



RULES FOR BUILDING AND CLASSING

STEEL VESSELS 2018

PART 3 HULL CONSTRUCTION AND EQUIPMENT

**American Bureau of Shipping
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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:

(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

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
3-2-14/17.1	Strength	To reflect current practice for cover plates and address vortex shedding for spade rudders with embedded trunks. (Incorporates Notice No. 1)
3-2-14/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)
3-2-14/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)
3-2-14/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)
3-2-14/17.1.2	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)
3-5-1/1	General	To inform owners, operators, and designers of the optional DWA notation. (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
3-1-1/3.1	Scantling Length (L)	To align the requirements with ICLL 1966/Reg. 3 & IACS UR S2.
3-1-1/3.3	Freeboard Length (L_f)	To align the requirements with ICLL 1966/Reg. 3 & IACS UR S2.
3-1-1/13.1	Freeboard Deck	To align the requirements with ICLL 1966/Reg. 3 & IACS UR S2.
3-1-1/15	Deadweight (DWT) and Lightship Weight	To incorporate interpretation made in IACS UI SC273 and MPC128.
3-1-2/Table 2	Material Class or Grade of Structural Members	To identify the minimum steel grades for deck plating other than strength deck (Line No. C4) at corners of cargo hatch openings adjacent to the engine room and/or deck house.
3-2-4/9.11	Inner Bottom Plating for Vessels Intended to Use Grabs	To align the requirements with IACS UI SC208 Corr.2 and SVR 5C-3-4/7.3.2 (a) & (b).
3-2-4/9.12 (New)	Optional Supplementary Requirement for Vessels Intended to Use Grabs	To align the requirements with IACS UI SC208 Corr.2 and SVR 5C-3-4/7.3.2 (a) & (b).
3-2-11/11.3.7 (New)	Bolted Connections	To specify requirements for bolted connections on helidecks.

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
3-2-11/11.7	Material	To clarify the requirements for aluminum helideck escape stairs and intermediate platforms.
3-2-11/11.9	Means of Escape and Access	To clarify the requirements for aluminum helideck escape stairs and intermediate platforms.
3-2-13/1.1	Plate Stems	To consider the material factor in the net thickness of the plate stem, in line with CSR-H.
3-2-14/7.3	Lower Rudder Stocks	To make the stress units consistent with the allowable stress.
3-2-14/Figure 4	Tapered Couplings	To be consistent with the requirements of 3-2-14/11.7.
3-2-14/17.5	Diaphragm Plates	To allow larger openings on diaphragm plates when the effects of openings are considered in the strength assessment.
3-2-17/7.5.1	General	To align the requirements with ICLL Reg 23(4)
3-2-17/8 (New)	Windows	To provide requirements for windows.
3-3-1/9	Onboard Computers for Stability Calculations	To incorporate IMO adopted amendments to MARPOL ANNEX I in MEPC 248(66).
3-3-A3 (Title)	Computer Software for Onboard Stability Calculations	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/5	Types of Stability Software	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/7.1	Calculation Program	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/7.5	Warning	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/7.15 (New)	Computer Model	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/7.17 (New)	Further Requirements for Type 4 Stability Software	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/Table 1	Acceptable Tolerances	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/11.1	Conditions of Approval of the Onboard Software for Stability Calculations	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/11.5	Specific Approval	To align the Rules with IACS UR L5, Revision 3.
3-3-A3/15	Installation Testing	To align the Rules with IACS UR L5, Revision 3.
3-4-A1/1.1	<No Title>	To align the requirements with ASTM F3059-15, in line with IACS, IMO, and USCG policy.
3-4-A1/5	Fire Test Requirements	To align the requirements with ASTM F3059-15, in line with IACS, IMO, and USCG policy.
3-4-A1/7	Structural Fire Integrity Test Procedures	To align the requirements with ASTM F3059-15, in line with IACS, IMO, and USCG policy.
3-4-A1/Table 1	Structural Fire Integrity Matrix	To align the requirements with ASTM F3059-15, in line with IACS, IMO, and USCG policy.
3-5-1/17.1	Scope	To clarify the applicable ships, in line with IMO MSC Resolution 35 (63).
3-7-1	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

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PART 3

CHAPTER 1 General

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PART

3

CHAPTER 1 General

SECTION 1 Definitions

1 Application

The following definitions of symbols and terms are to be understood (in the absence of other specifications) where they appear in the Rules.

3 Length

3.1 Scantling Length (L) (2018)

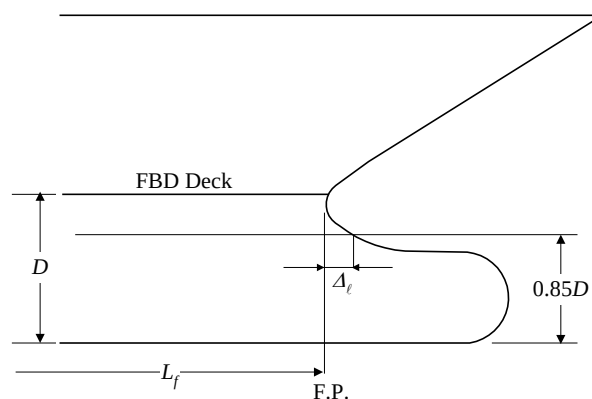
L is the distance in meters (feet) on the summer load line from the fore side of the stem to the centerline of the rudder stock. For use with the Rules, L is not to be less than 96% and need not be greater than 97% of the **extreme** length on the summer load line. The forward end of L is to coincide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

3.3 Freeboard Length (L_f) (2018)

L_f is the distance in meters (feet) on a waterline at 85% of the least molded depth measured from the top of the keel from the fore side of the stem to the centerline of the rudder stock or 96% of the length on that waterline, whichever is greater. Where the stem is a fair concave curve above the waterline at 85% of the least molded depth and where the aftermost point of the stem is above the waterline, the forward end of the length, L_f , is to be taken at the aftermost point of the stem above that waterline. See 3-1-1/Figure 1.

In ships designed with a raked keel, the waterline on which this length is measured is to be parallel to the designed waterline.

FIGURE 1



5 Breadth (B)

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

7 Depth

7.1 Molded Depth (D) (1997)

D is the molded depth at side in meters (feet) measured at the middle of L from the molded base line to the top of the freeboard-deck beams. In vessels having rounded gunwales, D is to be measured to the point of intersection of the molded lines of the deck and side shell plating. 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.

7.3 Scantling Depth (D_s) (1997)

The depth D_s for use with scantling requirements is the distance in meters (feet) from the molded base line to the strength deck as defined in 3-1-1/13.5.

9 Draft (d)

d is the molded draft, and is the distance in meters (feet) from the molded base line to the summer load line.

11 Molded Displacement and Block Coefficient (1997)

11.1 Molded Displacement (Δ)

Δ is the molded displacement of the vessel in metric tons (long tons), excluding appendages, taken at the summer load line.

11.3 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

Δ = molded displacement, as defined in 3-1-1/11.1.

L = scantling length, as defined in 3-1-1/3.1

d = draft, as defined in 3-1-1/9

B_{wl} = the greatest molded breadth at summer load line

13 Decks

13.1 Freeboard Deck (2018)

The freeboard deck is normally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all openings in the weather part thereof, and below which all openings in the sides of the ship are fitted with permanent means of watertight closing. Where a vessel is designed for a special draft, considerably less than that corresponding to the least freeboard obtainable under the International Load Line Regulations, the freeboard deck, for the purpose of the Rules, may be taken as the actual lowest deck from which the draft can be obtained under those regulations.

13.3 Bulkhead Deck

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

13.5 Strength Deck

The strength deck is the deck that forms the top of the effective hull girder at any part of its length. See 3-2-1/11.1.

13.7 Superstructure Deck

A superstructure deck is a deck above the freeboard deck to which the side shell plating extends. Except where otherwise specified, the term “superstructure deck” where used in the Rules refers to the first such deck above the freeboard deck.

15 Deadweight (DWT) and Lightship Weight (2018)

For the purpose of these Rules, deadweight, *DWT*, is the difference in metric tons (long tons) between the displacement of the vessel at its summer load line in water having a specific gravity of 1.025 and the lightship weight. For the purpose of these Rules, lightship weight is the displacement of the vessel 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 passengers or crew nor their effects. **The weight of mediums on board for the fixed fire-fighting systems (e.g., freshwater, CO₂, dry chemical powder, foam concentrate, etc.) are to be included in the lightweight and lightship condition.**

17 Units

These Rules are written in three systems of units, viz., 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 the 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 Material and Fabrication

1.1 Material

1.1.1 Steel

These Rules are intended for vessels of welded construction using steels complying with the requirements of Part 2, Chapter 1. Use of steels other than those in Part 2, Chapter 1 and the vessels' corresponding scantlings will be specially considered.

1.1.2 Aluminum Alloys

The use of aluminum alloys in hull structures will be considered upon submission of a specification of the proposed alloys and their proposed method of fabrication.

1.1.3 Design Consideration

Where scantlings are reduced in association with the use of higher-strength steel or where aluminum alloys are used, adequate buckling strength is to be provided. Where it is intended to use material of cold flanging quality for important longitudinal strength members, this steel is to be indicated on the plans.

1.1.4 Guidance for Repair

Where a special welding procedure is required for special steels used in the construction, including any low temperature steel and those materials not encompassed in Part 2, Chapter 1, a set of plans showing the following information for each steel is to be placed aboard the vessel:

- Material Specification
- Welding procedure
- Location and extent of application

These plans are in addition to those normally placed aboard the vessel, and are to show all material applications.

1.3 Application

The requirements of the Rules apply to steel vessels of all welded construction. Riveted hull construction, where used, is to comply with the applicable parts dealing with riveting in the 1969 edition of the Rules.

3 Application of Steel Materials 100 mm (4.0 in.) and Under in Thickness (2014)

3.1 Selection of Material Grade

Steel materials for particular locations are not to be of lower grades than those required by 3-1-2/Table 1 for the material class given in 3-1-2/Table 2.

3.3 Note for Users

The attention of users is drawn to the fact that when fatigue loading is present, the effective strength of higher-strength steel in welded construction may not be greater than that of ordinary-strength steel.

Precautions against corrosion fatigue may also be necessary.

TABLE 1
Material Grades (2017)

Plate Thickness <i>t</i> mm (in.)	Material Class		
	I	II	III
$t \leq 15$ ($t \leq 0.60$)	A ⁽²⁾ , AH	A, AH	A, AH
$15 < t \leq 20$ ($0.60 < t \leq 0.79$)	A, AH	A, AH	B, AH
$20 < t \leq 25$ ($0.79 < t \leq 0.98$)	A, AH	B, AH	D, DH
$25 < t \leq 30$ ($0.98 < t \leq 1.18$)	A, AH	D, DH	D ⁽¹⁾ , DH
$30 < t \leq 35$ ($1.18 < t \leq 1.38$)	B, AH	D, DH	E, EH
$35 < t \leq 40$ ($1.38 < t \leq 1.57$)	B, AH	D, DH	E, EH
$40 < t \leq 100$ ($1.57 < t \leq 4.00$)	D, DH	E, EH	E, EH

Notes

- Grade D, of these plate thicknesses, is to be normalized.
- (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 up to and including 19 mm (0.75 in.) for sections.

TABLE 2
Material Class or Grade of Structural Members (2018)

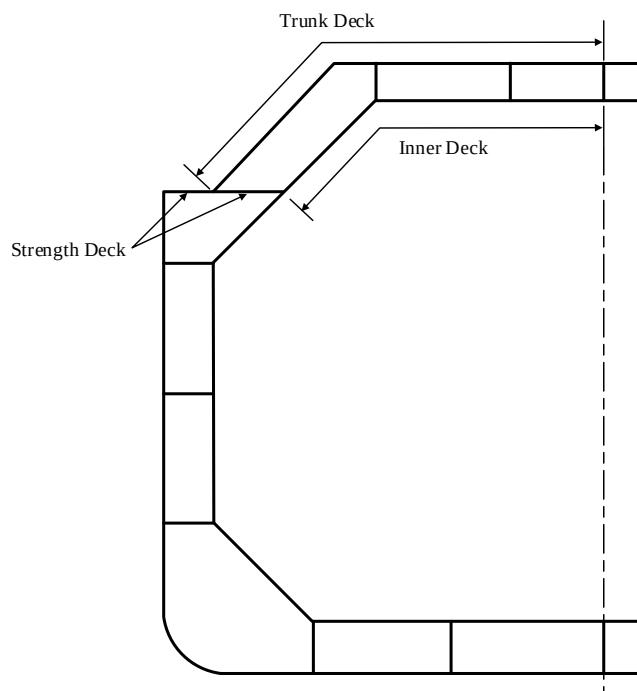
Line No.	Structural Members	Within 0.4L Amidships	Outside 0.4L amidships
		Material Class ⁽⁸⁾ or Grade	Material Class or Grade
A	Secondary		
A1	Longitudinal bulkhead strakes, other than those belonging to the Primary category	I	A ⁽¹⁰⁾ /AH
A2	Deck plating exposed to weather, other than that belonging to the Primary or Special category		
A3	Side plating ⁽¹²⁾		
B	Primary		
B1	Bottom plating, including keel plate	II	A ⁽¹⁰⁾ /AH
B2	Strength deck plating, excluding that belonging to the Special category ⁽¹³⁾		
B3	(1 July 2015) Continuous longitudinal plating of strength members above strength deck, excluding hatch coamings ^(13, 14)		
B4	Uppermost strake in longitudinal bulkhead		
B5	Vertical strake (hatch side girder) and uppermost sloped strake in top wing tank		
C	Special		
C1	Sheer strake at strength deck ^(1, 9, 13)	III	II (I outside 0.6L amidships)
C2	Stringer plate in strength deck ^(1, 9, 13)		
C3	Deck strake at longitudinal bulkhead ^(2, 9, 13)		
C4	Strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch opening configurations ^(3, 13)		
C5	Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers, combination carriers and other ships with similar hatch opening configurations ^(4, 13)		
C6	(1 July 2015) Trunk deck and inner deck plating at corners of openings for liquid and gas domes in membrane type liquefied gas carriers ^(4, 13)		
C7	Bilge strake ^(5, 6, 9)		
C8	(1 July 2015) Longitudinal hatch coamings of length greater than 0.15L including coaming top plate and flange ⁽⁷⁾		
C9	End brackets and deck house transition of longitudinal cargo hatch coamings ⁽⁷⁾		
D	Other Categories		
D1	(1 July 2015) Plating materials for stern frames supporting rudder and propeller boss, rudders, rudder horns, steering equipment ⁽¹⁵⁾ , propeller nozzles, and shaft brackets	-	II ⁽¹¹⁾
D2	Strength members not referred to in A to C and D1 ⁽¹⁷⁾	A ⁽¹⁰⁾ /AH	A ⁽¹⁰⁾ /AH
D3	(2017) Equipment foundations, Non-hull structure, Appurtenant structures	⁽¹⁶⁾	⁽¹⁶⁾

TABLE 2 (continued)
Material Class or Grade of Structural Members (2018)

Notes:

- 1 Not to be less than grade E/EH⁽⁹⁾ within 0.4L amidships in ships with length exceeding 250 m (820 ft).
- 2 Excluding deck plating in way of inner-skin bulkhead of double hull ships.
- 3 Not to be less than class III within the length of the cargo region.
- 4 Not to be less than class III within 0.6L amidships and class II within the remaining length of the cargo region.
- 5 May be of class II in ships with a double bottom over the full breadth and with length less than 150 m (492 ft).
- 6 Not to be less than grade D/DH within 0.4L amidships in ships with length exceeding 250 m (820 ft).
- 7 Not to be less than grade D/DH.
- 8 Special consideration will be given to vessels of restricted class.
- 9 Single strake required to be class III or E/EH are to have breadths not less than 800 + 5L mm (31.5 + 0.06L in.), but need not exceed 1800 mm (71 in.), unless limited by the geometry of the vessel's design.
- 10 (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 plates and up to and including 19 mm (0.75 in.) for sections.
- 11 For rudder and rudder body plates subjected to stress concentrations (e.g., in way of lower support or at upper part of spade rudders), class III is to be applied.
- 12 (1 July 2009) Single side strakes for ships exceeding 150 m (492 feet) without inner continuous longitudinal bulkheads between bottom and the single strength deck are not to be less than grade B/AH within cargo region in ships.
- 13 (1 July 2015) Not to be less than grade B/AH for members contributing to the longitudinal strength within 0.4L amidships in ships with length exceeding 150 m (492 feet) and single strength deck.
- 14 (1 July 2015) Not to be less than grade B/AH for inner deck plating and plating between the trunk deck and inner deck for members contributing to the longitudinal strength within 0.4L amidships in membrane type liquefied gas carriers and other similar ship types with a double deck arrangement above the strength deck and with length exceeding 150 m (492 feet). See 3-1-2/Figure 1.
- 15 (1 July 2015) Steering equipment components other than rudders, as described in Section 3-2-14.
- 16 (2017) ASTM A36 steel otherwise 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 plates and up to and including 19 mm (0.75 in.) for sections.
- 17 (2018) Deck plating below the strength deck at corners of cargo hatch openings immediately forward and aft of the engine room and/or deck house in container carriers and other ships with similar hatch opening configurations, is not to be less than Class I.

FIGURE 1
Typical Deck Arrangement for Membrane Type Liquefied Gas Carriers (1 July 2015)



3.5 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 3-1-2/3.7.

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 3-1-2/3.1.

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.

Single strakes 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 3-1-2/3.1.

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⁾		
Special	III	II
Sheer strake at strength deck ⁽²⁾		
Stringer plate in strength deck ⁽²⁾		
Deck strake at longitudinal bulkhead ⁽³⁾		
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 ships with length exceeding 250 meters (820 feet).
- In ships 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.).

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	-, -	-, -

3.7 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

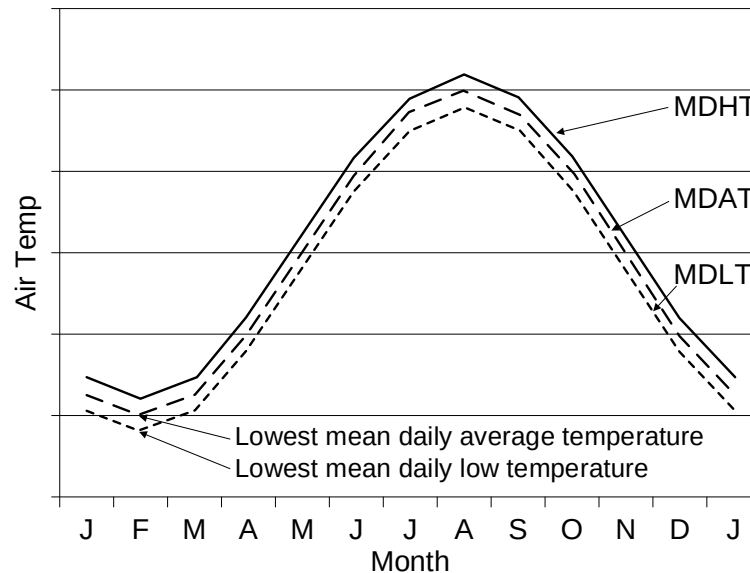
For seasonally restricted service the lowest value within the period of operation applies.

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 ship.

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 2 illustrates the temperature definition.

FIGURE 2
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

5 Scantlings (2013)

5.1 General

The midship scantlings specified in the Rules are to apply throughout the midship $0.4L$. End scantlings are not to extend for more than $0.1L$ from each end of the vessel. Reduction in scantlings from the midship to the end scantlings is to be effected in as gradual a manner as practicable. Sections having appropriate section moduli or areas, in accordance with their functions in the structure as stiffeners, columns or combinations of both, are to be adopted, due regard being given to the thickness of all parts of the sections to provide a proper margin for corrosion. It may be required that calculations be submitted in support of resistance to buckling for any part of the vessel's structure.

5.3 Dynamic Loading Approach

The symbols **SH-DLA** are assigned to vessels which have been reviewed based upon an acceptable load and structural analysis procedure, taking into consideration the dynamic load components acting on the vessel.

The dynamic load components considered are to include the external hydrodynamic pressure loads, dynamic loads from cargoes and inertial loads of the hull structure. The magnitude of the load components and their combinations are to be determined from appropriate ship motion response calculations for loading conditions which represent the envelope of maximum dynamically induced stresses in the vessel.

The adequacy of the hull structure for all combinations of the dynamic loadings is to be evaluated using an acceptable finite element analysis method.

In no case are the structural scantlings to be less than those obtained from other requirements in the Rules.

7 Proportions

In general, these Rules are valid for all vessels not exceeding 500 m (1640 ft) in length, L , and having a breadth, B , not exceeding one-fifth of the length, L , nor 2.5 times the depth, D_s , to the strength deck. Vessels beyond these proportions will be specially considered.

9 Workmanship (2008)

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. See also 3-7-3/1.

11 Drydocking

Consideration is to be given to drydocking the vessel within twelve months after delivery. For vessels 228.5 m (750 ft) in length, L , and over, information indicating docking arrangements is to be prepared and furnished onboard the vessel for guidance.

13 Structural Sections (1993)

13.1 General

The scantling requirements of these Rules are applicable to structural angles, channels, bars, and rolled or built-up sections.

13.3 Deep Supporting Members (1993)

The required section modulus of members such as girders, webs, etc., supporting frames, beams and stiffeners, is to be obtained on an effective width of plating basis in accordance with this subsection. The section is to include the structural member in association with an effective width of plating not exceeding one-half of the sum of the spacing on each side of the member or 33% of the unsupported span ℓ , whichever is less. For girders and webs along hatch openings, an effective breadth of plating not exceeding one-half of the spacing or 16.5% of the unsupported span ℓ , whichever is less, is to be used.

13.5 Frames, Beams and Stiffeners (1993)

13.5.1 Section Modulus

The required section modulus is to be provided by the stiffener and a maximum of one frame space of the plating to which it is attached.

13.5.2 Web Thickness

The depth to thickness ratio of the web portion of members is not to exceed the following:

Members with flange $50C_1C_2$

Members without flange $15C_1C_2$

where

$C_1 = 0.95$ (horizontal web within a tank)

$= 1.0$ (all other cases)

$C_2 = 1.0$ (ordinary strength steel)

$= 0.92$ (HT32)

$= 0.90$ (HT36)

15 Structural Design Details

15.1 General

The designer is to give consideration to the following:

- i) The thickness of internals in locations susceptible to rapid corrosion.
- ii) The proportions of built-up members for compliance with established standards for structural stability. See 3-1-2/13.5.2 and Appendix 3-2-A4.
- iii) The design of structural details, such as noted below, against the harmful effects of stress concentrations and notches:
 - Details of the ends, at the intersections of members and associated brackets.
 - Shape and location of air, drainage, and/or lightening holes.
 - Shape and reinforcement of slots or cut-outs for internals.
 - Elimination or closing of weld scallops in way of butts, “softening” of bracket toes, reducing abrupt changes of section or structural discontinuities.
- iv) Proportions and thickness of structural members to reduce fatigue response due to engine, propeller or wave-induced cyclic stresses, particularly for higher-strength steels.

A booklet of standard construction details based on the above considerations is to be submitted for review and comment.

15.3 Termination of Structural Members (1998)

Unless permitted elsewhere in the Rules, structural members are to be effectively connected to adjacent structures in such a manner as to avoid hard spots, notches and other harmful stress concentrations.

Where load-bearing members are not required to be attached at their ends, special attention is to be given to the end taper, by using a sniped end of not more than 30°.

Where the member has a face bar or flange, it is to be sniped and tapered not more than 30°.

The end brackets of large primary load-bearing members are to be soft-toed. Where any end bracket has a face bar it is to be sniped and tapered not more than 30°.

Bracket toes and sniped end members are to be kept within 25 mm (1.0 in.) of the adjacent member, unless the bracket or member is supported by another member on the opposite side of the plating. The depth of toe or sniped end is generally not to exceed 15 mm (0.60 in.).

Where a strength deck or shell longitudinal terminates without an end attachment, the longitudinal is to extend into the adjacent transversely framed structure, or stop at a local transverse member fitted at about one transverse frame space (see 3-2-5/1.5) beyond the last floor or web that supports the longitudinal.

The end attachments of non-load bearing members may, in general, be snipe ended. The sniped end is to be not more than 30° and is to be kept generally within 40 mm (1.57 in.) of the adjacent member unless it is supported by a member on the opposite side of the plating. The depth of the toe is generally not to exceed 15 mm (0.6 in.).

15.5 Fabrication (1 July 2011)

Structural fabrication is to be carried out in accordance with a recognized standard to the satisfaction of the attending Surveyor. If a recognized national standard or an appropriate shipbuilding and repair standard is not available, the latest version of IACS Recommendation No. 47 “Shipbuilding and Repair Quality Standard”, may be used. See Part 5C, Appendix 1 “SafeHull Construction Monitoring Program”.

PART 3

CHAPTER 2 Hull Structures and Arrangements

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PART

3

CHAPTER 2 Hull Structures and Arrangements

SECTION 1 Longitudinal Strength

1 Application

Vessels to be classed for unrestricted service, are to have longitudinal strength in accordance with the requirements of this section. Vessels, however, having one or more of the following characteristics will be subject to special consideration:

- i) Proportions: $L/B < 5, B/D > 2.5$
- ii) Length: $L > 500 \text{ m (1640 ft)}$
- iii) Block Coefficient: $C_b < 0.6$
- iv) Large deck opening
- v) Vessels with large flare
- vi) Carriage of heated cargoes
- vii) Unusual type or design

3 Longitudinal Hull Girder Strength

3.1 Sign Convention of Bending Moment and Shear Force

The sign convention for bending moment and shear force is shown in 3-2-1/Figure 1.

3.3 Still-water Bending Moment and Shear Force (1 July 2006)

3.3.1 General (1 July 2006)

Still-water bending moment and shear force calculations, determining the bending moment and hull girder shear force values along the vessel's entire length, are to be submitted together with the distribution of lightship weights.

For bulk carriers with notation **BC-A**, **BC-B** or **BC-C** and length as defined in 3-1-1/3.1 of 150 m (492 ft) or more, see also 5C-3-A6/5, 5C-3-3/3.1 and Appendix 5C-3-A5a for hold flooded conditions.

3.3.2 Design Cargo and Ballast Loading Conditions (1 July 2003)

The calculations are to consider the effect of bunker, fresh water and consumable stores at departure and arrival. Where their amount and disposition at any stage of the voyage are considered more severe, calculations for such intermediate conditions are to be submitted in addition to those for departure and arrival conditions.

Also, where any ballasting/deballasting is intended during a voyage, calculations for the intermediate condition just before and just after ballasting and/or deballasting any ballast tanks are to be submitted and, where approved, included in the loading manual for guidance.

3.3.3 Ballast Tanks in Ballast Loaded Conditions (1 July 2006)

Ballast loading conditions involving partially filled ballast tanks (peak tanks and/or other ballast tanks) are not permitted as design conditions unless:

- i) Design stress limits are satisfied for all filling levels between empty and full, and
- ii) For bulk carriers, the requirements in Appendix 5C-3-A5a, as applicable, are complied with for all filling levels between empty and full.

For the purpose of compliance with the “all filling levels” requirement, calculations for full and empty conditions at each departure and arrival, and where required by 3-2-1/3.3.2, at any intermediate condition, may be accepted. The tanks intended to be partially filled are assumed to be:

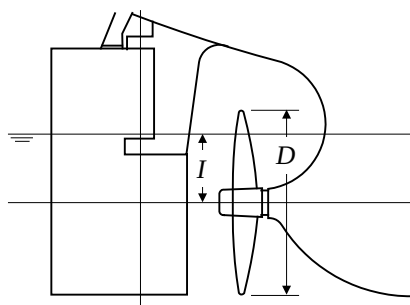
- Empty
- Full
- Partially filled at intended level

Where multiple tanks are intended to be partially filled, all combinations of empty, full or partially filled at intended level for those tanks are to be investigated.

However, for conventional ore carriers with large wing water ballast tanks in cargo area, where empty or full ballast water filling levels of one or maximum two pairs of these tanks lead to the vessel’s trim exceeding one of the following conditions, it is sufficient to demonstrate compliance with maximum, minimum and intended partial filling levels of these one or maximum two pairs of ballast tanks such that the ship’s condition does not exceed any of these trim limits. Filling levels of all other wing ballast tanks are to be considered between empty and full. The trim conditions mentioned above are:

- Trim by stern of 3% of the vessel’s length, or
- Trim by bow of 1.5% of the vessel’s length, or
- Any trim that cannot maintain propeller immersion (I/D) not less than 25%, where:

I = distance from propeller centerline to the waterline
 D = propeller diameter



The maximum and minimum filling levels of the above mentioned pairs of side ballast tanks are to be indicated in the loading manual.

3.3.4 Ballast Tanks in Cargo Loaded Conditions (1 July 2003)

Cargo loading conditions involving partially filled peak tanks are not permitted as design conditions unless the conditions indicated in 3-2-1/3.3.3 for partially filled tanks are complied with.

3.3.5 Sequential Ballast Water Exchange (1 July 2011)

The requirements of 3-2-1/3.3.3 and 3-2-1/3.3.4 are not applicable to ballast water exchange using the sequential method. However, bending moment and shear force calculations for each de-ballasting or ballasting stage in the ballast water exchange sequence are to be included in the loading manual or ballast water management plan of any vessel that intends to employ the sequential ballast water exchange method.

3.5 Wave Loads

3.5.1 Wave Bending Moment Amidships

The wave bending moment, expressed in kN-m (tf-m, Ltf-ft), may be obtained from the following equations:

$$M_{ws} = -k_1 C_1 L^2 B (C_b + 0.7) \times 10^{-3} \quad \text{Sagging Moment}$$

$$M_{wh} = +k_2 C_1 L^2 B C_b \times 10^{-3} \quad \text{Hogging Moment}$$

where

$$k_1 = 110 \text{ (11.22, 1.026)}$$

$$k_2 = 190 \text{ (19.37, 1.772)}$$

$$C_1 = 10.75 - \left(\frac{300 - L}{100} \right)^{1.5} \quad 90 \leq L \leq 300 \text{ m}$$

$$= 10.75 \quad 300 < L < 350 \text{ m}$$

$$= 10.75 - \left(\frac{L - 350}{150} \right)^{1.5} \quad 350 \leq L \leq 500 \text{ m}$$

$$C_1 = 10.75 - \left(\frac{984 - L}{328} \right)^{1.5} \quad 295 \leq L \leq 984 \text{ ft}$$

$$= 10.75 \quad 984 < L < 1148 \text{ ft}$$

$$= 10.75 - \left(\frac{L - 1148}{492} \right)^{1.5} \quad 1148 \leq L \leq 1640 \text{ ft}$$

$$L = \text{length of vessel, as defined in 3-1-1/3.1, in m (ft)}$$

$$B = \text{breadth of vessel, as defined in 3-1-1/5, in m (ft)}$$

$$C_b = \text{block coefficient, as defined in 3-1-1/11.3, but is not to be taken less than 0.6}$$

3.5.2 Envelope Curve of Wave Bending Moment

The wave bending moment along the length, L , of the vessel may be obtained by multiplying the midship value by the distribution factor M , given by 3-2-1/Figure 2.

3.5.3 Wave Shear Force

The envelopes of maximum shearing forces induced by waves, F_w , as shown in 3-2-1/Figure 3 and 3-2-1/Figure 4, may be obtained from the following equations.

$$F_{wp} = +k F_1 C_1 L B (C_b + 0.7) \times 10^{-2} \quad \text{For positive shear force}$$

$$F_{wn} = -k F_2 C_1 L B (C_b + 0.7) \times 10^{-2} \quad \text{For negative shear force}$$

where

$$F_{wp}, F_{wn} = \text{maximum shearing force induced by wave, in kN (tf, Ltf)}$$

$$C_1 = \text{as defined in 3-2-1/3.5.1}$$

$$L = \text{length of vessel, as defined in 3-1-1/3.1, in m (ft)}$$

$$B = \text{breadth of vessel, as defined in 3-1-1/5, in m (ft)}$$

$$C_b = \text{block coefficient, as defined in 3-1-1/11.3, but not to be taken less than 0.6}$$

$$k = 30 \text{ (3.059, 0.2797)}$$

$$F_1 = \text{distribution factor, as shown in 3-2-1/Figure 3}$$

$$F_2 = \text{distribution factor, as shown in 3-2-1/Figure 4}$$

FIGURE 1
Sign Convention

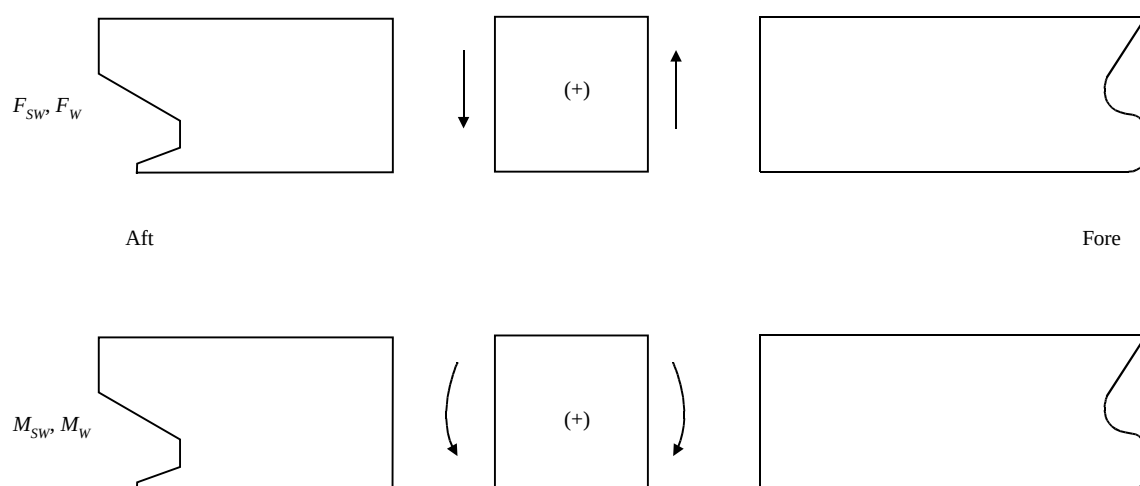


FIGURE 2
Distribution Factor M

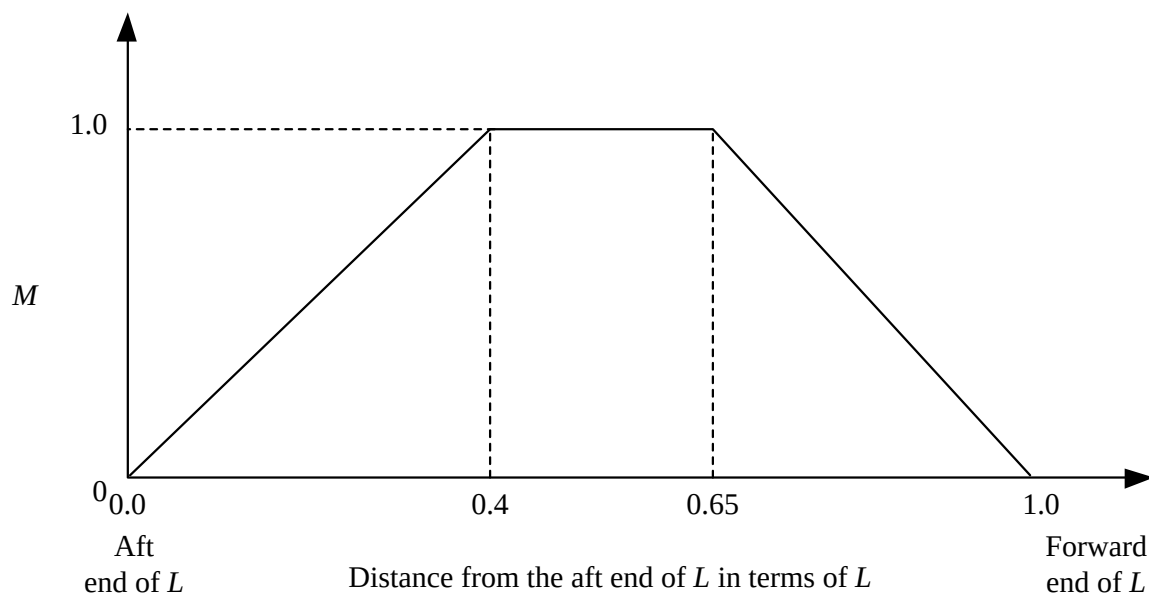


FIGURE 3
Distribution Factor F_1

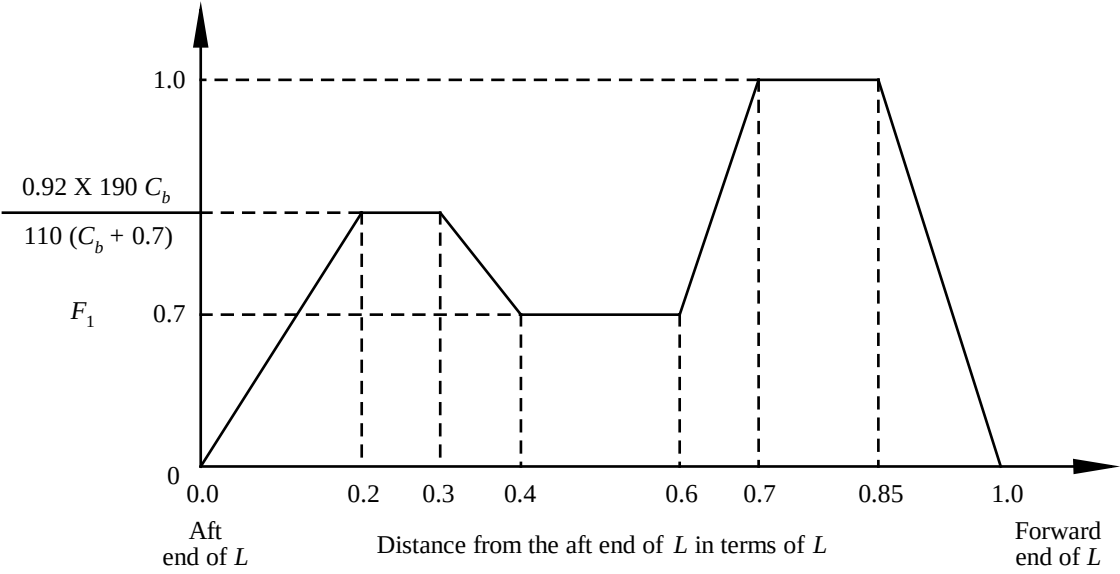
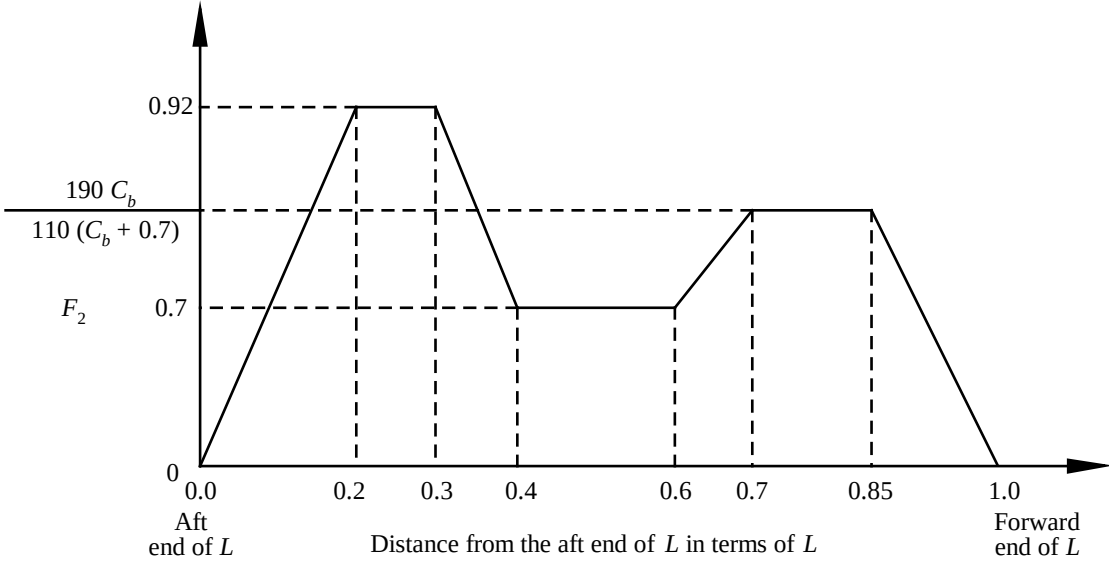


FIGURE 4
Distribution Factor F_2



3.7 Bending Strength Standard

3.7.1 Hull Girder Section Modulus

3.7.1(a) *Section Modulus.* The required hull girder section modulus for 0.4L amidships is to be the greater of the values obtained from the following equation or 3-2-1/3.7.1(b):

$$SM = M_t / f_p \quad \text{cm}^2\text{-m (in}^2\text{-ft)}$$

where

M_t = total bending moment, as obtained below

f_p = nominal permissible bending stress

= 17.5 kN/cm² (1.784 tf/cm², 11.33 Ltf/in²)

The total bending moment, M_t , is to be considered as the maximum algebraic sum (see sign convention in 3-2-1/3.1) of still-water bending moment and wave-induced bending moment, as follows:

$$M_t = M_{sw} + M_w$$

where

M_{sw} = still-water bending moment in accordance with 3-2-1/3.3, in kN-m (tf-m, Ltf-ft).

M_w = maximum wave-induced bending moment in accordance with 3-2-1/3.5.1

3.7.1(b) *Minimum Section Modulus.* The minimum hull girder section modulus amidships is not to be less than obtained from the following equation:

$$SM = C_1 C_2 L^2 B (C_b + 0.7) \quad \text{cm}^2\text{-m (in}^2\text{-ft)}$$

where

C_1 = as defined in 3-2-1/3.5

C_2 = 0.01 (0.01, 1.44×10^{-4})

L = length of vessel, as defined in 3-1-1/3.1, in m (ft)

B = breadth of vessel, as defined in 3-1-1/5, in m (ft)

C_b = block coefficient, as defined in 3-1-1/11.3, but is not to be taken less than 0.6

3.7.1(c) *Extension of Midship Section Modulus.* In general, where the still-water bending moment envelope curve is not submitted or where 3-2-1/3.7.1(b) governs, scantlings of all continuous longitudinal members of the hull girder are to be maintained throughout 0.4L amidships and then may be gradually tapered beyond.

Where the scantlings are based on the still-water bending moment envelope curves, items included in the hull girder section modulus amidships are to be extended as necessary to meet the hull girder section modulus required at the location being considered.

3.7.2 Hull Girder Moment of Inertia

The hull girder moment of inertia, I , amidships, is to be not less than:

$$I = L \cdot SM / 33.3 \quad \text{cm}^2\text{-m}^2 \text{ (in}^2\text{-ft}^2)$$

where

L = length of vessel, as defined in 3-1-1/3.1, in m (ft)

SM = required hull girder section modulus, in cm²-m (in²-ft). See 3-2-1/3.7.1.

3.7.3 Hull Girder Strength Outside of 0.4L Amidships (1 July 2011)

The strength of the hull girder is to be checked at sections outside of 0.4L amidships. The required section modulus for the regions outside 0.4L amidships is to be obtained based on the total bending moment at the section considered and applying the permissible bending stress as given in 3-2-1/3.7.1(a). As a minimum hull girder bending strength checks are to be carried out at the following locations:

- In way of the forward end of the engine room.
- In way of the forward end of the foremost cargo hold.
- At any locations where there are significant changes in the hull cross-section.
- At any locations where there are changes in the framing system.

Continuity of structure is to be maintained throughout the length of the ship. Where significant changes in the structural arrangement occur adequate transitional structure is to be provided.

For ships with large deck openings, such as containerships, sections at or near to the aft and forward quarter length positions are to be checked. For such ships with cargo holds aft of the superstructure, deckhouse or engine room, strength checks of sections in way of the aft end of the aft-most holds, and the aft end of the deckhouse or engine room are to be performed.

Buckling strength of members contributing to longitudinal strength and subjected to compressive and shear stresses is to be checked in accordance with 3-2-1/19, in particular in regions where changes in the framing system or significant changes in the hull cross-section occur.

3.9 Shearing Strength

3.9.1 General

In calculating the nominal total shear stress, f_s , due to still-water and wave-induced loads, the maximum algebraic sum of the shearing force in still-water F_{sw} and that induced by wave F_w at the station examined is to be used. The thickness of the side shell, and where fitted, the longitudinal bulkhead, is to be such that the nominal total shear stress f_s , as obtained from 3-2-1/3.9.2 or 3-2-1/3.9.4, are not greater than 11.0 kN/cm² (1.122 tf/cm², 7.122 Ltf/in²).

3.9.2 Shearing Strength for Vessels without Effective Longitudinal Bulkheads

For vessels without continuous longitudinal bulkheads, the nominal total shear stress f_s in the side shell plating may be obtained from the following equation:

$$f_s = (F_{sw} + F_w) m / 2t_s I$$

where

- | | | |
|----------|---|---|
| I | = | moment of inertia of the hull girder at the section under consideration, in cm ⁴ (in ⁴) |
| m | = | first moment, in cm ³ (in ³), about the neutral axis, of the area of the effective longitudinal material between the horizontal level at which the shear stress is being determined and the vertical extremity of effective longitudinal material, taken at the section under consideration. |
| t_s | = | thickness of the side shell plating at the position under consideration, in cm (in.) |
| F_{sw} | = | hull girder shearing force in still-water, in kN (tf, Ltf) |
| F_w | = | F_{wp} or F_{wn} , as specified by 3-2-1/3.5.3, in kN (tf, Ltf), depending upon loading |

3.9.3 Modification of Hull girder Shearing Force Peaks (1997)

The hull girder shearing force in still water, F_{sw} , to be used for calculating shear stresses in the side shell plating may be modified to account for the loads transmitted through the double bottom structure to the side shell through the transverse bulkhead. For this modification, unless a detailed calculation is performed, the following equation may be used as guidance to determine the shear force carried by the side shell at the transverse bulkhead (see 3-2-1/Figure 5), provided that the girders in the double bottom are arranged in accordance with 5C-3-4/7.1.1 or 5C-4-2/9.1, as appropriate.

$$F_s = F_{sw} - F_B \quad \text{kN (tf, Ltf)}$$

where

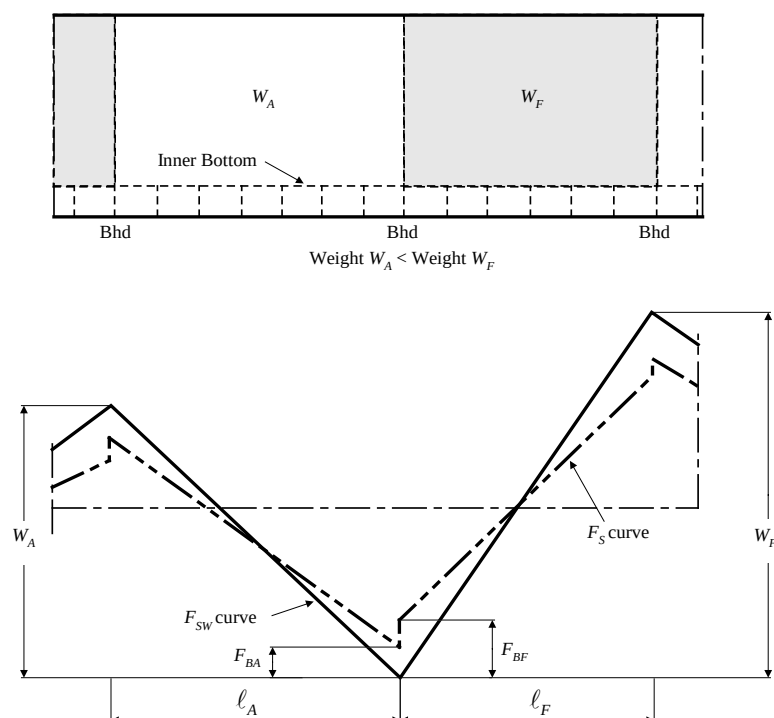
- F_{sw} = hull girder shearing force in still water as obtained by the conventional direct integration method, in kN (tf, Ltf).
- F_B = F_{BA} or F_{BF} , whichever is the lesser
- F_{BA} = $(0.45 - 0.2\ell_A/b_A)W_A b_A/B$
- F_{BF} = $(0.45 - 0.2\ell_F/b_F)W_F b_F/B$
- W_A, W_F = total load (net weight or net buoyancy) in the hold immediately abaft or forward of the bulkhead in question, in kN (tf, Ltf)
- ℓ_A, ℓ_F = length of the adjacent holds, respectively, containing W_A and W_F , in m (ft)
- b_A, b_F = breadth of the double bottom structure in the holds immediately abaft and forward of the bulkhead in question, respectively, in m (ft). For vessels having lower wing tanks with sloping tops, making an angle of about 45 degrees with the horizontal, the breadth may be measured between the midpoints of the sloping plating. For vessels having double skins with flat inner bottom, it may be measured to the inner skins.
- B = breadth of vessel, as defined in 3-1-1/5, in m (ft)

3.9.4 Shearing Strength for Vessels with Two or Three Longitudinal Bulkheads

For vessels having continuous longitudinal bulkheads, the total shear stresses in the side shell and the longitudinal bulkheads are to be calculated by an acceptable method. In determining the still-water shear force, consideration is to be given to the effects of non-uniform athwartship distribution of loads. The method described in Appendix 3-2-A1 may be used as a guide in calculating the nominal total shear stress f_s related to the shear flow in the side shell or longitudinal bulkhead plating.

Alternative methods of calculation will also be considered. Some acceptable methods are shown in 5C-1-4/5 and Appendix 5C-2-A1.

FIGURE 5
Shear Force Distribution (1997)



5 Longitudinal Strength with Higher-Strength Materials

5.1 General

Vessels where the effective longitudinal material of either the upper or lower flanges of the main hull girder, or both, are constructed of materials having mechanical properties greater than those of ordinary-strength hull structural steel (see Section 2-1-2), are to have longitudinal strength generally in accordance with the preceding paragraphs of this section, but the value of the hull girder section modulus and permissible shear stress may be modified as permitted by 3-2-1/5.5 and 3-2-1/5.7. Application of higher-strength material is to be continuous over the length of the vessel to locations where the stress levels will be suitable for the adjacent mild-steel structure. Higher-strength steel is to be extended to suitable locations below the strength deck and above the bottom, so that the stress levels will be satisfactory for the remaining mild steel structure. Longitudinal framing members are to be continuous throughout the required extent of higher-strength steel.

5.3 Hull Girder Moment of Inertia (2012)

The hull girder moment of inertia is to be not less than required by 3-2-1/3.7.2 using the mild steel section modulus obtained from 3-2-1/3.7.1.

5.5 Hull Girder Section Modulus

When either the top or bottom flange of the hull girder, or both, is constructed of higher-strength material, the section modulus, as obtained from 3-2-1/3.7, may be reduced by the factor Q .

$$SM_{hts} = Q (SM)$$

where

SM = section modulus as obtained from 3-2-1/3.7

Q = 0.78 for H32 strength steel

Q = 0.72 for H36 strength steel

Q = 0.68 for H40 strength steel

H32, H36, H40 = as specified in Section 2-1-3.

Q factor for steels having other yield points or yield strengths will be specially considered.

5.7 Hull Girder Shearing Force

Where the side shell or longitudinal bulkhead is constructed of higher strength material, the permissible shear stresses indicated in 3-2-1/3.9 may be increased by the factor $1/Q$. For plate panel stability, see 3-2-1/19.

7 Loading Guidance

7.1 Loading Manual and Loading Instrument (1 July 1998)

All vessels contracted for construction on or after 1 July 1998, are to be provided with a loading manual and, where required, a loading instrument in accordance with Appendix 3-2-A2.

In addition, bulk carriers, ore carriers and combination carriers 150 m (492 ft) or more in length (L_p) are to comply with the requirements in Appendix 3-2-A3.

7.3 Allowable Stresses (1 July 1998)

7.3.1 At Sea

See 3-2-1/3.7.1 for bending stress and 3-2-1/3.9.1 for shear stress for vessels with ordinary strength steel material. For higher-strength steel, the allowable stress may be increased by a factor of $1/Q$ where Q is as defined in 3-2-1/5.5.

7.3.2 In Port

The allowable still water in-port stress is 13.13 kN/cm² (1.34 tf/cm², 8.5 Ltf/in²) for bending and 10 kN/cm² (1.025 tf/cm², 6.5 Ltf/in²) for shear. For higher-strength steel, the allowable stress may be increased by a factor of $1/Q$ where Q is as defined in 3-2-1/5.5.