PART II RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF SHIPS IDENTIFIED BY THEIR MISSION

TITLE 16 OFFSHORE BARGES

SECTION 2 STRUCTURE

CHAPTERS

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CHAPTER A
SCOPE

CONTENTS

A1. APPLICATION

100. Types of barge missions

101. Ships intended to get the notations Barge or Pontoon are to be in accordance with the present Title.

102. The stability requirements of the IMO IS CODE to these kinds of ships are to be applied.

103. For barges and pontoons the positions of the bulkhead are to be in accordance with the Part II,Title 11, Section 1, subchapter H4.

200. Hull proportions

201. These rules are developed for proportions between the hull dimensions complying with the following limits:

NAVIGATION ZONE *	SHIP'S CONFIGURATION TYPES ACCORDING ILLC – SEE A.3.			
	TYPE B		TYPE A	
	L/D	B/D	L/D	B/D
O1	≤ 18	≤ 4	≤ 22	≤ 5
O2	≤ 16	≤ 3	≤ 20	≤ 4

* See Part I, Title 02, Section 2, Sub-chapter B.3.

202. On vessels with trunk deck (higher deck in the zone along the center line), for the purpose of checking the relationship length / depth, a fictional depth D_1 should be used, obtained by:

$$D_1 = D + hTx\frac{b}{B}$$

where:

h: trunk height;
b: trunk width

A2. DEFINITIONS

100. Terms

101. Meanings of terms used herein.

Strength deck: deck that comprises the upper flange of the hull girder and continuously extends, at least, over a distance of 0,4 x L, centered at the middle length L. It should be not necessarily the freeboard deck. A deck of superstructure can satisfy the definition.

Trunk deck: raised deck in relation to deck at side, along the center line of the ship.

Midship section modulus: is the strength modulus of the section at half ship, with the continuous longitudinal material along 0,4 x L, centered in the middle length L. If the shape of the hull aft or forward is tapered down, it should be checked that the modulus is satisfied in the limits of the 0,4 x L.

Pontoon: Non-propelled units intended to carry cargo and/or equipment on deck only. **[IMO IS Code]** A pontoon is considered to be normally:

a. non self-propelled;

b. unmanned;

c. carrying only deck cargo;

d. having a block coefficient of 0,9 or greater;

e. having a breadth/depth ratio of greater than 3; and

f. having no hatchways in the deck except small manholes closed with gasketed covers.

See note under barge definition.

Barge or lighter ship is considered to be normally:

a. non self-propelled;

b. unmanned;

c. carrying cargo;

d. having a breadth/depth ratio of greater than 3;

e. having cargo holds are suitable for the carriage of dry or liquid cargo;

f. having hatchways on deck;

Note: for stability purposes the Brazilian Maritime Authority presents alternative criteria for the following dimension relations:

a. having a breadth/depth ratio of greater than 3;

b. having a breadth/draught ratio of greater than 6.

Navigation Zone: area of navigation, classified as a function of wave height and other environmental agents. For the purpose of the present Rules tey are classified as follows:

a. O1: for coastal navigation (held in open sea within the limits of the coast visibility, established as 20 nautical miles from the coast);

b. O2: for long-distance navigation (navigation conducted between Brazilian and foreign ports), navigation in jurisdictional waters (“cabotagem”: navigation conducted between Brazilian ports, using sea or inland) and maritime support (logistical support for navigation conducted within the limit of 200 nautical miles from shore).

Type A: having no hatchways in the deck except small manholes closed with gasketed covers.

Type B: having hatchways in the deck.

A3. BARGE TOPOLOGIES

100. Ships and barges type "A"

101. Barge topologies considered are in accordance with ILLC and NORMAMs.

102. Typical barge and pontoon sections Type "A" are shown in figures F.A3.102.1. and F.A3.102.2., for systems of single hull with longitudinal and transverse structure, respectively. Typical topologies for tankers for petroleum products, chemicals and liquefied gas are dealt with in specific Titles.

103. Typical sections of barge "B" type are shown in figures F.3.103.1. and F.3.103.2. For double-hulled systems with longitudinal and transverse structure, respectively. Typical topologies for ships for carriage of vehicles and containers are dealt with in specific Titles.

104. Longitudinal or cross trusses should be arranged so that the span of the beams they support to be not greater than 4 meters.

105. When the ratio L/D is greater than 16 there should be at least one longitudinal truss at each side. When this ratio is greater than 20 there should be no less than two longitudinal trusses for each board. The adjacent diagonals should have opposite slopes and minimum area equal to half of the pillar area.

106. For the purpose of checking the relationship between length and depth for barges and pontoons with trunk decks, see Paragraph A1.202.

FIGURE F.A3.102.1. – BARGE AND PONTOON FOR SEAGOING TYPE "A" LONGITUDINAL SYSTEM – CROSS SECTION – WEB FRAME

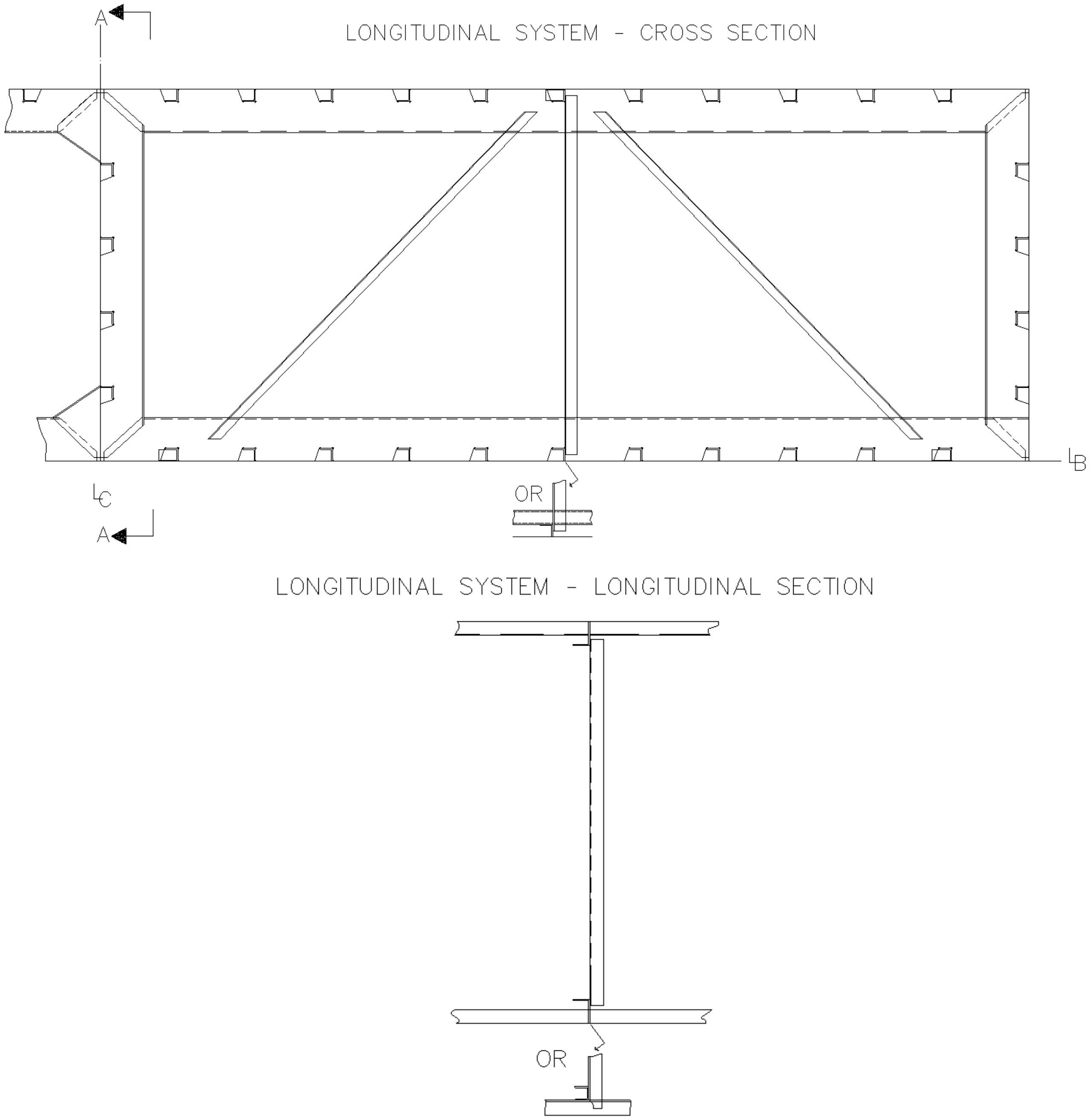


**FIGURE F.A3.102.2. – BARGE AN PONTOON FOR SEAGOING TYPE "A"
TRANSVERSAL SYSTEM – CROSS SECTION**

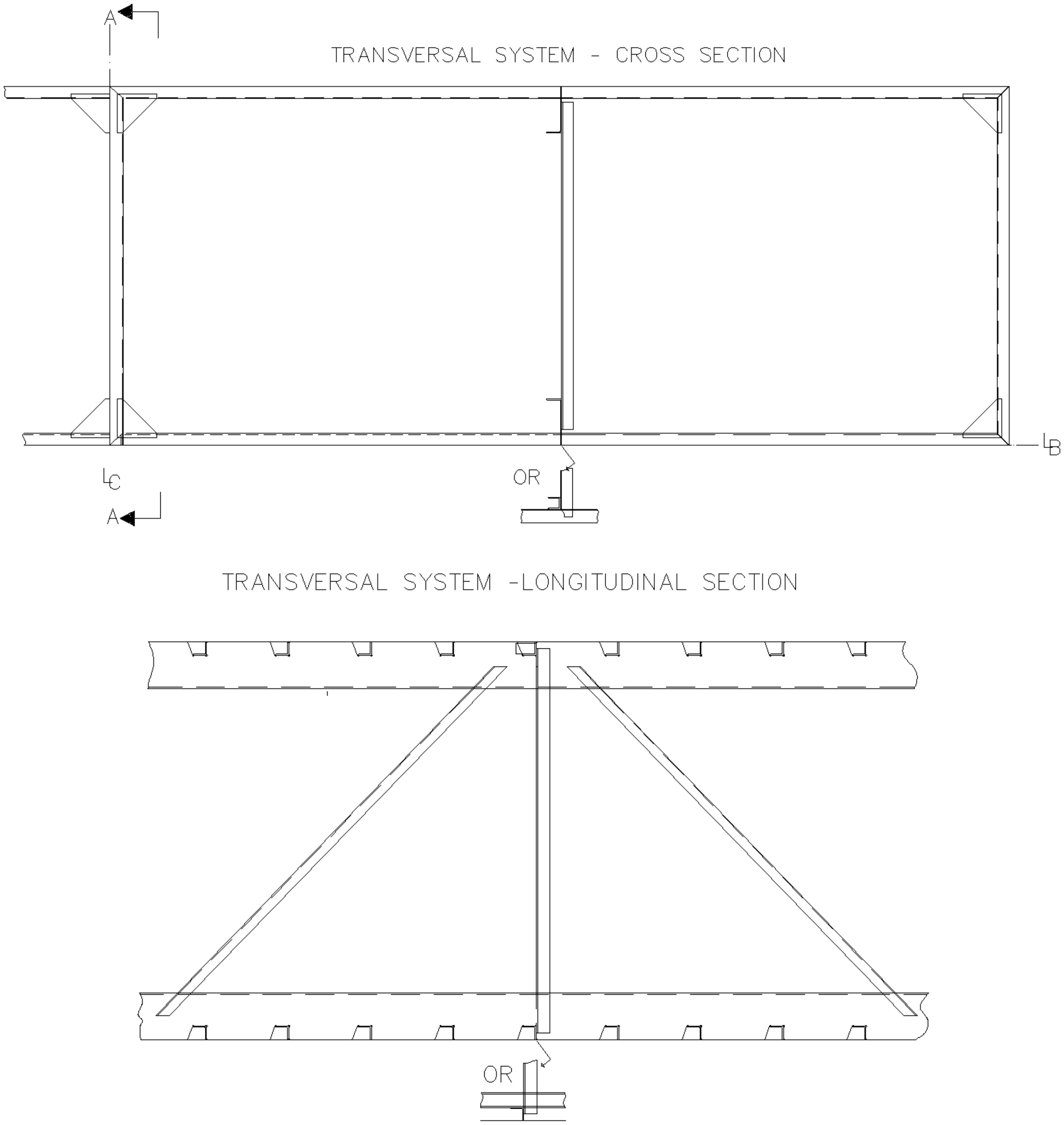


FIGURE F.A3.103.1. – BARGE FOR SEA GOING TYPE "B" DOUBLE HULL – LONGITUDINAL SYSTEM

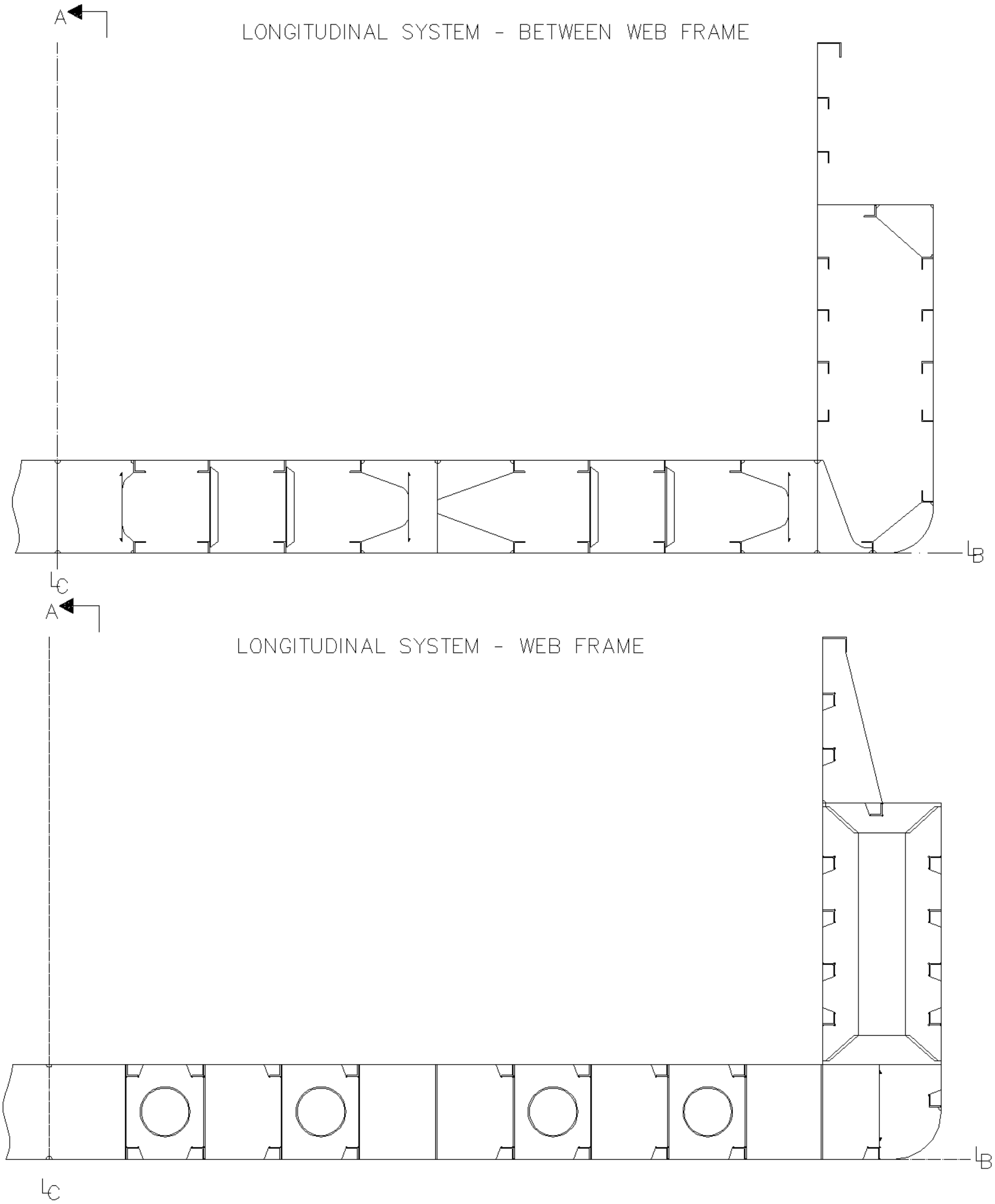
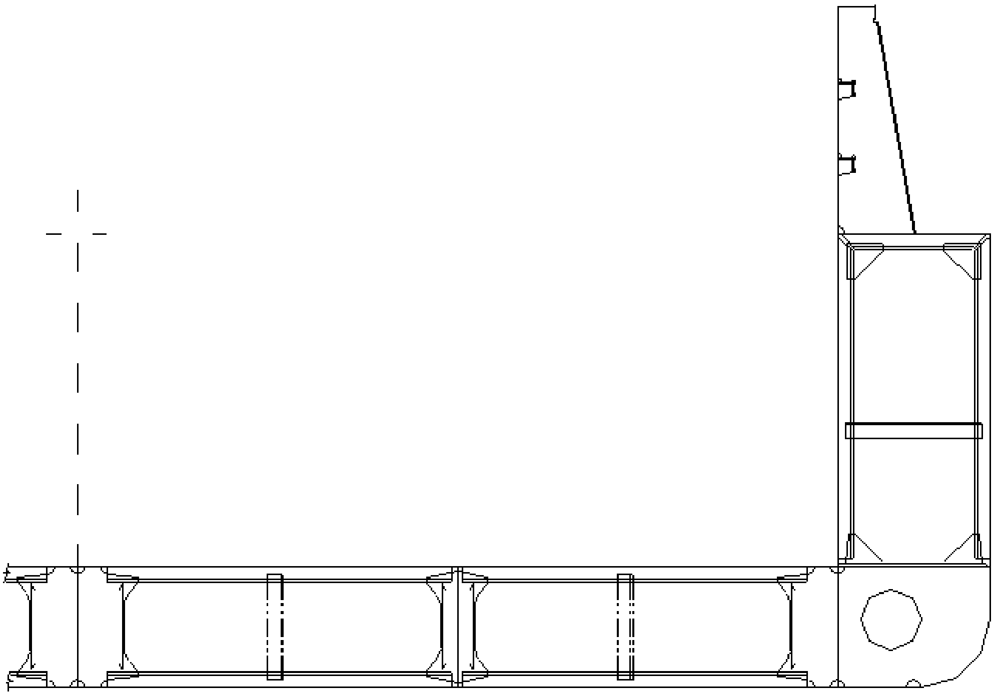
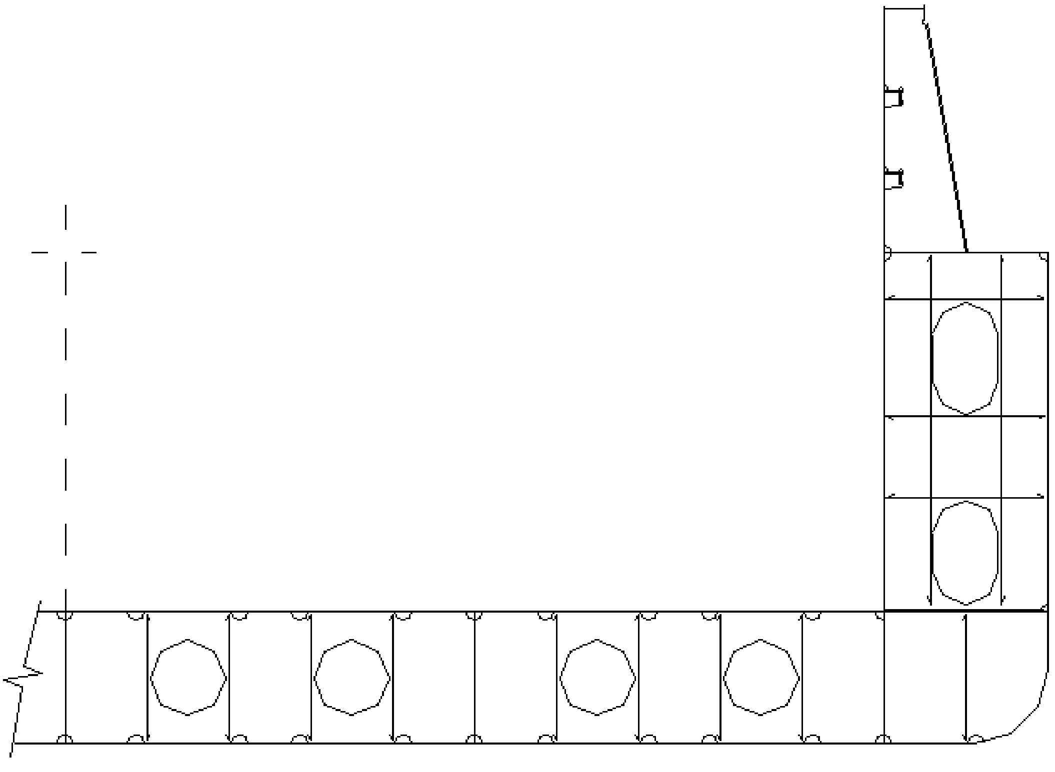


FIGURE F.A3.103.1. – BARGE FOR SEA GOING TYPE "B"
DOUBLE HULL – TRANSVERSAL SYSTEM



TRANSVERSAL SYSTEM – WEB FRAME



CHAPTER B
DOCUMENTS, REGULATIONS AND STANDARDS

CHAPTER CONTENTS

B1. DOCUMENTATION OF THE SECTION OF STRUCTURE

100. Documents of the ship

101. See Part II, Section 2, Title 11, Subchapter B1. To be attended as applicable.

B2. REGULATIONS

100. Freeboard to the structure

101. The structural dimensioning will be verified for the maximum draft required by the applicable freeboard regulation or by the draft indicated by the designer.

102. RBNA checks the calculation of the freeboard as required by the NORMAM 01, chapter 7, for ships with AB < 500.

103. RBNA checks the calculation of the freeboard as required by the ILL – International Load Line, for ships with AB $\geq$ 500.

B3. STANDARDS

100. Equivalent standards

101. Industrial standards are used in construction and materials, with proper control of the applicability by the RBNA.

CHAPTER C
MATERIALS AND WORKMANSHIP

CHAPTER CONTENT

C1. BASIC CHARACTERISTICS OF THE STRUCTURAL STEEL

100. Steel in general

101. The characteristics of the materials to be used in the construction of ships are to comply with the applicable requirements of Part III, Title 61, Section 2., Construction Components, Materials and Welding.

102. Materials with different characteristics may be accepted, provided their specification (manufacture, chemical composition, mechanical properties, welding, etc.) is submitted to RBNA for approval.

C2. STRUCTURAL STEEL FOR VESSELS WITH L < 90 m

100. Ordinary steel

101. The steel to be used is normal naval structural steel in accordance with Part III Title 61, Section 2, typically ASTM A-131. However, instead of ASTM.A-131 steels under standard ASTM A-36 may be used, pending of test to ascertain equivalence.

102. Normal strength hull structural steel is a hull structural steel with a minimum nominal upper yield point ReH of 235 N/mm2 and a tensile strength Rm of 400 – 520 N/mm2. (See Table T.C3.101.1 below).

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

104. Testing of materials: materials are to be tested in compliance with the applicable requirements of Part III Title 61, Section 2.

105. Manufacturing processes: the requirements of this Section presume that welding and other cold or hot manufacturing processes are carried out in compliance with current sound working practice and the applicable requirements of Part III Title 61, Section 2.

200. Adequacy of other steels

201. When the steel presents yield limit RY different from 235 N/mm² (24 kgf/mm²) and is not included within the requirements of the Part III, Title 61, Section 2 or indicated in Table T.C3.101.1., the scantlings may be changed by the ratios:

in the thickness: $\sqrt{\frac{24}{RY}}$ (in kgf/mm²)

$\sqrt{\frac{235}{RY}}$ (in N/mm²)

in the modulus: $\frac{24}{RY}$ (in kgf/mm²)

$\frac{235}{RY}$ (in N/mm²)

C3. USE OF STEEL GRADES FOR VARIOUS HULL MEMBERS – SHIPS OF 90 m LENGTH AND ABOVE

100. Application

101. Table T.C3.101.1. gives the mechanical characteristics of steels currently used in the construction of ships.

TABLE T.C3.101.1. – MECHANICAL CHARACTERISTICS OF STEELS CURRENTLY USED IN THE CONTRUCTION OF SHIPS

Steel grades t < 100 mm	Minimum yield stress R_{EH}, in N/mm^2	Ultimate minimum tensile strength Rm, in N/mm^2
A – B – D - E	235	400 - 520
AH32 - DH32 - EH32 - FH3	315	440 - 590
AH36 - DH36 - EH36 - FH36	355	490 - 620
AH40 - DH40 - EH40 - FH40	390	510 - 650
Ref: Part III, Title 61, Section 2.		

200. Factor k [IACS UR S4]

201. The material factor k, when indicated in calculation formulae is to be taken as here indicated:

k = 1,0 for normal strength hull structural steel.

k = 0,78 for steel with Y = 315 N/mm²

k = 0,72 for steel with Y = 355 N/mm²

k = 0,68 for steel with Y = 390 N/mm²

k= 295/(R_{EH}+60) when $R_{EH} \neq$ 315 or 355 N/mm²

where:

Y = minimum yield stress

R_{EH} = nominal upper yield stress of higher strength hull structural steels

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

203. For the application of the individual grades for the hull structural members, see Tables T.C3.401.1. to Table T.C3.401.1.

300. Higher strength hull structural steels

301. Higher strength hull structural steel is a hull structural steel, the yield and tensile properties of which exceed those of normal strength hull structural steel.

302. According to Part II, Title 11, Section 2, Subchapter C3., Topic 300., for three groups of higher strength hull structural steels, the nominal upper yield stress R_{EH} has been fixed according to Table T.C3.401.1.

303. Where higher strength hull structural steel is used, for scantling purposes, the values in Paragraph 201. above, are to be used for the material factor k mentioned in the various Chapters.

C4. OTHER MATERIALS

100. Aluminium

101. In the use of aluminium, with yield limit RY, the scantlings are changed by the same ratios above indicated, taking into account the metallurgical efficiency coefficient indicated in Part III, Title 61, Section 2, and Chapter G of these Rules.

102. The indications of the aluminium alloys follow the international designation of the Aluminium Association. The indications of tempers follow the US Standard ANSI H 35-1.

103. The aluminium extruded or rolled alloys are:

aluminium - magnesium (5000 series); and

aluminium - magnesium - silica (6000 series).

104. The characteristics considered here are:

Young's modulus = 70000 N/mm²; and

Poisson's coefficient = 0,33.

105. Considering the steel yield limit RY = 235 N/mm² (24 kgf/mm²)., and the aluminium yield limite RA, the scantlings here shown for aluminium may be adopted changed by the ratios:

in the thickness: $\sqrt{\frac{24}{RY}}$ (in kgf/mm²)

$\sqrt{\frac{235}{RY}}$ (in N/mm²)

in the modulus: $\frac{24}{RY}$ (in kgf/mm²)

$\frac{235}{RY}$ (in N/mm²)

200. Composite materials

201. The use of composite materials, such as fiberglass reinforced resins, will have their characteristics and dimensioning of elements especially checked by the RBNA.

300. Welding materials

301. See Section 2 da Parte III of these Rules.

C5. WORKMANSHIP

100. Qualification

101. Application of the present Rules requires workmanship with the appropriate professional qualifications for the design and construction of the hull structure.

200. Welders

201. The welders employed in the construction should be qualified by the RBNA for the welding types that they carry out in the form prescribed in Part III of the Rules.

CHAPTER F
DIMENSIONING OF LOCAL STRUCTURAL SYSTEM

CHAPTER CONTENT

F1. BOTTOM AND DOUBLE BOTTOM

100. Thickness of the bottom at ends

101. Thickness of bottom for 0,1L at ends to be the greater of the following values, valid also for the side shell, in mm:

$e_e = 0,85 \times \sqrt{L}$

$= 0,006 \times E \times \sqrt{D}$

$= 0,01 \times E$

where E is the stiffener spacing in mm.

102. Reinforcement of flat bottom forward:

extension: from 0,3 L abaft the FP to forward end;

thickness: amidship thickness (see Topic 200.) multiplied by D/(2,28x dav),

where:

dav = least forward operating draft and D/(2,28 x dav) ≥ 1

stiffeners: amidship modulus (see Topic 500.) multiplied by D/(2,28x dav) ≥ 1;

side stringers: spaced 4 times the spacing of stiffeners and modulus 4 times greater than the local beams; and

intercoastal girders: so that the length of plating panel does not exceed 4 times the width.

200. Bottom thickness along amidship

201. Thickness of bottom for 0,4L amidship to be the greater of the following values:

for transversal system:

$e = 0{,}07 \times L + 0{,}007 \times (E - E0) + 2{,}0$ mm

for longitudinal system:

$e = 0{,}1 \times L + 0{,}007(E - E0) + 1{,}0$ mm

202. Stringers or deep floors spacing should not exceed the following values:

- on ships with cargo hatches: 2,5 m; and

- on ships without cargo hatches: D.

203. The required modulus is calculated by the following equations: of the sub-chapter F4, except where below indicated in what follows.

for transversal system:

$W = 7 \times p \times E \times l^2$ cm^3

for longitudinal system:

$W = 7 \times p \times E \times l^2 \times (0{,}008 \times L + 1)$ cm^3

300. Inner bottom plating

301. The thickness of inner bottom plate is the greater of the values in mm:

$e = 0{,}01 \times E$

$$e = 0{,}0042 \times E \times \sqrt{p - 0{,}4} + c$$

where:

c = 4,0 for transversal system

c = 3,0 for longitudinal system

E is the stiffener spacing in mm, taken with at least of 500 and "e" should be no less than the following values:

the bottom thickness; and

the tank thickness + 1,0.

302. In case of unloading with grabs the thickness should be increased of 3,5 mm.

303. The required modulus for the inner bottom beams will be calculated by the following equation, taking into account the respective loads of the Part II, Title 11, Section 2, Table T.E3.101.1.

for transversal girders:

$W = 7 \times p \times E \times l^2$

400. Floors, longitudinals, stringers and double bottom plate floors

401. The required modulus for the inner bottom girders will be calculated by the equation of subchapter F4., taking into account the respective loads of the Subchapter E3. For inner bottom longitudinal beams apply the Paragraph 503. of this subchapter.

402. The modulus of the inner bottom beam should not be less than 0,8 times the modulus of the bottom beam and vice versa.

403. Plating floors should be provided with maximum spacing or of 3,00 meters or of 5 spaces of plate stiffeners.

404. The thickness of the floor plating is given by:

$$e = 0{,}01 \times h_{FD} - 1 \quad \text{mm}$$

where:

h_{FD} is the height of the double bottom in mm.

405. The floors must not have holes in the e extension of 0,25 x l from their support points and thickness of plating in that zone should not be less than:

$$e = 0{,}125 \times p \times E \times \frac{l}{h_{HA}} \quad \text{mm}$$

where:

E: stiffener spacement in mm

h_{HA}: height of the floor in the base in mm

l: unsupported span of the double bottom floor in m

406. Plated longitudinal beams should be provided with spacing not exceeding 4,0 meters, with the same thickness of the floors.

407. The floor vertical beams are to be calculated in accordance with the Topic F1.400.

408. In case of unloading with buckets the thickness should be multiplied by 1,1.

409. When struts are used between the bottom girders and inner bottom, these will be calculated in accordance with item F 4.700, but should not be smaller than the inner bottom stiffener.

F2. BULKHEADS

100. Definitions

101. Terms used herein:

AEC – Ordinary watertight bulkhead: built only for subdivision of a vessel or for separation of holds, without continuous liquid pressure.

ATQ – Tank bulkhead tank: built to limit tanks, i.e. subject to the pressure of liquids; in this case the heights of overflows and air pipes or regulations of pressure valves should be indicated on the plans.

102. AEC positions – The positions of the AECs are given in the Part 2, Title 11, Section 1, sub-chapter H4.

103. ATQ positions – In principle, the tanks will not have width of the full extension of the vessel breadth. The spacing of longitudinal ATQs width should not exceed 0,7 × B. Cofferdams will be built between compartments containing products at risk of contamination.

200. Loadings

201. The load on bulkhead shall be expressed in t / m² by the number which corresponds to the height, measured from the structural element considered, as indicated on the pertinent paragraph, in meters, to a point located as follows:

TABLE T.F2.201.1- LOADINGS

Type	Navigation area	
	O1	O2
AEC	level of main deck	
ATQ (the greater value)	0,7 m above the overflow or above the main deck or above the trunk-deck; and 1,3 m above tank top	0,9 m above the overflow or above the main or above the trunk-deck; and 1,5 m above tank top

300. Plating of AECs

301. The thickness of the AEC will be the greater of the values below in mm:

$$e = 0{,}004 \times E \times \sqrt{h} + 2$$ for the collision bulkhead

$$e = 0{,}0035 \times E \times \sqrt{h} + 2$$ for the others bulkheads

$$e = 0{,}8 \times \sqrt{L}$$

where :

h: load height, measured from the lower edge of the plate strake considered, in m.

302. Horizontal bulkheads shall have thickness increased by 1 mm.

303. When skeg is installed, thickness will follow bottom thicknesses.

304. For corrugated bulkhead, E is the width of the widest panel.

305. The inferior strip of plating on bulkheads of cargo holds, at a minimum height of 250 mm, shall have increasing thickness of 1 mm.

400. Stiffeners of AECs

401. The section modulus of practically vertical stiffeners, in general, on transversal or longitudinal AECs will be given by the equation:

$$W = 0{,}877 \times E \times l^2 \times (5 \times h + 3 \times h_p)$$

h : load height, measured from the upper edge of the span *l*, in m.

h_p: vertical distance, measured between the span ends *l*, in m.

402. For vertical stiffener the equation is written as follows:

$$W = 0{,}877 \times E \times l^2 \times (5 \times h + 3 \times l)$$

403. For horizontal girder of transverse bulkhead the equation is written as follows:

$$W = 4{,}39 \times h \times E \times l^2$$

404. For horizontal girder that support vertical stiffeners the above equation is used, where “E” is the average span of the stiffeners, above and below, that it supports. Besides that, where supporting shell stingers at their end, they should be checked for buckling.

405. For reinforced vertical girders that support the horizontal girder on transversal bulkhead, the modulus in the bottom end is calculated by the equations:

$$W = \sum W_i$$

where:

W_i is calculated for the horizontal girder “i” as follows:

$$Wi = 41{,}7 \times hi \times \frac{C}{l^2} \times \frac{E_1 + E_2}{2} \times \frac{Si_1 + Si_2}{2}$$

and:

h_i : load height for the horizontal girder “i”;

l : span for the reinforced vertical girder;

S_{il} and S_{i2} : horizontal girder spacing above and below the the horizontal girder “i”;

E_1 and E_2 : reinforced vertical girder spacing of each side of the reinforced vertical girder that is being calculated;

C : the greater of the values: $l_{i1} \times l_{i2}^2$ ou $l_{i1}^2 \times l_{i2}$;

where:

l_{i1} and l_{i2} are the distances from the horizontal girder "i" until the ends of the span l of the vertical girder that is being calculated;

406. For vertical girders of AEC that support longitudinal beams, the section modulus is calculated by the equations of the items 402. and 403., taking into account the spaces and spans.

407. For longitudinal bulkhead beams the equation is written as follows:

$W = 5{,}95 \times E \times l^2 \times h_i \times y_i$

where:

h_i: load height from the level of the element considered

$$y_i = 0{,}008 \times L \times \left(1 - \frac{d_i}{0{,}4 \times D}\right) + 1$$

and:

d_i: shortest distance of the bulkhead girder to the deck or to the bottom, without being greater than 0,4 × D; when it is greater, taking $y_i = 1$.

408. For horizontal girder that support vertical stiffeners on longitudinal bulkhead, the above equation is used, being “E” the average of the spans of the stiffeners, above and below, that is supported.

409. For reinforced vertical girders that support the horizontal girder on longitudinal bulkhead, the modulus in the bottom end is calculated by the equation of the Paragraph 405., where h_i is according Paragraph 406.

410. For reinforced vertical girders that support longitudinal beams on longitudinal bulkheads, the section modulus is calculated by the equations of the 401. and 402., taking into account spacing and spans.

411. Vertical girders that support transverse girders should be checked as pillars, supporting the load brought by the transverse girder, in accordance with Topic F4.600.

412. For corrugated bulkhead, consider half of the parallel panels to the bulkhead as the flanges of a Z shape, forming an I beam.

500. Plating of ATQs

501. The thickness of the ATQ will be the greater of the values below in mm:

$$e = 0{,}004 \times E \times \sqrt{h} + 2$$

$$e = 0{,}8 \times \sqrt{L}$$

where :

h: load height, measured from the lower edge of the plate strake considered, in m.

502. For corrugated bulkhead, E is the width of the widest panel.

600. Stiffeners on ATQs

601. The section modulus of vertical stiffeners of ATQ, in general, is given by the equation:

$W = 1{,}19 \times E \times l^2 \times (5 \times h + 3 \times h_p)$

where:

h: load height, measured from the upper edge of the span l in m.

h_p: vertical distance, measured between the span ends l, in m.

602. When the liquid density is greater than 1, the equation will change proportionally.

603. For vertical stiffener the equation is written as follows:

$W = 1{,}19 \times E \times l^2 (5 \times h + 3 \times l)$

604. When the liquid density is greater than 1, the equation will change proportionally.

605. For horizontal girder of transverse bulkhead the equation is written as follows:

$W = 5{,}95 \times h \times E \times l^2$

606. For horizontal girders that support vertical stiffeners, the above equation is used, being “E” the average of the spans of the stiffeners, above and below, that it supports.

607. For reinforced vertical girders that support the horizontal girder on transversal bulkhead, the modulus in the bottom end is calculated by the equation:

$W = \sum W_i$

where:

W_i is calculated for each horizontal girder “i” as follows:

$$Wi = 62{,}5 \times hi \times \frac{C}{l^2} \times \frac{E_1 + E_2}{2} \times \frac{Si_1 + Si_2}{2}$$

and:

hi : load height of the horizontal girder "i";

l : span of the vertical girder;

S_{i1} and S_{i2} : spacings of horizontal girder, above and below, of the stringer "i";

E_1 and E_2 : spacings of girders, of one side and the other, of the vertical girder that is being calculated;

C : the greater of the values: $l_{i1} \times l_{i2}^2$ ou $l_{i1}^2 \times l_{i2}$

where:

l_{i1} and l_{i2} are the distances from the stringer "i" to the ends of the span *l* of the vertical girder that is being calculated.

608. For horizontal girder on the longitudinal bulkhead the equation is written as follows:

$W = 8{,}93 \times E \times l^2 \times h_i \times y_i$

where:

h_i: load height from the level of the element considered;

$$yi = 0{,}008 \times L \times \left(1 - \frac{d_i}{0{,}4 \times D}\right) + 1$$

and:

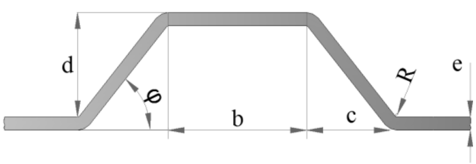
d_i: shortest distance of the bulkhead girder to the deck or to the bottom, without being greater than 0,4 × D; if it is greater, taking yi = 1.

609. For corrugated bulkhead, consider half of the parallel panels to the bulkhead as the flanges of a Z shape, forming an I beam.

700. Corrugated Bulkhead

701. For stiffener modulus of corrugated plate, consider half of the parallel panels to the bulkhead as the flanges, forming a stiffener in an beam form, for the offered modulus, where the angle φ of the inclined panel should not be lower than 45º.

FIGURE F.F2.701.1 – CORRUGATED BULKHEAD



702. The modulus of each stiffener is calculated as follows:

$$W = \frac{b}{2} * e * d + e * \frac{\sqrt{c^2 + d^2}}{c} * \frac{d^2}{6}$$

703. The bending radius is not to be less than the following values, in mm:

R = 3,0 x e

704. The section modulus of the corrugations in the remaining upper part of the bulkhead is to be not less than 75% of that required for the middle part, corrected for different minimum yield stresses.

705. When welds in a direction parallel to the bend axis are provided in the zone of the bend, the welding procedures are to be submitted to RBNA for approval.

800. Independent tanks

801. The elements will be calculated as tank bulkhead, with cargo height measure up to the level of the overflow, but not being taken less than 3 m above the tank.

F3. SIDE SHELL

100. Side shell thickness

101. The thickness of the ends will be consistent with the bottom thickness.

102. At amidships the thickness will be at least equal to the thickness of the ends or to the following value, whichever is greater:

$e = 0{,}095 \times L + 0{,}0063 \times (E – E0) + 1{,}8$ mm

103. In locations where there is possibility of dragging, impacts or rubbings of anchor chains use the following minimum value:

$$e = 1{,}1 \times \sqrt{L}$$

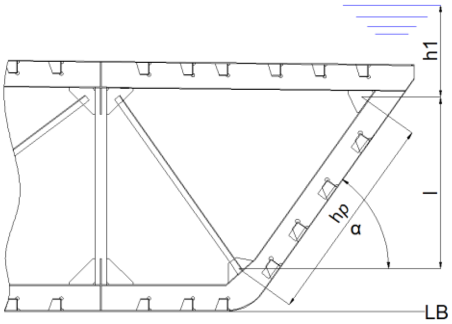
104. In vessels that are part of convoys where are subject to impacts themselves or subject to impacts in the side shell, the thickness of the belting should not be less than that given by the equation:

$e = 0{,}075 \times L + 6{,}5$

200. Practically vertical frames in side shell

201. The general configuration considered of side shell frames is shown onthe Figure F.F3.201.1.:

FIGURE F.F3.201.1 – SIDE SHELL FRAMES



202. For fully submerged frames, i.e., when the top of the web frame is below the design waterline, the strength modulus will be calculated by the equation:

$w = 0{,}887 \times E \times l^2 \times (5 \times h + 3 \times l \times \text{sen}\ \alpha)$

where:

E: spacing of frames, in m;

l: span of the frame: for inclined frame the span is measured in a straight line approximately parallel with the average slope of the frame, in m;

α: angle of the line above mentioned with the horizontal;

h: load height

$h = h_1 + a$.

and:

h_1 is the vertical distance measured from the top of the frame, that is, the upper end of the span l, up to the design waterline, in m;

a = 1,8 for mention "O2" or vessel type A for liquid cargo;

a = 1,2 in other cases;

203. For frames partially submerged, i.e., when the top of the frame is above the design water line, the strength modulus is calculated by equations of paragraph F3.202, for:

$h = h_2 + a$

where:

h_2: the vertical distance, measured from the top of the frame up to the deck or level of the support just above, in m.

204. For emerged frames, i.e., when, in deckhouses or superstructures, the bottom end of the frame stay above the design water line, the strength modulus is calculated by equations of the Paragraph F3.202, for:

$h = h_2 + 0{,}3$

300. Horizontal frames

301. The modulus of horizontal frames, in total or partially submerged position, is calculated by the equation:

$W = 5{,}95 \times E \times l^2 \times h_i \times y_i$

where:

h_i: load height from the level of the element considered = the distance to the unsheathed deck + a;

$$yi = 0{,}008 \times L \times \left(1 - \frac{d_i}{0{,}4 \times D}\right) + 1$$

and:

d_i: shortest distance from the horizontal frame to the deck or to the bottom, without being greater than 0.4 × D;

when it is greater, assume $y_i = 1$

a: as per paragraph F3.202.

302. For transverse horizontal frames, as in transom stern, apply the equation of item F2.603.

400. Stringers that support vertical web frames

401. For stingers that support web frames, apply the equation of,Paragraph F3.301., where "E" is the average of the spans of the stiffeners, above and below, that is supported.

402. Stringers that support the reinforced horizontal girder from transversal bulkheads, should be checked for buckling

500. Web frames

501. Web frames that support stringers the modulus in the bottom end is calculated by the equation:

$$W = 26{,}3 \times h \times \frac{b}{l^2}$$

where:

h: load height of the horizontal girder "i";

l: span of the reinforced transverse web frame;

b: the greater of the values: $l_1^2 \times l_2$ or $l_1 \times l_2^2$ and:
l_1 and l_2 the distances from the supported stringer to the ends of the span l of the transverse web frame. F3.501.

502. Transverse web frames that support longitudinal frames have the modulus calculated in accordance with the

respective cases of items F3.202./203./204., adjusted to their spacing parameters and span.

600. Other reinforced web frames

601. Frames, stringers and web frames in tanks should have their modulus checked as bulkhead stiffeners (ATQ), in accordance with the Subchapter F2.

602. Frames that support deck girders should be checked as pillars, supporting the load brought by the girder, in accordance with Sub-chapter F4.

603. On vessels with the stem, the stem frames, which stay in the region to 0,15L of the forward perpendicular, should have the modulus increased by 30%.

603. Web frames on spaces with machinery will specially considered by RBNA.

604. Bow frames which stay at 0,15L from forward perpendicular, on ships with bow form, should have modulus increased by 30%.

605. In side shells subject to impacts in function of the operation, the transverse frames or longitudinal frames at the region of the belting should have the section modulus multiplied by 1.25.

606 For web frame which supports cantilever, see Topic F3.700.

700. Web frame for cantilever

701. For web frame which supports cantilever, see Topic F3.700.

F4. DECK

100. Deck thickness at the ends

101. To be the least of the following values, in mm:

$$e_e = 0{,}85 \times \sqrt{L}$$

$$e_e = 0{,}006 \times E \times \sqrt{d}$$

$$e_e = 0{,}01 \times E$$

200. Strength deck thickness at amidship

201. To be at least equal to the thickness at the ends or the largest of the following values, whichever is greater:

$e_{CR} = 0{,}01 \times E \times \sqrt{p}$

$e_{CR} = 0{,}066 \times L + 3{,}5$ (for transverse system)

$e_{CR} = 0{,}066 \times L + 2{,}5$ (for longitudinal system)

e_{CR} = required to meet the section modulus strength amidships, prescribed in this Section on Chapter H.

202. In barges or pontoons when the load distribution mode is not homogeneous, the thickness should be verified for this condition.

203. For thickness that supports load of wheels see the Title 15 of these Rules.

204. Deck of trunk: plating of the deck and vertical sides follow the one of the strength deck.

205. In hatches with width greater than 0,15 × B, the thickness of the deck plating around corners should be reinforced, at least in 0,1× b_e, in longitudinal and transverse directions from the corners, meeting the following equation:

$ec = (0{,}8 + 0{,}4 \times (be / l_i)) \times e$

where:

ec: reinforced plate thickness in mm;

l_i: distance between two consecutive hatches on deck, measured longitudinally, in m;

be: width in m of the hatch, measured transversally;

e: actual thickness of the deck next to the hatches, in m;

the term $(0{,}8 + 0{,}4 \times (be / l_i))$ need not be greater than 1,6 and cannot be less than 1,0.

300. Thickness of decks under strength deck

301. To be equal to the thickness of the ends or the greatest of the following values:

$e_{DC} = 0{,}009 \times E$

$e_{DC} = 0{,}009 \times E \times \sqrt{p}$

400. Transverse beams and girders

401. The strength modulus of the strength deck transverse beam and transverse reinforced girder is calculated by the equation of the item E4. The equation is applied also for transversal beams and reinforced girder of other decks, as well the for the longitudinals when they are not included in the midship strength modulus.

402. The least value of the span for the above mentioned equation is 0,2 × B, for homogeneity of scantlings, unless local configuration justify differently.

403. In In barges and pontoons when the load distribution mode is not homogeneous, the modulus of the beams should be verified for this condition.

404. For beams that support load of wheels see the Title 15 of these Rules.

500. Longitudinal beams and reinforced girders

501. The required modulus for longitudinal beams of the strength deck, i. e., longitudinal beams and reinforced girders, is calculated by the equation, modified by a factor *f* , when applicable:

$W = 7 \times p \times E \times l^2 \times f$ cm³ or

$W = 7 \times h \times \rho \times E \times l^2 \times f$ cm³

where:

p : pressure of load in t/m²;

E: stiffener spacing in m;

l : beam span, in m (see Topics E2.300. e E2.400.);

h : cargo height in m.

ρ: load density = 0,7 if dry cargo; 1,05 if liquid cargo; or specified value, if greater;

f : factor that can be applied when the midship section modulus presented is greater than the minimum required, with a mimimum of 0,7:

$f = 0{,}451 \times \frac{WR}{W} + 0{,}56$

where:

W_R is the minimum required Chapter H;

W is the calculated modulus for the presented scantlings.

502. For beams in decks limiting tanks, the modulus should be checked by the requirements for the tank boundary, according Topic F2. for ATQ.

503. Longitudinal hatch side girder: the modulus will be calculated by the equation:

$W = 7 \times c \times (p \times b + p_e \times b_e) \times l^2 \times f$

where:

c : coefficient according Paragraph E2.401.

p : loading for the considered deck;

p_e: loading for the considered hatch;

b : deck width supported by the girder;

b_e: hatch width supported by the girder;

f : according paragraph 501.

504. When a hatch coaming, i. e. the part above the deck, aligned with the hatch side girder, extends for, at least, by two frame spaces beyond de hatch girder under the deck, this hatch coaming may be included in the modulus.

505. Where flanges of the under deck longitudinal and transversal girders cross in the corners of hatches, a diamond plate is to be installed with thickness not less than 80% of the plate thickness on the deck level.

600. Hatch side coaming

601. For coaming height see requirements of Part 2, Section 1.

603. For transverse or longitudinal coaming see Section 3-Hull Equipment - Topic D6.200. When the coaming is aligned with a hatch side or hatch end girder, under deck, and their ends exceed the support points for about 1 m as a minimum, their scantlings can be composed to meet the required modulus.

604. In continuous longitudinal coaming, the flange (stiffener of the top edge) should be as close as possible to the edge.

605. The lower edge (under the deck) of continuous longitudinal coaming, when the vessel is not of double side shell, should reach a minimum distance below the deck equal to 30 × D + 200 mm and this edge should have a stiffener made by a flange.

606. The minimum thickness of continuous longitudinal coaming (web) is given by the equation:

$$e_{mín.} = \sqrt{L}$$

607. The area of continuous longitudinal coaming top flange should not be less that 0,67 times the area of the stringer plate, taken over a width of 0,1×B.

608. The coefficient of slenderness of flange with associated area of continuous longitudinal coaming, taken into account the area of effective longitudinal material, should not be greater than 60, where:

$$\lambda = \frac{E_e}{r}$$

where:

E_e: spacing of stays (transverse vertical stiffeners) of the coaming.

r: radius of gyration = $\sqrt{\frac{I}{A}}$

I: lowest moment of inertia in cm4;

A: section area in cm^2, where, for this calculation, the associated area of half the height of the coaming can be taken into account.

609. The strength modulus of the hatch coaming vertical stiffeners should be approximately 40% of that of the flange with the associated plate. Their spacing should not

exceed L/20 or 4,0 m or that required to meet the slenderness coefficient of the flange.

610. Where flanges under the hatch girders cross in the corners of hatches, a diamond plate is to be installed, with thickness not less than 80% of the plate thickness of corner plate of the hatch opening at the deck level.

700. Pillars

701. Pillars should not have hollow section inside of tanks, without inner welding, since they work in traction, as well to prevent leakage for the inside.

702. The load acting on a pillar, in t, is given by the equation:

$P = p \times E_p \times b_p$

where:

p: loading for the decks considered in t/m^2;
q: spacing of pillars or length of the supported area in m; and
bp: width of the supported area in m.

703. The allowable load Pa on a profile or pipe that constitutes a pillar is given by the equations:

$$if\ \frac{l}{r} \leq 1{,}05\ Pa = \left[0{,}9 - 0{,}046x\left(\frac{l}{r^2}\right)\right]xA$$

$$if\ \frac{l}{r} > 1{,}05\ Pa = 0{,}777x\frac{A}{\left(\frac{l}{r}\right)^2}$$

where:

l : length of the pillar, in m;

r: radius of gyration = $\sqrt{\frac{I}{A}}$

I: lowest moment of inertia in cm^4;

A: section area in cm^2.

F5. STERN STRUCTURE

100. Internal structure

101. Plate thicknesses and beam section modulus to follow Sub-chapter F1. to F4.

200. Stern structural addends

201. When skegs or other structure are constructed, the attachment in the hull should be made by internal incorporation in the stern structure, supported by brackets that distributes the efforts throughout the hull girders. The thickness of the inserted shell plate, at about 300 mm width around the shell opening, should be increased by 50%.

F6. BOW STRUCTURE

100. Plate stem

101. When plate stem is used, the thickness, in mm, is given by the equation:

$e = 0{,}09 \times L + 5$

102. Breasthooks for strengthening should be laid down for, with thickness about 0,7 times the stem thickness and spacing on the range of 500 mm.

200. Bar stem

201. When stem bar is used, the area is given by the equation:

$A = 0{,}9 \times (0{,}54 \times L + 2{,}7)\ \ cm^2$

202. The minimum bar thickness is given by the equation:

$e = 0{,}27 \times L + 9$ mm

300. Internal structure

301. On longitudinal structural system, transverse trusses are to be installed, at a maximum space or 2,5 m.

302. On transversal structural system, longitudinal trusses are to be installed, one at center line and others at a maximum space of 4,5 m.

400. Flat part of bottom forward

401. See paragraph F1.102.

F7. SUPERSTRUCTURES AND DECKHOUSES

100. Configuration

101. When the length of the superstructure or deckhouse exceeds L/6, the deck above will be considered strength deck, that is, as the top of the hull girder, and will be dimensioned as such.

103. Se also E3.103.

200. Strength of end bulkheads

201. Thickness of plating of external bulkheads

$e = 0{,}002 \times E + 0{,}002 \times L + c_1$

where:

c_1 = 1 mm for frontal bulkhead of superstructures;

c_1 = 0,5 mm for frontal bulkhead of deckhouses;

c_1 = 0 for others bulkheads;

e_{min} = 4,8 mm.

202. Stiffener modulus on external bulkheads

$W = 1{,}5 \times E \times l^2 \times \sqrt{L} \times c_2$

where:

c_2 = 1,2 mm for frontal bulkhead of superstructures;

c_2 = 1,1 mm for frontal bulkhead of deckhouses;

c_2 = 0 for others bulkheads;

$W_{min} = 8\ cm^3$ with minimum thickness of 4,8 mm.

203. The section modulus of deckhouse side stiffeners need not be greater than that of side frames on the deck situated directly below, taking account of spacing and span.

204. These requirements assume the webs of lower tier stiffeners to be efficiently welded to the decks.

205. Scantlings for other types of end connections may be specially considered.

206. The section modulus of house side stiffeners need not be greater than that of side frames on the deck situated directly below, taking account of spacing and span.These requirements assume the webs of lower tier stiffeners to be efficiently welded to the decks. Scantlings for other types of end connections may be specially considered.

300. Strength of Deck

301. Thickness of plating of decks

$e = 0{,}007 \times E + 0{,}001 \times L + 1{,}5$

where:

e_{min} = 4,8 mm.

302. Stiffener modulus on deck beams

$W = 7 \times p \times E \times l^2 \times \sqrt{L} \times c_3$

where:

p = 0,5 t/m^2 for superstructure decks

0,45 t/m^2 for deckhouse decks

$c_3 = 0{,}008 \times L + 1$ for superstructures which participate on longitudinal strength of the ship;

c_3 =1 for others cases;

$W_{min} = 8\ cm^3$ with minimum thickness of 4,8 mm.

400. Pillars

401. See formulae on Tópic F4.600.

F8. SUMMARY OF FORMULAE FOR DIMENSIONING OF LOCAL COMMON STRUCTURE

100. Formulae and application

101. The Table T.F8.101.1. shows (on the next page), summary. of practical formulae of these Rules and their applications.

TABLE T.F8.101.1 – SUMMARY OF FORMULAE FOR THICKNESS

ELEMENT	**THICKNESSe =**	**TOPIC**
Bottom and side Shell in the ends	$0{,}85\sqrt{L}$ *ou* $0{,}006E\sqrt{d}$ *ou* $0{,}01E$	F1.100.
Bottom amidships	$0{,}1L + 0{,}007(E - E_0) + 2{,}0$ for transversal system $0{,}1L + 0{,}007(E - E_0) + 1{,}0$ for longitudinal system	F1.200.
Inner bottom	$0{,}01 \times E$ or $0{,}0042 \times E \times \sqrt{p - 0{,}4} + c$	F1.600.
AEC	$0{,}004E\sqrt{h} + 1$ collision bulkhead $0{,}0035E\sqrt{h} + 1$ other bulkheads with minimum of $0{,}8 \times \sqrt{L}$	F2.300.
ATQ	$0{,}004 E \sqrt{h} + 2$ $0{,}8\sqrt{L}$	F2.601.
Side shell amidships	$0{,}095 L + 0{,}0063 (E-E_0) + 1{,}8$	F3.102.
Strength deck	In the ends: $0{,}85\sqrt{L}$ or $0{,}006 \times E \times \sqrt{d}$ or $0{,}01 \times E$ Amidship: $0{,}01E\sqrt{p}$ or $0{,}006 \times L + 3{,}5$ (for transverse system) and $0{,}006 \times L + 2{,}5$ (for longitudinal system) or required to meet the midship section strength	F4.101. F4.201.
Decks under strength deck	$e_{DC} = 0{,}009 \times E$ $e = 0{,}01 \times E \times \sqrt{p}$	F4.301

TABLE T.F8.101.2 - SUMMARY OF FORMULAE FOR STRENGTH MODULUS

ELEMENT	WEB MODULUSW	TOPIC
Ordinary floor and deep floor	$7\ p\ E\ l^2$	F1.502.
Bottom and double bottom longitudinal and girder	7 p E l2 (0,008 L + 1)	F1.503.
AEC practically vertical stiffener	$0{,}877\ E\ l^2\ (5\ h + 3\ senh_p)$	F2.401.
Horizontal stiffener on transversal AEC	$4{,}39\ h\ E\ l^2$	F2.403.
Longitudinal stiffener on longitudinal AEC C	$5{,}95\ E\ l^2\ h_1 Y_1$	F2.406.
ATQ practically vertical stiffener	$1{,}19\ E\ l^2\ (5\ h + 3\ 1)$	F2.701.
Horizontal stiffener on transverseATQ	$5{,}95\ h\ E\ l^2$	F2.704.
Longitudinal stiffener of longitudinal ATQ	$8{,}93\ E\ l^2\ h_1 Y_1$	F2.708.
Side shell practically vertical frames	$0{,}877\ E\ l^2\ (5\ h + 3\ l sen\alpha)$	F3.200. to F3.204.
Side shell horizontal frames	$5{,}95\ E\ l^2\ h_1 Y_1$	F3.301.
Strength deck transversal beam and and transversal and longitudinals beams of decks under strength deck	$7\ p\ E\ l^2$	F4.401.
Strength deck longitudinal beam and reinforced girder	$7\ f\ p\ E\ l^2$ $7\ p\ E\ l^2\ (0{,}008\ L + 1)$	F7.501. and F7.504.

CHAPTER H
GLOBAL DIMENSIONING OF HULL GIRDER

CHAPTER CONTENT

H1. CALCULATION OF MIDSHIP SECTION MODULI FOR BARGES AND PONTOONS [IACS UR S5]

100. Application

101. the requiments of this chapter are applicable for Barges and Pontoons in accordance with RBNA definitions.

102. For container barges and pontoons or having partially opened deck for unrestricted worldwide navigation, having length L of 90 m or above, see Title 12 of the Rules.

200. Scantlings to be taken in account

201. When calculating the midship section modulus within 0,4L amidship the sectional area of all continuous longitudinal strength members is to be taken into account.

202. Large openings, i.e. openings exceeding 2,5 m in length or 1,2 m in breadth and scallops, where scallop-welding is applied, are always to be deducted from the sectional areas used in the section modulus calculation.

203. Smaller openings (manholes, lightening holes, single scallops in way of seams, etc.) need not be deducted provided that the sum of their breadths or shadow area breadths in one transverse section does not reduce the section modulus at deck or bottom by more than 3% and provided that the height of lightening holes, draining holes and single scallops in longitudinals or longitudinal girders does not exceed 25% of the web depth, for scallops maximum 75 mm.

204. A deduction-free sum of smaller opening breadths in one transverse section in the bottom or deck area of 0,06 (B - Σb) (where B = breadth of ship, Σb = total breadth of large openings) may be considered equivalent to the above reduction in section modulus.

205. The shadow area will be obtained by drawing two tangent lines with an opening angle of 30°.

300. References

301. The midship strength section modulus is calculated on the following elements (in their levels):

a. deck at side;

b. highest point of the continuous element connected to the main deck(as hatch coaming flange or trunk deck); and

c. bottom in the center line.

207. Continuous trunks and longitudinal hatch coamings are to be included in the longitudinal sectional area provided they are effectively supported by longitudinal bulkheads or deep girders. The deck modulus is then to be calculated by dividing the moment of inertia by the following distance, provided this is greater than the distance to the deck line at side:

$$y_t = y\left(0{,}9 + 0{,}2 * \frac{x}{B}\right)$$

where:

y = distance from neutral axis to top of continuous strength member.

x = distance from top of continuous strength member to centreline of the ship.

x and y to be measured to the point giving the largest value of y_t.

303. Longitudinal girders between multi-hatchway willbe considered by special calculations.

H2. MIDSHIP SECTION STRENGTH FOR BARGE AND PONTOONS WITH L <90 m

100. Application

101. This sub-chapter applies to barges and pontoons with L < 90 m.

200. Minimum required midship section modulus

201. The minimum cross scantling section modulus, SM_{min} is to be obtaneid from the equation below:

$$SM_{min} = 0{,}01 \times C_1 \times L^2 \times B \times (C_b + 0{,}7)\, k \quad cm^2 \times m$$

where:

C_1 = wave Coefficient defined in accordance with the length of the ship.

$C_1 = C_n$ for new ships

$= 0,9\ C_n$ for ships in service

L = length defined in Title 11, section 1, sub-chaper A2.

C_b = Rule block coefficient, C_b is not to be taken less than 0,60.

$C_n = 4,12$ for $30\ m \le L < 45\ m$

$C_n = 0,092L-0,02$ for $45\ m \le L < 60\ m$

$C_n = 0,0451L+3,65$ for $60\ m \le L < 90\ m$

$C_n = 10,75 - \left(\frac{300-L}{100}\right)^{3/2}$ for $90\ m \le L \le 300\ m$

$C_n = 10,75$ for $300\ m < L < 350\ m$

$C_n = 10,75 - \left(\frac{L-350}{150}\right)^{3/2}$ for $350\ m \le L \le 500 m$

k = material factor

k = 1,0 for ordinary hull structural steel

k < 1,0 for higher tensile steel according with C3.200.

202. The calculation of the actual midship section modulus should be submitted to RBNA for approval.

203. The Table T.H2.203.1. is presented for this calculation, as a reference.

204. When the modulus found W is found smaller than the WR (modulus required by the Rules), the following formula can be used, which gives the required area to be added at the deck level, on each board, to achieve this modulus WR:

$$a_R = \frac{(W_R - W) \times S_a}{(D - zF) \times S_a - (W_R - W)}$$

where:

a_R: area to be added;

S_a: sum of the areas from one board of the longitudinal elements of the midship section; and

z_F: distance from the baseline to the neutral axis.

205. The following formulae are indicatedas a reference for circular section of the bilge plate:

a. for circular bilge plata:

vertical distance to the base: $d = 0,362 \times R$

inertia: $i = 0,149 \times R^3 \times e$

area: $a = 1,571 \times R \times e$

where:

R: bilge radius

e: bilge thickness

b. for straight section of the bilge plate:

$i = a/2 * (e^2 * \cos^2\theta + h^2 * \mathrm{sen}^2\theta)$

where:

h : length of the section (m);

θ : slope of the bilge with the horizontal.

300. Midship inertia [IACS UR S11 3.1.2]

301. Moment of inertia of hull section at the midship point is not to be less than:

$I_{min} = 3 C_1 L^3 B (C_b + 0,7)$ cm^4

where:

C_1, L, B, C_b as specified in H2.201.

TABLE T.H2.203.1. - MIDSHIP STRENGTH AND INERTIA

CONFIGURATION:

ITEM	ELEMENT	DIMENSION b	DIMENSION h	Qt	a	d	a.d	a.d²	i
		cm	cm	n	cm^2	m	$cm^2.m$	$cm^2.m^2$	$cm^2.m^2$
					Σ a		Σa.d	Σ a.d	Σi

where:

b: horizontal dimension of the element;

h: vertical dimension of the element;

d: distance of the Neutral Axis to each element to the (LB) Base Line (reference axis);

i: own moment of inertia;

u: height of the top of the coaming or trunk above D; and

EN: neutral axis (of the own intertia) of the midship section

Distance from EN to LB: $zb = \frac{\Sigma(a \times d)}{\Sigma a} =$ Distance from the EN to the deck at side :zC = D – zF

Inertia: I= $\Sigma i + \Sigma(a \times d^2) - \frac{\Sigma(a \times d)}{\Sigma a} =$ Distance from the EN to top of the coaming: zU = zC + u

Modulus in the bottom: $Wb = \frac{I}{zF} =$ Modulus in the deck: WC = $\frac{I}{z_D}$

Modulus in the top of the continuous coaming: WU $= \frac{I}{z_B}$

Notes:
1) Consider only the continuous material of the coaming.
2) Consider the deck of the trunk.

H3. VERIFICATION OF THE GLOBAL-STRENGTH FOR BARGES ANDPONTOONS WITH L < 90 m

100. Still water bending moment

101. The still water bending moment Mc is calculated from the distribution of lightship weights, listed in the cargo booklet, in the departure, arrival or service conditions, with cargo or ballast, with list of data and the calculation method used.

102. The calculation should begin from the cargo ordinates per meter, inserting values before and after of bulkheads, or other marks, where the loading varies discontinuously.

103. 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 to RBNA.

104. For the condition of approximately uniform distribution of load, TableT. H3.202.2.can be used.

105. When the boarding of the cargo is performed in a ship with a single hold in one single pass, the bending moment should be calculated for the loading conditionswhich contemplate 60% of the total permissible cargo occupying only the hold abaft the midship sectionor only the hold forward the midship section.

106. In the case of a single hold, the bending moment should be calculated for the condition of half load occupying 40% of the hold length amidships.

107. In the two conditions above, stresses in the deck level and at the level of the upper edge of the continuous coaming are calculated only for the bending moment in the still water.

200. Wave loads [IACS UR S11.2.2.]

201. When the wave bending moment is not made by direct calculation, the moment caused by the waves, in special for vessels of $L \geq 60$ m, is to be calculated by the equations showed in H5.202.

300. Total longitudinal bending moment

301. The total longitudinal bending moment is the sum of the moment in still water with the moment caused by waves, for a given loading, given by:

$$Mt = M_c + M_w \qquad (t \times m)$$

where:

M_c: Still water bending moment $(t \times m)$; and

M_w: Wave moment $(t \times m)$.

400. Wave torsional moment

– See Paragraph H1.102.

TABLE T.H3.104.1. STILL WATER BENDING MOMENT MIDSHIPS ESTIMATION FOR SHIPS WITH L < 90 M

VESSEL: **TYPE:**

1. VESSEL DATA
L = **D =** **B =** **dmax =**

2. CONDITION DATA
Displacement = **Cb =** **d =**

3. LOAD / CONSUMABLE DISTRIBUTION

ABAFT OF Φ					**FWD OF Φ**				
ITEM	NAME	WEIGHT	DIST. TO Φ	MOMENT	ITEM	NAME	WEIGHT	DIST. TO Φ	MOMENT
	Σ PR		ΣMR			ΣPV		ΣMV	

VERIFICATION: Displacement = Σ PR + Σ PV + PH

4. MOMENT OF THE HULL WEIGHT PH IN RELATION TO AMIDSHIP

MACHINERY AMIDSHIPS: MH = PH × 0,224 × L.
MACHINERY AFT: MH = PH × 0,24 × L.

5. MOMENT IN STILL WATER: MC = 0,5 × [Σ Mr + ΣMv - Displac× (0,19 ×Cb + 0,056) × L]

(+) indicating HOGGING
(-) indicating SAGGING

500. Stresses

501. The fulfilment of the following equationis to be checked:

$$\sigma RL \leq \left(18 - \frac{14}{0{,}008xL + 1}\right) daN/mm^2$$

where$\sigma_{RL}$is calculated by the equation:

$$\sigma_{RL} = 10 \times \frac{Mt}{W}$$

where:

Mt : total bending moment in t × m; and

W : strength modulus of the midship section in cm²×m, withvalues for the elements cited on paragraph H1.207.:

502. On top of continuous coaming and trunk the stress should not exceed 12,3 daN/mm² (12,5 kgf/mm²).

Note: attention is to be drawn to the fact that, with higher continuous hatch coaming in respect to the depth, the material of the upper flange of the coaming will work with higher stresses than the longitudinal deck material.

H4. MIDSHIP SECTION STRENGTH FOR BARGES AND PONTOONS WITH L ≥ 90 m [IACS UR S7]

Note: this requirement is subject to periodical updating of IACS.

100. Application

101. This topic does not apply to CSR Bulk Carriers and Oil Tankers.

200. Minimum midship modulus

201. The minimum midship section modulus at deck and keel for ships 90 m ≤ L ≤ 500 m and made of hull structural steel is

$W_{min} = cL^2B(Cb + 0{,}7)k$ (cm^3)

where:

L = Rule length (m)

B = Rule breath (m)

Cb = Rule block coefficient: Cb is not to be taken less than 0,60

$c = c_n$ for new ships
$= c_s = 0{,}9\ c_n$ for ships in service

$cn = 10{,}75 - \left(\frac{300-L}{100}\right)^{3/2}$ for 90 m ≤ L ≤ 300 m

$cn = 10{,}75$ for 300 m < L < 350 m

$cn = 10{,}75 - \left(\frac{L-350}{150}\right)^{3/2}$ for 350 m ≤ L ≤ 500 m

k = material factor

k = 1,0 for ordinary hull structural steel

k < 1,0 for higher tensile steel according to Criteria for the Use of High Tensile Steel withMinimum Yield Stress of 315 N/mm^2, 355 N/mm^2 and 390 N/mm^2. **[IACS UR S4]**

202. Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement in Paragraph 201. are to be maintained within 0,4 L amidships. However, in special cases, based on consideration of type of ship, hull form and loading conditions, the scantlings may be gradually reduced towards the end of the 0,4 L part, bearing in mind the desire not to inhibit the vessel's loading flexibility. **[IACS UR S7.2]**

203. In ships where part of the longitudinal strength material in the deck or bottom area are forming boundaries of tanks for oil cargoes or ballast water and such tanks are provided with an effective corrosion protection system, certain reductions in the scantlings of these boundaries are allowed. These reductions, however, should in no case reduce the minimum hull girder section modulus for a new ship by more than 5%. **[IACS UR S7.3]**

Notes:

1. The above standard refers in unrestricted service with minimum midship section modulus only. However, it may not be applicable to ships of unusual type or design, e.g. for ships of unusual main proportions and/or weight distributions.

2. *'New Ships'* are ships in the stage directly after completion.

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