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

TITLE 11 SHIPS IN GENERAL

SECTION 2 STRUCTURE

CHAPTERS

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CHAPTER A
SCOPE

CHAPTER CONTENT

A1. APPLICATION

100. Types of ship missions

101. The presentTitle 11 applies to the common structures of all ships. In general, whose type/service is for the carriage of dry general cargo.

102. The items of IACS – International Association of Classification societies,where applicable, were incorporated.

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 O2	≤ 18 ≤ 16	≤ 4 ≤ 3	≤ 22 ≤ 20	≤ 5 ≤ 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 D1should be used, obtained by:

$$D1 = D + hTx\,\frac{b}{B}$$

where:

hT : 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:raiseddeck in relation to deck at side, along the centerline 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.

CSR- Common Structural Rules: adopted common rules by IACS for oil tanker, bulk carrier, ore carrier, combination carrier, ore/oil carrier, oil/bulk/ore carrier and chemical tanker.

ESP- Enhanced SurveyProgramme:IMOInternational Code on the Enhanced Programme of Inspections During Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP code).

A3. TOPOLOGIES

100. Sea going vessels with the topology of hull girder types "A" and "B"

101. Topologies of types "A" and "B" are defined on ILLC-International Load Line Convention, Rule 27.

200. Dredgers

201. The dredgers that have chosen the classification for Inland Navigation in Area 2, which operate in dumping or dredging outside the limits of this area, are framed as type "B" ship, according to NORMAM 01 (Brazilian Maritime Authority Regulations for Open SeaNavigation). They should meet the additional requirements of NORMAM 02 (Brazilian Maritime Authority Regulations for Inland Navigation).

202. Dredgers operating exclusively in inland navigation, in any conditions, are framed as, ship type "C", according to NORMAM 02.

300. Ship typesin the Enhanced Survey Program (ESP)

301. **Oil Tanker:** The ship type notation "OIL TANKER", or equivalent, and the notation "ESP" shall be assigned to sea going self-propelled shipswhich are constructed generally with integral tanks and intended primarily to carry oil in bulk. This type notation shall be assigned to tankers of both single and double hull construction, as well as tankers with alternative structural arrangements, e.g. mid-deck designs. Typical midship sections are given in Figures F.A3.401.1., F.A3.401.2.and F.A3.401.3. Oil Tankers that do not comply with MARPOL I/19 may be subject

to International and/or National Regulations requiring phase out under MARPOL I/20 and/or MARPOL I/21.

302. **Bulk Carrier:** The ship type notation "BULK CARRIER", or equivalent, and the notation "ESP" shall be assigned to sea going self-propelled ships which are constructed generally with single deck, double bottom, hopper side tanks and topside tanks and with single or double side skin construction in cargo length area and intended primarily to carry dry cargoes in bulk. Typical midship sections are given in Figure F.A3.402.1., F.A3.402.2., F.A3.402.3., and F.A3.402.4.

303. The ship type notation **"ORE CARRIER"**, or equivalent, and the notation "ESP" shall be assigned to sea going self-propelled which are constructed generally with single deck, two longitudinal bulkheads and a double bottom throughout the cargo length area and intended primarily to carry ore cargoes in the centre holds only. Typical midship sections are given in Figure F.A3.403.1.

304. **Combination Carrier:**

a. "**Combination carrier**" is a general term applied to ships intended for the carriage of both oil and dry cargoes in bulk; these cargoes are not carried simultaneously, with the exception of oily mixture retained in slop tanks. The ship types defined in .b) and .c) below shall be considered to be combination carriers.

b. The ship type notation "**ORE/OIL CARRIER**", or equivalent, and the notation "ESP" shall be assigned to sea going self-propelled ships which are constructed generally with single deck, two longitudinal bulkheads and a double bottom throughout the cargo length area and intended primarily to carry ore cargoes in the centre holds or of oil cargoes in centre holds and wing tanks. A typical midship sections are given in Figure F.A3.404.1. ORE/OIL carriers that do not comply with MARPOL I/19 may be subject to International and/or National Regulations requiring phase out.

c. The ship type notation "**OIL/BULK/ORE (OBO) CARRIER**", or equivalent, and the notation "ESP" shall be assigned to sea going self-propelled ships which are constructed generally with single deck, double bottom, hopper side tanks and topside tanks, and with single or double side skin construction in the cargo length area, and intended primarily to carry oil or dry cargoes, including ore, in bulk. Typical midship sections are given in Figure F.A3.404.2. OIL/BULK/ORE carriers that do not comply with MARPOL I/19 may be subject to International and/or National Regulations requiring phase out.

305. **Chemical Tankers:** The ship type notation "**CHEMICAL TANKER**", or equivalent, and the notation "ESP" shall be assigned to sea going self-propelled ships which are constructed generally with integral tanks and intended primarily to carry chemicals in bulk. This type notation shall be assigned to tankers of both single or double hull construction, as well as tankers with alternative structural arrangements. Typical midship sections are given in Figure F.A3.405.1.Reference is made to the IBC code for ships type 1, 2 or 3.

400. General dry cargo ships

401. General dry cargo ships: Figure F.A3.501.1.shows typical configurations of single deck and tween deck general cargo ships, respectively.

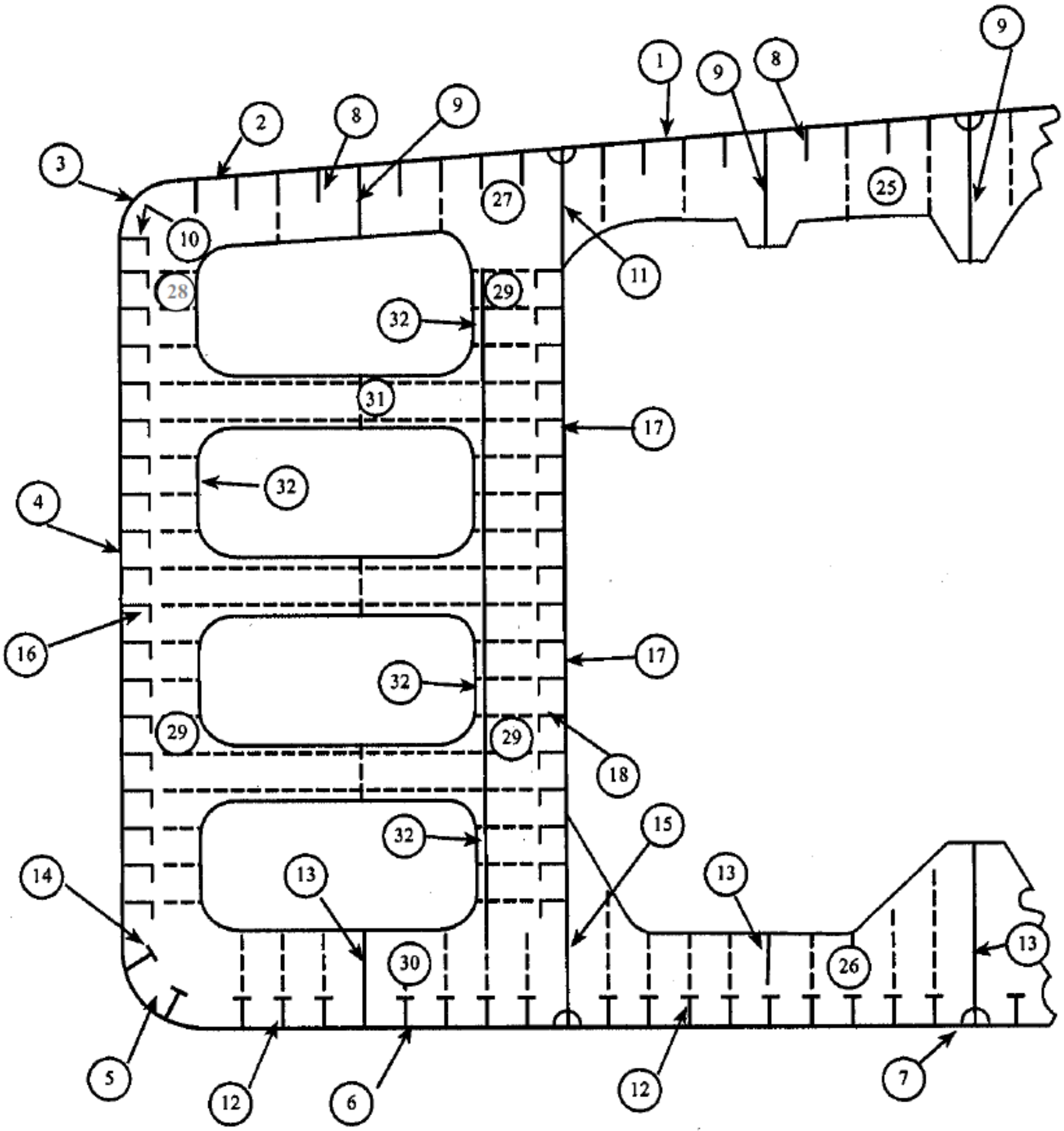
500. Liquefied gas carriers

501. Reference is made to the IGC code for liquefied gas carriers ships type. Figures F.A3.601.1.and F.A.601.2.shows typical transverse sections of gas carriers.

600. Container ships

601. Figure F.A3.701.1.shows typical transverse sections of container ships.

FIGURE F.A3.401.1 –NOMENCLATURES



1	Strength deck plating	14	Bilge longitudinals
2	Stringer plate	15	Longitudinal bulkhead lower strake
3	Sheer strake	16	Side shell longitudinals
4	Side shell plating	17	Longitudinal bulkhead plating
5	Bilge plating	18	Longitudinal bulkhead longitudinals
6	Bottom shell plating	25	Deck transverse centre tank
7	Keel plate	26	Bottom transverse centre tank
8	Deck longitudinals	27	Deck transverse wing tank
9	Deck girders	28	Side shell vertical web
10	Sheer strake longitudinal	29	Longitudinal bulkhead vertical web
11	Longitudinal bulkhead top strake	30	Bottom transverse wing tank
12	Bottom longitudinals	31	Cross ties
13	Bottom girders	32	Transverse web face plate

FIGURE F.A3.401.2 - SHIP TYPE AND ENHANCED SURVEY PROGRAMME (ESP) NOTATIONS TYPICAL MIDSHIP SECTION –DOUBLE HULL OIL TANKER

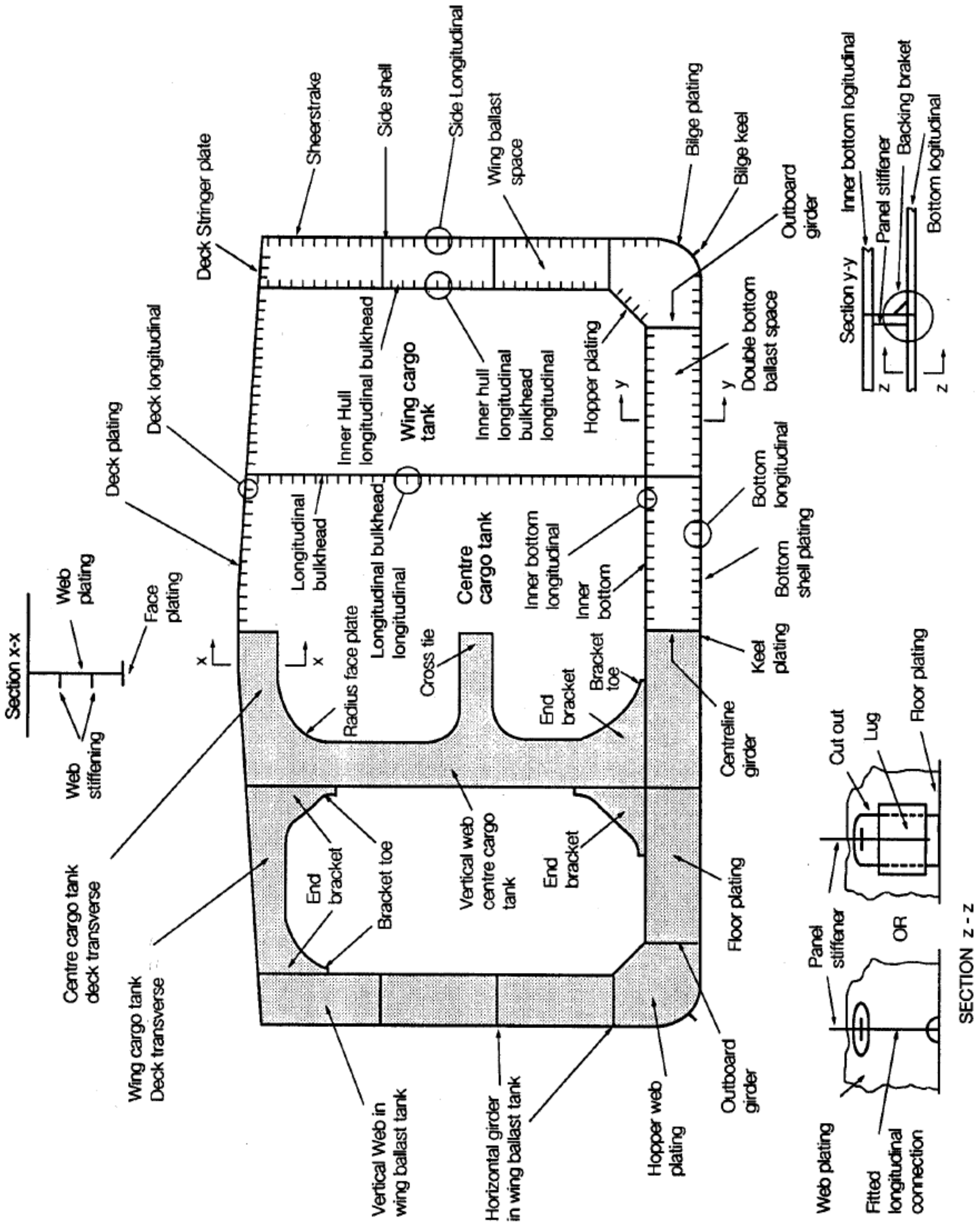
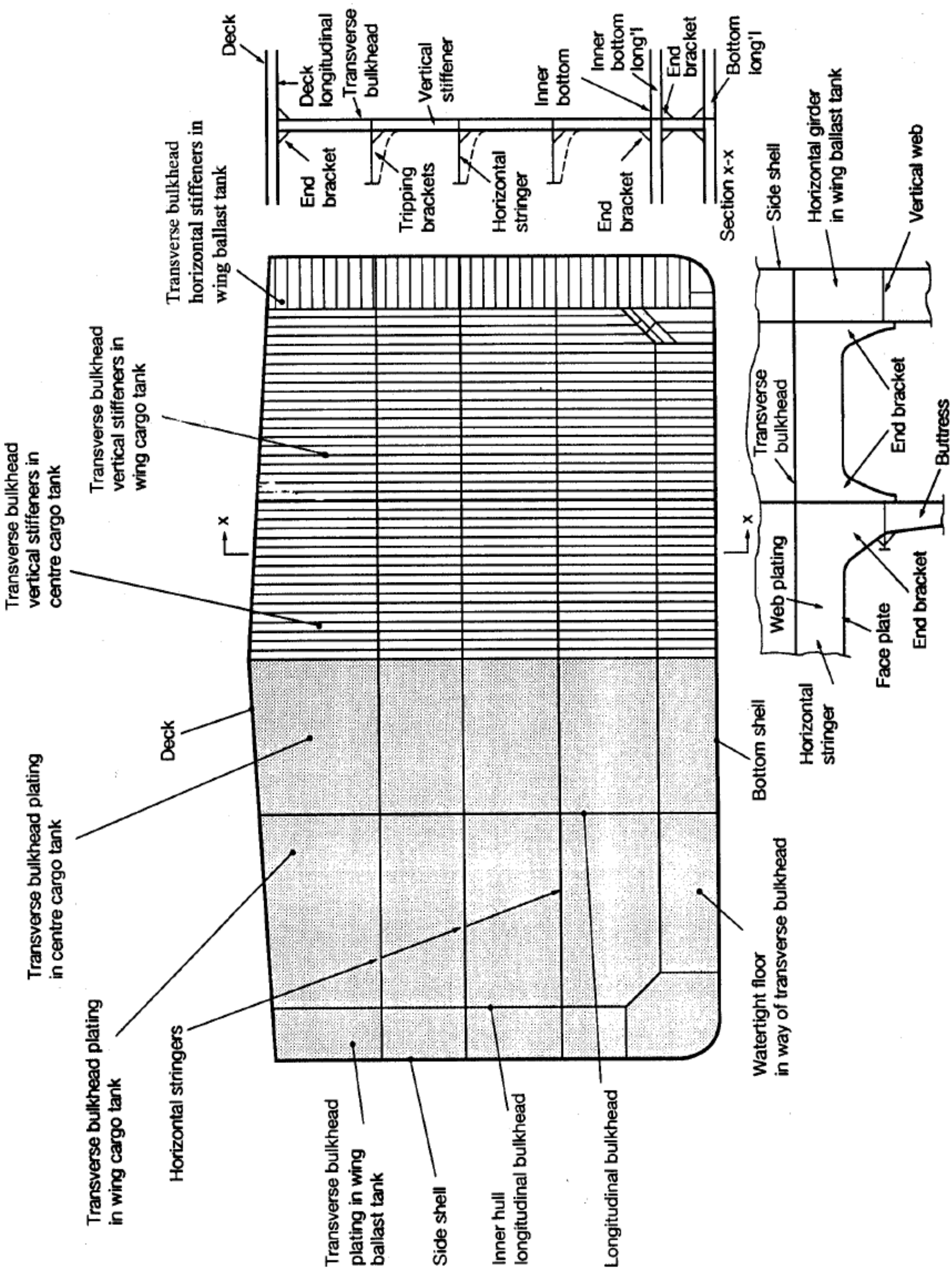
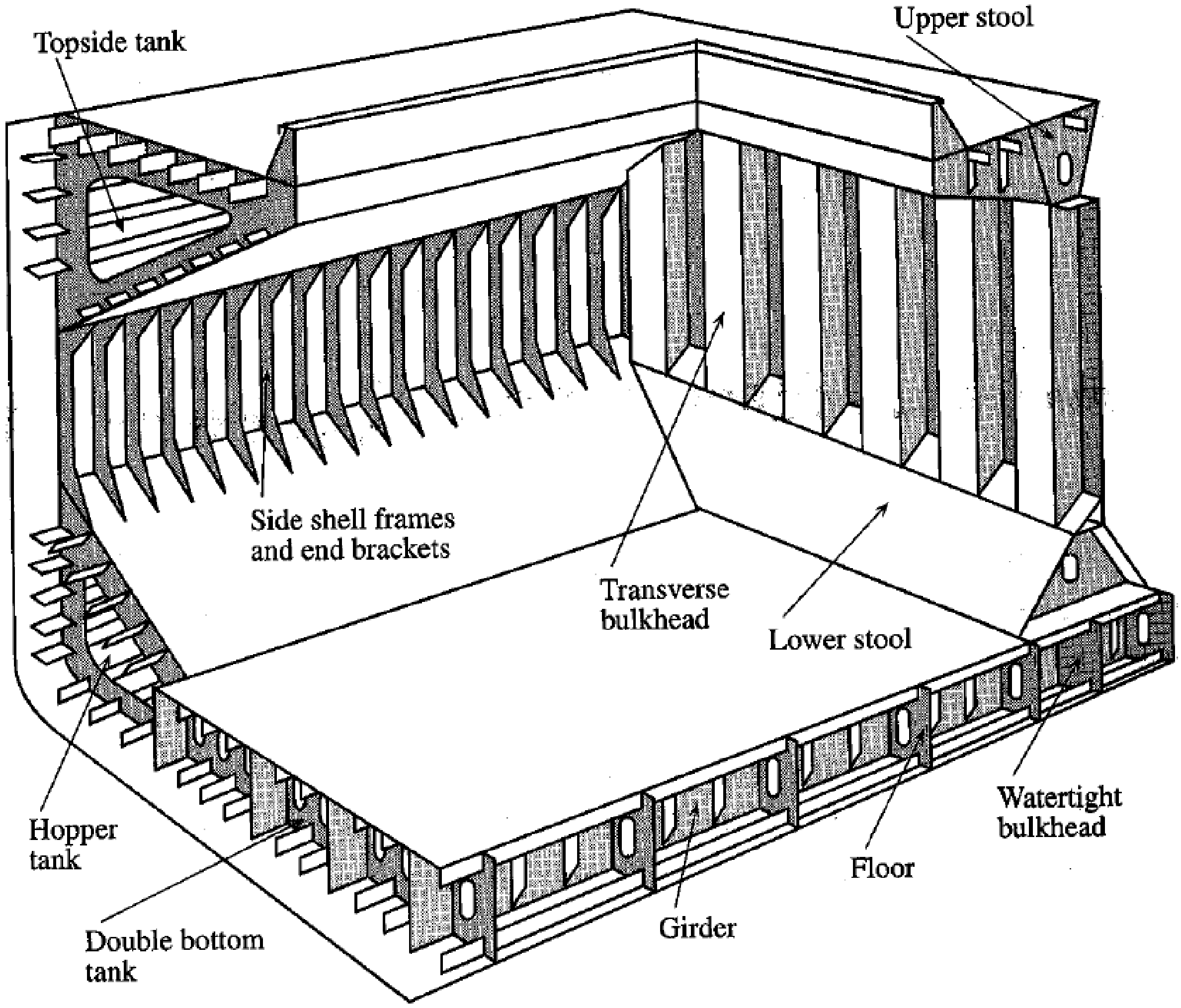


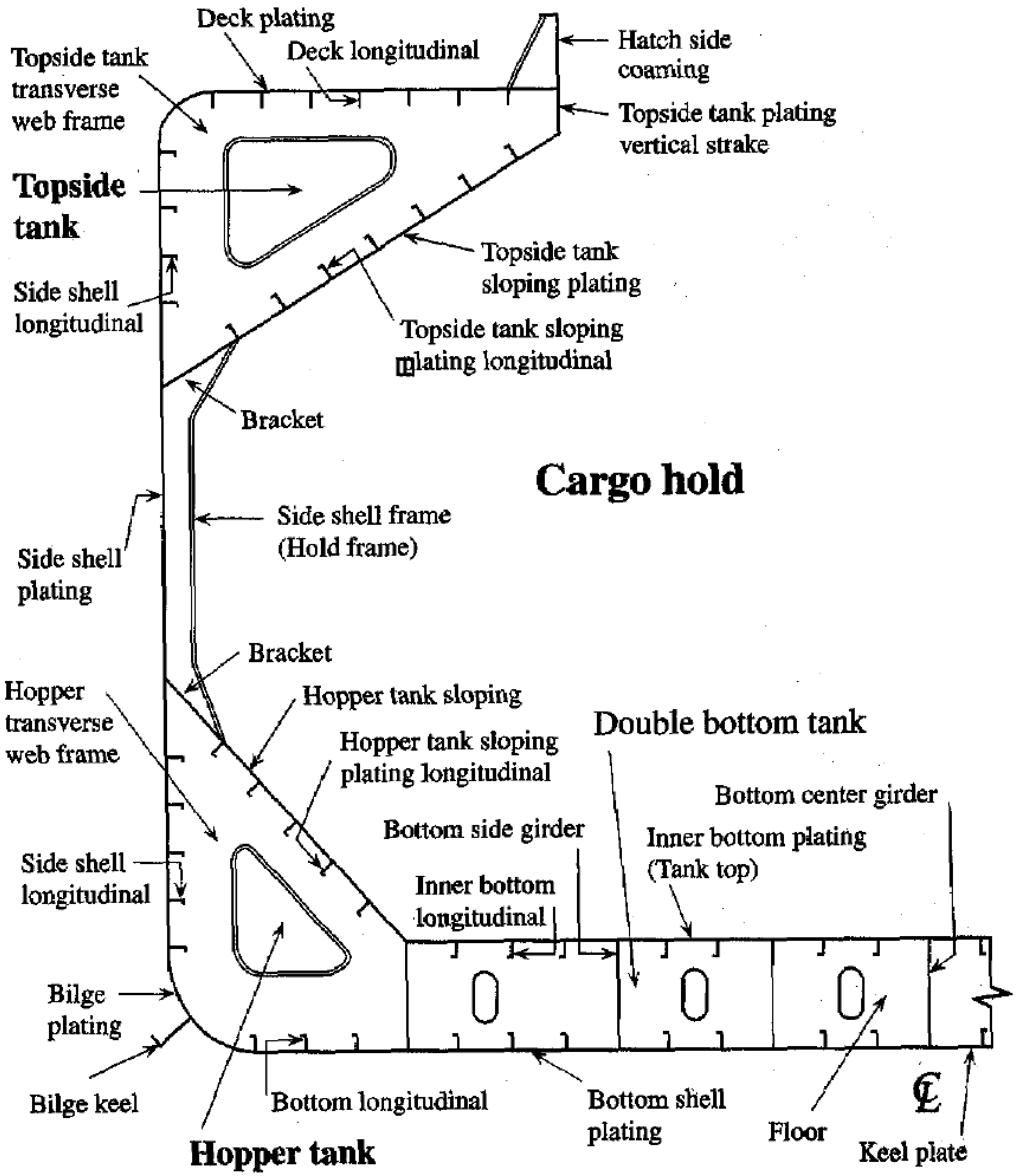
FIGURE F.A3.401.3 - SHIP TYPE AND ENHANCED SURVEY PROGRAMME (ESP) NOTATIONS TYPICAL MIDSHIP SECTION – DOUBLE OIL TANKER TYPICAL TRANSVERSE BULKHEAD



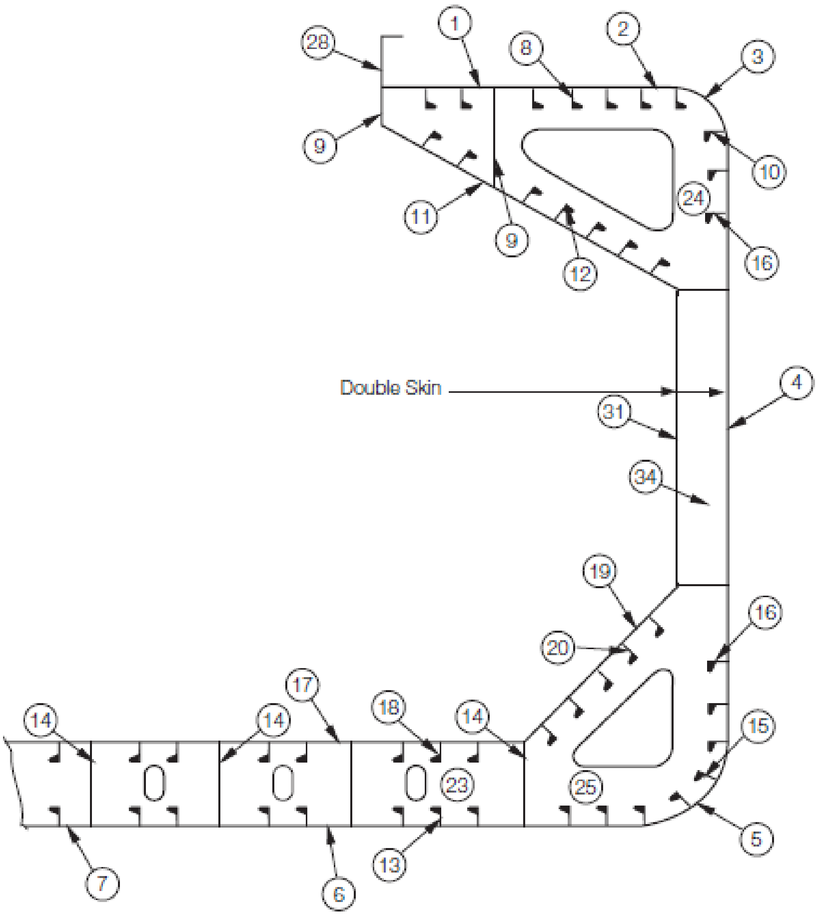
F.A3.402.1. - SINGLE HULL BULK CARRIER: CARGO HOLD TYPICAL STRUCTURAL CONFIGURATION



F.A3.402.2. - SINGLE HULL BULK CARRIER: CARGO HOLD TYPICAL TRANSVERSE SECTION



F.A3.402.3. - DOUBLE HULL BULK CARRIER: CARGO HOLD TYPICAL TRANSVERSE SECTION



Report on TM2-DSBC (i) & (ii)	
1.	Strength deck plating
2.	Stringer plate
3.	Sheerstrake
4.	Side shell plating
5.	Bilge plating
6.	Bottom shell plating
7.	Keel plate

Report on TM3-DSBC			
8.	Deck longitudinals	17.	Inner bottom plating
9.	Deck girders	18.	Inner bottom longitudinals
10.	Sheerstrake longitudinals	19.	Hopper plating
11.	Topside tank sloping plate	20.	Hopper longitudinals
12.	Topside tank sloping plate longitudinals	31.	Inner side plating
13.	Bottom longitudinals	-	Inner side longitudinals, if any
14.	Bottom girders	-	Horizontal girders in wing ballast tanks
15.	Bilge longitudinals		
16.	Side shell longitudinals, if any		

Report on TM4-DSBC	
23.	Double bottom tank floors
25.	Hopper side tank transverses
34.	Transverse web frame
-	Topside tank transverses

Report on TM6-DSBC	
28.	Hatch coamings
-	Deck plating between hatches
-	Hatch covers

F.A3.402.4. - BULK CARRIER: TYPICAL TRANSVERSE WATERTIGHT BULKHEAD

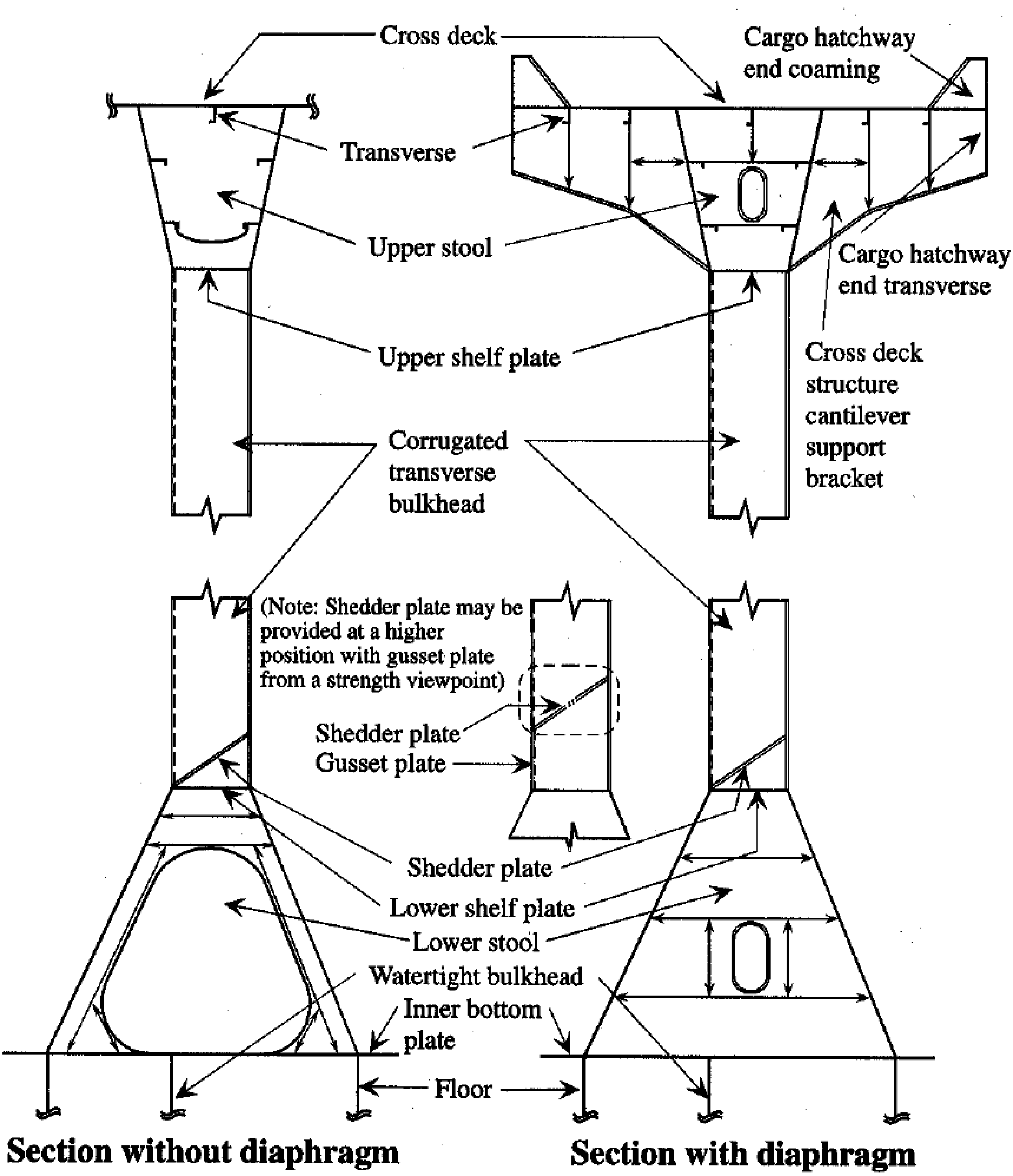
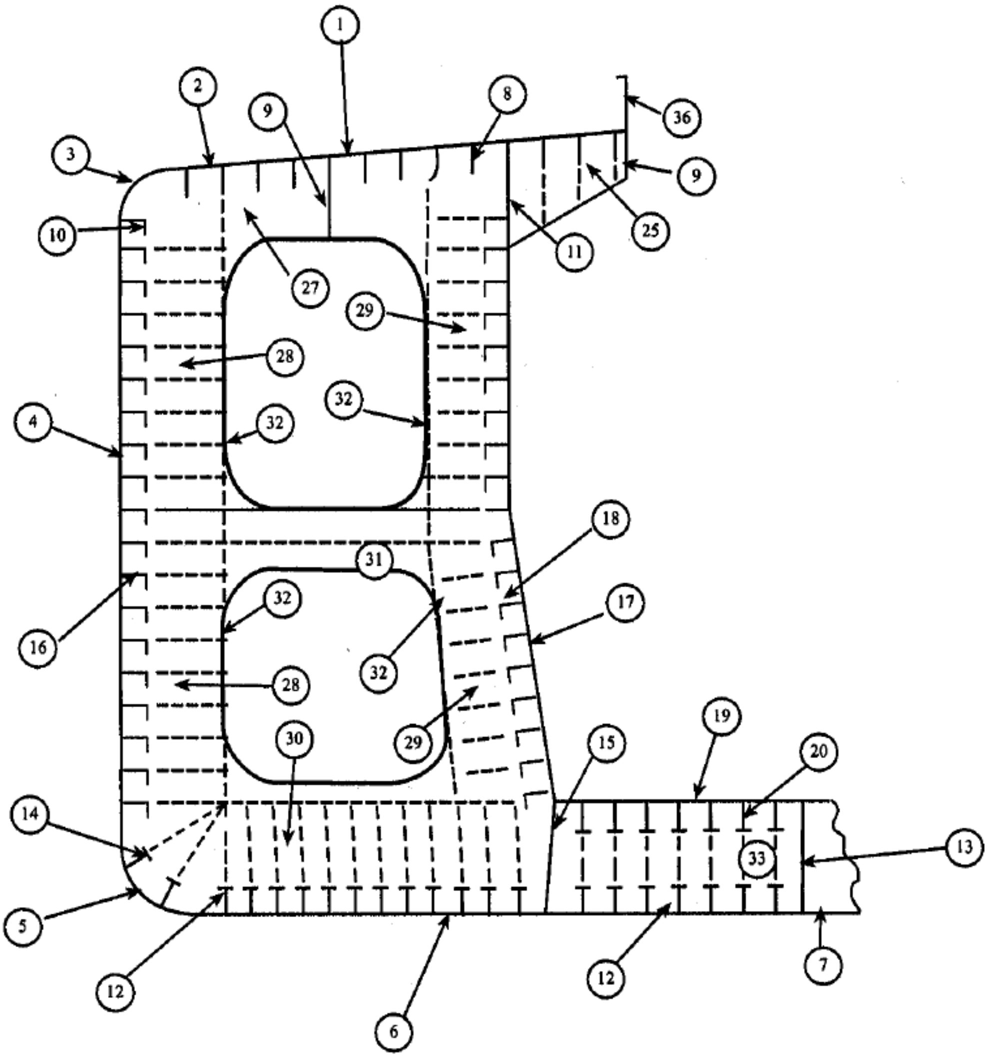


FIGURE F.A3.403.1 - SHIP TYPE AND ENHANCED SURVEY PROGRAMME (ESP) NOTATIONS TYPICAL MIDSHIP SECTION – SINGLE HULL ORE CARRIER



1	Strength deck plating	16	Side shell longitudinals
2	Stringer plate	17	Longitudinal bulkhead plating
3	Sheer strake	18	Longitudinal bulkhead longitudinals
4	Side shell plating	19	Inner bottom plating
5	Bilge plating	20	Inner bottom longitudinals
6	Bottom shell plating	25	Deck transverse centre tank
7	Keel plate	26	Bottom transverse centre tank
8	Deck longitudinals	27	Deck transverse wing tank
9	Deck girders	28	Side shell vertical web
10	Sheer strake longitudinal	29	Longitudinal bulkhead vertical web
11	Longitudinal bulkhead top strake	30	Bottom transverse wing tank
12	Bottom longitudinals	31	Cross ties
13	Bottom girders	32	Transverse web face plate
14	Bilge longitudinals	33	Double bottom floor
15	Longitudinal bulkhead lower strake	36	Hatch coamings

FIGURE F.A3.404.1 – ORE / OIL CARRIERS: TYPICAL STRUCTURAL CONFIGURATIONS

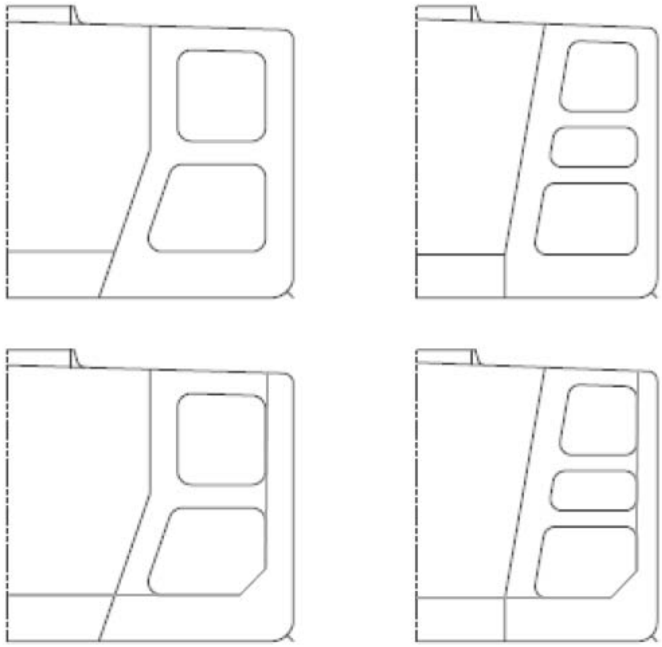
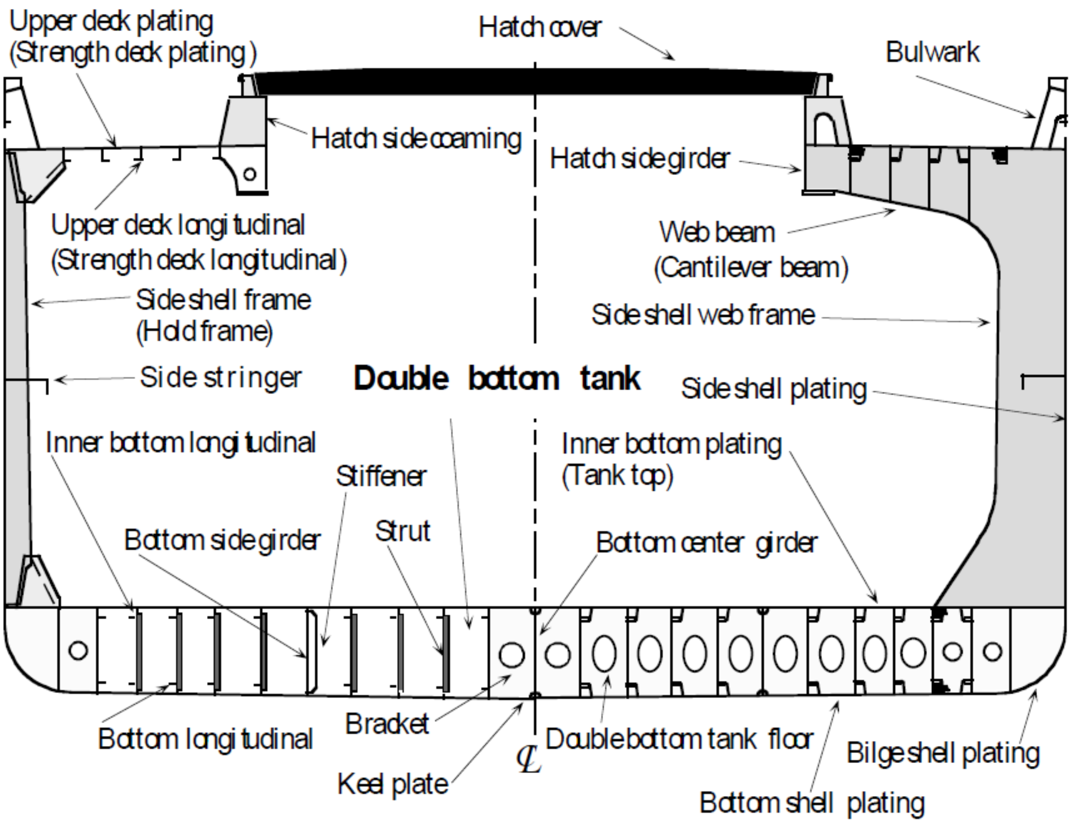


FIGURE F.A3.405.1. - GENERAL DRY CARGO SHIPS: SINGLE DECK AND TWEENDECK TYPICAL CARGO HOLD TRANSVERSE SECTIONS



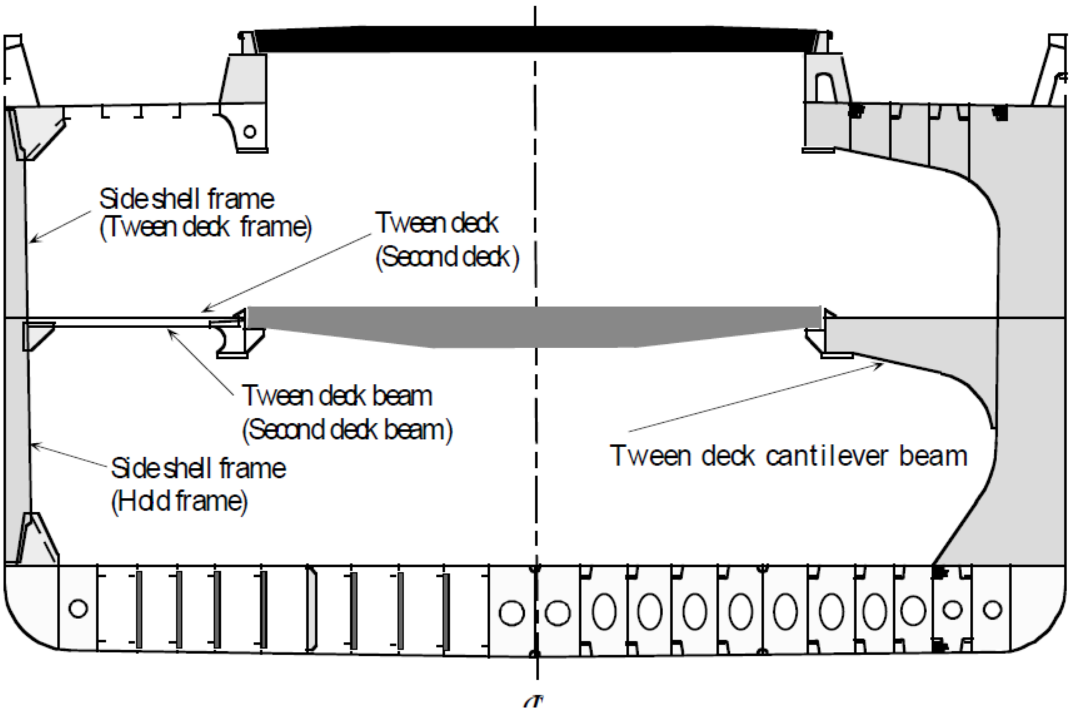


FIGURE F.A3.406.1. – LIQUEFIED GAS CARRIERS TYPICAL TRANSVERSE SECTIONS

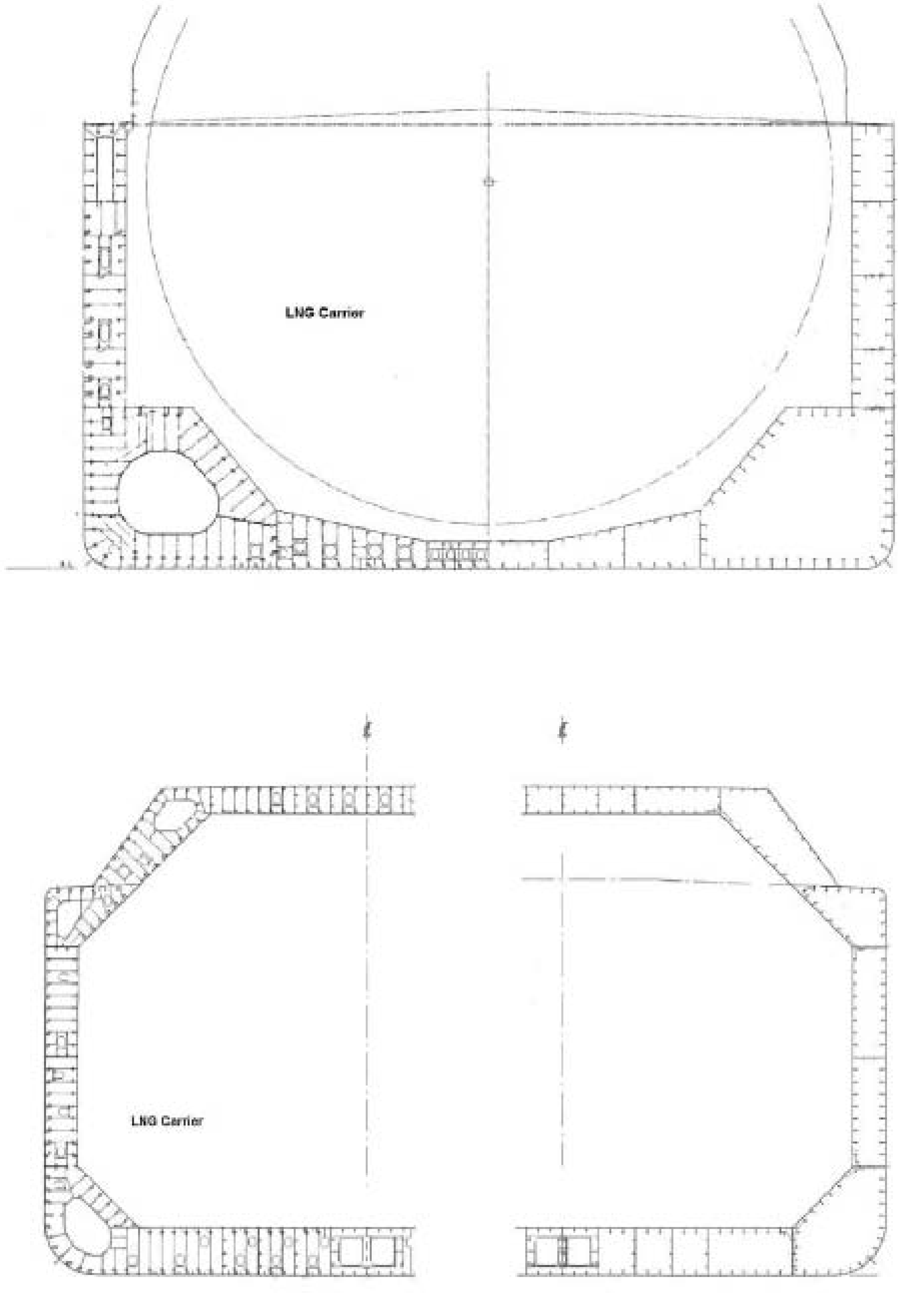
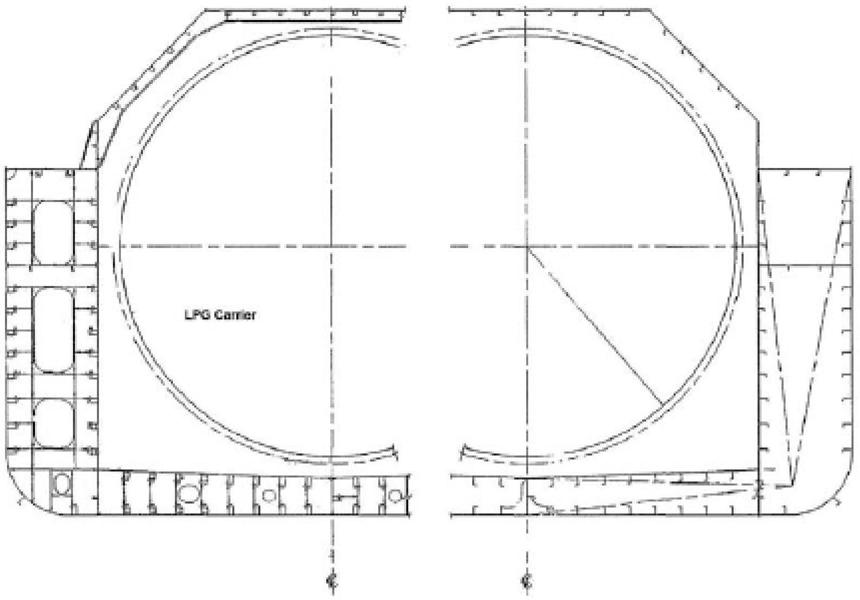


FIGURE F.A3.407.2. – LIQUEFIED GAS CARRIERS TYPICAL TRANSVERSE SECTIONS



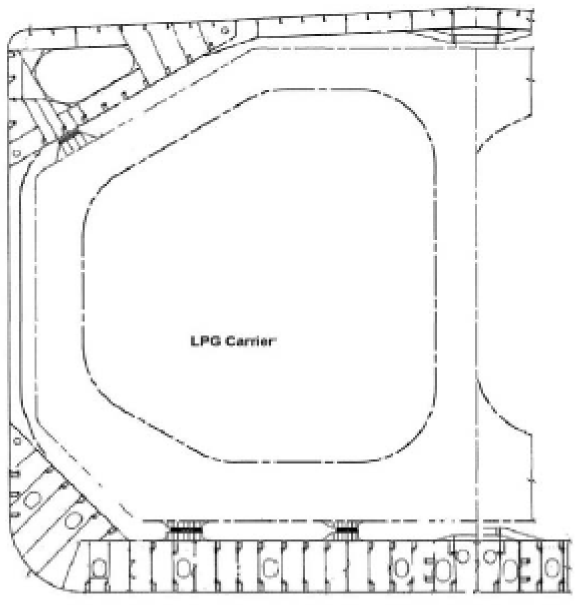
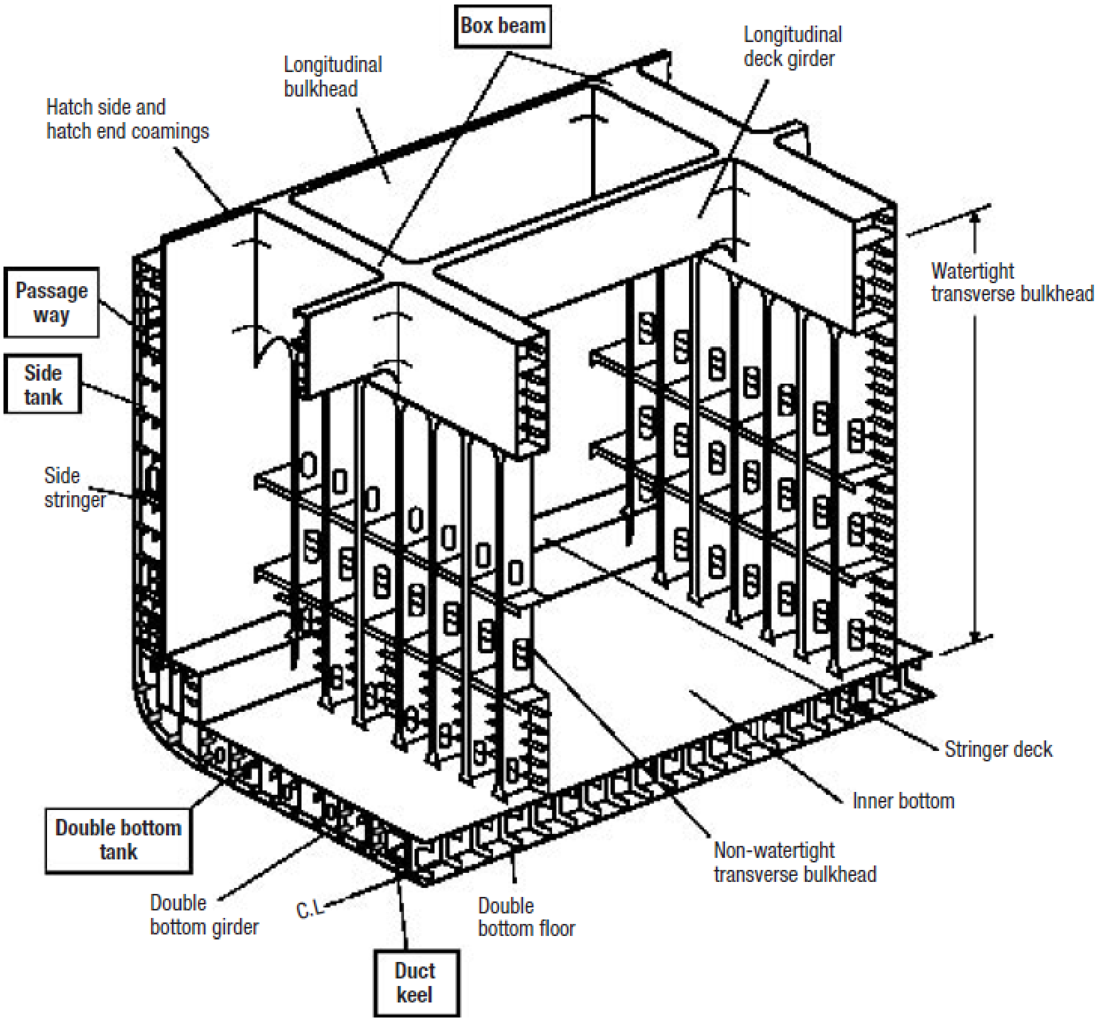


FIGURE F.A3.701.1. - TYPICAL CARGO HOLD CONFIGURATION FOR A CONTAINER SHIP



CHAPTER B
DOCUMENTS, REGULATIONS AND STANDARDS

CHAPTER CONTENT

B1. DOCUMENTATION OF THE SECTION OF-STRUCTURE

100. Documents of the ship

101. The documents of the structure of the ship to be approved by RBNA, in non-exclusive list, are:

a. scantling profile, with profile in the centerline, bottom and double bottom, longitudinal bulkheads and decks;

b. Midship section containing:

c. principal dimensions;

d. Maximum structural draft;

e. Spacing of longitudinal and transversal members;

f. CLASS Notation selected, (with the mention of navigation zone and the service/activity, numeral and anchoring and mooring equipment;

h. Other cross sections in regard to local accidents or discontinuities;

i. Ordinary watertight bulkheads and tank bulkheads, with indication of the height of overflows and venting pipes;

j. Side shell;

k. Hull plating expansion;

l. Sternframe with stern post, shaft struts, etc.;

m. Stem with chain locker openings, mooring pipes, etc.

n. Superstructures and deckhouses;

o. Appendages to the structure, as hatch coamings, masts, bulwark, bedplates of engine and important equipment with adjacent structure and details etc.;

p. Light weight distribution along the length;

q. Longitudinal strength, with bending moments, shear forces and midship section modulus; and

r. Welding planning and bevel scheme of the plates for welding.

200. Documents of components

201. Certificates of inspection and testing of materials and components of the structure are part of the documentation made by RBNA.

300. Documents of workmanship

301. Certificates of inspection and testing of workmanship (welders and where relevant) used in the structure are part of the documentation made by RBNA.

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 ≥ 500.

B3. STANDARDS

100. Equivalent standards

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

102. The present Chapter is according to the **IACS UR-S** unified requirements.

CHAPTER C
MATERIALS AND WORKMANSHIP

CHAPTER CONTENT

C1. BASIC CHARACTERISTICS OF THESTRUCTURAL STEEL

100. Steels 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 pointReH of 235 N/mm2 and a tensile strength Rm of 400 – 520 N/mm2. (See Table T.C3.103.1 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, Title61, Section 2 or indicatedin Table T.C3.101.1., the scantlings may be changed by the ratios:

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

$\sqrt{\dfrac{235}{RY}}$ (in N/mm²)

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

$\dfrac{235}{RY}$ (in N/mm²)

C3. USE OF STEEL GRADES FOR VARIOUS HULL MEMBERS – SHIPS OF 90 m IN LENGTH AND ABOVE [IACS UR-S4 and UR S6]

100. Application

Note: These URs do not apply to CSR Bulk Carriers and Oil Tankers.

101. Table T.C3.101.1.[UR S6 Table 6] 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-stressReH,in N/mm²	Ultimate minimum tensile strength Rm, in N/mm²
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

provided that the moment of inertia of the midship section is not less than:

Imin = 3 Wmin L (cm4)

Y = minimum yield stress

L = Rule length of ship (m)

Wmin = minimum mild steel section modulus (cm^2) as given for a new ship in Part II, Title 11, Sub-chapter H3.Any reduction for corrosion control is not to be taken account of. **IACS UR S7**

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 T.C3.401.7., T.C3.502.8 and T.C3.502.9

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 Sub-chapter C3.Topic 200., for three groups of higher strength hull structural steels, the nominal upper yield stress ReH has been fixed according to Table T.C3.101.1.

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.

400. Steel for ships in normal worldwide service

401. Materials in the various strength members are not to be of lower grade than those corresponding to the material classes and grades specified in Table T.C3.401.1.to Table T.C3.401.7.. General requirements are given in Table T.C3.401.1. [UR S6 Table 1] - Material Classes and Grades for Ships in General, while additional minimum requirements are given in the following:

a. table T.C3.401.2. [UR S6 Table 2] - Minimum Material Grades for Ships, excluding Liquefied Gas Carriers covered in Table T.C3.401.3., with Length exceeding 150 m and Single Strength Deck;

b. table T.C3.401.3. [UR S6 Table 3] - Minimum Material Grades for ships with length exceeding 150 m; Note:

c. table T.C3.401.3. is applicable to membrane type liquefied gas carriers with deck arrangements as shown in Figure F.C3.401.1. may apply to similar ship types with a “double deck” arrangement above the strength deck.

d. table T.C3.401.4.**[UR S6 Table 4]** - Minimum Material Grades for ships with length exceeding 250 m;

e. table T.C3.401.5.**[UR S6 Table 5]** - Minimum Material Grades for single-side skin bulk carriers subjected to SOLAS regulation XII/6.5.3;

f. table T.C3.401.6. [UR S6 Table 6] - Minimum Material Grades for ships with ice strengthening.

402. The material grade requirements for hull members of esch class depending on the thickness are define in Table T.C23.401.7.

403. For strength members not mentioned in Tables T.C3.401.1 to T.C3.401.6, Grade A/AH may generally be used.The steel grade is to correspond to the as-built plate thickness and material class.

404. Plating materials for sternframes,supporting the rudders, rudder horns and shaft brackets are in general not to be of lower grades than corresponding to Class II. For rudder and rudder body platessubjected to stress concentrations (e.g. in way of lower support of semi-spade rudders or at upper part of spade rudders)Class III is to be applied.

TABLE T.C3.401.1. - [UR S6 TABLE 1] - MATERIAL CLASSES AND GRADES FOR SHIPS IN GENERAL

Structural member category		Material class/grade
 A1. A2. A3.	SECONDARY: Longitudinal bulkhead strakes, other than that belonging to the Primary category Deck plating exposed to weather, other than that belonging to the Primary or Special category Side plating	- Class I within 0,4L amidships - Grade A/AH outside 0,4L amidships
 B1. B2. B3. B4. B5.	PRIMARY: Bottom plating, including keel plate Strength deck plating, excluding that belonging to the Special category Continuous longitudinal members above strength deck, excluding hatch coamings Uppermost strake in longitudinal bulkhead Vertical strake (hatch side girder) and uppermost sloped strake in top wing tank	- Class II within 0,4L amidships - Grade A/AH outside 0,4L amidships
 C1. C2. C3.	SPECIAL: Sheer strake at strength deck (*) Stringer plate in strength deck (*) Deck strake at longitudinal bulkhead, excluding deck plating in way of inner-skin bulkhead of double-hull ships (*)	- Class III within 0,4L amidships - Class II outside 0,4L amidships - Class I outside 0,6L amidships
C4.	Strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch opening configurations	- Class III within 0,4L amidships - Class II outside 0,4L amidships - Class I outside 0,6L amidships - Min. Class III within cargo region
C5. C5.1	Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers combination carriers and other ships with similar hatch opening configurations Trunk deck and inner deck plating at corners of openings for liquid and gas domes in membrane type liquefied gas carriers	- Class III within 0.6L amidships - Class II within rest of cargo region
C6.	Bilge strake in ships with double bottom over the full breadth and length less than 150 m (*)	- Class II within 0,6L amidships - Class I outside 0,6L amidships
C7.	Bilge strake in other ships (*)	- Class III within 0,4L amidships - Class II outside 0,4L amidships - Class I outside 0,6L amidships
C8. C9.	Longitudinal hatch coamings of length greater than 0,15L including coaming top plate and flange End brackets and deck house transition of longitudinal cargo hatch coamings	- Class III within 0,4L amidships - Class II outside 0,4L amidships - Class I outside 0,6L amidships - Not to be less than Grade D/DH

(*) Single strakes required to be of Class III within 0,4L amidships are to have breadths not less than 800+5L (mm),. They need not be greater than 1800 (mm), unless limited by the geometry of the ship's design.

TABLE T.C3.401.2.[UR S6 TABLE 2] - MINIMUM MATERIAL GRADES FOR SHIPS, EXCLUDING LIQUEFIED GAS CARRIERS COVERED IN TABLE T.C3.401.3., WITH LENGTH EXCEEDING 150 M AND SINGLE STRENGTH DECK

Structural member category	Material grade
. Longitudinal plating of strength deck where contributing to the longitudinal strength . Continuous longitudinal plating of strength members above strength deck	Grade B/AH within 0,4L amidship
Single side strakes for ships without inner continuous longitudinal bulkhead(s) between bottom and the strength deck	Grade B/AH within cargo region

TABLE T.C3.401.3.[UR S6 TABLE 3] - MINIMUM MATERIAL GRADES FOR MEMBRANE TYPE LIQUEFIED GAS CARRIERS WITH LENGTH EXCEEDING 150 M*

<table>
<tr><th colspan="2">Structural member category</th><th>Material grade</th></tr>
<tr><td colspan="2">Longitudinal plating of strength deck where contributing to the longitudinal strength</td><td>Grade B/AH within 0,4L amidship</td></tr>
<tr><td rowspan="2">Continuous longitudinal plating of strength members above the strength deck</td><td>Trunk deck plating</td><td>Class II within 0,4L amidship</td></tr>
<tr><td>. Inner deck plating
. Longitudinal strength member plating between the trunk deck and inner deck</td><td>Grade B/AH within cargo region</td></tr>
</table>

Note*: Table T.C3.401.3. is applicable to membrane type liquefied gas carriers with deck arrangements as shown in Figure F.C3.401.1. This Table may apply to similar ship types with a “double deck” arrangement above the strength deck.

FIGURE F.C3.401.1. TYPICAL DECK ARRANGEMENT FOR MEMBRANE TYPE LIQUEFIED NATURAL GAS CARRIERS

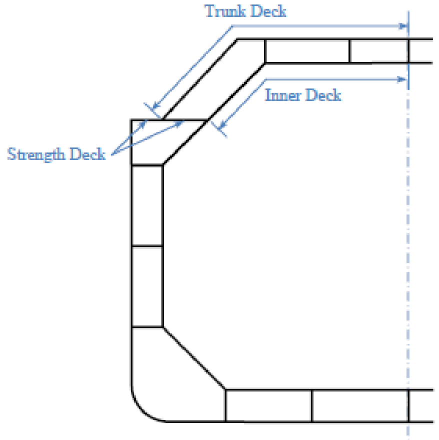


TABLE T.C3.401.4. [UR S6 TABLE 4]- MINIMUM MATERIAL GRADES FOR SHIPS WITH LENGTH EXCEEDING 250 M

Structural member category	Material grade
Shear strake at strength deck (*)	Grade E/EH within 0,4L amidship
Stringer plate in strength deck (*)	Grade E/EH within 0,4L amidship
Bilge strake)*)	Grade D/DH within 0,4L amidship

(*) Single stakes required to be of Grade E/EH and within 0,4L amidships are to have breadths not less than 800+5L. They need not be greater than 1800 mm, unless limited by the geometry of the ship’s desing.

Structuralmembercategory	Material grade
Shear strake at strength deck (*)	Grade E/EH within 0,4L amidships
Stringer plate in strength deck (*)	Grade E/EH within 0,4L amidships
Bilgestrake (*)	Grade D/DH within 0,4L amidships

(*) Single strakes required to be of Grade E/EH and within 0,4L amidships are to have breadths not less than 800+5L (mm), need not be greater than 1800 (mm), unless limited by the geometry of the ship’s design.

TABLE T.C3.401.5.[UR S6 TABLE 5] - MINIMUM MATERIAL GRADES FOR SINGLE-SIDE SKIN BULK CARRIERS SUBJECTED TO SOLAS REGULATION XII/6.5.3

Structural member category	Material grade
Lower bracket of ordinary side frame (*), (**)	Grade D/DH
Side shell strakes included totally or partially between the two points located to 0,125*l* above and below the intersection of side shell and bilge hopper sloping plate or inner bottom plate (**)	Grade D/DH

(*) The term "lower bracket" means webs of lower brackets and webs of the lower part of side frames up to the point of 0,125*l* above the intersection of side shell and bilge hopper sloping plate or inner bottom plate.

(**) The span of the side frame, l, is defined as the distance between the supporting structures.

TABLE T.C3.401.6.[UR S6 TABLE 6] - MINIMUM MATERIAL GRADES FOR SHIPS WITH ICE STRENGTHENING

Structural member category	Material grade
Shell strakes in way of ice strengthening area for plates	Grade B/AH

TABLE T.C3.401.7.[UR S6 TABLE 7]- MATERIAL GRADE REQUIREMENTS FOR CLASSES I, II AND III

Class	I		II		III	
Thickness, in mm	MS	HT	MS	HT	MS	HT
$t \leq 15$	A	AH	A	AH	A	AH
$15 < t \leq 20$	A	AH	A	AH	B	AH
$20 < t \leq 25$	A	AH	B	AH	D	DH
$25 < t \leq 30$	A	AH	D	DH	D	DH
$30 < t \leq 35$	B	AH	D	DH	E	EH
$35 < t \leq 40$	B	AH	D	DH	E	EH
$40 < t \leq 50$	D	DH	E	EH	E	EH

500. Structures exposed to low air temperatures

501. For ships intended to operate in areas with low air temperatures (below and including -20ºC), e.g. regular service during winter seasons to Arctic or Antarctic waters, the materials in exposed structures are to be selected based on the design temperature tD, to be taken as defined in Topic 600.

502. 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 T.C3.502.8. (UR S6 Table 8), depending on the categories of structural members (SECONDARY, PRIMARY and SPECIAL). For non-exposed structures and structures below the lowest ballast water line, see Topic 400.

T.C3.502.8.[UR S6 TABLE 8] - APPLICATION OF MATERIAL CLASSES AND GRADES – STRUCTURES EXPOSED AT LOW TEMPERATURES

	Material class	
Structural member category	**Within 0.4L amidships**	**Outside 0.4L amidships**
SECONDARY: Deck plating exposed to weather, in general Side plating above BWL Transverse bulkheads above BWL	I	I
PRIMARY: Strength deck plating [1] Continuous longitudinal members above strength deck, excluding longitudinal hatch coamings Longitudinal bulkhead above BWL Top wing tank bulkhead above BWL	II	I
SPECIAL: Sheer strake at strength deck [2] Stringer plate in strength deck [2] Deck strake at longitudinal bulkhead [3] Continuous longitudinal hatch coamings [4]	III	II

Notes:
[1] 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.
[2] Not to be less than Grade E/EH within 0,4L amidships in ships with length exceeding 250 metres.
[3] In ships with breadth exceeding 70 metres at least three deck strakes to be Class III.
[4] Not to be less than Grade D/DH.

503. The material grade requirements for hull members of each class depending on thickness and design temperature are defined in Tablle T.C3.505.9. For design temperatures t_D< -55ºC, materials are to be specially considered by RBNA. **[IACS UR S6 Table 9]**

TABLE T.C3.503.9 - MATERIAL GRADE REQUIREMENTS FOR CLASSES I, II AND III AT LOWTEMPERATURES [UR S6 TABLE 9]

Class I

Plate thickness, in mm	-20/-25°C MS	-20/-25°C HT	-26/-35°C MS	-26/-35°C HT	-36/-45°C MS	-36/-45°C HT	-46/-55°C MS	-46/-55°C HT
t ≤ 10	A	AH	B	AH	D	DH	D	DH
10 < t ≤ 15	B	AH	D	AH	D	DH	D	DH
15 < t ≤ 20	B	AH	D	AH	D	DH	E	EH
20 < t ≤ 25	D	DH	D	DH	D	DH	E	EH
25 < t ≤ 30	D	DH	D	DH	E	EH	E	EH
30 < t ≤ 35	D	DH	D	DH	E	EH	E	EH
35 < t ≤ 45	D	DH	E	EH	E	EH	Ø	FH
45 < t ≤ 50	E	EH	E	EH	Ø	EH	Ø	FH

Ø= Notapplicable

Class II

Plate thickness, in mm	-20/-25°C MS	-20/-25°C HT	-26/-35°C MS	-26/-35°C HT	-36/-45°C MS	-36/-45°C HT	-46/-55°C MS	-46/-55°C HT
t ≤ 10	B	AH	D	DH	D	DH	E	EH
10 < t ≤ 20	D	DH	D	DH	E	EH	E	EH
20 < t ≤ 30	D	DH	E	EH	E	EH	Ø	FH
30 < t ≤ 40	E	EH	E	EH	Ø	FH	Ø	FH
40 < t ≤ 45	E	EH	Ø	FH	Ø	FH	Ø	Ø
45 < t ≤ 50	E	EH	Ø	FH	Ø	FH	Ø	Ø

Ø= Notapplicable

Class III

Plate thickness, in mm	-20/-25°C MS	-20/-25°C HT	-26/-35°C MS	-26/-35°C HT	-36/-45°C MS	-36/-45°C HT	-46/-55°C MS	-46/-55°C HT
t ≤ 10	D	DH	D	DH	E	EH	E	EH
10 < t ≤ 20	D	DH	E	EH	E	EH	Ø	FH
20 < t ≤ 25	E	EH	E	EH	E	FH	Ø	FH
25 < t ≤ 30	E	EH	E	EH	Ø	FH	Ø	FH
30 < t ≤ 35	E	EH	Ø	FH	Ø	FH	Ø	Ø
35 < t ≤ 40	E	EH	Ø	FH	Ø	FH	Ø	Ø
40 < t ≤ 50	Ø	FH	Ø	FH	Ø	Ø	Ø	Ø

Ø= Notapplicable

\

504. 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.

505. Plating materials for stern frames, rudder horns, rudders and shaft brackets are not to be of lower grades than those corresponding to the material classes given in Topic 400.

600. Design temperature t_D [IACS UR S6.3]

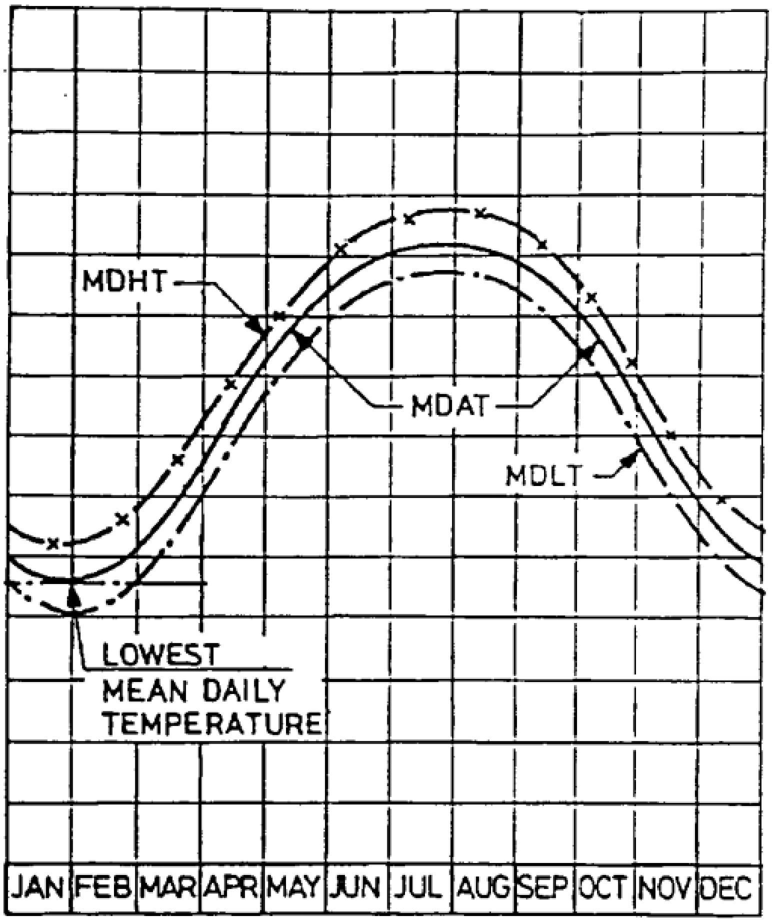
601. The design temperature tD is to be taken as the lowest mean daily average air temperature in the area of operation.See Figure F.C3.601.1. where:

Mean: Statistical mean over observation period (at least 20 years)

Average: Average during one day and night

Lowest: Lowest during year. For seasonally restricted service the lowest value within the period of operation applies.

FÍGURE F.C3.601.1. Commonly used definitions of temperatures**[IACS UR S6]**



MDHT = Mean Daily High (or maximum) Temperature
MDAT = Mean Daily Average Temperature
MDLT = Mean Daily Low (or minimum) Temperature

C4. OTHER MATERIALS

100. Aluminium

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

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

$\sqrt{\dfrac{235}{RY}}$ (in N/mm²)

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

$\dfrac{235}{RY}$ (in N/mm²)

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

103. The aluminium extruded or rolled alloys are:

a. aluminium - magnesium (5000 series); and

b. aluminium - magnesium - silica (6000 series).

104. The characteristics considered here are:

a. Young's modulus = 70000 N/mm²; and

b. Poisson's coefficient = 0,33.

105. For materials see Part III, Title 61, Section 2. Chapter G of these Rules.

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 requiresworkmanshipwith 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 these Rules.

CAPÍTULO D
PRINCIPLES OF HULL CONSTRUCTION

CHAPTER CONTENT

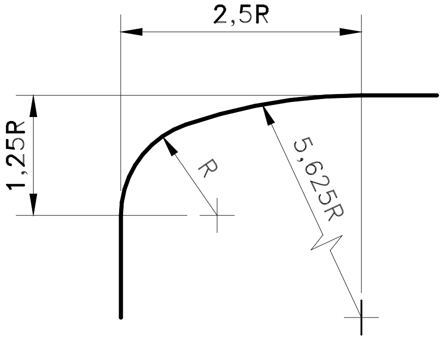
D1. PRINCIPLES OF DETAILS

100. Compliance with the design

101. The supervision of the construction is to be made after the approval of plans, for verification of compliance.

200. Openings in the structure

201. The openings and cut-outs in the structure should always have their corners rounded. In principle, on the cargo hatch corners the following scheme should be used:



where:

R= 0,04 x b (the value obtained, don't needtobe greater than 480 mm)

b: is the width of the cargo hatch opening

202. The drains at the bottom and tops of tanks, cut in web plates of beam and girders, should be sufficient to allow the liquid seeping up to the location of suction and not allowing air pockets that could not reach the air pipes. These drains

should not have height higher than 0,25 of the height of the beam with radius not less than 25 mm.

300. Discontinuities to avoid

301. The crimping of beams, or of structural parts, in other elements should extend into the crimping elements, from the crimp point, in order to be effective.

302. It should be observed the positions of thickness of the elements in relation to moulded lines, so that when welded on opposite side of a plate, the sides remain aligned.

303. It should be avoided “hard” points in the structure, that is, when the bracket tips, struts or any other element, ending in a plate panel, these tips should be extended until the next structural element or should be fixed reinforcements under the plate, lined with the element, and to prevent the effect of “punction”.

400. Openings in the strength deck

401. The number of openings in the strength deck should be the minimum possible. The openings should be apart from each other, from discontinuities of superstructures andof hatch corners. In particular, they should be cut as far as possible from the corners of the hatch openings.

402. Openings in areas hatched in the Figure F.D1.403.1. should be avoided.The following ratios to be met:

403. The nomenclature presented in Figure F. D1.403.2 is:

$e = 0{,}25(B - b)$ from the edge of opening

$c = 0{,}07l8 + 0.1b$ or $0{,}25b$, whichever is greater

where:

b : Width, in m, of the hatchway considered, measured in the transverse direction.

l: Width, in m, in way of the corner considered, of the cross deck strip between two consecutive hatchways, measured in the longitudinal direction.

FIGURE F.D1.403.1.POSITION OF OPENINGS IN STRENGTH DECK

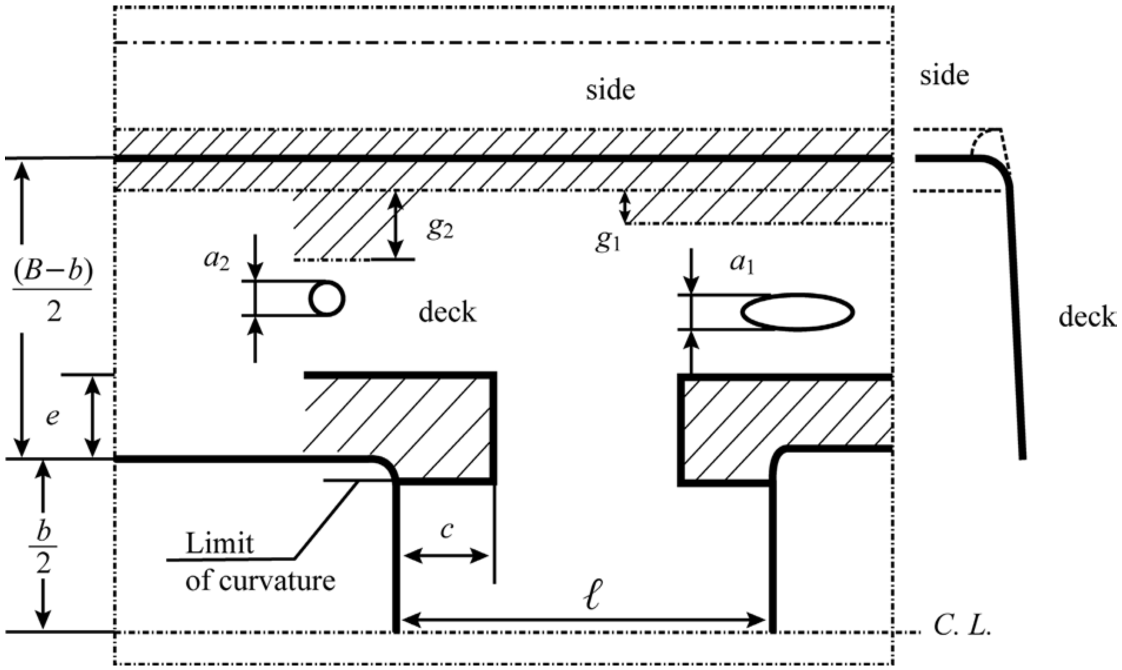
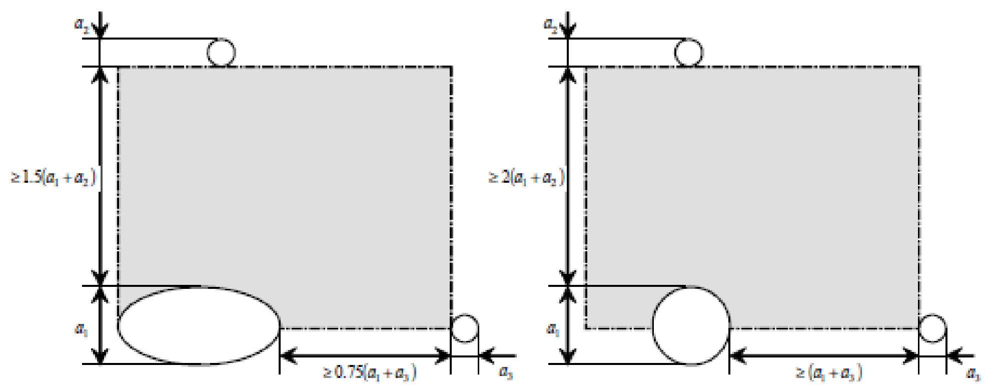


FIGURE F.D1.403.2. ELIPTICAL AND CIRCULAR OPENINGS IN STRENGTH DECK



404. Moreover the transverse distance between these limits and openings or between openings together is not to be less than the followings:

a. Transverse distance between the above limits and openings or between hatchways and openings as shown in the figure **F.D1.403.1.**

a.1. $g_2 = 2a_2$ for circular openings

a.2. $g_1 = a_1$ for elliptical openings

b. Transverse distance between openings as shown in the figureF.D1.403.1.

b.1. $2(a_1 + a_2)$ for circular openings

b.2. $1,5(a_1 + a_2)$ for elliptical openings

where:

a_1 : Transverse dimension of elliptical openings, or diameter of circular openings, as the case may be.

a_2 : Transverse dimension of elliptical openings, or diameter of circular openings, as the case may be.

a_3: Longitudinal dimension of elliptical openings, or diameter of circular openings, as the case may be.

c. Longitudinal distance between openings is not to be less than the followings:

c.1. $(a_1+ a_3)$ for circular openings

c.2. $0,75(a_1+ a_3)$ for elliptical openings and for an elliptical opening in line with a circular one.

500. Corner of hatchways

501. For hatchways located within the cargo area, insert plates, whose thickness is to be determined according tothe formula given after, are generally to be fitted in way of corners where the plating cut-out has a circular profile.

502. The radius of circular corners is to be not less than 5% of the hatch width, where a continuous longitudinal deckgirder is fitted below the hatch coaming.

503. Corner radius, in the case of the arrangement of two or more hatchways athwartship, is considered by the Society on a case by case basis.

504. For hatchways located within the cargo area, insert plates are, in general, not required in way of corners where the plating cut-out has an elliptical or parabolic profile and the half axes of elliptical openings, or the half lengths of the parabolic arch, are not less than:

a. 1/20 of the hatchway width or 600 mm, whichever is the lesser, in the transverse direction.

b. twice the transverse dimension, in the fore and aft direction.

505. Where insert plates are required, their net thickness is to be obtained, in mm, from the following formula:

$t_{INS}= (0.8+ 0.4\, l/ b)\, t$

without being taken less than t or greater than $1.6t$

where:

l : Width, in m, in way of the corner considered, of the cross deck strip between two consecutive hatchways, measured in the longitudinal direction figureF.D1.509.1

b : Width, in m, of the hatchway considered, measured in the transverse direction figureF.D1.509.1.

t : Actual net thickness, in mm, of the deck at the side of the hatchways.

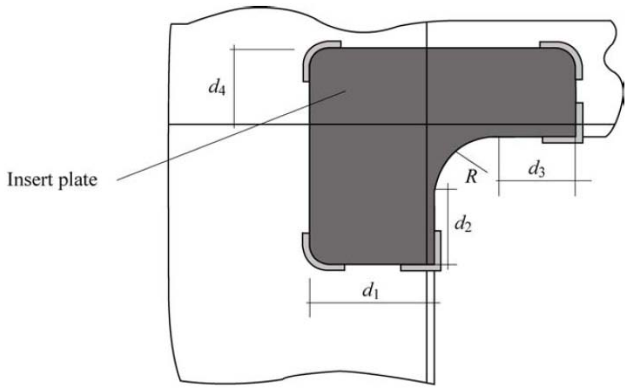
506. For the extreme corners of end hatchways, the thickness of insert plates is to be 60% greater than the actual thickness of the adjacent deck plating.

507. A lower thickness may be accepted by RBNA on the basis of calculations showing that stresses at hatch corners are lower than permissible values.

508. Where insert plates are required, the arrangement is shown in Figure F.D1.509.1., in which d_1, d_2, d_3 and d_4 are to be greater than the ordinary stiffener spacing.

509. For hatchways located outside the cargo area, a reduction in the thickness of the insert plates in way of corners may be considered by the Society on a case by case basis.

FIGURE F.D1.509.1.HATCH CORNER INSERT PLATE



D2. NEWBUILDING

100. Prefabricated elements

101. In case of bending of bars to build flanges, the radius should not be less than twice the thickness.

102. In case of assembling an angle bar formed with bent flange,itshould be checked, in addition to the previous requirement, that the modulus, for geometry adopted, with associated plate, is not less than that obtained with the rolled angle.

200. Steel cutting

201. The process of cutting, by acetylene or other, should not leave residues or scales that undermine the quality of the bevels for the weld.

202. The materials above 16 mm thick will be prepared for welding by grooving the edges in V or X, with inner angle of 60° and maximum height in the nose of the bevel of 7 mm. Designs and details of alternative joints will be considered if specially approved by the RBNA, depending on the specific application and the variation in the technique usually employed.

203. In general the joints will be prepared for welding in accordance with the requirements of the tables T.D3.107.3.

D3. BUTT WELDING

100. Metal arc welding with coated electrode

101. The manual welding of butt joints with coated electrode waives the angular bevel preparation between the edges, with thickness up to 7 mm.

102. The joints with thickness greater than 7 mm are prepared for welding by grooving the edges in Vor X, with root angle greater than 45º, root opening between 3 and 5 mm, and maximum height of the nose, in the bevel, of 3 mm.

103. The removing of filler metal and base metal at the root of partially welded joints should be performed through appropriate process before applying subsequent passes to attain metal without discontinuities and ensure full penetration.

104. When, in common welding techniques, is impracticable performing the back welding, the unilateral welding of V beveled joints will be allowed, forming an angle of 40^{o} to 50^{o}, small nose, root opening between 4 and 8 mm and joint cover.

105. The joint covers should be welded to one of the pieces to be welded. Their seams are with full penetration welds.

106. In general, joints are prepared for welding as per requirements of the tables T.D3.107.1. e T.D3.107.2.

200. Submerged arc welding

201. Automatic or semi-automatic submerged arc welding, using combinations of wire or tape and flux on the top joints, dispenses the preparation of angular bevel between the edges on materials with thickness up to 16 mm. Normally the welding will be performed in the flat and horizontal positions and in materials with thickness above 5 mm.

300. Electroslag welding

301. Automatic electroslag welding, with mix of wire(s) or consumable guide tube and flux, of butt joints dispenses preparation of angular bevel between the edges of the plates. Typically the welding will be performed only in an upright position and in materials with thickness up to 20 mm.

302. When employing the electroslag welding process there will be needed the use of appendage plate for the beginning of the welding and refrigerated water backing retention bars to contain the molten weld metal and slag.

303. Due to overheating in welded joint by slow displacement of the heat source, it is required the application of thermal treatment of normalization after the performing of the welding.

304. Designs and details of alternative joints will be considered if specially approved by the RBNA, depending on the specific application, assessment of the procedure for heat treatment after welding, and the variation in the technique normally employed.

400. Electro-gas welding

401. The automatic electro-gas welding using combinations of solid wire or gas tubular of butt joints will be employed only in flat position with vertical displacement and in materials with thickness between 10 and 75 mm.

402. The materials will be prepared with optional V-bevel, forming an internal angle greater than 45°, no nose, root opening between 17 and 20 mm and water refrigerated backing bars for retention of the weld metal and molten slag.

403. The requirements for application and approval of welding by electro-gas are similar to those of the electroslag welding.

500. Metal arc welding with gas atmosphere

501. Semi-automatic or automatic metal arc welding, with gas atmosphere with combinations of wire and gas or gases, of butt joints, follow the requirements set in Topic D3.100.

502. The welding of aluminium and aluminium base alloys will meet the requirements that follow and the table T.D3.203.1.

503. The metallic arc welding with gas atmosphere to butt joints dispenses the bevel angle preparation between the edges for thicknesses up to 5 mm.

504. The materials with thickness between 5 and 12 mm will have edges with V-groove, with inner angle greater than 60º, root opening of 3 mm and height of the nose in between 1 and 3 mm in the bevel.

505. The materials with thickness between 12 and 25 mm will have edges with V-groove, with inner angle ranging from 50 to 70º, root opening of 3 mm and height of the nose in between 3 and 5 mm in the bevel.

600. Tungsten arc welding with gas atmosphere

601. The manual or automatic welding tungsten arc with gas atmosphere using rod and gas or mixture of gases in butt joints of carbon steels and alloy steels will be prepared for performing the welding in accordance with the requirements of Topic D 3.100.

602. For welding of aluminium and aluminium-based alloys, the requirements that follow and table T.D3.203.2. will be met.

603. The materials with thickness up to 2 mm will have joints of the type aligned flange, in accordance with the requirements of the table T.D3.203.2.

604. The welding of butt welds with tungsten arc with gas atmosphere dispenses preparation of joints of angular bevel between the edges for thicknesses up to 4 mm.

605. The joints with thicknesses between 4 and 10 mm will have V-bevels with inner angle of 60°, small nose in the bevel and 2 mm root aperture.

700. Special Processes

701. Special procedures for welding, using variations of the basic techniques specified in this part, will be admitted with the specific approval of the RBNA, depending on the deviation when compared with good practice welding and after adequacy testing.

D4. FILLET WELDS

100. T- and cross joints

101. Unless otherwise specified, the connections will be welded from both sides of the joint and, depending on the degree of structure's load-bearing request, continuous double fillet welds will be required. The fillets should circumvent the thicknesses at the ends and at scallops of the beams.

102. The elements that limit watertight compartments will have continuous double sided welds.

103. In connections of elements with moderate tension requested, it will be allowed performing intermittent welds of escalated, enchained or scallopstype, as shown in Figure F. D4.103.1., except in the following locations and joints:

a. inside ballast tanks;

b. in external areas of the hull;

c. in floors to longitudinal stringer;

d. in floors to bilge plating;

e. in floors and longitudinal beams in the engine areas;

f. in primary structural girders, such as reinforcedverticalstiffener on bulkhead, side shell web frame, transverse deck girders and longitudinal deck girder;

g. in the area of the steering gear and propeller;

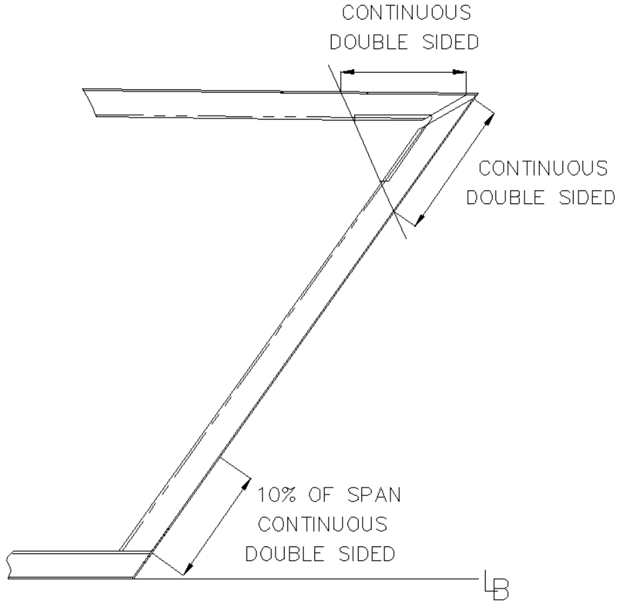
h. in the inner of the rudder blade, except in inaccessible areas, where the plug welding will be permitted.; and

i. in the bedplates and their connections.

104. In locations where .+is allowed, but subject to touches or impacts, the pass escalated will be equal to the length of the fillet.

105. At the ends of stiffeners of panels as frames, deck longitudinals, beams and bulkhead stiffeners welded intermittently, double continuous welds are required with a length of at least up to an extension line of the outside edge of the brackets or 10% of the span of the frame, as shown in the Figure F.D4.105.1.

FIGURE F.D4.105.1. CONTINUOUS DOUBLE SIDED



106. The size of the throat of fillet welds should be at least 70% of the size of the weld leg.

107. When the thickness of the thinnest element to be welded is greater than 25 mm, the size of the welding will be especially considered by RBNA.

200. Overlapping joints

201. The welds of overlapping joints will be allowed only in structural members with moderate load-bearing capacity and especially approved by the RBNA.

202. When it is unavoidable the welding of overlapping joints in longitudinal beams at 0,4L, connections supporting structures of engines, boilers and vessels subjected to pressure, should be required to be continuous welds on both edges with leg size equal to the thickness of the thinnest element.

203. Other overlapping joints will be welded with continuous welds double sided and dimensioned in such a way that the sum of the two legs of the weld is at least equal to 1,5 times the thickness of the thinnest element.

204. Unless particularly specified, the width of overlap will be equal to 2 times the thickness of thinnest element plus 25 mm.

300. Plug and slot joints

301. The plug and slot welds are allowed only when unavoidable and especially approved.

302. The plug and slot joints will have openings, in the outer element, with faces perpendicular to the inner element and with sufficient dimensions to allow complete melting across the whole boundary extension of the circumvention of the opening. In general the joints will be prepared in accordance with the requirements of figure F.D4.302.1.

400. Dimensioning

401. The size of the fillets are shown in Tables T.D4.401.1 to T.D4.401.6.

402. Annotations in these tables:

a. the dimensions specified are those of throats and the length of fillets, in mm;

b. “e”is the thickness of the thinnest element;

c. types of welding:

   c.1. continuous watertight double welding.

   c.2. double sided continuous welding non-watertight

   c.3. chain welding

   c.4. scallop weld

   c.5. plug weld ("scallop")

d. Figures F.D4.103.1 and F.D4.302.1 feature types of intermittent welds and plug welds.

403. The size of the throat should be no less than:

a. 3,0 mm for automatic processes using filler metals with high penetration;

b. 3,5 mm for all the processes applying continuous or intermittent fillet welds; and

c. 4,0 mm for high strength naval steel.

404. In intermittent welds the throat should have the size of the table that follows:

FIGURE F.D4.404.1 – INTERMITTENT WELDS THROAT

e	THROAT
4.8	3.5
6.4	4.0
7.9	4.5
9.5	5.0
12.5	5.5

TABLE T.D3.107.1. - PLATING BUTT WELDS (MANUAL)ARC WELDING WITH COATED ELECTRODE ROD

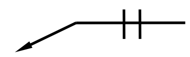
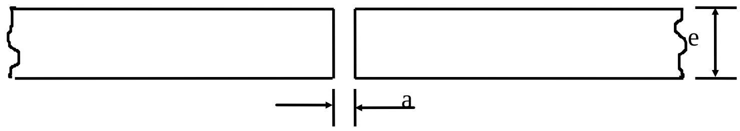
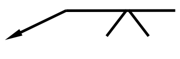
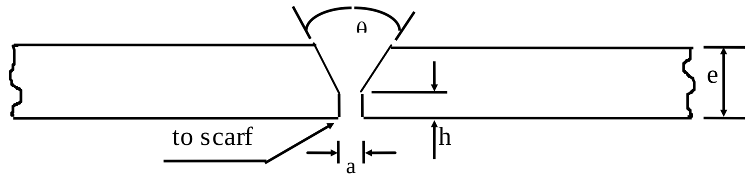
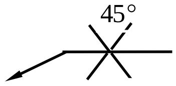
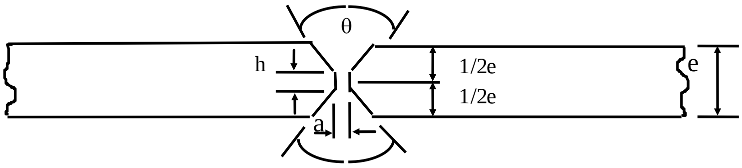
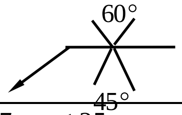
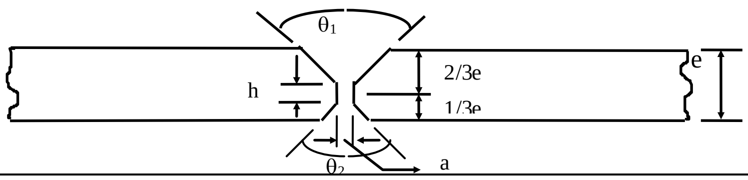
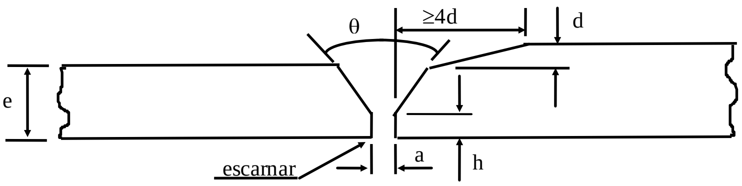
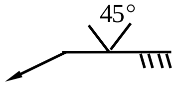
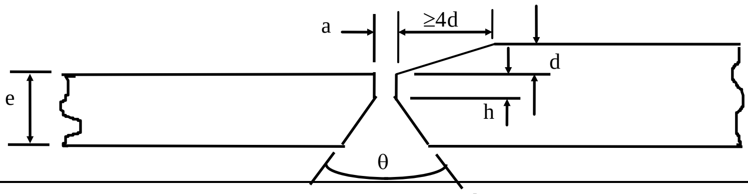
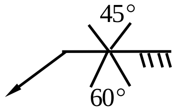
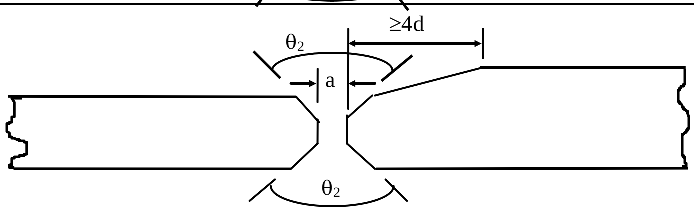
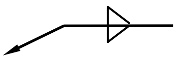
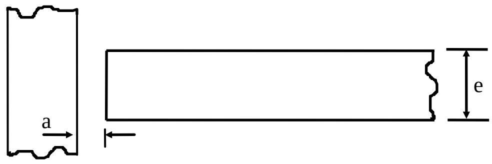
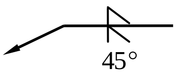
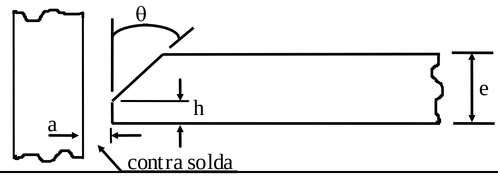
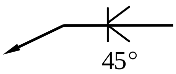
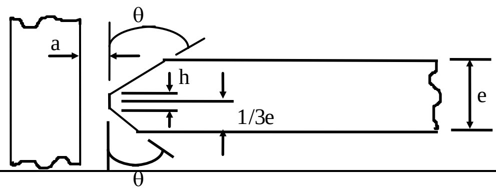
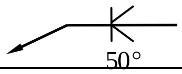
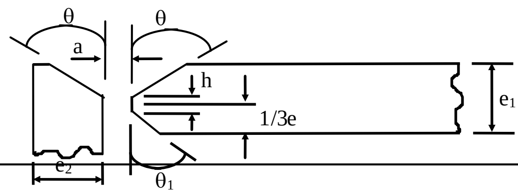
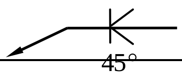
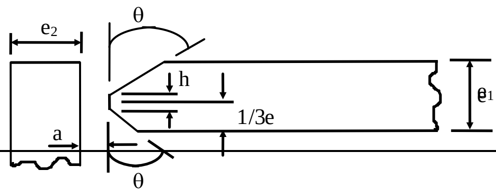
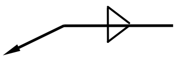
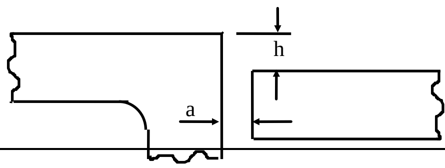
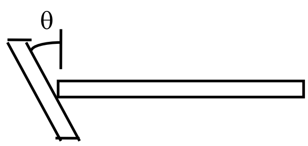
MANUAL WELDING		
SIMBOLOGY	**DETAIL OF THE GROOVE**	**DIMENSIONS**
e < 7 		a = 3mm
7 ≤ e ≤ 25 		a = 3 ~ 5mm h = 0 ~ 3mm θ = 45 ~ 60°
e ≥ 25 		a = 3 ~ 5mm h = 0 ~ 3mm θ = 45 ~ 60°
e > 25 		a = 3 ~ 5mm h = 0 ~ 3mm θ1 = 45 ~ 60° θ2 = 60 ~ 75°
7 < e ≤ 25 		a = 3 ~ 5mm h = 0 ~ 3mm θ = 45 ~ 60°
7 < e ≤ 25 		a = 3 ~ 5mm h = 0 ~ 3mm θ = 45 ~ 60°
e > 25 		a = 3 ~ 5mm h = 0 ~ 3mm θ1 = 60 ~ 75° θ2 = 45 ~ 60°

TABLE T.D3.107.2. -PLATING BUTT WELDS (MANUAL OR SEMI-AUTOMATIC)ARC WELDING WITH COATED ELECTRODE ROD

MANUAL OR SEMI-AUTOMATIC WELD (1)		
SIMBOLOGY	**DETAIL OF THE GROOVE**	**DIMENSIONS**
e < 7 	(2) 	e = 7mm a = 0 ~ 3mm
7 ≤ e ≤ 12  45°	(3) 	e = 7 ~ 12mm a = 0 ~ 3mm h = 0 ~ 3mm θ = 45 ~ 60°
e ≥ 12 45°  45°		e = 12mm a = 0 ~ 5mm h = 0 ~ 3mm θ = 45 ~ 60°
e_1> 12 e_2> 19 45°  50°		e_1 = 14mm e_2 = 19mm a = 0 ~ 3mm h = 0 ~ 3mm θ = 25° θ = 45 ~ 50°
e_1> 14 e_2≤ 19 45°  45°		e_1 = 14mm e_2 = 19mm a = 0 ~ 3mm h = 0 ~ 3mm θ = 45 ~ 50°
		a = 0 ~ 3mm h = ≥ 4mm

(1) Automatic welding if possible.
(2) Should not be used in strength decks, forecastle and poop.

(3)



When θ< 45° to groove.

TABLE T.D3.107.3. – PLATING BUTT WELDS (SEMI-AUTOMATIC) SUBMERGED ARC WELDING

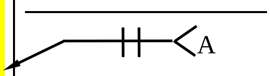
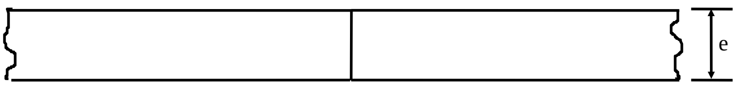
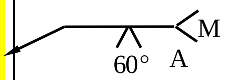
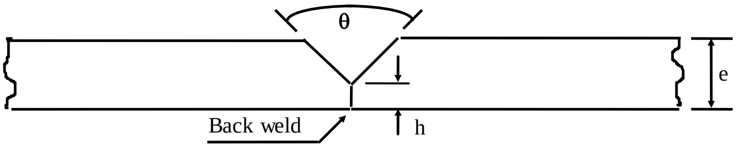
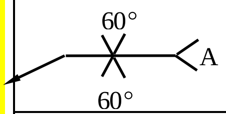
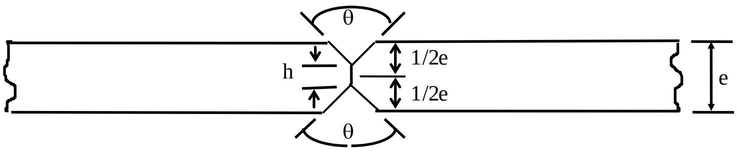
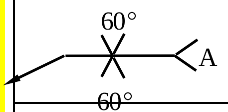
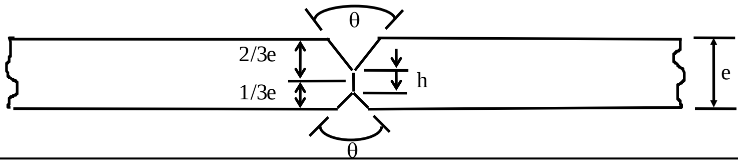
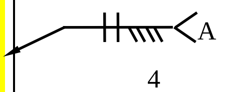
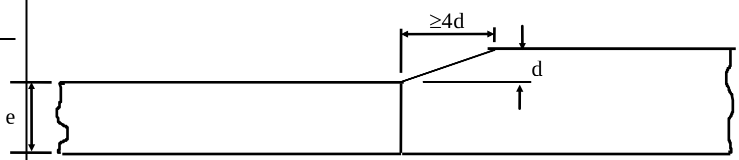
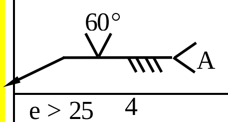
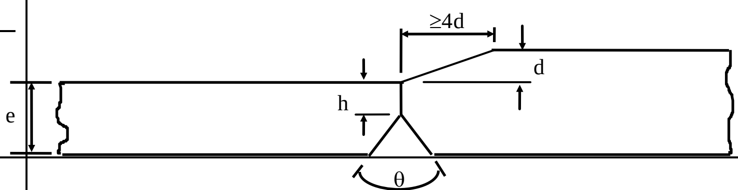
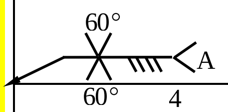
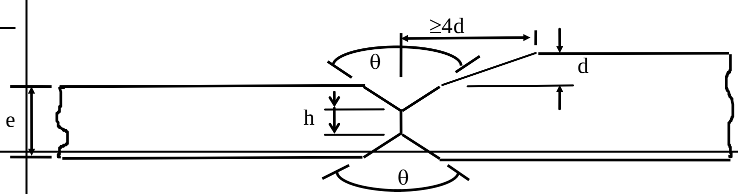
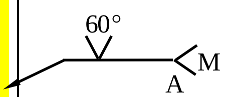
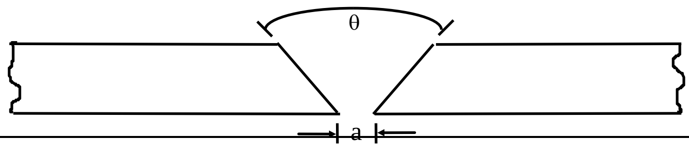
SEMI-AUTOMATIC WELDING		
SIMBOLOGY	**DETAIL OF THE GROOVE**	**DIMENSIONS**
e ≤ 16 		e = 5 ~ 16mm
16 ≤ e ≤ 25 		e = 16 ~ 25mm h = 6 ~ 7mm θ = 60°
25 ≤ e ≤ 30 		e = 25 ~ 30mm h = 6 ~ 8mm θ = 60 ~ 70°
e > 30 		e = 30mm h = 6 ~ 8mm θ = 60 ~ 70°
e ≤ 16 		e = 5 ~ 16mm
16 < e ≤ 25 		e = 16 ~ 25mm a = 6 ~ 7mm θ = 60°
e > 25 		e = 25mm h = 0 ~ 3mm θ = 60 ~ 70°
		a = 6 ~ 8mm θ = 40 ~ 50°

TABLE T.D3.203.1. – PLATING BUTT WELDS (SEMI-AUTOMATIC OR AUTOMATIC)METAL ARC WELDING WITH GAS ATMOSPHERE

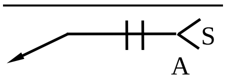
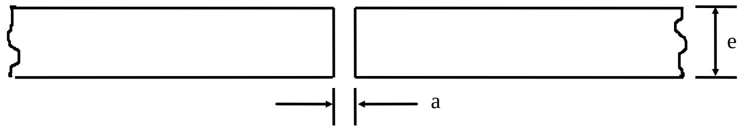
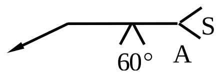
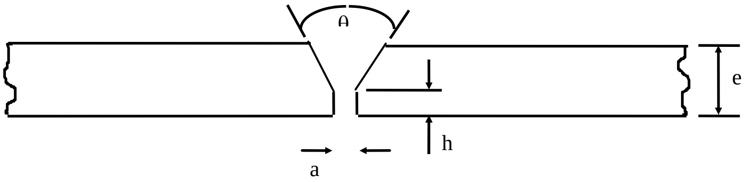
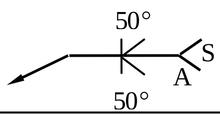
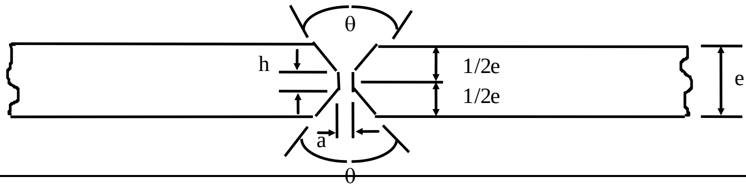
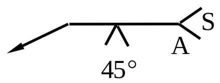
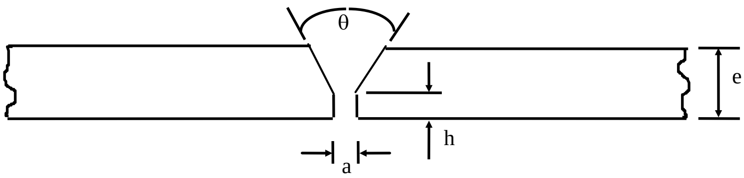
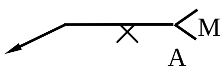
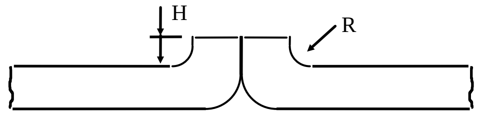
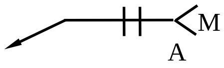
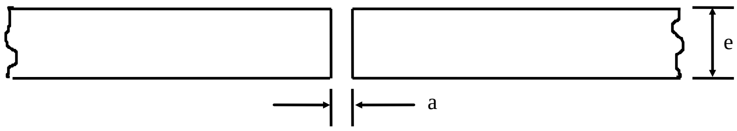
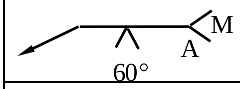
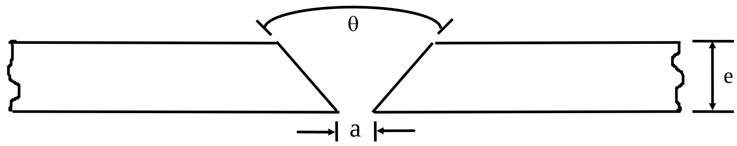
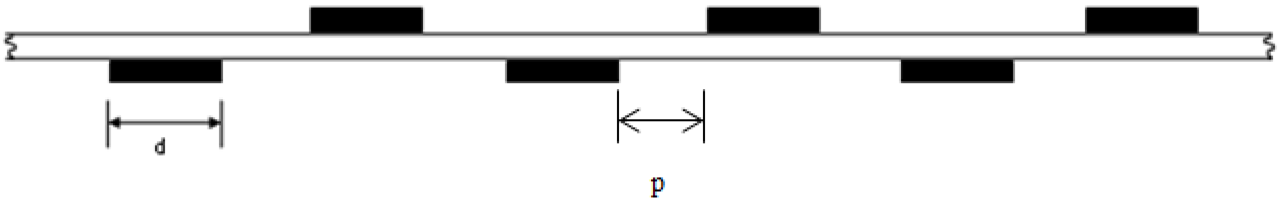
SEMI-AUTOMATIC OR AUTOMATIC WELD		
SIMBOLOGY	**DETAIL OF THE GROOVE**	DIMENSIONS
e < 5 		e = 1,5 ~ 5mm a = 0 ~ 2mm
5 ≤ e ≤ 12 		e = 5 ~ 12mm a = 0 ~ 3mm h = 1 ~ 3mm θ = 60 ~ 90°
12 ≤ e ≤ 25 		e = 12 ~ 25mm a = 0 ~ 3mm h = 3 ~ 5mm θ = 50 ~ 70°
8 < e ≤ 25 		e = 8 ~ 25mm a = 3 ~ 7mm h = 2 ~ 4mm θ = 45 ~ 60°

TABLE T.D3.203.2. - PLATING BUTT WELDS (MANUAL OR SEMI-AUTOMATIC)TUNGSTEN ARC WELDING WITH GAS ATMOSPHERE

SEMI-AUTOMATIC OR AUTOMATIC WELD		
SIMBOLOGY	**DETAIL OF THE GROOVE**	DIMENSIONS
e < 5 		e = 0,3 ~ 2mm R = e
12 ≤ e ≤ 25 		e = 2 ~ 4mm a = 0 ~ 2mm
8 < e ≤ 25 		e = 4 ~ 10mm a = 0 ~ 2mm θ = 60°

e = Material thickness.
a = Root opening.
h = Nose height.
d = Thickness difference.
R = Curvature radius.
H = Flange height.
θ = Groove angle.

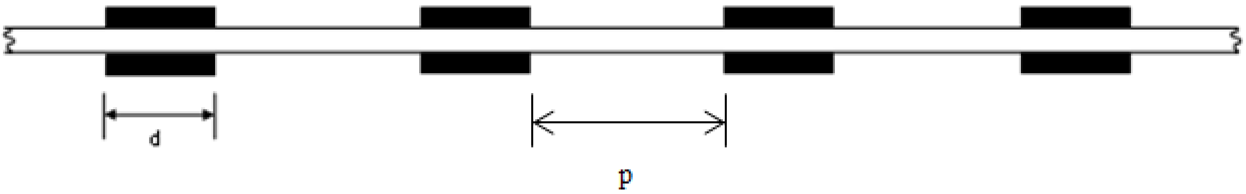
FIGURE F.D4.103.1. – FILLET WELDS – INTERMITTENTS INTERMITTENT WELD IN SCHELON



d ≥ 75mm
p ≤ 150mm

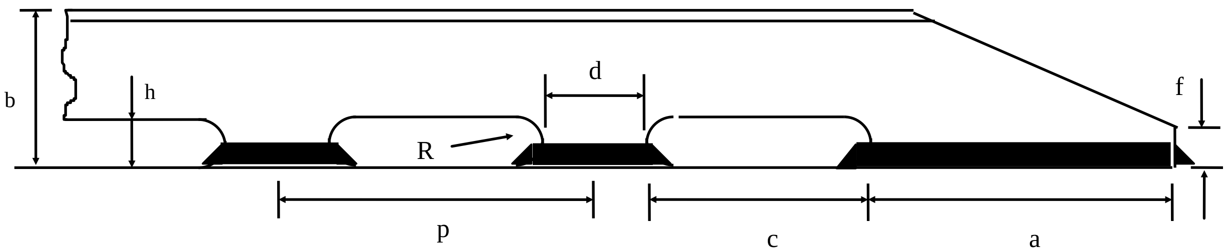
Note: see paragraph D4.104.

INTERMITTENT WELD IN CHAIN



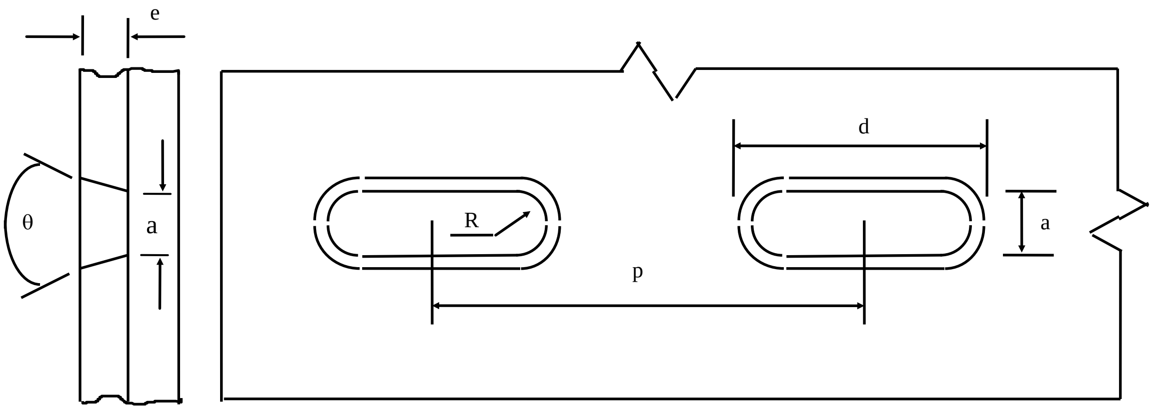
d ≥ 75mm
p ≤ 150mm

INTERMITTENT WELD IN PLUGS ("SCALLOPS")



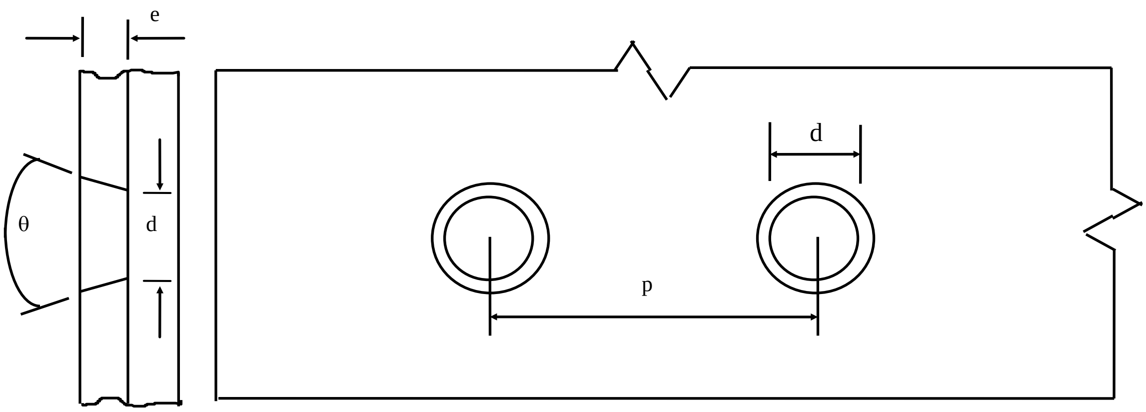
a ≥ 0,75 b
c ≤ 150mm
d ≤ 75mm
f ≥ throat/0,7 or10mm
h ≤ 0,25 b, not greater than 75mm
P ≤ 150mm
R ≥ 25mm

FIGURE F.D4.302.1. – FILLET WELDSPLUG FILLET WELDS SLOT



a ≥ e
50 mm> d ≤ 4 e, adopt the greater value
p ≤ 225mm
R ≥ e/2
30°>θ≤ 50°

CIRCULAR PLUG WELDS



d ≥ 4 e or, at least, 25mm
p ≤ 100mm
θ≥ 60°

TABLE T.D4.401.1 – DIMENSIONS OF FILLET WELD – BOTTOM SINGLE BOTTOM

STRUCTURAL MEMBERS			FILLET WELDS				
			CONTINUOUS DOUBLE		INTERMITTENT		
			A	B	C	D	E
FLOORS	To the hull plating	Forward bottom deep tanks Peak tanks	0.30e	0.20e	200	225	125
		Other parts	---	0.14e	200	300	150
	To face bar	Engine room Boiler room	0.20e	0.15e	200	225	125
		Other parts	---	0.12e	200	300	150
	In the ends	Side shell Longitudinal bulkhead	0.35e	0.25e	---	---	---
		Bottom longitudinal	0.35e	0.20e	---	---	---
CENTRAL LONGITUDINAL GIRDER	To bottom center girder	Forward bottom	0.40e	0.35e	---	---	---
		Other parts	---	0.12e	200	300	150
	To face bar		---	0.12e	200	300	150
SIDE LONGITUDINAL GIRDER	To the bottom plating	Forward bottom	0.35e	0.20e	200	---	100
		Other parts	---	0.12e	200	300	150
	To face bar	Engine room Pump room	---	0.30e	150	200	100
		Other parts	---	0.12e	200	300	150
OTHER MEMBERS	To the hull plating	Forward bottom	0.35e	0.20e	150	200	100
		Other parts	---	0.12e	200	300	150

TABLE T.D4.401.1 – DIMENSIONS OF FILLET WELD – BOTTOM (continued)DOUBLE BOTTOM

STRUCTURAL MEMBER			WELDS IN FILLET				
			CONTINUOUS DOUBLE		INTERMITTENT		
			A	B	C	D	E
SOLID FLOOR	to the hull plating	forward bottom peak tanks	0.35e	0.20e	200	225	125
		outraspartes	---	0.12e	200	300	150
	to the plating of the tank top of the double bottom	forward bottom	0.35e	0.20e	200	250	125
		engine room pump room	0.40e	0.40e	---	---	---
		other parts	---	0.12e	200	300	150
	To the plating	side or bilge	0.40e	0.40e	---	---	---
	To structural	stiffeners	---	0.12e	200	300	150
FLOOR OPEN	to the bottom web frames	shell plating top of the double bottom	---	0.12e	200	300	150
	side shell plating or bilge	shell plating top of the double bottom	0.35e	0.35e	---	---	---
CENTRAL LONGITUDINAL GIRDER	to the shell plating	foreword bottom	0.35e	0.25e	---	---	---
		keel plating	0.40e	0.25e	---	---	---
		other pars	---	0.12e	200	200	150
	to the plating of the top of the double bottom	praça de máquinas. praça de caldeiras	0.35e	0.25e	---	---	---
		other pars	---	0.12e	125	150	---
SIDE LONGITUDINAL GIRDER	to the shell plating	forward bottom	0.35e	0.25e	150	100	100
		other parts	---	0.15e	200	250	125
	to the plating of the top of the double bottom	engine room pump room	0.35e	0.25e	150	150	100
		oher parts	0.35e	0.14e	200	300	150
VERTICAL STRUT	to the plating	floors under buldkheads	---	0.14e	150	175	100
		ends	---	0.30e	---	---	---
		other parts	---	0.12e	200	300	150
BRACKET	to side shell frames to longitudinal girders	to the hull side shell	---	0.30e	---	---	---

TABLE T.D4.401.2 – DIMENSIONS OF FILLET WELD BULKHEAD

STRUCTURAL MEMBERS			FILLET WELDS				
			CONTINUOUS DOUBLE		INTERMITTENT		
			A	B	C	D	E
BULKHEAD	to shell plating and inner bottom plating	water and oil tightness	0.40e	0.40e	---	---	---
		weather exposed in superstructure and deckhouses	0.35e	0.35e	---	---	---
		solid floor	---	0.35e	200	200	150
		non watertight	---	0.25	200	225	150
VERTICAL STIFFENER	to the plating	watertight bulkhead	---	0.14e	200	250	150
		ends	---	0.18e	---	---	---
		other parts	---	0.12e	200	300	150

TABLE T.D4.401.3 - DIMENSIONS OF FILLET WELD SIDE SHELL

STRUCTURAL MEMBERS			FILLET WELDS				
			CONTINUOUS DOUBLE		INTERMITTENT		
			A	B	C	D	E
TRANSVERSAL WEB FRAME	to the shell plating	forward bottom deep tanks	---	0.15e	150	150	125
		aft peak	---	0.25e	---	---	---
		other parts	---	0.12e	200	275	150
LONGITUDINAL WEB FRAME	To the inner bottom plating	forward bottom	---	0.15e	200	225	125
		aft peak	---	0.20e	---	---	---
		other parts	---	0.12e	200	300	150
TRANSVERSE WEB FRAME AND STRINGER	to the shell plating and to the face bar		---	0.15e	200	225	125
SEA CHEST	to the shell plating	inner	0.50e	---	---	---	---
		outer	0.30e	---	---	---	---
STEM	to the shell plating	bar	0.70e	---	---	---	---
	To diaphragm plating and stiffeners	plate	0.25e	0.25e	175	225	125
BILGE KEEL	to the shell plating		---	0.12e	200	300	150

TABLE T.D4.401.4 – DIMENSIONS OF FILLET WELDDECK

STRUCTURAL MEMBERS			FILLET WELDS				
			CONTINUOUS DOUBLE		INTERMITTENT		
			A	B	C	D	E
DECK	to the plating	strength water-tight open deck	0.40e	0.40e	---	---	---
		other parts	---	0.30e	---	---	---
DECK BEAMS	to the plating	forward peak deep tanks	---	0.13e	200	250	125
		aft peak	---	0.20e	---	---	---
		girders	---	0.15e	200	250	125
		other parts	---	0.12e	200	275	150
	to the face bar		---	0.12e	200	275	150
	In the ends		---	0.15e	---	---	---
DECK GIRDERS	in 0.15 of the span, at each side of bulkheads and pillars		---	0.25e	---	---	---
	to the face bar		---	0.15e	200	250	125
	other parts		---	0.11e	200	275	150
LONGITU-DINAL BEAMS	to the plating	deck	---	0.15e	200	250	125
		other parts	---	0.12e	200	275	150
DECK STIFFEN-ERS	to the plating	inside of tanks	---	0.18e	175	250	125
		outside of tanks	---	0.12e	200	300	150
	in the ends	with bracketts	---	0.18e	---	---	---
		without bracketts	---	0.30e	---	---	---
	to the face bar	ends	---	0.18e	---	---	---
		other parts	---	0.12e	200	300	150
PILLARS	to the deck	ends	---	0.38e	---	---	---
HATCH COAM-INGS	to the deck plating		0.40e	---	---	---	---
	to the face bar in the ends to hatch corners		0.50e	---	---	---	---
	to longitudinal stiffeners		---	0.30e	---	---	---
	to stays		---	0,12e	175	225	125
	other parts		---	0.11e	200	275	150

TABELA T.D4.401.5 - DIMENSIONS OF FILLET WELDHULL EQUIPMENT AND APPENDAGES

STRUCTURAL MEMBERS			FILLET WELDS				
			CONTINUOUS DOUBLE		INTERMITTENT		
			A	B	C	D	E
MASTS	to the plating		---	0.43e	---	---	---
BEDPLATES	to shell plating to inner bottom plating	main engine essential auxiliaries thruster bearing	0.43e	0.43e	---	---	---
	to the face bar	boiler other auxiliaries	0.35e	0.35e	---	---	---
COAMINGS OF VENTILATORS	to the plating	exposed joints	---	---	---	---	---
		other joints	0.35e	0.20e	---	---	---

TABLE T.D4.401.6 – DIMENSIONS OF FILLET WELDEQUIPMENTS

STRUCTURAL MEMBERS			FILLET WELDS				
			CONTINUOUS DOUBLE		INTERMITTENT		
			A	B	C	D	E
HATCHWAY COVERS	to plating	watertight	0.30e	---	---	---	---
		other parts	---	0.15e	---	---	---
	to web frame and stiffeners	plating face bar	---	0.12e	200	275	125
		ends	---	0.18e	---	---	---
RUDDERS	to the horizontal diaphragm	side plating	---	---	150	150	---
		vertical diaphragm	---	0.24e	---	---	---
		rudder stock	---	0.35e	---	---	---
	to the vertical diaphragm	side plating	---	---	150	150	---
		end castings	---	0.35e	---	---	---
	to the rudder stock	side plating	0.43e	0.43e	---	---	---
		side castings	penetration	full			
	plug welds	in the side plating	0.43e	0.43e	---	---	---

D5. BLOCK ASSEMBLY / SHIPERECTION

100. Assembly adjustments

101. The assemblage of sets, mounting blocks and the building of the ship should take into account tolerances for adjustments, in order to avoid introducing additional tensions in positioning and welding and keep the designed geometry.

200. Throughway openings

201. Passage openings should be provided sufficient to access and arrangement so as to enable locomotion, service and inspect the interior of tanks with safety.

300. Access for service and inspection

301. The structure built should provide safety means of access and positioning (scaffolding etc.) for close-up inspection, even during the operation of the ship

CHAPTER E
DESIGN PRINCIPLES OF LOCAL STRUCTURE
CHAPTER CONTENT

E1. DIRECT CALCULATION/DEFINITIONS

100. Calculation premises

101. On the designer's aiming or in case of special structures or solutions, the RBNA will assess the structural dimensioning based in the direct calculation, instead of the expeditious implementation of the Rules.

200. Definitions

201. Terms used herein.

Stiffeners: secondary beams as profiles in: bottom and inner bottom,bottomfloor, bulkhead, side shell and deck.

Primary girders: the ones that support the secondary beams.

300. Units used

301. The units are of the International System.

Beam spacing: in the formulas of thickness is in mm and in the formulas of modules is in m.

Force or cargo weight:in N (or daNsimilarvalues to those of kilogram force: kgf)

E2. CONFIGURATIONS OF THE LOCAL STRUCTURE

100. Strength requirements

101. The plates and beams are dimensioned firstly contemplating the local structural systems, such as bottom, double bottom, bulkheads, side shells and decks, proportionally to their respective loadings, although they have enough to reserve, in case of participating in the strength the ship girder, to support the overall strength requirement.

102. When the deck or side shell were tank limits, their plates and beams should be verified by the requirements for tank bulkheads.

200. Strength distribution

201. The structural beam distribution should take into consideration the way the loads are distributed and how the stresses are disseminated to the adjacent structures, that is, to whom the strength is transferred and who withstands what.

202. So, when the span of a beam or strut is excessive, a stringer can be installed, in order to provide intermediate support between en supports, reducing the span The stringer will receive a distributed loading from the beams and transmit a concentrated force to each on of their supports, provided by other girder or pillars, which will have their supports also.

300. Beam span

301. The span of beams without brackets is measured up to its end. When there is a bracket,the span may be measured up to the middle of bracket.

400. Moduli for the beam supporting conditions

401. Structural beams here mentioned, in principle, are considered bi-imbedded and supporting evenly distributed loads. When one end is considered simply supported, the calculated value will be multiplied by a coefficient c=1,15. When this is the case for both ends, the calculated value will be multiplied by a coefficient c=1,3.

402. In the case of girders thatsupportother primary beams, they are verified for concentrated loads, brought by the reaction load in the ends of those primary girders.

500. Brackets

501. The dimension "b" on the bracket, measured in the edges of the connected profiles, that is, without including the overlap, will be the greater of the values:

$b = 0{,}08 \times l$ (where l is the span of the beam in mm);

$0{,}1 \times l$ (in the strut toe or web frame);

$c \times h$

where:

h = height of the profile that is connected;

c = 1.0 for flat bar or fabricated Tee-beam;

c = 1,5 for bulb profile;

c = 2,0 for angle bar.

502. The thickness, in mm, is given by the equations below, for b in mm:

for bracket without flange: $e = \frac{b}{100} + 6$

for bracket with flange: $e = \frac{b}{100} + 4$

with flange width = $8 \times e$

600. Standard spacing of stiffeners

601. For transversal framed panels the standard stiffener spacing E_0, for reference, is given by the equation:

$E_0 = 2 \times L + 450$ mm

602. For longitudinal framed panels the standard stiffener spacing E_0, for reference, is given by the equation:

$E_0 = 2 \times L + 550$ mm

E3. LOADINGS

100. Approach

101. Distributed loads for the structural elements of the structure, to be used in the equation of subchapter E4. for reference, are given as pressure, in t/m^2, or load height for liquid load or load height with specific load density, in meters, as shown in Table T.E3.101.1.

102. In this Table:

h : highest height that the load can reach in m;

h_s: height of the vent pipe referred to the freeboard deck;

P : heaviest weight of the load in the compartment, in t;

V : volume of the load in the compartment, in m³;

p_1: design loading in t/m²;

A : type A vessel;

B : type B vessel;

D : depth;

d : design draft.

103. When stiffeners are cut on window and doors, horizontal stiffeners are to be installed above and under the openings, in such a way that they load the adjacent stiffeners, which will have enough strength for the new spacing each one supports.

TABLE T.E3.101.1 – LOADING PRESSURE (t/m²)

	NAVEGATION AREA	
STRUCTURAL SYSTEM	**O1**	**O2**
Single bottom For load in the deck or type B vessel (the highest value)	D d + 1,2	D d + 1,3
For type A vessel (liquid cargo)	$D + h_s$	$D + h_s$
Bottom where there is double bottom	D d + 1.2	D d +1.3
Inner bottom with dry cargo (the highest value)	0,7×h; (P/V)×h; d	0,7×h; (P/V)×h; d
Inner bottom with liquid cargo	h	h
Common watertight bulkhead (AEC)	See Sub-chapter F2	
Tank bulkhead (ATQ)	See Sub-chapter F2	
Side shell	See Sub-chapter F3	
Unsheathed strength deck with load $p_1 \leq 0.5$ t/m^2	0,80+0,007×L	0,85+0,008×L
Unsheathed strength deck with load $p_1 > 0.5$ t/m^2	0,80+0,007×L+ (p_1- 0.5)	0,85+0,008×L+ (p_1- 0.5)
Sheathed strength deck or platform deck greater than 0.6×D with load $p_1 \leq 0.5$ t/m^2	0,4+0,007× L	0,4+0,008× L
Sheathed deck or platform deck greater than 0.6×D with load $p_1 > 0.5$ t/m^2 (the highest value)	0,75×h; (P/V)×h; 0,4+ 0,004×L+ (p_1- 0,5)	0,75×h; (P/V)×h; 0,4+ 0,005×L+ (p_1- 0,5)
Platform deck less than 0.6×D (the highest value)	0,75×h; (P/V)×h; 0,5	0,75×h; (P/V)×h; 0,5

E4. GENERAL EQUATIONS FOR THICKNESSES AND BEAM STRENGTH MODULUS

100. General equation for thicknesses

101. In general the thicknesses are calculated by formulae of the type:

$$e = coefíc. \times E \times \sqrt{p} + e_r \quad \text{mm}$$

or

$$e = coefíc. \times E \times \sqrt{h \times \rho} + e_r \quad \text{mm}$$

where:

coefic: coefficient that depends on each location;

p : pressure of load in t/m^2 ;

E: stiffener spacing in mm;

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

h : highest cargo height that the load can reach in m;

e_r: margin thickness that depends on each location.

200. General equation for strength modulus

201. When not indicated explicitly in several sections, the modulus of the beams supporting local uniformly distributed loads (without contribution to longitudinal strength of the hull girder) can be calculated by the equation below, taking into account the values given for each case:

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

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

where:

p : pressure of load in t/m^2;

E: stiffener spacing in m;

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

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

h : cargo height in m.

202. Where the element contributes to the longitudinal hull girder strength, the local admissible stress shall reserve part for the global stress. This is obtained multiplying the equations above by the factor (0,008 x L + 1).

203. If the actual midshipsectionmodulus is greater than the minimum required, the value above can multiplied by the factor:

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

where:

f minimum to be used = 0,7

W_R is the minimum Section modulus requiredintheChapter H;

W is the section modulus for the actualMidship Section of the ship.

E5. SELECTION OF THE SCANTLINGS TO BEUSED

100. Thickness

101. The minimum thickness of plates and beam elements is 4,5 mm.

102. The calculated thickness, differing from commercial thickness in fraction of mm, can be rounded up so that the difference for less should not exceed 0,20 mm.

103. The actual thickness in the construction should not differ from those of the plans observing the following tolerances:

0,3 mm	for	$e < 5$ mm
0,4	for	$5 \le e < 10$
0,5	for	$10 \le e < 20$
$0{,}02 \times e + 0.1$	for	$20 \le e$

where “e” is the thickness specified in the plans.

200. Proportions and details of beams

201. Beams of T or L types will have the following minimum sizes:

-web plate height d_V:

$d_V = 0{,}05 \times l$ for dry cargo;
$0{,}07 \times l$ for tank;

-web plate thickness:

$$e = \frac{d_v}{100} + 4$$

-maximum height of cut-outs for passage of profiles:

$$e = \frac{d_v}{2}$$

Note: at the beam ends and on locations subjected to shearing stresses, full collar plates are to be fitted on cut-outs.

300. Modulus of laminated beams

301. The determination of laminated beams for stiffeners is made considering the section modulus combined with associated plate that has a width equal to the spacing of these stiffeners.

302. It is given in Table T.E4.302.1. the section modulus of some beams and angles, including some steel mill standards, combined with an area of associated plate of 500 mm width and thickness equal to the web of the beam.

303. In this Table, threevalues are given:

a. Profile cross section area, in cm²;

b. Strength section modulus with associated plate, in cm³;

c. Variation of the modulus for 5 cm² variation of areain the associated plate.

304. In the case of construction of primary beams with profile "U" overlapped to the stiffeners, the modulus considered is the one of the profile itself.

305. Where the angle Ø that the web of the profile makes the associated plate, measured in the middle of the span, is less than 70^{o}, the tabulated section modulus is multiplied by sin Ø.

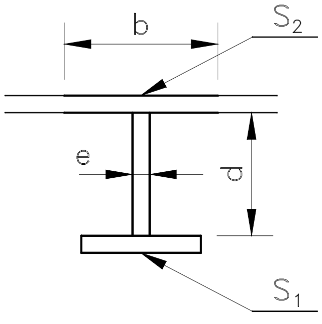
400. Modulus of fabricated beams

401. For the modulus of fabricated beams may be used the formula:

$$W = S_1 \times d + \frac{e \times d^2}{6} \times \left[1 + \frac{S_2 - S_1}{S_2 + \frac{e \times d}{2}} \right]$$

for the notations see the figure:

FIGURE F.E5.401.1 – MODULUS OF FABFICATED BEAMS



where:

S_1 and S_2 are area of the sections as shown on the figure F.E5.401.1

S_2 is always greater than S_1; and

for calculation of plate area associated, the width b considered is to be determined by the smaller of the following values:

b = E
b = c × *l*

where:

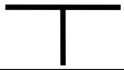
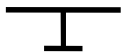
E : width supported by the beam;

l : span of the beam

c : 0,1 for fabricated flange forming the associated plate on one single side of the girder web;and

c : 0,2 for fabricated flange forming associated plate on both sides of the girder web

TABLE T.E5.302.1. - MODULUS OF BEAMS WITH ASSOCIATED PLATE OF AREA 500 mmxe*l*

Range of Modulus				
	PROFILE **d*l* x e*l***	**a - w - var. w**	PROFILE **d*l* x d*b* x e*l* (e*l* = e*b*)**	**a - w - var. w**
5	50 × 5	2,5 - 4,6 - 0,10		
	60 × 5	3,0 - 6,4 - 0,12		
8	60 × 6	3,6 - 7,8 - 0,15		
	80 × 8	6,4 - 18,3 - 0,26		
30	100 × 8	8,0 - 27,7 - 0,35	63 × 63 × 6,3	7,67 - 30,4 - 0,35
	100 × 10	10,0 - 35,4 - 0,42	89 × 63 × 6,3	9,29 - 46,9 - 0,49
50			76 × 76 × 8,0	11,48 - 54,4 - 0,55
			89 × 63 × 8,0	11,48 - 57,5 - 0,66
			102 × 89 × 6,3	11,67 - 72,0 - 0,74
80			102 × 76 × 8,0	13,48 - 79,4 - 0,76
			102 × 89 × 8,0	14,51 - 88,5 - 0,82
90			102 × 76 × 9,5	16,00 - 93,3 - 0,82
			102 × 102 × 8,0	15,57 - 97,5 - 0,72
			102 × 102 × 9,5	18.45 - 114,9 - 1,07
120			127 × 89 × 8,0	16,51 - 118,8 - 1,11
140			127 × 89 × 9,5	19,67 - 140,2 - 1,20
			127 × 127 × 9,5	23,29 - 182,7 - 1,54
200			152 × 102 × 9,5	23,28 - 196,6 - 1,70
			152 × 152 × 9,5	28,12 - 263,1 - 2,23
300			178 × 102 × 12,7	33,80 - 338,6 - 2,20
			152 × 152 × 12,7	37,09 - 343,5 - 2,50
			203 × 102 × 12,7	37,09 - 377,9 - 2,89
400			178 × 102 × 15,9	41,85 - 410,6 - 2,40
			127 × 127 × 15,9	45,86 - 342,1 - 2,24
	PROFILE		203 × 102 × 15,9	45,86 - 465,1 - 3,12
600	dl x el + db x eb		203 × 203 × 12,7	49,99 - 609,4 - 2,38
			203 × 203 × 15,9	61,98 - 752,8 - 4,90
900	400 × 8 + 150 × 10	47,00 - 908,6 - 9,68		
	450 × 9 + 200 × 10	60,50 - 1320 - 13,34		
2000	500 × 9 + 250 × 12,5	76,25 - 2014 - 20,59		
	550 ×10 + 250 × 12,5	86,25 - 2345 - 23,16		

NOTE : Symbols:

d*l* : height of the beam web, in mm;
e*l* : thickness of the beam web, in mm;
d*b* : width of the beam flange, in mm;
e*b* : thickness of the beam flange, in mm;
a : area of the beam only in cm²;
w : modulus with associated plate of 500 mm × e*l*, in cm^3; and
var. w : variation of modulus for the variation of 5 cm² between the effective area of the associated plate and the area of 500 mm× e*l*.

E6. EXTERNAL PRESSURES

100. Application

101. These Rules apply to the hull structures of single side skin and double side skin with unrestricted worldwide navigation, having length *L* of 90 m or above.

102. Symbols

L_2 : Rule length *L*, but to be taken not greater than 300 m

C : Wave coefficient, as defined in the figure H.H2.201.1

λ: Wave length, in m, corresponding to the load case, defined in accordance with E6.401

fp: Coefficient corresponding to the probability, defined in accordance with the following values:

f_p= 1.0 for strength assessments corresponding to the probability level of 10^{-8}

f_p= 0.5 for strength assessments corresponding to the probability level of 10^{-4}

TLCi: Draught in the considered cross section, in m, in the considered loading condition.

Bi : Moulded breadth at the waterline, in m, in the considered cross section

x, y, z : *X*, *Y* and *Z* co-ordinates, in m, of the load point with respect to the reference co-ordinate system

200. External sea pressures on side shell and bottom

201. General

202. The total pressure *p* at any point of the hull, in kN/m2, to be obtained from the following formula is not to benegative:

$p = p_S + p_W$

where:

p_S: Hydrostatic pressure defined in tableT.E6.301.1.

p_W: Wave pressure equal to the hydrodynamic pressure defined in table T.E6.401.1, E6.500 or T.E6.601.as the case may be, and corrected according to E6.700.

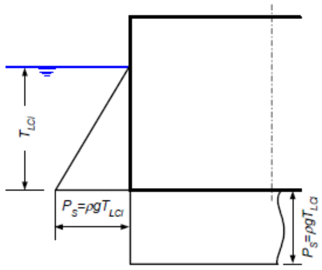
300. hydrostatic pressure

301. The hydrostatic pressure $p_S$at any point of the hull, in kN/m^2, corresponding to the draught in still water is obtained, for each loading condition, from the formulae in the table T.E6.301.1. and in the figure F.E6.301.1.

TABLE T.E6.301.1. – HYDROSTATIC PRESSURE P_S

Location	Hydrostatic pressure, pS, in kN/m2
Points at and below the waterline ($z \leq T_{LCi}$)	$\rho g(T_{LCi} - z)$
Points above the waterline (z >TLCi)	0

FIGURE F.E6.301.1.-HYDROSTATIC PRESSURE p_S



400. Hydrodynamic pressures for load cases H1, H2, F1 and F2

401. The hydrodynamic pressures *pH* and *pF*, for load cases H1, H2, F1 and F2, at any point of the hull below the waterline are to be obtained, in kN/m2, from table T.E6.401.1.

402. The distribution of pressure p_{F2} is schematically given in the figure F.E6.402.1.

TABLE T.E6.401.1 – HYDRODYNAMIC PRESSURES FOR LOAD CASES H1, H2, F1 AND F2

Load case	**Hydrodynamic pressure, in kN/m²**
H1	$p_{H1} = - k\_k_p p_{HF}$
H2	$p_{H2} = k\_k_p p_{HF}$
F1	$p_{F1} = - p_{HF}$
F2	$p_{F2} = p_{HF}$

where:

$pHF = 3 f p f n l C \sqrt{\frac{L+\lambda-125}{L}} \left(\frac{z}{TLCi} + \frac{|2y|}{Bi} + 1\right.$;with |2|/Bi≤1,0

and z is to be taken not greater than TLCif

f_{nl}=0,9 fot the probability level of 10^{-8}

f_{nl}=1,0 fot the probability level of 10^{-4}

k_l=Amplitude coeficiente in the longitudinal direction of the ship, taken equal to:

$kl = 1 + \frac{12}{CB}\left(1 - \sqrt{\frac{|2y|}{B}} . \left|\frac{x}{L} - 0{,}5\right|^3\right)$ for 0,0≤ x/L ≤ 0,5

$kl = 1 + \frac{6}{CB}\left(3 - \left|\frac{4y}{B}\right| . \left|\frac{x}{L} - 0{,}5\right|^3\right)$ for 0,5≤ x/L ≤ 1,0

$k_{p=}$phase coefficientin the longitudinal direction of the ship, taken equal to:

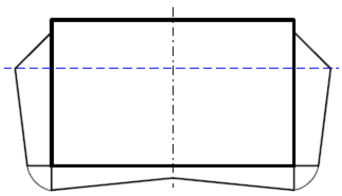
$kp = \left(1,25 - \frac{TLc}{Ts}\right)\cos\left(2\pi\left|\frac{x-0,5L}{L}\right|\right) - \frac{TLc}{Ts} + 0,25$ for local strength analysis in conditions other than full load condition, for direct strength assessments kp=-1,0, for strength analysis in full load condition.

λ= wave length, in m, taken equal to:

$\lambda = 0,6\left(1 + \frac{TLc}{Ts}\right)L$ for load case H1 and H2

$\lambda = 0,6\left(1 + \frac{2}{3}\frac{TLc}{Ts}\right)L$ for load case F1 and F2

FIGURE F.E6.402.1- DISTRIBUTION OF HYDRO-DYNAMIC PRESSURE P_{F2} AT MIDSHIP



500. Hydrodynamic pressures for load cases R1 and R2

501. The hydrodynamic pressures pR, for load cases R1 and R2, at any point of the hull below the waterline are to be obtained, in kN/m2, from the following formulae. The distribution of pressure $pR1$ is schematically given in figure F.E6.601.1

$$PR1 = fn1(10ysin\theta + 0,88fpC\sqrt{\frac{L+\lambda-125}{L}}(\frac{|2y|}{B}+1)$$

where:

f_{nl}: Coefficient considering nonlinear effect, taken equal to:

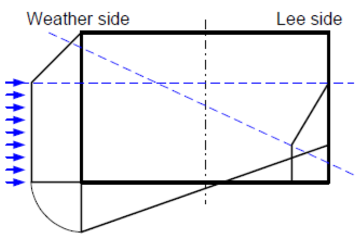
f_{nl}= 0.8 for the probability level of 10^{-8}

f_{nl}= 1.0 for the probability level of 10^{-4}

$$\lambda = \frac{g}{2\pi}TR^2$$

y : Y co-ordinate of the load point, in m, taken positive on the portside.

FIGURE F.E6.501.1- DISTRIBUTION OF HYDRO-DYNAMIC PRESSURE P_{R1} AT MIDSHIP



600. Hydrodynamic pressures for load cases P1 and P2

601. The hydrodynamic pressures pP, for the load cases P1 and P2, at any point of the hull below the waterline are to be obtained, in kN/m2, from the tableT.E6.601.1. The distribution of pressure p_{P1} is schematically given in figureF.E6.601.1.

TABLE T.E6.601.1: HYDRODYNAMIC PRESSURES FOR LOAD CASES P1 AND P2

Load case	Hydrodynamic pressure, in kN/m2	
	weatherside	leeside
P1	$p_{P1} = p_P$	$p_{P1} = p_P/3$
P2	$p_{P2} = -p_P$	$p_{P2} = -p_P/3$

where:

$$pHF = 4,5fpfnlC\sqrt{\frac{L+\lambda-125}{L}}\left(2\frac{|z|}{TLCi} + 3\frac{|2y|}{Bi}\right)$$

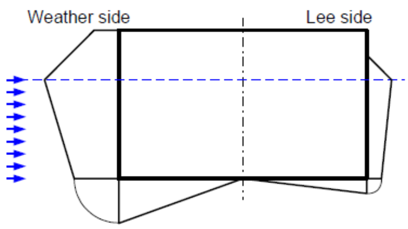
f_{nl}=0,65 fot the probability level of 10^{-8}

f_{nl}=1,0 fot the probability level of 10^{-4}

$$\lambda = \left(0,2 + 0,4\frac{TLc}{Ts}\right)$$

y= Y co-ordinate of the load point , as defined in xxxx

FIGURE F.E6.601.1- DISTRIBUTION OF HYDRO-DYNAMIC PRESSURE $PP1$ AT MIDSHIP



700. CORRECTION TO HYDRODYNAMIC PRESSURES

701. For the positive hydrodynamic pressure at the waterline (in load cases H1, H2, F1, R1, R2 and P1), the hydrodynamic pressure PW,C at the side above waterline is given in the figureF.E6.702.1in kN/m2, by:

$pw,c = pw,wl + \rho g(TLCi - z)$ for $T_{LCi} \leq z \leq hw + T_{LCi}$

Pw,c = 0 for $z \geq hw + T_{LCi}$

where:

$p_{W,WL}$: positive hydrodynamic pressure at the waterline for the considered load case

$$hw = \frac{pw,wl}{\rho g}$$

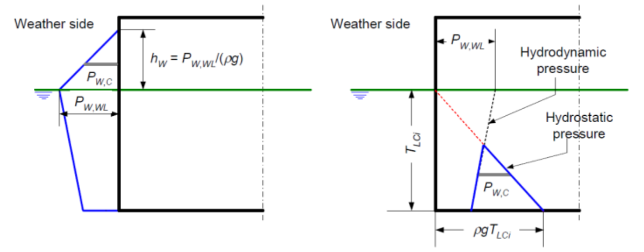
702. For the negative hydrodynamic pressure at the waterline (in load cases H1, H2, F2, R1, R2, and P2), the hydrodynamic pressure $P_{W,C}$, under the waterline is given figure F.E6.702.1, in kN/m², by:

$p_{W,C} = p_W$, without being taken less than $\rho g(z - T_{LCi})$

where:

p_W: Negative hydrodynamic pressure under the waterline for the considered load case

FIGURE F.E6.702.1: CORRECTION TO HYDRODYNAMIC PRESSURE



When hydrodynamic pressure is positive When hydrodynamic pressure is negative

E7. EXTERNAL PRESSURES ON EXPOSED DECKS

100. General

101. If a breakwater is fitted on the exposed deck, no reduction in the external pressures defined in E7.200 and E7.300 is allowed for the area of the exposed deck located aft of the breakwater.

200. Load cases H1, H2, F1 and F2

201. The external pressure pD, for load cases H1, H2, F1 and F2, at any point of an exposed deck is to be obtained, in kN/m2, from the following formula:

$$P_D = \varphi p_W$$

where:

p_W: Pressure obtained from the formulae in table T.E7.201.1.

φ: Coefficient defined in table T.E7.201.2.

TABLE T.E7.201.1.: PRESSURES ON EXPOSED DECKS FOR H1, H2, F1 AND F2

Location	Pressure p_W, in kN/m²	
	$L \geq 100$ m	$L_{LL} < 100$ m
$0 \leq x/L_{LL} \leq 0{,}75$	34,3	$14{,}9 + 0{,}195\, L_{LL}$
$0{,}75 < x/L_{LL} < 1$	$34{,}3+(14{,}8+a(L_{LL}-100)) * (4x/L_{LL} - 3)$	$12{,}2 + L_{LL}/9\ (5*x/L_{LL} - 2) + 36*x/L_{LL}$

where:

a : Coefficient taken equal to:

a = 0,0726 for Type B freeboard ships

a = 0,356 for Type B-60 or Type B-100 freeboard ships.

TABLE T.E7.201.2: COEFFICIENT FOR PRESSURE ON EXPOSED DECKS

Exposed deck location	φ
Freeboard deck and forecastle deck	1
Superstructure deck, excluding forecastle deck	0,75
1st tierofdeckhouse	0,56
2nd tierofdeckhouse	0,42
3rd tierofdeckhouse	0,32
4th tierofdeckhouse	0,25
5th tierofdeckhouse	0,2
6th tierofdeckhouse	0,15
7th tier of deckhouse and above	0,1

300. Load cases R1, R2, P1 and P2

301. The external pressure pD, for load cases R1, R2, P1 and P2, at any point of an exposed deck is to be obtained, in kN/m2, from the following formula:

$$p_D = 0{,}4\ \varphi p_W$$

where:

p_W Hydrodynamic pressure at side of the exposed deck for the load cases P1, P2 , R1 and R2, in kN/m2, can be determined by E6.700 at the z co-ordinate. p_W is to be taken greater one of the hydrodynamic pressures $p_{W,C}$ at both sides of the exposed deck (portside and starboard), and is not to be taken less than zero.

φ =Coefficient defined in Table T.E7.201.2.

400. Pressure due to distributed load on exposed deck

401. If a distributed load is carried on an exposed deck, the static pressure ps corresponding to this load is to be defined by the designer and, in general, is not to be taken less than 10 kN/m2.

402. The total pressure p due to this load is to be considered not simultaneously to the pressures defined in ta-

ble:T.E7.201.1and E7.300. It is to be taken equal, in kN/m2, to the greater value obtained from the following formulae:

$p = p_S + P_w$

$p = p_D$

where:

p_S: Static pressure due to the distributed load carried, if any

p_W: Dynamic pressure due to the distributed load carried, in kN/m2, taken equal to:

$$pw = \frac{az}{g} ps$$

aZ: Vertical acceleration at the centre of gravity of the distributed load carried for the load case considered, in m/s2, obtained by the formulae defined in E7.700

p_D: Pressure for the exposed deck, for the load case considered, as defined in Tables T.E7.201.1and E7.300.

500. Concentrated forces due to unit load

501. If a unit load is carried on an exposed deck, the static and dynamic forces due to the unit load carried are considered.

502. The total force *F* due to this load is to be considered not simultaneously to the pressures defined in E7.200. and E7.300. It is to be taken, in kN, equal to value obtained from the following formula:

$F = F_S + F_W$

where:

FS : Static force due to the unit load carried, in kN, taken equal to:

$F_S = m_U g$

FW : Dynamic force due to unit load carried, in kN, taken equal to:

$FW = m_U aZ$

m_U: Mass of the unit load carried, in t

a_Z: Vertical acceleration at the centre of gravity of the unit load carried for the load case considered, in m/s2, obtained by the formulae defined in E7.600.

600. External pressures on superstructure and deckhouses

601. External pressures on exposed decks of superstructures and deckhouses are to be obtained according to E7.100. to E7.403.

700. EXPOSED WHEEL HOUSE TOPS

701. The lateral pressure for exposed wheel house tops, in kN/m², is not to be taken less than:

$p = 2{,}5$

800. SIDES OF SUPERSTRUCTURES

801. The lateral pressure for sides of superstructures, in kN/m², is to be obtained from the following formula:

$Psi=2{,}1Cf_pc_F(CB+0{,}7)*20/(10+z-T)$

fp : Probability factor, taken equal to:

fp =1,0 for plate panels

fp = 0,75 for ordinary stiffeners and primary supporting members

cF: Distribution factor according to Table T.E7.800.1.

TABLE T.E7.800.1. DISTRIBUTION FACTOR C_F

Location	C_F
$0 \leq x/L < 0{,}2$	$1+5/C_B(0{,}2-x/L)$, without taking *x/L* less than 0.1
$x/L \geq 0{,}2$	1,0

900. SUPERSTRUCTURE END BULKHEADS AND DECKHOUSE WALLS

901. The lateral pressure, in kN/m2, for determining the scantlings is to be obtained from the greater of the following formulae:

$$PA = nc[(bC - (z - T)]$$

$p_A = pA_{min}$

where:

n : Coefficient defined in T.E7.902.1., depending on the tier level.

902. The lowest tier is normally that tier which is directly situated above the uppermost continuous deck to which the depth *D* is to be measured. However, where the actual distance exceeds the minimum noncorrected tabular freeboard according to ILLC as amended by at least one standard superstructure height as defined in Table T.E7.902.1., this tier may be defined as the 2nd tier and the tier above as the 3rd tier.

Ref. ILLC, as amended (Resolution MSC.143(77) Reg. 33) The standard height of superstructure is defined in tab-leT.E7.902.1.

TABLE T.E7.902.1. STANDARD HEIGHT OF SUPER-STRUCTURE

Freeboard length L_{LL}, in m	Standard height *hs*, in m	
	Raisedquarter deck	Allother superstructures
$90 < L_{LL} < 125$	$0.3 + 0.012\ L_{LL}$	$1.05 + 0.01\ L_{LL}$
$L_{LL} \geq 125$	1.80	2.30

c : Coefficient taken equal to:

$$c = 0{,}3 + 0{,}7\frac{b1}{B1}$$

For exposed parts of machinery casings, *c* is not to be taken less than 1,0

b_1 : Breadth of deckhouse at the position considered

B_1 : Actual maximum breadth of ship on the exposed weather deck at the position considered.

$b1\ B_1$is not to be taken less than 0,25

b : Coefficient defined in **TABLE T.E7.902.2.**

x : *X* co-ordinate, in m, of the calculation point for the bulkhead considered. When determining sides of a dec house, the deckhouse is to be subdivided into parts of approimately equal length, not exceeding 0,15*L* each, and *x* is to be taken as the *X* co-ordinate of the centre of each part considered.

z : *Z* co-ordinate, in m, of the midpoint of stiffener span, or to the middle of the plate field

l : Span, in m, to be taken as the superstructure height or deckhouse height respectively, and not less than
2.0 m

$p_{A\min}$: Minimum lateral pressure, in kN/m^2, defined in Table T.E.7.902.3.

TABLE T.E7.902.1. COEFFICIENT *n*

Typeof bulkhead	Location	*n*
Unprotected front	Lowesttier	$20 + L2/12$
	Secondtier	$10 + L2/12$
	Thirdtierandabove	$5 + L2/15$
Protected front	Alltiers	$5 + L2/15$
Sides	Alltiers	$5 + L2/15$
Aftend	Abaftamidships	$7 + L2/100$- 8 x/ $L2$
	Forwardofamidships	$5 + L2/100$- 4 x/ $L2$

TABLE T.E7.902.2. COEFFICIENT *b*

Locationofbulkhead	*b*
$x/L < 0{,}45$	$1{,}0 + \left(\frac{\frac{x}{L} - 0{,}45}{CB + 0{,}2}\right)^2$
$x/L \geq 0{,}45$	
Where: C_B : Block coefficient with $0{,}6 \leq C_B \leq 0{,}8$. When determining scantlings of aft ends forward of amidships, C_B need not be taken less than 0,8.	

TABLE T.E7.902.3. MINIMUM LATERAL PRESSURE P_{AMIN}

L	*pA*min, in kN/m2	
	Lowest tier of unprotected fronts	Elsewhere(1)
$90 < L \leq 250$	25+L/10	12,5+L/10
$L > 250$	50	25
(1) For the 4th tier and above, $p_{A\min}$is to be taken equal to 2,5 kN/m².		

E8. PRESSURE IN BOW AREA

100. BOW FLARE AREA PRESSURE

101. The bow pressure, in kN/m², to be considered for the reinforcement of the bow flare area is to be obtained from the following formula:

$$PFB = K(ps + pw)$$

where:

p_S, p_W: Hydrostatic pressure and maximum hydrodynamic pressures among load cases H, F, R and P, calculated in normal ballast condition at *TB*

K : Coefficient taken equal to:

$$K = \frac{cFL\left(0{,}2V + 0{,}6\sqrt{L}\right)^2}{42C(CB + 0{,}7)\left(1 + \frac{20}{CB}\left(\frac{x}{L} - 0{,}7\right)^2\right)}(10 + z - TB)$$

Not to taken not less than 1,0.

cFL: Coefficient taken equal to:

$CFL = \frac{0{,}4}{1{,}2 - 1{,}09 sin\alpha}$ where the flare α is greater than 40°

200. DESIGN BOTTOM SLAMMING PRESSURE

201. The bottom slamming pressure, in kN/m², to be considered for the reinforcement of the flat bottom forward is to be obtained from the following formula:

$Psl=162c_1C_{SL}\sqrt{L}$ for $L \leq 150\ m$

$Psl=1984c_1C_{SL}(1,3-0,002L)$ for $L > 150\ m$

where:

$c1$: Coefficient taken equal to:

$c1 = 3,6 - 6,5(\frac{TBFP}{L})^{0,2}$, to be taken not greater than 1,0

with:

T_{BFP}: Smallest design ballast draught, in m, defined at forward perpendicular for normal ballast conditions.

202. Where the sequential method for ballast water exchange is intended to be applied, T_{BFP} is to be considered for the sequence of exchange.

c_{SL}: Distribution factor taken equal to(see F.E7.202.1.):

$$cSL = 0\ for\ \frac{x}{L} \leq 0,5$$

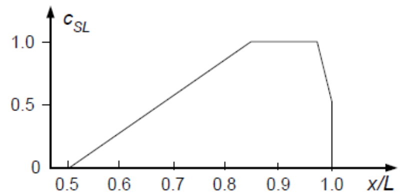
$$cSL = \frac{\frac{X}{L} - 0,5}{c2}\quad for\ 0,5 < \frac{x}{L} \leq 0,5 + c2$$

$$cSL = 1\qquad for\ 0,5 + c2 < \frac{x}{L} \leq 0,65 + c2$$

$$cSL = 0,5\left(1 + \frac{1 - \frac{x}{L}}{0,35 - c2}\right)$$

$c2 = 0,33CB + \frac{L}{2500}$, to be taken not greater than 0,35.

FIGURE F.E7.202.1.: DISTRIBUTION FACTOR C_{SL}



203. It is the Master's responsibility to observe, among others, the weather conditions and the draught at forward perpendicular during water ballast exchange operations, in particular when the forward draught during these operations is less than T_{BFP}.

204. The above requirement and the draught T_{BFP} is to be clearly indicated in the operating manuals.

CHAPTER F
DIMENSIONING OF LOCAL STRUCTURAL SYSTEMS

CHAPTER CONTENTS

F1. BOTTOM AND DOUBLE BOTTOM

100. Thickness of the bottom at ends

101. Thickness of bottom for 0,1L at ends tobe 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 abaftthe FP to forward end;

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

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

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

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. To be at least equal to the greater of the following values:

For transversal system:

$e = 0{,}07 \times L + 0{,}007 \times (E - E_0) + 2{,}0$ mm

For longitudinal system:

$e = 0{,}1 \text{ x } L + 0{,}007(E- E_0) + 1{,}0$ mm

202. In vessels which may run aground in operation, the thickness should not be less than that of the equation:

$e = 0{,}07 \times L + 5$ mm

203. The plating of the sea chests follows the formula on paragraph 201., adjusted to local spacing of the panel in relation to E_0, but with at least the thickness of the bottom.

204. The bilge thickness will be at least equal to that of the bottom.

300. Keel

301. The width of the flat-plate keel should be 0,1 × B or 900 mm and need not be greater than 2000 mm.

302. The thickness will be at least equal to that of the bottom increased by about 10%, for provision for wear due to the dockings.

303. Bar keel will have area given by:

$A = 0{,}6 \times L + 3$ cm^2

304. For non-propelled vessels this area may be reduced by 10%.

305. Bar keel will have thickness given by:

$e = 0{,}3 \times L + 10$ mm

400. Connection to stern frame and to the stem

401. At the union with stern sill or with the bar stem, the keel plate thickness should be increased by 30%, in a minimum length of 2 meters, from this union. See also Subchapter F5. Stern Structure.

500. Floors, longitudinal beams, stringers and deep floors on single bottom

501. 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.

502. The required modulus for transversal beams is calculated by the following equation:.

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

503. The required modulus for longitudinal beams and stringers, is calculated by the following equation:

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

where:

L mín in the formula = 40 m

504. The spans are defined by structural elements that support the beams, such as pillars, reinforced stiffeners of bulkheads or other beams.

505. For every two space of bottom stiffeners, it should be located, in the web of the floor or stringer, a stiffening bar of the same thickness of the floor or stringer with width of 8 times the thickness.

600. Inner bottom plating

601. In vessels type **B** and with L ≥ 50 , a double bottom should be built.

602. For vessels of type **A**, see Title 31 for ships for liquid bulk carriage.

603. The inner bottom thickness 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 the least of 500 and “e” should be no less than:

the bottom thickness; and

the tank thickness + 1,0.

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

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

701. The required modulus for the inner bottom girders will be calculated by the equation of subchapter E4., taking into account the respective loads of the subchapter E3. For inner bottom longitudinal beams apply the Paragraph 503. of this subchapter.

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

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

704. 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.

705. The floors must not have holes in the extension of two secondary space of their support points and plating thickness in this area should not be less than:

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

where:

E : in mm

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

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

707. The modulus of floor stiffeners are to be calculated in accordance with the Topic F2.700.

708. In case of unloading with grabs, the modulus should be multiplied by 1,1.

709. When struts are used at mid-span between plate floors, joining the bottom beams and inner bottom beams, these they will be calculated in accordance with item F1.700, for the span between plate floors multiplied by 0,5, but should not be smaller than the inner bottom beam. The strut should be calculated as per Topic F4.700.

F2. BULKHEADS

100. Definitions

101. Terms used herein:

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

ATQ – Tank bulkhead 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 positionsof 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 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 of the main deck or of the trunk-deck; and 1,3 m above tank top	0,9 m above the overflow or of the main deck or of the trunk-deck; and 1,5 m above tank top

202. When the liquid density is greater than 1, the equations will change proportionally.

300. Plating of AECs

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

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

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

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

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. In the zone of the stern tube the thickness will be increased of 60%.

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

305. The inferior strakeofplatingon bulkhead of cargo holds, at a minimum height of 250 mm, shall have increasing thickness of 1 mm.

400. Stiffeners of AECs

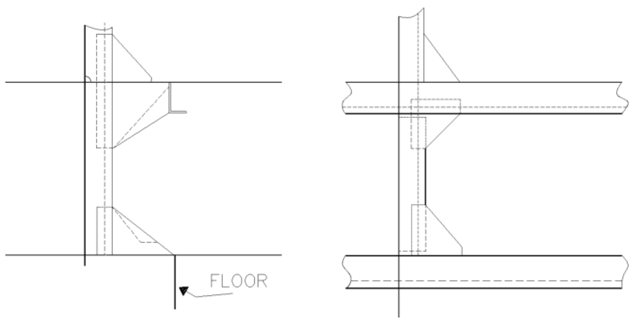
401. The section modulus of practically vertical stiffeners, in general, on transversal or longitudinal AECs will be given by the equation:

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

where (see Figure F.F2.401.1):

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.

FIGURE F.1. F.F2.401.1. - TIPICAL BULKHEAD (WITH VERTICAL STIFFENERS ON LONGITUNAL SYSTEMS)



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

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

403. For horizontal stiffener 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 on transversal bulkhead,theabove equation is used, where “E” is the average of the spans of the stiffeners, above and below, that is supported.Besides that, where supporting shell stingers at their end, they should be checked for buckling.

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

$$W = \sum Wi$$

where:

W_i is calculated for each 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_{i1} and Si_2 : horizontal girder spacings above and below the horizontal girder “i”;

E_1 and E_2 : reinforced vertical girder spacingsof 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 reinforced vertical girder that is being calculated.

406. For longitudinal beams on longitudinal bulkhead 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 from the longitudinal beam to the deck or to the bottom, without being greater than 0,4 × D;
when it is greater, assume $y_i = 1$.

407. For reinforced 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.

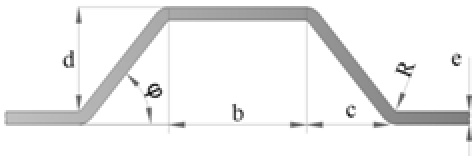
408. For reinforced vertical girders that support the reinforced horizontal girder on longitudinal bulkhead, the modulus in the bottom end is calculated by the equation of the Paragraph 405., where hi is according Paragraph 406.

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

410. Reinforced vertical girders that support girders should be checked as pillars, supporting the load brought by the girder, in accordance with Topic F4.700.

411. When stiffener is constructed with corrugated plate, consider half of the parallel panels to the bulkhead as the flanges,forminga stiffener in an I beam form, for the offered modulus, where the angle φof the inclined panel should not be lower than 45°.

FIGURE F.F2.411.1 –CORRUGATED BULKHEAD



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

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

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

R = 3,0 x e

414. 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 pressure on the mid height of the bulkhead.

415. 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.

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 strake considered, in m.

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

600. Stiffeners of ATQs

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

$W = 1{,}19 \times E \times l^2 \times (5 \times h + 3 \times h_p)$
where (see Figure F.F2.401.1):

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. For vertical stiffener the equation is written as follows:

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

603. For horizontal stiffener of transverse bulkhead the equation is written as follows:

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

604. Forhorizontal girders that support vertical stiffeners on transversal bulkhead, the above equation is used, being "E" the average of the spans of the stiffeners, above and below, that it supports.

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

$W = \sum Wi$

where:

Wi 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 reinforced vertical girder;

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

$E_1$and E_2 : reinforced vertical girderspacings 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 reinforced horizontal girder "i" to the ends of the span l of the reinforced vertical girder that is being calculated.

606. For longitudinal beams on 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 longitudinal beam to the deck or to the bottom, without being greater than 0.4 × D; when it is greater, assume $y_i = 1$.

607. For reinforced 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.

608. For reinforced vertical girders that support the reinforced horizontal girder on longitudinal bulkhead, the modulus in the bottom end is calculated by the equation of the Paragraph 605, where hi is according Paragraph 606.

609. For vertical girders that support longitudinal beams on longitudinal bulkhead, the section modulus is calculated by the equations of the Paragraphs 701. and 702., taking into account the spacing and spans.

610. Reinforced vertical girders that support deck girders should be checked as pillars, supporting the load brought by the girder, in accordance with Topic F4.700.

611. When stiffener is constructed whith corrugated plate, see Paragraphs 411. To 415.

700. Independent tanks

701. The elements will be calculated as tank bulkhead, with cargo height measured 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 at the ends will be similar to that of the bottom.

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

$e = 0{,}095 \times L + 0{,}0063 \times (E - E_0) + 1{,}8$ mm

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

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

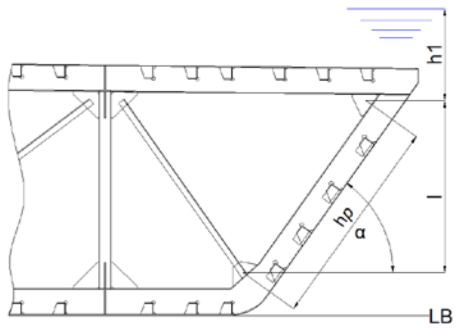
104. In vessels that are part of convoys where they are subject to impact themselves or subject to impacts in the side shell, the thickness of the belting should not be less than that given by the equation:

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

200. Practically vertical framesin side shell

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

FIGURE F.F3.201.1. –SIDE SHELL FRAMES



202. For fully submerged frames, i.e., when the top of the 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, equal to the distance to the exposed 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 reinforced girders

401. For stringers that support web frames, apply the equation ofParagraph 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. For reinforcedverticalgirdersthat support stringers, the modulus in the bottom end is calculated by the equation:

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

$$W = \sum Wi$$

where :

W_i is calculated for each stringer "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 reinforced vertical girder;

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

E_1 e E_2 : reinforced vertical girder spacings on each side of the reinforced vertical girder that is being calculated;

C : the greater of the values: $li_1 \times li_2^2$ or $li_1^2 \times li_2$

and:

li_1 and li_2 are the distances from the stringer "i" until the ends of the span l of the reinforced vertical girder that is being calculated.

502. For web frames that support longitudinal frames, the modulus is calculated in accordance with the respective cases of Paragraphs F3.202 to 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 SubchapterF2.

602. Frames that support deck girders should be checked as pillars, supporting the load brought by the girder, in accordance with Topic F4.700.

603. Web frames in engine room, in principle, will be located in maximum intervals of 5 frames or 3 m, whichever is less, with a height of web twice the ordinary frame and modulus 4 times higher. They must compose, along with deep floors and deck transverse girders of similar modulus to form a coherent structural ring.

604. On vessels with the stem, the stem frames, which stay in the region to 0,15 L of the forward perpendicular, should have the 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.

700. Web frame for cantilever

701. The configurations in the cases of loadings to be combined are in the Figure F.F3.701.1. and are:

Case 1:for the upper deck: loading by concentrated load, brought by the hatch coaming, plus the distributed load in the deck strake, both related to the deck length that supports, i.e., to the spacing of cantilever (for loads, see Table T.E3.101.1.of this Section 2);

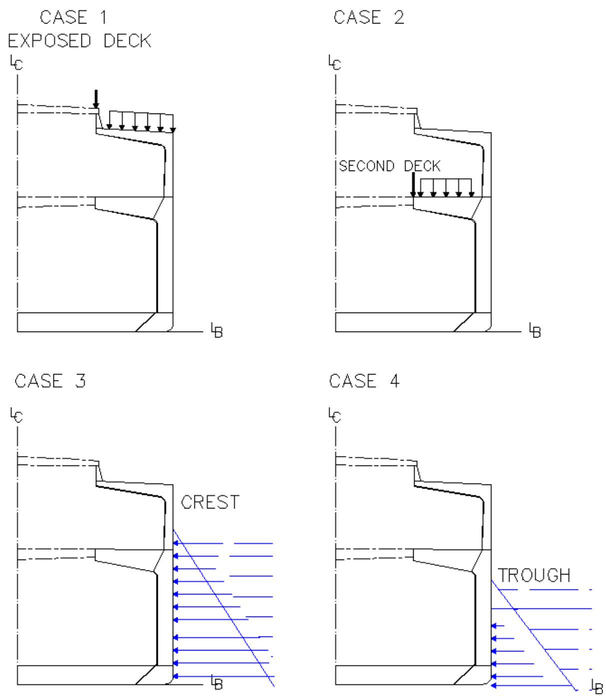
Case 2: the same for a second deck when it exists;
Case 3: hydrostatic loading for the top of the water column in the following height:

for O2: d + 1.0, not exceeding the level of the deck; and

for O1: d + 0.7, not exceeding the level of the deck:

Case 4: only applied to mention O2, hydrostatic loading for the top-of the water column equal to d – 0,7.

FIGURE F.F3.701.1 –CONFIGURATIONS OF CASES OF LOADING TO BE COMBINED



702. The stresses from the bending moments and shearing forces are calculated case by case. It can be used the Cross method or another approved method to be submitted. The cases are combined so to define the maximum bending moments and shear stresses in key points of the structure.

703. The bearing reactions provided by the deck will come from a load that acts in the horizontal beam that has the deck as the web and the hatch coaming and a strake of the side shell as the flanges.

704. The bending moment and the shear stress will be calculated in the clipped end of this deck-beam, and in the bottom end of the web frame. The combined stress should meet the equation:

$$\sigma_c = \sqrt{\sigma^2 + 3 \times \tau^2} \quad \leq 13{,}73 \text{daN/mm}^2 \ (14 \quad \text{kgf/mm}^2)$$

705. The width of the strake of the side shell that act as a flange will be the smallest of the following values:

a. for the highest deck: half the distance of the considered deck up to the top of the floor or to the inner bottom plating or to the next deck when applicable;

b. for intermediate deck: half the sum of the dis-stances to the decks above and below this deck; and

c. for any deck: $0{,}1 \times l_e$, where l_e is the beam span, that is i.e., the length of the hatch opening.

706. When the hatch coaming is a beam with enough stiffness to provide elastic support on the inner end of the transverse girder, the model of the structure can incorporate this consideration and the method of calculation should be submitted for approval.

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 amidships

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

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

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

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

e_{CR}= required to meet the midshipsection modulus strength, prescribed on Chapter H.

202. In vessels in which 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 0,15B, the thickness of the deck plating around corners should be reinforced, at least in $0{,}1b_e$, in longitudinal and transverse directions from the corners, meeting the following equation:

$e_c = (0{,}8 + 0{,}4 \times (b_e / li)) \times e$

where:

e_c: reinforced plate thickness in mm;

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

b_e: 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×(b_e / li)) 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:

$$e_{DC} = 0{,}009 \times E_{\text{A}}$$

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

400. Transverse beams and girders

401. The strength modulus of strength deck transverse beamandtransverse 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,unlesslocal configuration justify differently.

403. In vessels in which 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:

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

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

where:

f coefficient defined in Paragraph E4.203. of these Rules; minimum to be used = 0,7;

p : pressure of load in t/m²;

h : cargo height in m;

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

E: stiffener spacing in m;

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

502. See also Paragraph E2.402. for concentrated load.

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

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

$$W = c \times 7 \times (p \times b + p_e \times b_e) \times l^2 \times (0{,}008 \times L + 1)$$

where:

c : coefficient =1 or 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.

l : unsupported span of the hatch girder.

602. 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 mmand 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 (transverseverticalstiffeners) 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;

E_p: spacing of pillars or length of the supported area in m; and

b_p: 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:

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

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

where:

l : length of the pillar, in m;

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

I: lowest moment of inertia in cm4;

A: section area in cm^2.

F5. STERN STRUCTURE

100. Stern bar

101. The bar area is given by the equation:

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

102. For non-propelled vessels this area can be reduced by 10%.

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

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

104. Additions to be provided:

- 10%, when the stern frame is connected to the shoe piece that is a bearing for the rudder pin; and

- 20%, when the shoe piece is a bearing for the propeller nozzle pin.

200. Stern plate

201. The thickness of the plates should not be less than 0,3 times the thickness of the stern frame bar, at a distance of 1,7 times its width, from the aft edge, and the strength modulus of the horizontal section related to the longitudinal centershouldbe 1,5 times the strength modulusof the stern frame bar, calculated as per previous paragraph.

300. Stern frame shoe piece

301. The strength modulus of the cross section of the shoe piece that is the bearing of the rudder lower pintle, next to the insertion of the stern frame, with respect to a vertical center, is given by the equation:

$$W = 0{,}35 \times A \times V^2 \times a \qquad cm^3$$

where:

A: rudder area in m^2;

V: vessel speed in km/h;

a: distance of the rudder pintle to the section that can be considered as the insertion on the stern shoe piece.

302. When the shoe piece is the bearing of the propeller steering nozzle or when the shoe piece is part of fixed nozzle supporting the rudder pintle, the modulus should be increased by 20%.

303. The connection of shoe piece, stern frame and keel is to be made of material with section compatible and with gradual interactions.

400. Structural boss as bearing of rudder lower pintle (at the level of the hull)

401. The height of effective support should be 1,0 to 1,2 times the diameter of the pintle and the thickness of the material, after machining, should be at least 0,33 times this diameter.

500. Support of semi-suspended rudder

501. The force calculated on the rudder, according to Part II, Section 3, is applied by the lower pintle of the rudder onthe rudder horn.

502. The rudder support horn is calculated in each part, as a cantilever beam, for the active efforts of bending moment, normal force and shear force.

503. The stresses should satisfy the equation:

$$\sigma_c = \sqrt{\sigma^2 + 3 \times \tau^2} \leq 13{,}73 \text{daN/mm}^2 \quad (14 \quad \text{kgf/mm}^2)$$

where :

σ: normal stress plus bending stress;and

τ: shear stress plus torsion stress.

600. Boss of stern tube

601. The material of the structural boss, after machining, should have the following minimum dimensions, in mm:

thickness (least value): $e = 0{,}35 \times d_e$ or $e = (0{,}84 \times L + 13) \times a$

length: $c = 3{,}0 \times d_e$

where:

d_e: thruster shaft diameter, in mm;

a: 1,0 for O2 zone;
0,9 for O1 zone.

700. Struts for tube bosses in cantilever and for fixed propeller nozzles

701. When two struts are fabricated, the angle between them should be as close as possible to 90°. Their dimensions are indicated by:

thickness: the greatest value: $0{,}33 \times d_e$ or $20 \times b$ mm;

each area: $0{,}44 \times d_e^2$ mm^2.

where:

d_e: thruster shaft diameter, in mm.

b : length of the strut measured from the center of the shaft to the hull in m.

702. When the strut is made of double plate, the modulus should be at least equal to the one of the solid section.

703. The attachment of the strut 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 same applies to the fixed propeller nozzle attached to the hull. The thickness of the inserted shell plate, at about one strut width, around the shell opening, should be increased by 50%.

704. When there is one strut, its strength modulus in relation to the longitudinal shaft should range from 2 times, next to the boss, up to 4 times, next to the hull, the strength modulus of the thruster shaft.

F6. BOW STRUCTURE

100. Bow bar

101. The thickness, in mm, is given by the equation:

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

102. Breasthooksfor 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. The area and thickness follow the Topic F5.100.

300. Flat part of bottom forward

301. 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.

102. Where there are machinery space inside superstructures, the overall stiffness of the structure is to be considered as a transversal gantry, subjected to forces from ship's movement, in order to support the stresses where attached to the hull.

103. See also E3.103.

200. Strength of end bulkheads for existent ships withL< 150 m

201. Thickness of plating of external bulkheads

e = 0,002 x E + 0,002 x 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;

$e_{minimum}$ = 4,8 mm.

202. Stiffener modulus on external bulkheads

W = 1,5 x E x l^2 x $\sqrt{L}$ x 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 minimum = 8 cm^3 with minimum thickness of 4,8 mm.

203. Pillars are to be calculated by Topic F4.700. for the load and spacing that they support.

300. Strength of end bulkheads of superstructures anddeckhouses(new buildings and existent ships with L > 150 m) [IACS UR S3]

301. **Scope:**the following proposal applies to bulkheads forming the only protection for openings as per Regulation 18 of LLC 1966 and for accommodations. These requirements define minimum scantlings based upon local lateral loads and it may be required that they be increased in individual cases. Scantlings of tiers not specifically mentioned in this proposal are to be analyzed by RBNA. This UR does not apply to CSR Bulk Carriers.

302. Design pressure headto be applied.

$$p = \frac{a}{100}(bf - y)c$$

where:

P = design pressure in N/mm² (MPa)

$a = 2,0 + \frac{L1}{120}$ For lowest tier of unprotected fronts

303. The lowest tier is normally that tier which is directly situated above the uppermost continuous deck to which the rule depth D is to be measured. However, where the freeboard is excessive, it may be left to discretion of RBNA to define this tier as an upper tier. It is recommended that excessive freeboard' is that which exceeds the minimum tabular freeboard by more than one standard superstructure height.

$a = 1.0 + \frac{L1}{120}$ for 2^{nd} of unprotected fronts

$a = 0,5 + \frac{L1}{150}$ for 3^{rd} tier of unproncted fronts and for sides and protected dronts.

$a = 0,7 + \frac{L1}{1000} - 0,8\frac{x}{L}$ for aft ends aft of amidships

$a = 0,5 + \frac{L1}{1000} - 0,4\frac{x}{L}$ for aft ends forward of amiships

L,L1 = length in metres, L1 need not to be taken greater than 300 m

$$b = 1.0 + \left(\frac{\frac{x}{L} - 0.45}{Cb + 0.2}\right)^2 for \frac{x}{L} \leq 0.4$$

$$b = 1.0 + 1.5\left(\frac{\frac{x}{L} - 0.45}{Cb + 0.2}\right)^2 for \frac{x}{L} > 0.45$$

Cb = block coefficient, 0.6 < Cb < 0.45

when determining aft ends forward of amidships, C_b need not be taken less than 0.8

x = distance in metres between bulkhead considered and AP

304. When determining sides of a deckhouse, the deckhouse is to be subdivided into parts of approximately equal length, not exceeding 0.15L each x is to be taken as the distance between AP and the centre of each part considered.

$$f = \frac{L}{10}e^{\frac{-L}{300}} - \left[1 - \left(\frac{L}{150}\right)^2\right] for\ L < 150\ m$$

$f = \frac{L}{10}e^{\frac{-L}{300}}$ for 150 m <L<300

f=11,03 for L>300 m

y = vertical distance In metres form summer waterline to midpoint of stiffener span

$$c = \left(0.3 + 0.7\frac{b'}{B'}\right)$$

b' = breadth of deckhouse at the position considered

B' = actual maximum breadth of ship on the exposed weather deck at the position considered.

305. For exposed parts of machinery casings *c* is not to be taken less than 1.0

306. The design pressure *p* is not to be taken less than the minimum values given in Table T.F7.205.1.

TABLE T.F7.205.1 – DESIGN PRESSURE

L(m)	P (N/mm² or MPA)	
	Lowest tier of un-protected fronts	Elsewhere
$L \leq 50$	0,03	0,015
$50 < L < 250$	0,025 + 10x4L	0,0125 + 0,5 x 10-4L
$L \geq 250$	0,05	0,025

400. Stiffener modulus [IACS URS 3]

401. Stiffener modulus as per formulae:

$$W = 350sl^2p$$

where

W = stiffener modulus (cm3)

s = spacing of stiffeners (m), measured along the plating

l = unsupported span (m), which is to be taken as the 'tween deck height l_{min} = 2,0 m

p = pressure in N/mm2 (MPa) as defined above.

402. 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.

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

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

405. 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.

500. Deck plating

501. Thickness of plating of decks

e = 0,007 x E + 0,001 x L + 1,5

where:

$e_{minimum}$ = 4,8 mm.

502. 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/m² for superstructure decks
0,45 t/m² for deckhouse decks

c_3 = 0,008 x L + 1 for superstructures which participate on longitudinal strength of the ship;

c_3 = 1 for others cases;

W minimum = 8 cm3 with minimum thickness of 4,8 mm.

F8. SUMMARY OF FORMULAE FORDIMENSIONING OF LOCALCOMMONSTRUCTURE

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	THICKNESS e =	TOPIC
Bottom and side Shell in the ends	$0{,}85\sqrt{L}$ *or* $0{,}006E\sqrt{d}$ *or* $0{,}01E$	F1.100.
Bottom amidships	$0{,}07L + 0{,}007(E - E_0) + 2{,}0$ 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 MODULUS W**	**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	$0{,}877\ E\ l^2\ (5\ h + 3\ \mathrm{sen} h_p)$	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	$1{,}19\ E\ l^2\ (5\ h + 3\ l)$	F2.701.
Horizontal stiffener ontransverseATQ	$5{,}95\ h\ E\ l^2$	F2.704.
Longitudinal stiffener of longitudinal ATQ	$8{,}93\ E\ l^2\ h_1 Y_1$	F2.708.
Side shell practically vertical frames	$0{,}877\ E\ l^2\ (5\ h + 3\ l \mathrm{sen}\alpha)$	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	$f\ 7\ p\ E\ l^2$ $7\ p\ E\ l^2\ (0{,}008\ L + 1)$	F7.501. and F7.504.

CHAPTER G
PRINCIPLES OF HULL GIRDER DESIGN

CHAPTER CONTENT

G1. SCOPE

100. Application

101. The longitudinal strength is calculated for vessels that fit in the following cases:

when the loading cannot be considered evenly distributed;

for type B ships, when loading of the cargo along of the hold is made in only one pass or in a particular way;

for length L ≥ 90 meters; and

when AB ≥ 500.

Note: definitions of Type A and Type B ships according Rule 27 of ILLC.

G2. CONFIGURATION OF THE GLOBAL STRUCTURE

100. Type "B" vessels

101. In general the following itens need to be applied to all kinds of vessels discriminated in accordance with the definitions showed here.

102. In the case of vessels having only one hold and double bottom and side shell, in order to provide proper fastening of the side shells so as to resist twisting stresses, a locking horizontal panel properly stiffened, along the cargo hold, should be built at the deck level (with no obligation of a bulkhead under this one), as follows:

Length of the hold opening *l* (m)	Numberofpanels
50 ≤ *l* < 60	one
l ≥ 60	two

103. Vessels having only one hold and without double hull will be object of special study by RBNA.

200. Special vessels

201. Special vessels, such as those of type B, which do not have hatch covers, will be submitted to special assessment of the RBNA in each case.

202. The loading factors for dimensioning are listed in the Titles or in the pertinent Sections.

CHAPTER H
GLOBAL DIMENSIONING OF HULL GIRDER

CHAPTER CONTENT

H1. CALCULATION OF MIDSHIP SECTION-MODULI FORCONVENTIONAL SHIP FOR-SHIP'S SCANTLINGS [IACS UR S5]

100. Application

101. This section applies to ships in general, however does not applies to CSR Bulk CarriersorOil Tankers.

200. Scantlings to be considered

201. When calculating the midship section modulus within 0,4L amidships 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°.
207. Longitudinal girders between multi-hatchway will be considered by special calculations.

300. References

301. The deck modulus is related to the molded deck line at side.The bottom modulus is related to the base line.

302. 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:

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

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.

H2. MIDSHIP SECTION STRENGTH FOR SHIPS WITH L <90 m

100. Application

101. This sub-chapter apply to conventional ships 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:

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

where:

L = length defined in Title 11, section 1, sub-chaper A2.
B = greatest moulded breadth in metres.
C_b = block coefficient not to be taken less than 0,6.

C= C_n for new ships
C= 0,9 C_n for ships in service

C_n= 11,35-0,123L for $30\ m \leq L < 45\ m$

C_n= 6,8 for $45\ m \leq L < 60\ m$

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

k = material factor .

k = 1,0 for ordinary hull structural steel.
k < 1,0 for higher tensile steel according with Part II, Title 11, Section 2, Topic 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:

$$a_R = \frac{(WR - W) \times Sa}{(D - zF) \times Sa - (WR - W)}$$

where:

aR: area to be added;

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

zF: distance from the baseline to the neutral axis.

205. The following formulae are indicated as a reference for computation of the bilge plate:

a. for circular bilge plate:

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 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. Moment of inertia
[IACS UR S11 3.1.2]

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

$$Imin = 3CL^3B(Cb + 0{,}7) \quad cm^4$$

where:

C, L, B, C_b as specified in Paragraph 201.

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

CONFIGURATION:

ITEM	ELEMENT	DIMENSION		Qt	a	d	a.d	a.d²	i
		b cm	h cm	n	cm^2	m	$cm^2.m$	$cm^2.m^2$	$cm^2.m$
					Σ a =		Σ ad =	Σ ad2 =	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: element 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 SHIPSWITH 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. H3.104.1.can be used.

105. When the boarding of the cargo is performed in a ship witha single hold in one single pass, the bending moment should be calculated for the loading conditioswhich contemplate 60% of the total permissible cargo occupying only the hold abaft the midshipsectionor 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 Moment

301. The total moment is given by the sum:

$$Mt = Mc + Mw \qquad (t \times m)$$

where:

Mc: Still water moment ($t \times m$); e

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

400. Wave torsional moment

401. These topic apply to Container ships, ships having partially opened deck and bulk carriers with hull structures of single side skin and double side for unrestricted worldwide navigation, having length *L* of 90 m or above.

TABLET. H3.104.1.STILL WATER BENDING MOMENTMIDSHIPSESTIMATIONFOR SHIPS WITH L < 90 M

VESSEL: **TYPE:**

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

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

3. LOAD / CONSUMABLE DISTRIBUTION

ABAFT OF Φ					FWD OFΦ				
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 σ_{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. MINIMUM LONGITUDINAL STRENGTH STANDARS FOR SHIPSWITHL≥ 90 m [IACS UR S7]

Note: this requirement is subject to periodical updating.

100. Application

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

200. Minimum mideship 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

$W_{min} = cL^2B(Cb + 0{,}7)k$ (cm³)

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 of315 N/mm², 355 N/mm²and 390 N/mm².**[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.

H5. LONGITUDINAL STRENGTH STANDARDFOR SHIPS WITH L≥ 90 METERS [IACS UR S11]

100. Application [IACS UR S11.1]

101. This requirement applies only to steel ships of length 90 m and greater in unrestricted service. For ships having one or more of the following characteristics, special additional considerations will be given by RBNA:

a. proportion L/B≤ 5 B/D ≥ 2,5

b. length L ≥ 500 m

c. block coefficient Cb< 0,6

d. large deck opening

e. ships with large flare

f. carriage of heated cargoes

g. unusual type or design

102. For bulk carriers with notation BC-A, BC-B or BC-C, this sub-chapter H5. is to be complied with by ships contracted for construction on or after 1 July 2003. For other ships, this revision of this sub-chapter H5. is to be complied with by ships contracted for construction on or after 1 July 2004.

Note: this UR does not apply to CSR Bulk Carriers and Oil Tankers.

200. Loads

201. Still water bending moment and shear force[IACS UR S11.2.1]

a. **General**: Still water bending moments, Ms (kN-m), and still water shear forces, Fs (kN), are to be calculated at each section along the ship length for design cargo and ballast loading conditions as specified in H5.201.b.[UR S11.2.1.2]. For these calculations, downward loads are assumed to be taken as positive values, and are to beintegrated in the forward direction from the aft end of L. The sign conventions of Ms and Fs are as shown in Fig.F.H5.201.a.1.**[IACS UR S11.2.1.1]**

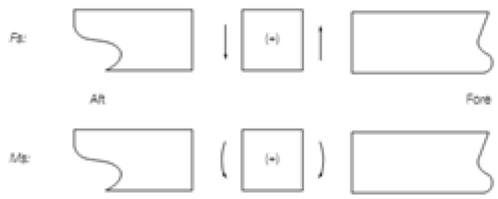
Notes:

1. the “contracted for construction” date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder;for further details regarding the date of “contract for construction”, refer to IACS Procedural Requirement (PR) No. 29.

2. changes introduced in Rev.5 of the referred UR are to be uniformly applied by RBNA on ships contracted for construction on or after 1 July 2006.

3. changes introduced in Rev.7 of the referred UR are to be uniformly implemented by RBNA on ships contracted for construction on or after 1 July 2011.

FIGURE F.H5.201.a.1. Sign conventions of Ms and Fs



b. **Design loading conditions[IACS UR S11.2.1.2]**

b.1. In general, the following design cargo and ballast loading conditions, based on amount of bunker, fresh water and stores at departure and arrival, are to be considered for the Ms and Fs calculations. Where the amount and disposition of consumables at any intermediate 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 and/or deballasting is intended during voyage, calculations of the intermediate condition just before and just after ballasting and/or deballasting any ballast tank are to be submitted and where approved included in the loading manual for guidance.

b.2. for general cargo ships, container ships, roll-on/roll-off and refrigerated cargo carriers, bulk carriers, ore carriers:

i. homogeneous loading conditions at maximum draught;

ii. ballast conditions;

iii. special loading conditions e.g., container or light load conditions at less than the maximum draught, heavy cargo, empty holds or non-homogeneous cargo conditions, deck cargo conditions, etc., where applicable;

iv. all loading conditions specified in iacs for bulk carriers with notation BC-A, BC-B or BC-C, as applicable. **[IACS UR S25]**

b.1.2. for oil tankers:

i. homogeneous loading conditions (excluding dry and clean ballast tanks) and ballast or part loaded conditions;

ii. any specified non-uniform distribution of loading;and

iii. mid-voyage conditions relating to tank cleaning or other operations where these differ significantly from the ballast conditions.

b.1.3. for chemical tankers:

i. Conditions as specified for oil tankers

ii. Conditions for high density or segregated cargo.

b.1.4. for liquefied gas carriers:

i. homogeneous loading conditions for all approved cargoes

ii. ballast conditions

iii. cargo conditions where one or more tanks are empty or partially filled or where more than one type of cargo having significantly different densities are carried.

b.1.5. for combination carriers:

i. conditions as specified for oil tankers and cargo ships.

c. **Partially filled ballast tanks in ballast loading conditions[IACS S11.2.1.3]**

c.1. Ballast loading conditions involving partially filled peak and/or other ballast tanks at departure, arrival or during intermediate conditions are not permitted to be used as design conditions unless:

i. design stress limits are satisfied for all filling levels between empty and full, and

ii. for bulk carriers, as applicable, is complied with for all filling levels between empty and full.**[IACS UR S17]**

c.2. To demonstrate compliance with all filling levels between empty and full, it will be acceptable if, in each condition at departure, arrival and where required by H4.202 any intermediate condition, the tanks intended to be partially filled are assumed to be:**[IACS UR S11.2.1.2]**

i. empty

ii. full

iii. partially filled at intended level

c.3. 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.

c.4. 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 ship'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:

i. trim by stern of 3% of the ship's length, or

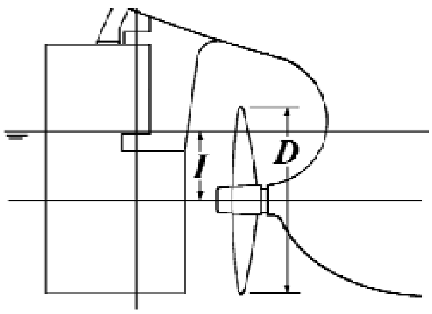
ii. trim by bow of 1.5% of ship's length, or

iii. any trim that cannot maintain propeller immersion (I/D) not less than 25%,

where:

I = the distance from propeller centerline to the waterline
D = propeller diameter
(see the following Figure F.H5.201.c.1.)

FIGURE F.H5.201.c.1.[IACS UR S11]



c.5. The maximum and minimum filling levels of the above mentioned pairs of side ballast tanks are to be indicated in the loading manual.

d. **Partially filled ballast tanks in cargo loading conditions**

d.1. In cargo loading conditions, the requirements in iten c. applies to the peak tanks only.**[IACS S11.2.1.4]**

e. Sequential ballast water exchange

e.1. Requirements of itens c. and d. above are not applicable to ballast water exchange using the sequential method.However, bending moment and shear force calculations for each deballasting 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. **[IACS S11.2.1.5]**

202. Wave loads [IACS UR S.11.2.2]

a. Wave bending moment

a.1. The wave bending moments, Mw, at each section along the ship length are given by the following formulae: **[IACS UR S11.2.2.1]**

Mw (+) = + 190 M C L^2 B Cb × 10^{-3} kN.m for positive moment

Mw (+) = - 110 M C L^2 B (Cb + 0,7) × 10^{-3} kN.m for negative moment

where:

M = distribution factor given in Figure F.H5.202.a.1.

C = c_n as indicated in H3.101.

L = length of the ships in metres, defined by UR S2

B = greatest moulded breadth in metres

Cb = block coefficient, defined in UR S2, but not to be taken less than 0,6

FIGURE F.H5.202.a.1. DISTRIBUTION FACTOR M [IACS UR S11]

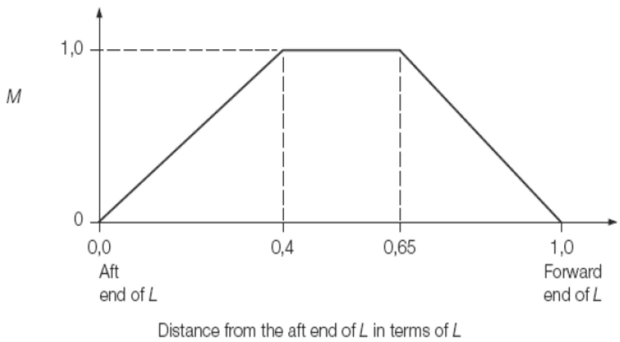


TABLE T.H5.202.a.1: DISTRIBUTION FACTOR M

HULL TRANSVERSE SECTION LOCATION	DISTRIBUTION FACTOR M
$0 \leq x < 0{,}4L$	$2{,}5\frac{x}{L}$
$0{,}4L \leq x \leq 0{,}65L$	1,0
$0{,}65L < x \leq L$	$2{,}86\left(1 - \frac{x}{L}\right)$

b. Wave shear force

b.1. The wave shear forces, Fw, at each section along the length of the ship are given by the following formulae: **[IACS UR S11.2.2.2]**

Fw (+) = + 30 F1 C L B (Cb + 0,7) kN for positive shear force

Fw (-) = - 30 F2 C L B (Cb + 0,7) × 10-2 kN for negative shear force

where:

F1, F2 = Distribution factors given in Figures F.H5.202.b.1. and F.H5.202.b.2.

C, L, B, Cb = As specified in Topic H4.300.

FIGURE F.H5.202.b.1. DISTRIBUTION FACTOR F1 [IACS S11]

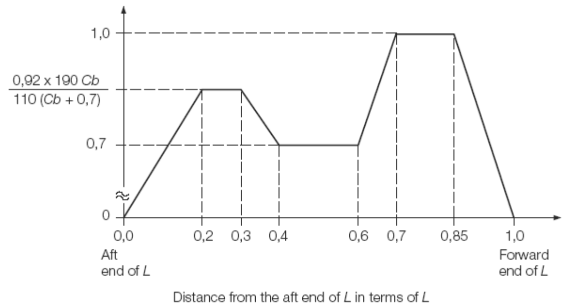


FIGURE F.H5.202.b.2.DISTRIBUTION FACTOR F2 [IACS S11]

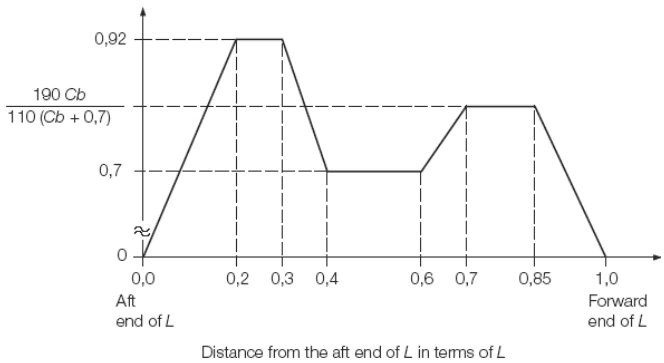


TABLE T.H5.202.b.2. DISTRIBUTION FACTOR F_2

HULL TRANSVERSE SECTION LOCATION	POSITIVE WAVE SHEAR FORCE	NEGATIVE SHEAR FORCE
$0 \leq x < 0{,}2L$	$2{,}5A\frac{x}{L}$	$4{,}6\frac{x}{L}$
$0{,}2L \leq x < 0{,}3L$	0,95A	0,92
$0{,}3L < x < 0{,}4L$	$(0{,}92A-7)\left(0{,}4 - \frac{x}{L}\right) + 0{,}7$	$2{,}2\left(0{,}4 - \frac{x}{L}\right) + 0{,}7$
$0{,}4L \leq x \leq 0{,}6L$	0,7	0,7
$0{,}6L < x < 0{,}7L$	$3\left(\frac{x}{L} - 0{,}6\right) + 0{,}7$	$(10A-7)\left(\frac{x}{L} - 0{,}6\right) + 0{,}7$
$0{,}7L \leq x \leq 0{,}85L$	1	A
$0{,}85L < x \leq L$	$6{,}67\left(1 - \frac{x}{L}\right)$	$6{,}67A\left(1 - \frac{x}{L}\right)$
NOTE: $A = \frac{190CB}{110\,(CB+0{,}7)}$		

300. Bending strength [IACS S11.3]

301. Bending strength amidships:**[IACS UR S11.3.1]**

a. Section modulus**[IACS UR S11 3.1.1]**

a.1. hull section modulus, Z, calculated in accordance with S5, is not to be less than the values given by the following formula in way of 0,4 L midships for the still water bending moments Ms given in Part II, Title 11, Section 2. paragraph H5.201.[IACS UR S11.2.1.1] and the wave bending moments Mw given in Part II, Title 11, Section 2. paragraph H5.202.[UR S11.2.2.1], respectively:

$$\frac{|Ms + Mw|}{\sigma} \; x\, 10^3 \; cm^3$$

where:

σ= permissible bending stress = 175/k N/mm^2

k = material factor
k = 1,0 for ordinary hull structural steel
k < 1,0 for higher tensile steel according to IACS UR S4 Criteria for the Use of High Tensile Steel with Minimum Yield Stress of 315 N/mm^2, 355 N/mm^2 and 390 N/mm^2.

a.2. in any case, the longitudinal strength of the ship is to be in compliance with Sub-Chapter H3.**[IACS UR S7].**

b. Moment of inertia

b.1. Moment of inertia of hull section point is not to be less than

$$I_{mín} = 3CL^3B(C_b+0{,}7)\ cm^4$$

where:

C, L, B, Cb as specified in 202.a.

302. **Bending strength outside amidships[IACS UR S11.3.2]**

a. The required bending strength outside 0,4 L amidships is to be determined at the discretion of RBNA.

b. As aminimum, hull girder bending strength checks are to be carried out at the following locations:

b.1. in way of the forward end of the engine room;

b.2. in way or the forward end of the foremost cargo hold;

b.3. at any locations where there are significant changes in hull cross-section;

b.4. at any locations where there are changes in the framing system.

c. Buckling strength of members contributing to the longitudinal strength and subjected to compressive and shear stresses is to be checked in particular in regions where changes in the framing system or significant changes in the hull cross-section occur. The buckling evaluation criteria use for this check is determined by RBNA.

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

e. 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 or the aft end or the art-most holds and the aft end of the deckhouse or engine room are to be performed.

400. Shearing strength [IACS UR S11.4]

401. **General**: The thickness requirements given in paragraph 402.**[IACS UR S11.4.2]**or paragraph403.**[IACS UR S11.4.3]** apply unless smaller values are proved satisfactory by a method of direct stress calculation approved by RBNA, where the calculated shear stress is not to exceed 110/k (N/mm^2).**[IACS UR S11.4.1]**

402. Shearing strength for ships without effectivelongitudinal bulkheads. **[IACS S11.4.2]**

a. The thickness of side shell is not to be less than the values given by the following formula for the still water shearforcesFs given in paragraph H4.301. and the wave shear forces Fw given in Paragraph H4.302., respectively:[IACS UR S11.2.2.2]

$$t = \frac{|Fs + Fw|}{\tau}\frac{S}{l}\, x10^2 \quad (mm)$$

where:

I = Moment of inertia in cm^4 about the horizontal neutral axis at the section under consideration,

S = First moment in cm^3 , about the neutral axis, of the area of the effective longitudinal members between the vertical level at which the shear stress is being determined and the vertical extremity of effective longitudinal members, taken at the section under consideration

τ = permissible shear stress = 110/k (N/mm^2)

k = As specified in H5.301.a.**[IACS UR S11.3.1.1 (i)]**

b. The value of Fs may be corrected for the direct transmission of forces to the transverse bulkheads at the discretion of RBNA.

403. Shearing strength for ships with two effective longitudinal bulkheads:

a. The thickness of side shell and longitudinal bulkheads are not to be less than the values given by the following formulae: **[IACS UR S11.4.3]**

a.1. for side shell:

$$t = \frac{|(0.5 - \phi)(Fs + Fw) + \Delta Fsh|}{\tau} \frac{S}{l} x 10^2 \quad (mm)$$

a.2. for longitudinal bulkheads:

$$t = \frac{|\phi(Fs + Fw) + \Delta Fbl|}{\tau} \frac{S}{l} x 10^2 \quad (mm)$$

where:

ϕ = ratio of shear force shared by the longitudinal bulkhead to the total shear force,and given by RBNA.

ΔFsh, ΔFbl = shear force acting upon the side shell plating and longitudinal bulkhead plating, respectively, due to local loads, and given by RBNA, subject to the sign convention specified in S11.2.1.1

S,I,Ʈ = As specified in S11.4.2(i)

500. Buckling strength [IACS S11.5]

501. Application: These requirements apply to plate panels and longitudinals subject to hull girder bending and shear stresses

502. Elastic buckling stresses [IACSS11.2.1]

a. Compression

a.1. The ideal buckling sress is given by:

$$\sigma E = 0{,}9mE\left(\frac{tb}{1000s}\right) \qquad (N/mm^2)$$

a.2. For plating with longitudinal stiffeners (parallel to compressive stress):

$$m = \frac{8.4}{\Psi + 1{,}1} \quad for\ 0 \leq \Psi \leq 1$$

a.3. For plating with transverse stiffeners (perpendicular to compressive stress):

$$m = c\left[1 + \left(\frac{s}{l}\right)^2\right]\frac{2.1}{\Psi + 1{,}1}\ for\ 0 \leq \Psi \leq 1$$

where:

E = modulus of elasticity of material

$$= 2{,}06x10^6\ \frac{N}{mm^2} \quad for\ steel$$

tb = net thickness, in mm, of plating, considering standard deductions equal to the values given in the table here after:

TABLE T.H5.502.a.1. NET THICKNESS OF PLATING IN MM, CONSIDERING STANDARD DEDUCTION

Structure	Standard deduction (mm)	Limitvalues min-max (mm)
Compartments carrying dry bulk cargoes	0,05 t	0,5 - 1
One side exposure to ballast and/or liquid cargo vertical surfaces and surfaces sloped at an angle greater than 25º to the horizontal line		
Onesideexposureto ballast and/or liquid cargo horizontal surfaces and surfaces sloped at an angle less than 25º to the horizontal line	0,10 t	2 - 3
Twosideexposureto ballast and/or liquid cargo vertical surfaces and surfaces sloped at an angle greater than 25º to the horizontal line		
Two side exposure to ballast and/or liquid cargo horizontal surfaces and surfaces sloped at an angle less than 25º to the horizontal line	0,15 t	2-4

s = shorter side of plate panel, in m

ℓ = longer side of plate panel, in m

c = 1,3 when plating stiffened by floors or deep girders
= 1,21 when stiffeners are angles or T-sections

= 1,10 when stiffeners are bulb flats
= 1,05 when stiffeners are flat bars

ψ = ratio between smallest and largest compressive σa stress when linear variation across

600. shear

601. The ideal elastic buckling stress in given by:

$$\tau = 0{,}9ktE\left(\frac{tb}{1000s}\right)^2 \quad \left(\frac{N}{mm^2}\right)$$

$$kt = 5{,}34 + 4\left(\frac{s}{l}\right)^2$$

E,Tb, s and l are given in 1.

700. Elastic buckling of longitudinal [IACS S11.5.2.2]

701. Column buckling without rotation of the cross section.

702. For the column buckling mode (perpendicular to plane of plating) The ideal elastic buckling stress is given by:

$$\sigma E = 0{,}001E\,\frac{la}{Al^2} \quad \left(\frac{N}{mm^2}\right)$$

where:

I_a= moment of inertia, in cm^4, of longitudinal, including plate flange and calculated with thickness as specified in **[IACS S11.5.2.1.1]**

A = Cross-sectional area, in cm^2, of longitudinal, including plate flange and calculated with thickness as specified in **[IACS S11.5.2.1.1]**

703. A plate flange equal to the frame spacing may be included.

800. Torsional buckling mode

801. The ideal elastic buckling stress for the torsional mode is given by:

$$\sigma E = \frac{\pi^2 ELw}{10^4\,Ipl^2}\left(m^2 + \frac{K}{m^2}\right) + 0{,}385E\,\frac{It}{Ip} \quad \left(\frac{N}{mm^2}\right)$$

$$K = \frac{Cl^4}{\pi^4\,EIw}10^6$$

where:
m = number of half waves, given by the following table:

	0<K<4	4<K<36	36<K<144	$(m+1)^2m^2<K<=m^2(m+1)^2$
m	1	2	3	m

I_t = St Vernant's moment of inertia, in cm, of profile (without plate flange)

$$= \frac{hwtw^3}{3}10^4 \qquad for\ flat\ bars\ (slabs)$$

$$= \frac{1}{3}\left[hwtw^3 + bftf^3\left(1 - 0.63\frac{tf}{bf}\right)\right] \text{ for flanged profiles}$$

Ip = polar moment of inertia, in cm^4, of profile about connection of stiffener to plate

$$= \frac{hw^3tw}{3}10^{-4} \text{ for flat bars (slabs)}$$

$= (h_w^3 t_w/3 + h_w^2 b_f t_f)10^{-4}$ for flanged profiles

Iw = sectorial moment of inertia, in cm, of profile about connection of stiffener to plate

$$= \frac{hw^3tw^3}{36}10^{-6} \text{ for flat bars (slabs)}$$

$$= \frac{tfbf^3hw^2}{12}10^{-6} \text{ for "tee" profiles}$$

$= b_f^2 t_f^2/12(b_f + t_f)^2\, [t_f(b_f^2+2\, b_f h_w+4h_w^2)+3t_w b_f h_w]10^{-6}$

for angles and bulb profiles

h_w = web height, in mm

t_w= web thickness, in mm, considering standard deductions as specified in S11.5.1.1

b_f = flange width, in mm
t_f = flange thickness, in mm, considering standard deductions as specified in S11.5.2.1.1.For bulb profiles the mean thickness of the bulb may be used.

l= span of profile in m

s = spacing of profiles, in m

c = spring stiffness exerted by supporting plate p

$$= \frac{kpEtp^3}{\left(1 + \frac{1.33kp\,hwt\,p^3}{1000\,stw^3}\right)}10^{-3}$$

$$kp = 1 - \eta p \qquad \text{not to be taken less then zero}$$

Tp = plate thickness, in mm, considering standard deductions as specified in S11.5.2.1.1

$$\eta p = \frac{\sigma a}{\sigma EP}$$

σa = calculated compressive stress. For longitudinal, see **[IACS S11.5.4.1]**

σEP = elastic buckling stress of supporting plate as calculated in S11.5.2.1

900. Web and flange buckling

901. For web plate of longitudinal the ideal elastic buckling stress is given by:

$\sigma_E = 3{,}8E(t_w/h_w)^2$

902. For flanges on angles and T-sections of longitudinals, buckling is taken care of by the following requirement:

$$\frac{bf}{tf} \leq 15$$

where:

b_f = flange width, in mm, for angles, half the flangewidth for T- sections

t_f = as built flange thickness

910. **Critical buckling stresses [IACS UR S11.5.3]**

911. **Compression**: The critical buckling stress in compression σc is determined as follows:

$$\sigma c = \sigma E \qquad when\ \sigma E \leq \frac{\sigma F}{2}$$

$$\sigma F\left(1 - \frac{\sigma F}{4\sigma E}\right) \quad when\ \sigma > \frac{\sigma F}{2}$$

σF = yield stress of material, in N/mm². σF = may be taken as 235 N/mm² for mild steel

σ_E = ideal elastic buckling stress calculated according to **[IACS UR S11.5.2]**

920. **Shear**

921. The critical buckling stress in shear τc is determined as follows:**[IACS UR S11.5.3.2]**

$$\sigma c = \sigma E \qquad when\ \tau E \leq \frac{\tau F}{2}$$

$$= \sigma F\left(1 - \frac{\sigma F}{4\sigma E}\right) \qquad when\ \tau E > \frac{\sigma F}{2}$$

$$\tau = \frac{\sigma F}{\sqrt{3}}$$

σ_F = as given in**[UR S11.5.3.1]**

τ_E = ideal elastic buckling stress in shear calculated according to **[IACS UR S11.5.2.1.2]**

930. **Working stress [IACS UR S11.5.4]**

931. **Longitudinal compressive stresses** The compressive stresses are given in the following formula:**[IACS S11.5.4.1]**

$$\sigma a = \frac{Ms + Mw}{In} yx10^5\ N/mm^2$$
$$= minimum\ \frac{30}{k}$$

where:

Ms = still water bending moment (kN.m), as given in **[IACS UR S11.2.1]**

Mw = wave bending moment (kN.m) as given in **[IACS UR S11.2.2.1]**

In = moment of inertia, in cm⁴, of the hull girder

y = vertical distance, in m, from neutral axis to considered point

k = as specified in **[IACS UR S11.3.1.1]**

Ms and Mw are to be taken as sagging or hogging bending moments, respectively, formembers above or below the neutral axis.Where the ship is always in hogging condition in still water, the sagging bending moment(Ms + Mw) is to be specially considered.

940. **Shear stresses [IACS UR S11.5.4.2]**

941. for ships without effective longitudinal bulkheads-for side shell.

$$\tau a = \frac{0.5|Fs + Fw|}{t}\frac{S}{l} \qquad 10^2 N/mm^2$$

Fs,Fw,t,S,I as specified in S11.4.2.

942. ships with two effective longitudinal bulkheads for side shell.

$$\tau a = \frac{|(0.5 - \phi)(FS + FW) + \Delta Fsn|}{t}\frac{S}{l}10^2 \quad N/mm^2$$

943. For longitudinal bulkheads

$$\tau a = \frac{|\phi(Fs + Fw) + \Delta Fbl|}{t}\frac{S}{l}10^2 \quad N/mm^2$$

Fs, Fw, ΔFsh, ΔFbl, t, S, I as specified in S11.4.3.

944. Scantling criteria**[IACS UR S11.5.5]**

945. Buckling Stress: **[IACS UR S11.5.5.1]**

946. The design buckling stress σc of plate panels and longitudinals (as calculated in**[IACS S11.5.3.1]** is not to be less than:

$$\sigma c \geq \beta\sigma a$$

where,

$\beta = 1$ for plating and for web plating of stiffeners
$\beta = 1.1$ for stiffeners

947. The critical buckling stress τc of plate panels (as calculated in **[IACS UR S11.5.3.2]** is not to be less than:
$\tau c \geq \tau a$

CHAPTER I
STRUCTURAL COMPLEMENTS

CHAPTER CONTENTS

I1. FOUNDATIONS FOR MAIN PROPULSION UNITS, REDUCTION GEARS, SHAFT AND THRUST BEARING

100. Configuration

101. Longitudinal supporting beams should be continuous between the end bulkheads of the machinery space and transverse stiffeners to be arranged up to the side shells and pillars that distribute static and dynamic loads.

200. Guidance for scantlings

201. In addition to the calculation as support girders, the elements of the foundations should follow the next guideline:

Power P of the engine (kW)	Longitudinal thicknesses (mm)	
	Web	Flange
$P \leq 100$	8	12
$100 < P \leq 250$	8	16
$250 < P \leq 500$	10	19
$500 < P \leq 1000$	13	25
$1000 < P \leq 1750$	13	28
$1750 < P \leq 2500$	14	31
$2500 < P \leq 3500$	16	35
$3500 < P$	19	44

202. Starting up from static weight or dynamic load generated by the ship motion, verify that the combined stresses of foundation and hull structure do not exceed the following value:

$$\sigma_C = \sqrt{\sigma^2 + 3 \times \tau^2} \leq 13,73 \text{ da N/mm}^2$$
$(14 \quad \text{kgf/mm}^2)$

where :

σ: bending plus compression stress

τ: shear stress

I2. MASTS AND OTHER APPENDAGES

100. Load application in masts and in crane support-columns

101. The load scheme applied in the masts by cargo handling appliances should be submitted for verification of the stresses in the masts.

102. Starting up from the cargo system force diagram, calculate the stresses in the mast and in the deck imbedding, or decks and bulkheads.

200. Bulwark and handrail

201. The stresses on the deck connection should be calculated for the following horizontal forces applied in its upper flange or handrail:

a. for the Mention O2: 200 kgf/m; and

b. for the Mention O1: 100 kgf/m.

300. Stress in the material

301. Should meet the equation:

$$\sigma_C = \sqrt{\sigma^2 + 3 \times \tau^2} \leq 13,73 \text{ da N/mm}^2$$
$(14 \quad \text{kgf/mm}^2)$

where :

σ: bending plus compression stress

τ: shear plus torsion stresses

I3. REINFORCEMENT FOR SHIP MOTIONS

100. Loads of the ship motion

101. In the case of foundations that support elements which stay in high parts of masts or away from midship of vessels operating in locations where there are significant oscillations, the strength should be verified minding the effects of the horizontal or vertical load due to heave, pitch, and the ship's rolling motion, applied in the center of gravity of the element to be supported.

200. Accelerations, induced load and values

201. Accelerations, induced load and values are presented in Section 1 of the Part II of these Rules.

300. Stress in the material

301. The moduli of the elements in bases, imbeddings and in the support structure are verified regarding that the resulting stresses meet the equation:

$$\sigma_C = \sqrt{\sigma^2 + 3 \times \tau^2} \leq 13{,}73 \text{ da N/mm}^2$$

$$(14 \quad \text{kgf/mm}^2)$$

where :

σ: bending plus compression stress

τ: shear plus torsion stresses

CHAPTER T
INSPECTIONS AND TESTS

CHAPTER CONTENT

T1. INSPECTIONS OF MATERIAIS

100. Approach

101. For materials, see Parte III of these Rules.

T2. WELDING INSPECTION ONPRODUCTION WORK

100. Environmental Conditions

101. Welding should not be carried under rain, strong wind and abrasive dust. In this case, areas effectively protected against weather should be available.

102. The welding of joints, where there is moisture, will be allowed after drying by calls of at least 100 mm on either side of the edges.

103. The joint welding in environments with temperature up to 5°C will be allowed if subjected to heating of 50° C within a strip of 150 mm of each side of the edges.

200. Welding Supervision

201. The Surveyors should ensure that only qualified welding procedures are used and that all welders and operators performing the welding are qualified for the service in which they are employed.

202. The welding operations should be carried out in accordance with the approved procedures and to the satisfaction of the Surveyor.

300. Individual protection

301. The welders should have the conventional safety devices for their individual protection.

302. In welding in confined spaces will be required the installation of forced ventilation equipment.

T3. PREPARATION FOR THE WELDING

100. Assembly

101. The parts to be welded should be adjusted precise and uniformly to ensure compliance with the approved plans.In sub assembled groups, eventual distortions due to welding heat should be prevented or corrected.

102. The auxiliary mounting devices, used to adjust and align parts to be welded, should be employed in order to allow them to expand and contract. Preferably to use devices that control the angular deformation.

103. In general, corrections on settings,anddistortions and removal of mounting auxiliary devices will be permitted with control of the surveyor.

200. Pre-heating

201. When required, pre-heating will be performed in accordance with approved welding procedure and to the satisfaction of the Surveyor.

202. Pre-heating is recommended on occasions of special steels, pieces of large thickness, structural members subject to excessive vibration or humidity, or in case of temperatures below 5º C.

203. In general, the heating temperature is obtained from the opposite side of the source. However,when it is not possible to have the temperature by the heating source side or if pre-heating is made with flame, the process should be interrupted, at least for one minute for every 25 mm of thickness of material, in order to equalize the temperature of the parts symmetrically, before the measurement.

300. Cleaning of the joints

301. The joints to be welded should be free from oil, grease, residues of tests or of any harmful substance to the good quality of welds, at least 20 mm on either side of the seams.

302. Corrosion oxides, carbon deposits and slag in passes or subsequent layers of the welding should be removed by means of steel brush or adequate process.

303. The slag from the oxy-acetylene cutting should be removed, at least, by grinder, to remove residues resulting from chamfered surfaces.

304. In welding with metallic arc or tungsten arc with gas atmosphere, cleaning of bevels and seams should provide that the surface of the material bebright, at least, in a strip of 10 mm from the internal and external sides of the joint.

400. Provisional and tack welding

401. The provisional and tack welding used in initial assembly may be accepted as definitive welds if evidence was presented that they were executed with the same filler metal used in the production, considered of good quality by the surveyor and without interference in the sequence of welding.

402. The provisional and tack weld areas shall be examined to the satisfaction of the surveyor who may require assessment by non-destructive method for detection of discontinuities.

500. Gouging

501. The removal of addition metals and base on the opposite side of the weld in partially welded joints should be performed in order to eliminate the discontinuities and to ensure full penetration for subsequent passes.

502. The gouging of joints in important locations will be examined to the satisfaction of the surveyor, which may require inspection by non-destructive method for detection of discontinuities.

503. Cracks, slag, porosity or other harmful defects will be removed before applying subsequent passes.

600. Pounding

601. The pounding is not allowed on root passes, single passes, finishing passes materials and in materials with a thickness of less than 15 mm.

602. The pounding to straight up distortions or residual stress reduction will be performed immediately after welding and cleaning of the joint at each pass.

700. Heattreatment

701. When required, will be performed in accordance with the approved welding procedure and to the satisfaction of the surveyor.

T4. WELDING PROCEEDINGS

100. Quality of the welds

101. Inspection should not be made immediately after the welding, as some materials and elements retained can propagate cracks with a delay.

102. Weldsshouldbemadeof good quality,freefromcracks, free of slag inclusions, overlap, lack of fusionandpenetration.

103. The weld surfaces are visually examined throughoutits length before testing and paint, to enable control their surface finish associated with grooves, porosities, splashes and arc gaps.

104. When the addition materials used have proven to be of deep penetration, the dimension of the weld throat may be reduced till 15% of the value specified in table T. D4.401.1/9.of the Part II, Section 2 of these Rules, if specially approved by the surveyor.

105. Where the contact gap between the surfaces exceeds 2 mm, up to 5 mm, the size of weld is increased in the proportion of the size of thegap. When exceeds 5 mm the welding procedure, the weld sizing details and the quality of the finished joint should be subjected to the surveyor for approval.

200. Welding sequence

201. Welding should be in sequence not to restrict freedom for expansion of the welded joints that come after.

202. Welding should be initialized on restricted areas which have less freedom to move and progress in such a way that symmetrically advance in every direction.

203. On union of blocks on pre-erection and on erection, the welds must progress from keel to upward and from midship to forward and after ends. On decks and bottom tops the welding should progress from center to edges.

204. On welding of plating to construct panels and its stiffeners, the welds will be executed from the central area to edges. Welding of joints of plates and of stiffeners on plates will leave the end length without weld, to be completed on erection phase. After the blocks be in position, one joint should be welded without cross the perpendicular joint that will be welded in sequence. The weld junctions of the stiffeners are made after that.

205. On welding of vertical joints with shielded metal arc welding and low hydrogen, the progression ascendant only will be applied, except on root passes, which will be removed after gouging.

T5. NON-DESTRUCTIVE TESTING OF SHIP HULL STEEL WELDS [IACS Rec 20]

100. General

101. This document is intended to give guidance on the minimum requirements on the methods and quality levels that may be adopted for the non-destructive testing (NDT) of ship hull steel welds during new building and ship repair.

102. The quality levels given in this document refer to production quality and not to fitness-for-purpose of the welds examined.

103. The non-destructive testing is normally to be performed by the Shipbuilder or its subcontractors in accordance with these requirements. TheRBNAsurveyor may require to witness some testing.

104. The Shipbuilderhas the responsibility to assure that testing specifications and procedures are adhered to during the construction and the report is made available toRBNAon the findings made by the NDT.

105. The extent of testing and the number of checkpoints are normally agreed between the ship yard and RBNA. They are ruled by:

a. for ships with AB < 500, the number of x-rays or ultrasound points are indicated in table T.T5.105.1. The extensionexaminedshould be at least 1000 mm of length of each weld bead.

TABLE T.T5.105.1. – NUMBER OF RAGIOGRAPHS AND POINTS OF ULTRASOUND FOR SHIIPS WITH AB < 500

LENGTH (m) (1)	O1 (2)	O2
L ≤ 20	08	10
L < 30	10	12
L < 40	12	16
L < 50	16	20
L < 60	20	24
L < 70	24	28
L < 80	28	34
L < 90	34	42
90 ≤ L ≤ 100 (3)	42	50

(1) To intermediate length L, obtain the number by linear interpolation.
(2) The examinations by x-ray or ultra sound will be made as conditions found by the surveyor.
(3) For L length L ≥100madd the value for the L-90 to that of L≤100.

b. for vessels with AB≥ 500 the points of thickness measurement are indicated for each type of ship in the Tables of Part I. Title 2, Section 2.

106. In the evaluation of radiographic and ultrasonic testing should be adopted the requirements of NBR-8420 and ASTM E-164, respectively, or of other certified institutions.

107. The inspection of the welding in joints, subjected to root material removal, root beads, intermediate beads and finishing, will be carried out in accordance with the requirements of table T.T5.202.1. to the satisfaction of the surveyor.

108. The number of Ray-x and ultra-sound points are indicated on the Table T.T5.203.1

109. The inspection by liquid penetrating or magnetic particles will be made on number of points as per surveyor instruction on, at least, extension of 1000 mm on the length of the welding seam.

110. The inspections and non-destructive tests of welding will be performed on the structural members as indications on the Table T.T5.202.1.

200. Limitations

201. Materials:this document applies to fusion welds made in normal and higher strength hull structural steels in accordance with UR W11, high strength quenched and tempered steels in accordance with UR W16 and connections welds with hull steel forgings in accordance with UR W7 and hull steel castings in accordance with UR W8.

202. Welding processes:this document applies to fusion welds made using shielded metal arc welding, flux cored arc welding, gas metal arc welding, gas tungsten arc welding, submerged arc welding, electro-slag welding and electro-gas welding processes.

203. Weld joints: this document applies to butt welds with full penetration, tee, corner and cruciform joints with or without full penetration, and fillet welds.

204. Timing of NDT: NDT should be conducted after welds have cooled to ambient temperature and after post weld heat treatment where applicable.

a. For steels with specified minimum yield stress of 420 N/mm2 and above, NDT should not be carried out before 48 hours after completion of welding. Where post weld heat treatment (PWHT) is carried out the requirement for testing after 48 hours may be relaxed.

704. Testing methods

a. The methods mentioned in this document for detection of surface imperfections are visual testing (VT), liquid penetrant testing (PT) and magnetic particle testing (MT). The methods mentioned for detection of internal imperfections are ultrasonic testing (UT) and radiographic testing (RT).

b. Applicable methods for testing of the different types of weld joints are given in Table T.T5.205.1 Applicable methods for testing of weld jointsare given in Table T.T5.205.2. Applicable methods for structural members.

TABLE T.T5.305.1-APPLICABLE METHODS FOR TESTING OF WELD JOINTS

WELD JOINT	PARENTMATERIAL THICKNESS	APPLICABLETESTING METHODS
Butt welds with full penetration	thickness ≤10 mm	VT, PT, MT, RT
	thickness > 10 mm	VT, PT, MT, UT, RT
Tee joints, corner joints and cruciform joints with full penetration	thickness ≤10mm	VT, PT, MT
	thickness > 10mm	VT, PT, MT, UT
Tee joints, corner joints and cruciform joints without full penetration and fillet welds	All	VT, PT, MT, UT[1]

Note: UT can be used to monitor the extent of penetration in tee, corner and cruciform joints.

TABLE T.T5.205.2. – APPLICABLE METHODS FOR STRUCTURAL MEMBERS

STRUCTURAL MEMBERS	**O1 or O2 c/ L≤65**			**O2 L > 65**		
REGION AMIDSHIP	**A**	**B**	**C**	**A**	**B**	**C**
Keel plating	LP/PM	VISUAL	RX/US	LP/PM	VISUAL	RX/US
Bilge strake seams	LP/PM	VISUAL	RX/US	LP/PM	VISUAL	RX/US
Side shell plating	LP/PM	VISUAL	RX/US	LP/PM	VISUAL	RX/US
Sheer strake	LP/PM	VISUAL	RX/US	LP/PM	VISUAL	RX/US
Stringer plate	LP/PM	VISUAL	RX/US	LP/PM	VISUAL	RX/US
Strength deck hatch coaming edges	LP	VISUAL	US	LP/PM	VISUAL	RX/US
Circumferential joints in masts	LP	VISUAL	US	LP/PM	VISUAL	RX/US
Discontinuities in superstructure	LP	VISUAL	US	LP/PM	VISUAL	US
Stringers (1)	--------	VISUAL	LP	--------	VISUAL	LP
Inner bottom plating (1)	LP	VISUAL	LP	LP	VISUAL	LP
Bulkheads (1)	LP	VISUAL	LP	LP	VISUAL	LP
Deck girders (1)	---------	VISUAL	LP	--------	VISUAL	LP
REGION OUTSIDE AMIDSHIP	**A**	**B**	**C**	**A**	**B**	**C**
Stem	LP	VISUAL	US	LP/PM	VISUAL	RX/US
Stern frame	LP	VISUAL	US	LP/PM	VISUAL	RX/US
Strut	LP	VISUAL	US	LP/PM	VISUAL	RX/US
Members subjected to excessive vibrations	LP	VISUAL	US	LP/PM	VISUAL	RX/US
Pieces of huge thickness	LP	VISUAL	US	LP/PM	VISUAL	RX/US

NOTATIONS

A – JOINTS THAT WERE SUBJECTED TO MATERIAL REMOVAL
B – SUBSEQUENT PASSES
C – FINISH PASSES

LP - LIQUID PENETRANT
PM – MAGNETIC PARTICULE
RX - X RAY
US - ULTRA SOUND

(1) CONTRIBUTING ELEMENTS TO THE LONGITUDINAL STRENGTH, RANDOMLY CHOSEN BY THE SURVEYOR

300. Qualification of personnel involved in NDT

301. For each inspection method, operators should be qualified according to a nationally recognised scheme with a grade equivalent to level II qualification of ISO 9712, SNT-TC-1A, EN 473 or ASNT Central Certification Program (ACCP). Operators qualified to level I may be engaged in the tests under the supervision of personnel qualified to level II or III.

302. Personnel responsible for the preparation and approval of NDT procedures should be qualified according to a nationally recognised scheme with a grade equivalent to level III qualification of ISO 9712, SNT-TC-1A, EN 473 or ASNT Central Certification Program (ACCP).

303. Personnel qualifications should be verified by certification.

400. Surface condition

401. Zones to be examined should be free from scale, loose rust, weld spatter, oil, grease, dirt or paint that might affect the sensitivity of the testing method.

500. General method of testing

501. The extent of testing should be planned by the Shipbuilder according to the ship design, ship type and welding processes used. Particular attention should be paid to highly stressed areas.

502. For each construction, the Shipbuilder should submit a plan for approval by the Classification Society, specifying the areas to be examined and the extent of testing with reference to the NDT procedures to be used. The plan should only be released to the personnel in charge of the NDT and its supervision.

503. The identification system should identify the exact locations of the lengths of weld examined.

504. All welds should be subject to visual testing by personnel designated by the Shipyard.

505. As far as practicable, magnetic particle testing should be preferred over liquid penetrant testing and should cover a minimum weld length of 500mm.

506. Welded connections of large cast or forged components (stern frame, stern boss, rudder parts, shaft brackets and similar) should be tested over their full length using MT or PT and at agreed locations using RT or UT.

507. As given in Table 1, UT or RT or a combination of UT and RT can be used for testing of butt welds with full penetration of 10mm thickness or greater. Methods to be used should be agreed withRBNA.

508. All start/stop points in welds made using automatic (mechanised) welding processes should be examined using RT or UT, except for internal members where the extent of testing should be agreed.

509. Within the agreed NDT plan, the minimum RT test length should be 300mm and the minimum UT test length should be 500mm.

600. Testing techniques

601. General:

602. The testing method, equipment and conditions should comply with recognized National or International standards, or other documents to the satisfaction of RBNA.

603. Sufficient details should be given in a written procedure for each NDT technique submitted to RBNA for acceptance.

700. Visual testing:

701. The welds examined should be clean and free from paint.

702. Liquid penetrating testing :

703. The procedure should detail as a minimum the calibration equipment, surface preparation, cleaning and drying prior to testing, temperature range, type of penetrant, cleaner and developer used, penetrant application and removal, penetration time, developer application and development time and lighting conditions during testing.

704. The surface to be examined should be clean and free from scale, oil, grease, dirt or paint and should include the weld bead and base metal for at least 10mm on each side of the weld, or the width of the heat affected zone, whichever is greater.

705. The temperature of parts examined should be typically between 5^{o} C and 5^{o}C.Outside this temperature range special low/high temperature penetrant and reference comparator blocks should be used.

706. The penetration time should not be less than 10 minutes and in accordance with the manufacturer's specification. The development time should not be less than 10 minutes and in accordance with the manufacturer's specification, normally between 10-30 minutes.

707. Magnetic particle testing

a. the procedure should detail as a minimum the surface preparation, magnetizing equipment, calibration methods, detection media and application, viewing conditions and post demagnetization.

b. the surface to be examined should be free from scale, weld spatter, oil, grease, dirt or paint and should be clean and dry.

c. when using current flow equipment with prods, care shall be taken to avoid local damage to the material. copper prod tips must not be used. the prod tips should be lead, steel, aluminium or aluminium-copper braid.

d. to ensure detection of discontinuities of any orientation, the welds are magnetized in two directions approximately perpendicular to each other with a maximum deviation of 30º. adequate overlapping shall ensure testing of the whole zone.

e. continuous wet particle method should be used as far as practicable.

708. Radiographic testing

a. the procedure should detail as a minimum the type of radiation source, considering the thickness to be radiographed, test arrangement and films overlapping, type and position of image quality indicators (IQI), image quality, film system and intensifying screens used if any, exposure conditions, scattered radiation control, film processing, film density and viewing conditions.

b. processed films should display hull no., frame no., weld boundary indicators, Port/Starboard, location (or film serial number) and date as radiographic image.

c. RBNA may require to duplicate some radiographs in order that some processed films are handed over to the RBNAtogether with testing reports.Alternative method to duplicate the processed film can be agreed with the RBNA.

d. the type of source is selected by the shipbuilder in accordance with item 7.2 of ISO 17636.

e. single-wall exposure technique should be used as far as practicable.

f. the image quality should be verified using an IQI (Image Quality Indicator) in accordance with ISO 19232 or equivalent. In general the IQI is to be placed on the source side of the weld examined. The minimum image quality should be in accordance with Class A of ISO 17636 or equivalent, as given in Table T.T5.605.1.for IQI's of wire type placed on source side.

g. when using IQI's of wire type, the image of a wire is considered visible on the film if a continuous length of at least 10mm is clearly visible in a section of uniform optical density.

h. the optical density of the radiographs should be selected by the shipbuilder in accordance with Table 5 of ISO 17636.

i. traditional radiographic film may be replaced by digital radiographic techniques where it can be shown, to the satisfaction of the classification society, that the sensitivity of the digital image is better than or equal to the image obtained with traditional radiographic film.

TABLE T.T5.605.1.: MINIMUM IMAGE QUALITY USING IQI WIRE TYPE PLACED ON SOURCE SIDE WITH SINGLE WALL TECHNIQUE

NOMINAL THICKNESS RANGE	WIRE NUMBER 1) VISIBLE ON THE FILM (NOMINAL DIAMETER)
5 mm < t ≤ 7 mm	W14 (0,16 mm)
7 mm < t ≤ 10 mm	W13 (0,20 mm)
10 mm < t ≤ 15 mm	W12 (0,25 mm)
15 mm < t ≤ 25 mm	W11 (0,32 mm)
25 mm < t ≤ 32 mm	W10 (0,40 mm)
32 mm < t ≤ 40 mm	W9 (0,50 mm)
40 mm < t ≤ 55 mm	W8 (0,63 mm)
55 mm < t ≤ 85 mm	W7 (0,80 mm)
85 mm < t ≤ 150 mm	W6 (1,0 mm)

Note: When using Iridium 192 sources, lower values can be accepted:

a. up to 2 values for 10mm < t ≤ 24mm

b. up to one value for 24mm < t ≤ 30mm

709. Ultrasonic testing

a. the procedure should detail the equipment, type of probes (frequency, angle of incidence), coupling media, type of reference blocks, method for range and sensitivity setting, method for transfer corrections, scanning technique, sizing technique and intervals for calibration checks during testing.

b. the equipment (instrument and probes) should be verified by the use of appropriate standard calibration blocks at suitable time intervals.

c. the range and sensitivity should be set prior to each testing and checked at regular intervals as per the procedure and whenever needed.

d. the scanning surfaces should be sufficiently clean and free from irregularities like rust, loose scale, paint (excluding primer), weld spatter or grooves which may interfere with probe coupling.

e. the surface profile should be such to avoid loss of probe contact by rocking.

f. the scanning technique should be determined to allow the testing of the entire volume of the weld bead and base metal for at least 10mm on each side of the weld, or the width of the heat affected zone, whichever is greater.

g. the probe frequency should be within the range 2 MHz to 5 MHz.

h. the reference level for testing should be set using a Distance-Amplitude-Corrected curve (DAC curve) for a series of 3mm diameter side-drilled holes in a reference block or other methods like the Distance-Gain-Size (DGS) system based on a disc shaped reflector provided the same sensitivity is achieved. The reference block used should be made in a material giving equivalent ultrasonic response to that of the material to be tested.

i. the indications with an echo height below 33% of DAC curve (DAC minus 10 dB) should be disregarded. The indications with an echo height equal to or exceeding 33% of DAC curve (DAC minus 10 dB) should be evaluated.

j. base material in the scanning zone should be examined with a straight beam technique to check the absence of imperfections which would interfere with the angle beam technique, unless already demonstrated at a previous fabrication stage.

k. angle beam technique should be used to search for longitudinal and transverse weld discontinuities. An angle probe with an incident angle of the sound wave equal to that of the weld preparation should be used as a minimum.

800. Acceptancecriteria

801. General

a. this section details the acceptance criteria for assessment of the NDT results.

b. as far as necessary, testing techniques should be combined to facilitate the assessment of indications against the acceptance criteria.

c. the assessment of indications not covered by this document should be made in accordance with a standard agreed with the Classification Society.

802. Visual testing

a. acceptance criteria are given in Table T.T5.702.1

803. Liquid penetrant and magnetic particle testing

a. only the indications which have any dimension greater than 2mm should require evaluation.

b. welds examined using liquid penetrant or magnetic particle technique should be evaluated on the basis of the criteria for visual testing.

804. Radiographic testing

a. acceptance criteria are given in Table T.T5.704.1.

b. when discontinuities like undercut or incomplete filled groove are detected on a radiograph, additional testing is recommended to state their acceptance. Criteria for visual testing apply.

805. Ultrasonic testing

a. acceptance criteria are given in T.T5.705.1.

b. the length of the indication should be determined using a suitable technique (like 6dB drop tip location technique).

900. Reporting

901. Reports of non-destructive testing required should be prepared by the Shipbuilder and should be made available to RBNA.

902. Reports of non-destructive testing should include the following generic items:

a. date of testing

b. names, qualification level and signature of personnel that have performed the testing

c. identification of the component examined

d. identification of the welds examined

e. steel grade, type of joint, thickness of parent material, welding process

f. acceptance criteria

g. testing standards used

h. testing equipment and arrangement used

i. any test limitations, viewing conditions and temperature

j. results of testing with reference to acceptance criteria, location and size of reportable indications

k. statement of acceptance / non-acceptance

l. number of repairs if specific area repaired more than twice

903. In addition to generic items, reports of liquid penetrant testing should include the following specific items:

a. type of penetrant, cleaner and developer used

b. penetration time and development time

904. In addition to generic items, reports of magnetic particle testing should include the following specific items:

a. type of magnetization

b. magnetic field strength

c. detection media

d. viewing conditions

e. demagnetization, if required

905. In addition to generic items, reports of radiographic testing should include the following specific items:

a. type and size of radiation source

b. type of film

c. type of intensifying screens

d. exposure technique, time of exposure and source-to-film distance

e. sensitivity, type and position of IQI

f. density

g. geometric un-sharpness

906. Reports of ultrasonic testing should include the following specific items:

a. type and identification of ultrasonic equipment used, probes and couplant

b. sensitivity levels calibrated and applied for each probe

c. transfer loss correction applied

d. type of reference blocks

e. signal response used for defect detection

907. Unacceptable indications should be eliminated and repaired where necessary. The repair welds should be examined on their full length using magnetic particle and ultrasonic or radiographic testing method.

908. When unacceptable indications are found, additional areas of the same weld length should be examined unless the indication is judged isolated without any doubt. In case of automatic welded joints, additional NDT should be extended to all areas of the same weld length.

909. The extent of testing can be extended at the surveyor discretion when repeated nonacceptable discontinuities are found.

910. The Shipbuilder should take appropriate actions to monitor and improve the quality of welds to the required level. The repair rate at which corrective action is to be instigated should be identified in the builder's system.

911. Repairs on joints with discontinuities or unacceptable defects must be made on entire extension of the affected area until complete restoration, following approved procedure performed by qualified welders.

912. On adjacent areas to repaired joints, additional test should be required to attest the extension of discontinuities. When detected discontinuities above limits, the surveyor will reject totally the joint or will require complementary tests in order to establish the extension to repair, until it will be evident that there are not unacceptable discontinuities.

913. When the gap between the contact surfaces exceeds 2 mm, up to 5 mm, the dimensions of the weld throat is increased in the proportion of the gap value. When exceeding 5 mm, the welding procedure, details of the welding dimensioning and the finished joint quality shall be submitted to the surveyor for approval.

TABLE T.T5.702.1: ACCEPTANCE CRITERIA FOR VISUAL TESTING, MAGNETIC PARTICLE AND LIQUID PENETRANT TESTING

SURFACE DISCONTINUITY	**CLASSIFICATION ACCORDING TO ISO 6520-1**	**ACCEPTANCE CRITERIA FOR VISUAL TESTING**
Crack	100	not accepted
Lack of fusion	401	not accepted
Incomplete root penetration in butt joints welded from one side	4021	not accepted
Surface pore	2017	Single pore diameter $d \leq 0.25t$ [1)] for butt welds ($d \leq 0.25a$ [1)] for fillet welds) with maximum diameter 3mm; 2.5d as minimum distance to adjacent pore.
Undercut in butt welds	501	depth ≤ 0.5mm whatever is the length depth ≤ 0.8mm with a maximum continuous[2)] length of90mm
Undercut in fillet welds	501	depth ≤ 0.8mm whatever is the length

Notes:
1) "t' is the plate thickness of the thinnest plate and "a" is the throat of the fillet weld.
2) Adjacent undercuts separated by a distance shorter than the shortest undercut should be regarded as a single continuous undercut.

TABLE T.T5.704.1: ACCEPTANCE CRITERIA FOR RADIOGRAPHIC TESTING

DISCONTINUITY	**CLASSIFICATION ACCORDING TOISO 6520-1**	**ACCEPTANCE CRITERIA FOR RADIOGRAPHIC TESTING[1)]**
Crack	100	not accepted
Lack of fusion	401	continuous[2)] maximum length t/2 or 25mm whichever is the less intermittent cumulative[3)] length maximum t or 50mm
Incomplete root penetration	4021	not accepted in butt joint welded from one side
		continuous[2)] maximum length t/2 or 25mm whichever is the less intermittent cumulative[3)] length maximum t or 50mm
Slag inclusion	301	continuous[2)] maximum length t or 50mm whichever isthe less intermittent cumulative[3)4)] length maximum 2t or 100mm

Notes:
1) "t" is the plate thickness of the thinnest plate.
2) Two adjacent individual discontinuities of length L1 and L2 situated on a line and where the distance L between them is shorter than the shortest discontinuity should be regarded as a continuous discontinuity of length L1+L+L2.
3) Sum of the length of individual continuous discontinuities.
4) Parallel inclusions not separated by more than 3 times the width of the largest inclusion should be regarded as one continuous discontinuity.

TABLE T.T5.705.1: ACCEPTANCE CRITERIA FOR ULTRASONIC TESTING

ECHO HEIGHT	ACCEPTANCE CRITERIA FOR ULTRASONIC TESTING 1)
Greater than 100% of DAC curve	maximum length t/2 or 25 mm whichever is the less
Greater than 50% of DAC curve but less than 100% of DAC curve	maximum length t or 50mm whichever is the less
Indications evaluated to be cracks are unacceptable regardless of echo height; Indications evaluated to be lack of penetration in joints welded from one side are unacceptable regardless of echo height.	

Note:
1) Two adjacent individual discontinuities of length L1 and L2 situated on a line and where the distance L between them is shorter than the shortest discontinuity should be regarded as a continuous discontinuity of length L1+L+L2.

T6. TESTING PROCEDURES OF WATERTIGHT COMPARTMENTS [IACS UR S14]

100. general

101. The test procedures are to confirm the watertightness of tanks and watertight boundaries,the structural adequacy of tanks and weathertightness of structures/shipboard outfitting. Thetightness of tanks and tight boundaries of:

a. new ships prior to delivery, and

b. structures involved in, or affected by, majorconversions or repairs(major repair means a repair affecting structural integrity) is to be confirmedby these test procedures.

200. application

201. All gravity tanks(gravity tank means a tank that is subject to vapour pressure not greater than 70 kPa)[2] and other boundaries required to be watertight or weathertight are to betested in accordance with this Procedure and proven tight and structurally adequate asfollows:

a. gravity tanks for their tightness and structural adequacy;

b. watertight boundaries other than tank boundaries for their watertightness, and

c. weathertight boundaries for their weathertightness.

202. The testing of the cargo containment systems of liquefied gas carriers is to be in accordance with standards deemed appropriate by the Classification Society.

203. Testing of structures not listed in Table or is to be specially considered.

300. types of tests and definition of test

301. The following two types of test are specified in this requirement:

a. *Structural test*: A test to verify the structural adequacy of the construction of the tanks;

302. This may be a hydrostatic test or, where the situation warrants, ahydropneumatic test.

a. *Leak test*: A test to verify the tightness of the boundary. Unless a specific test isindicated, this may be a hydrostatic/hydropneumatic test or air test. *Leak test* with remark *3 in Table includes hose test as an acceptablemedium of the test.

303. Definition of each type of test is as follows:

Hydrostatic Test: *(Leak and Structural)*	A test by filling the space with a liquid to a specified head.
Hydropneumatic Test: *(Leak and Structural)*	A test wherein the space is partially filled with liquid and air pressure applied on top of the liquid surface.
Hose Test: *(Leak)*	A test to verify the tightness of the joint by a jet of water.
Air Tests: *(Leak)*	A test to verify the tightness by means of air pressure differential and leak detection solution. It includes tank air tests and joint air tests, such as a *compressed air test* and *vacuum box test*.
Compressed Air Fillet WeldTest: *(Leak)*	An air test of a fillet welded tee joint with a leak indicating solution applied on the fillet welds.
Vacuum Box Test: *(Leak)*	A box over a joint with leak indicating solution applied on the fillet or butt welds. A vacuum is created inside the boxto detect any leaks.
Ultrasonic Test: *(Leak)*	A test to verify the tightness of a sealing by means ofultrasound.
Penetration Test: *(Leak)*	A test to verify that no continuous leakages exist in the boundaries of a compartment by the application of low surface tension liquids.

400. test procedures

401. General

a. tests are to be carried out in the presence of the Surveyor at a stage sufficiently close to thecompletion of the work with all hatches, doors, windows, etc., installed and all penetrationsincluding pipe connections fitted, and before any ceiling and cement work is applied over thejoints. Specific test requirements are given in 404. and Table T.T5.401.1.. For the timing of application ofcoating and the provision of safe access to joints, see 405,406. and Table T.T5.401.2.

402. Structural test procedures

a. type and time of test:

a.1. where a structural test is specified in Table T.T5.401.1. or Table T.T5.402.1., a hydrostatic test in accordance with404.1. will be acceptable. Where practical limitations (strength of building berth, density ofliquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test inaccordance with 404.2. may be accepted as an equivalent method.Provided the results of a leak test are confirmed satisfactory, a hydrostatic test forconfirmation of structural adequacy may be carried out while the vessel is afloat.

b. number of Structural Tests

b.1. A structural test is to be carried out for at least one tank of the same construction (i.e.tanks of the same structural design and configuration and same general workmanshipas determined by the attending Surveyor) on each vessel provided all subsequent tanks are tested for leaks by an air test. However, where structural adequacy of a tank was verified by structural testingrequired in Table T.T5.401.a., the subsequent vessels in the series (i.e. sister ships built in thesame shipyard) may be exempted from such testing for other tanks which have thestructural similarity to the tested tank, provided that the water-tightness in allboundaries of exempted tanks are verified by leak tests and thorough inspection. Forsister ships built several years after the last ship of the series, such exemption may bereconsidered. In any case, structural testing is to be carried out for at least one tankfor each vessel in order to verify structural fabrication adequacy.

c. for watertight boundaries of spaces other than tanks (excluding chain lockers),structural testing may be exempted, provided that the watertightness in all boundariesof exempted spaces are verified by leak tests and thorough inspection.

d. these subsequent tanks may require structural testing if found necessary after thestructural testing of the first tank.

e. Tanks for structural test are to be selected so that all representative structuralmembers are tested for the expected tension and compression.

403. Leak test procedures

a. For the leak test specified in Table T.T5.401.a., a tank air test, compressed air fillet weld test, vacuumbox test in accordance with 404.c. to 404.e., or their combination will be acceptable. Ahydrostatic or hydropneumatic test may also be accepted as the leak test providedthat 405.and406. are complied with. A hose test will also be acceptable for the locations as specified inTable with note 3.A joint air test may be carried out in the block stage provided all work on the block that mayaffect the tightness of the joint is completed before the test.

See also for the applicationof final coating and 406. for safe access to the joint and their summary in TableT.T5.401.2..

404. Details of Tests

a. hydrostatic test:

a.1. unless other liquid is approved, the hydrostatic test is to consist of filling the space by freshwater or sea water, whichever is appropriate for testing of the space, to the level specified inTableT.T5.401.a.or Table T.T5.402.a..In case a tank for cargoes with higher density is to be tested with fresh water or sea water,the testing pressure height is to be specially considered.

b. hydropneumatic test

b.1. ahydropneumatic test where approved is to be such that the test condition in conjunctionwith the approved liquid level and air pressure will simulate the actual loading as far aspracticable. The requirements and recommendations for tank air tests in404.2. will also applyto the hydropneumatic test.

c. hose test

c.1. a hose test is to be carried out with the pressure in the hose nozzle maintained at least at2·105 Pa during the test. The nozzle is to have a minimum inside diameter of 12 mm and beat a distance to the joint not exceeding 1.5 m.

c.2. where a hose test is not practical because of possible damage to machinery, electricalequipment insulation or outfitting items, it may be replaced by a careful visual examination ofwelded connections, supported where necessary by means such as a dye penetrant test orultrasonic leak test or an equivalent.

d. tank air test

d.1. all boundary welds, erection joints and penetrations including pipe connections are to beexamined in accordance with the approved procedure and under a pressure differentialabove atmospheric pressure not less than 0.15·105 Pa with a leak indication solution applied.It is recommended that the air pressure in the tank be raised to and maintained at about0.20·105 Pa for approximately one hour, with a minimum number of personnel around thetank, before being lowered to the test pressure of 0.15·105 Pa.A U-tube with a height sufficient to hold a head of water corresponding to the required testpressure is to be arranged. The cross sectional area of the U-tube is not to be less than thatof the pipe supplying air to the tank. In addition to U-tube, a master gauge or other approvedmeans to verify the pressure is to be approved.

e. compressed air fillet weld test

e.1. in this air test, compressed air is injected from one end of a fillet welded joint and thepressure verified at the other end of the joint by a pressure gauge on the opposite side.Pressure gauges are to be arranged so that an air pressure of at least 0.15·105 Pa can beverified at each end of all passages within the portion being tested.

Note:

where a leak test of partial penetration welding is required and the root face issufficiently large (i.e.,6-8mm), the compressed air test is to be applied in thesame manner as for a fillet weld.

b. vacuum boxtest

f.1. A box (vacuum tester) with air connections, gauges and inspection window is placed over thejoint with leak indicator applied. The air within the box is removed by an ejector to create avacuum of 0.20·105 – 0.26·105 Pa inside the box.

c. ultrasonic test

g.1. an arrangement of an ultrasonic echoes transmitter placed inside of a compartment and areceiver outside. A location where the sound is detectable by the receiver displays a leakagein the sealing of the compartment.

d. Penetration test

h.1. A test of butt welds by applying a low surface tension liquid to one side of a compartmentboundary. When no liquid is detected on the opposite side of the boundary after expiration ofa definite time, the verification of tightness of the compartments boundary can be assumed.

e. Other test

i.1. Other methods of testing may be considered by each society upon submission of fullparticulars prior to commencement of the testing.

405. Application of coating

a. Final coating

a.1. For butt joints by automatic process, final coating may be applied anytime before completionof the leak test of the space bounded by the joint.For all other joints, final coating is to be applied after the completion of the leak test of thejoint. See also Table T.T5.401.b..The Surveyor reserves the right to require a leak test prior to the application of the finalcoating over automatic erection butt welds.

b. Temporary coating

b.1. Any temporary coating which may conceal defects or leaks is to be applied at a time asspecified for final coating. This requirement does not apply to shop primer.

406. Safe access to joints

a. For leak tests, a safe access to all joints under examination is to be provided. See also TableT.T5.401.b..

TABLE T.T6.401.1.TEST REQUIREMENTS FOR TANKS AND BOUNDARIES

	Tank or boundary to be tested	**Test type**	**Test head or pressure**	**Remarks**
1	Double bottom tanks *4	Leak & Structural*1	The greater of - top of the overflow, - to 2.4m above top oftank*2, or - to bulkhead deck	
2	Double bottom voids *5	Leak	See 404.d.through 404.e., as applicable	
3	Double side tanks	Leak & Structural*1	The greater of - top of the overflow, - to 2.4m above top oftank*2, or - to bulkhead deck	
4	Double side voids	Leak	See 404.d. through 404.e., as applicable	
5	Deep tanks other than those listed elsewhere in this table	Leak & Structural*1	The greater of - top of the overflow, or - to 2.4m above top of tank *2	
6	Cargo oil tanks	Leak & Structural*1	The greater of - top of the overflow, - to 2.4m above top oftank*2, or - to top of tank *2plussetting of any pressurerelief valve	
7	Ballast hold of bulk carriers	Leak & Structural*1	The greater of - top of the overflow, or - top of cargo hatchcoaming	
8	Peak tanks	Leak & Structural*1	The greater of - top of the overflow, or - to 2.4m above top of tank *2	After peak to be tested after installation of sterntube
9	a. Fore peak voids	Leak	See 404.d. through 404.e., as applicable	
	b. Aft peak voids	Leak	See 404.d. through 404.e., as applicable	After peak to be tested after installation of stern tube
10	Cofferdams	Leak	See 404.d. through 404.e., as applicable	
11	a. Watertight bulkheads	Leak	See 404.c. through 404.e., as applicable*7	
	b. Superstructure end bulkhead	Leak	See 404.c. through 404.e., as applicable	
12	Watertight doors below freeboard or bulkheaddeck	Leak *6,*8	See 404.c. through 404.e., as applicable	
13	Double plate rudder blade	Leak	See 404.d. through 404.e., as applicable	
14	Shaft tunnel clear of deep tanks	Leak *3	See 404.c. through 404.e., as applicable	
15	Shell doors	Leak *3	See 404.c. through 404.e., as applicable	
16	Weathertight hatch covers and closing appliances	Leak *3, *8	See 404.c. through 404.e., as applicable	Hatch covers closed by tarpaulins and battens excluded
17	Dual purpose tank/dry cargo hatch cover	Leak *3, *8	See 404.c. through 404.e., as applicable	In addition to structural test in item 6 or 7
18	Chain locker	Leak & Structural	Top of chain pipe	
19	Independent tanks	Leak & Structural*1	The greater of - top of the overflow, or - to 0.9m above top of tank	
20	Ballast ducts	Leak & Structural*1	The greater of - ballast pump maximum pressure, or - setting of any pressure relief valve	

Notes:

*1 Structural test is to be carried out for at least one tank of the same construction (i.e., same design and same workmanship) on each vessel provided all subsequent tanks are tested for leaks by an air test. However, where structural adequacy of a tank was verified by structural testing, the subsequent vessels in the series (i.e., sister ships built in the same shipyard) may be exempted from such testing for other tanks which have the structural similarity to the tested tank, provided that the watertightness in all boundaries of exempted tanks are verified by leak testsand thorough inspection is carried out. In any case, structural testing is to be carried out for at least one tank for each vessel in order to verify structural fabrication adequacy. (See 402.c.1.).

*2 Top of tank is deck forming the top of the tank excluding any hatchways.

*3 *Hose Test* may also be considered as a medium of the test. See 302.

*4 Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4.

*5 Including duct keels and dry compartments arranged in accordance with the provisions ofSOLAS regulation II-1/9.4.

*6 Where water tightness of watertight door has not been confirmed by prototype test, testing by filling watertight spaces with water is to be carried out. See SOLAS regulation II-1/16.2 and MSC/Circ.1176.

*7 Where a hose test is not practicable, other testing methods listed in 404.f. through 404.g. may be applicable subject to adequacy of such testing methods being verified. See SOLAS regulation II-1/11.1.

*8 As an alternative to the hose testing, other testing methods listed in 404.g. through 404.i. may be applicable subject to the adequacy of such testing methods being verified. See SOLAS regulation SOLAS regulation II-1/11.1.

TABLE T.T6.402.1. - ADDITIONAL TEST REQUIREMENTS FOR SPECIAL SERVICE SHIPS/TANKS

	Type of Ship/Tank	**Structures to be tested**	**Type of Test**	**Test Head or Pressure**	**Remarks**
1	Liquefied gas carrier	Cargo containment systems (See remarks)	See 404.1.	See 404.1.	See also Table T.T5.401.1.for other tanks and boundaries
2	Edible liquid tanks	Independent tanks	Leak & Structural	The greater of - top of the overflow, or - to 0.9m above top of tank *1	
3	Chemical carrier	Integral or independent cargo tanks	Leak & Structural	The greater of - to 2.4m above top of tank *1, or - to top of tank *1 plus setting of any pressure relief valve	

Note: *1 Top of tank is deck forming the top of the tank excluding any hatchways.

TABLE T.T6.401.2.APPLICATION OF LEAK TEST, COATING AND PROVISION OF SAFE ACCESS FOR TYPE OF WELDED JOINTS

Type of WeldedJoints		Leak Test	Coating *1		Safe Access *2	
			BeforeLeak Test	AfterLeak Test & beforeStructuralTest	Leak Test	Structural Test
Butt	Automatic	Not required	Allowed	N/A	Not required	Not required
	Manual or Semiautomatic	Required	Not allowed	Allowed	Required	Not required
Fillet	Boundary including penetrations	Required	Not allowed	Allowed	Required	Not required

Notes:

*1 Coating refers to internal (tank/hold coating), where applied, and external(shell/deck) painting. It does not refer to shop primer.

*2 Temporary means of access for verification of the leak test.

T7. SURVEY IN SEMI-HARD COATINGS IN BALLAST TANKS [IACS Rec 54]

100. Surveys

101. When semi hard coatings are applied to surfaces of ballast tanks, the ballast tanks are to be examined on an annual basis.

102. Prior to application of the semi hard coating, the ballast tanks have been examined by the surveyor including thickness measurements as necessary and structural repairs if so required have been carried out with satisfactory result.

103. Satisfactory documentation is provided confirming that the surface preparation, coating application and film thickness are in accordance with the manufacturer's specification.

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