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

TITLE 12 CONTAINER SHIPS

SECTION 2 STRUCTURES

CHAPTERS

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A1. SCOPE

100. Application

101. The present Title 12 Chapter applies to ships are eligible for the assignment of the Class Notation "**Container Ship**".

102. The requirements of this Chapter are additional to those of Part II, Title 11, and Section 2.

CAPÍTULO E
DESIGN PRINCIPLES OF LOCAL STRUCTURAL SYSTEMS

CHAPTER CONTENTS

E2. CONFIGURATION AND DESIGN PRINCIPLES OF THE LOCAL STRUCTURAL SYSTEMS [Based on IACS Rec 84]

100. Configuration

101. Figures F.E2.101.1 to F.E2.101.3 show typical structural configurations for a container ship.

FIGURE T.E2.101.1 TYPICAL CARGO HOLD CONFIGURATION FOR A CONTAINER SHIP

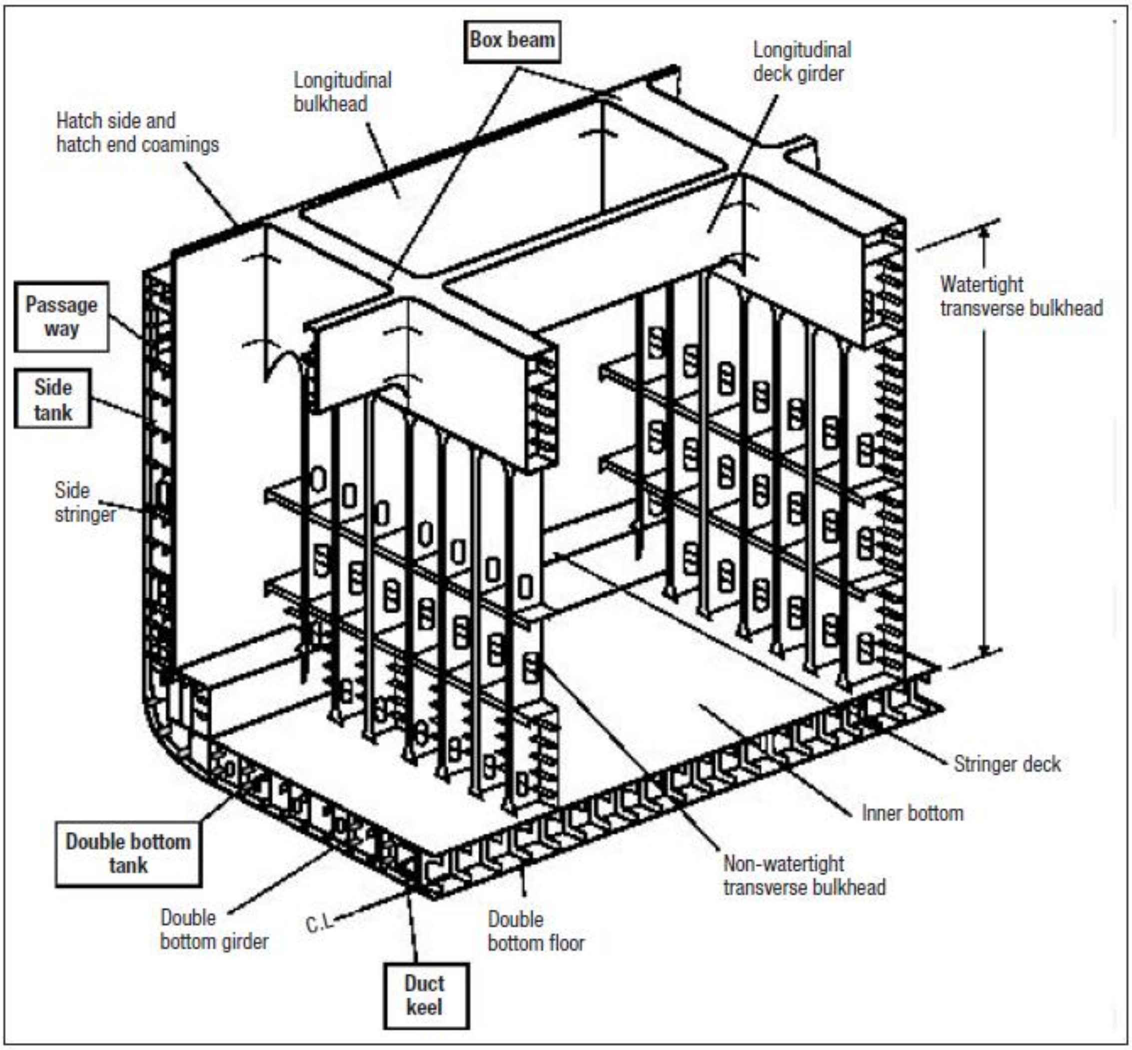


FIGURE T.E2.101.2 NOMENCLATURE FOR TYPICAL TRANSVERSE SECTION IN WAY OF CARGO HOLD

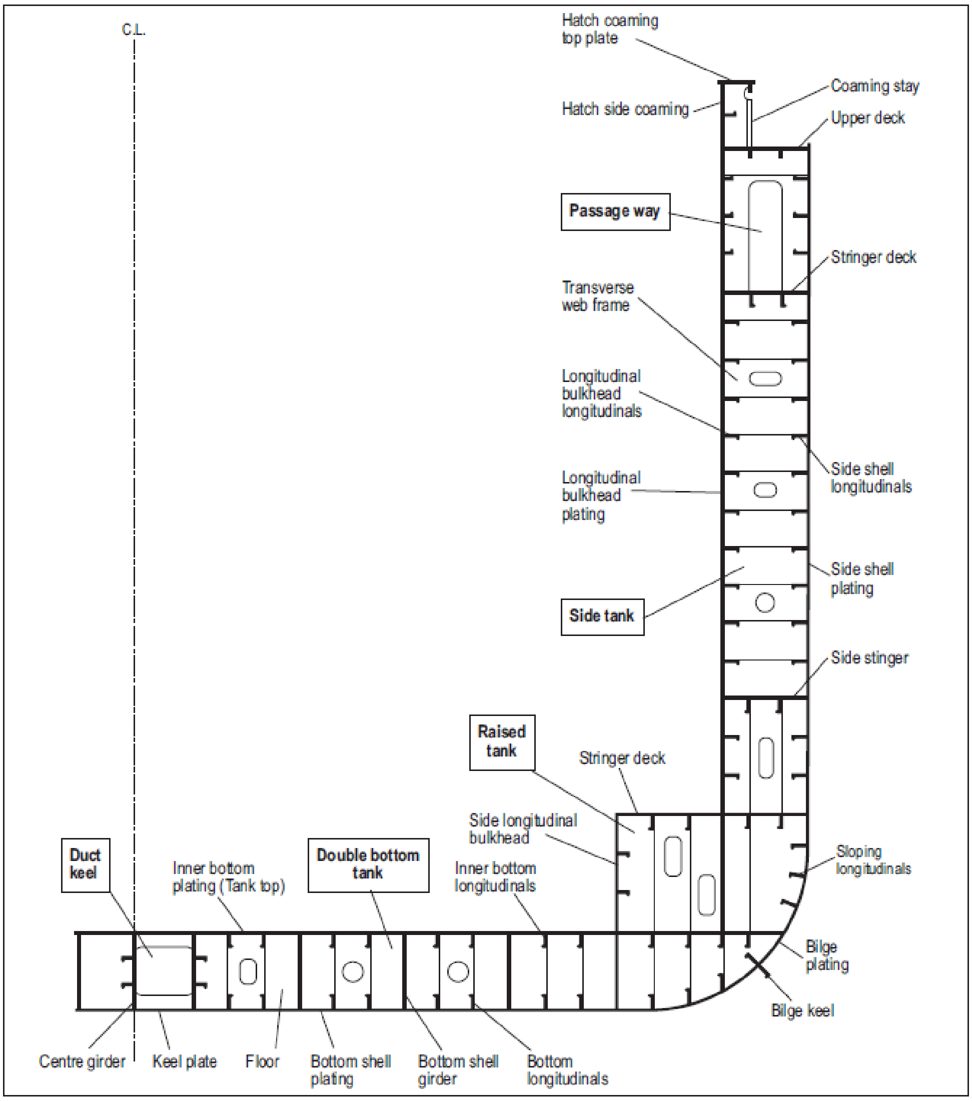
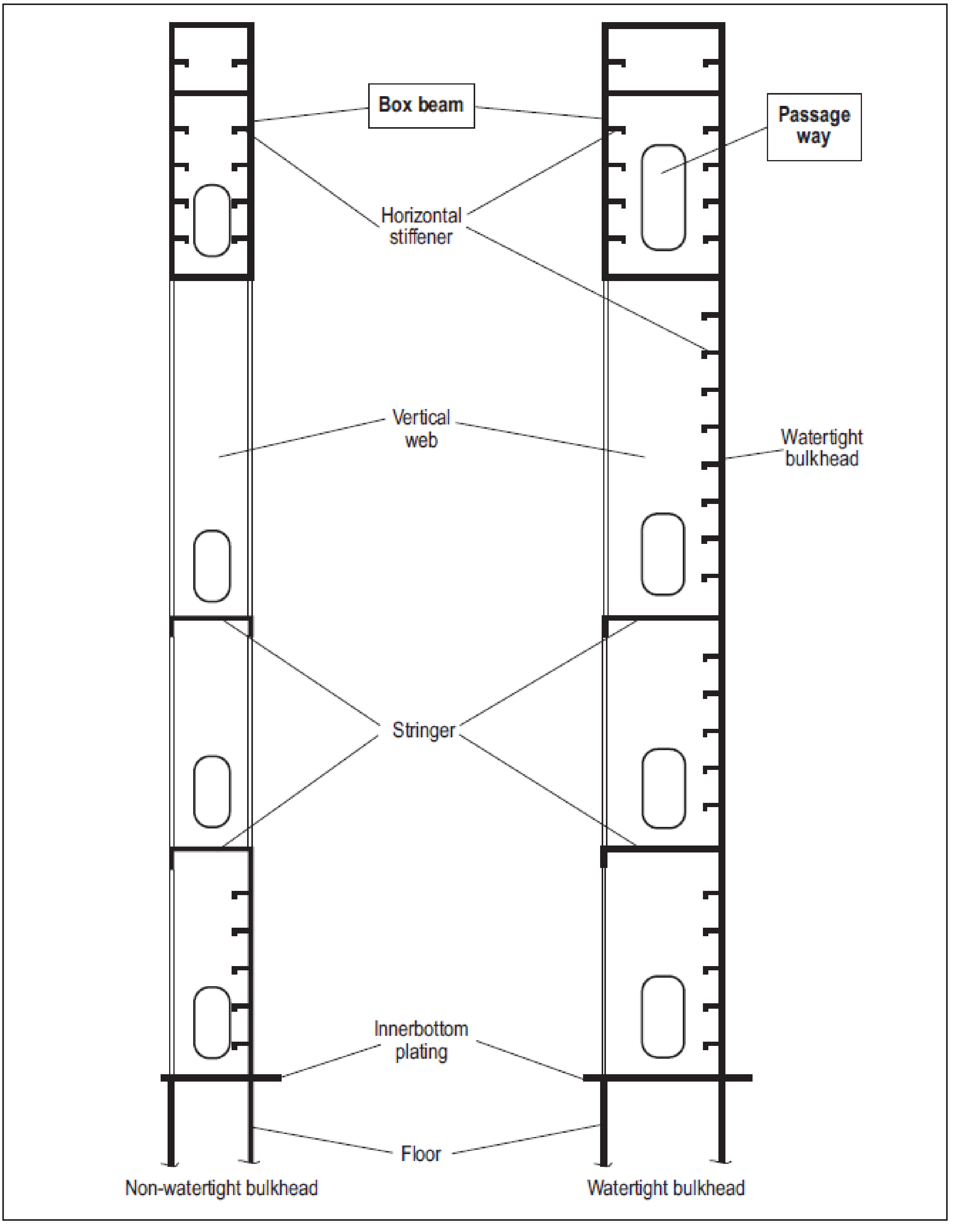


FIGURE T.E2.101.3 NOMENCLATURE FOR TYPICAL TRANSVERSE BULKHEADS FOR A CONTAINER SHIP



102. In general, container ships have double hull side structure in the cargo hold area. The double hull is used as deep tanks, i.e. ballast tanks, heeling tanks or fuel oil tanks. In most cases, the upper part of the double hull is used as a passageway. Smaller container ships (and the foremost cargo hold in the case of larger container ships) may have a single side structure, at least in the upper part. Stringer decks (raised tanks) may be arranged in the foremost and aft cargo holds to provide additional space for container stacks.

103. In addition to contributing to the shear strength of the hull girder, the side structure forms the external boundary of a cargo hold and is naturally the first line of defence against ingress or leakage of sea water when the ship's hull is subjected to wave and other dynamic loading in heavy weather.

104. Two different types of transverse bulkheads are found in the cargo holds of container ships: watertight bulkheads and non-watertight bulkheads.

105. The transverse bulkheads are located at the end of each cargo hold and are commonly constructed as plane double plated bulkheads with internal stiffening. In general every second transverse bulkhead is watertight i.e. with watertight plating on one side and with large cut-outs on the opposite side.

106. The non-watertight bulkhead is constructed as plane double plated bulkhead with large cut-outs in the plating on both sides. Normally cell guides are fitted at the bulkheads in order to guide the containers during loading and unloading as well as to support the containers during the voyage.

107. **Cell guides** are strong vertical structures constructed of metal installed into a ship's cargo holds. These structures guide containers into well-defined rows during the loading process and provide some support for containers against the ship's rolling at sea.See figures F.E2.107.1 and F.E2.107.2.

FIGURE F.E2.107.1 – CELL GUIDES IN A CONTAINER SHIP'S HOLD

FIGURE F.E2.107.2 – CELL GUIDE TOP IN A CONTAINER SHIP'S HOLD

200. Design principles for decks

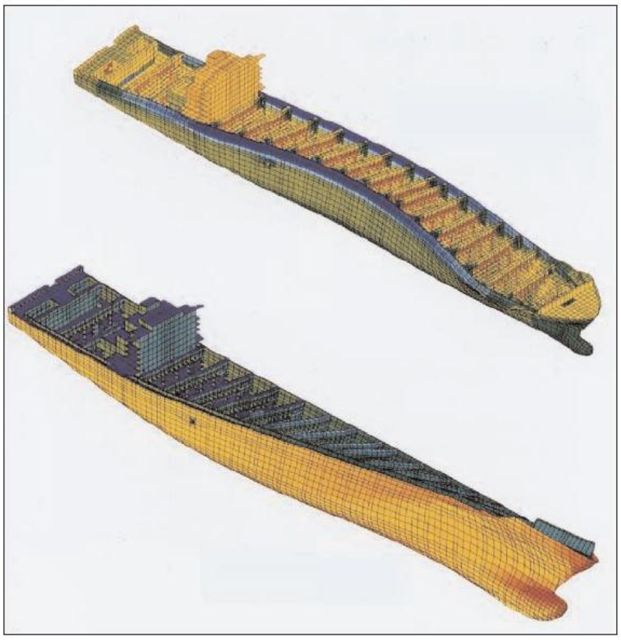
201. In calculating the deck structure by the Rules or by direct calculation methods, the following factors are to be taken into consideration:

a. Due to the large hatch openings for loading and unloading of containers the hull structure is very flexible showing considerable elastic deformations in a seaway as well as high longitudinal stresses.

b. Normally containerships meet only hogging still water bending moment conditions of the hull causing high tensile stresses in the continuous longitudinal deck structures such as longitudinal hatch coamings, upper deck plating and longitudinals.

c. The range of these higher bending stresses is extended over the complete cargo hold area. Particular areas of the deck may also be subjected to additional compressive stresses in heavy weather, caused by slamming or bow flare effect at the fore part of the ship. Longitudinal deck girders, even though in general not completely effective for the longitudinal hull girder strength, are also subject to high longitudinal stresses.

d. In particular in case of the use of higher tensile steel in such high stressed areas special attention is to be paid to the detail design of the structure.



e. The cross deck structure between cargo hatches is subjected to transverse compression from the sea pressure on the ship sides and in-plane bending due to torsional distortion of the hull girder under wave action.

f. The area around the corners of a main cargo hatch can be subjected to high cyclical stresses due to the combined effect of hull girder bending moments, transverse and torsional loads.

g. Cargo hatch side coamings can be subjected to stress concentrations at their ends.

h. Considerable horizontal frictional forces in way of the hatch cover resting pads can result from the elastic deformation of the deck structure in combination with the hatch covers which are extremely rigid against horizontal in-plane loads. The magnitude of these frictional forces depends on the material combination in way of the bearing.

i. The marine environment and the high temperature on deck and hatch cover plating due to heat from the sun may result in accelerated corrosion of plating and stiffeners making the structure more vulnerable to the exposures described above. Therefore, due consideration is to be given to a corrosion margin.

202. Local reinforcements are to be fitted under container corners.

203. The width of the hatch coamings is to be such as to accommodate the hatch covers and their securing arrangements.

204. The connections of the deck longitudinal girders in way of the holds and in way of the machinery space structure and aft and fore part structures is to be designed in such a manner as to ensure proper transmission of stresses.

205. **Cross decks**: transverse deck strips between the hatches are subject to a shear force induced by the overall torsion of the ship. The adequate strength of these strips is to be verified taking this factor into account.

300. Design principles for side structures including side tanks

301. In calculating the side structures including tanks by the Rules or by direct calculation methods, the following factors are to be taken into consideration:

a. Due consideration if to be given to the ship side structure, which is prone to damage caused by contact with the quay during berthing and impacts of cargo and cargo handling equipment during loading and unloading operations.

b. In longitudinally stiffened areas the side shell is more prone to damage due to action of fenders and tugs. A careful positioning of reinforced parts of the side shell structure in these areas, using the service experience of the owner, can reduce any damage.

c. In some cases cell guides are fitted at the longitudinal bulkheads in order to guide containers during loading and unloading as well as to support the containers during the voyage.

d. The structure in the transition regions at the fore and aft ends of the ship is subject to stress concentrations due to structural discontinuities.

e. The side shell plating in the transition regions is also subject to panting.

f. The lack of continuity of the longitudinal structure, and the increased slenderness and flexibility of the side structure, makes the structure at the transition regions more prone to fracture damage.

400. Design principles for transverse bulkhead structure

401. The bulkheads serve as main transverse strength elements in the structural design of the ship. Additionally the watertight bulkhead serves as a subdivision to prevent progressive flooding in an emergency situation.

402. **Reinforcements in way of cell guides**: where cell guides are fitted on transverse or longitudinal bulkheads which for boundaries of the holds, such structures are to be adequately reinforced taking into account the loads transmitted by the cell guides.

500. Design principles for double bottom tank structure

501. In calculating the bottom tank structure by the Rules or by direct calculation methods, the following factors are to be taken into consideration:

a. In addition to contributing to the longitudinal bending strength of the hull girder, the double bottom structure provides support for the cargo in the holds.

b. The tank top structure is subjected to impact forces of containers during loading and unloading operations. The bottom shell at the forward part of the ship may sustain increased dynamic forces caused by slamming in heavy weather

c. Normally, on container ships, a strict observance of a maintenance programme in the cargo holds could be difficult due to the fact that cargo holds are very seldom completely empty. Therefore, the tank top and the adjacent areas of bulkheads are prone to increased corrosion and need particular attention.

502. The double bottom spacing of the floors is to be such as to provide support for the container corner fittings. Girders are to be fitted in way of the container corners.

600. Design principles for fore end structures

601. In calculating the side structures including tanks by the Rules or by direct calculation methods, the following factors are to be taken into consideration:

a. In general container ships have a high power main engine and are operated to a tight schedule. Therefore, ships can proceed in comparatively heavy weather at a relatively high speed. In particular in the case of larger bow flare high local pressure due to bow flare slamming as well as increased global bending moments and shear forces in the fore end of the ship can cause hull damage such as deformations and fractures.

b. Deformation can be caused by contact which can result in damage to the internal structure leading to fractures in the shell plating.

c. Fractures of internal structure in the fore peak tank and spaces also result from wave impact load due to slamming and panting.

d. The forecastle structure is exposed to green water and can suffer damage such as deformation of deck structures, deformation and fracture of bulwarks and collapse of masts, etc. Bulwarks are provided for the protection of the crew and of the anchor and mooring equipment. Due to the bow flare effect bulwarks are subject to impact forces which result in alternating tension and compression stresses which can cause fractures and corrosion at the bulwark bracket connections to the deck. These fractures may propagate to the deck plating and cause serious damage.

e. The shell plating around the anchor and hawse pipe may suffer corrosion, deformation and possible fracture due to the movement of an improperly stowed and secured anchor, especially in the case of an unsheltered position as the same high hydrodynamic impact forces act on the anchor as on the hull structure, influencing the motion of the anchor in the hawse pipe.

700. Design principles for aft end structures

701. In calculating the side structures including tanks by the Rules or by direct calculation methods, the following factors are to be taken into consideration:

a. Deformation can be caused by contact or wave impact action from astern (which can result in damage to the internal structure leading to fractures in the shell plating).

b. Fractures to the internal structure in the aft peak tank and spaces can also result from main engine and propeller excited vibration.

800. Structural continuity

801. In double side skin ships where the machinery space is located between two holds the inner side is, in general, to be continuous within the machinery space. Where the machinery space is situated aft, the inner side is to extern as far aft as possible and be tapered at the ends.

E3. LOADINGS

100. Scope

101. The present Subchapter E3 is related to loads on the ship's structure introduced by the containers.

200. Loads introduced by containers

201. The loads transmitted by the cargo to the container fittings, lashing and securing are to be calculated in addition to the structural loads as per Part II, Title 11, Section 2.

202. The determination of the loads takes into account:

a. The maximum weight of the containers;

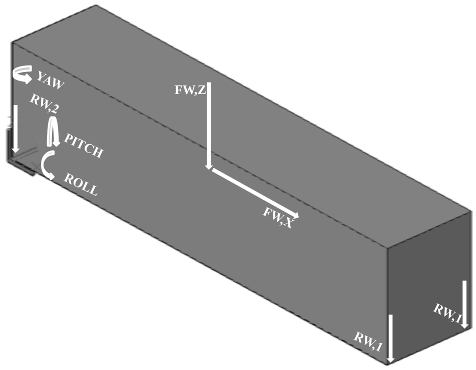
b. The ship's movements; and

c. Environmental conditions (wind, wave impact, etc.).

203. The loads introduced by the container cargo are to be applied at the centre of gravity of the container or container stack according to the factors given in nest topics, for the determination of the forces at the supports.

300. Geometry of the forces

FIGURE F.E3.301 – INERTIAL AND WIND FORCES UPRIGHT SHIP CONDITION



301. Still water forces to a container unit

$$F_p = m * g$$

302. External dynamic forces to a container unit in longitudinal, transversal and vertical direction should be obtained by the formula:

$$F_x = m * a_x + F_{wx} + F_{sx}$$

$$F_y = m * a_{xy} + F_{wy} + F_{sy}$$

$$F_z = m * a_z$$

where

$F_{(x, y, z)}$ = longitudinal, transverse and vertical forces

m = unit mass of the container
$a_{(x, y, z)}$ = longitudinal, transverse and vertical accelerations (see table T.E3.301.1.)

$F_{w(x,y)}$ = longitudinal and transverse forces by wind pressure

$F_{s(x, y)}$ = longitudinal and transverse forces by sloshing

303. The basic acceleration data is presented in table T.E3.303.1

TABLE T.E3.303.1 – BASIC ACCELERATION DATA

Transverse acceleration a_y in m/s²											**Longitudinal acceleration a_x in m/s²**
On deck, high		7,1	6,9	6,8	6,7	6,7	6,8	6,9	7,1	7,4	***3,8***
On deck, low		6,5	6,3	6,1	6,1	6,1	6,1	6,3	6,5	6,7	***2,9***
'tween deck		5,9	5,6	5,5	5,4	5,4	5,5	5,6	5,9	6,2	***2,0***
Lower hold		5,5	5,3	5,1	5,0	5,0	5,1	5,3	5,5	5,9	***1,5***
% L	***0***	***10***	***20***	***30***	***40***	***50***	***60***	***70***	***80***	***90***	***% L***
Vertical acceleration a_z in m/s²											
		7,6	6,2	5,0	4,3	4,3	5,0	6,2	7,6	9,2	

304. The given transverse acceleration figures include components of gravity, pitch and heave parallel to the deck.

305. The given vertical acceleration figures do not include the static weight component.

306. The basic accelerations considered are valid under the following operating conditions:

a. Operation in unrestricted area

b. Operation during the whole year

c. Duration of the voyage 25 days

d. Length of ship 100 meters

e. Service speed 15 knots

f. B/GM ≥ 13

307. For ships under of a length other than 100 m, the figures should be corrected by a factor given in Table T.E3.307.1

TABLE T.E3.307.1 – CORRECTION TABLE FOR SHIP'S LENGTH

Length (m) **Speed(kn)**	**50**	**60**	**70**	**80**	**90**	**100**	**120**	**140**	**160**	**180**	**200**
9	1,20	1,09	1,00	0,92	0,85	0,79	0,70	0,63	0,57	0,53	0,49
12	1,34	1,22	1,12	1,03	0,96	0,90	0,79	0,72	0,65	0,60	0,56
15	1,49	1,36	1,24	1,17	1,07	1,00	0,89	0,80	0,73	0,68	0,63
18	1,64	1,49	1,37	1,27	1,18	1,10	0,98	0,89	0,82	0,76	0,71
21	1,78	1,62	1,49	1,38	1,29	1,21	1,08	0,98	0,90	0,83	0,78
24	1,93	1,76	1,62	1,50	1,40	1,31	1,17	1,07	0,98	0,91	0,85

308. For length/speed combinations not directly tabulated, the following formula may be used to obtain the correction factor with v = speed in knots and L = length between perpendiculars in metres:

Correction factor = $(0{,}345) * \frac{v}{\sqrt{L)}} + (58{,}62 * L - 1034{,}5)/L^2$

TABLE T.E3.309.1 – CORRECTION FACTORS FOR B/GM

B/GM	7	8	9	10	11	12	13 or above
On deck, high	1,56	1,40	1,27	1,19	1,11	1,05	1,00
On deck, low	1,42	1,30	1,21	1,14	1,09	1,04	1,00
1tweendeck	1,26	1,19	1,14	1,09	1,06	1,03	1,00
Lower hold	1,15	1,12	1,09	1,06	1,04	1,02	1,00

310. Notes:

a. In cases of roll resonance with amplitudes ≥ 30º, the given values of transverse acceleration may be exceeded;

b. In case of heading into the seas at high speed with marked slamming, the figures of vertical and longitudinal acceleration may be exceeded;

c. In case of running before large or quartering seas, large rolling motions are to be expected with the figures of transverse accelerations exceeded;

d. Forces by wind and sea to cargo units above the weather deck should be accounted for by a simple approach:

e. Forces by wind pressure = 1 kN per m^2

f. Forces by sea sloshing = 1 kN per m^2

g. Sea sloshing forces need only to be applied to a height of deck cargo up to 2 metresabove the weather deck or hatch top.

h. For voyages in restricted sea areas, sloshing forces may be neglected.

311. The still water and inertial forces applied to one container at level “i” is as per Table T.E3.3111.1 below.

312. The forces applied to a container stack containing “n” containers, and the reactions at each of the container corner are as per Table T.E3.312.1 below.

TABLE T.E3.311.1 – STILL WATER AND DYNAMIC FORCES ACTING ON A SINGLE CONTAINER UNIT “I”

Ship condition	Still water and dynamic forces acting on a single container unit “I”
Still water	$F_p = m * g$
Upright heave motion	Up to 2 meters from weather deck: $F_{xi} = m * a_x i + F_{wxi} + F_{sxi}$ $F_{zi} = m * a_{zi}$ More than 2 meters from weather deck: $F_{xi} = m * a_{xi} + F_{wxi}$ $F_z i = m * a_z i$
Inclined roll motion	Up to 2 meters from weather deck: $F_{yi} = m * a_{yi} + F_{wyi} + F_{syi}$ $F_{zi} = m * a_{zi}$ More than 2 meters from weather deck: $F_{yi} = m * a_{yi} + F_{wyi}$ $F_{zi} = m * a_{zi}$

ABLE T.E3.312.1 – STILL WATER AND DYNAMIC FORCES ACTING ON EACH CONTAINER STACK

Ship condition	Still water and dynamic forces acting on each container stack	Still water and dynamic forces transmitted at the corners of each container stack
Still water	$Fp_{,st} = \sum_1^n Fp$	
Upright heave motion	Up to 2 meters from weather deck: $F_{st,xi} = \sum_1^n (F_{xi} + F_{wxi} + F_{sxi})$ $F_{st,zi} = \sum_1^n Fz_i$ More than 2 meters from weather deck: $F_{st,xi} = \sum_1^n (F_{xi} + F_{wxi})$ $F_{st,zi} = \sum_1^n Fz_i$	
Inclined roll motion	Up to 2 meters from weather deck: $F_{st,yi} = \sum_1^n (F_{xyi} + F_{wyi} + F_{syi})$ $F_{st,zi} = \sum_1^n Fz_i$ More than 2 meters from weather deck: $F_{st,yi} = \sum_1^n (F_{yi} + F_{wyi})$ $F_{st,zi} = \sum_1^n Fz_i$	

CHAPTER H
GLOBAL DIMENSIONING OF THE HULL GIRDER

CHAPTER CONTENTS

H4. WAVE LOADS

100. Torsional moment for container ships

101. In addition to the bending moments and shear stress in Part II, Title 11, Section 2, Chapter H, the torsional moment is to be calculated for container ships.

101. Still water torsional moment due to uneven distribution of cargo and other weights is to be calculated.

102. Wave induced torsional moment is to be calculated in accordance with the topic H4.200.

200. Wave torsional moment

201. Application

202. These topic applies to Container ships having large deck openings. The hull structures of single side skin and double side skin with unrestricted worldwide navigation, having length *L* of 90 m or above.

203. The scantling draught considered when applying the present Rules is to be not less than that corresponding to the assigned freeboard.

204. The structural response of the hull girder and the primary structural members under normal, shear, bending and torsional loads is characterized by global (large area) deformations and stresses. Furthermore, crane load cases are important and need to be analyzed.

205. The torsional moment is to be indicated on the structural plans of the cargo part and on the midship section plan.

206. The wave torsional moment at any hull transverse section, in kN.m, is given by:

$$M_{WT} = fp\,(M_{WT1} + M_{WT2})$$

where:

$$M_{WT} = 0{,}4C\sqrt{\frac{L}{T}}\,B^2 \,.\, D \,.\, C_B \,.\, F_{T1}$$

$$M_{WT} = 0{,}22.C.L.\,B^2\, C_B \,.\, F_{T2}$$

$$F_{T1} = \sin\left(\frac{2\pi x}{L}\right)$$

$$F_{T1} = \sin^2\left(\frac{\pi x}{L}\right)$$

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

fp = 1,0 for strength assessments corresponding to the probability level of 10^{-8}

fp = 0,5 for strength assessments corresponding to the probability level of 10^{-4}

C=Wave coefficient, as defined in H4.302

300. Wave bending moment

301. When the wave bending moment is not made by direct calculation, the moment caused by the waves, in special for vessels of L ≥ 60 m, is to be calculated by the equations showed in H2.602.

302. The vertical Wave bending moment Mw, at each section along the ship length are given by the following formulae: [IACS UR S11.2.2.1]

$MWV,H = +190\,MCL^2BCb \times 10^{-3}$ kN.m for positive moment.

$MWV,S = -110\,MCL^2B(Cb + 0{,}7) \times 10^{-3}$ kN.m for negative moment.

where:

M = distribution factor given in Figure F.H4.301.1.

C = c_n as indicated in H3.101.

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

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

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

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, Subchapter C3.200.
L = length defined in Title 11, section 1, sub-chapter A2.

B = greatest moulded breadth in metres.

C_b = block coefficient not to be taken less than 0,6.

FIGURE F.H4.302.1. – DISTRIBUTION FACTOR M [IACS UR S11]

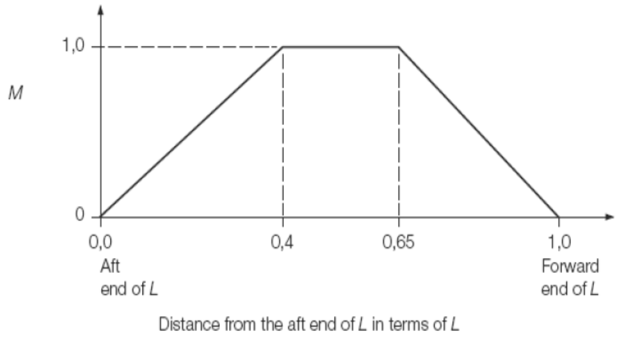


TABLE T.H4.302.1: DISTRIBUTION FACTOR *M*

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
$0{,}65L < x \leq L$	$2{,}86\left(1-\frac{x}{L}\right)$

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

$QWV(+) = +30\, F_1 CLB\,(Cb + 0{,}7)$ kN for positive shear force

$QWV(-) = -30\, F_2 CLB\,(Cb + 0{,}7) \times 10^{-2}$ kN for negative shear force.

where:

F_1, F_2 = Distribution factors given in Figures F. H4.303.1 and F.H4.303.2

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

FIGURE F. H4.303.1 – DISTRIBUTION FACTOR F1 [IACS S11]

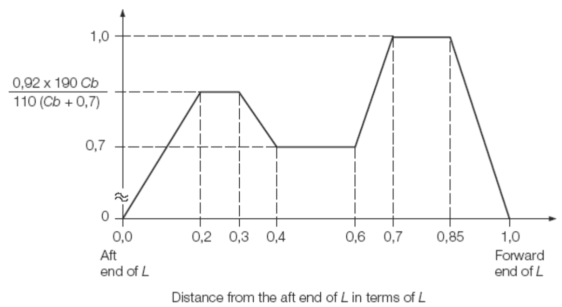


FIGURE F.H4.303.2 – DISTRIBUTION FACTOR F_2 [IACS S11]

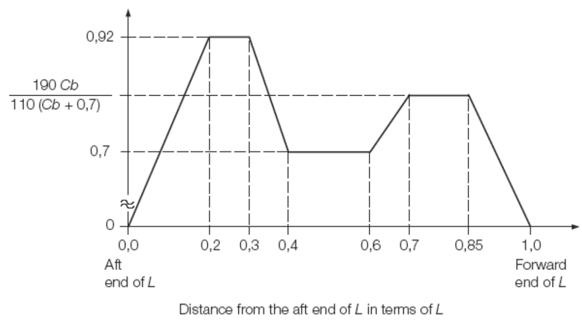


TABLE T.H4.303.1: DISTRIBUTION FACTOR *F2*

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: $A = \frac{190CB}{110(CB+0{,}7)}$		

400. Flooded condition

401. The vertical wave shear force in flooded condition at any hull transverse section are obtained, in kN, from the following formula:

$Q_{WV,F}$ □□0,8Q_{WV}

where Q_{WV} is defined in H4.303

500. Harbour condition

501. The vertical wave shear force in harbor condition at any hull transverse section is obtained, in kN, from the following formula:

QWV ,P 0,4*QWV*
where:

QWV is defined in H4.303

600. Horizontal wave bending moment

601. The horizontal wave bending moment at any hull transverse section, in kN.m, is given by:

$M_{WH} = (0,3 + \frac{L}{2000}) M f_p C L^2 T_{LC} C_B$

where:

M = Distribution factor given in Figure F.H4.302.1 and the Table T.H4.302.1

T_{LC} = Midship draught, in m, in the considered loading condition

602. For verification of the external pressure apply the conditions showed in the Part II, Title 1, section 2, subchapter E6.

700. Still water bending moment

701. The design still water bending moments *MSW,H* and *MSW,S* at any hull transverse section are the maximum still water bending moments calculated, in hogging and sagging conditions, respectively, at that hull transverse section for the loading conditions. Greater values may be considered if defined by the designer.

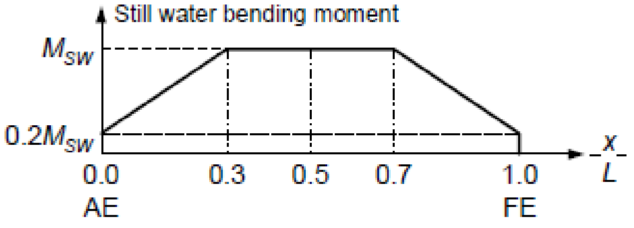
702. If the design still water bending moments are not defined, at a preliminary design stage, at any hull transverse section, the longitudinal distributions shown in Figure F.H4.703.1. may be considered.

703. Figure F.H4.803.1, *MSW* is the design still water bending moment amidships, in hogging or sagging conditions, whose values are to be taken not less than those obtained, in kN.m, from the following formulae:

MSW,H = 175CL²B(CB+0,7)10^{-3}- $M_{WV,H}$, hogging conditions.

MSW,S = 175CL²B(CB+0,7) 10^{-3} - $M_{WV,S}$, sagging conditions.

FIGURE F.H4.703.1. – PRELIMINARY STILL WATER BENDING MOMENT DISTRIBUTION



H5. HULL GIRDER STRESSES

100. Normal stresses

101. General

102. The normal stresses in a member made in material other than steel with a Young's modulus *E* equal to 2.06 10^5 N/mm², included in the hull girder transverse sections obtained from the following formula:

$\sigma_1 = \frac{E}{2{,}06.10^5} \sigma_{1S}$

where:

σ_{1S}= Normal stress, in N/mm2, in the member under consideration, calculated according to H5.201 considering this member as having the steel equivalent sectional area *ASE* defined in H5.103.

103. Where a member contributing to the longitudinal strength is made in material other than steel with a Young's modulus *E* equal to 2,06 10^5 N/mm^2, the steel equivalent sectional area that may be included in the hull girder transverse sections is obtained, in m^2, from the following formula:

$A_{SE} = \frac{E}{2{,}06.10^5} A_M$

where:

A_M = Sectional area, in m^2, of the member under consideration.

200. Normal stresses induced by vertical bending moments

201. The normal stresses induced by vertical bending moments are obtained, in N/mm2, from the following formulae:

a. at any point of the hull transverse section, located below *zVD* , where *zVD* = *VD* + *N*:

$\sigma_1 = \frac{Msw+Mwv}{ZA} 10^{-3}$

b. at bottom:

$\sigma_1 = \frac{Msw+Mwv}{ZAB} 10^{-3}$

$\sigma_1 = \frac{Msw+Mwv}{ZAD} 10^{-3}$

where:

M_{SW} = Design still water bending moment, in kN.m, at the hull transverse section considered:

MSW = *MSW,H,* in hogging conditions.

MSW = *MSW,S*, in sagging conditions.

MWV = Vertical wave bending moment, in kN.m, at the hull transverse section considered:

MWV = *MWV,H*, in hogging conditions.

MWV = *MWV,S*, in sagging conditions.

Z_A= The section modulus at any point of a hull transverse section obtained in m³.

Z_{AB}= The section modulus at bottom and at deck obtained, in m^3.

Z_{AD}= The section modulus at deck obtained in m^3.

where:

VD : Vertical distance, in m, taken equal to:

VD □□*zD* □□*N*

where:

z_D : *Z* co-ordinate, in m, of strength deck at side, with respect to the reference coordinate system.

202. if continuous trunks or hatch coamings are taken into account in the calculation of *IY*.

$$V_D = (Z_T - N)\left(0{,}9 + 0{,}2\frac{YT}{B}\right) \geq Z_D - N$$

where:

yT, *zT* : *Y* and *Z* co-ordinates, in m, of the top of continuous trunk or hatch coaming with respect to the reference co-ordinate system defined in y_T and z_T are to be measured for the point which maximizes the value of *VD.*

if longitudinal ordinary stiffeners or girders welded above the strength deck are taken into account in the calculation of I_Y , V_D is to be obtained from the formula given above for continuous trunks and hatch coamings. In this case, y_T and z_T are the *Y* and *Z* co-ordinates, in m, of the top of the longitudinal stiffeners or girders with respect to the reference co-ordinate system defined below:

N = Vertical distance, in m, from the base line to the horizontal neutral axis of the hull transverse section.

I_Y = Moment of inertia, in m^4, of the hull transverse section about its horizontal neutral axis calculated by the following equation:

$I_{Y\,R}$ = 3 $SM_{min.}$L. 10^{-6}

$SM_{min.}$ = Minimum section modulus defined in Part II, Title 11, Section 2, Subchapter H2.

IZ : Moment of inertia, in m4, of the hull transverse section about its vertical neutral defined in Part II, Title 11, Section 2, Subchapter H2.