



RULES FOR BUILDING AND CLASSING

HIGH-SPEED NAVAL CRAFT 2018

NOTICES AND GENERAL INFORMATION

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

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Notices and General Information

CONTENTS

Introduction 1

TABLE 1 Applicable Editions of Booklets Comprising 2018 Rules 2

TABLE 2 Division and Numbering of Rules and Guides 2

Rule Change Notice (2018)..... 3

TABLE 3 Summary of Changes from the 2017 Rules.....3

Notices and General Information

Introduction

1. The year 2018 edition of the *Rules for Building and Classing High-Speed Naval Craft* consists of the eight (8) booklets as shown in Table 1. With regard to three booklets, Part 1, Part 2, and Part 7:
 - a) The purpose of the generic title *ABS Rules for Conditions of Classification – High-Speed Craft (Part 1)* is to reflect the expanded contents of PART 1, as a result of including consolidated requirements for “Classification” applicable to all types of and sizes of high-speed craft as specified in the Foreword to Part 1. Additional specific requirements are contained in Chapters 2 and 3 of Part 1.
 - b) The purpose of the generic title *ABS Rules for Materials and Welding* of PART 2 is to emphasize the common applicability of the requirements to ABS-classed vessels, other marine structures and their associated machinery, and thereby make PART 2 more readily a common “PART” of various ABS Rules and Guides, as appropriate.
 - c) The purpose of the generic title *ABS Rules for Survey After Construction (Part 7)* is to reflect the expanded contents of PART 7, as a result of including consolidated requirements for “Surveys After Construction” applicable to all types and sizes of vessels, barges and specific shipboard arrangements/systems, etc., as specified in Part 7, Chapter 1, Section 1.
2. The numbering system applied in the Rules is shown in Table 2.
3. The primary changes from the 2017 Rules are identified and listed in Table 3. The effective date of the indicated Rule Changes is 1 January 2017, unless specifically indicated otherwise.
4. The effective date of each technical change since 1993 is shown in parenthesis at the end of the subsection/paragraph titles within the text of each Part. Unless a particular date and month are shown, the years in parentheses refer to the following effective dates:

(2000) and after	1 January 2000 (and subsequent years)	(1996)	9 May 1996
(1999)	12 May 1999	(1995)	15 May 1995
(1998)	13 May 1998	(1994)	9 May 1994
(1997)	19 May 1997	(1993)	11 May 1993
5. Until the next edition of the *Rules for Building and Classing High-Speed Naval Craft* is published, Rule Change Notices and/or Corrigenda, as necessary, will be published on the ABS website – www.eagle.org – only, and will be available free for downloading. It is not intended to publish hard copies of future Rule Change Notices and/or Corrigenda to existing Rules or Guides. The consolidated edition of the *Rules for Building and Classing High-Speed Naval Craft*, which includes Rule Change Notices and/or Corrigenda using different colors for easy recognition, will be published on the ABS website only when RCN and/or Corrigenda are issued.
6. The listing of CLASSIFICATION SYMBOLS AND NOTATIONS is available from the ABS website www.eagle.org for download.

TABLE 1
Applicable Editions of Booklets Comprising 2018 Rules

Notices and General Information		2018
Part 1:	Rules for Conditions of Classification – High-Speed Craft	2018*
Part 2:	Rules for Materials and Welding Rules for Testing and Certification of Materials Rules for Welding and Fabrication	2018*
Part 2:	Rules for Materials and Welding – Aluminum and Fiber Reinforced Plastics (FRP)	2018*
Part 2:	Rule Requirements for Materials and Welding – Supplementary Requirements for Naval Vessels	2000*
Part 3:	Hull Construction and Equipment	2018
Part 4:	Craft Systems and Machinery	2018
Part 7:	Rules for Survey After Construction	2018*

* *Note:* The latest edition of these Rules is to be referred to. These Rules may be downloaded from the ABS website at www.eagle.org, Rules and Guides, Downloads or may be ordered separately from the ABS Publications online catalog at www.eagle.org, Rules and Guides, Catalog.

TABLE 2
Division and Numbering of Rules and Guides

<i>Division</i>	<i>Number</i>
Part	Part 1
Chapter	Part 1, Chapter 1
Section	Section 1-1-1
Subsection (see Note 1)	1-1-1/1
Paragraph (see Note 1)	1-1-1/1.1
Subparagraph	1-1-1/1.1.1
Item	1-1-1/1.1.1(a)
Subitem	1-1-1/1.1.1(a)i
Appendix	Appendix 1-1-A1 or Appendix 1-A1-1

Note:

- 1 An odd number (1, 3, 5, etc.) numbering system is used for the Rules and Guides. The purpose is to permit future insertions of even-numbered paragraphs (2, 4, 6, etc.) of text and to avoid the necessity of having to renumber the existing text and associated cross-references, as applicable, within the Rules and associated process instructions, check sheets, etc.

Rule Change Notice (2018)

TABLE 3
Summary of Changes from the 2017 Rules
EFFECTIVE DATE 1 March 2017 – shown as (1 March 2017)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 1	Rules for Conditions of Classification – High-Speed Craft	
1-1-1/7	Scope of Classification	To align with the other sections of Part 1 regarding disclaimers of liability for the responsibilities of vessel owners/operators in this article.
1-1-6/11 (New)	Plan Submittal	To align ABS plan submittal process with our legal duty to protect client and third party intellectual property rights.

EFFECTIVE DATE 1 May 2017 – shown as (1 May 2017)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 1	Rules for Conditions of Classification – High-Speed Craft	
1-1-4/3.1	Effective Date	To remove the application of the six-month rules for Guides, which are meant for immediate implementation. (Incorporates Notice No. 2)

EFFECTIVE DATE 1 January 2018 – shown as (2018)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 1	Rules for Conditions of Classification – High-Speed Craft	
1-1-A2/5.1.5	Duplicate Product Design Assessment	To clarify ABS policy for PDA-DUP issuance, confirmed by ABS Programs.

EFFECTIVE DATE 1 July 2017 – shown as (1 July 2016)
(based on the contract date for new construction between builder and Owner)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 3	Hull Construction and Equipment	
3-2-8/17.1	Strength	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-8/Figure 5 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-8/Figure 6 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-8/Figure 7 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-8/17.1.2	In way of Cutouts	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 4	Craft Systems and Machinery	
4-2-1/13.9.2iv)	<No Title>	To include the alternative of normal continuous cruise power, in line with IACS UR M51 Rev.4, Feb. 2015. (Incorporates Notice No. 1)
4-2-1/Table 1	Required Material and Nondestructive Tests of Diesel Engine Parts	To clarify the scope of hydraulic testing for high pressure fuel injection pipes including common fuel rail and high pressure common servo oil systems, in line with IACS UR M72 rev. 1 Mar. 2016. (Incorporates Notice No. 1)
4-2-1/Table 2	Test Pressures for Parts of Internal-combustion Engines	To clarify the scope of hydraulic testing for high pressure fuel injection pipes including common fuel rail and high pressure common servo oil systems, in line with IACS UR M72 rev. 1 Mar. 2016. (Incorporates Notice No. 1)
4-2-2/1.1	Application	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/1.3.1	Turbocharger	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/1.3.3 (New)	Generic Range	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/1.5.1ii)	<No Title>	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/3.3	Category A and B Turbochargers	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/3.5	Category C Turbochargers	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/3.7.3	Certification Under Quality Assurance Assessment PQA (IACS UR Z26 Alternative Certification Scheme)	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/5.1	General	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/5.3	Containment	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/5.7	Type Testing (applicable to category B and C turbochargers)	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/7	Piping Systems for Turbochargers	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/8 (New)	Alarms and Monitoring	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/11.1	Shop Inspection and Tests	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/11.1.1	Material Tests	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/11.1.5	Shop Trial	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-2-2/11.3	Certification of Turbochargers	To clarify the categorization of turbochargers and the application of Type Approval. (Incorporates Notice No. 1)
4-3-4/13.1.9 (New)	System Response Under Failure	To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1)
4-3-4/Table 1	Steering Gear Instrumentation	To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios and to require a deviation alarm in addition to basic failure detection, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1)

Notices and General Information

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-3-5/1.1	Application	To clarify the various terms used for steering systems and their associated equipment, in line with IACS UI SC242 Rev.1, Apr. 2016. (Incorporates Notice No. 1)
4-3-5/1.5.6 (New)	Steering System	To clarify the various terms used for steering systems and their associated equipment, in line with IACS UI SC242 Rev.1, Apr. 2016. (Incorporates Notice No. 1)
4-3-5/5.12.2(b)iii)	<No Title>	To clarify that the capacity requirements apply regardless whether the steering systems are arranged with common or dedicated power units that the requirements of 4-3-4/11.1 apply to each steering system in ships fitted with multiple steering systems, in line with IACS UI SC242 Rev.1, Apr. 2016. (Incorporates Notice No. 1)
4-3-5/5.12.4 (New)	Electric and Electrohydraulic Steering Systems	To clarify that the capacity requirements apply regardless whether the steering systems are arranged with common or dedicated power units that the requirements of 4-3-4/11.1 apply to each steering system in ships fitted with multiple steering systems, in line with IACS UI SC242 Rev.1, Apr. 2016. (Incorporates Notice No. 1)
4-3-5/7.5 (New)	Failure Detection and Response	To detect failure in the steering gear control system and provide the operator with sufficient information to decide what action is required for the different failure scenarios, in line with IACS UR E25 June 2016. (Incorporates Notice No. 1)
4-6-2/5.7.3(c)	Fire Resistance	To clarify the cases in which flexible hoses need not be of fire-resistant type. (Incorporates Notice No. 1)
4-6-2/5.9.1(c) (Deleted)	Operational Conditions	To minimize the use of slip-on joints for pipe connection except for cases where compensation of axial pipe deformation is necessary and to clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.1(e)	Fire Testing	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.1(f)	Locations	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.1(h) (Deleted)	Application	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.1(g)	Joints	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.1(i)	Slip-on Joints	To minimize the use of slip-on joints for pipe connection except for cases where compensation of axial pipe deformation is necessary and to clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.1(j)	Application	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.2(e)iii)	Selection of Test Specimen	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.2(e)v) 1(a)	<No Title>	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.2(e)v)2	Vibration (Fatigue) Test	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.2(e)v)4	Burst Pressure Test	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.2(e)v)5	Pull-out Test	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.2(e)v)6	Fire Endurance Test	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/5.9.2(e)v)7	Vacuum Test	To clarify the requirements, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)

Notices and General Information

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-6-2/Table 9	Examples of Mechanical Joints	To update the figures for “Machine Grooved Type” and “Slip Type” slip-on joints, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-6-2/Table 10	Application of Mechanical Joints	To clarify the restrictions for on slip-on joints and flexible hoses used for L.O. lines and other flammable oils, and installed on open decks, in line with IACS UR P2 Rev.2, Mar. 2016. (Incorporates Notice No. 1)
4-8-2/7.25	Harmonics	To specify that the harmonic distortion calculation report is to be kept on board for exceptions to the 8% limit in cases where all installed equipment and systems have been designed for higher THD levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1)
4-8-2/9.24 (New)	Harmonic Distortion for Ship Electrical Distribution System including Harmonic Filters	To introduce requirements for survey of harmonic filters and harmonic distortion levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1)
4-8-2/9.25	Protection of Harmonic Filter Circuits Associated with Electric Propulsion	To introduce requirements for survey of harmonic filters and harmonic distortion levels, in line with IACS UR E24 June 2016. (Incorporates Notice No. 1)
4-8-3/9.1	Standard of Compliance	To identify the standards that have been withdrawn or replaced by new ones and to consider approaches for cables not manufactured to IEC standards identified, in line with IACS UR E7 Rev.4 Apr. 2016. (Incorporates Notice No. 1)
4-9-3/Table 3	Instrumentation and Safety System Functions in Centralized Control Station – Medium and High Speed (Trunk Piston) Diesel Engines	To require turbocharger speed alarm for Categories B and C turbochargers, in line with IACS UR M35 rev. 7 Mar. 2016. (Incorporates Notice No. 1)
4-9-3/Table 5B	Instrumentation and Safety System Functions in Centralized Control Station – Generator Prime Mover for Electric Propulsion	To require turbocharger speed alarm for Categories B and C turbochargers, in line with IACS UR M35 rev. 7 Mar. 2016. (Incorporates Notice No. 1)
4-9-6/Table 6	Instrumentation and Safety System Functions in Centralized Control Station – Auxiliary Turbines and Diesel Engines	To require turbocharger speed alarm for Categories B and C turbochargers, in line with IACS UR M35 rev. 7 Mar. 2016. (Incorporates Notice No. 1)

EFFECTIVE DATE 1 January 2018 – shown as (2018)
(based on the contract date for new construction between builder and Owner)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
PART 3	Hull Construction and Equipment	
3-1-1/3	Length	To align the requirements with ICLL 1966/Reg. 3 & IACS UR S2.
3-1-1/11.1	Freeboard Deck	To align the requirements with ICLL 1966/Reg. 3 & IACS UR S2.
3-2-8/7.3	Lower Rudder Stocks	To make the stress units consistent with the allowable stress.
3-2-8/Figure 4	Tapered Couplings	To be consistent with the requirements of 3-2-8/11.7.
3-2-8/17.5	Diaphragm Plates	To allow larger openings on diaphragm plates when the effects of openings are considered in the strength assessment.
3-3-A2 (Title)	Computer Software for Onboard Stability Calculations	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/5	Types of Stability Software	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/7.1	Calculation Program	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/7.5	Warning	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/7.15 (New)	Computer Model	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/7.17 (New)	Further Requirements for Type 4 Stability Software	To align the Rules with IACS UR L5, Revision 3.

Notices and General Information

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
3-3-A2/Table 1	Acceptable Tolerances	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/11.1	Conditions of Approval of the Onboard Software for Stability Calculations	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/11.5	Specific Approval	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/15	Installation Testing	To align the Rules with IACS UR L5, Revision 3.
3-6-1	Tank, Bulkhead and Rudder Tightness Testing	To reflect the comments from Administrations, Industry Organizations and IMO considered during review of the proposed Testing Guidelines associated with SOLAS Chapter II-1, Regulation 11, reflected in IACS UR S14 (Rev.6, Sept 2016).

PART 4 Craft Systems and Machinery

4-3-1/5.13	Alternative Gear Rating Standards	To refer to the latest edition of the standards.
4-4-1/9.3.2	Diameter Over 457 mm (18 in.)	To clarify that the diameter is the inside diameter.
4-4-1/9.3.3	Diameter Over 305 mm (12 in.)	To clarify that the diameter is the inside diameter.
4-4-1/9.3.4	Diameter 305 mm (12 in.) or Less	To clarify that the diameter is the inside diameter.
4-6-4/5.7.4(c)	Sludge Piping	To align the requirement with Regulation 12 of MARPOL Annex 1, as amended by Resolution MEPC. 266(68).
4-6-4/9.5.7 (New)	Fuel Oil Overflow	To align the requirements with ABS practice.
4-6-5/17 (New)	Storage and Use of SCR Reductants	To provide requirements for Selective Catalytic Reduction (SCR) systems, in line with IACS UR M77 Sept. 2016.
4-6-7/3.5.4	Accumulators	To clarify the requirements for accumulators of extruded seamless construction.
4-7-3/23.3.1(f)i	<No Title>	To clarify the acceptability for individually identifiable fire detectors without individual short circuit isolator, in line with 2.1.6.1 of FSS Code in IMO Resolution MSC.311(88)
4-7-3/25.1.3	Distribution Piping and Nozzles	To clarify the requirements for the pressure rating of the distribution pipe.
4-7-3/25.1.6	Medium Release Warning Alarm	To align the requirements with IACS UI SC132 (Rev.4).
4-8-2/5.3.1	General	To explicitly prohibit the installation of other unrelated equipment in the emergency generator room.
4-8-2/7.11.1(d)	Current Carrying Capacity Correction	To clarify the application of the reduction factor of 0.85 where more than six cables are expected to operate simultaneously and are laid close together in a bunch in such a way that are an absence of free air circulation around them.
4-8-2/7.17.1	Main Lighting System	To align the requirement with other ABS Rules.
4-8-3/5.5.2(e)	Clearance and Creepage	To align the requirement with IEC 60092-302 and IEC 61892-3.
4-8-3/Table 2	Minimum Degree of Protection	To permit plugs and socket outlets installed in hazardous areas, in line with IEC 61892-7 Para. 8.11.1 and IEC 60079-14 Para. 5.13.
4-8-3/Table 5	Equipment and Instrumentation for Switchboards	To provide a reference to the requirements for high voltage systems.
4-8-3/Table 6	Maximum Current Carrying Capacity for Cables	To clarify the application of the reduction factor of 0.85 where more than six cables are expected to operate simultaneously and are laid close together in a bunch in such a way that are an absence of free air circulation around them.
4-8-4/19.3	Cable Current Carrying Capacity	To clarify the application of the reduction factor of 0.85 where more than six cables are expected to operate simultaneously and are laid close together in a bunch in such a way that are an absence of free air circulation around them.
4-8-5/3.3.2	Earth Fault Detection and Indication	To clarify the requirements for audible and visual indication of earth faults for high voltage systems.
4-9-1/5.3.5 (New)	Worst Case Execution Time (WCET)	To define terms used in 4-9-1/7.3.9, in line with ISO 17894:2005 and IEC 61508-3.

Notices and General Information

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
4-9-1/5.3.6 (New)	Worst Case Response Time (WCRT)	To define terms used in 4-9-1/7.3.9, in line with ISO 17894:2005 and IEC 61508-3.
4-9-1/7.3.12	Programmable Electronic System (PES)	To mitigate the danger of critical alarms missing their deadlines.
4-9-1/9.7.2	Audible Alarms	To require a visual alarm for cases where the audible alarm may not be heard due to high noise levels in the machinery space.
4-9-3/19.3.1	Bilge Level	To clarify the number of bilge level switches/sensors required for vessels with ACC or ACCU notation, in line with IAC UR M27.
4-9-3/21.5vi)	<No Title>	To require that weathertight doors fitted in the engine casing bulkhead also be a type of self-closing door or could be closed from fire control station, to prevent the release of CO ₂ from the unintentional remaining opened doors when fixed CO ₂ system in engine room is active, and to align the requirements for a high-expansion foam fire extinguishing system with IACS UI SC262.
4-9-3/21.7.1ii) (New)	Emergency Generator Spaces	To align the requirements with ABS practice.



RULES FOR BUILDING AND CLASSING

HIGH-SPEED NAVAL CRAFT 2018

PART 3 HULL CONSTRUCTION AND EQUIPMENT

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

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Rule Change Notice (2018)

The effective date of each technical change since 1993 is shown in parenthesis at the end of the subsection/paragraph titles within the text of each Part. Unless a particular date and month are shown, the years in parentheses refer to the following effective dates:

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(1999)	12 May 1999	(1995)	15 May 1995
(1998)	13 May 1998	(1994)	9 May 1994
(1997)	19 May 1997	(1993)	11 May 1993

Listing by Effective Dates of Changes from the 2017 Rules

Notice No. 1 (effective on 1 July 2017) to the 2017 Rules, which is incorporated in the 2018 Rules, is summarized below.

EFFECTIVE DATE 1 July 2017 – shown as (1 July 2017) (based on the contract date for new construction between builder and Owner)

Part/Para. No.	Title/Subject	Status/Remarks
3-2-8/17.1	Strength	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-8/Figure 5 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-8/Figure 6 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-8/Figure 7 (New)	<No Title>	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-8/17.1.2	In way of Cutouts	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)

EFFECTIVE DATE 1 January 2018 – shown as (2018) (based on the contract date for new construction between builder and Owner)

Part/Para. No.	Title/Subject	Status/Remarks
3-1-1/3	Length	To align the requirements with ICLL 1966/Reg. 3 & IACS UR S2.
3-1-1/11.1	Freeboard Deck	To align the requirements with ICLL 1966/Reg. 3 & IACS UR S2.
3-2-8/7.3	Lower Rudder Stocks	To make the stress units consistent with the allowable stress.
3-2-8/Figure 4	Tapered Couplings	To be consistent with the requirements of 3-2-8/11.7.
3-2-8/17.5	Diaphragm Plates	To allow larger openings on diaphragm plates when the effects of openings are considered in the strength assessment.
3-3-A2 (Title)	Computer Software for Onboard Stability Calculations	To align the Rules with IACS UR L5, Revision 3.
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3-3-A2/7.5	Warning	To align the Rules with IACS UR L5, Revision 3.
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3-3-A2/7.17 (New)	Further Requirements for Type 4 Stability Software	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/Table 1	Acceptable Tolerances	To align the Rules with IACS UR L5, Revision 3.

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
3-3-A2/11.1	Conditions of Approval of the Onboard Software for Stability Calculations	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/11.5	Specific Approval	To align the Rules with IACS UR L5, Revision 3.
3-3-A2/15	Installation Testing	To align the Rules with IACS UR L5, Revision 3.
3-6-1	Tank, Bulkhead and Rudder Tightness Testing	To reflect the comments from Administrations, Industry Organizations and IMO considered during review of the proposed Testing Guidelines associated with SOLAS Chapter II-1, Regulation 11, reflected in IACS UR S14 (Rev.6, Sept 2016).

Hull Construction and Equipment

CONTENTS

CHAPTER 1	General	1
Section 1	Definitions	3
Section 2	General Requirements.....	10
Section 3	Direct Analysis Methods	20
CHAPTER 2	Hull Structures and Arrangements	32
Section 1	Primary Hull Strength.....	44
Section 2	Design Pressures.....	56
Section 3	Plating	72
Section 4	Internals	90
Section 5	Hull Structural Arrangement.....	102
Section 6	Arrangement, Structural Details and Connections	108
Section 7	Keels, Stems, Shaft Struts, and Propeller Nozzles	123
Section 8	Rudders and Steering Equipment.....	131
Section 9	Protection of Deck Openings	159
Section 10	Protection of Shell Openings	167
Section 11	Bulwarks, Rails, Ports, Portlights, Windows, Ventilators, Tank Vents and Overflows.....	180
Section 12	Protective Coatings.....	189
Section 13	Welding, Forming and Weld Design	193
Appendix 1	Guidelines for Calculating Bending Moment and Shear Force in Rudders and Rudder Stocks.....	197
Appendix 2	Guide on Analysis of the Cross Deck Structure of a Multi-hull Craft.....	207
Appendix 3	Alternative Method for Determination of "V" Shaft Strut Requirements.....	211
CHAPTER 3	Subdivision and Stability	213
Section 1	General Requirements.....	215
Appendix 1	Alternative Requirements for the Subdivision and Stability of High Speed Naval Craft	217
Appendix 2	Onboard Computers for Stability Calculations.....	229
CHAPTER 4	Fire Safety Measures.....	239
Section 1	Structural Fire Protection	240

CHAPTER 5	Equipment.....	241
Section 1	Anchoring and Mooring Equipment	242
Appendix 1	Alternative Standard for the Required Anchor Size.....	254
CHAPTER 6	Testing, Trials and Surveys During Construction – Hull	255
Section 1	Tank, Bulkhead and Rudder Tightness Testing	256
Section 2	Trials	265
Section 3	Surveys	266

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PART 3

CHAPTER 1 General

CONTENTS

SECTION 1	Definitions.....	3
1	Application	3
3	Length	3
5	Breadth.....	3
7	Depth.....	3
9	Draft for Scantlings	3
11	Decks	3
11.1	Freeboard Deck.....	3
11.3	Bulkhead Deck	3
11.5	Strength Deck.....	4
11.7	Superstructure Deck.....	4
13	Superstructure	4
15	Deckhouses	4
17	Displacement and Block Coefficient	4
17.1	Displacement.....	4
17.3	Block Coefficient (C_b).....	4
18	Deadweight (DWT)	4
19	Significant Wave Height.....	4
21	Rabbit Line (Fiber Reinforced Plastic).....	5
23	Naval Administration	5
25	Military Personnel	5
27	Passenger.....	5
29	Safe Harbor.....	5
31	Fiber-Reinforced Plastic (FRP)	5
31.1	Reinforcement	5
31.3	Resin	7
31.5	Laminate.....	8
31.7	Encapsulation	9
33	Units	9
SECTION 2	General Requirements	10
1	Materials.....	10
1.1	Selection of Material Grade	10
1.3	Note for the Users	11
1.5	6000 Series Aluminum Alloys.....	11
1.7	Structures Exposed to Low Air Temperatures	12
1.9	Design Temperature t_D	14
3	Workmanship	14

5	Design	15
5.1	Continuity	15
5.3	Openings	15
5.5	Brackets.....	16
5.7	Structural Design Details	17
5.9	Termination of Structural Members.....	18
7	Effective Width of Plating	18
7.1	FRP Laminates	18
7.3	Steel and Aluminum Plating.....	19
TABLE 1	Material Grades.....	10
TABLE 2	Material Class of Structural Members.....	11
TABLE 3	Application of Material Classes and Grades – Structures Exposed at Low Temperatures	12
TABLE 4	Material Grade Requirements for Classes I, II and III at Low Temperatures	13
TABLE 5A	Brackets (Steel).....	17
TABLE 5B	Brackets (Aluminum).....	17
FIGURE 1	Commonly Used Definitions of Temperatures	14
FIGURE 2		15
FIGURE 3		15
FIGURE 4		15
FIGURE 5	Bracket	16
FIGURE 6	Effective Width of FRP Plating.....	19

SECTION 3 Direct Analysis Methods..... 20

1	General	20
3	Loading Conditions	20
3.1	General.....	20
3.3	Environmental and Service Conditions	20
3.5	Loading Conditions for Direct Analysis	21
5	Motion Predictions	22
5.1	Model Testing	22
5.3	Accelerations from Direct Analysis	23
7	Load Predictions	23
7.1	Global Loads	23
7.3	Local Loads	24
9	Structural Response	26
9.1	Global Response	26
9.3	Local Response	27
11	Structural Acceptability	29
11.1	Beam, Grillage, or Plane Frame Analysis	29
11.3	Finite Element Analysis	29

TABLE 1	Sea States.....	20
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PART

3

CHAPTER 1 General

SECTION 1 Definitions

1 Application

The following definitions of terms apply throughout the requirements in these Rules.

3 Length (2018)

L is the distance, in meters (feet), on the full load design waterline in the displacement mode, from the fore side of the stem to the centerline of the rudder stock. For use with these Rules, L is not to be less than 96% and need not be greater than 97% of the **extreme** length on the full load design waterline in the displacement mode. The forward end of L is to coincide with the fore side of the stem on the waterline on which L is measured.

5 Breadth

B is the greatest molded breadth, in meters (feet).

Breadth used in 3-2-1/1.1.1 for craft which have flare or tumblehome, is the mean breadth of the waterline breadth and the maximum breadth between the waterline and main deck at the longitudinal center of flotation (LCF).

7 Depth

D is the molded depth, in meters (feet), measured at the middle of the length L , from the molded keel line to the top of the freeboard deck beams at the side of the craft. On craft with rabbeted keel construction, D is to be measured from the rabbet line. In cases where watertight bulkheads extend to a deck above the freeboard deck and are to be recorded in the *Record* as effective to that deck, D is to be measured to the bulkhead deck.

9 Draft for Scantlings

d is the draft, in meters (feet), measured at the middle of the length L from the molded keel or the rabbet line at its lowest point to the estimated summer load waterline or the design load waterline in the displacement mode.

11 Decks

11.1 Freeboard Deck (2018)

The freeboard deck is normally the uppermost **complete deck exposed to weather and sea, which has permanent means of** closing all in its weather portions, and below which all openings in the craft side are equipped with permanent means for watertight closure.

11.3 Bulkhead Deck

The bulkhead deck is the highest deck to which watertight bulkheads extend and are made effective.

11.5 Strength Deck

The strength deck is the deck which forms the top of the effective hull girder at any part of its length. See Section 3-2-1.

11.7 Superstructure Deck

A superstructure deck is a deck above the freeboard deck to which the side shell plating extends or of which the sides are fitted inboard of the hull side not more than 4% of the breadth, B . Except where otherwise specified, the term superstructure deck where used in these Rules refers to the first such deck above the freeboard deck.

13 Superstructure

A superstructure is an enclosed structure above the freeboard deck having side plating as an extension of the shell plating, or not fitted inboard of the hull side more than 4% of the breadth B .

15 Deckhouses

A deckhouse is an enclosed structure above the freeboard deck, having side plating set inboard of the hull side-shell plating more than 4% of the breadth B of the craft.

17 Displacement and Block Coefficient

17.1 Displacement

The displacement Δ , is the mass displacement of the craft in the design condition in metric tons (long tons), unless otherwise specifically noted.

17.3 Block Coefficient (C_b)

C_b is the block coefficient obtained from the following equation:

$$C_b = \Delta / 1.025 L B_{wl} d \quad (\text{SI \& MKS units})$$

$$C_b = 35 \Delta / L B_{wl} d \quad (\text{US units})$$

where

$$\Delta = \text{molded displacement, as defined in 3-1-1/17.1}$$

$$L = \text{scantling length, as defined in 3-1-1/3}$$

$$d = \text{draft, as defined in 3-1-1/9}$$

$$B_{wl} = \text{greatest molded breadth at the design load line}$$

18 Deadweight (DWT)

For the purpose of these Rules, deadweight (DWT), is the difference, in metric tons (long tons), between the displacement of the craft at its summer load line or the craft with all tanks filled, maximum cargo loaded, maximum stores, and naval personnel or passengers and their effects on board, in water having a specific gravity of 1.025, and the unloaded weight of the craft. For the purpose of these Rules, the unloaded weight is the displacement of the craft, in metric tons (long tons), with no cargo, fuel, lubricating oil, ballast water, fresh water nor feed water in tanks, no consumable stores, and no naval personnel or passengers nor their effects.

19 Significant Wave Height

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

21 Rabbet Line (Fiber Reinforced Plastic)

The rabbet line is the line intersection between the outside of a craft's bottom and a craft's keel. Where there is no keel, the rabbet line is the bottom of the craft.

23 Naval Administration

The department, directorate, bureau or command to whom the National Government has delegated authority over the acquisition, acceptance, maintenance and technical requirements of naval vessels, and who acts on the Government's behalf in all matters relating to the procurement and support of the vessels. In the case where these authorities are invested in separate departments within the naval organization, the term "Naval Administration" means the ensemble of departments having those authorities, or the command that overarches these departments. The Naval Administration may exist as part of the Navy, or within a separate arm of the government, such as a material procurement directorate.

25 Military Personnel

All people that are riding the craft, including the crew, that either have a function in the operation of the craft or are trained personnel that are taking part in the overall mission of the craft.

27 Passenger

Any personnel on the craft other than military personnel as defined above in 3-1-1/29

29 Safe Harbor

A friendly natural or artificial sheltered area which may be used as a shelter by a craft under conditions likely to endanger its safety.

31 Fiber-Reinforced Plastic (FRP)

FRP consists of two basic components: a glass-filament or other material fiber reinforcement and a plastic, or resin, in which the reinforcing material is imbedded.

31.1 Reinforcement

Reinforcement is a strong, inert material bonded into the plastic to improve its strength, stiffness and impact resistance. Reinforcements are usually fibers of glass (a lime-alumina-silicate composition having a low alkali content) or other approved material such as aramid or carbon fiber, in a woven or non-woven form, with a strong adhesive bond to the resin.

31.1.1 Strand

A bundle of continuous filaments combined in a single, compact unit.

31.1.2 Roving

A band or ribbon of parallel strands grouped together.

31.1.3 Yarn

A twisted strand or strands suitable for weaving into a fabric.

31.1.4 Binder

The agent applied in small quantities to bond the fibers in mat form.

31.1.5 Coupling Agent

An active water soluble chemical that allows resin to adhere to glass.

31.1.6 Chopped-strand Mat

A blanket of randomly oriented chopped-glass strands held together with binder.

31.1.7 Woven Roving

A coarse fabric woven from rovings.

31.1.8 Cloth

A fabric woven from yarn

31.1.9 Peel-Ply

An “E” glass fabric that does not have any coupling agent applied, used as a protective covering on a laminate being prepared for a secondary bond to keep foreign particles from adhering to the surface.

31.1.10 Uni-directional

A woven or non-woven reinforcement with substantially more fibers in one principal axis of the reinforcing ply.

31.1.11 Double Biased

A woven or non-woven reinforcement with fibers primarily at $+45^\circ$ to the principal axes of the reinforcing ply.

31.1.12 Knitted or Stitched Fabrics

Two or more layers of unidirectional fabrics that are stitched together.

31.1.13 Bi-axial Fabric

A stitched or knitted reinforcement with fibers primarily in the two principal axes of the reinforcing ply.

31.1.14 Tri-axial Fabric

A stitched or knitted reinforcement with fibers running in one principal axis of the ply and in addition, with fibers running at $+$ and -45° to the warp.

31.1.15 Ply Principal Axes

The two principal axes of a reinforcing ply are the axis that is parallel to the warp and the axis that is parallel to the fill.

31.1.16 Warp

The roving or yarn running lengthwise in woven fabric (in the “roll direction”).

31.1.17 Fill, Weft or Woof

The roving or yarn running at right angles to the warp in a woven fabric.

31.1.18 “E” glass

A family of glass reinforcement material of aluminoborosilicate composition and having high electrical resistivity.

31.1.19 “S” glass

A family of glass reinforcement material of magnesium aluminosilicate composition that contains a higher silicon content and provides higher strength and stiffness properties than “E” glass.

31.1.20 Kevlar

An aramid fiber reinforcement.

31.1.21 Carbon Fiber

A reinforcement material made of mostly carbon produced by the pyrolysis of organic precursor fibers in an inert environment.

31.3 Resin

Resin is a highly reactive synthetic that in its initial stage is a liquid, but upon activation is transformed into a solid.

31.3.1 Accelerator

A material that, when mixed with a catalyst or resin, speeds the cure time.

31.3.2 Additive

A substance added to another substance, usually to improve properties, such as plasticizers, initiators, light stabilizers and flame retardants.

31.3.3 Catalyst or Initiator

A material that is used to activate resin, causing it to harden.

31.3.4 Crazeing

Hairline cracks, either within or on the surface of resin, caused by mechanical or thermal stresses.

31.3.5 Cure

To change resin from a liquid to a solid.

31.3.6 Cure time

The time required for resin to change from a liquid to a solid after a catalyst has been added.

31.3.7 Exothermic Heat

The heat given off as the result of the action of a catalyst on resin.

31.3.8 Filler

A material added to resin to modify its working properties or other qualities, or to lower densities.

31.3.9 Gel

A partially cured resin in a semi-solid state similar to gelatin in consistency.

31.3.10 Gel Time

The time required to change a flowable, liquid resin into a nonflowing gel.

31.3.11 Inhibitor

A material that retards activation or initiation of resin, thus extending shelf life or influencing exothermic heat or gel time.

31.3.12 Polymerization

The reaction that takes place when resin is activated or initiated.

31.3.13 Pot Life

The length of time that a catalyzed resin remains workable.

31.3.14 Shelf Life

The length of time that an uncatalyzed resin maintains its working properties while stored in a tightly sealed, opaque container.

31.3.15 Tack

The degree of stickiness of the resin.

31.3.16 Thixotropy

The property or phenomenon, exhibited by some resins, of becoming jelly-like at rest but becoming fluid again when stirred or agitated. This facilitates the application of the resin to inclined or vertical surfaces

31.3.17 Polyester Resin

A thermosetting resin that is formed by combining saturated and unsaturated organic acids. Such as orthophthalic and isophthalic acids.

31.3.18 Vinylester Resin

A thermosetting resin that consists of a polymer chain and an acrylate or methacrylate termination.

31.3.19 Epoxy

A resin that contains one or more of the epoxide groups.

31.5 Laminate

A laminate is a material composed of successive bonded layers, or plies, of resin and fiber or other reinforcing substances.

31.5.1 Bi-directional Laminate

A laminate having essentially the same strength and elastic properties in the two in plane principal axes. Bi-directional laminates may be constructed of bi-axial, double bias, tri-axial, mat or unidirectional reinforcing layers, or a combination of any of these.

31.5.2 Uni-directional Laminate

A laminate with substantially more of the fibers in the plane of the laminate oriented in one of the two principal axis of the laminate plane so that the mechanical properties along that axis are appreciably higher than along the other natural axis.

31.5.3 Sandwich Laminate

A laminate consisting of two fiber reinforced plastic skins attached to a non-structural or structural core (see 3-1-1/31.7 "Encapsulation").

31.5.4 Barcol Hardness

A measurement of the hardness of a laminate and thereby the degree of completion of the cure.

31.5.5 Delamination

The separation of the layers of material in a laminate.

31.5.6 Gel Coat

The first resin applied to mold when fabricating a laminate to provide a smooth protective surface for the laminate.

31.5.7 Layup

The process of applying to a mold the layers of resin and reinforcing materials that make up a laminate. These materials are then compressed or densified with a roller or squeegee to eliminate entrapped air and to spread resin evenly. Also a description of the component materials and geometry of a laminate.

31.5.8 Verified Minimum Mechanical Property

The mechanical properties, in Part 2, Chapter 6, of laminates differing from the basic, verified by the appropriate test(s) listed in 2-6-1/Table 1.

31.5.9 Laminate Principal Axes

The two principal axes of a square or rectangular plate panel are for the application of these Rules those perpendicular and parallel to the plate panel edges.

31.5.10 Vacuum Bagging

A method used to apply a uniform pressure over an area by applying a vacuum to that area.

31.5.11 Resin Impregnation

A process of construction for large layers of fabric that consists of running a roll of fabric through a resin bath to completely saturate the fabric.

31.5.12 Resin Transfer Molding

A closed mold method that mechanically pumps resin through dry fabric previously placed in the mold.

31.5.13 Resin Infusion

A method of FRP construction that uses a vacuum to pull catalyzed resin through dry fabric.

31.5.14 Primary Bond

The bond that is formed between two laminated surfaces when the resin on both surfaces has not yet cured.

31.5.15 Secondary Bond

The bond that is formed between two laminated surfaces when the resin on one of the two surfaces has cured.

31.5.16 Post Cure

The act of placing a laminate in an autoclave and raising the temperature to assist in the cure cycle of the resin.

31.5.17 Autoclave

A large oven used in post curing large laminated parts.

31.7 Encapsulation

The containment of a core material, such as softwoods, balsa, PVC (cross linked) or linear polymer, within FRP laminates. The cores may be structurally effective or ineffective.

31.7.1 Bedding Putty

Material used to adhere the core material to the FRP skins.

31.7.2 Scores

Slits cut into the core material to aid in forming the core to complex shapes.

33 Units

These Rules are written in three systems of units: SI units, MKS units and US customary units. Each system is to be used independently of any other system.

Unless indicated otherwise, the format of presentation in these Rules of the three systems of units is as follows:

SI units (MKS units, US customary units)

PART

3

CHAPTER 1 General

SECTION 2 General Requirements

1 Materials

These Rules are intended for welded craft constructed of steel, welded craft constructed of aluminum, and fiber reinforced plastic (FRP) craft; complying with the requirements of Part 2, Chapters 1, 2, 5 and 6 respectively, including the Naval ship supplementary requirements indicated in Part 2, Chapter 11. The use of materials other than those specified in Part 2, Chapters 1, 2, 5, 6, 11 and the corresponding scantlings will be specially considered.

1.1 Selection of Material Grade

For craft 61 m (200 ft) and over in length, steel materials are not to be lower grades than those required by 3-1-2/Table 1 for the material class given in 3-1-2/Table 2 for the particular location.

TABLE 1
Material Grades (2017)

Plate Thickness (<i>t</i>) mm (in.)	Material Class	
	<i>I</i>	<i>II</i>
$t \leq 15$ ($t \leq 0.60$)	A ⁽¹⁾ , AH	A, AH
$15 < t \leq 20$ ($0.60 < t \leq 0.79$)	A, AH	A, AH
$20 < t \leq 25$ ($0.79 < t \leq 0.98$)	A, AH	B, AH
$25 < t \leq 30$ ($0.98 < t \leq 1.18$)	A, AH	D, AH
$30 < t \leq 35$ ($1.18 < t \leq 1.38$)	B, AH	D, AH
$35 < t \leq 40$ ($1.38 < t \leq 1.57$)	B, AH	D, AH
$40 < t \leq 100$ ($1.57 < t \leq 4.0$)	D, AH	E, DH

Notes:

- (2017) ASTM A36 steel otherwise manufactured by an ABS approved steel mill, tested and certified to the satisfaction of ABS may be used in lieu of Grade A for a thickness up to and including 12.5 mm (0.5 in.) for plate and 19 mm (0.75 in.) for sections.

TABLE 2
Material Class of Structural Members (2017)

Structural Members	Material Class	
	Within 0.4L Amidships	Outside 0.4L Amidships
Shell		
Bottom plating including keel plate	II	A ⁽³⁾ /AH
Bilge strake	II	A ⁽³⁾ /AH
Side Plating	I	A ⁽³⁾ /AH
Sheer Strake at strength deck ⁽¹⁾	II	A ⁽³⁾ /AH
Decks		
Strength deck plating ⁽²⁾	II	A ⁽³⁾ /AH
Stringer plate in strength deck ⁽¹⁾	II	A ⁽³⁾ /AH
Strength deck strake on tankers at longitudinal bulkhead	II	A ⁽³⁾ /AH
Strength deck plating within line of hatches and exposed to weather, in general	I	A ⁽³⁾ /AH
Longitudinal Bulkheads		
Lowest strake in single bottom craft	I	A ⁽³⁾ /AH
Uppermost strake including that of the top wing tank	II	A ⁽³⁾ /AH
Other Structures in General		
External continuous longitudinal members and bilge keels	II	A ⁽³⁾ /AH
(1 July 2015) Plating materials for stern frames supporting rudder and propeller boss, rudders, rudder horns, steering equipment ⁽⁴⁾ , propeller nozzles, and shaft brackets	-	I
Strength members not referred to in above categories and above local structures	A ⁽³⁾ /AH	A ⁽³⁾ /AH

Notes:

- 1 A radius gunwale plate may be considered to meet the requirements for both the stringer plate and the sheer strake, provided it extends suitable distances inboard and vertically. For formed material see 2-4-1/3.13.
- 2 Plating at the corners of large hatch openings are to be specially considered.
- 3 (2017) ASTM A36 steel otherwise manufactured by an ABS approved steel mill, t tested and certified to the satisfaction of ABS may be used in lieu of Grade A for thickness up to and including 12.5 mm (0.5 in.) for a plate and 19 mm (0.75 in.) for sections.
- 4 (1 July 2015) Steering equipment components other than rudders, as described in Section 3-2-8.

1.3 Note for the Users

The attention of users is drawn to the fact that when fatigue loading is present, the effective strength of higher-strength steel in a welded construction may not be greater than that of ordinary-strength steel. Precautions against corrosion fatigue to higher strength steel and aluminum alloy materials may also be necessary.

1.5 6000 Series Aluminum Alloys (1 January 2004)

The use of 6000 series aluminum alloys is only permitted in structural applications in the extrusion form above the freeboard deck. The welded yield strength, σ_{yw} , for these alloys is based on the fully annealed condition, and is to be taken as 55 N/mm² (5.5 kgf/mm², 8000 psi). The use of 6000 series aluminum alloys in other locations is permitted only when approved in writing by the Naval Administration, and the following requirements are complied with:

- i) The welding procedure is to be submitted for review and approval. This procedure is needed for process control in all welds and not allow for pre/post heating of the alloy. It will need to establish methods for certifying welders to this process and methods for inspection of the completed welds.
- ii) Since pre/post heating is not permitted on 6000 series alloys, areas that can accumulate large “pre-stresses” such as the forward bow structure and water jet duct structure are to be examined. This examination is to include a determination of the actual pre-stress in the members and the reactions in the member when loaded with the required hydrostatic and slamming pressures.

- iii) The procedure for the repair of the 6000 series alloys is to be submitted for review and approval. This procedure will need to demonstrate that the repair will not lower the heat affected zone below the level used for design.

The use of a welded yield strength, σ_{yw} , greater than the fully annealed condition may be considered when low heat welding techniques are used or with specialty extrusions that minimize the amount of weld. As part of this consideration, a test program will need to be established to validate the proposed welded yield strength. This test program is to include tensile, hardness, and fatigue “coupon” type testing of the alloy in the heat affected zone. Testing of samples that have been effectively repaired to determine the effects of multiple weld passes and the possible annealing of the alloy are also to be performed. In all cases, the Naval Administration is to confirm the use of the greater welded yield strength in writing.

1.7 Structures Exposed to Low Air Temperatures (2017)

For ships intended to operate in areas with low air temperatures [below and including -20°C (-4°F)], the materials in exposed structures are to be selected based on the design temperature t_D , to be taken as defined in 3-1-2/1.9.

Materials in the various strength members above the lowest ballast water line (BWL) exposed to air are not to be of lower grades than those corresponding to Classes I, II and III, as given in 3-1-2/Table 3, depending on the categories of structural members (secondary, primary and special). For non-exposed structures (except as indicated in Note 5 of 3-1-2/Table 3) and structures below the lowest ballast water line, see 3-1-2/1.1.

TABLE 3
Application of Material Classes and Grades – Structures Exposed at Low Temperatures (2017)

Structural Member Category	Material Class	
	Within 0.4L Amidships	Outside 0.4L Amidships
Secondary	I	I
Deck plating exposed to weather, in general		
Side plating above BWL		
Transverse bulkheads above BWL ⁽⁵⁾		
Primary	II	I
Strength deck plating ⁽¹⁾		
Continuous longitudinal members above strength deck, excluding longitudinal hatch coamings		
Longitudinal bulkhead above BWL ⁽⁵⁾		
Top wing tank bulkhead above BWL ⁽⁵⁾	III	II
Special		
Sheer strake at strength deck ⁽²⁾		
Stringer plate in strength deck ⁽²⁾		
Deck strake at longitudinal bulkhead ⁽³⁾	III	II
Continuous longitudinal hatch coamings ⁽⁴⁾		

Notes:

- Plating at corners of large hatch openings to be specially considered. Class III or Grade E/EH to be applied in positions where high local stresses may occur.
- Not to be less than Grade E/EH within 0.4L amidships in craft with length exceeding 250 meters. (820 feet).
- In craft with breadth exceeding 70 meters (230 feet) at least three deck strakes to be Class III.
- Not to be less than Grade D/DH.
- (2017) Applicable to plating attached to hull envelope plating exposed to low air temperature. At least one strake is to be considered in the same way as exposed plating and the strake width is to be at least 600 mm (24 in.).

The material grade requirements for hull members of each class depending on thickness and design temperature are defined in 3-1-2/Table 4. For design temperatures $t_D < -55^\circ\text{C}$ (-67°F), materials are to be specially considered.

TABLE 4
Material Grade Requirements for Classes I, II and III at Low Temperatures (2015)
Class I

Thickness, in mm (in.)	-20 to -25°C (-4 to -13°F)	-26 to -35°C (-14 to -31°F)	-36 to -45°C (-32 to -49°F)	-46 to -55°C (-50 to -68°F)
$t \leq 10$ ($t \leq 0.39$)	A, AH	B, AH	D, DH	D, DH
$10 < t \leq 15$ ($0.39 < t \leq 0.60$)	B, AH	D, DH	D, DH	D, DH
$15 < t \leq 20$ ($0.60 < t \leq 0.79$)	B, AH	D, DH	D, DH	E, EH
$20 < t \leq 25$ ($0.79 < t \leq 0.98$)	D, DH	D, DH	D, DH	E, EH
$25 < t \leq 30$ ($0.98 < t \leq 1.18$)	D, DH	D, DH	E, EH	E, EH
$30 < t \leq 35$ ($1.18 < t \leq 1.38$)	D, DH	D, DH	E, EH	E, EH
$35 < t \leq 45$ ($1.38 < t \leq 1.80$)	D, DH	E, EH	E, EH	-, FH
$45 < t \leq 50$ ($1.80 < t \leq 1.97$)	E, EH	E, EH	-, FH	-, FH

Class II

Thickness, in mm (in.)	-20 to -25°C (-4 to -13°F)	-26 to -35°C (-14 to -31°F)	-36 to -45°C (-32 to -49°F)	-46 to -55°C (-50 to -68°F)
$t \leq 10$ ($t \leq 0.39$)	B, AH	D, DH	D, DH	E, EH
$10 < t \leq 20$ ($0.39 < t \leq 0.79$)	D, DH	D, DH	E, EH	E, EH
$20 < t \leq 30$ ($0.79 < t \leq 1.18$)	D, DH	E, EH	E, EH	-, FH
$30 < t \leq 40$ ($1.18 < t \leq 1.57$)	E, EH	E, EH	-, FH	-, FH
$40 < t \leq 45$ ($1.57 < t \leq 1.80$)	E, EH	-, FH	-, FH	-, -
$45 < t \leq 50$ ($1.80 < t \leq 1.97$)	E, EH	-, FH	-, FH	-, -

Class III

Thickness, in mm (in.)	-20 to -25°C (-4 to -13°F)	-26 to -35°C (-14 to -31°F)	-36 to -45°C (-32 to -49°F)	-46 to -55°C (-50 to -68°F)
$t \leq 10$ ($t \leq 0.39$)	D, DH	D, DH	E, EH	E, EH
$10 < t \leq 20$ ($0.39 < t \leq 0.79$)	D, DH	E, EH	E, EH	-, FH
$20 < t \leq 25$ ($0.79 < t \leq 0.98$)	E, EH	E, EH	E, FH	-, FH
$25 < t \leq 30$ ($0.98 < t \leq 1.18$)	E, EH	E, EH	-, FH	-, FH
$30 < t \leq 35$ ($1.18 < t \leq 1.38$)	E, EH	-, FH	-, FH	-, -
$35 < t \leq 40$ ($1.38 < t \leq 1.57$)	E, EH	-, FH	-, FH	-, -
$40 < t \leq 50$ ($1.57 < t \leq 1.97$)	-, FH	-, FH	-, -	-, -

Single strokes required to be of Class III or of Grade E/EH or FH are to have breadths not less than $800 + 5L$ mm, maximum 1800 mm.

Plating materials for sternframes, rudder horns, rudders and shaft brackets are not to be of lower grades than those corresponding to the material classes given in 3-1-2/1.1.

1.9 Design Temperature t_D (2017)

The design temperature t_D is to be taken as the lowest mean daily average air temperature in the area of operation.

- *Mean:* Statistical mean over observation period
- *Average:* Average during one day and night
- *Lowest:* Lowest during year

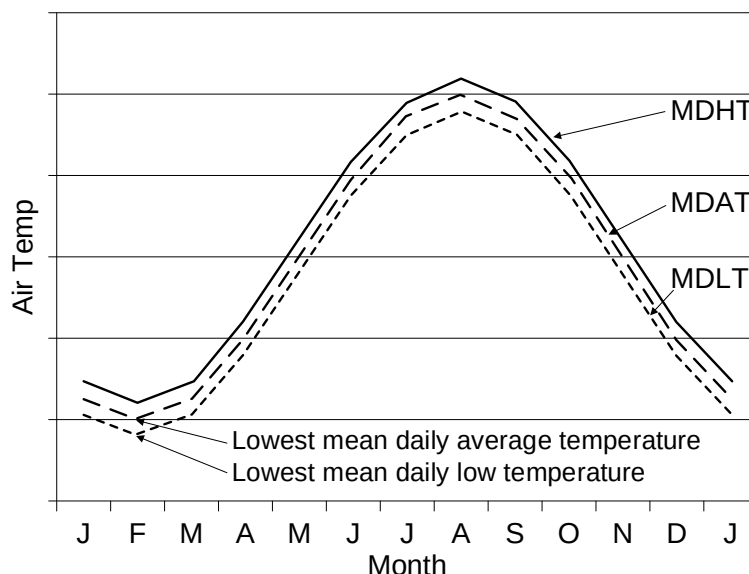
For seasonally restricted service the lowest value within the period of operation applies.

For the purpose of issuing a Polar Ship Certificate in accordance with the Polar Code, the design temperature t_D shall be no more than 13°C (23.6°F) higher than the Polar Service Temperature (PST) of the craft.

In the Polar Regions, the statistical mean over observation period is to be determined for a period of at least 10 years.

3-1-2/Figure 1 illustrates the temperature definition.

FIGURE 1
Commonly Used Definitions of Temperatures (2017)



MDHT = Mean Daily High (or maximum) Temperature

MDAT = Mean Daily Average Temperature

MDLT = Mean Daily Low (or minimum) Temperature

3 Workmanship

All workmanship is to be of commercial marine quality and acceptable to the Surveyor. Welding is to be in accordance with the requirements of Part 2, Chapter 4, Appendix 2-5-A1, Part 2, Chapter 14, and Section 3-2-13.

5 Design

5.1 Continuity

Care is to be taken to provide structural continuity. Changes in scantlings are to be gradual, such that the maximum angle from horizontal is 45° , see 3-1-2/Figure 2. Strength members are not to change direction abruptly, such that the maximum change in direction is 45° , see 3-1-2/Figure 3. Where primary structural members terminate at another structural member, tapering of the primary member or tapering brackets may be required beyond the other structural member, as indicated in 3-1-2/Figure 4, and as required in 3-2-5/1. Stanchions and bulkheads are to be aligned to provide support and to minimize eccentric loading. Major appendages outside the hull and strength bulkheads in superstructures are to be aligned with major structural members within the hull.

FIGURE 2

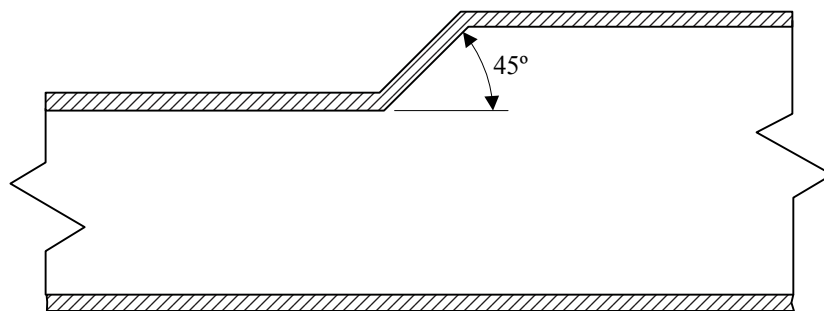


FIGURE 3

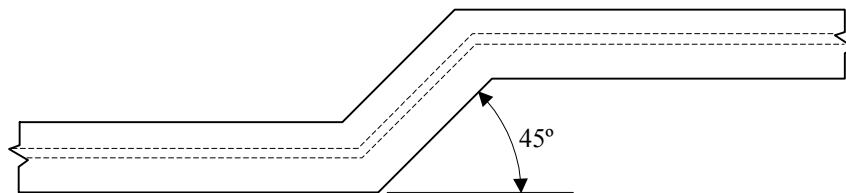
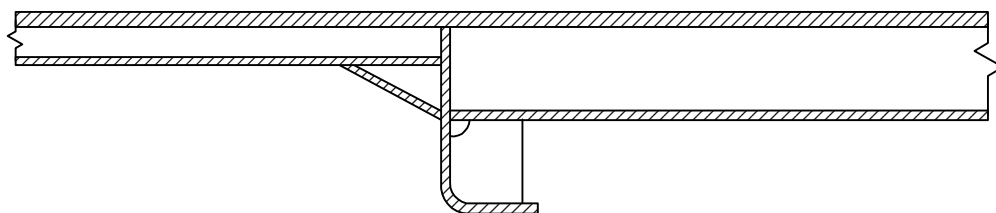


FIGURE 4



5.3 Openings

The structural arrangements and details are to be in accordance with Section 3-2-6. In general, major openings such as doors, hatches, and large vent ducts are to be avoided in the hull in close proximity to the gunwale. Corners of openings in strength structures are to have generous radii. Compensation may be required for openings.

5.5 Brackets

5.5.1 Steel Brackets

Where brackets are fitted having thicknesses as required by 3-1-2/Table 5A and faces at approximately 45 degrees with the bulkhead deck or shell, and the bracket is supported by a bulkhead, deck or shell structural member, the length of each member, ℓ , may be measured at a point 25% of the extent of the bracket beyond the toe of the bracket as shown in 3-1-2/Figure 5. The minimum overlap of the bracket arm along the stiffener is not to be less than obtained from the following equation:

$$x = 1.4y + 30 \text{ mm}$$

$$x = 1.4y + 2 \text{ in.}$$

where

x = length of overlap along stiffener, in mm (in.)

y = depth of stiffener, in mm (in.)

Where a bracket laps a member, the amount of overlap generally is to be 25.5 mm (1 in.).

5.5.2 Aluminum Brackets

Aluminum brackets are to comply with 3-1-2/5.5.1 except that the thicknesses given in 3-1-2/Table 5B are to be multiplied by 1.45 for the same length of face.

**FIGURE 5
Bracket**

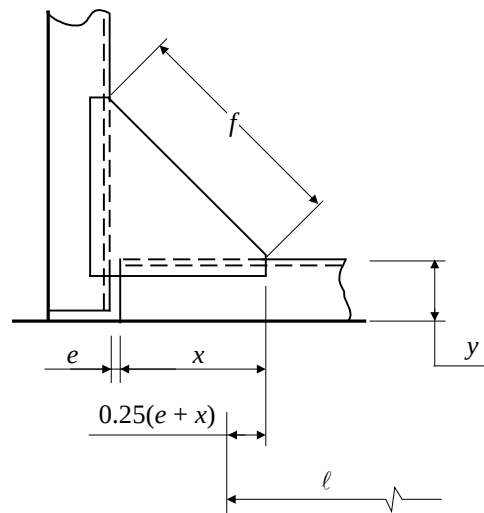


TABLE 5A
Brackets (Steel)

Thickness			
Length of Face, f, mm	Millimeters		Width of Flange, mm
	Plain	Flanged	
Not exceeding 305	5.0	—	—
Over 305 to 455	6.5	5.0	40
Over 455 to 660	8.0	6.5	50
Over 660 to 915	11.0	8.0	65
Over 915 to 1370	14.0	9.5	75

Thickness			
Length of Face <i>f</i> , in.	Inches		Width of Flange, in.
	Plain	Flanged	
Not exceeding 12	$\frac{3}{16}$	—	—
Over 12 to 18	$\frac{1}{4}$	$\frac{3}{16}$	$1\frac{1}{2}$
Over 18 to 26	$\frac{5}{16}$	$\frac{1}{4}$	2
Over 26 to 36	$\frac{7}{16}$	$\frac{5}{16}$	$2\frac{1}{2}$
Over 36 to 54	$\frac{9}{16}$	$\frac{3}{8}$	3

TABLE 5B
Brackets (Aluminum)

Thickness			
Length of Face, <i>f</i> , mm	Millimeters		Width of Flange, mm
	Plain	Flanged	
Not exceeding 305	7.0	—	—
Over 305 to 455	9.5	7.0	40
Over 455 to 660	11.5	9.5	50
Over 660 to 915	16.0	11.5	65
Over 915 to 1370	20.0	13.5	75

Thickness			
Length of Face <i>f</i> , in.	Inches		Width of Flange, in.
	Plain	Flanged	
Not exceeding 12	1/4	—	—
Over 12 to 18	3/8	1/4	1 1/2
Over 18 to 26	7/16	3/8	2
Over 26 to 36	5/8	7/16	2 1/2
Over 36 to 54	13/16	9/16	3

5.7 Structural Design Details

The designer is to give consideration to the following:

5.7.1

The thickness of internals in locations susceptible to rapid corrosion.

5.7.2

The proportions of built-up members to comply with established standards for buckling strength.

5.7.3

The design of structural details such as noted below, against the harmful effects of stress concentrations and notches:

- i) Details of the ends, the intersections of members and associated brackets.
- ii) Shape and location of air, drainage or lightening holes.
- iii) Shape and reinforcement of slots or cutouts for internals.
- iv) Elimination or closing of weld scallops in way of butts, "softening" of bracket toes, reducing abrupt changes of section or structural discontinuities.

5.7.4

Proportions and thickness of structural members to reduce fatigue response due to engine, propeller or wave-induced cyclic stresses, particularly for higher-strength steels.

Standard construction details based on the above considerations are to be indicated on the plans or in a booklet submitted for review and comment.

5.9 Termination of Structural Members

Unless permitted elsewhere in these Rules, structural members are to be effectively connected to the adjacent structures in such a manner to avoid hard spots, notches and other harmful stress concentrations. Where members are lightly loaded and not required to be attached at their ends, special attention is to be given to the end taper, by using soft-toed concave brackets or by a sniped end of not more than 30°. Bracket toes or sniped ends are to be kept within 25 mm (1.0 in.) of the adjacent member and the depth at the toe or snipe end is generally not to exceed 15 mm (0.60 in.). Where a strength deck or shell longitudinal terminates without end attachment, it is to extend into the adjacent transversely framed structure or stop at a local transverse member fitted at about one transverse frame space beyond the last floor or web that supports the longitudinal.

7 Effective Width of Plating

The section modulus and moment of inertia of stiffening members are provided by the member and a portion of the plating to which it is attached. The effective width is as given in the following paragraphs. The section modulus and moment of inertia of a shape, bar, fabricated section, or laid-up member not attached to plating is that of the member only.

7.1 FRP Laminates

Where the plating is an FRP single-skin laminate, the maximum effective width of plating for floors, frames, beams and bulkhead stiffeners is not to exceed either the stiffening member spacing or the width obtained from the following equation, whichever is less. See 3-1-2/Figure 6.

$$w = 18t + b$$

where:

- w = effective width of plating, in mm (in.)
- t = thickness of single skin plating, in mm (in.)
- b = net width of stiffening member, in mm (in.), but not more than $18t$

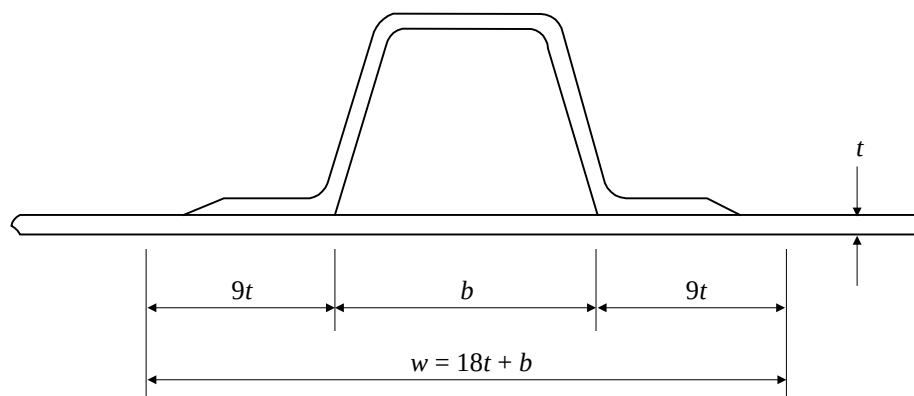
Where the plating is an FRP sandwich laminate with a flexurally and compressively ineffective (balsa, cross linked PVC, or linear polymer) core, t in the above equation is the thickness of a single skin laminate having the same moment of inertia per unit width as the two skins of the sandwich about the neutral axis of the sandwich, excluding the core.

For a stiffening member along an opening, the maximum effective width of plating is equal to either one-half the stiffening member spacing or the width obtained from the following equation, whichever is less.

$$w = 9t + b$$

where w , t and b are as defined above.

FIGURE 6
Effective Width of FRP Plating



7.3 Steel and Aluminum Plating

7.3.1 Primary Structural Members

The effective width of plating for deep supporting members is to equal to the lesser of either one half the sum of spacing on each side of the member, 0.33 time the unsupported span, ℓ , or 750 mm (30 in.). For girders and webs along hatch openings, the effective width of plating is to be half of that obtained from the above. Due account is to be taken in regards to plate buckling, see 3-2-3/1.1.

7.3.2 All Other Structural Members

The maximum effective width of plating is equal to either one-half the sum of spacing on each side of the member or the width obtained from the following equation, whichever is less.

$$\text{Steel Members} \quad w = 80t$$

$$\text{Aluminum Members} \quad w = 60t$$

where

$$w = \text{effective width of plating, in mm (in.)}$$

$$t = \text{thickness of single skin plating, in mm (in.)}$$

For a stiffening member along an opening, the maximum effective width of plating is one-half of the effective width given above.

PART

3

CHAPTER 1 General

SECTION 3 Direct Analysis Methods

1 General

This Section states requirements for a variety of direct analysis methods that can be used in lieu of or in conjunction with the specific requirements given in Sections 3-2-1, 3-2-2, 3-2-3, and 3-2-4 or to meet the requirements in 1-1-4/5. If the structure of the craft complies with 3-1-3/3.5, 3-1-3/5.3, 3-1-3/7.1.2, 3-1-3/7.3, 3-1-3/9.1, 3-1-3/9.3.3, and 3-1-3/11.3 of this section and the requirements in Sections 3-2-1, 3-2-2, 3-2-3, and 3-2-4 it will be eligible to receive the **SH-DLA** Class Notation. For guidance on the **SH-DLA** class notation not given in this Section, see the *ABS Guidance Notes on Structural Direct Analysis for High-Speed Craft*.

3 Loading Conditions

3.1 General

The loading conditions considered are to include all intended operational conditions of the craft as specified by the Naval Administration. These operating conditions are to be defined by significant wave height, wave period, and maximum operating speed. 3-1-3/Table 1 is to be used when the significant wave height is given in terms of Sea States. When the wave period is not given, the most probable modal period is to be used in the analysis.

TABLE 1
Sea States

<i>Sea State</i>	<i>Significant Wave Height m (ft)</i>
0-1	0.10 (0.3)
2	0.50 (1.6)
3	1.25 (4.1)
4	2.5 (8.2)
5	4 (13.1)
6	6 (19.7)
7	9 (29.5)
8	14 (45.9)
>8	>14 (45.9)

3.3 Environmental and Service Conditions

3.3.1 General

The environmental condition is anticipated to be described by appropriate sets of wave data. The sources and reliability of this data are to be submitted. The wave parameters used in the analysis are to be selected and documented based on the conditions given in the craft specification. If these parameters are to be used in conjunction with the requirements in 3-1-3/3.5, 3-1-3/5.3, 3-1-3/7.1.2, 3-1-3/7.3, 3-1-3/9.1, 3-1-3/9.3.3, and 3-1-3/11.3, then they are to be compatible with the stochastic response and extreme value prediction methods.

3.3.2 Types of Wave Spectra

3.3.2(a) *Deep-water Ocean Waves.* Two-parameter spectra, such as the Bretschneider or P-M wave spectral formulations, are to be used. If the swell and wave components are known to interact, a bi-modal Ochi-Hubble spectrum is to be used. Directional spreading appropriate to coastal conditions is also to be applied.

3.3.2(b) *Shallow-water Waves.* Wave conditions that include the effects of bathymetry, wind field, coastal contours of the region are to be used. For fetch-limited sea conditions, JONSWAP spectrum or a modified version of the spectrum is to be used.

3.5 Loading Conditions for Direct Analysis

3.5.1 Dominant Load Parameters

A list of *Dominant Load Parameters* (DLP) is to be developed. This will include select motion and load effect parameters. Other loads, such as those due to wave impacts on the bow and stern, flare and bottom slamming, wet-deck slamming (multi-hulls) and vibration effects on local structural strength, have to be treated separately. Considerations for slamming analysis are given in 3-1-3/3.5.7.

3.5.2 Load Cases

Load cases are defined by a combination of craft loading conditions, a set of global motion and load effect parameters set forth in terms of each of the DLPs, other load components accompanying the DLPs and an equivalent wave system for the specified DLP. Justification for load cases selected for use in the structural analysis is to be submitted to ABS for review.

3.5.3 Analyses of Ship Motions, Wave Loads, and Extreme Values

Calculations are to be made using the spectral analysis-based approach, which by definition relies on the use of *Response Amplitude Operators* (RAOs). Each RAO is to be calculated for regular waves of unit amplitude for a range of wave frequencies and wave headings that will be given below.

3.5.4 Essential Features of Spectral Analysis of Motions and Loads

3.5.4(a) *General Modeling Considerations.* The model of the hull is to include the masses of all equipment, vehicles and supporting structure. There is also to be sufficient compatibility between the hydrodynamic and structural models so that the application of fluid pressures onto the finite element mesh of the structural model can be done appropriately.

For the load component types and structural responses of primary interest, software formulations derived from linear idealizations are deemed to be sufficient. The capabilities and limitations of the software are to be known, and in cases where the software is not known to ABS, it may be necessary to demonstrate the adequacy of the software.

3.5.4(b) *Diffraction-Radiation Methods.* Computations of the wave-induced motions and loads are to be carried out through the application of seakeeping analysis codes utilizing three-dimensional potential flow based diffraction-radiation theory. Computation of the hydrodynamic pressures is to take account of, as a minimum, all six degree-of-freedom rigid-body motions of the hull. These codes may be based either on linear (small) wave and motion amplitude assumptions or nonlinear (large) amplitude motion and wave formulations.

3.5.4(c) *Panel Model Development.* The Rankine source panel method is recommended for solving the hydrodynamic boundary value problem.

3.5.4(d) *Motion and Load-Effect Response Amplitude Operators.* For each loading condition, RAOs of all the selected DLPs are to be calculated. The RAOs are to represent the pertinent range of wave headings (β), in increments not exceeding 15 degrees. A range of wave frequencies is to be considered based on the route-specific wave conditions (see 3-1-3/3.3). The nominal range is 0.2 rad/s to 1.8 rad/s in increments of 0.05 rad/s.

The worst frequency-heading (ω , β) combination is to be determined from an examination of the RAOs for each DLP. Only the heading $\beta_{\max}$ and the wave frequency ω_e at which the RAO of the DLP is a maximum, need to be used in DLA or direct analysis.

3.5.5 Extreme Values Analysis

Extreme value analysis is to be performed for each DLP to determine the maximum values. An extreme value method that follows the so-called long-term approach is to be used. The use of a validated short-term extreme value approach, which is appropriate to the craft type and route-specific environmental data, will also be considered. The supplementary use of such a short-term approach to confirm or test the sensitivity of the long-term based design values is recommended.

The relevant value to be obtained from the long-term response analysis is the most probable extreme value (MPEV) having a probability of level of 10^{-8} in terms of wave encounters.

3.5.6 Equivalent Wave

For each load case, an equivalent wave is to be determined which simulates the magnitude and location of the extreme value of the dominant load component of the load case.

The amplitude of the equivalent wave is to be determined using the extreme values of the DLP (see 3-1-3/3.5.4) and the RAO of that DLP occurring at the wave frequency and wave heading corresponding to the maximum amplitude (peak) of the RAO. The amplitude of the equivalent wave is given by:

$$a_{wj} = MPEV_j / \text{Max } RAO_j$$

where

a_{wj} = wave amplitude

$MPEV_j$ = Most Probable Extreme Value of the j^{th} DLP at a probability level equivalent to the design criterion

$\text{Max } RAO_j$ = maximum amplitude of the j^{th} DLP's RAO

3.5.7 Slamming Loads

Loads due to slamming and wave impact on craft hulls are categorized into global slamming effects and local slam-induced structural response.

3.5.7(a) Global Slamming Effects. The simplified formulae given in Section 3-2-1 may be used to account for global slamming effects in the preliminary design stage. For detailed analysis, a direct time-domain simulation involving short-term predictions are to be used for the global strength assessment of monohulls. In most cases involving high speeds, the absolute motions or relative motions will be of such large amplitude that nonlinear calculations will be required. In catamarans, wet deck slam-induced global whipping effects of the hull is to be assessed using methods that account for coupling of the symmetric and anti-symmetric modes of responses. These calculations will require time-domain analysis methods.

3.5.7(b) Local Impact Loads. Panel structures with horizontal flat or nearly flat surfaces such as a wet deck of a multi-hull craft will need to be hydroelastically modeled, where in the dynamics of the fluid and the elastic response of the plate and stiffeners are simultaneously modeled.

5 Motion Predictions

5.1 Model Testing

Craft hull motions and accelerations obtained from scale model tests may be used to validate motions predicted by computer programs. Model testing is required to be performed and reported to ABS when loads are being submitted in lieu of the loads determined in Section 3-2-2 or other loads determined by ABS. This paragraph is to be complied with when model testing is required by the Naval Administration. The model is to accurately represent the structure that is to be built in both principal particulars and hull geometry.

5.1.1 Testing Program

The model is to be tested over a range of speeds, headings, and wave characteristics (height, length, and period), as indicated by the Naval Administration. When this is not specified, the testing program is to include the following:

5.1.1(a) Speeds. The model is to be tested at the minimum speed required by the Naval Administration and the maximum achievable speed of the craft for a particular wave profile and heading.

5.1.1(b) Headings. The model is to be tested in head, beam, quartering, and following seas.

5.1.1(c) Wave Parameters. The model is to be tested in both deep water and shallow water wave conditions. These are defined in 3-1-3/3.3.2. For craft that are limited to operation in coastal regions (Coastal Naval Craft and Riverine Naval Craft), deep water wave profile testing is not required.

5.1.2 Model Measurements and Reporting

The parameters listed below are to be measured and reported based on the model test program. Some of the parameters listed may be derived through statistical analysis of measured data obtained from testing. When statistical analysis is used, the methods of analysis employed are to be indicated in the report.

5.1.2(a) Vertical or Heave Acceleration. The significant, $1/10^{\text{th}}$ highest, or $1/100^{\text{th}}$ highest vertical acceleration at the longitudinal center of gravity, bow, and stern are to be reported. The accelerometer is to be adjusted such that the acceleration due to gravity is not measured. The $1/100^{\text{th}}$ highest vertical acceleration at the longitudinal center of gravity may be used in place of n_{cg} in 3-2-2/1 and 3-2-2/3.

5.1.2(b) Roll Acceleration. The significant roll acceleration about a longitudinal axis through the center of gravity and the maximum roll angle are to be reported.

5.1.2(c) Pitch Angle and Acceleration. The significant coupled pitch-and-heave acceleration at the bow and the stern and the maximum pitch angle are to be reported.

5.3 Accelerations from Direct Analysis

5.3.1 General

The wave-induced craft motions may be determined by direct analysis. When this analysis is not performed by ABS, it is to be verified by model testing as indicated in 3-1-3/5.3.

5.3.2 Global Accelerations

Global accelerations are to be determined using the loading conditions indicated in 3-1-3/3.5 above. The $1/100^{\text{th}}$ highest vertical (heave) acceleration at the longitudinal center of gravity may be used in place of n_{cg} in Sections 3-2-1 and 3-2-2.

5.3.3 Local Accelerations

Local accelerations at points where the lightship weight of the structure, (non-liquid cargo), are located, including deck-mounted equipment, are to be calculated to determine the inertia loads. For vehicle decks, wheel loading is to be applied. An evenly distributed load equivalent to the weight of the vehicles may be used. The acceleration RAO at a location of interest is to be calculated to account for all translational and rotational components of motions.

The components of the gravitational acceleration in the craft's coordinate system are to be included.

7 Load Predictions

7.1 Global Loads

As a minimum, the still-water hogging and sagging moments and shear forces, the wave-induced hogging and sagging moments and shear forces and the slam-induced moments and shear force, are to be determined for monohull craft. Multi-hulled craft are to have the transverse bending moment, the torsional (or pitch connecting) moment and the transverse shear force determined in addition to the moments and shear forces determined for monohull craft. These loads are to be reported so that they can be used in conjunction with the requirements in 3-1-3/9 or Section 3-2-1.

7.1.1 Computation of Global Load Effects

7.1.1(a) Still-water Bending Moment and Shear Force. The still-water bending moments and shear forces are to be calculated in the light load, half load, and full load conditions. The light load condition consists of all components of the craft (structure, machinery, piping equipment, outfitting, wiring, interiors, paint, etc.) plus 10% of tank and cargo capacity. The half load condition is to include all components of the craft plus 50% of the tank and cargo capacity. The full load condition consists of all components of the craft plus 100% of the tank and cargo capacity. The distribution of the load is to capture all major weight discontinuities, and no single weight distribution segment is to be greater than $0.20L$.

7.1.1(b) Wave-Induced Longitudinal Bending Moment and Shear Force. The wave-induced bending moments and shear forces can be determined by using the environmental conditions outlined in 3-1-3/3.3.

7.1.1(c) Transverse Bending Moment and Shear Force – Multi-hulled Craft. The transverse bending moment and shear force may be determined by distributing the weights and loads athwartships across the craft and using the environmental conditions outlined in 3-1-3/3.3

7.1.1(d) Torsion Bending Moment. The torsional bending moment may be determined by distributing the weights and loads on segments of the hull sliced at a 45° angle from centerline and using the environmental conditions outlined in 3-1-3/3.3.

7.1.1(e) Slamming Induced Bending Moment and Shear Force. The slam induced bending moment and shear force may be calculated by applying the acceleration determined in 3-1-3/5 or in 3-2-2/1 to the lumped masses developed for 3-1-3/7.2.1(a).

7.1.2 Global Loads from Computations

Global loads from computer software programs are to be developed by loading the structure as outlined in 3-1-3/3.5. The computer program is to be capable of determining the moments and shear forces in 3-1-3/7.1 or developing loads that can be used in conjunction with finite element methods as outlined in 3-1-3/9.1.

7.3 Local Loads

Loads that differ from the pressure loads developed in Section 3-2-2 may be used to determine the required scantlings in conjunction with the requirements in 3-1-3/9.3 or Sections 3-2-3 and 3-2-4. These loads are to be developed under the loading conditions in 3-1-3/3 and the following subparagraphs.

7.3.1 External Hydrodynamic Pressure

The hydrodynamic pressures at selected points on the external contours of the hull sections, are to be calculated in regular waves.

7.3.1(a) External Pressure Components. The total hydrodynamic pressure is to include the pressure components due to waves and the components due to craft motion. Components of the hydrodynamic pressure are to be calculated from the panel model analysis of 3-1-3/3.5.3.

7.3.1(b) Pressures Accompanying the Dominant Load Parameter and Their Distribution. The external pressure is to be calculated either as a complex number or in terms of the amplitude and phase. Then, ‘simultaneously’ acting pressures over the wetted surface can be represented in the form:

$$P = (A)(a_w)\sin(\omega_e t + \varepsilon_f)$$

where

P	=	simultaneous pressure
A	=	amplitude of the pressure RAO
a_w	=	equivalent wave amplitude
ω_e	=	frequency of the equivalent wave when the RAO of the dominant load component of the load case reaches its maximum

t = time under consideration.

ε_l = phase angle of the (other) load component's RAO

7.3.1(c) *Pressure Loading for Finite Element Models.* The hydrodynamic pressure can be linearly interpolated to obtain the nodal pressures for the finite element models required for structural analysis.

7.3.1(d) *Pressure Loading for Rule Requirements.* For pressures that are to be used in conjunction with the requirements in Sections 3-2-3 and 3-2-4 for determining the local scantlings, the hydrodynamic pressures are to be resolved into kN/m² (tf/m², psi).

7.3.2 Internal Tank Pressure

Liquid pressures in the cargo tanks are to be calculated and applied to the structural model used in finite element analysis. Both static and dynamic pressures are to be included in the analysis, assuming that there is no relative motion between the tank and the contained fluid.

7.3.2(a) *Pressure Components.* The internal tank pressure is to account for both the quasi-static and motion-induced (dynamic) pressure components. The quasi-static component results from gravity and is to include craft roll and pitch rotations. The dynamic component is to be developed from the accelerations in the liquid at the tank boundary caused by the hull's motions in six degrees of freedom. These are to be obtained from motion analysis as specified in 3-1-3/3.

The total instantaneous internal tank pressure for each of the tank boundary points is to be calculated by combining the inertial and quasi-static components as follows:

$$p = p_o + \rho h_t [(g_x + a_x)^2 + (g_y + a_y)^2 + (g_z + a_z)^2]^{1/2}$$

where

p = total instantaneous internal tank pressure at a tank boundary point

p_o = vapor pressure or the relief valve pressure setting

ρ = fluid density, cargo or ballast

h_t = total pressure head defined by the height of the projected fluid column in the direction of the total instantaneous acceleration vector

$a_{x,y,z}$ = longitudinal, lateral, and vertical wave-induced accelerations relative to the craft's axis system at a point on a tank's boundary

$g_{x,y,z}$ = longitudinal, lateral, and vertical components of gravitational accelerations relative to the craft's axis system at a tank boundary point

7.3.2(b) *Roll and Pitch Motions.* The influence of ship motions on tank pressures is to be taken into account using the maximum pitch and roll angles. As reflected in the previous formulations, the inclination of the tank due to craft roll and pitch is to be considered in the calculation of the hydrostatic pressure. The direction of gravitational forces in the ship-fixed coordinate system varies with roll and pitch, resulting in a change in pressure head and a corresponding change in the static pressure.

7.3.2(c) *Simultaneously Acting Tank Pressure.* At each wave condition, for each load case described in 3-1-3/3.5, simultaneously acting tank pressures (quasi-static and dynamic) are to be calculated. Each wave condition is defined by wave amplitude, frequency, heading angle and wave crest position, as explained in 3-1-3/3.5. Using the wave amplitude and phase angle determined based on the RAO of a DLP, the simultaneously acting tank pressure is to be calculated for the instant when the maximum value of the DLP occurs. These internal tank pressures are to be used in the structural finite element model.

7.3.3 Inertia Force of Lumped Structural Mass

The inertia force, or point load, of a structural mass, such as deck equipment or cargo, can be determined by the following equation:

$$F = m(A_t)$$

where

- F = inertial load of the item
 m = mass of the lumped weight of the structural member
 A_t = amplitude of the acceleration RAO

For finite element models, the inertia forces in three (global) directions are to be calculated and applied. For a first-principles analysis, the inertia force in the vertical direction is to be calculated and applied.

9 Structural Response

9.1 Global Response

The global bending moments developed in 3-1-3/7.1 can either be applied to the requirements in 3-2-1/1.1.2(e), 3-2-1/1.5, 3-2-1/1.9.4, and 3-2-1/3.5 or to a global finite element model as outlined in this paragraph.

9.1.1 General

The load cases of 3-1-3/3.5 are to be applied to the global structural analysis model described in 3-1-3/9.1.4. Each load case is to include the hydrostatic and still-water load components that have not otherwise been directly included in the load component determination performed in accordance with 3-1-3/7.3.1 and 3-1-3/7.3.3. These hydrostatic or still-water components are to be included in the hydrostatics analysis.

9.1.2 Equilibrium Check

The model of the hull girder structure is to be close to equilibrium when all the loads (static and dynamic) are applied.

The unbalanced forces in the model's global axis system for each load case need to be determined and resolved. The magnitudes of the unbalanced forces, and the procedure used to balance the structural model in equilibrium is to be fully documented.

9.1.3 General Modeling Considerations

To the maximum extent practicable, the overall model of the hull structure is to comprise the entire hull. There is also to be sufficient compatibility between the hydrodynamic and structural models so that the application of fluid pressures onto the finite element mesh of the structural model can be done appropriately.

For the load component types and structural responses of primary interest, analysis software formulations derived from linear idealizations are sufficient. Enhanced bases of analysis may be required so that non-linear loads, such as hull slamming, may be required. The adequacy of the selected software is to be demonstrated to the satisfaction of ABS.

The results of overall (global) model analysis are to be directly employed in the creation and analysis of the required finer mesh, local structural models. Appropriate boundary conditions determined in the larger scale model are to be imposed onto the local models for appropriate structural continuity and load transfer between the various levels of models.

9.1.4 Analysis of the Global Hull Structure

The global structural and load model is to be as detailed and complete as possible. The stress results of the global model are used only to assess the hull girder plating of the deck (and wet deck for multi-hulled craft), side shell, bottom, inner bottom, longitudinal bulkheads, transverse bulkheads and stools or deck box girders. The main supporting members of the hull girder may be evaluated using 2-D fine-mesh local models. In developing the 3-D global finite element model, the following requirements apply:

- i) The finite element model is to include all primary load-carrying members. Secondary structural members which may affect the overall load distribution are also to be included.
- ii) Structural idealization is to be based on the stiffness and anticipated response of the structure, not wholly on the geometry of the structure itself.
- iii) The relative stiffness between associated structural members and their anticipated response under the specified loading is to be considered.
- iv) A judicious selection of nodes, elements, and degrees of freedom is to be made to represent the stiffness and mass properties of the hull, while keeping the size of the model and required data generation within manageable limits. Lumping of plating stiffeners, use of equivalent plate thickness, and other techniques may be used for this purpose.
- v) The finite elements, whose geometry, configuration, and stiffness closely approximate the actual structure, can typically be of three types:
 - Truss or bar elements with axial stiffness only
 - Beam elements with axial, shear, and bending stiffness
 - Membrane plate elements, either triangular or quadrilateral.
- vi) When possible, the finite element structure is to be based on the use of gross or as-built scantlings.

9.3 Local Response

The local loads developed in 3-1-3/7.3 may be used in conjunction with the scantling requirements in Sections 3-2-3 and 3-2-4. For local structure that forms a grillage, or that is arranged in a manner not indicative of the principles given in the other Sections of these Rules, or structure that is being examined in conjunction with a finite element analysis may be reviewed using the following:

9.3.1 Non-Prismatic Beam Analysis

Beams that do not have uniform cross-sections may be analyzed using a non-prismatic beam program. The adequacy of the selected software is to be demonstrated to the satisfaction of ABS. In developing the non-prismatic beam model, the following requirements apply:

- i) The program is to be capable of calculating the shear and bending moment at all locations along the length of the beam.
- ii) Section properties of the beam are to be inputted into the program to resemble the actual construction of the beam and are to have a maximum segment length of 300 mm (1 foot).
- iii) The loads for the beam may be derived from Section 3-2-2 or 3-1-3/7.
- iv) The boundary conditions of the beam are to reflect the structural arrangement.

9.3.2 Grillage or Plane Frame Analysis

Structure that forms a grillage, or an area of structure that is arranged in a manner that is different from the principles of these Rules, may be analyzed using a grillage or plane frame analysis program. The adequacy of the selected software is to be demonstrated to the satisfaction of ABS. In developing the grillage or plane frame model, the following requirements apply:

- i) The beam elements in the model are to be arranged to reflect all of the structure in the area under consideration.
- ii) The program is to be capable of applying off-axis loads to the elements and nodes.
- iii) The program is to be capable of calculating and reporting the bending moments and shear forces at each node.
- iv) The loads for the model may be derived from Section 3-2-2 or 3-1-3/7.
- v) The boundary conditions of the model are to reflect the structural arrangement. Boundary conditions that model symmetry will be specially considered.

9.3.3 Local Fine Mesh Model from Global 3-D Model

Detailed local stresses are to be determined by fine mesh FEM analysis of local structures, based on the results of the global 3-D analysis.

The requirements for developing the 3-D coarse mesh global model in 3-1-3/9.3.4 are also applicable to the development of the 2-D fine-mesh models. In developing the 2-D fine mesh model, the following requirements apply:

- i) The mesh size of the 2-D finite element model are to be determined by adequately modeling the stiffness of the individual structural members forming the local structure.
- ii) In modeling a local transverse structure, the web plating is modeled by membrane plates, using both quadrilateral and triangular elements. Stiffeners on the web plating, such as panel breakers, tripping brackets, flat bar stiffeners, etc., and the face plates of the webs are modeled by rod elements of equivalent cross sectional areas. Where face plates on brackets are tapered at the ends, the area of the rod elements is to be reduced accordingly. The out-of-plane hull girder plating (i.e., deck, side shell, bottom shell, girders, etc.) is also to be modeled by rod elements, using an appropriate effective width.
- iii) The mesh size used is to be adequate to represent the overall stiffness of the considered local structure as a whole, such that smooth stress distributions in the structure can be obtained.
- iv) Finer meshes are to be used in the probable high stressed areas in order to obtain more accurate stress distributions for these areas. The use of a uniform mesh with smooth transition and with avoidance to abrupt changes in mesh sizes is recommended.
- v) In laying out the mesh, the shapes of membrane elements created are to be as regular as possible. The aspect ratios of plate elements are to be kept within 2:1. Elements with an aspect ratio higher than 5:1 may be used for convenience of modeling in way of low stress areas, or areas of low interest.
- vi) The grid line spacing and element sizes for the transverse section can be determined by the spacing of the longitudinals on the bottom shell, inner bottom, and topside tank. The grid lines can either be in line with the longitudinals, or for a finer mesh, an additional one division can be added between the longitudinal spacing.
- vii) Cutout openings for longitudinals and access holes need not be considered in the 2-D models. This is also applies to all lightening holes or other small openings in the webs.
- viii) The stiffeners, panel breakers, and ribs that prevent local buckling that are parallel to the principal direction of stress are to be included in the model.

Boundary displacements obtained from the 3-D global analysis are to be used as boundary conditions in the fine mesh analysis. As applicable, the fine mesh models are to include at least the following local structures:

- A number of transverse web frames
- Centerline longitudinal girder
- Side longitudinal girder
- Horizontal stringers of watertight transverse bulkhead
- Other areas of high stress indicated from the 3-D global analysis.

Where the 3-D global analysis is not comprehensive enough to determine adequately the total stress in the longitudinal plating (e.g., deck and shell) and transverse bulkhead plating of the craft, additional analyses may be required. Such analyses may not require the performance of fine mesh FEM analysis, where the needed results can be provided by another acceptable method.

9.3.4 Local Fine Mesh Model without Global 3-D Model

Structure that forms a grillage or an area of structure that is arranged in a manner different from the principles of these Rules may be analyzed using a local finite element model. The adequacy of the selected software is to be demonstrated to the satisfaction of ABS. In developing the local finite element model, the following requirements apply:

- i) The requirements in 3-1-3/9.3.4 are to be applied as applicable.
- ii) The loads for the model may be derived from Section 3-2-2 or 3-1-3/7.
- iii) The boundary conditions of the model are to reflect the structural arrangement. Boundary conditions that model symmetry will be specially considered.

11 Structural Acceptability

11.1 Beam, Grillage, or Plane Frame Analysis

The allowable bending stress for elements in beam, grillage or plane frame models is given in 3-2-4/Table 1 or 3-2-4/Table 2. The allowable shear stress for aluminum and steel elements is $0.5\tau_y$ ($0.75\tau_y$ for bottom primary structures) where τ_y is the minimum shear yield strength of the material. For aluminum structure, τ_y is to be in the welded condition. The allowable shear stress for composite members is $0.4\tau_u$, where τ_u is the lesser of the ultimate shear strength in either the warp or fill of the web laminate.

11.3 Finite Element Analysis

11.3.1 General

The adequacy of the finite element analysis results is to be assessed for the failure modes of material yielding and buckling. The requirements in this section are for steel, aluminum and FRP craft. The acceptance criteria for craft constructed of other materials will be specially considered.

11.3.2 Yielding (2014)

For a plate element subjected to biaxial stress, a specific combination of stress components, rather than a single maximum normal stress component constitutes the limiting condition. In this regard, the total equivalent stress is to be based on the Hencky von-Mises criterion as the following equation:

$$\sigma_e = [\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}^2]^{1/2}$$

where

- σ_x = normal stress in the x coordinate direction of the element
- σ_y = normal stress in the y coordinate direction of the element
- τ_{xy} = in-plane shearing stress

The total equivalent stress (Hencky von-Mises stress) is to be less than or equal to the following design stress:

Steel:	$0.95\sigma_{yield}$
Aluminum:	$0.85\sigma_{yield}$
FRP:	$0.37\sigma_u$

where σ_{yield} is the yield strength for steel structures or the welded yield strength for aluminum structure, and σ_u is the ultimate tensile or compressive strength of the laminate, whichever is less.

Component stresses (σ_x , σ_y , τ_{max}) are to be less than or equal to allowable local structure design stress.

For a solid element, a specific combination of stress components, instead of a single maximum normal stress component constitutes the limiting condition. In this regard, the total equivalent stress is to be based on Hencky von-Mises criterion as the following equation:

$$\sigma_e = \sqrt{1/2[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2] + 6(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)}$$

where

σ_x	=	normal stress in the x coordinate direction of the element
σ_y	=	normal stress in the y coordinate direction of the element
σ_z	=	normal stress in the z coordinate direction of the element
τ_{xy}	=	shear in x-y plane
τ_{yz}	=	shear in y-z plane
τ_{zx}	=	shear in z-x plane

The total equivalent stress (Hencky von-Mises) is to be less than or equal to the following design stress:

Steel:	$0.95\sigma_{yield}$
Aluminum:	$0.85\sigma_{yield}$
FRP:	$0.37\sigma_u$

where σ_{yield} is the yield strength for steel structures or the welded yield strength for aluminum structure, and σ_u is the ultimate tensile or compressive strength of the laminate, whichever is less.

Component stresses (σ_x , σ_y , σ_z , and τ_{max}) are to be less than or equal to allowable local structure design stress.

τ_{max} is the Maximum Shear through the solid element. The Maximum Shear occurs along the principle angle through the element and is not to be confused with the three in- plane shears.

11.3.3 Design Global Hull Girder Stresses (2007)

The design stresses are as follows:

- Global Longitudinal Strength of All Hull Types

σ_a	=	design longitudinal bending stress, f_p/CQ N/mm ² (kgf/mm ² , psi)
τ_a	=	design shear stress, $110/Q$ N/mm ² (1.122/Q tf/cm ² , 7.122/Q Ltf/in ²)
f_p	=	17.5 kN/cm ² (1.784 tf/cm ² , 11.33 Ltf/in ²)
C	=	1.0 for steel craft
	=	0.90 for aluminum craft
	=	0.80 for fiber-reinforced plastic craft

Q for steel:

=	1.0	for ordinary strength steel
=	0.78	for grade H32 steel
=	0.72	for grade H36 steel

Q for aluminum:

=	$0.9 + q_5$	but not less than Q_o
q_5	=	$115/\sigma_y$ (12/ σ_y , 17000/ σ_y)
Q_o	=	$635/(\sigma_y + \sigma_u)$ [$65/(\sigma_y + \sigma_u)$, 92000/ $(\sigma_y + \sigma_u)$]

σ_y = minimum yield strength of unwelded aluminum in N/mm² (kgf/mm², psi)
(not to be greater than $0.7\sigma_u$)

σ_u = minimum ultimate strength of welded aluminum in N/mm² (kgf/mm², psi)

Q for fiber reinforced plastic:

= $400/0.75\sigma_u$ ($41/0.75\sigma_u$, $58000/0.75\sigma_u$)

σ_u = minimum ultimate tensile or compressive strength, whichever is less, verified by approved test results, in N/mm² (kgf/mm², psi). See Section 2-6-5.
Strength properties in the longitudinal direction of the craft are to be used.

- Global Transverse Strength of Multihulls

σ_a = design transverse bending stress, $0.66\sigma_y$ for aluminum and steel craft and $0.33\sigma_u$ for FRP craft, in N/mm² (kgf/mm², psi)

σ_{ab} = design torsional or combined stress, $0.75\sigma_y$ for aluminum and steel craft and $0.367\sigma_u$ for FRP craft, in N/mm² (kgf/mm², psi)

τ_a = design transverse shear stress, $0.38\sigma_y$ for aluminum and steel craft and $0.40\tau_u$ for FRP craft, in N/mm² (kgf/mm², psi)

σ_y = minimum yield strength of the material, in N/mm² (kgf/mm², psi). For aluminum the yield strength is to be for the unwelded condition and not to be greater than $0.7\sigma_{uw}$

σ_u = minimum tensile or compressive strength, whichever is less, in N/mm² (kgf/mm², psi)

σ_{uw} = ultimate tensile strength of material in the welded condition, in N/mm² (kgf/mm², psi)

δ_m = maximum deflection for FRP craft, $(\sigma_a/E)L_p$, in m (in.)

τ_u = minimum ultimate through thickness shear strength, in N/mm² (kgf/mm², psi)

L_I = mean span of cross structure, in cm (in.), as indicated in 3-2-A2/Figure 2

E = tensile or compressive modulus of the FRP laminate, whichever is lesser, in N/mm² (kgf/mm², psi)

11.3.4 Buckling and Ultimate Strength

Plate panels, stiffened panels and primary supporting members are to be checked against buckling and ultimate strength using the stresses obtained from the finite element analyses by the criteria in 5C-1-5/5.3.1 and 5C-1-5/5.3.2 of the *ABS Rules for Building and Classing Steel Vessels*.

Plate buckling between stiffeners in the elastic range is considered acceptable provided that the plate satisfies the ultimate strength requirements.

Plate panels and stiffened panels are subjected to loads due to hull girder bending and shear and water pressure. Combined loads include bi-axial compression/tension, edge shear and compression/tension, in-plane loads and lateral pressure. The effects of combined load components are to be accounted for, and the interaction formulae for combined loads is to be applied. Proper modifications to the buckling and ultimate strength criteria are to be made, taking into account the differences in gross and net scantling.

The local stiffness and geometric proportions given in 5C-1-A2/11 of the *ABS Rules for Building and Classing Steel Vessels* to limit local buckling failures are to be observed in highly stressed areas. The *ABS Guide for Buckling and Ultimate Strength Assessment for Offshore Structures* may be used for reference.

PART 3

CHAPTER 2 Hull Structures and Arrangements

CONTENTS

SECTION 1	Primary Hull Strength.....	44
1	Longitudinal Hull Girder Strength – Monohulls	44
1.1	Section Modulus	44
1.3	Extension of Midship Section Modulus	48
1.5	Moment of Inertia.....	48
1.7	Section Modulus and Moment of Inertia Calculation.....	49
1.9	Hull Girder Shear Strength Calculation – For Craft 24 m (79 ft) in Length and Over	50
1.11	Hull Girder Torsional Loads	52
3	Primary Hull Strength – Twin-Hulled Craft.....	52
3.1	Longitudinal Hull Girder Strength.....	52
3.3	Catamaran Transverse Loadings.....	52
3.5	Transverse Strength for Catamarans and Surface Effect Craft	53
3.7	Items included in Transverse Moment of Inertia and Section Modulus Calculation	53
3.9	Craft with More Than Two Hulls	54
3.11	Hull Girder Torsional Loads	54
5	Strength Considerations for Hydrofoil Borne Craft	54
5.1	Longitudinal Strength.....	54
5.3	Calculation of Loads from Hydrofoil Appendages	54
7	Effective Decks	55
9	Operating Manual	55
TABLE 1	Minimum Vertical Acceleration.....	47
TABLE 2	Factor, K	49
FIGURE 1	Sign Convention.....	46
FIGURE 2	Distribution Factor M	48
FIGURE 3	Distribution Factor F_1	50
FIGURE 4	Distribution Factor F_2	51
SECTION 2	Design Pressures	56
1	Monohulls.....	56
1.1	Bottom Design Pressure	56
1.3	Side and Transom Structure, Design Pressure	59
3	Multi-Hull and Surface Effect Craft	60
3.1	Bottom Design Pressure.....	60
3.3	Side and Transom Structure, Design Pressure	61
3.5	Wet Deck or Cross Structure	62

5	Deck Design Pressures – All Craft	62
7	Superstructures and Deckhouses – All Craft.....	63
9	Bulkhead Structure, Design Pressure – All Craft.....	64
9.1	Tank Boundaries	64
9.3	Watertight Boundaries	64
11	Military Mission Loads.....	64
11.1	Loads Imposed Against Own-Craft Weapons Firing Effects.....	65
11.3	Human Loads	66
11.5	Helicopter Decks	66
11.7	Masts.....	67
TABLE 1	Design Significant Wave Heights, $h_{1/3}$, and Speeds, V	58
TABLE 2	Minimum Values for F_D ($L \leq 24$ m, 79 ft).....	58
TABLE 3	Values of a	63
TABLE 4	Deck Design Pressures, p_d	67
TABLE 5	Superstructures and Deckhouses Design Pressures	68
FIGURE 1	Deadrise, Flare, and Entry Angles	59
FIGURE 2		65
FIGURE 3		66
FIGURE 4	Decks, Superstructures, and Deckhouse Pressures	69
FIGURE 5	Decks, Superstructures, and Deckhouse Pressures	69
FIGURE 6	Design Area Factor F_D	70
FIGURE 7	Vertical Acceleration Distribution Factor K_V	70
FIGURE 8	Vertical Acceleration Distribution Factor F_V	71
FIGURE 9	Wet Deck Pressure Distribution Factor F_I	71

SECTION 3	Plating	72
1	Aluminum or Steel.....	72
1.1	General.....	72
1.3	Thickness	72
1.5	Buckling Criteria	75
1.7	Water Jet Tunnels and Transverse Thruster Tubes	78
1.9	Decks Provided for the Operation or Stowage of Vehicles.....	78
3	Aluminum Extruded Planking, Aluminum Sandwich Panels and Corrugated Panels.....	79
3.1	Aluminum Extruded Planking	79
3.3	Aluminum Sandwich Panels	80
3.5	Corrugated Panels	81
5	Fiber Reinforced Plastic.....	81
5.1	General.....	81
5.3	Fiber Reinforcement.....	82
5.5	Single Skin Laminate.....	82
5.7	Sandwich Laminate	84
7	Plating Subject to Military Mission Loads	88

TABLE 1	Aspect Ratio Coefficient for Isotropic Plates.....	73
TABLE 2	Design Stress, σ_a , Aluminum and Steel.....	73
TABLE 3	Buckling Coefficients m_1 and m_2	77
TABLE 4	Design Stresses for FRP, σ_a	83
TABLE 5	Aspect Ratio Coefficient for Isotropic Plates.....	84
TABLE 6	Coefficient ν for FRP Sandwich Panels Shear Strength.....	87
TABLE 7	Core Shear Design Strength.....	87
TABLE 8		89
FIGURE 1	Values for β	79
FIGURE 2	Extruded Planking.....	80

SECTION 4 Internals 90

1	Aluminum and Steel.....	90
1.1	General.....	90
1.3	Strength and Stiffness	90
1.5	Elastic Buckling of Longitudinal Members	92
1.7	Corrugated Panels.....	96
1.9	Web Thickness	97
1.11	Attachments.....	97
1.13	Direct Analysis Methods	98
1.15	Decks Exposed to Vehicle Loads	98
3	Fiber Reinforced Plastic.....	98
3.1	General.....	98
3.3	Fiber Reinforcement	98
3.5	Strength and Stiffness	98
3.7	Proportions	99
3.9	Buckling	99
5	Stanchions	100
5.1	General.....	100
5.3	Stanchion Analysis	100
5.5	Stanchion Load.....	100
5.7	Permissible Load	100
5.9	FRP Stanchions.....	101
5.11	Support by Bulkheads.....	101
7	Internals Subject to Military Mission Loads.....	101

TABLE 1	Design Stress, σ_a	91
TABLE 2	Maximum Stresses.....	101
FIGURE 1	Transverse Side Frame	91
FIGURE 2	Transverse Side Frame	91
FIGURE 3	Corrugated Bulkhead	96
FIGURE 4	Corrugated Bulkhead End Connections.....	96