures shall initiate an alarm.

7.9.8.2.2 Specific requirements for wireless data links.

.1 Category III systems shall not use wireless data links unless specifically considered by the Register on the basis of an engineering analysis carried out in accordance with an international or a national standard acceptable to the Register;

.2 Other categories of systems may use wireless data links with the following requirements:

recognized international wireless communication system protocols shall be employed, incorporating:

message integrity; fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;

configuration and device authentication; it shall only be permitted to connect devices that are included in the system design;

message encryption; protection of the confidentiality and/or criticality of the data content;

security management; protection of network assets, prevention of unauthorized access to network assets;

.3 The internal wireless system within the ship shall comply with the radio frequency and power level requirements of International Telecommunication Union and flag state requirements;

.4 Consideration shall be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions;

.5 For wireless data communication equipment, tests during harbour and sea trials shall be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not self-fail as a result of electromagnetic interference during expected operating conditions.

7.9.8.3 Verification of technical requirements by the Register.

Implementation of the technical requirements provided in 7.9.8 shall be verified by the Register as part of the system description (see 7.9.5.2.3), FAT (see 7.9.5.2.7), and SAT (see 7.9.5.3.6), as described above.

APPENDIX 1

SUMMARY OF DOCUMENTATION SUBMITTAL

Table 1 and Table 2 below summarize the documentation to be submitted to the Register.

Table 1

Summary of documentation submittal by the system supplier

Item		Responsible role	System category		
Para	Document		**I**	**II**	**III**
7.9.5.2.1	Quality plan	System supplier	—	FI on demand	FI on demand
7.9.5.2.3	System description	System supplier	FI on demand	A	A
7.9.5.2.4	Environmental compliance	System supplier	FI on demand	FI	FI
7.9.5.2.5	Software test report	System supplier	—	FI on demand	FI on demand
7.9.5.2.6	System test report	System supplier	—	FI on demand	FI on demand
7.9.5.2.7	FAT program	System supplier	—	A	A
7.9.5.2.7	FAT report	System supplier	—	FI	FI

Item		Responsible role	System category		
Para	Document		**I**	**II**	**III**
7.9.5.2.7	Additional FAT docs (e.g. user manual, etc.)	System supplier	—	FI on demand	FI on demand
7.9.5.2.8	Change management procedure	System supplier	—	FI on demand	FI on demand
Legend: "A" — Approval; "FI" — For information; "—" — No requirements; "on demand" — Upon demand from the Register					

Table 2

Summary of documentation submittal by the systems integrator

Item		Responsible role	System category		
Para	Document		**I**	**II**	**III**
7.9.5.3.2	Quality plan	Systems integrator	—	FI on demand	FI on demand
7.9.5.3.3	List of system categorizations	Systems integrator	A on demand	A on demand	A on demand
7.9.5.3.4	Risk assessment report	Systems integrator	A on demand	A on demand	A on demand
7.9.5.3.5	Ship’s system architecture	Systems integrator	FI on demand	FI on demand	FI on demand
7.9.5.3.6	SAT program	Systems integrator	—	A	A
7.9.5.3.6	SAT report	Systems integrator	—	FI	FI
7.9.5.3.7	SOST program	Systems integrator	—	A	A

Item		Responsible role	System category		
Para	Document		**I**	**II**	**III**
7.9.5.3.7	SOST report	Systems integrator	—	FI	FI
7.9.5.3.8	Change management procedure for software	Systems integrator	—	FI on demand	FI on demand
Legend: "A" — Approval; "FI" — For information; "—" — No requirements; "on demand" — Upon demand from the Register					

APPENDIX 2

SUMMARY OF TEST WITNESSING AND SURVEY

Table 3 below summarizes the activities that shall be witnessed or surveyed by the Register.

Table 3

Summary of test witnessing and survey

Item		Responsible role	System category		
Para	Activity		**I**	**II**	**III**
7.9.5.2.7	FAT witnessing	System supplier	—	X	X
7.9.5.3.6	SAT witnessing	Systems integrator	—	X	X
7.9.5.3.7	SOST witnessing	Systems integrator	—	X	X
7.9.7.12	Verification of changes	Systems integrator	—	X	X
Legend: "X" — Witnessing required; "—" — Witnessing not required					

".

PART XVII. DISTINGUISHING MARKS AND DESCRIPTIVE NOTATIONS IN THE CLASS NOTATION SPECIFYING STRUCTURAL AND OPERATIONAL PARTICULARS OF SHIPS

1 REQUIREMENTS FOR POLAR CLASS SHIPS

1.2 STRUCTURAL REQUIREMENTS FOR POLAR CLASS SHIPS

Table 1.2.12.4 is replaced by the following text:

"Table 1.2.12.4

Steel grades for weather exposed plating[1]

Thickness t, in mm	Material Class I				Material Class II				Material Class III					
	PC1 to **PC5**		**PC6** and **PC7**		**PC1** to **PC5**		**PC6** and **PC7**		**PC1** to **PC3**		**PC4** and **PC5**		**PC6** and **PC7**	
	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
$t \leq 10$	B	AH	B	AH	B	AH	B	AH	E	EH	E	EH	B	AH
$10 < t \leq 15$	B	AH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$15 < t \leq 20$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$20 < t \leq 25$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$25 < t \leq 30$	D	DH	B	AH	E	EH[2]	D	DH	E	EH	E	EH	E	EH
$30 < t \leq 35$	D	DH	B	AH	E	EH	D	DH	E	EH	E	EH	E	EH
$35 < t \leq 40$	D	DH	D	DH	E	EH	D	DH	-	FH	E	EH	E	EH
$40 < t \leq 45$	E	EH	D	DH	E	EH	D	DH	-	FH	E	EH	E	EH
$45 < t \leq 50$	E	EH	D	DH	E	EH	D	DH	-	FH	-	FH	E	EH

Notes: 1. Includes weather-exposed plating of hull structures and appendages, as well as their outboard framing members, situated above a level of 0,3 m below the lowest ice waterline.
2. Grades D, DH are allowed for a single strake of side shell plating not more than 1,8 m wide from 0,3 m below the lowest ice waterline.

".

Chapter 1.3 is replaced by the following text:

"1.3 REQUIREMENTS FOR MACHINERY OF POLAR CLASS SHIPS

1.3.1 Application.

The requirements of this Chapter apply to main propulsion, steering gear, emergency and auxiliary systems essential for the safety of the ship and the crew.

The ice descriptions for polar class ships are provided in chapter 1.1.

The requirements herein are additional to those applicable for ships without an ice class assigned.

1.3.2 General.

1.3.2.1 The documentation submitted to the Register in accordance with Section 3, Part I "Classification" shall contain the following information with regard to the requirements of this Chapter:

.1 details of the intended environmental operational conditions and the required ice strengthening for the machinery, if different from ship's polar class;

.2 detailed drawings and descriptions of the main propulsion, steering, emergency and auxiliary machinery and information on the essential main propulsion load control functions. The descriptions shall include operational limitations;

.3 description detailing where main, emergency and auxiliary systems are located and how they are protected to prevent problems from freezing, ice and snow accumulation and evidence of their capability to operate in intended environmental conditions;

.4 calculations and documentation indicating compliance with the requirements of this Chapter.

1.3.2.2 System design.

1.3.2.2.1 Systems, subject to damage by freezing, shall be drainable.

1.3.2.2.2 Ships classed **PC1** to **PC5** inclusive shall have means provided to ensure sufficient ship operation in the case of propeller damage including the Controllable Pitch (CP) mechanism. Sufficient ship operation means that the ship shall be able to reach safe haven (safe location) where repairs can be undertaken. This may be achieved either by a temporary repair at sea, or by towing, assuming assistance is available, which has to be approved by the Register.

1.3.2.2.3 Means shall be provided to free a stuck propeller by turning it in reverse direction. This shall also be possible for a propulsion plant intended for unidirectional rotation.

1.3.2.2.4 The propeller shall be fully submerged at the ships LIWL.

1.3.3 Materials.

Materials shall be of an approved ductile material. Ferritic nodular cast iron may be used for parts other than bolts. For nodular cast iron an averaged impact energy value of 10 J at testing temperature is regarded as equivalent to the Charpy V test requirements defined below.

1.3.3.1 Materials exposed to sea water.

Materials exposed to sea water, such as propeller blades, propeller hubs and cast thruster bodies shall have an elongation not less than 15 % on a test specimen according to requirements of 2.2.2 of Part XIII "Materials".

Charpy V-notch impact testing (determination of impact energy KV for sharply-notched specimen) shall be carried out for materials other than bronze and austenitic steel. The tests shall be carried out on three specimens at minus 10 °C, and the average energy value shall be not less than 20 J. However, Charpy V impact test requirements of 3.7 of Part XIII "Materials" or 3.12 of Part XIII "Materials" as applicable for ships with a polar class notation, shall also be applied to ships covered by this Chapter.

1.3.3.2 Materials exposed to sea water temperature.

Charpy V-notch impact testing shall be carried out for materials other than bronze and austenitic steel. The tests shall be carried out on three specimens at minus 10 °C, and the average energy value shall be not less than 20 J. However, the Charpy V impact test requirements of 3.7 of Part XIII "Materials" as applicable for ships with a polar class notation, shall also be applied to ships covered by this Chapter.

This requirement applies to components such as but not limited to blade bolts, CP-mechanisms, shaft bolts, propeller shaft, strut-pod connecting bolts, etc. This requirement does not apply to surface hardened components, such as bearings and gear teeth or sea water cooling lines (heat exchangers, pipes, valves, fittings, etc.). For a definition of structural boundaries exposed to sea water temperature refer to Fig. 1.2.12.3.

1.3.3.3 Materials exposed to low air temperature.

Materials of exposed machinery and foundations shall be manufactured from steel or other approved ductile material. An average impact energy value of 20 J taken from three Charpy V tests shall be obtained at 10 °C below the lowest design temperature. Charpy V impact tests are not required for bronze and austenitic steel.

This requirement does not apply to surface hardened components, such as bearings and gear teeth. For a definition of structural boundaries exposed to air temperature refer to Fig. 1.2.12.3.

1.3.4 Definitions.

1.3.4.1 Definition of symbols.

Table 1.3.4.1

Symbol	Unit	Definition
c	m	Chord length of the blade section

Symbol	Unit	Definition
$c_{0,7}$	m	Chord length of the blade section at 0,7R propeller radius
CP	—	Controllable pitch
d	m	Propeller hub external diameter (at propeller plane)
d_{pin}	mm	Diameter of shear pin
D	m	Propeller diameter
D_{limit}	m	Limit value for the propeller diameter
EAR	—	Expanded blade area ratio
F_b	kN	Maximum backward blade force for the ship's service life (negative sign)
F_{ex}	kN	Ultimate blade load resulting from blade failure through plastic bending
F_f	kN	Maximum forward blade force for the ship's service life (positive sign)
F_{ice}	kN	Ice load
$(F_{ice})_{\max}$	kN	Maximum ice load for the ship's service life
FP	—	Fixed pitch
h_0	m	Depth of the propeller centreline from lower ice waterline (LIWL)
H_{ice}	m	Ice block dimension for propeller load definition
I	kgm^2	Equivalent mass moment of inertia of all parts on engine side of component under consideration
I_t	kgm^2	Equivalent mass moment of inertia of the whole propulsion system
k	—	Shape parameter for Weibull distribution
$LIWL$	—	Lower ice waterline
m	—	Slope for S-N curve in log/log scale
M_{BL}	kNm	Blade bending moment
MCR	—	Maximum continuous rating
n	rev/s	Propeller rotational speed
n_n	rev/s	Nominal rotational propeller speed at MCR, in free running open water conditions
N	—	Number of ice load cycles
N_{class}	—	Reference number of ice impacts per propeller revolution per a polar class
N_{ice}	—	Total number of load cycles on propeller blade for the ship's service life
N_R	—	Reference number of loads for equivalent fatigue stress (10^8 cycles)
N_Q	—	Number of propeller revolution during a milling sequence
$P_{0,7}$	m	Propeller pitch at 0.7 R radius
$P_{0,7b}$	m	Propeller pitch at 0,7 R radius at MCR in bollard condition
$P_{0,7n}$	m	Propeller pitch at 0,7 R radius at MCR in free running condition
PCD	mm	Pitch circle diameter
$Q(\varphi)$	kNm	Torque
$Q_{A\max}$	kNm	Maximum response torque amplitude as a simulation result
$Q_{e\max}$	kNm	Maximum engine torque
$Q_F(\varphi)$	kNm	Ice torque excitation for frequency domain calculations

Symbol	Unit	Definition
Q_{fr}	kNm	Friction torque in pitching mechanism, reduction of spindle torque
$Q_{\max}$	kNm	Maximum torque on a propeller due to propeller-to-ice interaction
Q_{motor}	kNm	Electric motor peak torque
Q_n	kNm	Nominal torque at MCR in free running condition
$Q_r(t)$	kNm	Response torque along the propeller shaft line
Q_{peak}	kNm	Maximum of the response torque $Q_r(t)$
Q_{sex}	kNm	Extreme spindle torque corresponding to the blade failure load F_{ex}
$Q_{s\max}$	kNm	Maximum blade spindle torque for the ship's service life
Q_{vib}	kNm	Vibratory torque at considered component, taken from frequency domain open water TVC
r	m	Blade section radius
R	m	Propeller radius
S	—	Safety factor
S_{fat}	—	Safety factor for fatigue
S_{ice}	—	Ice strength index for blade ice force
t	m	Maximum blade section thickness
T	kN	Hydrodynamic propeller thrust in bollard condition
T_b	kN	Maximum backward propeller ice thrust for the ship's service life
T_f	kN	Maximum forward propeller ice thrust for the ship's service life
$T_{k\max}$	kNm	Maximum torque capacity of flexible coupling
$T_{k\max1}$	kNm	$T_{k\max}$ at N = 5·10^4 load cycles
$T_{k\max2}$	kNm	$T_{k\max}$ at N = 1 load cycle
T_{kv}	kNm	Vibratory torque amplitude at N = 10^6 load cycles
T_n	kN	Nominal propeller thrust at MCR in free running condition
T_r	kN	Maximum response thrust along the shaft line
TVC	—	Torsional vibration calculation
$\Delta T_{k\max}$	kNm	Maximum range of $T_{k\max}$ at N = 5·10^4 load cycles
Z	—	Number of propeller blades
z_{pin}		Number of shear pins
α_i	deg	Duration of propeller blade/ice interaction expressed in rotation angle
γ_ε	—	Reduction factor for fatigue; scatter and test specimen size effect
γ_v	—	Reduction factor for fatigue; variable amplitude loading effect
γ_m	—	Reduction factor for fatigue; mean stress effect
ρ	—	Reduction factor for fatigue correlating the maximum stress amplitude to the equivalent fatigue stress for 10^8 stress cycles
$\sigma_{0,2}$	MPa	Proof yield strength of material at 0,2 % plastic strain
σ_{exp}	MPa	Mean fatigue strength of blade material at 10^8 cycles to failure in sea water
σ_{fat}	MPa	Equivalent fatigue ice load stress amplitude for 10^8 stress cycles
σ_{fl}	MPa	Characteristic fatigue strength for blade material
σ_{ref1}	MPa	Reference stress, equal to $\sigma_{ref1} = 0{,}6\,\sigma_{0,2} + 0{,}4\,\sigma_u$

Symbol	Unit	Definition
σ_{ref2}	MPa	Reference stress, equal to $\sigma_{ref2} = \mathrm{Min}(0{,}7\ \sigma_u, 0{,}6\ \sigma_{0,2} + 0{,}4\ \sigma_u)$
σ_{st}	MPa	Maximum stress, resulting from F_b or F_f
σ_u	MPa	Ultimate tensile strength for blade material
$(\sigma_{ice})_A(N)$	MPa	Blade stress amplitude distribution
$(\sigma_{ice})_{A\max}$	MPa	Maximum ice load stress amplitude at the considered location on the blade
$(\sigma_{ice})_{b\max}$	MPa	Principal stress caused by the maximum backward propeller ice load
$(\sigma_{ice})_{f\max}$	MPa	Principal stress caused by the maximum forward propeller ice load
σ_{mean}	MPa	Mean stress

1.3.4.2 Definition of loads.

Table 1.3.4.2

	Definition	Use of the load in design process
F_b	The maximum lifetime backward force on a propeller blade resulting from propeller-to-ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0.7 R chord line (refer to Fig. 1.3.4.2)	Design force for strength calculation of the propeller blade
F_f	The maximum lifetime forward force on a propeller blade resulting from propeller-to-ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0,7 R chord line	Design force for strength calculation of the propeller blade
$Q_{s\max}$	The maximum lifetime spindle torque on a propeller blade resulting from propeller-to-ice interaction, including hydrodynamic loads on that blade	When designing the propeller strength, the spindle torque is automatically taken into account because the propeller load is acting on the blade as distributed pressure on the leading edge or tip area
T_b	The maximum lifetime thrust on propeller (all blades) resulting from propeller-to-ice interaction. The direction of the thrust is the propeller shaft direction and the force is opposite to the hydrodynamic thrust	Used for estimating of the response thrust T_r. T_b can be used as an estimate of excitation in axial vibration calculations. However, axial vibration calculations are not required by the rules
T_f	The maximum lifetime thrust on propeller (all blades) resulting from propeller-to-ice interaction. The direction of the thrust is the propeller shaft direction acting in the direction of hydrodynamic thrust	Used for estimating of the response thrust T_r. T_f can be used as an estimate of excitation in axial vibration calculations. However, axial vibration calculations are not required by the rules
$Q_{\max}$	The maximum ice-induced torque resulting from propeller-to-ice interaction on one propeller blade, including hydrodynamic loads on that blade	Used for estimating of the response torque (Q_r) along the propulsion shaft line and as excitation for torsional vibration calculations
F_{ex}	Ultimate blade load resulting from blade loss through plastic bending. The force that is needed to cause total failure of the blade so	Blade failure load is used to dimension the blade bolts, pitch control mechanism, propeller shaft, propeller shaft bearing and trust bearing. The objective shall guarantee

	Definition	Use of the load in design process
	that plastic hinge appear in the root area. The force is acting on 0,8 R	that total propeller blade failure does not lead to damage to other components
Q_{sex}	Maximum spindle torque resulting from blade failure load	Used to ensure pyramid strength principle for the pitching mechanism
Q_r	Maximum response torque along the propeller shaft line, with account for the dynamic behaviour of the shaft line for ice excitation (torsional vibration) and hydrodynamic mean torque on propeller	Design torque for propeller shaft line components
T_r	Maximum response thrust along shaft line, with account for the dynamic behaviour of the shaft line for ice excitation (axial vibration) and hydrodynamic mean thrust on propeller	Design thrust for propeller shaft line components

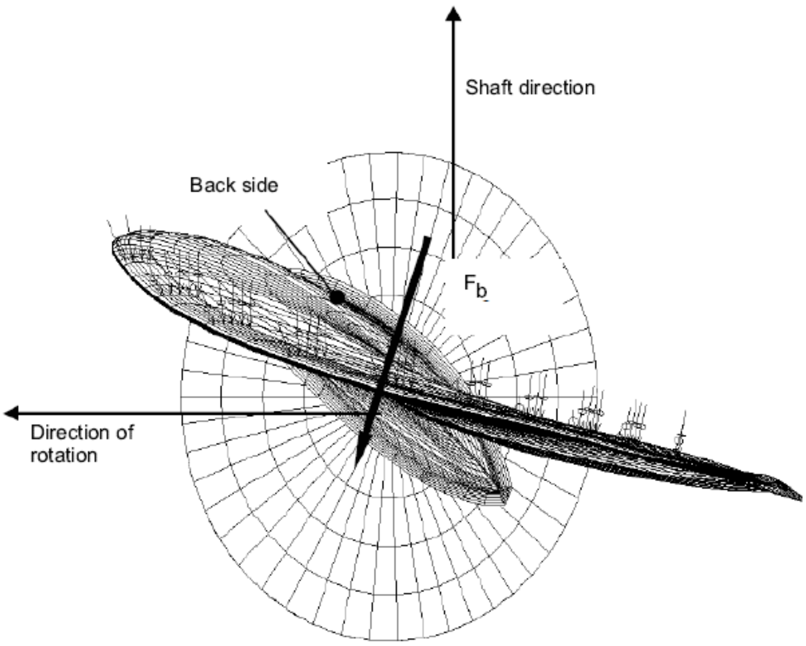


Fig. 1.3.4.2
Direction of the backward blade force resultant taken perpendicular to chord line at radius 0,7 R.
Ice contact pressure at the leading edge is shown with small arrows

1.3.5 Design ice loads.

1.3.5.1 General.

1.3.5.1.1 The present requirements cover open and ducted type propellers situated at the stern of a ship having controllable pitch or fixed pitch blades. Ice loads on bow-mounted propellers shall be agreed with the Register.

1.3.5.1.2 The given loads are expected, single occurrence, maximum values for the whole ship's service life for normal operational conditions, including loads resulting from directional change of rotation where applicable. These loads do not cover off-design operational conditions, for example when a stopped propeller is dragged through ice.

1.3.5.1.3 These requirements also cover loads due to propeller ice interaction for azimuthing and fixed thrusters with geared transmission or an integrated electric motor ("geared and podded propulsors"). However, the load models of the regulations do not include propeller-to-ice interaction loads when ice enters the propeller of a turned azimuthing thruster from the side (radially) or loads when ice blocks hit on the propeller hub of a pulling propeller. Ice loads resulting from ice impacts on the body of thrusters shall be estimated on a case-by-case basis, considering provisions of Section 6 of the Rules for Active Means of Polar Class Ships' Steering.

1.3.5.1.4 The loads given in 1.3.5.3 are total loads including ice-induced loads and hydrodynamic loads (unless otherwise stated) during ice interaction and shall be applied separately (unless otherwise stated) and are intended for component strength calculations only.

F_b is the maximum force experienced during the lifetime of the ship that bends a propeller blade backwards when the propeller mills an ice block while rotating ahead.

F_f is the maximum force experienced during the lifetime of the ship that bends a propeller blade forwards when the propeller mills an ice block while rotating ahead.

F_b and F_f originate from different propeller-to-ice interaction phenomena, which do not act simultaneously. Hence, they shall be applied separately.

1.3.5.2 Polar class factors.

The dimensions of the considered design ice block are $H_{ice} \times 2 \cdot H_{ice} \times 3 \cdot H_{ice}$. The design ice block and ice strength index S_{ice} are used for the estimation of the propeller-to-ice loads. Both H_{ice} and S_{ice} are defined for each polar class in Table 1.3.5.2.

Table 1.3.5.2

Design polar-class factors

Polar class	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
H_{ice}, in m	4,00	3,50	3,00	2,50	2,00	1,75	1,50
S_{ice}	1,20	1,10	1,10	1,10	1,10	1,00	1,00

1.3.5.3 Propeller-to-ice interaction loads.

1.3.5.3.1 Maximum backward blade force F_b for open propellers.

The maximum backward blade force F_b, in kN, for open propellers is equal to:

when $D < D_{limit}$: $$F_b = 27S_{ice}(nD)^{0,7}\left(\frac{EAR}{Z}\right)^{0,3}D^2, \qquad (1.3.5.3.1\text{-}1)$$

when $D \geq D_{limit}$: $$F_b = 23S_{ice}(nD)^{0,7}\cdot\left(\frac{EAR}{Z}\right)^{0,3}(H_{ice})^{1,4}D, \qquad (1.3.5.3.1\text{-}2)$$

where D_{limit} = 0,85 $(H_{ice})^{1,4}$, in m;
n = nominal rotational speed at MCR in free running open water condition_in rps, taken as follows:
$n = n_n$ for CP propellers;
$n = 0{,}85n_n$ for FP propellers.

For ships with the additional notation **Icebreaker**, the above stated backward blade force F_b shall be multiplied by a factor of 1,1.

1.3.5.3.2 Maximum forward blade force F_f for open propellers.

The maximum forward blade force F_f, in kN, for open propellers is equal to:

when $D < D_{limit}$: $$F_f = 250\frac{EAR}{Z}D^2, \qquad (1.3.5.3.2\text{-}1)$$

when $D \geq D_{limit}$: $F_f = 500 \frac{1}{1-\frac{d}{D}} H_{ice} \frac{EAR}{Z} D$, (1.3.5.3.2-2)

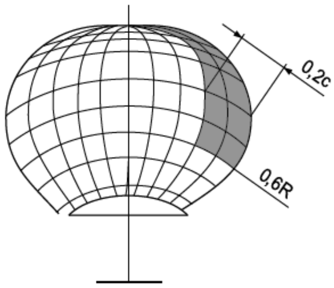
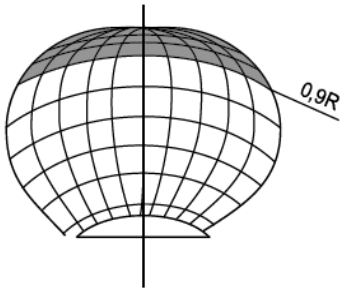
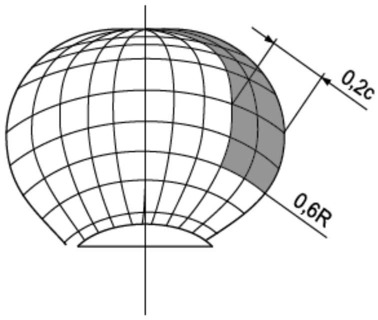
where $D_{limit} = \frac{2}{1-\frac{d}{D}} H_{ice}$.

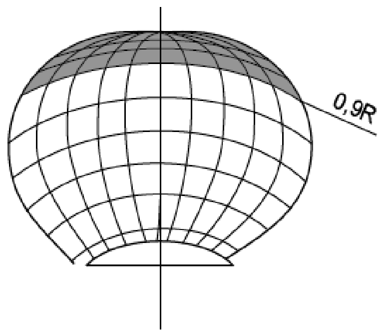
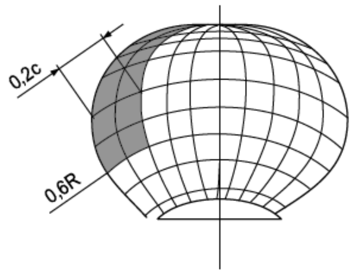
1.3.5.3.3 Loaded area on the blade for open propellers.

Load cases 1 to 4 given in Table 1.3.5.3.3 shall be verified for both the CP and FP propellers. In order to obtain blade ice loads for a reversing propeller, load case 5 shall also be checked for propellers where reversing is possible.

Table 1.3.5.3.3

Loaded areas and load case definition for open propeller

Load case No.	Force	Loaded area	Right handed propeller blade seen from behind
1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6·R to the tip and from the leading edge to 0,2 times the chord length	
2	$0{,}5F_b$	Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside of 0,9·R radius	
3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6·R to the tip and from the leading edge to 0,2 times the chord length	

Load case No.	Force	Loaded area	Right handed propeller blade seen from behind
4	$0{,}5F_f$	Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside 0,9·R radius	
5	$0{,}6\ \mathrm{Max}(F_b, F_f)$	Uniform pressure applied on propeller face (pressure side) to an area from 0,6·R to the tip and from the trailing edge to 0,2 times the chord length	

1.3.5.3.4 Maximum backward blade force F_b for ducted propellers.
The maximum backward blade force F_b, in kN, for ducted propellers is equal to:

when $D < D_{limit}$: $$F_b = 9{,}5\, S_{ice}(nD)^{0{,}7}\left(\frac{EAR}{Z}\right)^{0{,}3} D^2, \qquad (1.3.5.3.4\text{-}1)$$

when $D \geq D_{limit}$: $$F_b = 66\, S_{ice}(nD)^{0{,}7}\left(\frac{EAR}{Z}\right)^{0{,}3} (H_{ice})^{1{,}4} D^{0{,}6}, \qquad (1.3.5.3.4\text{-}2)$$

where D_{limit} = $4 \cdot H_{ice}$, in m;
n = nominal rotational speed at MCR in free running open water condition in rps, taken as follows:
$n = n_n$ for CP propellers;
$n = 0{,}85 n_n$ for FP propellers.

For ships with the additional notation **Icebreaker**, the above stated backward blade force F_b shall be multiplied by a factor of 1.1.

1.3.5.3.5 Maximum forward blade force F_f for ducted propellers.
The maximum forward blade force F_f, in kN, for ducted propellers is equal to:

when $D \leq D_{limit}$: $$F_f = 250\frac{EAR}{Z}D^2, \qquad (1.3.5.3.5\text{-}1)$$

when $D > D_{limit}$: $$F_f = 500\frac{1}{1-\frac{d}{D}}\, H_{ice}\frac{EAR}{Z}D, \qquad (1.3.5.3.5\text{-}2)$$

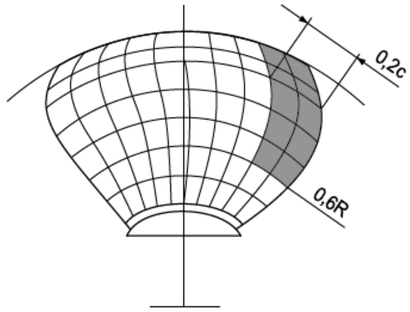
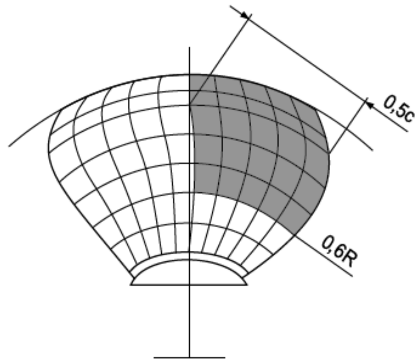
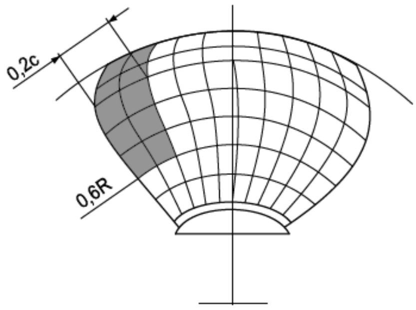
where $D_{limit} = \frac{2}{1-\frac{d}{D}}\, H_{ice}$.

1.3.5.3.6 Loaded area on the blade for ducted propellers.

Load cases 1 and 3 given in Table 1.3.5.3.6 shall be verified for all propellers. In order to obtain blade ice loads for a reversing propeller, the load case 5 shall also be covered for propellers where reversing is possible.

Table 1.3.5.3.6

Loaded areas and load case definition for ducted propeller

Load case No.	Force	Loaded area	Right handed propeller blade seen from behind
1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6·R to the tip and from the leading edge to 0,2 times the chord length	
3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6·R to the tip and from the leading edge to 0,5 times the chord length	
5	0,6 $\text{Max}(F_b, F_f)$	Uniform pressure applied on propeller face (pressure side) to an area from 0,6·R to the tip and from the trailing edge to 0,2 times the chord length	

1.3.5.3.7 Maximum blade spindle torque $Q_{s\max}$ for open and ducted propeller.

The spindle torque $Q_{s\max}$ around the axis of the blade fitting shall be calculated both for the maximum backward blade force F_b and forward blade force F_f, which are applied as per Tables 1.3.5.3.3 and 1.3.5.3.6.

If the above method gives a value which is less than the default value given by the formula below, in kNm, the default value shall be used.

$$Q_{s\max-Def} = 0{,}25 \cdot F \cdot c_{0,7}, \qquad (1.3.5.3.7\text{-}1)$$

where $F = \text{Max}[|F_b|, |F_f|]$. (1.3.5.3.7-2)

1.3.5.3.8 Load distributions (spectra) for blade loads.

The Weibull-type distribution, probability that F_{ice} exceeds $(F_{ice})_{\max}$, as given in Fig. 1.3.5.3.8, is used for the fatigue design of the blade.

$$P\left[\frac{F_{ice}}{(F_{ice})_{\max}} \geq \frac{F}{(F_{ice})_{\max}}\right] = e^{-\left(\frac{F}{(F_{ice})_{\max}}\right)^{k}\ln(N_{ice})}, \qquad (1.3.5.3.8\text{-}1)$$

where k = shape parameter of the spectrum;
N_{ice} = number of load cycles in the spectrum, as defined in 1.3.5.3.9;
F_{ice} = random variable for ice loads on the blade, such as $0 \leq F_{ice} \leq (F_{ice})_{\max}$.

The resulting blade stress amplitude distribution is given by the following formula:

$$(\sigma_{ice})_A(N) = (\sigma_{ice})_{A\max}\left(1 - \frac{\log(N)}{\log(N_{ice})}\right)^{1/k}, \qquad (1.3.5.3.8\text{-}2)$$

where $(\sigma_{ice})_{A\max}$ = maximum ice load stress amplitude at the considered location on the blade, in MPa, as given by:

$$(\sigma_{ice})_{A\max} = \frac{(\sigma_{ice})_{f\max} - (\sigma_{ice})_{b\max}}{2};$$

k = shape parameter for the ice force distribution to be taken as:
for open propeller k = 0,75;
for ducted propeller k = 1,0.

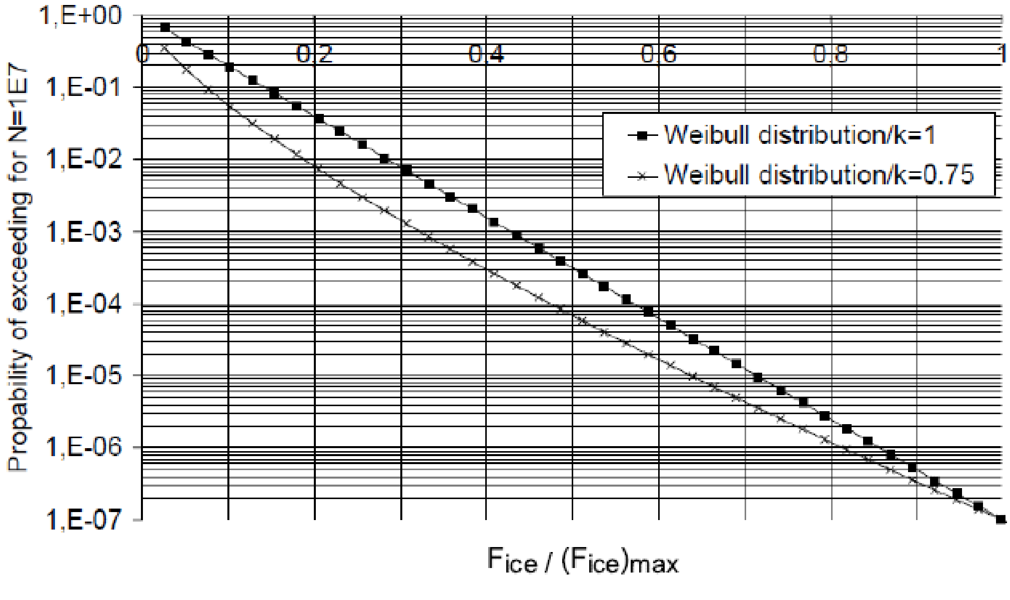


Fig. 1.3.5.3.8
Weibull-type distribution for fatigue design

1.3.5.3.9 Number of ice loads.

The number of load cycles, N_{ice}, used in the load spectrum per blade is given by the following formula:

$$N_{ice} = k_1 k_2 N_{class} n, \qquad (1.3.5.3.9)$$

where k_1 = coefficient defined as:
k_1 = 1 for centre propeller;

k_1 = 2 for wing propeller;
k_1 = 3 for pulling propeller, wing and centre;
k_2 = coefficient defined as:
$k_2 = 0{,}8 - f$ for $f < 0$;
$k_2 = 0{,}8 - 0{,}4f$ for $0 \leq f \leq 1$;
$k_2 = 0{,}6 - 0{,}2f$ for $1 < f \leq 2{,}5$;
$k_2 = 0{,}1$ for $f > 2{,}5$;

f = coefficient taken equal to $f = \frac{h_0 - H_{ice}}{D/2} - 1$;
when h_0 is unknown, $h_0 = D/2$;
N_{class} = reference number of impacts per propeller revolution for each polar class taken according to Table 1.3.5.3.9.

For components that are subject to loads resulting from propeller-to-ice interaction with all the propeller blades, the number of load cycles, N_{ice}, shall be multiplied by the number of propeller blades, Z.

Table 1.3.5.3.9

Reference number of impacts

Polar class	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
N_{class}	$21{\cdot}10^6$	$17{\cdot}10^6$	$15{\cdot}10^6$	$13{\cdot}10^6$	$11{\cdot}10^6$	$9{\cdot}10^6$	$6{\cdot}10^6$

1.3.5.4 Blade failure load for both open and ducted propellers.

1.3.5.4.1 Bending force F_{ex}.

The minimum load required resulting in blade failure through plastic bending shall be calculated iteratively along the radius of the blade from blade root to 0,5 R using the following formula with the ultimate load assumed to be acting at 0,8 R in the weakest direction.

$$F_{ex} = \frac{0{,}3ct^2}{0{,}8D - 2r}\sigma_{ref1}10^3, \quad (1.3.5.4.1)$$

where F_{ex} = blade failure load, in kN;
c = chord length of the considered blade section, in m;
c, t, r = values as defined in Symbols taken at the cylindrical root section of the blade, i.e. at the weakest section outside the root fillet located typically at the termination of the fillet into the blade profile;
$\sigma_{ref1} = 0{,}6 \cdot \sigma_{0,2} + 0{,}4 \cdot \sigma_u$ in [MPa],
where σ_u (minimum ultimate tensile strength to be specified on the drawing) and $\sigma_{0,2}$ (minimum yield or 0,2 % proof strength to be specified on the drawing) are representative values for the blade material.

Register may approve alternative means of failure load calculation by means of an appropriate stress analysis reflecting the non-linear plastic material behaviour of the actual blade. A blade is regarded as having failed, if the tip is bent by more than 10 % of the propeller diameter.

1.3.5.4.2 Spindle torque Q_{sex}.

The force that causes blade failure typically reduces when moving from the propeller centre towards the leading and trailing edges. The maximum spindle torque occurs at a certain distance from the blade centre of rotation.

The maximum spindle torque, Q_{sex}, due to a blade failure load acting at 0,8 R is defined either by an appropriate stress analysis or with the following formula:

$$Q_{sex} = \mathrm{Max}(c_{LE0,8}; 0{,}8 \cdot c_{TE0,8}) \cdot C_{spex} \cdot F_{ex}, \quad (1.3.5.4.2)$$

where $c_{LE0,8}$ = leading edge portion of the chord length at 0,8$\cdot R$;

$c_{TE0,8}$ = trailing edge portion of the chord length at 0,8·R;
C_{spex} = coefficient defined by the following formula without being less than 0,3:
$C_{spex} = C_{sp} \cdot C_{fex}$,
where C_{sp} = non-dimensional parameter with account for the spindle arm equal to 0,7;
C_{fex} = non-dimensional parameter with account for the reduction of blade failure force at the location of maximum spindle torque, taken as:
$C_{fex} = 1 - \left(4 \cdot \frac{EAR}{Z}\right)^3$.

Figure 1.3.5.4.2 illustrates the spindle torque values due to blade failure loads across the whole chord length.

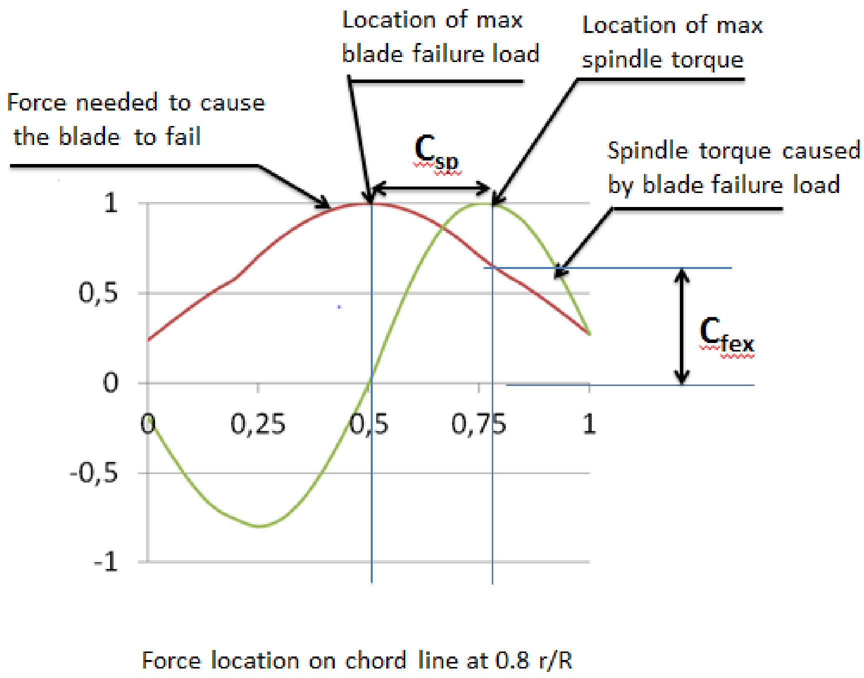


Fig. 1.3.5.4.2
Force location on chord line at 0,8 r/R. Schematic figure showing the blade failure load and the related spindle torque when the force acts at different location on the chord line at radius 0,8 R

1.3.5.5 Axial design loads acting on open and ducted propellers.

1.3.5.5.1 Maximum ice thrust acting on open and ducted propellers.

The maximum forward and backward ice thrusts, T_f and T_b, in kN, acting on open or ducted propellers are given by the following formula:

$$T_f = 1{,}1 \cdot F_f, \quad (1.3.5.5.1\text{-}1)$$
$$T_b = 1{,}1 \cdot F_b. \quad (1.3.5.5.1\text{-}2)$$

However, the attention is drawn that the load models within this Chapter do not include propeller-to-ice interaction loads where an ice block hits the propeller hub of a pulling propeller.

1.3.5.5.2 Design thrust along the propulsion shaft line for open and ducted propellers.

The design thrust along the propeller shaft line, T_r, in kN, shall be calculated with the following formulae. The greater value of the forward and backward directional loads shall be taken as the design load for both directions. Factors 2,2 and 1,5 take into account the dynamic magnification resulting from axial vibration.

In forward direction:

$$T_r = T + 2,2 \cdot T_f; \qquad (1.3.5.5.2\text{-}1)$$

in backward direction:

$$T_r = 1,5 \cdot T_b, \qquad (1.3.5.5.2\text{-}2)$$

where T = hydrodynamic bollard thrust, in kN.

When the hydrodynamic bollard thrust is unknown, T shall be taken from Table 1.3.5.5.2.

Table 1.3.5.5.2

Guidance for hydrodynamic bollard thrust values

Propeller type		T[1]
CP propellers	Open	1,25 T_n
	Ducted	1,1 T_n
FP propellers driven by turbine or electrical motor		T_n
FP propellers driven by diesel engine	Open	0,85 T_n
	Ducted	0,75 T_n
[1] T_n — the nominal propeller thrust at MCR in the free running open water condition		

For pulling type propellers, ice interaction loads on propeller hub shall be considered in addition to the above and to be submitted to the Register for consideration.

1.3.5.6 Torsional design loads acting on open and ducted propellers.

1.3.5.6.1 Design ice torque on propellers.

The design ice torque, $Q_{\max}$, in kNm, acting on propellers is equal to:

when $D < D_{limit}$:

$$Q_{\max} = k_{prop} \cdot \left(1 - \frac{d}{D}\right) \cdot \left(\frac{P_{0,7}}{D}\right)^{0,16} \cdot (nD)^{0,17} \cdot D^3; \qquad (1.3.5.6.1\text{-}1)$$

when $D \geq D_{limit}$:

$$Q_{\max} = 1,9 \cdot k_{prop} \cdot \left(1 - \frac{d}{D}\right) \cdot H_{ice}^{1,1} \cdot \left(\frac{P_{0,7}}{D}\right)^{0,16} \cdot (nD)^{0,17} \cdot D^{1,9}, \qquad (1.3.5.6.1\text{-}2)$$

where D_{limit} = $1,8\ H_{ice}$;

k_{prop} = coefficient depending on the propeller type and taken as:

$k_{prop} = k_{open}$ for open propeller;

$k_{prop} = k_{ducted}$ for ducted propeller;

k_{open} = coefficient taken as:

$k_{open} = 14,7$ for **PC1** to **PC5**;

$k_{open} = 10,9$ for **PC6** and **PC7**;

k_{ducted} = coefficient taken as:

$k_{ducted} = 10,4$ for **PC1** to **PC5**;

$k_{ducted} = 7,7$ for **PC6** and **PC7**;

n = rotational propeller speed in bollard condition, in rps;
If unknown, n shall be taken from Table 1.3.5.6.1.

For CP propellers, the propeller pitch $P_{0,7}$ shall correspond to MCR in bollard condition. If not known, $P_{0,7}$ shall be taken as 0,7 $P_{0,7n}$ where $P_{0,7n}$ is the propeller pitch at MCR in free running condition.

Table 1.3.5.6.1

Guidance for rotational propeller speed n

Propeller type	n
CP propellers	n_n
FP propellers driven by turbine or electrical motor	n_n
FP propellers driven by diesel engine	0,85 n_n

1.3.5.6.2 Ice torque excitation for open and ducted propellers.

The given excitations are used to estimate the maximum torque likely to be experienced once during the service life of the ship. The following load cases are intended to reflect the operational loads on the propulsion system when the propeller interacts with ice and the corresponding reaction of the complete system. The ice impact and system response cause loads in the individual shaft line components. The ice torque $Q_{\max}$ may be taken as a constant value in the complete speed range. When considerations at specific shaft speeds are performed a relevant $Q_{\max}$ may be calculated using the relevant speed.

Diesel engine plants without an elastic coupling shall be calculated at the least favourable phase angle for ice versus engine excitation, when calculated in time domain. The engine firing pulses shall be included in the calculations and their standard steady state harmonics can be used. A phase angle between ice and gas force excitation does not need to be regarded in frequency domain analysis. Misfiring does not need to be considered.

If there is a blade order resonance just above MCR speed, calculations shall cover the rotational speeds up to 105 % of MCR speed.

Refer also to guidelines for calculations given in 1.3.5.7.

1.3.5.6.2.1 Excitation for the time domain calculation.

The propeller ice torque excitation for shaft line transient dynamic analysis (time domain) is defined as a sequence of blade impacts which are of half sine shape and occur at the blade. The torque due to a single blade ice impact as a function of the propeller rotation angle is then defined as:

when φ rotates from 0 to α_i plus integer revolutions:

$$Q(\varphi) = C_q \cdot Q_{\max} \cdot \sin\left(\varphi \frac{180}{\alpha_i}\right), \qquad (1.3.5.6.2.1\text{-}1)$$

when φ rotates from α_i to 360 plus integer revolutions:

$$Q(\varphi) = 0, \qquad (1.3.5.6.2.1\text{-}2)$$

where φ = rotation angle, in deg, starting when the first ice impact occurs;

C_q = parameter given in Table 1.3.5.6.2.1;

α_i = duration of propeller blade/ice interaction expressed in propeller rotation angle, given in Table 1.3.5.6.2.1, in deg.

The total ice torque is obtained by summing the torque of single blades, with account for the phase shift $360/Z$, in deg.

At the beginning and at the end of the milling sequence (within calculated duration), linear ramp functions shall be used to increase C_q to its maximum within one propeller revolution and vice versa to decrease it to zero.

The number of propeller revolutions during a milling sequence shall be obtained from the formula:

$$N_q = 2 \cdot H_{ice}, \qquad (1.3.5.6.2.1\text{-}3)$$

with $Z \cdot N_Q$ = number of impacts for blade order excitation.

An illustration of all excitation cases for different blade numbers is given in the Appendix.

The dynamic simulation shall be performed for all excitation cases starting at MCR nominal, MCR bollard condition and just above all resonance speeds (1st engine and 1st blade harmonic), so that the resonant vibration responses can be obtained. For a fixed pitch propeller plant the dynamic simulation is also to cover bollard pull condition with a corresponding speed assuming maximum possible output of the engine.

If a speed drop occurs down to stand still of the main engine, it indicates that the engine may not be sufficiently powered for the intended service task. For the consideration of loads, the maximum occurring torque during the speed drop process shall be applied. The excitation shall follow the shaft speed, if a speed drop occurs.

Table 1.3.5.6.2.1

Ice impact magnification and duration factors for different blade numbers

Torque excitation	Propeller-to-ice interaction	C_q	α_i, in deg			
			$Z = 3$	$Z = 4$	$Z = 5$	$Z = 6$
Case 1	Single ice block	0,75	90	90	72	60
Case 2	Single ice block	1,00	135	135	135	135
Case 3	Two ice blocks (phase shift 360/(2·Z) deg.)	0,50	45	45	36	30
Case 4	Single ice block	0,50	45	45	36	30

1.3.5.6.2.2 Frequency domain excitation.

For frequency domain calculations the following torque excitation, $Q_F(\varphi)$, may be used. The excitation has been derived so that the time domain half sine impact sequences have been assumed to be continuous and the Fourier series components for blade order and twice the blade order components have been derived. The frequency domain analysis is generally considered as conservative compared to the time domain simulation provided there is a first blade order resonance in the considered speed range.

$$Q_F(\varphi) = Q_{\max}\left[C_{q0} + C_{q1} \cdot \sin(Z \cdot E_0 \cdot \varphi + \alpha_1) + C_{q2} \cdot \sin(2 \cdot Z \cdot E_0 \cdot \varphi + \alpha_2)\right], \qquad (1.3.5.6.2.2\text{-}1)$$

where C_{q1} = mean torque component given in Table 1.3.5.6.2.2;
C_{q0} = first blade order excitation amplitude given in Table 1.3.5.6.2.2;
C_{q2} = second blade order excitation amplitude given in Table 1.3.5.6.2.2;
φ = rotation angle, in deg;
α_1, α_2 = phase angles of excitation component given in Table 1.3.5.6.2.2;
Z = number of blades.

Torsional vibration responses shall be calculated for all excitation cases.

The results of the relevant excitation cases at the most critical rotational speeds shall be used in the following way:

The highest response torque (between the various lumped masses in the system) is in the following referred to as peak torque Q_{peak}.

The highest torque amplitude during a sequence of impacts shall be determined as half of the range from max to min torque and is referred to as $Q_{A\max}$, that can be determined, in kNm, by the following formula:

$$Q_{A\max} = \frac{\mathrm{Max}[Q_r(time)] - \mathrm{Min}[Q_r(time)]}{2}. \qquad (1.3.5.6.2.2\text{-}2)$$

An illustration of $Q_{A\max}$ is given in Fig. 1.3.5.6.2.2.

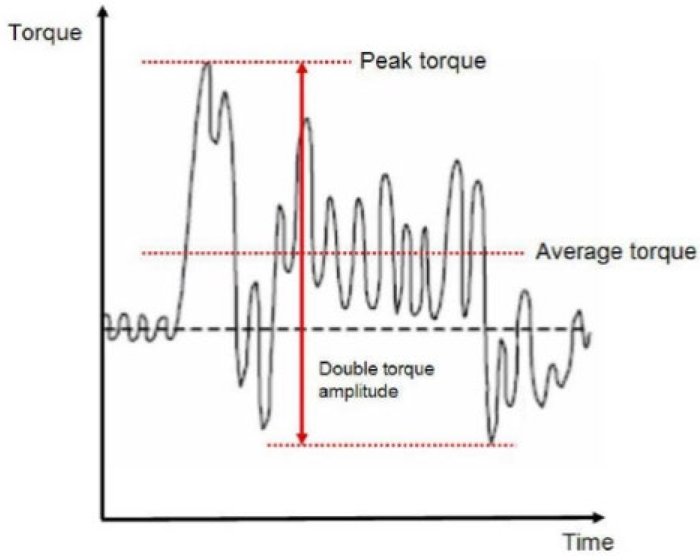


Fig. 1.3.5.6.2.2
Interpretation of different torques in a measured curve, as example

Table 1.3.5.6.2.2
Coefficients for simplified excitation torque estimation

No. of blades, Z	Excitation Case	C_{q0}	C_{q1}	α_1	C_{q2}	α_2	E_0
3	1	0,3750	0,375	-90	0,0000	0	1
	2	0,7000	0,330	-90	0,0500	-45	1
	3	0,2500	0,250	-90	0,0000	0	2
	4	0,2000	0,250	0	0,0500	-90	1
4	1	0,4500	0,360	-90	0,0600	-90	1
	2	0,9375	0,000	-90	0,0625	-90	1
	3	0,2500	0,251	-90	0,0000	0	2
	4	0,2000	0,250	0	0,0500	-90	1
5	1	0,4500	0,360	-90	0,0600	-90	1
	2	1,1900	0,170	-90	0,0200	-90	1
	3	0,3000	0,250	-90	0,0480	-90	2
	4	0,2000	0,250	0	0,0500	-90	1
6	1	0,4500	0,375	-90	0,0500	-90	1
	2	1,4350	0,100	-90	0,0000	0	1
	3	0,3000	0,250	-90	0,0480	-90	2
	4	0,2000	0,250	0	0,0500	-90	1

1.3.5.6.3 Design torque along shaft line.

1.3.5.6.3.1 If there is no relevant first order propeller torsional resonance in the range 20 % of n_n above and 20 % below the maximum operating speed in bollard condition (refer to Table 1.3.5.6.1.), the following estimation of the maximum response torque Q_r, in kNm, can be used to calculate the design torque along the propeller shaft line:

For directly coupled two stroke diesel engines without flexible coupling:

$$Q_r = Q_{e\max} + Q_{vib} + Q_{\max} \cdot \frac{I}{I_t}; \quad (1.3.5.6.3.1\text{-}1)$$

for all other plants:

$$Q_r = Q_{e\max} + Q_{\max} \cdot \frac{I}{I_t}, \quad (1.3.5.6.2.2\text{-}2)$$

where I = equivalent mass moment of inertia of all parts on engine side of component under consideration;
I_t = equivalent mass moment of inertia of the whole propulsion system;
$Q_{e\max}$ = maximum torque, in kNm.

If $Q_{e\max}$, is not known, it shall be taken as follows:
$Q_{e\max} = Q_{motor}$ for propellers driven by electric motor, where Q_{motor} is the electric motor peak torque, in kNm,
$Q_{e\max} = Q_n$ for CP propellers not driven by electric motor,
$Q_{e\max} = Q_n$ for FP propellers driven by turbine,
$Q_{e\max} = 0{,}75\ Q_n$ for FP propellers driven by diesel engine.

All the torques and the inertia moments shall be reduced to the rotation speed of the component being examined.

1.3.5.6.3.2 If there is a first blade order torsional resonance in the range 20 % of n_n above and 20 % below the maximum operating speed (bollard condition), the design torque Q_r of the shaft component shall be determined by means of a dynamic torsional vibration analysis of the entire propulsion line in the time domain or alternatively in the frequency domain. It is then assumed that the plant is sufficiently designed to avoid harmful operation in barred speed range.

1.3.5.7 Guideline for torsional vibration calculation.

The aim of torsional vibration calculations is to estimate the torsional loads for individual shaft line components over the life time in order to determine scantlings for safe operation. The model can be taken from the normal lumped mass elastic torsional vibration model (frequency domain) including the damping. Standard harmonics may be used to consider the gas forces. The engine torque - speed curve of the actual plant shall be applied.

For time domain analysis the model shall include the ice excitation at propeller, the mean torques provided by the prime mover and the hydrodynamic mean torque produced by the propeller as well as any other relevant excitations. The calculations shall cover the variation of phase between the ice excitation and prime mover excitation. This is extremely relevant for propulsion lines with direct driven combustion engines.

For frequency domain calculations the load shall be estimated as a Fourier component analysis of the continuous sequence of half sine load peaks. The first and second order blade components shall be used for excitation. The calculation shall cover the whole relevant shaft speed range. The analysis of the responses at the relevant torsional vibration resonances may be performed for open water (without ice excitation) and ice excitation separately. The resulting maximum torque can be obtained for directly coupled plants by the following superposition:

$$Q_{peak} = Q_{e\max} + Q_{opw} + Q_{ice}, \text{ kNm}, \quad (1.3.5.7)$$

where $Q_{e\max}$ = the maximum engine torque at considered rotational speed;
Q_{opw} = is the maximum open water response of engine excitation at considered shaft speed and determined by frequency domain analysis;
Q_{ice} = is the calculated torque using frequency domain analysis for the relevant shaft speeds, ice excitation cases 1 — 4, resulting in the maximum response torque due to ice excitation.

1.3.6 Design.

1.3.6.1 Design principle.

The propulsion line shall be designed according to the pyramid strength principle in terms of its strength. This means that the loss of the propeller blade shall not cause any significant damage to other propeller shaft line components.

The propulsion line components shall withstand maximum and fatigue operational loads with the relevant safety margin. The loads do not need to be considered for shaft alignment or other calculations of normal operational conditions.

1.3.6.2 Fatigue design in general.

The design loads shall be based on the ice excitation and where necessary (shafting) dynamic analysis, described as a sequence of blade impacts (refer to 1.3.5.6.2.1). The shaft response torque shall be determined according to 1.3.5.6.3.

The propulsion line components shall be designed so as to prevent accumulated fatigue failure when considering the relevant loads using the linear elastic Miner's rule as defined below:

$$D = \sum_{j=1}^{k} \frac{n_j}{N_j} \le 1, \qquad (1.3.6.2)$$

where D = Miner's damage sum;
k = number of stress levels;
N_j = number of load cycles to failure of the individual stress level class, j from 1 to k;
n_j = accumulated number of load cycles of the case under consideration, per class, j from 1 to k.

N o t e . The stress distribution shall be divided into a frequency load spectrum having min. 10 stress blocks (every 10 % of the load). The maximum allowable load is limited to σ_{ref2} for propeller blades and yield strength for all other components. The load distribution (spectrum) shall be in accordance with the Weibull distribution.

1.3.6.3 Propeller blades.

1.3.6.3.1 Calculation of blade stresses due to static loads.

The blade stresses, i.e. equivalent and principal stresses, shall be calculated for the design loads given in 1.3.5.3. Finite element analysis (FEA) shall be used for stress analysis as part of the final approval for all propeller blades.

The von Mises stresses, σ_{st}, in MPa, shall comply with acceptability criterion given in 1.3.6.3.2.

Alternatively, the following simplified equation can be used in estimating the blade stresses for all propellers in the root area ($r/R < 0{,}5$) for final approval:

$$\sigma_{st} = C_1 \cdot \frac{M_{BL}}{100ct^2}, \qquad (1.3.6.3.1)$$

where C_1 = ratio between the actual stress and the one obtained from beam theory. If C_1 is not available, $C_1 = 1{,}6$;
M_{BL} = bending moment applied on the blade taken equal to:
$M_{BL} = \left(0{,}75 - \frac{r}{R}\right) \cdot R \cdot F$, for relative radius $r/R < 0{,}5$,
where $F = \mathrm{Max}[F_b;\ F_t]$.

1.3.6.3.2 Acceptability criterion for static loads.

The following criterion for calculated blade stresses shall be fulfilled:

$$\sigma_{st} \le \frac{\sigma_{ref2}}{1{,}3}, \qquad (1.3.6.3.2)$$

where σ_{st} = calculated stress for the design loads, in MPa.

If finite element analysis is used in estimating the stresses, von Mises stresses shall be used.

1.3.6.3.3 Fatigue design of propeller blade.

1.3.6.3.3.1 General.

For materials with a two slope S-N curve (refer to Fig. 1.3.6.3.3.1-1), the fatigue calculations defined in this rule are not required if the following criterion is fulfilled:

$$\sigma_{\exp} \ge B_1 \cdot \sigma_{ref2}{}^{B_2} \cdot \log(N_{ice})^{B_3}, \qquad (1.3.6.3.3.1\text{-}1)$$

where B_1, B_2, B_3 = coefficients defined according to Table 1.3.6.3.3.1-1:

Table 1.3.6.3.3.1-1

Coefficient	Open propeller	Ducted propeller
B_1	0,00328	0,00223
B_2	1,0076	1,0071
B_3	2,101	2,471

Where the above criterion is not fulfilled the fatigue requirements defined below shall be applied:

the fatigue design of the propeller blade is based on an estimated load distribution for the service life of the ship and the S-N curve for the blade material;

an equivalent stress σ_{fat} that produces the same fatigue damage as the expected load distribution shall be calculated according to Miner's rule;

the acceptability criterion for fatigue shall be fulfilled as given in this requirement;

the equivalent stress is normalised for 10^8 cycles.

The blade stresses at various selected load levels for fatigue analysis shall be taken proportional to the stresses calculated for maximum loads given in 1.3.5.3.

The peak principal stresses σ_f and σ_b are determined from F_f and F_b using FEA.

The peak stress range $\Delta\sigma_{\max}$, in MPa, is given by the following formula:

$$\Delta\sigma_{\max} = 2\sigma_{A\max} = \left|(\sigma_{ice})_{f\max}\right| + \left|(\sigma_{ice})_{b\max}\right|, \qquad (1.3.6.3.3.1\text{-}2)$$

where $\Delta\sigma_{\max}$ = peak stress range, in MPa;
$\sigma_{A\max}$ = maximum stress amplitude, in MPa, determined on the basis of load cases 1 and 3, 2 and 4.

The load spectrum for backward loads is normally expected to have a lower number of cycles than the load spectrum for forward loads. Taking this into account in a fatigue analysis introduces complications that are not justified considering all uncertainties involved.

For the calculation of equivalent stress, two types of S-N curves are available:

two slope S-N curve (slopes 4.5 and 10), refer to Fig. 1.3.6.3.3.1-1;

one slope S-N curve (the slope can be chosen), refer to Fig. 1.3.6.3.3.1-2.

The type of the S-N-curve shall be selected to correspond with the material properties of the blade. If the S-N-curve is not known the two slope S-N curve shall be used.

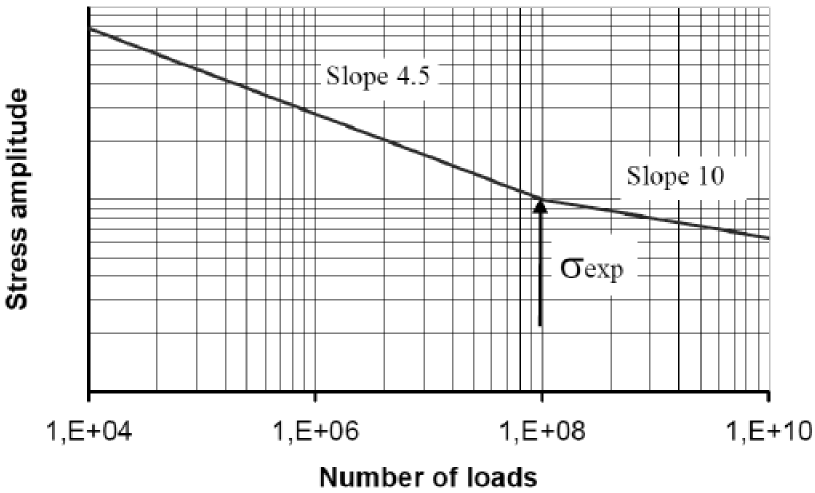


Fig. 1.3.6.3.3.1-1
Two-slope S-N curve

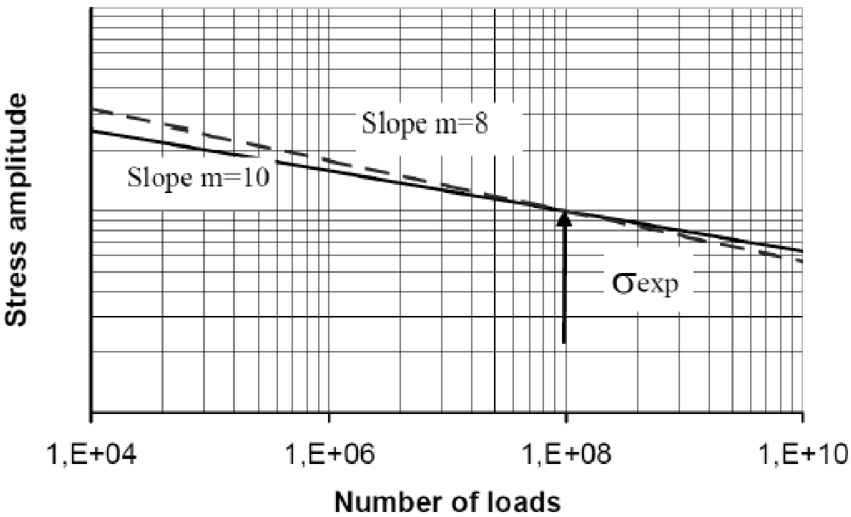


Fig.1.3.6.3.3.1-2
Constant-slope S-N curve

1.3.6.3.3.2 Equivalent fatigue stress.

The equivalent fatigue stress, in MPa, for 10^8 cycles which produces the same fatigue damage as the load distribution is given by the following formula:

$$\sigma_{fat} = \rho(\sigma_{ice})_{\max}, \qquad (1.3.6.3.3.2\text{-}1)$$

where $(\sigma_{ice})_{\max}$ = value of the principal stress amplitudes resulting from design forward and backward blade forces at the location being studied, in MPa, taken equal to:

$$(\sigma_{ice})_{\max} = 0{,}5\left[(\sigma_{ice})_{f\max} - (\sigma_{ice})_{b\max}\right].$$

In the calculation of $(\sigma_{ice})_{\max}$, case 1 and case 3 or case 2 and case 4 are considered as pairs for $(\sigma_{ice})_{fmax}$ and $(\sigma_{ice})_{b\max}$ calculations. Case 5 is excluded from the fatigue analysis.

$(\sigma_{ice})_{f\max}$ = principal stress resulting from forward load, in MPa;
$(\sigma_{ice})_{b\max}$ = principal stress resulting from backward load, in MPa.

ρ = parameter related to S-N curve, taken as follows:
.1 for two-slope S-N curve:
the error of the following method to determine ρ is sufficiently small, if the number of load cycles N_{ice} is within the range $5 \times 10^6 \leq N_{ice} \leq 10^8$;
parameter ρ relates the maximum ice load to the distribution of ice loads according to the regression formula:

$$\rho = C_1 \cdot (\sigma_{ice})_{\max}{}^{C_2} \cdot \sigma_{fl}{}^{C_3} \cdot \log(N_{ice})^{C_4}, \quad (1.3.6.3.3.2\text{-}2)$$

where σ_{fl} = blade material fatigue strength at 10^8 load cycles, in MPa, given as:
$\sigma_{fl} = \gamma_{\varepsilon 1} \cdot \gamma_{\varepsilon 2} \cdot \gamma_v \cdot \gamma_m \cdot \sigma_{exp}$ (refer to 1.3.6.3.3.3 for the parameters used in the formula);
C_1, C_2, C_3, C_4 = coefficients given in Table 1.3.6.3.3.2-1;

.2 for constant-slope S-N curve:
for materials with a constant-slope S-N curve ρ shall be calculated from the following formula:

$$\rho = \left(G \cdot \frac{N_{ice}}{N_r}\right)^{1/m} [\ln(N_{ice})]^{-1/k}, \quad (1.3.6.3.3.2\text{-}3)$$

where k = shape parameter of the Weibull distribution:
for ducted propellers: $k = 1{,}0$;
for open propellers: $k = 0{,}75$;
N_{ice} = number of load cycles to be taken between 5×10^6 and 10^8;
N_r = reference number of load cycles, $N_r = 10^8$;
G = parameter defined in Table 1.3.6.3.3.2-2. Linear interpolation may be used to calculate the value of G for intermediate values of m/k ratios.

Table 1.3.6.3.3.2-1

Coefficients C_1, C_2, C_3, and C_4

	C_1	C_2	C_3	C_4
Open propeller	0,000747	0,0645	−0,0565	2,220
Ducted propeller	0,000534	0,0533	–0,0459	2,584

Table 1.3.6.3.3.2-2

G parameter as a function of m/k

m/k	3	3,5	4	4,5	5	5,5	6	6,5
G	6	11,6	24	52,3	120	287,9	720	1871
m/k	7	7,5	8	8,5	9	9.5	10	
G	5040	14034	40320	119292	362880	$1{,}133 \cdot 10^6$	$3{,}623 \cdot 10^6$	

N o t e . A more general method of determining the equivalent fatigue stress of propeller blades is described in 1.3.6.5, where the principal stresses are considered according to 1.3.5.3 using the Miner's rule. For a total number of load blocks $n_{bl} > 100$, both methods deliver the same result. Therefore, they are regarded as equivalent.

1.3.6.3.3.3 Acceptability criterion for fatigue.

The equivalent fatigue stress, σ_{fat}, in MPa, at all locations on the blade shall fulfil the following acceptability criterion:

$$\sigma_{fat} \leq \frac{\sigma_{fl}}{1{,}5}, \quad (1.3.6.3.3.3)$$

where σ_{fat} = fatigue strength, in MPa, corresponding to the fatigue limit at 10^8 load cycles;
σ_{fl} = blade material fatigue strength at 10^8 load cycles, in MPa, given as:
$\sigma_{fl} = \gamma_{\varepsilon1} \cdot \gamma_{\varepsilon2} \cdot \gamma_v \cdot \gamma_m \cdot \sigma_{exp}$,

where $\gamma_{\varepsilon1}$ = reduction factor due to scatter, equal to one standard deviation; if the actual value is not known, $\gamma_{\varepsilon1}$ = 0,85;
$\gamma_{\varepsilon2}$ = geometrical size factor for test specimen size effect given as:
$\gamma_{\varepsilon2} = 1 - a \cdot \ln\left(\frac{t}{0{,}025}\right)$,
where: $a = 0{,}10$ for bronze and brass;
$a = 0{,}05$ for stainless steel;
$t =$ maximum blade thickness at the considered point, in m;
γ_v = reduction factor for variable amplitude loading; if the actual value is not known, γ_v = 0,75;
γ_m = reduction factor for mean stress, given as:
$\gamma_m = 1 - \left(1{,}4 \cdot \frac{\sigma_{mean}}{\sigma_u}\right)^{0{,}75}$; if the actual value is not known, γ_m = 0,75;
σ_{exp} = mean fatigue strength of the blade material at 10^8 cycles to failure in seawater. σ_{exp} provided in Table 1.3.6.3.3.3 has been defined from the results of constant amplitude loading fatigue tests at 10^7 load cycles and 50 % survival probability and has been extended to 10^8 load cycles.

Fatigue strength values and correction factors other than those given in Table 1.3.6.3.3.3 may be used, provided the values are determined under conditions approved by the Register.

The characteristics of the S-N curve are based on two slopes, the first slope is equal to 4,5 from 1000 to 10^8 load cycles; the second slope is equal to 10 over 10^8 load cycles.

The maximum allowable stress for one or low number of cycles is limited to σ_{ref2}/S, with $S = 1{,}3$ for static loads.

Table 1.3.6.3.3.3

Mean fatigue strength σ_{exp} for different material types at 10^8 load cycles and stress ratio $R = -1$ with a survival probability of 50 %

Bronze and brass	σ_{exp}, MPa	Stainless steel	σ_{exp}, MPa
Mn-Bronze, CU1 (high tensile brass)	84	Ferritic (12Cr 1Ni)	144[1]
Mn-Ni-Bronze, CU2 (high tensile brass)	84	Martensitic (13Cr 4Ni/13Cr 6Ni)	156
Ni-Al-Bronze, CU3	120	Martensitic (16Cr 5Ni)	168
Mn-Al-Bronze, CU4	113	Austenitic (19Cr 10Ni)	132
1 This value may be used provided a perfect galvanic protection is active. Otherwise a reduction of about 30 MPa shall be applied.			

1.3.6.4 Blade bolts and pitch control mechanism.

1.3.6.4.1 General.

The blade bolts, pitch control mechanism, and the fitting of the propeller to the propeller shaft shall be designed to withstand the maximum static and fatigue design loads (as applicable), as defined in 1.3.5.3 and 1.3.6.3.

The safety factor S, against yielding due to static loads and against fatigue shall be greater than 1,5, if not stated otherwise. The safety factor S for loads, resulting from propeller blade failure as defined in 1.3.5.4 shall be greater than 1,0 against yielding.

Provided that calculated stresses duly considering local stress concentrations are less than yield strength, or maximum of $0{,}7\ \sigma_u$ of respective materials, detailed fatigue analysis is not required. In all other cases components shall be analysed for cumulative fatigue. An approach similar to that used for shafting assessment may be applied (refer to 1.3.6.5).

1.3.6.4.2 Blade bolts design.

Blade bolts shall withstand the following bending moment, in kNm, considered around a tangent on bolt pitch circle, or any other relevant axis for non-circular joints, parallel to considered root section:

$$M_{bolt} = S \cdot F_{ex}\left(0{,}8 \cdot \frac{D}{2} - r_{bolt}\right), \qquad (1.3.6.4.2\text{-}1)$$

where r_{bolt} = radius from the shaft centreline to the blade bolt plane, in m;
S = safety factor taken as $S = 1$;
F_{ex} = bending force, in kN, given in 1.3.5.4.1.

Blade bolt pre-tension shall be sufficient to avoid separation between mating surfaces when the maximum forward and backward ice loads defined in 1.3.5.3 (open and ducted propellers respectively) are applied. For conventional arrangements, the blade bolts effective diameter d_{bb}, in mm, may be obtained by the following formula:

$$d_{bb} = 41\sqrt{\frac{F_{ex} \cdot (0{,}8D - d) \cdot S \cdot \alpha}{\sigma_{0,2} \cdot Z_{bb} \cdot PCD}}, \qquad (1.3.6.4.2\text{-}2)$$

where d_{bb} = effective diameter of blade bolt in way of thread, in mm;
S = safety factor taken as $S = 1$;
z_{bb} = number of blade bolts;
α = coefficient taken equal to:
$\alpha = 1{,}6$ for torque guided tightening;
$\alpha = 1{,}3$ for elongation guided;
$\alpha = 1{,}2$ for angle guided;
$\alpha = 1{,}1$ for elongated by other additional means.
Other value of α may be used, provided evidence is demonstrated to the Register.

1.3.6.4.3 Pitch control mechanism.

Separate means, e.g. dowel pins, shall be provided in order to withstand the spindle torque resulting from blade failure Q_{sex} (refer to 1.3.5.4.2) or ice interaction $Q_{s\max}$ (refer to 1.3.5.3.7), whichever is greater. Other components of the pitch control mechanism shall not be damaged by the maximum spindle torques ($Q_{s\max}$, Q_{sex}). One third of the spindle torque is assumed to be consumed by friction, if not otherwise documented through further analysis.

The diameter of fitted pins d_{fp}, in mm, between the blade and blade carrier can be determined as follows:

$$d_{fp} = 66\sqrt{\frac{Q_s - Q_{fr}}{PCD \cdot Z_{pin} \cdot \sigma_{0,2}}}, \qquad (1.3.6.4.3\text{-}1)$$

where Q_s = spindle torque, in kNm, equal to:
$Q_s = \mathrm{Max}(S \cdot Q_{s\max}; S \cdot Q_{sex})$;
where:
$S = 1{,}3$ for $Q_{s\max}$;
$S = 1{,}0$ for Q_{sex}
Q_{fr} = friction between connected surfaces, $Q_{fr} = 0{,}33\, Q_s$.
Alternative values of Q_{fr} according to reaction forces due to F_{ex}, or F_f, F_b whichever is relevant, utilising a friction coefficient equal to 0,15 may be used, provided they are approved by the Register.

The stress in the actuating pin can be estimated by

$$Q_{vMises} = \sqrt{\left(\frac{\left(F \cdot \frac{h_{pin}}{2}\right)}{\frac{\pi \cdot d_{pin}^3}{32}}\right)^2 + 3 \cdot \left(\frac{F}{\frac{\pi}{4} \cdot d_{pin}^2}\right)^2}, \qquad (1.3.6.4.3\text{-}2)$$

where:

$F = \frac{Q_s - Q_{fr}}{l_m}$, in kN;

l_m = distance from the pitching centre of the blade to the pin axis, in m;

h_{pin} = height of actuating pin, in mm;

d_{pin} = diameter of actuating pin, in mm;

Q_{fr} = friction torque in blade bearings acting on the blade palm and caused by the reaction forces due to F_{ex}, or F_f, F_b whichever is relevant, taken $Q_{fr} = 0{,}33\ Q_s$.

The blade failure spindle torque Q_{sex} shall not lead to any consequential damage.

Fatigue strength shall be considered for parts transmitting the spindle torque from the blade to a servo system considering the ice spindle torque acting on one blade. The maximum amplitude $Q_{sa\max}$ is defined as:

$$Q_{sa\max} = \frac{Q_{sb} + Q_{sf}}{2}, \qquad (1.3.6.4.3\text{-}3)$$

where Q_{sb} = spindle torque due to $|F_b|$, in kNm;

Q_{sf} = spindle torque due to $|F_f|$, in kNm.

1.3.6.4.4 Servo pressure.

The design pressure for the servo system shall be taken as the pressure caused by $Q_{s\max}$, or Q_{sex} when not protected by relief valves on the hydraulic actuator side, reduced by relevant friction losses in bearings caused by the respective ice loads. The design pressure is in any case not to be less than relief valve set pressure.

1.3.6.5 Propulsion line components.

The ultimate load resulting from total blade failure F_{ex} as defined in 1.3.5.4 consists of combined axial and bending load components, wherever this is significant. The minimum safety factor against yielding shall be 1,0 for all shaft line components.

The shafts and shafting components, such as bearings, couplings and flanges shall be designed to withstand the operational propeller-to-ice interaction loads as given in 1.3.3.2.

The given loads are not intended to be used for shaft alignment calculation.

Cumulative fatigue calculations shall be conducted according to the Miner's rule. A fatigue calculation is not necessary, if the maximum stress is below fatigue strength at 10^8 load cycles.

The torque, $Q_{A\max}$, and thrust amplitude distribution (spectrum), $Q_A(N)$, in the propulsion line shall be taken as (because Weibull exponent $k = 1$):

$$Q_A(N) = Q_{A\max} \cdot \left[1 - \frac{\log N}{\log(Z \cdot N_{ice})}\right], \qquad (1.3.6.5\text{-}1)$$

where $Z \cdot N_{ice}$ = number of load cycles in the load spectrum.

The ratio $Q_{A\max}/Q_A(N)$ is illustrated by the example in Fig. 1.3.6.5-1.

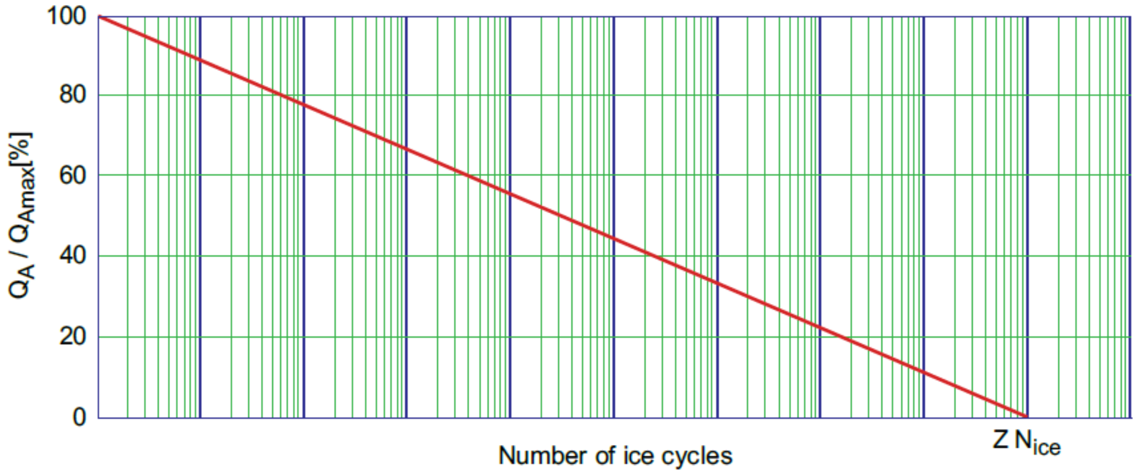


Fig.1.3.6.5-1
Cumulative torque distribution

The Weibull exponent shall be considered as k = 1.0 for both open and ducted propeller torque and bending forces. The load distribution is an accumulated load spectrum, and the load spectrum shall be divided into a minimum of ten load blocks when using the Miner summation method.

The load spectrum used counts the number of cycles for 100 % load to be the number of cycles above the next step, e.g. 90 % load. This ensures that the calculation is on the conservative side. Consequently, the fewer stress blocks used the more conservative the calculated safety margin.

The load spectrum is divided into N_{bl} load blocks for the Miner summation method. The following formula can be used for calculation of the number of cycles for each load block (refer to Fig. 1.3.6.5-2).

$$n_i = N_{ice}^{1-\left(1-\frac{i}{Nbl}\right)^k} - \sum_{j=2}^{i} n_{j-1}, \qquad (1.3.6.5\text{-}2)$$

where i = single load block i;
N_{bl} = number of load blocks.

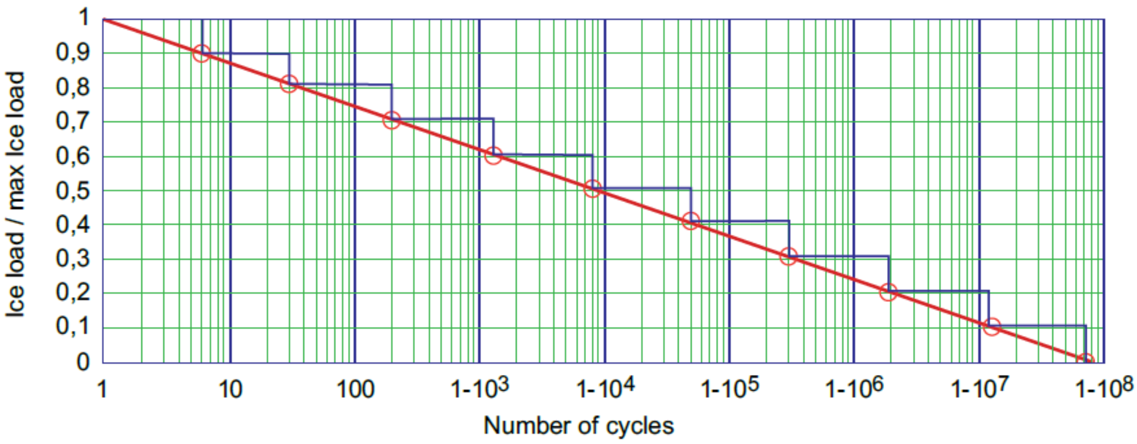


Fig.1.3.6.5-2
Example of ice load distribution (spectrum) for the shafting with Weibull exponent $k = 1$

1.3.6.5.1 Propeller fitting to the shaft.

1.3.6.5.1.1 Keyless cone mounting.

The friction capacity at 0 °C shall correspond at least to 2 times the highest value of the peak torque, Q_{peak}, as determined in 1.3.5.6 without exceeding the permissible hub stresses.

The minimum surface pressure p_0 at 0 °C shall be determined as:

$$p_0 = \frac{2 \cdot S \cdot Q_{peak}}{\pi \cdot \mu \cdot D_S^2 \cdot L \cdot 10^3}, \qquad (1.3.6.5.1.1)$$

where μ = friction coefficient taken as:
$\mu = 0{,}15$ for steel-steel friction;
$\mu = 0{,}13$ for steel-bronze friction.
These friction coefficients may be increased by 0,04 if glycerine is used in wet mounting.
D_S = shrinkage diameter at the mid-length of the taper, in m;
L = effective length of taper, in m;
S = safety factor, equal to 2,0.

The contact pressure corresponding to the actual pull-up length and to the ambient temperature during the propeller fitting shall guarantee that the required safety factor will be fulfilled in ice operating conditions.

1.3.6.5.1.2 Key mounting.

Key mounting is not permitted.

1.3.6.5.1.3 Flange mounting.

The flange thickness shall be at least 25 % of the required aft end shaft diameter.

Any additional stress raisers such as recesses for bolt heads shall not interfere with the flange fillet unless the flange thickness is increased correspondingly.

The flange fillet radius shall be at least 10 % of the required shaft diameter.

The diameter of shear pins, d_{pin}, in mm, shall be determined as follows:

$$d_{pin} = 66\sqrt{\frac{Q_{peak} \cdot S}{PCD \cdot Z_{pin} \cdot \sigma_{0,2}}}, \qquad (1.3.6.5.1.3\text{-}1)$$

where z_{pin} = number of shear pins;
S = safety factor taken as $S = 1{,}3$.

The bolts shall be designed so that the blade failure load F_{ex} (refer to 1.3.5.4) in backward direction does not cause yielding of the bolts. The flange bolt diameter is determined as:

$$d_b = 41\sqrt{\frac{F_{ex} \cdot \left(\frac{0{,}8 \cdot D}{PCD} + 1\right) \cdot \alpha}{\sigma_{0,2} \cdot Z_b}}, \qquad (1.3.6.5.1.3\text{-}2)$$

where α = coefficient taken equal to:
$\alpha = 1{,}6$ for torque guided tightening;
$\alpha = 1{,}3$ for elongation guided;
$\alpha = 1{,}2$ for angle guided;
$\alpha = 1{,}1$ for elongated by other additional means.
Other α values may be used, if evidence is demonstrated to the Register;
d_b = flange bolt diameter, in mm;
z_b = number of flange bolts.

1.3.6.5.2 Propeller shaft.

The design of the propeller shaft shall fulfil the following.

1.3.6.5.2.1 The blade failure load F_{ex} (refer to 1.3.5.4) applied parallel to the shaft (forward or backwards) shall not cause yielding. The bending moment need not to be combined with any other loads. The diameter in way of the aft stern tube bearing, d_{pastb}, in mm, shall not be less than:

$$d_{pastb} = 160\sqrt{\frac{F_{ex} \cdot D}{\sigma_{0,2} \cdot \left[1 - \left(\frac{d_i}{d_p}\right)^4\right]}}, \qquad (1.3.6.5.2.1)$$

where d_p = propeller shaft diameter, in mm;
d_i = propeller shaft inner diameter, in mm.

Forward from the aft stern tube bearing the shaft diameter may be reduced based on direct calculation of the actual bending moment, or by the assumption that the bending moment caused by F_{ex} is linearly reduced to 25 % at the next bearing and in front of this linearly to zero at third bearing.

Bending due to maximum blade forces F_b and F_f have been disregarded since the resulting stress levels are much lower than the stresses caused by the blade failure load.

1.3.6.5.2.2 The stresses due to the peak torque Q_{peak} shall have a minimum safety factor equal to 1,5 against yielding in plain sections and to 1,0 in way of stress concentrations in order to avoid bent shafts.

Minimum diameter of the plain and notched shafts are defined as follows, in mm:

for the plain shaft:

$$d_p = 210\sqrt{\frac{Q_{peak} \cdot S}{\sigma_{0,2} \cdot \left[1 - \left(\frac{d_i}{d}\right)^4\right]}}, \qquad (1.3.6.5.2.2\text{-}1)$$

for the notched shaft:

$$d_p = 210\sqrt{\frac{Q_{peak} \cdot S \cdot \alpha_t}{\sigma_{0,2} \cdot \left[1 - \left(\frac{d_i}{d}\right)^4\right]}}, \qquad (1.3.6.5.2.2\text{-}2)$$

where α_t = local stress concentration factor in torsion.

In any case, the actual notched shaft diameter shall not be less than the required plain shaft diameter.

1.3.6.5.2.3 The torque amplitudes (refer to 1.3.5.6.3) with the corresponding number of load cycles shall be used in an accumulated fatigue evaluation where the fatigue safety factor is $S_{fat} = 1{,}5$. If the plant has high engine excited torsional vibrations (e.g. direct coupled 2-stroke engines), this shall also be considered.

1.3.6.5.2.4 The fatigue strengths σ_F and τ_F ($3\ 10^6$ cycles) of shaft materials may be assessed on the basis of the material's yield or 0,2 % proof strength as:

$$\sigma_F = 0{,}436 \cdot \sigma_{0,2} + 77 = \sqrt{3} \cdot \tau_F. \qquad (1.3.6.5.2.4)$$

This formula is valid for small polished specimens (no notch) and reversed stresses.

The high cycle fatigue (HCF) shall be assessed based on the above fatigue strengths, notch factors (i.e. geometrical stress concentration factors and notch sensitivity), size factors, mean stress influence and the required safety factor of 1,6 at 3 10^6 cycles increasing to 1,8 at 10^9 cycles.

The low cycle fatigue (LCF) representing 10^4 cycles shall be based on the smaller value of yield or 0,7 of tensile strength/√3. The criterion utilises a safety factor of 1,25.

The LCF and HCF as given above represent the upper and lower knees in a stress-cycle diagram. Since the required safety factors are included in these values, a Miner sum of unity is acceptable.

1.3.6.5.3 Intermediate shafts.

The design of intermediate shafts shall fulfil the requirements of 1.3.6.5.2.2 — 1.3.6.5.2.4.

1.3.6.5.4 Shaft connections.

1.3.6.5.4.1 Shrink fit couplings (keyless).

The requirements in 1.3.6.5.1.1 apply with a safety factor S equal to 1,8 ($S = 1{,}8$).

1.3.6.5.4.2 Key mounting.

Key mounting is not permitted.

1.3.6.5.4.3 Flange mounting.

The flange thickness shall be at least 20 % of the required shaft diameter.

Any additional stress raisers such as recesses for bolt heads shall not interfere with the flange fillet unless the flange thickness is increased correspondingly.

The flange fillet radius shall be at least 8 % of the shaft diameter.

The diameter of ream fitted (light press fit) bolts shall be chosen so that the peak torque is transmitted with a safety factor of 1,9. This accounts for a pre-stress. Pins shall transmit the peak torque with a safety factor of 1,5 against yielding (refer to d_{pin} in 1.3.6.5.1.3).

The bolts shall be designed so that the blade failure load (refer to 1.3.5.4) in backward direction does not cause yielding.

1.3.6.5.4.4 Splined shaft connections.

Splined shaft connections can be applied where no axial or bending loads occur. A safety factor of $S = 1{,}5$ against allowable contact and shear stress resulting from Q_{peak} shall be applied.

1.3.6.5.5 Gear transmissions.

.1 Shafts.

Shafts in gear transmissions shall meet the same safety level as intermediate shafts, but where relevant, bending stresses and torsional stresses shall be combined (e.g. by von Mises for static loads).Maximum permissible deflection in order to maintain sufficient tooth contact pattern shall be considered for the relevant parts of the gear shafts.

.2 Gearing.

The gearing shall fulfil following three acceptance criteria:

tooth root stresses;

pitting of flanks;

scuffing.

In addition to above 3 criteria subsurface fatigue need to be considered.

Common for all criteria is the influence of load distribution over the face width. All relevant parameters shall be considered, such as elastic deflections (of mesh, shafts and gear bodies), accuracy tolerances, helix modifications, and working positions in bearings (especially for twin input single output gears).

The load spectrum (refer to 1.3.6.5) shall be applied in such a way that the numbers of load cycles for the output wheel are multiplied by a factor equal to the number of pinions on the wheel divided by the number of propeller blades, Z. For pinions and wheels operating at higher speeds the numbers of load cycles are found by multiplication with the gear ratios. The peak torque (Q_{peak}) shall also be considered during calculations.

Cylindrical gears can be assessed on the basis of the international standard ISO 6336 series (i.e. ISO 6336-1:2019, ISO 6336-2:2019, ISO 6336-3:2019, ISO 6336-4:2019, ISO 6336-5:2016 and ISO 6336-6:2019), provided that "method B" is used. Bevel gears can be assessed on the basis of the international standard ISO 10300 series (i.e. ISO 10300-1:2014, ISO 10300-2:2014 and ISO 10300-3:2014).

Tooth root safety shall be assessed against the peak torque, torque amplitudes (with the pertinent average torque) as well as the ordinary loads (open water free running) by means of accumulated fatigue analyses. The resulting factor of safety shall be at least 1,5.

The safety against pitting shall be assessed in the same way as tooth root stresses, but with a minimum resulting safety factor of 1,2 (refer to ISO 6336-1:2019, ISO 6336-2:2019 and ISO 6336-6:2019).

The scuffing safety (flash temperature method - ref. ISO/TR 13989-1:2000 and ISO/TR 13989-2:2000) based on the peak torque shall be at least 1.2 when the FZG class of the oil, as defined in ISO 14635-1:2000, is assumed one stage below specification.

The safety against subsurface fatigue of flanks for surface hardened gears (oblique fracture from active flank to opposite root) shall be assessed at the discretion of Register. (It shall be noted that high overloads can initiate subsurface fatigue cracks that may lead to a premature failure. In lieu of analyses UT inspection intervals may be used).

.3 Gear wheel shaft connections.

The torque capacity shall be at least 1,8 times the highest peak torque Q_{peak} (at considered rotational speed) without exceeding the permissible hub stresses of 80 % yield.

1.3.6.5.6 Clutches.

Clutches shall have a static friction torque of at least 1,3 times the peak torque Q_{peak} and dynamic friction torque of 2/3 of the static.

Emergency operation of clutch after failure of e.g. operating pressure shall be made possible within reasonably short time. If this is arranged by bolts, it shall be on the engine side of the clutch in order to ensure access to all bolts by turning the engine.

1.3.6.5.7 Elastic couplings.

A separation margin of at least 20 % is required between the peak torque Q_{peak} and the torque $T_{k\max}$:

$$Q_{peak} < 0{,}8 \cdot T_{kmax}(N = 1). \qquad (1.3.6.5.7\text{-}1)$$

A separation margin of at least 20 % is required between the maximum response torque Q_{peak} (refer to Fig. 1.3.5.6.2.2) and the torque where any mechanical twist limitation and/or the permissible maximum torque of the elastic coupling, valid for at least a single load cycle ($N = 1$), is reached.

A sufficient fatigue strength shall be demonstrated at design torque level $Q_r(N = x)$ and $Q_A(N = x)$. This may be demonstrated by interpolation in a Weibull torque distribution (similar to Fig. 1.3.6.5-1):

$$\frac{Q_r(N=x)}{Q_r(N=1)} = 1 - \frac{\log x}{\log(Z \cdot N_{ice})}, \qquad (1.3.6.5.7\text{-}2)$$

$$\frac{Q_A(N=x)}{Q_A(N=1)} = 1 - \frac{\log x}{\log(Z \cdot N_{ice})}, \qquad (1.3.6.5.7\text{-}3)$$

respectively,

where $Q_r(N = 1)$ = torque level corresponding to Q_{peak}, in kNm;
$Q_A(N = 1)$: torque level corresponding to $Q_{A\max}$, in kNm;
$Q_r(N = 5 \times 10^4) \cdot S < T_{k\max}(N = 5 \times 10^4)$,
$Q_r(N = 1 \times 10^6) \cdot S < T_{KV}$ ...,

$Q_A(N = 5 \times 10^4) \cdot S < \Delta T_{\max}(N = 5 \times 10^4)$,
S = general safety factor for fatigue, equal to 1,5 ($S = 1{,}5$).

The torque amplitude (or range, Δ) shall not lead to fatigue cracking, i.e. exceeding the permissible vibratory torque. The permissible torque is obtained by interpolation in a Weibull torque distribution where $T_{k\max1}$ and $\Delta T_{k\max}$ refer to 5 10^4 cycles and T_{KV} to 10^6 cycles respectively.

$T_{k\max1} \geq Q_r$ at 5×10^4 load cycles. (1.3.6.5.7-4)

Refer to illustration of $T_{k\max1}$, $\Delta T_{k\max}$ and T_{KV} = f (time) in Figs. 1.3.5.6.7-1, 1.3.5.6.7-2 and 1.3.5.6.7-3, respectively.

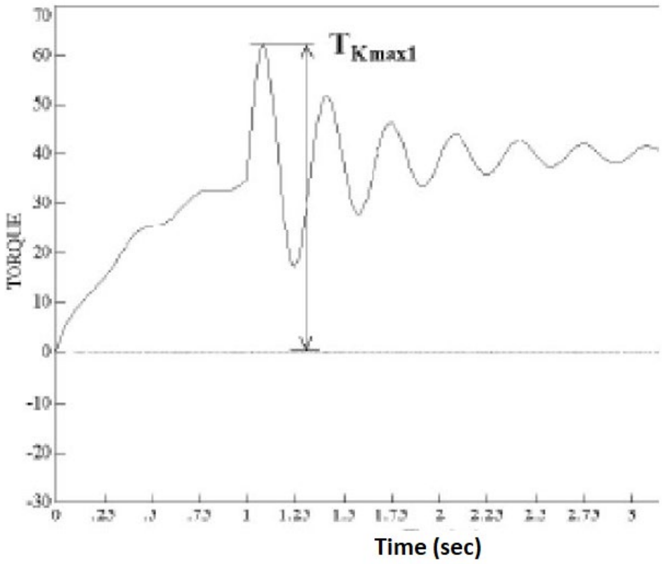


Fig. 1.3.5.6.7-1
$T_{k\max1}$

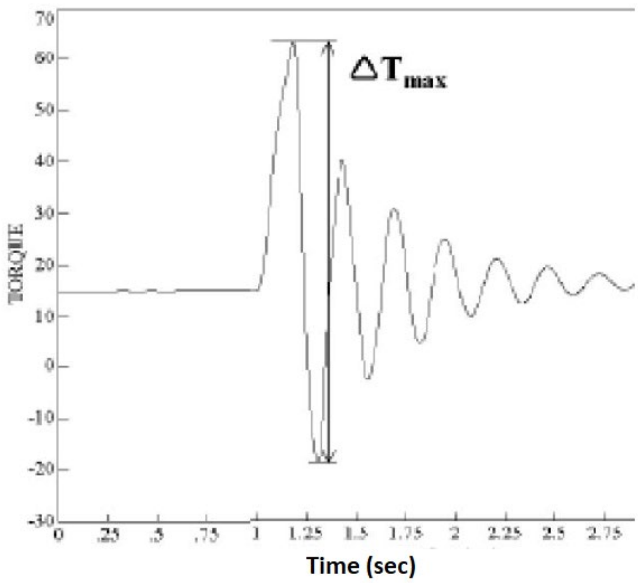


Fig. 1.3.5.6.7-2
$\Delta T_{k\max}$

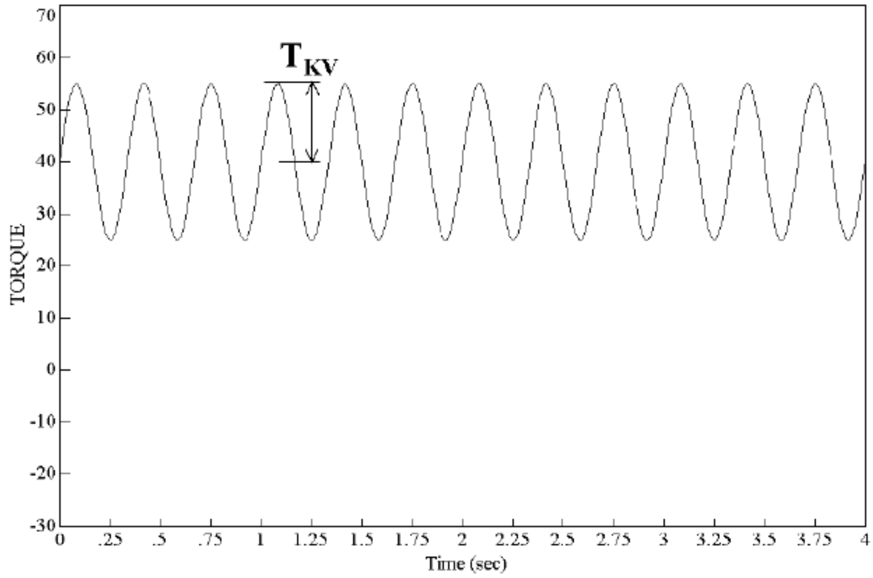


Fig. 1.3.5.6.7-3.
T_{KV} = f (time)

1.3.6.5.8 Crankshafts.

Special considerations apply for plants with large inertia (e.g. flywheel, tuning wheel or PTO) in the non-driving end front of the engine (opposite to main power take off).

1.3.6.5.9 Bearings.

The aft stern tube bearing as well as the next shaft line bearing shall withstand F_{ex} as given in 1.3.5.4, in such a way that the ship can maintain operational capability. Rolling bearings shall have an L_{10a} lifetime of at least 40000 hours according to ISO 281:2007. Thrust bearings and their housings shall be designed to withstand with a safety factor $SS = 1{,}0$ the maximum response thrust 1.3.5.5 and the axial force resulting from the blade failure load F_{ex} in 1.3.5.4. For the purpose of calculation, except for F_{ex}, the shafts are assumed to rotate at rated speed. For pulling propellers special consideration shall be given to loads from ice interaction on the propeller hub.

1.3.6.5.10 Seals.

Seals shall prevent egress of pollutants and be suitable for the operating temperatures. Contingency plans for preventing the egress of pollutants under failure conditions shall be documented.

Seals installed shall be suitable for the intended application. The manufacturer shall provide for consideration an information on operating experience under similar conditions and/or test results.

1.3.6.6 Azimuthing main propulsors.

In addition to the above requirements, special consideration shall be given to those loading cases which are extraordinary for propulsion units when compared with conventional propellers. The estimation of load cases shall reflect the way the thrusters are intended to operate on the specific ship. In this respect, for example, the loads caused by the impacts of ice blocks on the propeller hub of a pulling propeller shall be considered. Furthermore, loads resulting from the thrusters operating at an oblique angle to the flow shall be considered. The steering mechanism, the fitting of the unit, and the body of the thruster shall be designed to withstand the loss of a blade without damage. The loss of a blade shall be considered for the propeller blade orientation which causes the maximum load on the component being studied. Typically, top-down blade orientation places the maximum bending loads on the thruster body.

Azimuth thrusters shall also be designed for estimated loads caused by thruster body-to-ice interaction considering the provisions of Section 6 of the Rules for Active Means of Polar Class Ships' Steering. The thruster body shall withstand the loads arising due to an impact on the thruster body by an ice block of the maximum size specified in 1.3.5.2, when the ship is at a typical ice operating speed. In addition, the design situation in which an ice sheet glides along the ship's hull and presses against the thruster body shall be considered. The thickness of such sheet shall be taken as the thickness of the maximum-size ice block entering the propeller, as defined in 1.3.5.2.

1.3.7 Prime movers.

1.3.7.1 Propulsion engines.

Engines shall be capable of being started and running the propeller in bollard condition. Propulsion plants with CP propeller shall be capable being operated even when the CP system is at full pitch as limited by mechanical stoppers.

1.3.7.2 Starting arrangements.

The capacity of the air receivers shall be sufficient to provide, without recharging, not less than 12 consecutive starts of the propulsion engine, if this has to be reversed for going astern or 6 consecutive starts if the propulsion engine does not have to be reversed for going astern.

If the air receivers serve any other purposes than starting the propulsion engine, they shall have additional capacity sufficient for these purposes.

The capacity of the air compressors shall be sufficient for charging the air receivers from atmospheric to full pressure in one (1) hour, except for ships with polar classes **PC1** — **PC6**, if its propulsion engine has to be reversed for going astern, in which case the compressor shall be able to charge the receivers in half an hour.

1.3.7.3 Emergency power units.

Provisions shall be made for heating arrangements to ensure ready starting from cold of the emergency power units at an ambient temperature applicable to the ship's polar class.

Emergency power units shall be equipped with starting devices with a stored energy capability of at least three consecutive starts at the above-mentioned temperature. The source of stored energy shall be protected to preclude critical depletion by the automatic starting system, unless a second independent mean of starting is provided. A second source of energy shall be provided for an additional three starts within 30 min., unless manual starting can be demonstrated to be effective.

1.3.8 Equipment fastening loading accelerations.

1.3.8.1 General.

Essential equipment and supports shall be suitable for the accelerations as indicated in the following paragraphs. Accelerations shall be considered as acting independently.

1.3.8.2 Longitudinal impact accelerations, a_l.

The maximum longitudinal impact acceleration at any point along the hull girder, in m/s^2, is defined as:

$$a_1 = \frac{F_{IB}}{\Delta} \cdot \left(1{,}1 \cdot \tan(\gamma + \varphi) + 7 \cdot \frac{H}{L}\right), \qquad (1.3.8.2)$$

where F_{IB} = vertical design ice force, in kN;
Δ = displacement, in t;
γ = bow stem angle at waterline, in deg;
φ = maximum friction angle between steel and ice, normally taken as 10 deg, φ = 10;
H = distance from the water line to the point being considered, in m;
L = ship length between perpendiculars, in m.

1.3.8.3 Vertical impact acceleration, a_v.
The combined vertical impact acceleration at any point along the hull girder, in m/s², is defined as:

$$a_v = 2{,}5 \cdot \frac{F_{IB} \cdot F_X}{\Delta}, \tag{1.3.8.3}$$

Coefficient F_x is taken as:

F_x = 1,3 at FP;

F_x = 0,2 at midship perpendicular;

F_x = 0,4 at AP;

F_x = 1,3 at AP for ships conducting ice breaking astern.

Intermediate values are obtained by linear interpolation.

1.3.8.4 Transverse impact acceleration, a_t.
The combined transverse impact acceleration at any point along hull girder, in m/s², is defined as:

$$a_t = 3 \cdot \frac{F_i \cdot F_X}{\Delta}, \tag{1.3.8.4}$$

F_i = total design ice force normal to shell plating in the bow area due to oblique ice impact, in kN, as defined in 1.2.3.2.1.

F_x is coefficient taken as:

F_x = 1,5 at FP;

F_x = 0,25 at midship perpendicular;

F_x = 0,5 at AP;

F_x = 1,5 at AP for ships conducting ice breaking astern;

Intermediate values are obtained by linear interpolation.

1.3.9 Auxiliary systems.

1.3.9.1 Machinery shall be protected from the harmful effects of ingestion or accumulation of ice or snow. Where continuous operation is necessary, means shall be provided to purge the system of accumulated ice or snow.

1.3.9.2 Means shall be provided to prevent damage to tanks containing liquids due to freezing.

1.3.9.3 Vent pipes, intake and discharge pipes and associated systems shall be designed to prevent blockage due to freezing or ice and snow accumulation.

1.3.10 Sea inlets and cooling water systems.

1.3.10.1 Cooling water systems for machinery that is essential for the propulsion and safety of a ship, including sea chest inlets, shall be designed for the environmental conditions applicable to the ship's polar class.

1.3.10.2 At least two sea chests shall be arranged as ice boxes (sea chests for water intake in severe ice conditions) for polar classes **PC1** — **PC5**. The calculated volume for each of the ice boxes shall be at least 1 m³ for every 750 kW of the totally installed power. For polar classes **PC6** and **PC7**, there shall be at least one ice box located preferably near centre line.

1.3.10.3 Ice boxes shall be designed for an effective separation of ice and venting of air.

1.3.10.4 Sea inlet valves shall be secured directly to the ice boxes. The valve shall be a full-bore type.

1.3.10.5 Ice boxes and sea bays shall have vent pipes and shall have shut off valves connected directly to the shell.

1.3.10.6 Means shall be provided to prevent freezing of sea bays, ice boxes, ship side valves and fittings above the load water line.

1.3.10.7 Efficient means shall be provided to re-circulate cooling seawater to the ice box. Total sectional area of the circulating pipes shall not be less than the area of the cooling water discharge pipe.

1.3.10.8 Detachable gratings or manholes shall be provided for ice boxes. Manholes shall be located above the deepest load line. Access shall be provided to the ice box from above.

1.3.10.9 Openings in ship sides for ice boxes shall be fitted with gratings, or holes or slots in shell plates. The net area through these openings shall be not less than 5 times the area of the inlet pipe. The diameter of holes and width of slot in shell plating shall be not less than 20 mm. Gratings of the ice boxes shall be provided with a means of clearing. The means of clearing shall be of a type using low pressure steam. Clearing pipes shall be provided with screw-down type non-return valves.

1.3.11 Ballast tanks.

Efficient means shall be provided to prevent freezing in fore and after peak tanks and wing tanks located above the water line and where otherwise found necessary.

1.3.12 Ventilation systems.

1.3.12.1 The air intakes for machinery and accommodation ventilation shall be located on both sides of the ship at locations where manual de-icing is possible. Anti-icing protection of the air inlets may be accepted as an equivalent solution to location on both sides of the ship and manual de-icing at the Register's discretion. Notwithstanding the above, multiple air intakes shall be provided for the emergency generating set and shall be as far apart as possible.

1.3.12.2 The temperature of the inlet air shall be suitable for the safe operation of the machinery; and the thermal comfort in the accommodation.

Accommodation and ventilation air intakes shall be provided with means of heating, if needed.

1.3.13 Steering systems.

1.3.13.1 Rudder stops shall be provided. The design ice force on rudder shall be transmitted to the rudder stops without damage to the steering system. An ice knife shall, in general, be fitted to protect the rudder in centre position. The ice knife shall extend below the ballast waterline (BWL). Design forces shall be determined according to the 1.2.15.

1.3.13.2 The rudder actuator shall comply with the following requirements 1.3.13.2.1 and 1.3.13.2.2.

1.3.13.2.1 The rudder actuator shall be designed for a holding torque obtained by multiplying the open water torque resulting from the application of SOLAS-74 Reg. II-1/29.3.2 (considering however a maximum speed of 18 knots) by the following factors:

Table 1.3.13.2.1

Polar class	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Factor	5	5	3	3	3	1,5	1,5

1.3.13.2.2 The design pressure for calculations to determine the scantlings of the rudder actuator shall be at least 1,25 times the maximum working pressure corresponding to the holding torque defined in 1.3.13.2.1 (according to SOLAS-74 Reg. II-1/29.2.2).

1.3.13.3 The rudder actuator shall be protected by torque relief arrangements, assuming the following turning speeds [deg/s] without an undue pressure rise (Table 1.3.13.3).

Table 1.3.13.3

Steering gear turning speeds for polar class ships

Polar class	**PC1** and **PC2**	**PC3** to **PC5**	**PC6** and **PC7**
Turning speed [deg/s]	10	7,5	6

If the rudder and actuator design can withstand such rapid loads, this special relief arrangement is not necessary and a conventional one may be used instead.

1.3.13.4 Additionally for icebreakers, fast-acting torque relief arrangements shall be fitted in order to provide effective protection of the rudder actuator in case of the rudder being pushed rapidly hard over against the stops.

For hydraulically operated steering gear, the fast-acting torque relief arrangement shall be so designed that the pressure cannot exceed 115 % of the set pressure of the safety valves when the rudder is being forced to move at the speed indicated in Table 1.3.13.4, also when with account for the oil viscosity at the lowest expected ambient temperature in the steering gear compartment.

For alternative steering systems the fast-acting torque relief arrangement shall demonstrate an equivalent degree of protection to that required for hydraulically operated arrangements.

The turning speeds to be assumed for each icebreaker's polar class are shown in Table 1.3.13.4 below.

Table 1.3.13.4

Steering gear turning speeds for icebreakers

Polar class	**PC1** and **PC2**	**PC3** to **PC5**	**PC6** and **PC7**
Turning speed [deg/s]	40	20	15

The fast-acting torque relief arrangement shall be designed so to ensure the ship's steering capacity to be promptly regained.

1.3.14 Alternative design.

1.3.14.1 General.

As an alternative, a comprehensive design study may be submitted to the Register and may be requested for validation as per an agreed test programme.

APPENDIX

ILLUSTRATION OF EXCITATION CASES FOR DIFFERENT BLADE NUMBERS

The illustrations in Figures 1 and 2 show the excitation torque for all torsional load cases given in this Chapter (refer to 1.3.6.3.3.2) for different blade numbers (Z). The curves have been made using data for **PC7** ($Hice$=1,5).

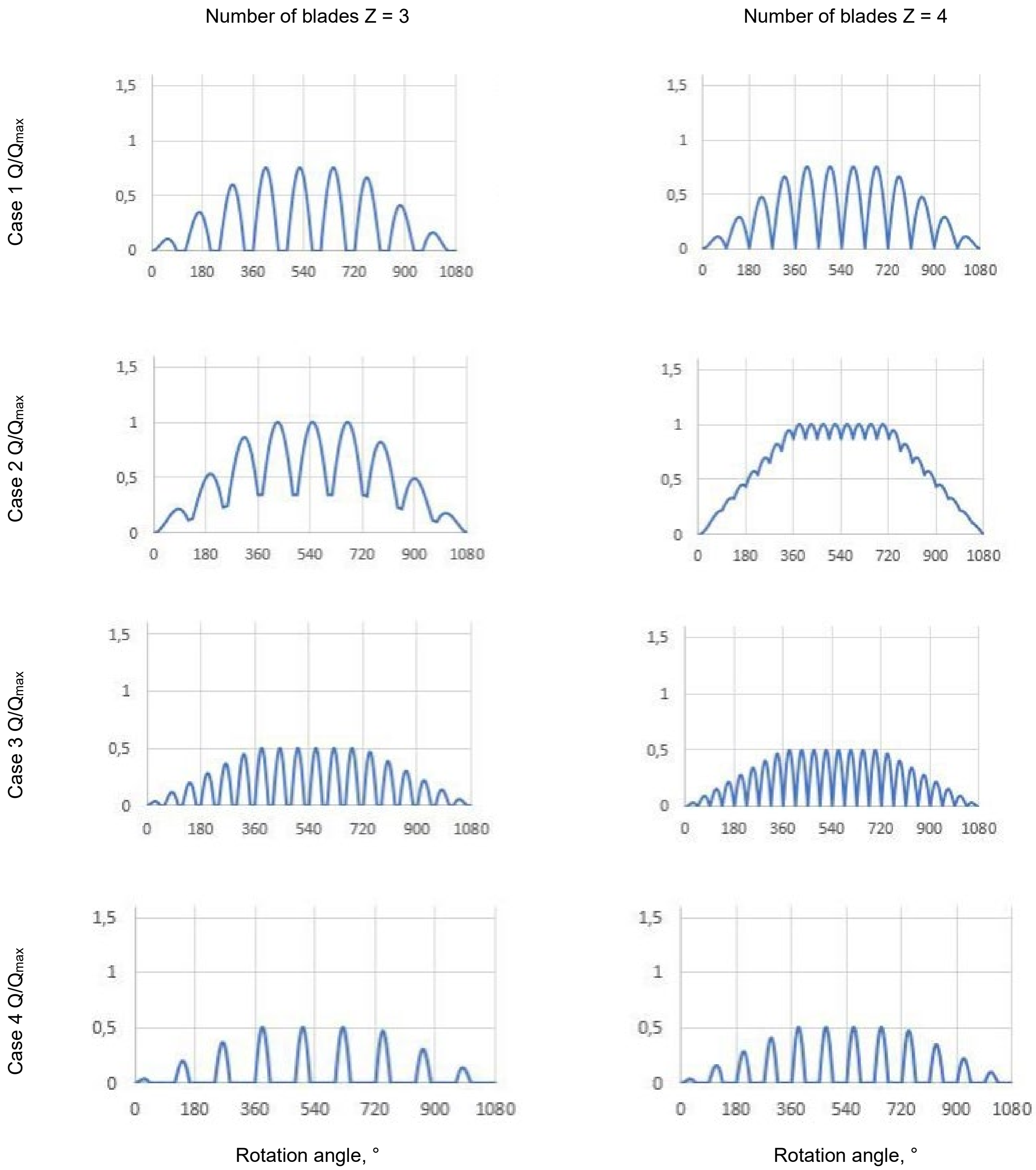


Fig. 1

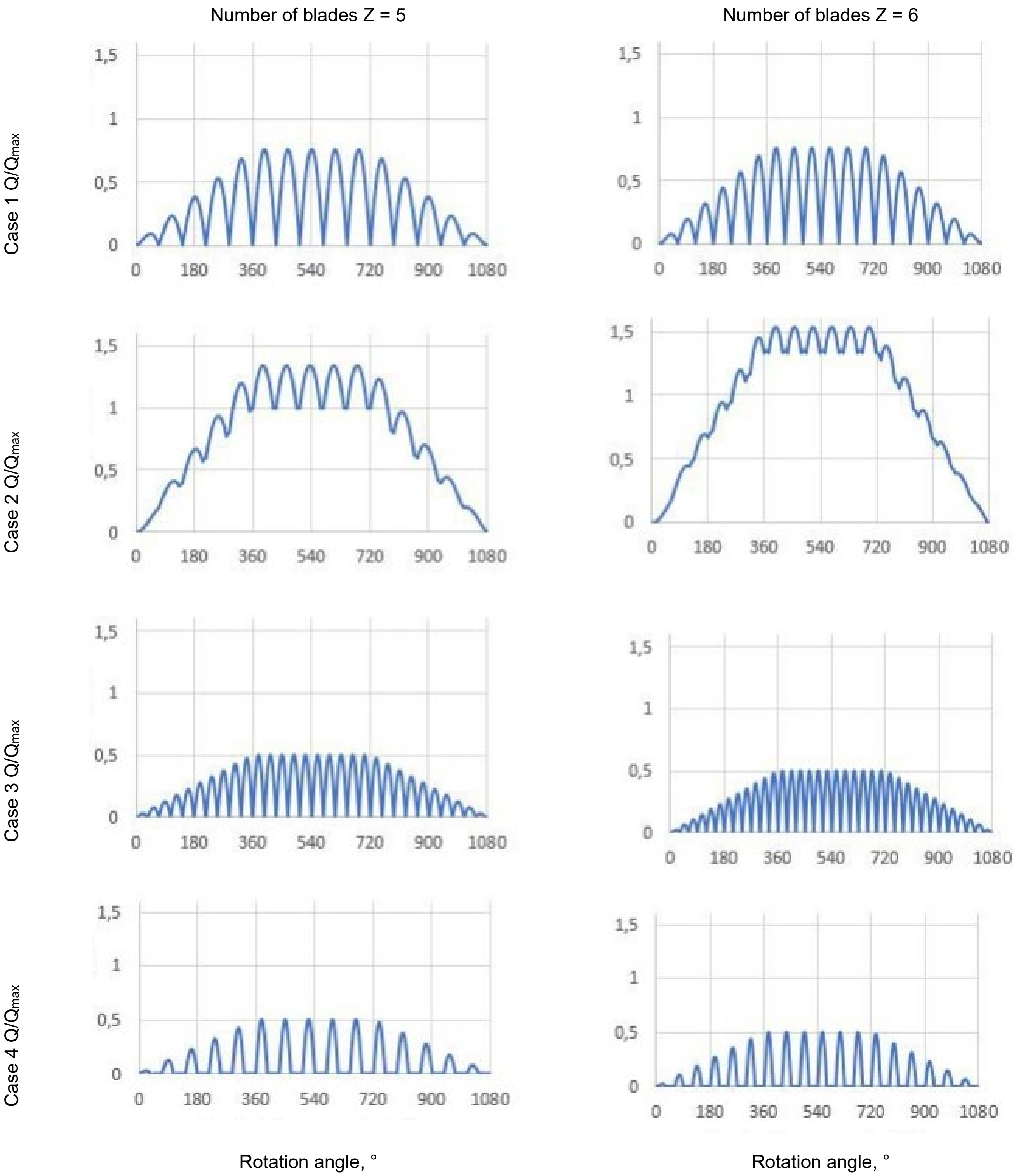

Number of blades Z = 5
Number of blades Z = 6
Case 1 Q/Qmax
Case 2 Q/Qmax
Case 3 Q/Qmax
Case 4 Q/Qmax
1,5
1
0,5
0
0
180
360
540
720
900
1080
Rotation angle, °
Rotation angle, °

Fig. 2''.

9 REQUIREMENTS FOR SHIPS EQUIPPED FOR USING GASES OR LOW-FLASHPOINT FUELS

9.5 FUEL SYSTEM

Para 9.5.4.11 is amended as follows:

"**9.5.4.11** ~~Fuel~~ Gaseous fuel pipes passing through enclosed spaces outside the machinery spaces shall be protected by a secondary enclosure. This enclosure can be a ventilated duct or a double wall piping system. The duct or double wall piping system shall be mechanically ventilated with 30 air changes per hour, and gas detection as required in 9.10.4 shall be provided. This requirement may be omitted for fully welded fuel gas vent pipes passing through mechanically ventilated spaces.".

New para 9.5.4.12 is introduced reading as follows:

"**9.5.4.12** Liquefied fuel pipes passing outside the machinery spaces shall be protected by a secondary enclosure able to contain leakages. This requirement may be omitted for pipes in a fuel preparation room or a tank connection space.

Detection of leaks in the space between the secondary enclosure and the piping shall be provided by a gas detection system in accordance with 9.10.4 using sensors suitable for monitoring the leak media or by means of temperature and/or pressure monitoring systems.

The secondary enclosure shall be able to withstand the maximum pressure that may build up in the enclosure in case of leakage from the liquefied gas fuel piping. For this purpose, the secondary enclosure may be arranged with a pressure relief system that prevents the enclosure from being subjected to pressures above their design pressures.".

Para 9.5.5.1 is amended as follows:

"**9.5.5.1** Fuel piping in gas-safe machinery spaces shall be completely enclosed in external pipes or ducts fulfilling one of the following conditions:

.1 the gas piping shall be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes shall be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes. When the inner pipe contains high pressure gas, the system shall be so arranged that the pipe between the master gas valve and the engine is automatically purged with inert gas when the master gas valve is closed; or

.2 the gas fuel piping shall be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the wall of the outer pipe or duct shall be equipped with mechanical underpressure ventilation having a capacity of at least 30 air changes per hour. This ventilation capacity may be reduced to 10 air changes per hour provided automatic filling of the duct with nitrogen upon detection of gas is arranged for. The fan motors shall comply with the required explosion protection in the installation area. The ventilation outlet shall be screened and placed in a position where there are no flammable sources.

Gas fuel piping enclosed in external pipes or ducts, shall, as far as practicable, use a minimum of flange connection. There shall be no single flange or other components of piping system, where one single failure itself may result in a gas leak into surrounding area causing danger to the persons on board, the environment or the ship.

A single common flange with two sealing systems may be using at the fuel connection to the gas consumers including gas combustion unit (GCU), boilers and components of the engine, such as gas regulating units.".

9.6 GAS FUEL CONSUMERS ON BOARD SHIP

Para 9.6.1.1 is replaced by the following text:

"**9.6.1.1** The exhaust gas system shall be equipped with explosion relief systems unless designed to accommodate the worst-case overpressure due to ignited gas leaks or justified by the safety concept of the engine. A detailed evaluation of the potential for unburnt gas in the exhaust system is to be undertaken covering the complete system from the cylinders up to the open end. This detailed evaluation shall be reflected in the safety concept of the engine.".

9.7 FIRE PROTECTION

Para 9.7.2.2 is amended as follows:

"**9.7.2.2** Fuel storage hold spaces and ventilation ducts serving these spaces shall be separated from accommodation, service, cargo and machinery spaces by class A-60 fire structures. They may be separated from other spaces with low fire risk by class A-0 fire structures. The space containing fuel containment system shall be separated from the machinery spaces of category A or other rooms with high fire risks. The separation shall be done by a cofferdam of at least 900 mm with insulation of A-60 class. When determining the insulation of the space containing fuel containment system from other spaces with lower fire risks, the fuel containment system shall be considered as a machinery space of category A. The boundary between spaces containing fuel containment systems shall be either a cofferdam of at least 900 mm or A-60 class division.

For type C tanks, the fuel storage hold space may be considered as a cofferdam, provided that the type C tank is not located directly above machinery spaces of category A or other rooms with high fire risk specified below, and the minimum distance to the A-60 boundary from the outer shell of the type C tank or the boundary of the tank connection space, if any, is not less than 900 mm.

The following "other rooms with high fire risk" shall as a minimum be considered, but not be restricted to:

.1 cargo spaces except cargo tanks for liquids with flashpoint above 60 °C and except cargo spaces for general cargo apart from dangerous goods which may not be fitted with fixed fire extinguishing systems (in passenger ships engaged in short voyages, in passenger ships of less than 1000 gross tonnage, as well as 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 Footnote 10 of Table 3.1.2.1, Part VI "Fire Protection");

.2 vehicle, ro-ro and special category spaces;

.3 service spaces (high risk) on passenger ships carrying up to 36 passengers, cargo and oil tankers: galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m^2 or more, spaces for the storage of flammable liquids and workshops other than those forming part of the machinery space (refer to 2.2.1.5 (*9*), 2.3.3 (*9*), 2.4.2 (*9*) of Part VI "Fire Protection");

.4 accommodation spaces of greater fire risk on passenger ships carrying more than 36 passengers: saunas, sale shops, barber shops and beauty parlours and public spaces containing furniture and furnishing of other than restricted fire risk and having deck area of 50 m^2 or more (refer to 2.2.1.3 (*8*) of Part VI "Fire Protection").".

11 REQUIREMENTS FOR LNG BUNKERING SHIPS

11.5 FIRE PROTECTION

Para 11.5.2 is amended as follows:

"**11.5.2** Fire extinguishing systems of LNG bunkering ship shall meet the requirements of Part V "Fire Protection" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases and the following additional requirements:

.1 water-spray system shall be fitted to protect the bunkering manifolds, associated piping, arms, loading hoses and the transfer area. The system capacity shall not be less than those specified in 3.3.2 of Part V "Fire Protection" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk;

.2 in the bunkering station area a permanently installed dry powder system shall cover all possible LNG leak points. The capacity shall be at least 3,5 kg/s for a maximum of 45 s discharges. The manual release shall be located at easily accessible and safe position outside the protected area;

.3 additional cargo transfer equipment (including transfer loading arms, bunkering booms, transfer hoses, adaptors, reducers, spool pieces and transfer hose reels) installed in different locations around the ship, shall comply, where applicable, with the requirements in 3.3.1.4, 3.3.1.5, 3.4.1 and 3.4.3 of Part V "Fire Protection" and 3.23.7.2 of Part VI "Systems and Piping" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk for fire detection and fire protection in the cargo area (ESD system functionality and fusible elements (refer to 3.17.4, Part VI "Systems and Piping" of that Rules), water-spray system and dry chemical powder fire-extinguishing system protection, drip trays), including hull protection from low temperatures.

~~.3~~ **.4** one dry powder fire-extinguisher of at least 5 kg capacity shall be located near the bunkering station.".

13 ADDITIONAL REQUIREMENTS FOR SHIPS OF SPECIAL TYPES

13.2 STANDBY VESSELS AND SALVAGE SHIPS, AS WELL AS SHIPS CARRYING EQUIPMENT FOR FIRE FIGHTING ABOARD OTHER SHIPS

Para 13.2.3.11 is deleted.

Existing **para 13.2.3.12 and references thereto** are renumbered **13.2.3.11**.

Para 13.2.4.1.1 and references thereto are deleted.

Existing **paras 13.2.4.1.2 — 13.2.4.1.6 and references thereto** are renumbered **13.2.4.1.1 — 13.2.4.1.5** accordingly.

Renumbered para 13.2.4.1.5 is replaced by following text:

"**.5** ship shall be additionally equipped with lifejackets complying with the requirements of section 2.2 of the LSA Code, provided for 25 % of the number of survivors for which the ship is intended to carry. The number of survivors for which the ship is intended to carry shall be recorded in section "Other characteristics" of the Classification Certificate.".

19 REQUIREMENTS FOR DOUBLE ACTING SHIPS

19.2 REQUIREMENTS FOR HULL STRUCTURE

New para 19.2.4.8 is introduced reading as follows:

"**19.2.4.8** Consideration of interaction between ice and an azimuth thruster (determination of global ice loads).

19.2.4.8.1 The passaging of a ship through a wide channel made by an icebreaker in hummocked ice is taken as the basic design mode of the ship's operation to specify the global ice loads (a load due to impact with an ice block and a load due to a contact between the azimuth thruster and a ridge keel).

The design parameters of an ice feature to specify the global ice loads on the azimuth thruster due to impact with an ice block are given in Table 19.2.4.8.1-1, and those due to a contact between the thruster and an ice ridge — in Table 19.2.4.8.1-2. The maximum of the values for the below calculated cases is taken as the design load.

Table 19.2.4.8.1-1

Ice Class notation	H_{con}, m	H_{ch}, m	σ_v, MPa	σ_H, MPa	l_d, m	b_d, m	H_d, m	m_d, kg
Arc4	1,8	1,6	11,5	9,5	2,3	3,8	1,8	7315
Arc5	2	1,9	12,5	10	3,2	5,4	2	16070
Arc6	2,6	2,5	13	10,5	3,6	5,7	2,7	25763
Arc7 **Arc8** **Arc9**	4,5	4,0	14	11,5	6,22	10,44	4,8	144938

where H_{con} — design thickness of the ridge consolidated layer, m;
H_{ch} — design thickness of ice packed in the channel, m;
σ_v — design ice strength due to coaxial compression under vertical loading, MPa;
σ_H — design ice strength due to uniaxial compression under horizontal loading, MPa;
l_d — design length of an ice block;
b_d — design width of an ice block, m;
H_d — design thickness of an ice block, m;
m_d — weight of an ice block, kg

Table 19.2.4.8.1-2

Ice Class notation	Design depth of a ridge keel H_{keel}, m	Design thickness of ice packed in the channel H_{ch}, m
Arc4	11	1,9
Arc5	11,8	2,3
Arc6	12	2,7
Arc7 **Arc8** **Arc9**	15,5	4,0

19.2.4.8.2 For double acting ships, the design speed of interaction between the thruster and an ice feature is determined for the stern-first and the bow-first operation modes. In the stern-first operation, the design speed of interaction with an ice feature, V_{ice}, m/s, is taken equal to the design ship speed in ice, V, m/s, in accordance with the ship's specifications, but shall be no less than 5 knots. The design speed can be taken based on the results of model tests, but shall be no less than 5 knots.

19.2.4.8.3 A point in the buttock plane at a distance of $3\,B/8$ from the centerline is taken as the design point of a contact between the ship's aft end and the ice cover to specify the dimensions of ice blocks. This buttock corresponds to the entry angles of the ice waterline, α, φ_2 (see Fig. 19.2.4.8.3-1 to determine the angles).

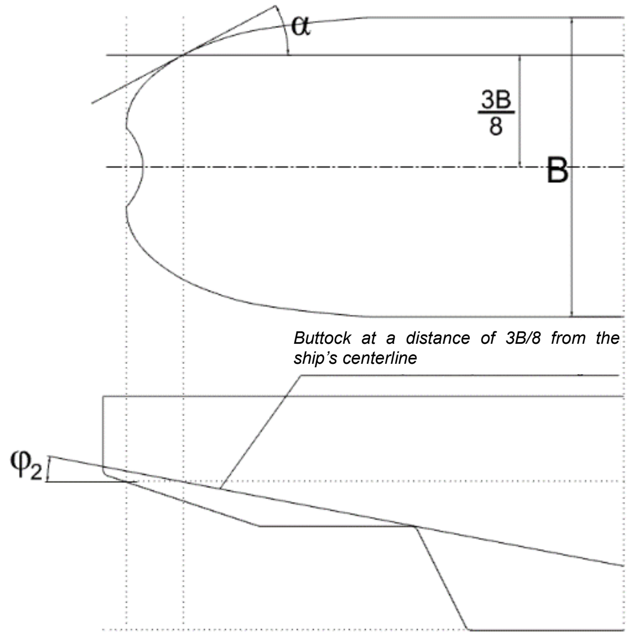


Fig. 19.2.4.8.3 — Values for angles α, φ_2

19.2.4.8.4 Width of an ice block, b_{block}, is calculated by the formula:

$$b_{block} = \frac{10H_{con}}{k_{dyn}}, \qquad (19.2.4.8.4\text{-}1)$$

where k_{dyn} — the dynamic factor to define the dynamic magnification of the ice cover failure load and a decrease in the characteristic dimensions of ice blocks depending on the loading rate:

$$k_{dyn} = \frac{1}{\left(0{,}13031+0{,}45717\cdot exp\left(\frac{-Fr(H_{con})}{0.0595777}\right)+0.41251\cdot exp\left(\frac{-Fr(H_{con})}{0.256}\right)\right)}, \qquad (19.2.4.8.4\text{-}2)$$

where $Fr(H_{con}) = \frac{V \sin\alpha\, \mathrm{tg}(90-\beta_1)}{\sqrt{gH_{con}}}$. (19.2.4.8.4-3)

Length of an ice block, l_{block}, is calculated by the formula:

$$l_{block} = 0.5\, b_{block}/\mathrm{tg}\,\alpha. \qquad (19.2.4.8.4\text{-}4)$$

19.2.4.8.5 To specify the ice force due to impact with an ice block, the following values are taken as the design length l_d and the design width b_d of an ice block:

$$l_d = \min(b_{block}; l_{block});$$

$$b_d = \max(b_{block}; l_{block}).$$

19.2.4.8.6 Weight of an ice block, m_d, kg, is calculated by the formula:

$$m_d = 930k_{fb} \cdot b_d \cdot l_d \cdot H_d, \qquad (19.2.4.8.6)$$

where $k_{fb} = 0.5$ — the shape factor of an ice block;
$H_d = H_{con}$ — the design thickness of an ice block.

19.2.4.8.7 The global load due to impact with an ice block.
19.2.4.8.7.1 The longitudinal ice force acting on the propeller cone of a pulling thruster and the pod cone of a pushing thruster, F_{cl}, MN, is calculated by the formula:

$$F_{cl} = 3.14 \cdot R_c^2 \cdot p_0 \left(2\bar{l} - (\bar{l})^2\right) \cdot k_{form}(\bar{l}) \cdot k_{dyn}, \qquad (19.2.4.8.7.1\text{-}1)$$

where R_c — radius of the cone, m;
$p_0 = 2.4\sigma_v^{0,6}$ — average local pressure, MPa;
σ_v — ice strength in uniaxial compression under vertical loading, see Table 19.2.4.8.1-1, MPa;
$\bar{l}$ — non-dimensional distance of the cone penetration into ice, see Fig. 19.2.4.8.7.1;

$$\bar{l} = 0.44\left(\frac{m_d v_{ice}^2}{R_c^3 p_0 \cdot 10^6}\right)^{0.6}, \qquad (19.2.4.8.7.1\text{-}2)$$

where m_d — weight of an ice block, kg, in accordance with 19.2.4.8.6;
V_{ice} — speed of interaction with an ice feature in accordance with 19.2.4.8.2;

$k_{form}(\bar{l})$ — the shape factor;

$$k_{form}(\bar{l}) = -0.1525\bar{l}^3 + 0.402\bar{l}^2 - 0.3897\bar{l} + 1; \qquad (19.2.4.8.7.1\text{-}3)$$

$k_{dyn} = 1.2$ — the dynamic magnification factor.

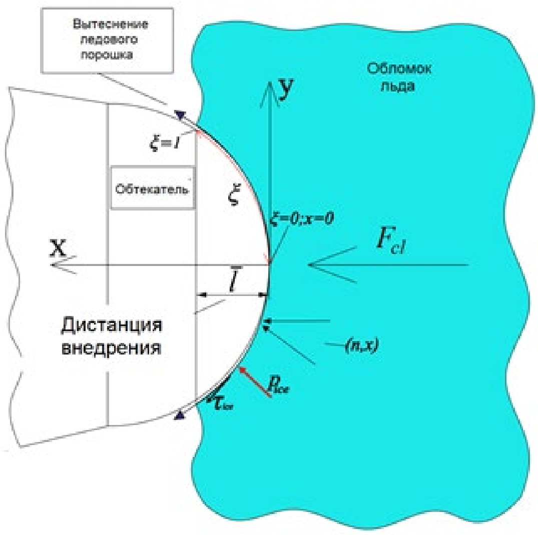


Fig. 19.2.4.8.7.1 — Interaction pattern between the propeller cone of a pulling thruster and the pod cone of a pushing thruster

19.2.4.8.7.2 The longitudinal ice force acting on the thruster strut due to impact with an ice block, F_{sl}, MN, is calculated by the formula:

$$F_{sl} = b \cdot l_{ice} \cdot k_{scale}(l_{ice}) \cdot k_{form}(\bar{l}) \cdot p_0, \qquad (19.2.4.8.7.2\text{-}1)$$

where l_{ice}— the contact height, m, calculated as follows:

$$l_{ice} = \begin{cases} H_d, at\ \Delta z \geq H_d \\ \Delta z,\ \ at\ \Delta z < H_d \end{cases}, \qquad (19.2.4.8.7.2\text{-}2)$$

where H_d — the design thickness of an ice block, see 19.2.4.8.6;
Δz — height of the thruster strut, see Fig. 19.2.4.8.7.4-1;

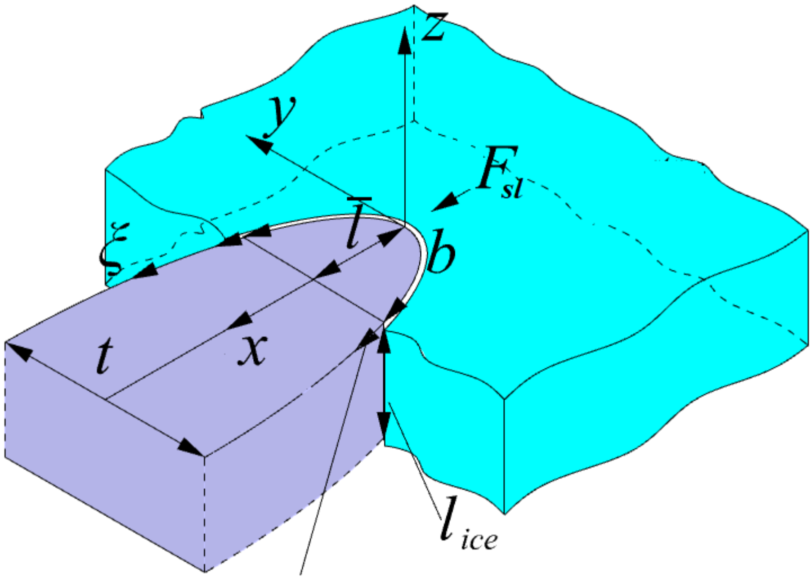


Fig. 19.2.4.8.7.2 — Interaction pattern between the thruster strut and an ice block

$k_{scale}(l_{ice})$ — the ice strength scale factor due to the non-simultaneity of the ice failure;

$$k_{scale}(l_{ice}) = 0.7853 \cdot exp\left[-\frac{l_{ice}}{1{,}99}\right] + 0.2146; \quad (19.2.4.8.7.2\text{-}3)$$

p_0— the average local pressure, MPa;

$$p_0 = 2.4 \cdot \sigma_H{}^{0.6}, \quad (19.2.4.8.7.2\text{-}4)$$

where σ_H — the uniaxial compression ice strength under horizontal loading, see Table 19.2.4.8.11;

$k_{form}(\bar{l})$ — the shape factor;

$$k_{form}(\bar{l}) = -0.1525\bar{l}^3 + 0.402\bar{l}^2 - 0.3897\bar{l} + 1,$$

where $\bar{l}$ — the non-dimensional depth of the thruster strut penetration into ice, see Fig. 19.2.4.8.7.2;

$$\bar{l} = 1.0864 \cdot \left[\frac{\frac{m_d \cdot V_{ice}{}^2}{2}}{l_{ice} \cdot t^2 \cdot p_0 \cdot 10^6 \cdot k_{scale}(l_{ice})}\right]^{0.65}, \quad (19.2.4.8.7.2\text{-}5)$$

where m_d — weight of an ice block, kg, see 19.2.4.8.6;
V_{ice} — speed of interaction between the nozzle and an ice block, m/s, see 19.2.4.8.2;
t — the nozzle characteristic dimension, m, see Fig. 19.2.4.8.7.2;

b — the contact area in the plane of the profile cross-section, m, see Fig. 19.2.4.8.7.2;

$$b = 2\arccos(1 - \bar{l}) \cdot (t/2). \quad (19.2.4.8.7.2\text{-}6)$$

19.2.4.8.7.3 The longitudinal ice force acting on the thruster nozzle due to impact with an ice block, F_{nl}, MN, is calculated by the formula:

$$F_{nl} = b \cdot l_{ice} \cdot k_{scale}(l_{ice}) \cdot k_{form}(\bar{l}) \cdot p_0 \cdot k_{dyn}, \quad (19.2.4.8.7.3\text{-}1)$$

where l_{ice} — the contact length of an ice block along the nozzle leading edge, m;

$$l_{ice} = 2\arccos(1 - \bar{\delta}_{ice}) \cdot R, \quad (19.2.4.8.7.3\text{-}2)$$

where R — the nozzle radius, m, see Fig. 19.2.4.8.7.3;

$\bar{\delta}_{ice}$ — the non-dimensional contact height;

$$\bar{\delta}_{ice} = \delta_{ice}/R_n; \quad (19.2.4.8.7.3\text{-}3)$$

$$\delta_{ice} = \begin{cases} H_d, at\ H_d < (R - R_{hub}); \\ R - R_{hub}\ at\ H_d \geq (R - R_{hub}), \end{cases} \quad (19.2.4.8.7.3\text{-}4)$$

where H_d — the design thickness of an ice block, see 19.2.4.8.1;

R_{hub}—the hub radius;

$k_{scale}(l_{ice})$ — the ice strength scale factor due to non-simultaneity of the ice failure;

$$k_{scale}(l_{ice}) = 0.7853 \cdot exp\left[-\frac{l_{ice}}{1.99}\right] + 0.2146; \quad (19.2.4.8.7.3\text{-}5)$$

p_0 — the average local pressure (the bearing strength), MPa;

$$p_0 = 2.4 \cdot \sigma_H{}^{0.6}, \quad (19.2.4.8.7.3\text{-}6)$$

where σ_H - the uniaxial compression ice strength under horizontal loading, see Table 19.2.4.8.1-1;

$k_{form}(\bar{l})$ — the shape factor;

$$k_{form}(\bar{l}) = -0.1525\bar{l}^{-3} + 0.402\bar{l}^{-2} - 0.3897\bar{l} + 1. \quad (19.2.4.8.7.3\text{-}7)$$

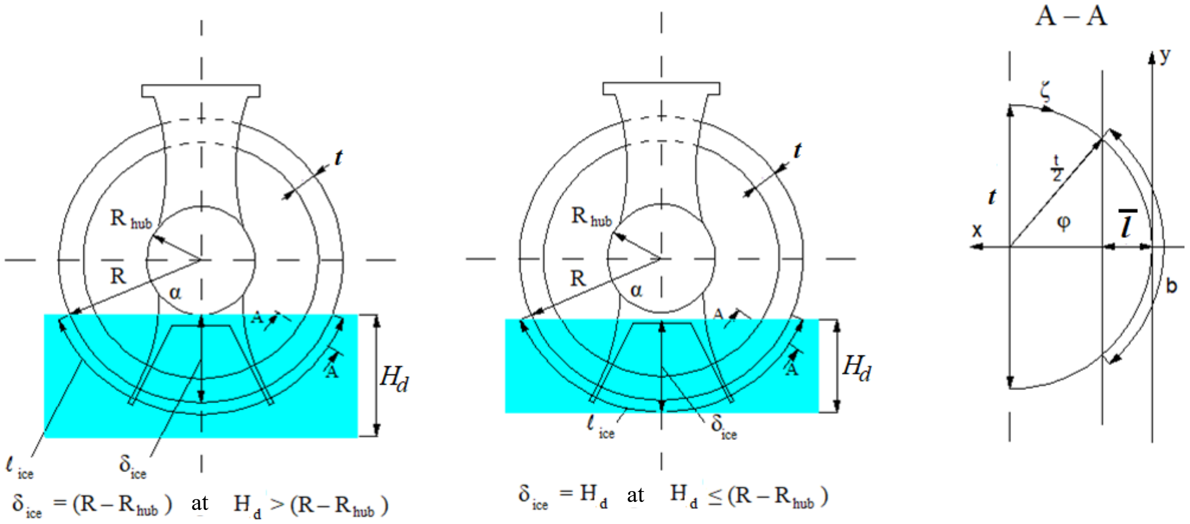


Fig. 19.2.4.8.7.3 — Interaction pattern between ice and the nozzle

$\bar{l}$ — the non-dimensional depth of ice block penetration into the nozzle, see Fig. 19.2.4.8.7.3;

$$\bar{l} = 1.0864 \cdot \left[\frac{(m_d \cdot V_{ice}{}^2)/2}{\arccos(1-\bar{\delta}_{ice}) \cdot R \cdot t^2 \cdot p_0 \cdot 10^6 \cdot k_{scale}(l_{ice})}\right]^{0.65}, \tag{19.2.4.8.7.3-8}$$

where t — the nozzle characteristic dimension;
m_d — weight of an ice block, kg, see 19.2.4.8.6;
V_{ice} — speed of interaction between the nozzle and an ice block, m/s, see 19.2.4.8.2;

b — the contact area in the plane of the profile cross-section, m, see Fig. 19.2.4.8.7.3;

$$b = 2\arccos(1-\bar{l}) \cdot (t/2); \tag{19.2.4.8.7.3-9}$$

$k_{dyn} = 1.2$ — the dynamic magnification factor.

19.2.4.8.7.4 The longitudinal ice force acting on the thruster strut due to milling, F_{sc}, MN, is calculated by the formula

$$F_{sc} = p_0 \cdot l_{ice} \cdot k_{scale}(l_{ice}) \cdot k_{form} \cdot t, \tag{19.2.4.8.7.4-1}$$

where t — the strut characteristic transverse dimension, m, see Fig. 19.2.4.8.7.2;
$k_{form} = 0.7$ — the shape factor;
l_{ice} — the contact height, see Fig. 19.2.4.8.7.2, calculated by the formula:

$$l_{ice} = \begin{cases} at \Delta z \geq H_d \\ \Delta z, \ \Delta z < H_d \end{cases}, \tag{19.2.4.8.7.4-2}$$

where H_d — the design thickness of an ice block, see 19.2.4.8.1;

$k_{scale}(l_{ice})$ — the ice strength scale factor;

$$k_{scale}(l_{ice}) = 0{,}7853 \cdot \exp\left[-\frac{l_{ice}}{1{,}99}\right] + 0{,}2146; \tag{19.2.4.8.7.4-3}$$

$p_0 = 2{,}4 \cdot \sigma_H{}^{0{,}6}$ — the average local pressure (the bearing strength), MPa.

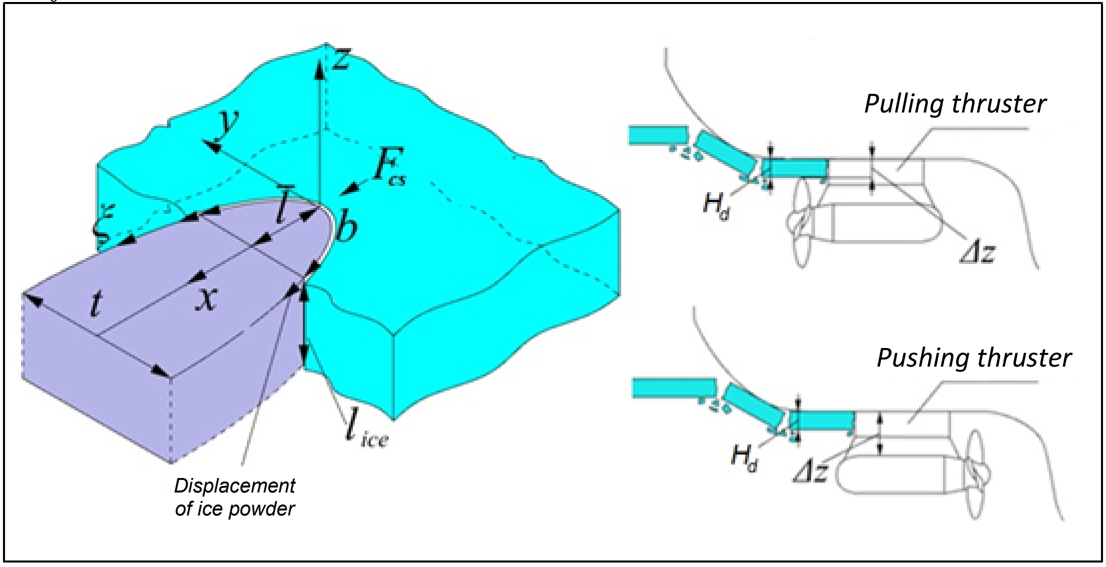


Fig. 19.2.4.8.7.4-1

19.2.4.8.7.5 The transversal ice force acting on the strut, F_{st}, MN, is calculated by the formula:

$$F_{st} = \omega \cdot b_{ice} \cdot p_0 \cdot k_{scale}(\omega), \quad (19.2.4.8.7.5\text{-}1)$$

where $\omega = b_d \cdot \bar{l}$ — width of contact area, m;

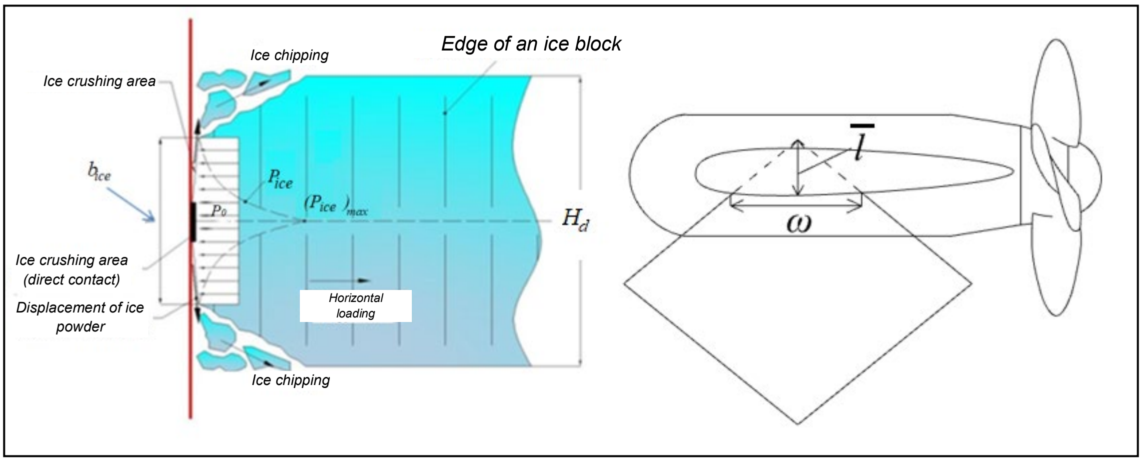


Fig. 19.2.4.8.7.5 — Interaction pattern between the thruster strut and an ice block

$\bar{l}$ — the non-dimensional penetration distance, see Fig. 19.2.4.8.7.5;

$$\bar{l} = C_2 \cdot f^2 + C_1 \cdot f + C_0; \quad (19.2.4.8.7.5\text{-}2)$$

$$C_2 = -19.849 \cdot b_d - 420.7; \quad (19.2.4.8.7.5\text{-}3)$$

$$C_1 = 0.439 \cdot b_d + 13.906; \quad (19.2.4.8.7.5\text{-}4)$$

$$C_0 = -0.0003 \cdot b_d + 0.0287; \quad (19.2.4.8.7.5\text{-}5)$$

$$f = 1.273 \left(\frac{\rho_{ice} \cdot k_{fb}}{k_{split} \cdot p_0 \cdot 10^6}\right) {V_{ice}}^2, \quad (19.2.4.8.7.5\text{-}6)$$

where $\rho_{ice} = 930\ kg/m^3$ — the ice density;
$k_{fb} = 0.5$ — the ice block shape factor;
$k_{split} = 0.4$ — the chipping factor to take into account a decrease in the contact height due to the ice chipping;
p_0 — the average local pressure (the bearing strength), MPa;

$$p_0 = 2.4 \cdot {\sigma_H}^{0.6}; \quad (19.2.4.8.7.5\text{-}7)$$

V_{ice} — speed of interaction with an ice feature in accordance with 19.2.4.8.2;

b_{ice} — height of the contact area, m;

$$b_{ice} = k_{split} \cdot H_d, \quad (19.2.4.8.7.5\text{-}8)$$

где H_d — the ice block design thickness, see 19.2.4.8.1;

$k_{scale}(\omega)$ — the ice strength scale factor;

$k_{scale}(\omega) = 0.7853 \cdot \exp\left[-\frac{\omega}{1,99}\right] + 0.2146.$ (19.2.4.8.7.5-9)

19.2.4.8.7.6 The transversal ice force acting on the thruster pod (nozzle) due to impact with an ice block, F_{pnt}, MN, is calculated by the formula:

$$F_{pnt} = 0.65 \cdot \omega \cdot b_{ice} \cdot p_0 \cdot k_{scale}(b_{ice}) \cdot k_{dyn}, \quad (19.2.4.8.7.6\text{-}1)$$

where ω — width of the contact area, m;

$$\omega = 2 \cdot \bar{l} \cdot R \cdot \frac{b_d}{l_d}, \quad (19.2.4.8.7.6\text{-}2)$$

where R — the pod (nozzle) radius, m;
b_d, l_d — the ice block design dimensions, m, see 19.2.4.8.1;
$\bar{l}$ — non-dimensional distance of an ice block penetration into the pod (nozzle), see Fig. 19.2.4.8.7.6;

$$\bar{l} = a\psi^b; \quad (19.2.4.8.7.6\text{-}3)$$

$$\psi = 0,245\left(\frac{{l_d}^2 H_d}{R^3}\right)\left(\frac{\rho_{ice} \cdot k_{fb}}{p_0 \cdot 10^6}\right){V_{ice}}^2, \quad (19.2.4.8.7.6\text{-}4)$$

where $\rho_{ice} = 930\ kg/m^3$ — the ice density;
V_{ice} — speed of interaction with an ice feature in accordance with 19.2.4.8.2;
H_d — the ice block design thickness, see 19.2.4.8.1;
p_0 — the average local pressure (the bearing strength), MPa;

$$p_0 = 2.4 \cdot {\sigma_H}^{0.6}; \quad (19.2.4.8.7.6\text{-}5)$$

b_{ice} — height of the contact area;

$$b_{ice} = 2R\sin(\arccos(1 - \bar{l})); \quad (19.2.4.8.7.6\text{-}8)$$

$k_{scale}(b_{ice})$ — the ice strength scale factor;

$$k_{scale}(b_{ice}) = 0.7853 \cdot \exp\left[-\frac{b_{ice}}{1,99}\right] + 0.2146; \quad (19.2.4.8.7.6\text{-}9)$$

$k_{dyn} = 1.2$ — the dynamic magnification factor.

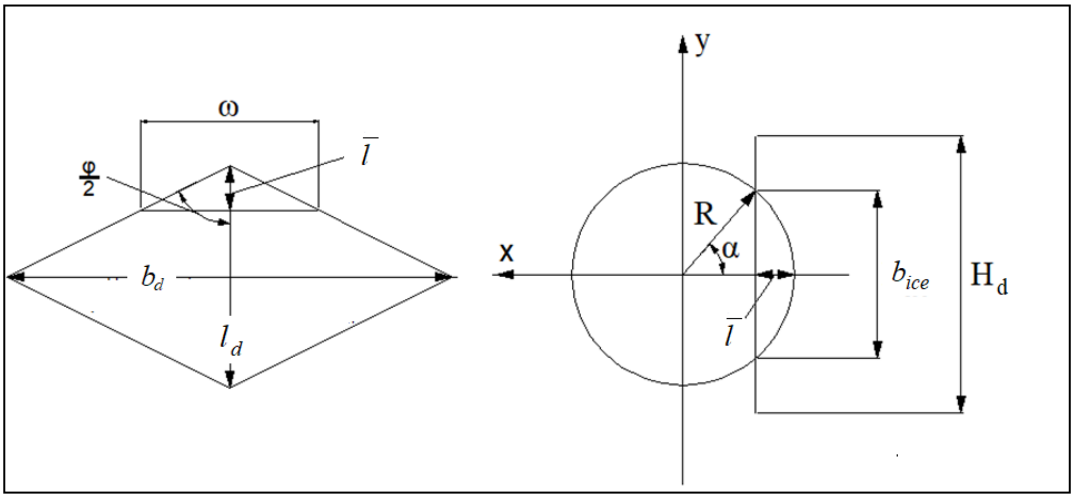


Fig. 19.2.4.8.7.6 — Interaction pattern between the thruster pod (nozzle) and an ice block

19.2.4.8.7.7 The total transversal ice force acting on the thruster due the strut and the pod (nozzle) impact with an ice block, F_{tt}, MN, is calculated by the formula:

$$F_{tt} = k_{red} \cdot (F_{st} + F_{pnt}), \qquad (19.2.4.8.7.7)$$

where $k_{red} = 0.7$ — the reduction factor of the total transverse load due to the non-simultaneous implementation of the maximum values of the load components (the effect of non-simultaneous failure);
F_{st} — the transversal ice force acting on the thruster strut, MN, see 19.2.4.8.7.5;
F_{pnt} — the transversal ice force acting on the thruster pod (nozzle), MN, see 19.2.4.8.7.6.

19.2.4.8.8 Load due to a contact with a ridge keel.
19.2.4.8.8.1 The transversal ice force acting on the thruster pod (nozzle) due to a contact with a ridge keel, F_{kt}, MN, is calculated by the formula:

$$F_{kt} = S \cdot p_{keel} \cdot V_{ice}^{0.66}, \qquad (19.2.4.8.8.1\text{-}1)$$

where V_{ice} — speed of interaction with an ice feature in accordance with 19.2.4.8.2;
S — total area of the thruster side projection, m^2;
p_{keel} — the normal shear stress in a ridge keel, MPa;

$$p_{keel} = 0.0149 \cdot H_{keel} + 0.0397, \qquad (19.2.4.8.8.1\text{-}2)$$

where H_{keel} — the design depth of a ridge keel, see Table 19.2.4.8.1-2.".

New Section 34 is introduced reading as follows:

"34 REQUIREMENTS FOR SHIPS CARRYING THE INDUSTRIAL PERSONNEL

34.1 GENERAL

34.1.1 Application.
34.1.1.1 The requirements of this Section apply to cargo ships carrying the industrial personnel as determined in 1.1.1, Part I "Classification".
34.1.1.2 Wherever the number of the industrial personnel is mentioned in this Section as a parameter, it shall be the aggregate number of the industrial personnel, special personnel

and passengers carried on board. Herewith, the number of passengers shall not exceed 12 persons.

34.1.1.3 The requirements for safe transfer of the industrial personnel on high-speed craft are given in Part XXI "Craft for Personnel Transportation" of the Rules for the Classification and Construction of High-Speed Craft.

34.1.1.4 The cargo ship carrying in total not more than 12 persons of the industrial personnel, special personnel and passengers shall comply with the Rules for the Classification and Construction of Sea-Going Ships as well as SOLAS-74 or the Rules for the Equipment of Sea-Going Ships (whatever is applicable) for cargo ships.

34.1.1.5 The cargo ship carrying in total more than 12 persons of the industrial personnel, special personnel and passengers shall comply at least with the Rules for the Classification and Construction of Sea-Going Ships for cargo ships considering its dimensions and type as well as additional requirements of 34.2 — 34.4 depending on the number of persons on board and gross tonnage.

34.1.1.6 A distinguishing mark may be added to the character of classification of ships specified in 34.1.1.5:

.1 IPS1(N) — for ships of 500 gross tonnage and upwards complying with the requirements of this Section except the requirements of 34.4. This mark may be assigned to special purpose ships carrying the industrial personnel and engaged on international voyages, provided that the requirements of this Section related to the personnel transfer appliances (refer to 34.3.2), life-saving appliances (refer to 34.3.12) and, if applicable, carriage of dangerous goods (refer to 34.3.13) are complied with. Besides, this mark may be assigned to special purpose ships carrying the industrial personnel and not engaged on international voyages, provided that the requirements of this Section related to life-saving appliances (refer to 34.3.12) depending on the number of persons on board and, if applicable, to carriage of dangerous goods (refer to 34.3.13) are complied with; herewith, the requirements of 34.3.2 related to the personnel transfer appliances are not mandatory to fulfill.

.2 IPS2(N) — for ships of less than 500 gross tonnage complying with the requirements of 34.2 and 34.4. This mark may be assigned to special purpose ships carrying the industrial personnel, provided that the requirements of this Section related to life-saving appliances (refer to 34.4.5) depending on the number of persons on board are complied with.

34.1.1.7 Ships specified in 34.1.1.4 are not assigned with the distinguishing marks listed in 34.1.1.6. Herewith, the Section "Other Characteristics" of the Classification Certificate may be supplemented with an entry confirming the possibility to carry up to 12 persons of the industrial personnel.

34.1.2 Definitions.

For the purpose of this Section the following definitions apply. For terms not defined in this Section, there shall be applied definitions given in the corresponding parts of the Rules for the Classification and Construction of Sea-Going Ships.

L e n g t h is the ship's length L_{LL} as it is defined in Part II "Hull".

C a r r i a g e means transportation or accommodation or both.

P e r s o n n e l t r a n s f e r means the full sequence of the operation of transferring personnel and their equipment at sea to or from a ship carrying the industrial personnel or to or from another ship or an offshore facility.

I P a r e a is any area or compartment where the industrial personnel (IP) are normally intended to stay during voyage or are allowed to access.

34.2 TECHNICAL DOCUMENTATION

34.2.1 To assign distinguishing mark **IPS1(N)** or **IPS2(N)** to ships carrying the industrial personnel, the documentation listed in 3.2.1 — 3.2.10, 3.2.17.28 and 3.3, Part I "Classification" shall be submitted to the Register to confirm fulfillment of the requirements of 34.3 or 34.4 accordingly.

34.3 ADDITIONAL REQUIREMENTS FOR CARGO SHIPS OF 500 GROSS TONNAGE AND UPWARDS

34.3.1 Hull.

34.3.1.1 A double bottom shall comply with the requirements of 1.1.6, Part II "Hull", as applicable to passenger ships.

34.3.2 Personnel transfer appliances.

34.3.2.1 Ships shall be fitted with appliances to transfer personnel at sea.

34.3.2.2 The personnel transfer appliances (PTA) shall be designed, manufactured, tested and installed in accordance with the requirements of this Section as well as 5.8 of the Rules for the Cargo-Handling Gear of Sea-Going Ships.

34.3.2.3 The PTA design shall account for structural particulars of the ship.

34.3.2.4 To ensure a safe transfer of personnel an analysis shall be performed in order to evaluate failures in PTA and all its associated systems which might impair serviceability of the transfer appliance(s) and/or endanger the safety of all those involved in the transfer operations. The analysis is recommended to perform using FMEA (the failure mode and effects analysis).

To perform the analysis, proceed as follows:

.1 consider the effect of failure for all the equipment and systems in the case of a single failure, fire in any space or flooding of any watertight compartment that may affect serviceability of the transfer appliance(s);

.2 provide solutions to ensure serviceability of PTA and safety of all those involved in case of failures specified in 34.3.2.4.1;

.3 when a single failure results in a failure of more than one component of a system (the common-cause failure), all the resulting failures shall be considered altogether. If a failure directly causes further failures, all such failures shall be considered altogether;

.4 means for position keeping shall be provided and arranged so to prevent accidents during the personnel transfer and be consistent with an operating mode of and interaction with other ships or offshore facilities. For doing so, the ship's maneuverability along with the expected need for the ship to keep own position over time shall be evaluated, to ensure the correct use of position-keeping equipment;

.5 procedures shall be in place to ensure consistent monitoring of the number of persons on board during the personnel transfer operations.

34.3.2.5 To operate PTA, there shall be provided means of communication between the responsible ship's officer overseeing the personnel transfer operations and the navigation bridge.

34.3.2.6 All PTA shall be permanently marked so to enable identification of each appliance for the purpose of survey, inspection and record-keeping. All the records of use and maintenance of the ship's PTA shall be kept onboard.

34.3.2.7 Passageways for the industrial personnel shall ensure safe and unobstructed movement of people between PTA and a place, where the industrial personnel are intended to be stationed or accommodated onboard a ship.

34.3.2.8 In addition to the requirements of 6.1.1 of Part XI "Electrical Equipment", lighting with power from the emergency source of electrical power shall be provided so to illuminate PTA, the water below PTA and passageways to PTA, as specified in 34.3.2.7.

34.3.2.9 To arrange PTA onboard the ship, there shall be designated a deck area free from any obstructions (e.g. air pipes, valves, hatches, fixed and/or detachable structures, ship's supplies or cargo, etc.).

34.3.2.10 When carrying dangerous goods, the requirements of 34.3.13.4.3.3 and 34.3.13.4.3.4 related to PTA shall be fulfilled.

34.3.3 Equipment, arrangements and outfit.

34.3.3.1 Steering system for ships having length of 120 m and more or having three (3) or more vertical zones carrying more than 240 persons shall comply with the requirements of 2.2.6.7.2 and 2.2.6.8 of Part VI "Fire Protection".

34.3.3.2 Steering gears of ships carrying more than 240 persons shall comply with the requirements of 2.9.5 of Part III "Equipment, Arrangements and Outfit".

34.3.3.3 Doors fitted in the subdivision bulkheads shall comply with the requirements of 7.12.5 except for 7.12.5.15, Part III "Equipment, Arrangements and Outfit".

34.3.3.4 The power-operated doors fitted in the subdivision bulkheads for ships having length of 120 m or more or those having three (3) or more vertical zones carrying more than 240 persons shall comply with the requirements of 2.2.6.7.3 and 2.2.6.8 of Part VI "Fire Protection".

34.3.3.5 Exits and doors shall comply with the requirements of 8.5.2.1, 8.5.2.2 of Part III "Equipment, Arrangements and Outfit".

34.3.3.6 Corridors, passageways and means of escape for ships carrying more than 60 persons shall comply with the requirements of 8.5.3.1, 8.5.3.7, while stairways and vertical ladders for escape routes shall comply with the requirements of 8.5.4.2 of Part III "Equipment, Arrangements and Outfit".

34.3.3.7 Low-location lighting for ships carrying more than 240 persons shall comply with the requirements of 8.5.5 of Part III "Equipment, Arrangements and Outfit".

34.3.4 Stability.

34.3.4.1 A ship carrying more than 240 persons shall comply with the requirements of Part IV "Stability" for passenger ships except for 1.5.5 related to the periodical light-weight check. To apply the requirements of the said Part, the industrial personnel shall be considered as passengers.

34.3.4.2 A ship carrying not more than 240 persons shall comply with the requirements of Part IV "Stability" for cargo ships, herewith the industrial personnel shall be considered as a crew.

34.3.4.3 For ships of 500 gross tonnage and upwards, which are not engaged on the international voyages, as well as for ships less than 500 gross tonnage carrying not more than 240 persons, which are of a similar type to the support vessels, the requirements for the righting lever curve are allowed to be mitigated, as specified in 3.11.4 of Part IV "Stability".

34.3.5 Subdivision.

34.3.5.1 Ships shall comply with the requirements of 3.4.3 of Part V "Subdivision".

34.3.6 Fire protection.

34.3.6.1 Ships carrying more than 60, but not more than 240 persons shall comply with the requirements of Part VI "Fire Protection" for passenger ships carrying not more than 36 passengers, except for 2.2.6 and 2.2.7.

34.3.6.2 Ships carrying more than 240 persons shall comply with the requirements of Part VI "Fire Protection" for passenger ships carrying more than 36 passengers.

34.3.7 Systems and piping.

34.3.7.1 The piping laying through the collision bulkhead shall comply with the requirements of 5.1.2 of Part VIII "Systems and Piping".

34.3.7.2 Bilge system shall comply with the requirements of 7.1.2 — 7.1.6 and 7.3.6, Part VIII "Systems and Piping", except for 34.3.7.3.

34.3.7.3 Bilge system for ships having length of 120 m and more or having three or more main vertical zones carrying more than 240 persons shall comply with the requirements of 2.2.7.4, 2.2.6.7.5 and 2.2.6.8 of Part VI "Fire Protection".

34.3.7.4 Ballast system for ships carrying more than 240 persons and having length of 120 m and more or having three or more main vertical zones shall comply with the requirements of 2.2.6.7.5 and 2.2.6.8 of Part VI "Fire Protection".

34.3.7.5 Ventilation system for ships carrying not more than 240 persons, shall comply with the requirements of 12.2 of Part VIII "Systems and Piping" as on passenger ships carrying not more than 36 passengers.

34.3.7.6 Ventilation system for ships carrying more than 240 persons shall comply with the requirements of 12.3 of Part VIII "Systems and Piping" as on passenger ships carrying more than 36 passengers, while for ships carrying more than 240 persons, having length of 120 m and more or having three or more main vertical zones the ventilation system shall comply with the requirements of 2.2.6.10 of Part VI "Fire Protection".

34.3.8 Machinery installations.

34.3.8.1 The fuel oil tanks for ships carrying more than 60 persons shall comply with the requirements of 4.3.2 of Part VII "Machinery Installations", provided that the Register has agreed installation of free-standing tanks.

34.3.9 Machinery.

34.3.9.1 It is not allowed to connect piping systems of power-operated sliding watertight doors with other hydraulic systems on board.

34.3.9.2 Hydraulic systems of power-operated sliding watertight doors shall comply with the requirements of 7.1.5 of Part IX "Machinery".

34.3.9.3. Steering gears for ships carrying more than 240 persons, having length of 120 m or more or having three or more main vertical zones shall comply with the requirements of 2.2.6.7.2 and 2.2.6.8 of Part VI "Fire Protection".

34.3.10 Electrical equipment.

34.3.10.1 Emergency sources of electrical power for ships having length of 50 m and more, carrying not more than 60 persons shall comply with the requirements of 20.1.2.3.1 of Part XI "Electrical Equipment".

34.3.10.2 Emergency sources of electrical power for ships carrying more than 60 persons shall comply with the requirements of 20.1.2 of Part XI "Electrical Equipment".

34.3.10.3 Distribution systems on ships carrying more than 60 persons shall comply with the requirements of 20.1.1.4 of Part XI "Electrical Equipment".

34.3.11 Automation.

34.3.11.1 Ships shall comply with the requirements of Part XV "Automation" depending on the automation mark in the class notation in order to ensure the same safety level as in the normally attended machinery spaces.

34.3.12 Life-saving appliances.

34.3.12.1 Ships carrying more than 60 persons and engaged on international voyages shall comply with the requirements of SOLAS-74 Chapter III for life-saving appliances of passenger ships engaged on international voyages which are not short international voyages.

34.3.12.2 Ships carrying more than 60 persons and not engaged on international voyages shall comply with the requirements of Section 3, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

34.3.12.3 To apply the requirements of SOLAS-74 Chapter III or the Rules for the Equipment of Sea-Going Ships as stated in 34.3.12.1, 34.3.12.2, the industrial personnel shall be considered as passengers.

34.3.12.4 Notwithstanding the requirements of 34.3.12.3, the required number of lifejackets for infants or lifejackets for children shall be calculated solely based on the number of passengers on board.

34.3.13 Dangerous goods.

34.3.13.1 The industrial personnel may only carry dangerous goods on board for their use off the ship, provided the consent of the ship's master. These dangerous goods shall be considered as cargo and be transported in accordance with 7.2 of Part VI "Fire Protection".

34.3.13.2 Carriage of dangerous goods in a packaged form.

34.3.13.2.1 Ships carrying more than 240 persons on board shall comply with the requirements of 7.2.10.2 of Part VI "Fire Protection" for passenger ships carrying more than 36 passengers; herewith, for complying with the International Maritime Dangerous Goods Code adopted by IMO resolution MSC.122(75), as amended, ships carrying more than 240 persons on board shall be considered as passenger ships and those carrying not more than 240 persons on board shall be considered as cargo ships.

34.3.13.3 Carriage of dangerous goods in solid form in bulk.

34.3.13.3.1 Ships carrying more than 240 persons on board shall comply with the requirements of 7.2.10.2 of Part VI "Fire Protection" for passenger ships carrying more than 36 passengers; herewith, for complying with the International Maritime Solid Bulk Cargoes Code adopted by IMO resolution MSC.268(85), as amended, the industrial personnel shall be considered as personnel in the context of personnel protection.

34.3.13.4 Carriage of chemically hazardous substances, liquefied gases and oil.

34.3.13.4.1 When simultaneously carrying the industrial personnel and chemically hazardous substances as cargo in bulk, the ship shall either comply with the Rules for the Classification and Construction of Chemical Tankers and/or the International Code for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by IMO resolutions MSC.4(48) and MEPC.19(22), as amended, or the Code for the transport and handling of hazardous and noxious liquid substances in bulk on offshore support vessels, adopted by IMO resolution A.1122(30), whatever is applicable, and possess a relevant certificate.

34.3.13.4.2 When simultaneously carrying the industrial personnel and liquefied gases as cargo in bulk, the ship shall either comply with the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk and/or the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the IMO resolution MSC.5(48), as amended, if applicable, and possess a relevant certificate. When carrying liquefied gases in bulk for complying with the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the IMO resolution MSC.5(48), as amended, the industrial personnel shall be considered as personnel in the context of personnel protection.

34.3.13.4.3 Additionally, the following requirements shall be fulfilled:

.1 carriage of toxic products, low-flashpoint products or acids shall not be allowed when the total number of persons on board exceeds 60;

.2 for the purpose of carrying the industrial personnel, the areas and compartments onboard shall be clearly marked where the industrial personnel are not allowed to enter;

.3 PTA shall be arranged beyond the limits of the cargo area;

.4 an access to PTA shall be located outside the cargo area as far as practicable; and

.5 embarkation or transfer of the personnel and loading or unloading of cargo shall not take place simultaneously.

34.3.13.4.4 When simultaneously carrying the industrial personnel and oil as cargo, as defined in Annex I to MARPOL 73/78, there shall be applied the additional requirements of 34.3.13.4.3.

34.3.13.4.5 For the purpose of 34.3.13.4, the following definitions shall apply:

.1 "low-flashpoint products" means the following:

.1.1 noxious liquid substances with a flashpoint not exceeding 60 °C;
.1.2 oil with a flashpoint not exceeding 60 °C; and
.1.3 liquefied gases which require flammable vapour detection in accordance with chapter 19 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the IMO resolution MSC.5(48), as amended;
.2 "toxic products" means the following:
.2.1 dangerous chemicals to which special requirement 15.12 of the International Code for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by IMO resolutions MSC.4(48) and MEPC.19(22), as amended, applies (4.8 and 4.9 of Part VI "Systems and Piping" of the Rules for the Classification and Construction of Chemical Tankers);
.2.2 liquefied gases which require toxic vapour detection in accordance with chapter 19 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the IMO resolution MSC.5(48), as amended (Appendices to the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk); and
.2.3 "acids", which means dangerous chemicals to which special requirement 15.11 of the International Code for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by IMO resolutions MSC.4(48) and MEPC.19(22), as amended, applies.

34.4 ADDITIONAL REQUIREMENTS FOR CARGO SHIPS OF LESS THAN 500 GROSS TONNAGE

34.4.1 General.
34.4.1.1 Unless otherwise is stated in this chapter, the ships shall comply with the Rules for the Classification and Construction of Sea-Going Ships and the Rules for the Equipment of Sea-Going Ships for cargo ships of less than 500 gross tonnage as well as the requirements of 34.3.2, 34.3.3, 34.3.7 — 34.3.11 and 34.3.13 as far as reasonable and practicable, with account for the ship's structural particulars, operating conditions and voyage duration.
34.4.2 Stability.
34.4.2.1 Stability shall comply with the requirements of 3.6 and 3.11.4 of Part IV "Stability".
34.4.3 Subdivision.
34.4.3.1 Subdivision and damage stability of a ship shall comply with the requirements of 3.4.3 of Part V "Subdivision".
34.4.4 Fire protection.
34.4.4.1 Fire protection of a ship shall comply with the requirements of Section 8, Part VI "Fire Protection".
34.4.5 Life-saving appliances.
34.4.5.1 For ships carrying more than 60 persons, the requirements of Section 3, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships shall apply.
34.4.5.2 To apply the requirements of Section 3, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships the industrial personnel shall be considered as passengers.
34.4.5.3 Notwithstanding the provisions of 34.4.5.2 above, the required number of lifejackets for infants or lifejackets for children shall be calculated solely based on the number of passengers on board.".

PART XX. ADDITIONAL REQUIREMENTS FOR YACHTS

5 TECHNICAL REQUIREMENTS

5.2 EQUIPMENT, ARRANGEMENTS AND OUTFIT

Para 5.2.1 is amended as follows:

"**5.2.1** Equipment, arrangements and outfit of yachts shall comply with the requirements of Part III "Equipment, Arrangements and Outfit", unless provided otherwise in this Chapter. The yachts of less than 500 gross tonnage not carrying more than 12 passengers are subject to provisions of Part XIX "Additional Requirements for Cargo Ships of Less Than 500 Gross Tonnage", unless provided otherwise in this Chapter.".

New Para 5.2.4 is introduced reading as follows:

"**5.2.4 Doorways and access to stairways for yachts not carrying more than 12 passengers.**

5.2.4.1 All the openings directly exposed to greenseas and intended for access below the freeboard deck shall be fitted with watertight closing appliances.

5.2.4.2 All the doors shall be permanently ready for use, fitted with locking devices, and with opening outward.

5.2.4.3 Doorways and access to companionways shall be fitted with coamings having the following minimum height:

.1 for doors on the freeboard deck within a quarter of the ship's length from the forward perpendicular, and which are used while at sea: 600 mm;

.2 for doors on the freeboard deck abaft a quarter of the ship's length from the forward perpendicular:

300 mm — for doors in the forward bulkhead of superstructures and wheelhouses directly exposed to greenseas;

150 mm — for doors in the side bulkhead of superstructures and wheelhouses;

100 mm — for doors in the aft bulkhead of superstructures and wheelhouses protected by bulwark or other structures and for doors in the side bulkheads of superstructures and wheelhouses fitted with closing means ensuring the door closure at maximum list of 15° to either side and at maximum trim of 5°;

.3 for doors at the 1st tier of the freeboard deck within a quarter of the ship's length from the forward perpendicular: 150 mm;

.4 for doors with direct access to machinery space: 600 mm. For doors in the aft bulkhead of superstructure/wheelhouse this height may be reduced to 380 mm where the doors are protected by bulwark or other structures and fitted with closing means to ensure the door closure at maximum list of 15° to either side and at maximum trim of 5°.

5.2.4.4 Doors not used while at sea can be arranged without coamings. Such doors shall be permanently closed at sea and be fitted with inscriptions to the effect the openings shall be permanently closed at sea.

For engine room and steering gear compartments, doors with no coamings are only acceptable if a second access to these compartments is provided.

5.2.4.5 Removable coamings.

Except for doors at the forward of the freeboard deck, a number of the required coamings may be made removable, provided the following:

.1 the removable coaming is permanently stored close to the door opening;

.2 watertightness of a completely assembled coaming is proven by a hose test.

5.2.4.6 For yachts of coastal navigation within a 20-mile zone which in the course of their voyage do not proceed more than 6 h distance at operational speed from a place of refuge or a safe anchorage in fully loaded condition, the height of coamings as required in 5.2.4.3 may be reduced by half, except for access to engine room, where the height of coamings may be reduced to 450 mm (instead of 600 mm) and to 200 mm (instead of 380 mm).

The arrangement of reduced removable coamings is not accepted.

5.2.4.7 For commercial yachts engaged in international voyages, the application of requirements 5.2.4.1 — 5.2.4.6 is subject to agreement with a Flag State MA, with regard to the International Convention on Load Lines or national requirements of the Flag State MA.".

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