PARTE II RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF SHIPS ACCORDING TO THEIR MISSION

TITLE 14 BULK CARRIERS

SECTION 2 STRUCTURE

CHAPTERS

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CHAPTER A
SCOPE

CHAPTER CONTENTS

A1. IMPLEMENTATION OF THE ADDITIONAL REQUIREMENTS IN CHAPTERS UR S19 AND UR S22 FOR EXISTING SINGLE SKIN BULK CARRIERS

A1. IMPLEMENTATION OF THE ADDITIONAL REQUIREMENTS IN CHAPTERS UR S19 AND UR S22 FOR EXISTING SINGLE SKIN BULK CARRIERS [IACS UR S23]

100. Application and Implementation Timetable*

101. Application and Implementation Timetable

a. Unified Requirements S19 and S22 are to be applied in conjunction with the damage stability requirements set forth in S23.2. Compliance is required:

b. for ships which were 20 years of age or more on 1 July 1998, by the due date of the first intermediate, or the due date of the first special survey to be held after 1 July 1998, whichever comes first;

c. for ships which were 15 years of age or more but less than 20 years of age on 1 July 1998, by the due date of the first special survey to be held after 1 July 1998, but not later than 1 July 2002;

d. for ships which were 10 years of age or more but less than 15 years of age on 1 July 1998, by the due date of the first intermediate, or the due date of the first special survey to be held after the date on which the ship reaches 15 years of age but not later than the date on which the ship reaches 17 years of age;

e. for ships which were 5 years of age or more but less than 10 years of age on 1 July 1998, by the due date, after 1 July 2003, of the first intermediate or the first special survey after the date on which the ship reaches 10 years of age, whichever occurs first;

f. for ships which were less than 5 years of age on 1 July 1998, by the date on which the ship reaches 10 years of age.

g. Completion prior to 1 July 2003 of an intermediate or special survey with a due date after 1 July 2003 cannot be used to postpone compliance. However, completion prior to 1 July 2003 of an intermediate survey the window for which straddles 1 July 2003 can be accepted.

102. Damage Stability

a. Bulk carriers which are subject to compliance with Unified Requirements S19 and S22 shall, when loaded to the summer loadline, be able to withstand flooding of the foremost cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium, as specified in SOLAS regulation XII/4.3 to 4.7.

b. A ship having been built with an insufficient number of transverse watertight bulkheads to satisfy this requirement may be exempted from the application of Unified Requirements S19, S22 and this requirement provided the ship fulfills the requirement in SOLAS regulation XII/9.

200. Surveys to be held

201. The term "survey to be held" is interpreted to mean that the survey is "being held" until it is "completed".

202. Due dates and completion allowance

a. intermediate survey: Intermediate survey carried out either at the second or third annual survey: 3 months after the due date (i.e. 2nd or 3rd anniversary) can be used to carry out and complete the survey;

b. Intermediate survey carried out between the second and third annual survey: 3 months after

c. the due date of the 3rd Annual Survey can be used to carry out and complete the survey;

d. renewal : 3 months extension after the due date may be allowed subject to the terms/conditions of PR4;

e. ships controlled by “1 July 2002”: same as for renewal survey;

f. 4 ships controlled by ”age 15 years” or “age 17 years”: same as for renewal survey.

203. Intermediate Survey Interpretations/Applications

a. 3.1 If the 2nd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed prior to or on 1 July 1998, the ship need not comply until the next renewal survey.

b. If the 2nd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed within the window of the 2nd annual survey but after 1 July 1998, the ship need not comply until the next renewal survey.

c. If the 2nd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed outside the window of the 2nd annual survey and after 1 July 1998, it is taken that the intermediate survey is held after 1 July 1998 and between the second and third annual surveys. Therefore, the ship shall comply no later than 3 months after the 3rd anniversary.

d. If the 2nd anniversary is after 1 July 1998 and the intermediate survey is completed within the window of the 2nd annual survey but prior to or on 1 July 1998, the ship need not comply until the next special survey

e. If the 3rd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed prior to or on 1 July 1998, the ship need not comply until the next special survey.

f. If the 3rd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed within the window of the 3rd annual survey but after 1 July 1998, the ship need not comply until the next special survey.

g. If the 3rd anniversary is after 1 July 1998 and the intermediate survey is completed within the window prior to or on 1 July 1998, the ship need not comply until the next special survey.

204. Special Survey Interpretations/Applications

a. If the due date of a renewal survey is after 1 July 1998 and the renewal survey is completed within the 3 month window prior to the due date and prior to or on 1 July 1998, the ship need not comply until the next relevant survey (i.e. renewal survey for ships under 20 years of age on 1 July 1998, intermediate survey for ships 20 years of age or more on 1 July 1998).

205. Early Completion of an Intermediate Survey (coming due after 1 July 1998 to postpone compliance is not allowed):

a. Early completion of an intermediate survey means completion of the survey prior to the opening of the window (i.e. completion more than 3 months prior to the 2nd anniversary since the last special survey).

b. The intermediate survey may be completed early and credited from the completion date but in such a case the ship will still be required to comply not later than 3 months after the 3^{rd} anniversary.

206. Early Completion of a Renewal Survey (coming due after 1 July 1998 to postpone compliance is not allowed):

a. Early completion of a renewal survey means completion of the survey more than 3 months prior to the due date of the special survey.

b. The renewal survey may be completed early and credited from the completion date, but in such a case the ship will still be required to comply by the due date of the special survey.

CHAPTER F
DIMENSIONING OF THE STRUCTURAL SYSTEM

CHAPTER CONTENTS

F1. ADDITIONAL REQUIREMENTS FOR SIDE STRUCTURES IN SINGLE SIDE SKIN BULK CARRIERS

F1. ADDITIONAL REQUIREMENTS FOR SIDE STRUCTURES IN SINGLE SIDE SKIN BULK CARRIERS [IACS UR S12]

100. Application and definitions

101. These requirements apply to side structures of cargo holds bounded by the side shell only of bulk carriers constructed with single deck, topside tanks and hopper tanks in cargo spaces intended primarily to carry dry cargo in bulk, which are contracted for construction on or after 1st July 1998.

102. This Sub Chapter F1 does not apply to CSR Bulk Carriers.

200. Scantlings of side structures

201. The thickness of the side shell plating and the section modulus and shear area of side frames are to be determined according to the Society's criteria.

202. The scantlings of side hold frames immediately adjacent to the collision bulkhead are to be increased in order to prevent excessive imposed deformation on the shell plating. As an alternative, supporting structures are to be fitted which maintain the continuity of forepeak stringers within the foremost hold.

300. Minimum thickness of frame webs

301. The thickness of frame webs within the cargo area is not to be less than $t_{w,min}$, in mm, given by:
$t_{w,min} = C(7 + 0{,}03L)$

Where:

C = 1.15 for the frame webs in way of the foremost hold;

C = 1.0 for the frame webs in way of other holds.

where L is the Rule length, in m, but need not be taken greater than 200 m.

400. Lower and upper brackets

401. The thickness of the frame lower brackets is not to be less than the greater of t_w and $t_{w,min}$ + 2 mm, where t_w is the fitted thickness of the side frame web. The thickness of the frame upper bracket is not to be less than the greater of t_w and $t_{w,min}$.

402. The section modulus SM of the frame and bracket or integral bracket, and associated shell plating, at the locations shown in Figure F.F1.402.1, is not to be less than twice the section modulus SMF required for the frame midspan area.

403. The dimensions of the lower and upper brackets are not to be less than those shown in Figure F F1.403.1.

404. Structural continuity with the upper and lower end connections of side frames is to be ensured within topsides and hopper tanks by connecting brackets as shown in Figure F.F1.404.1 The brackets are to be stiffened against buckling according to the Society's criteria.

405. The section moduli of the side longitudinals and sloping bulkhead longitudinals which support the connecting brackets are to be determined according to the Society's criteria with the span taken between transverses. Other arrangements may be adopted at the Society's discretion. In these cases, the section moduli of the side longitudinals and sloping bulkhead longitudinals are to be determined according to the Society's criteria for the purpose of effectively supporting the brackets.

500. Side frame sections

501. Frames are to be fabricated symmetrical sections with integral upper and lower brackets and are to be arranged with soft toes.

502. The side frame flange is to be curved (not knuckled) at the connection with the end brackets. The radius of curvature is not to be less than r, in mm, given by:

$$r = \frac{0{,}4bf^2}{tf}$$

where b_f and t_f are the flange width and thickness of the brackets, respectively, in mm. The end of the flange is to be sniped.

503. In ships less than 190 m in length, mild steel frames may be asymmetric and fitted with separate brackets. The face plate or flange of the bracket is to be sniped at both ends. Brackets are to be arranged with soft toes.

504. The web depth to thickness ratio of frames is not to exceed the following values:

a. 60 $k^{0.5}$ for symmetrically flanged frames

b. 50 $k^{0.5}$ for asymmetrically flanged frames

where k = 1.0 for ordinary hull structural steel and k < 1 for higher tensile steel according to Part II, Title 11, Section 2, Chapter C.

505. The outstanding flange is not to exceed 10 $k^{0.5}$ times the flange thickness.

600. Tripping brackets

601. In way of the foremost hold, side frames of asymmetrical section are to be fitted with tripping

700. Weld connections of frames and end brackets

701. Double continuous welding is to be adopted for the connections of frames and brackets to side shell, hopper and upper wing tank plating and web to face plates.

702. For this purpose, the weld throat is to be (see Figure F.F1.402.1):

a. 0.44 t in zone "a"

b. 0.4 t in zone "b"

where t is the thinner of the two connected members.

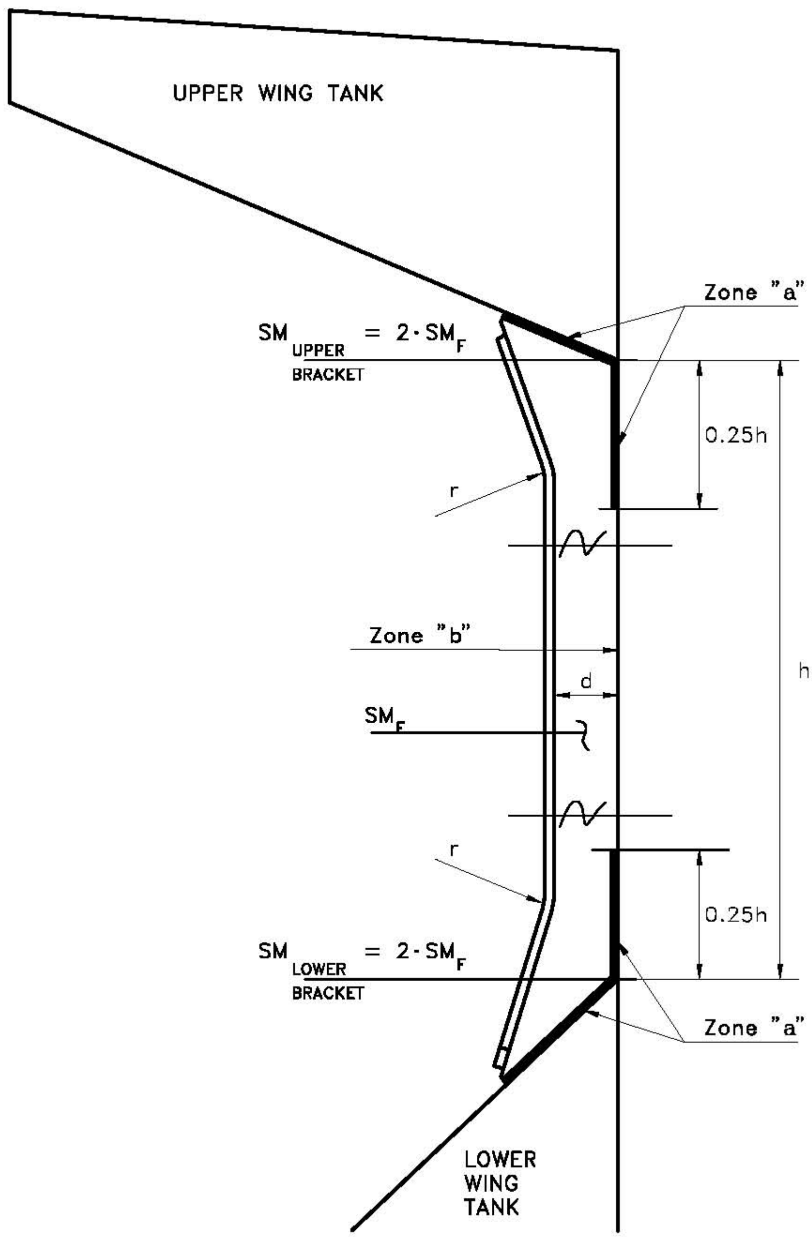
703. Where the hull form is such to prohibit an effective fillet weld, edge preparation of the web of frame and bracket may be required, in order to ensure the same efficiency as the weld connection stated above.

800. Minimum thickness of side shell plating

The thickness of side shell plating located between hopper and upper wing tanks is not to be less than $t_{p,min}$ in mm, given by:

$$t_{p,min} = \sqrt{L}$$

FIGURE F.F1.401.1



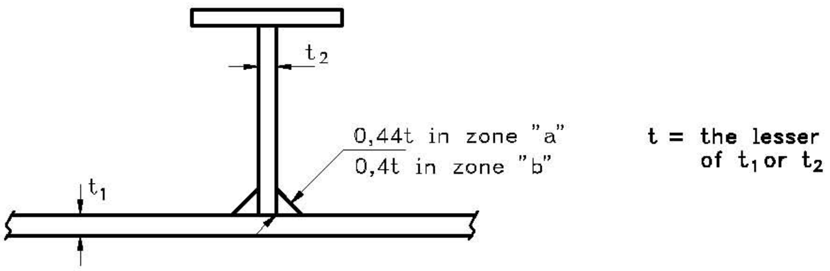


FIGURE F.F1.403.1

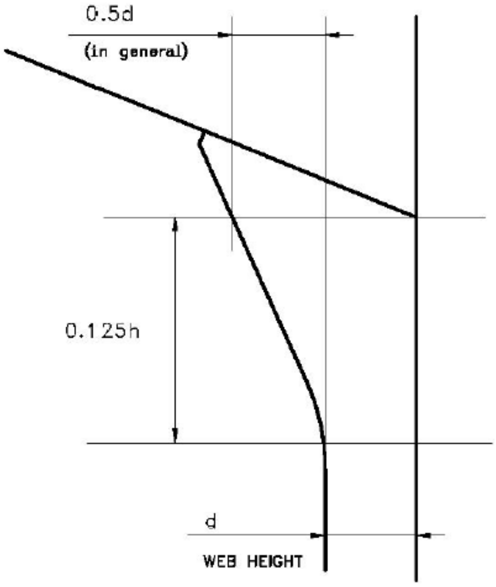


FIGURE F.F1.404.1

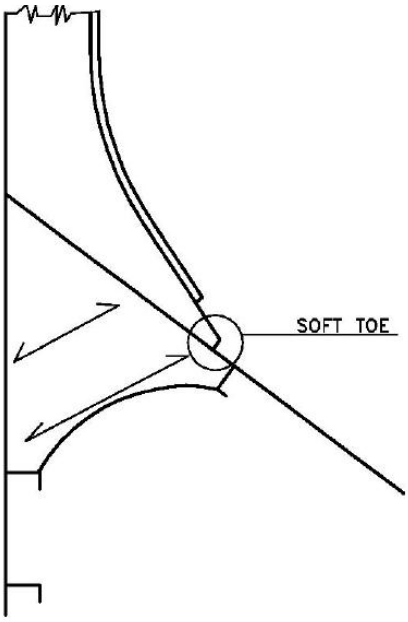
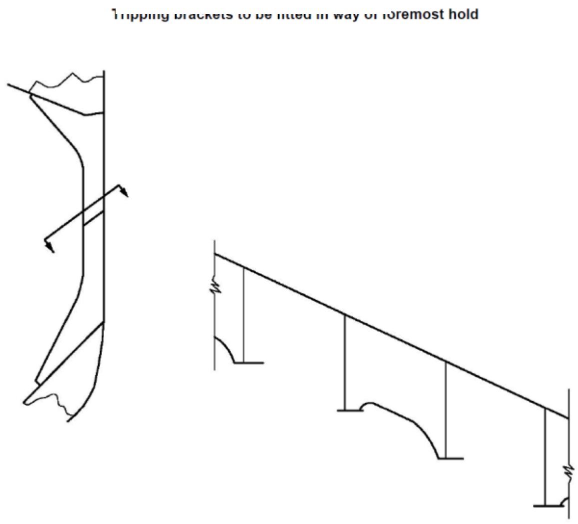


FIGURE F.F1.601.1



F2. LONGITUDINAL STRENGTH OF HULL GIRDER IN FLOODED CONDITION FOR BULK CARRIERS [IACS UR S17]

100. General

101. This sub chapter G4 is to be complied with in respect of the flooding of any cargo hold of bulk carriers with notation BC-A or BC-B.

102. Such ships are to have their hull girder strength checked for specified flooded conditions, in each of the cargo and ballast loading conditions defined in Part II, Title 11, Section 2, Chapter G, items G4.202 to G4.204 and in every other condition considered in the intact longitudinal strength calculations, including those according to Part II, Title 11, Section 1, Chapter K, except that harbour conditions, docking condition afloat, loading and unloading transitory conditions in port and loading conditions encountered during ballast water exchange need not be considered.

103. This UR does not apply to CSR Bulk Carriers.

200. Flooding conditions

201. Floodable holds: each cargo hold is to be considered individually flooded up to the equilibrium waterline.

202. Loads: the still water loads in flooded conditions are to be calculated for the above cargo and ballast loading conditions.

203. The wave loads in the flooded conditions are assumed to be equal to 80% of those given in Part II, Title 11, Section 2, Chapter G, sub chaprter G4 (UR S11).

300. Flooding criteria

301. To calculate the weight of ingressed water, the following assumptions are to be made:

a. The permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo is to be taken as 0.95.

b. Appropriate permeabilities and bulk densities are to be used for any cargo carried.

b.1. For iron ore, a minimum permeability of 0.3 with a corresponding bulk density of 3.0 t/m3 is to be used.

b.2. For cement, a minimum permeability of 0.3 with a corresponding bulk density of 1.3 t/m3 is to be used. In this respect, "permeability" for solid bulk cargo means the ratio of the floodable volume between the particles, granules or any larger pieces of the cargo, to the gross volume of the bulk cargo.

b.3. For packed cargo conditions (such as steel mill products), the actual density of the cargo should be used with a permeability of zero.

400. Stress assessment

401. The actual hull girder bending stress σ_{fld}, in N/mm2, at any location is given by:

$$\sigma_{fd} = \frac{Mef + 0,8Mw}{Wz} . 10^3$$

where:

Msf = still water bending moment, in kNm, in the flooded conditions for the section under consideration

M_W = wave bending moment, in kNm, as given in Part II, Section 2, Chapter G. G4.301 for the section under consideration

W_Z = section modulus, in cm3, for the corresponding location in the hull girder.

402. The shear strength of the side shell and the inner hull (longitudinal bulkhead) if any, at any location of the ship, is to be checked according to the requirements specified in Part II, Section 2, Chapter G. G4.401 to G4.406 in which F_S and F_W are to be replaced respectively by F_{SF} and F_{WF}, where:

F_{SF} = still water shear force, in kN, in the flooded conditions for the section under consideration

F_{WF} = 0.8 F_W

F_W = wave shear force, in kN, as given in Part II, Section 2, Chapter G. G4.302 for the section under consideration

500. Strength criteria

501. The damaged structure is assumed to remain fully effective in resisting the applied loading. Permissible stress and axial stress buckling strength are to be in accordance with Part II, Section 2, Chapter G. sub chapter G4.

CHAPTER J
EVALUATION OF SCANTLINGS OF HATCH COVERS AND HATCH COAMINGS OF CARGO HOLDS OF BULK CARRIERS, ORE CARRIERS AND COMBINATION CARRIERS
[IACS UR S21]

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J1. APPLICATION AND DEFINITIONS

J2. HATCH COVER LOAD MODEL

J3. HATCH COVER STRENGTH CRITERIA

J4. HATCH COAMINGS AND LOCAL DETAILS

J5. CLOSING ARRANGEMENTS

J6. CORROSION ADDITION AND STEEL RENEWAL

J1. APPLICATION AND DEFINITIONS

100. Application and definitions

101. These requirements apply to all bulk carriers, ore carriers and combination carriers and are for all cargo hatch covers and hatch forward and side coamings on exposed decks in position 1, as defined in ILLC.

102. The present Chapter J applies to ships contracted for construction on or after 1 January 2004.

103. This UR does not apply to CSR Bulk Carriers.

104. The strength requirements are applicable to hatch covers and hatch coamings of stiffened plate construction. The secondary stiffeners and primary supporting members of the hatch covers are to be continuous over the breadth and length of the hatch covers, as far as practical. When this is impractical, sniped end connections are not to be used and appropriate arrangements are to be adopted to provide sufficient load carrying capacity.

105. The spacing of primary supporting members parallel to the direction of secondary stiffeners is not to exceed 1/3 of the span of primary supporting members.

106. The secondary stiffeners of the hatch coamings are to be continuous over the breadth and length of the hatch coamings.

107. These requirements are in addition to the requirements of the ILLC.

108. The net minimum scantlings of hatch covers are to fulfill the strength criteria given in:

a. J3.300, for plating,

b. J3.400, for secondary stiffeners,

c. J3.500 for primary supporting members,

the critical buckling stress check in J3.600 and the rigidity criteria given in J3.700, adopting the load model given in J2.

109. The net minimum scantlings of hatch coamings are to fulfil the strength criteria given in:

a. J4.200, for plating,

b. J4.300, for secondary stiffeners,

c. J4.400, for coaming stays,

adopting the load model given in J4.100.

110. The net thicknesses, t_{net}, are the member thicknesses necessary to obtain the minimum net scantlings required by J3 and J4.

111. The required gross thicknesses are obtained by adding the corrosion additions, t_s, given in J6 to t_{net}.

112. Material for the hatch covers and coamings is to be steel according to the requirements for ship's hull.

J2. HATCH COVER LOAD MODEL

100. Hatch cover load model

101. The pressure p, in kN/m2, on the hatch covers panels is given by:

a. For ships of 100 m in length and above

$$p = 34{,}3 + \frac{pfp - 34{,}3}{0{,}25}\left(0{,}25 - \frac{x}{L}\right) \geq 34{,}3$$

for hatchways located at the freeboard deck, where：

p_{FP} = pressure at the forward perpendicular

= 49.1 + (L-100)*a

a = 0.0726 for type B freeboard ships
0.356 for ships with reduced freeboard

L = Freeboard length, in m, as defined in Regulation 3 of Annex I to the 1966 Load Line Convention as modified by the Protocol of 1988, to be taken not greater than 340 m
x = distance, in m, of the mid length of the hatch cover under examination from the forward end of L
Where a position 1 hatchway is located at least one superstructure standard height higher than the freeboard deck, the pressure p may be 34.3kN/m^2.

b. For ships less than 100 m in length

$$p = 15{,}8 + \frac{L}{3}\left(1 - \frac{5}{3}\frac{x}{L}\right) - 3{,}6\frac{x}{L} \geq 0{,}195L + 14{,}9$$

for hatchways located at the freeboard deck

Where two or more panels are connected by hinges, each individual panel is to be considered separately.

J3. HATCH COVER STRENGTH CRITERIA

100. Allowable stress checks

101. The normal and shear stresses σ and τ in the hatch cover structures are not to exceed the allowable values, σ_a and τ_a, in N/mm^2, given by:

$\sigma_a = 0{,}8\sigma_f$

$\tau_a = 0{,}46\sigma_f$

σ_F being the minimum upper yield stress, in N/mm2, of the material.

102. The normal stress in compression of the attached flange of primary supporting members is not to exceed 0.8 times the critical buckling stress of the structure according to the buckling check as given in J3.600.

103. The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members are to be determined by a grillage or a FE analysis.

104. When a beam or a grillage analysis is used, the secondary stiffeners are not to be included in the attached flange area of the primary members.

105. When calculating the stresses σ and τ, the net scantlings are to be used.

200. Effective cross-sectional area of panel flanges for primary supporting members

100. The effective flange area A_f, in cm^2, of the attached plating, to be considered for the yielding and buckling checks of primary supporting members, when calculated by means of a beam or grillage model, is

obtained as the sum of the effective flange areas of each side of the girder web as appropriate:

$$A_F = \frac{\Sigma}{nf}(10\, bef * t)$$

where:

n_f = 2 if attached plate flange extends on both sides of girder web
= 1 if attached plate flange extends on one side of girder web only

t = net thickness of considered attached plate, in mm

b_{ef} = effective breadth, in m, of attached plate flange on each side of girder web
= b_p, but not to be taken greater than 0.165ℓ

b_p = half distance, in m, between the considered primary supporting member and the adjacent one

ℓ = span, in m, of primary supporting members

300. Local net plate thickness

301. The local net plate thickness t, in mm, of the hatch cover top plating is not to be less than:

$$T = F_p 15,8s\sqrt{\frac{p}{0{,}95\sigma f}}$$

but to be not less than 1% of the spacing of the stiffener or 6 mm if that be greater.

where:

F_p = factor for combined membrane and bending response
= 1.50 in general

= 1.90 $\sigma/f\sigma_a$, for $\sigma/f\sigma_a \geq 0.8$, for the attached plate flange of primary supporting members

s = stiffener spacing, in m

p = pressure, in kN/m2, as defined in S21.2

σ = as defined in J3.500

σ_a = as defined in J3.101.

400. Net scantlings of secondary stiffeners

The required minimum section modulus, Z, in cm3, of secondary stiffeners of the hatch cover top plate, based on stiffener net member thickness, are given by:

$$Z = \frac{1000l^2sp}{12\sigma a}$$

where:

l= secondary stiffener span, in m, to be taken as the spacing, in m, of primary supporting members or the distance between a primary supporting member and the edge support, as applicable. When brackets are fitted at both ends of all secondary stiffener spans, the secondary stiffener span may be reduced by an amount equal to 2/3 of the minimum brackets arm length, but not greater than 10% of the gross span, for each bracket.

s = secondary stiffener spacing, in m

p = pressure, in kN/m^2, as defined in J2

σ_a = as defined in J3.100.

402. The net section modulus of the secondary stiffeners is to be determined based on an attached plate width assumed equal to the stiffener spacing.

500. Net scantlings of primary supporting members

501. The section modulus and web thickness of primary supporting members, based on member net thickness, are to be such that the normal stress σ in both flanges and the shear stress τ, in the web, do not exceed the allowable values σ_a and τ_a, respectively, defined in J3.100.

502. The breadth of the primary supporting member flange is to be not less than 40% of their depth for laterally unsupported spans greater than 3.0 m. Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

503. The flange outstand is not to exceed 15 times the flange thickness.

600. Critical buckling stress check

601**. Hatch cover plating**

a. The compressive stress σ in the hatch cover plate panels, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, is not to exceed 0.8 times the critical buckling stress σ_{C1}, to be evaluated as defined below:

$\sigma_{C1} = \sigma_{E1}$ when $\sigma_{E1} \leq \frac{\sigma F}{2}$

$\sigma_{C1} = \sigma_E\left[1 - \frac{\sigma f}{(4\sigma E1)}\right]$ when $\sigma_{E1} > \frac{\sigma F}{2}$

where:

σ_F = minimum upper yield stress, in N/mm2, of the material

$$\sigma E1 = 3{,}6E\left(\frac{t}{1000s}\right)^2$$

E = modulus of elasticity, in N/mm^2
= 2.06 x 105 for steel

t = net thickness, in mm, of plate panel

s = spacing, in m, of secondary stiffeners

b. The mean compressive stress σ in each of the hatch cover plate panels, induced by the bending of primary supporting members perpendicular to the direction of secondary stiffeners, is not to exceed 0.8 times the critical buckling stress σ_{C2}, to be evaluated as defined below:

$\sigma_{C2} = \sigma_{E2}$ when $\sigma_{E2} \leq \frac{\sigma F}{2}$

$\sigma_{C1} = \sigma_E\left[1 - \frac{\sigma f}{(4\sigma E2)}\right]$ when $\sigma_{E2} > \frac{\sigma F}{2}$

where:

σ_F = minimum upper yield stress, in N/mm², of the material

$$\sigma E2 = 0{,}9mE\left(\frac{t}{1000Ss}\right)^2$$

$$m = c\left[1 + \left(\frac{ss}{ls}\right)^2\right]^2 \frac{2.1}{\Psi + 1{,}1}$$

E = modulus of elasticity, in N/mm²
=2,06 x 10^5 for steel

t = net thickness, in mm, of plate panel

s_s = length, in m, of the shorter side of the plate panel

ls = length, in m, of the longer side of the plate panel

ψ = ratio between smallest and largest compressive stress

c = 1.3 when plating is stiffened by primary supporting members
c = 1.21 when plating is stiffened by secondary stiffeners of angle or T type

c = 1.1 when plating is stiffened by secondary stiffeners of bulb type

c = 1.05 when plating is stiffened by flat bar

c. The biaxial compressive stress in the hatch cover panels, when calculated by means of FEM shell element model, is to be in accordance with each classification society's rule as deemed equivalent to the above criteria.

602. **Hatch cover secondary stiffeners**

The compressive stress σ in the top flange of secondary stiffeners, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, is not to exceed 0.8 times the critical buckling stress σ_{CS}, to be evaluated as defined below:

$\sigma_{CS} = \sigma_{ES}$ when $\sigma_{ES} \leq \frac{\sigma F}{2}$

$\sigma_{CS} = \sigma_F\left[1 - \frac{\sigma f}{(4\sigma ES)}\right]$ when $\sigma_{ES} > \frac{\sigma F}{2}$

where:

σ_F = minimum upper yield stress, in N/mm2, of the material

σ_{ES} = ideal elastic buckling stress, in N/mm², of the secondary stiffener,
σ= minimum between σ_{E3} and σ_{E4}

$$\sigma E3 = \frac{0{,}001E * Ia}{A * l^2}e3$$

E = modulus of elasticity, in N/mm²
= 2,06 x 105 for steel

I_a = moment of inertia, in cm⁴, of the secondary stiffener, including a top flange equal to the spacing of secondary stiffeners

A = cross-sectional area, in cm², of the secondary stiffener, including a top flange equal to the spacing of secondary stiffeners .

l = span, in m, of the secondary stiffener

700. Torsional buckling mode

701. 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)²m²<K<=m²(m+1)²
m	1	2	3	m

I_t = St Vernant'smoment of inertia, in cm, of profile (without plate flange)

$$= \frac{hwtw^3}{3}10^4 \qquad for\ flat\ bars\ (slabs)$$

$= \frac{1}{3}\left[hwtw^3 + bftf^3\left(1 - 0.63\frac{tf}{bf}\right)\right]$ for flanged profiles

Ip = polar moment of inertia,in cm⁴, of profile about connection of stiffener to plate
$= \frac{hw^3tw}{3}10^{-4}$ 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

$= \frac{hw^3tw^3}{36}10^{-6}$ for flat bars (slabs)

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.

$= \frac{tfbf^3hw^2}{12}10^{-6}$ for "tee" profiles

$= b_f^{\,2}\, t_f^{\,2}/12(b_f+t_f)^2\, [t_f(b_f^2+2\, b_f h_w+4h_w^2)+3t_w\, b_f h_w]10^{-6}$

l= span of profile in m

s = spacing of profiles, in m

c = spring stiffness exerted by supporting plate p

$$= \frac{kpEtp^3}{\left(1+\frac{1.33kphwtp^3}{1000stw^3}\right)}10^{-3}$$

$$kp = 1 - \frac{1}{\eta p}$$ not to be taken less then zero

Tp = plate thickness, in mm, considering standard deductions as specified in S11.5.2.1.1

$$\eta p = \frac{\sigma a}{\sigma EP}$$

603. Web panels of hatch cover primary supporting members

a. This check is to be carried out for the web panels of primary supporting members, formed by web stiffeners or by the crossing with other primary supporting members, the face plate (or the bottom cover plate) or the attached top cover plate.

b. The shear stress τ in the hatch cover primary supporting members web panels is not to exceed 0.8 times the critical buckling stress τC, to be evaluated as defined below:

$\tau_C = \tau_E$ when $\tau_E = \leq \frac{\tau F}{2}$

$= \tau_F\left[1-\frac{\tau f}{(4\,\tau E)}\right]$ when $\tau_E > \frac{\sigma F}{2}$

where:
$\tau_F = \frac{\sigma F}{\sqrt{3}}$

$\tau_E = 0,9\, k_t E\left[\frac{t\,pr,n}{1000d}\right]^2$

E = modulus of elasticity, in N/mm^2
= 2.06 x 105 for steel

T pr,n = net thickness, in mm, of primary supporting member

$K\,t = 5,35 + \frac{4,0}{\left(\frac{a}{d}\right)^2}$

a = greater dimension, in m, of web panel of primary supporting member

d = smaller dimension, in m, of web panel of primary supporting member.

c. For primary supporting members parallel to the direction of secondary stiffeners, the actual dimensions of the panels are to be considered.

d. For primary supporting members perpendicular to the direction of secondary stiffeners or for hatch covers built without secondary stiffeners, a presumed square panel of dimension d is to be taken for the determination of the stress τ_C. In such a case, the average shear stress τ between the values calculated at the ends of this panel is to be considered.

700. Deflection limit and connections between hatch cover panels

701. Load bearing connections between the hatch cover panels are to be fitted with the purpose of restricting the relative vertical displacements.

702. The vertical deflection of primary supporting members is to be not more than 0.0056. ℓ, where ℓ is the greatest span of primary supporting members.

J4. HATCH COAMINGS AND LOCAL DETAILS

100. Load model

The pressure p_{coam}, in kN/m^2, on the No. 1 forward transverse hatch coaming is given by:

p_{coam} = 220, when a forecastle is fitted in accordance with UR S28
= 290 in the other cases

The pressure p_{coam}, in kN/m^2, on the other coamings is given by:

p_{coam} = 220

200. Local net plate thickness

The local net plate thickness t, in mm, of the hatch coaming plating is given by:

$$t = 14{,}9s\sqrt{\frac{p\,coam}{\sigma a,coam}} * Scoam$$

where:

s = secondary stiffener spacing, in m

p_{coam} = pressure, in kN/m2, as defined in J4.100

S_{coam} = safety factor to be taken equal to 1.15

$\sigma_{,coam}$ = 0.95 σ_F

The local net plate thickness is to be not less than 9.5 mm.

300. Net scantlings of longitudinal and transverse secondary stiffeners

The required section modulus Z, in cm3, of the longitudinal or transverse secondary stiffeners of the hatch coamings, based on net member thickness, is given by:

$$Z = \frac{1000Scoam\, l^2\, sp\, coam}{m * cp * \sigma a,coam}$$

where:

m = 16 in general
= 12 for the end spans of stiffeners sniped at the coaming corners

S_{coam} = safety factor to be taken equal to 1, 15

l = span, in m, of secondary stiffeners

s = spacing, in m, of secondary stiffeners

p_{coam} = pressure in kN/m^2 as defined in J4.100

c_p = ratio of the plastic section modulus to the elastic section modulus of the secondary stiffeners with an attached plate breadth, in mm, equal to 40 t, where t is the plate net thickness
= 1.16 in the absence of more precise evaluation

$\sigma_{a,coam}$ = 0.95 σ_F

400. Net scantlings of coaming stays

401. The required minimum section modulus, Z, in cm^3, and web thickness, t_w, in mm of coamings stays designed as beams with flange connected to the deck or sniped and fitted with a bracket (see Figures F.J4.401.1 and F.J4.401.2) at their connection with the deck, based on member net thickness,are given by:

$$Z = \frac{1000 * H^2 C * s * p\, coam}{2\sigma a,coam}$$

$$t_w = \frac{1000 * Hc * s * p\, coam}{h * \tau\, a,coam}$$

H_C = stay height, in m

s = stay spacing, in m

h = stay depth, in mm, at the connection with the deck

p_{coam} = pressure, in kN/m^2, as defined in J4.100

$\sigma_{a,coam}$ = 0.95 σ_F

$\tau_{a,coam}$ = 0.5 σ_F

FIGURE F.J4.401.1

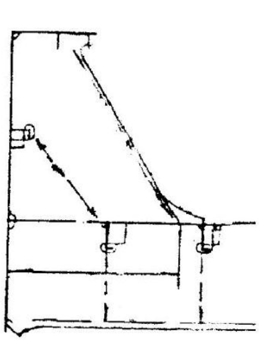
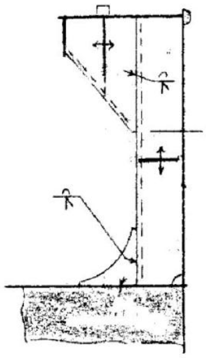


FIGURE F.J4.401.2



402. For calculating the section modulus of coaming stays, their face plate area is to be taken into account only when it is welded with full penetration welds to the deck plating and adequate underdeck structure is fitted to support the stresses transmitted by it.

403. For other designs of coaming stays, such as, for examples, those shown in Figures F.J4.403.1 and F.J4.403.2, the stress levels in J3.100 apply and are to be checked at the highest stressed locations.

FIGURE F.J4.403.1

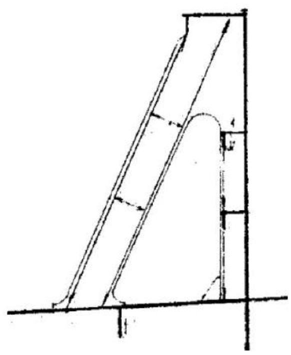
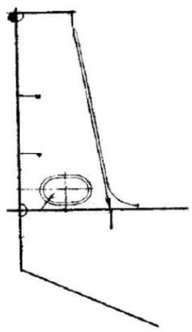


FIGURE F.J4.403.2



500. Local details

501. The design of local details is to comply with the Society requirement for the purpose of transferring the pressures on the hatch covers to the hatch coamings and, through them, to the deck structures below. Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

502. Underdeck structures are to be checked against the load transmitted by the stays, adopting the same allowable stresses specified in J4.400.

503. Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the Society requirements.

504. Double continuous welding is to be adopted for the connections of stay webs with deck plating and the weld throat is to be not less than 0.44 t_W, where t_W is the gross thickness of the stay web.

505. Toes of stay webs are to be connected to the deck plating with deep penetration double bevel welds extending over a distance not less than 15% of the stay width.

J5. CLOSING ARRANGEMENTS

100. Securing devices

101. The strength of securing devices is to comply with the following requirements:

102. Panel hatch covers are to be secured by appropriate devices (bolts, wedges or similar) suitably spaced alongside the coamings and between cover elements.

103. Arrangement and spacing are to be determined with due attention to the effectiveness for weather-tightness, depending upon the type and the size of the hatch cover, as well as on the stiffness of the cover edges between the securing devices.

104. The net sectional area of each securing device is not to be less than:

$A = 1{,}4\ a/f\ (cm^2)$

where:

a = spacing in m of securing devices, not being taken less than 2 m

$f = \left(\frac{\sigma}{235}\right)^{e}$

σ_Y = specified minimum upper yield stress in N/mm^2 of the steel used for fabrication, not to be taken greater than 70% of the ultimate tensile strength.

e = 0,75 for $\sigma y > 235$
e = 1 for $\sigma y \leq 235$

105. Rods or bolts are to have a net diameter not less than 19 mm for hatchways exceeding 5 m^2 in area.

106. Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weathertightness is to be maintained by the securing devices.

107. For packing line pressures exceeding 5 N/mm, the cross section area is to be increased in direct proportion. The packing line pressure is to be specified.

108. The cover edge stiffness is to be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia, I, of edge elements is not to be less than:

$I = 6 * p * a^4\ (cm^4)$

p = packing line pressure in N/mm, minimum 5 N/mm.

a = spacing in m of securing devices.

109. Securing devices are to be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

110. Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

111. Where hydraulic cleating is adopted, a positive means is to be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

200. Stoppers

201. Hatch covers are to be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 kN/m^2.

202. With the exclusion of No.1 hatch cover, hatch covers are to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 kN/m^2.

203. No. 1 hatch cover is to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 230 kN/m^2.

204. This pressure may be reduced to 175 kN/m^2 when a forecastle is fitted in accordance with Chapter PUR **[IACS RU S28]**.

The equivalent stress:

a. in stoppers and their supporting structures, and

b. calculated in the throat of the stopper welds

is not to exceed the allowable value of 0.8 σ_Y.

205. **Materials and welding**: stoppers or securing devices are to be manufactured of materials, including welding electrodes, meeting relevant RBNA requirements.

300. Corrosion addition and steel renewal

301. **Hatch covers: f**or all the structure (plating and secondary stiffeners) of single skin hatch covers, the corrosion addition t_s is to be 2.0 mm.

a. For double skin hatch covers, the corrosion addition is to be:

a.1. 2.0 mm for the top and bottom plating

a.2. 1.5 mm for the internal structures.

b. For single skin hatch covers and for the plating of double skin hatch covers, steel renewal is required where the gauged thickness is less than t_{net} + 0.5 mm. Where the gauged thickness is within the range t_{net} + 0.5 mm and t_{net} + 1.0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating is to be maintained in GOOD condition.

c. For the internal structure of double skin hatch covers, thickness gauging is required when plating renewal is to be carried out or when this is deemed necessary, at the discretion of the Society Surveyor, on the basis of the plating corrosion or deformation condition. In these cases, steel renewal for the internal structures is required where the gauged thickness is less than t_{net}.

302. **Hatch coamings:**

a. For the structure of hatch coamings and coaming stays, the corrosion addition t_s is to be 1.5 mm.

b. Steel renewal is required where the gauged thickness is less than t_{net} + 0.5 mm. Where the gauged thickness is within the range t_{net} + 0.5 mm and t_{net} + 1.0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating is to be maintained in GOOD condition.

J6. CARGO HATCH COVER SECURING ARRANGEMENTS FOR BULK CARRIERS NOT BUILT IN ACCORDANCE WITH UR S21 (REV.3) [IACS UR S30]

100. Application and Implementation

101. These requirements apply to all bulk carriers which were not built in accordance with UR S21(Rev.3) and are for steel hatch cover securing devices and stoppers for cargo hold hatchways No.1 and No.2 which are wholly or partially within 0.25L of the fore perpendicular, except pontoon type hatch cover.

102. All bulk carriers not built in accordance with UR S21 (Rev.3) are to comply with the requirements of this UR in accordance with the following schedule:

a. For ships which will be 15 years of age or more on 1 January 2004 by the due date of the first intermediate or special survey after that date;

b. For ships which will be 10 years of age or more on 1January 2004 by the due date of the first special survey after that date;

c. For ships which will be less than 10 years of age on 1 January 2004 by the date on which the ship reaches 10 years of age.

103. Completion prior to 1 January 2004 of an intermediate or special survey with a due date after 1 January 2004 cannot be used to postpone compliance. However, completion prior to 1 January 2004 of an intermediate survey the window for which straddles 1 January 2004 can be accepted.

200. Securing Devices

201. The strength of securing devices is to comply with the following requirements:

202. Panel hatch covers are to be secured by appropriate devices (bolts, wedges orsimilar) suitably spaced alongside the coamings and between cover elements. Arrangement and spacing are to be determined with due attention to the effectiveness for weather-tightness, depending upon the type and the size of the hatch cover, as well as on the stiffness of the cover edges between the securing devices.

203. The net sectional area of each securing device is not to be less than:

A = 1.4 a / f (cm2)

where:

a = spacing between securing devices not to be taken less than 2 meters

f = (Y / 235)e

Y = specified minimum upper yield stress in N/mm2 of the steel used for fabrication, not to be taken greater than 70% of the ultimate tensile strength.

e = 0.75 for _Y > 235
= 1.0 for _Y ≤ 235

Rods or bolts are to have a net diameter not less than 19 mm for hatchways exceeding 5 m2 in area.

204. Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weathertightness is to be maintained by the securing devices. For packing line pressures exceeding 5 N/mm, the cross section area is to be increased in direct proportion. The packing line pressure is to be specified.

205. The cover edge stiffness is to be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia, I, of edge elements is not to be less than:

I = 6 p a4 (cm4)

p = packing line pressure in N/mm, minimum 5 N/mm

a = spacing in m of securing devices.

206. Securing devices are to be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

207. Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

208. Where hydraulic cleating is adopted, a positive means is to be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

300. Stoppers

301. No. 1 and 2 hatch covers are to be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 kN/m2.

302. No. 2 hatch covers are to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 kN/m2.

303. No. 1 hatch cover is to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 230 kN/m2.
This pressure may be reduced to 175 kN/m2 if a forecastle is fitted.

304 The equivalent stress:

a. in stoppers and their supporting structures, and

b. calculated in the throat of the stopper welds is not to exceed the allowable value of 0.8 _Y.

400. Materials and Welding

401. Where stoppers or securing devices are fitted to comply with this Subchapter J6, they are to be manufactured of materials, including welding electrodes, meeting relevant RBNA requirements.

CHAPTER K
EVALUATION OF SCANTLINGS OF CORRUGATED TRANSVERSE WATERTIGHT BULKHEADS IN BULK CARRIERS CONSIDERING HOLD FLOODING
[IACS UR S18]

CHAPTER CONTENTS

K1. APPLICATION AND DEFINITIONS

K2 LOAD MODEL

K3. BENDING MOMENT AND SHEAR FORCE IN THE BULKHEAD CORRUGATIONS

K.4 STRENGTH CRITERIA

K5. LOCAL DETAILS, CORROSION ADDITION AND STEEL RENEWAL

K1. APPLICATION AND DEFINITIONS

100. Application and definitions

101. This sub chapter K1 is to be complied with in respect of the flooding of any cargo hold of bulk carriers, of 150 m in length and above, with single deck, topside tanks and hopper tanks, and of single side or double side skin construction, intending to carry solid bulk cargoes having a density of 1.0 t/m3, or above, with vertically corrugated transverse watertight bulkheads.

102. The net thickness t_{net} is the thickness obtained by applying the strength criteria given in Part II, Title 14, Section 2, sub chapter K4.

103. The required thickness is obtained by adding the corrosion addition t_s, given in Part II, Tiutle 14, Section 2, sub chapter K5 item 100, to the net thickness t_{net}.

104. In this requirement, homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, does not exceed 1.20, to be corrected for different cargo densities.

This Chapter K does not apply to CSR Bulk Carriers.

K2. LOAD MODEL

100. General

101. The loads to be considered as acting on the bulkheads are those given by the combination of the cargo loads with those induced by the flooding of one hold adjacent to the bulkhead under examination. In any case, the pressure due to the flooding water alone is to be considered.

102. The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of each bulkhead, depending on the loading conditions included in the loading manual:

a. homogeneous loading conditions;

b. non homogeneous loading conditions;

c. considering the individual flooding of both loaded and empty holds.

103. The specified design load limits for the cargo holds are to be represented by loading conditions defined by the Designer in the loading manual.

104. Non homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not to be considered according to these requirements.

105. Holds carrying packed cargoes are to be considered as empty holds for this application.

106. Unless the ship is intended to carry, in non homogeneous conditions, only iron ore or cargo having bulk density equal or greater than 1.78 t/m3, the maximum mass of cargo which may be carried in the hold shall also be considered to fill that hold up to the upper deck level ***at centreline***.

200. Bulkhead corrugation flooding head

201. The flooding head h_f (see Figure F.K2. 201.1) is the distance, in m, measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f, in m, from the baseline equal to:

a. in general:

Where the ship is to carry cargoes having bulk density less than 1.78 t/m3 in non homogeneous loading conditions, the following values can be assumed:

a.1. 0.95D for the foremost transverse corrugated bulkhead

a.2. 0.85D for the other bulkheads

b. for ships less than 50,000 tonnes deadweight with Type B freeboard:

b.1. 0.95D for the foremost transverse corrugated bulkhead

b.2. 0.85D for the other bulkheads

Where the ship is to carry cargoes having bulk density less than 1.78 t/m3 in non homogeneous loading conditions, the following values can be assumed:

b.4. 0.9D for the foremost transverse corrugated bulkhead

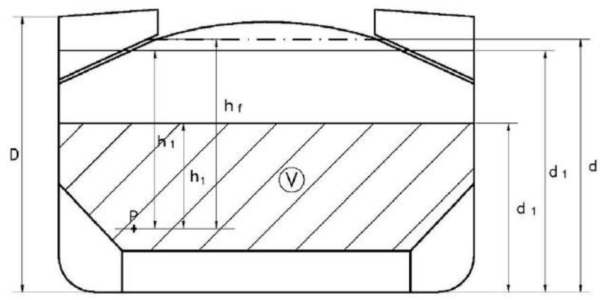
b.5. 0.8D for the other bulkheads

D being the distance, in m, from the baseline to the freeboard deck at side amidship (see Figure F.K2.201.1).

b.6. D for the foremost transverse corrugated bulkhead

b.7. 0.9D for the other bulkheads

FIGURE F.K2.201.1



V = Volume of cargo

P = Calculation point

300. Pressure in the non-flooded bulk cargo loaded holds

301. At each point of the bulkhead, the pressure pc, in kN/m2, is given by:

$P_c = \rho c * g * h1 * tan^2\gamma$

where:

ρ_c = bulk cargo density, in t/m3

g = 9.81 m/s2, gravity acceleration

h_1 = vertical distance, in m, from the calculation point to horizontal plane corresponding to the level height of the cargo (see Figure F.K2.201.1), located at a distance d_1, in m, from the baseline.

$\gamma = 45° - (\varphi/2)$

φ = angle of repose of the cargo, in degrees, that may generally be taken as 35° for iron ore and 25° for cement

302. The force Fc, in kN, acting on a corrugation is given by:

$$F_C = \rho c * g * s1\left(\frac{d1-hDB-hLS}{2}\right)^2 tan^2\gamma$$

where:
ρ_c, g, d1, γ = as given above
s_1 = spacing of corrugations, in m (see F.K2.301.1)

h_{LS} = mean height of the lower stool, in m, from the inner bottom

h_{DB} = height of the double bottom, in m

400. Pressure in the flooded holds:

401. **Bulk cargo holds:** Two cases are to be considered, depending on the values of d_1 and d_f.

a. **df ≥ d1**

a.1. At each point of the bulkhead located at a distance between d1 and df from the baseline, the pressure $p_{c,f}$, in kN/m2, is given by:

$P_{c,f} = \rho c * g * hf$

where:

ρ = sea water density, in t/m3

g = as given in K2.300

h_f = flooding head as defined in K2.200

a.2. At each point of the bulkhead located at a distance lower than d1 from the baseline, the pressure $p_{c,f}$, in kN/m2, is given by:

$P_c = \rho c * g * hf + [\rho c - \rho * (1 - perm) * g * h1 * tan^2\gamma$

where:

ρ, h_f = as given above

ρ_c, g, h_1, γ = as given in K2.300

perm = permeability of cargo, to be taken as 0.3 for ore (corresponding bulk cargo density for iron ore may generally be taken as 3.0 t/m3), coal cargoes and for cement (corresponding bulk cargo density for cement may generally be taken as 1.3 t/m3)

a.3. The force Fc,f, in kN, acting on a corrugation is given by:

$$F_{c,f} = s1 * \left[\rho c * g \frac{(df-d1)^2}{2} + \frac{\rho * g * (df-di) + (p\,c,f)le}{2} * (d1 - hDB - h\,ls)\right]$$

where:

ρ = as given above

s_1, g, d_1, h_{DB}, h_{LS} = as given in K2.300

d_f = as given in K2.200

$(p_{c,f})_{le}$ = pressure, in kN/m2, at the lower end of the corrugation

b. **df < d1**

b.1. At each point of the bulkhead located at a distance between df and d1 from the baseline, the pressure pc,f, in kN/m2, is given by:

$p\,c,f = \rho c * g * h1 * tan^2\gamma$

where:

ρ_c, g, h_1, γ = as given in K2.300

b.2. At each point of the bulkhead located at a distance lower than df from the baseline, the pressure pc,f, in kN/m2, is given by:

$P_c = \rho c * g * hf + [\rho c * h1 - \rho * (1 - perm) * hf] * g * tan^2\gamma$

where:

ρ, h_f, perm = as given in a) above

ρc, g, h1, γ = as given in K2.300

b.3. The force $F_{c,f}$, in kN, acting on a corrugation is given by:

$$F_{c,f}=s1*\left[\rho c*g\frac{(df-d1)^2}{2}+\frac{\rho*g*(df-di)+(p\ c,f)le}{2}*(d1-hDB-h\ ls)\right]$$

where:

s_1, ρ_c, g, d_1, γ, h_{DB}, h_{LS} = as given in K2.300

d_f = as given in K2.200

$(p_{c,f})_{le}$ = pressure, in kN/m2, at the lower end of the corrugation

402. **Pressure in empty holds due to flooding water alone**

At each point of the bulkhead, the hydrostatic pressure pf induced by the flooding head hf is to be considered.

The force Ff, in kN, acting on a corrugation is given by:

$$F_f = S_1*\rho*g*\frac{(df-h\ DB-hLS)^2}{2}$$

where:

s1, g, hDB, hLS = as given in K2.300

ρ = as given in K2.401 a)

df = as given in K2.200

500. Resultant pressure and force

501. **Homogeneous loading conditions**

At each point of the bulkhead structures, the resultant pressure p, in kN/m2, to be considered for the scantlings of the bulkhead is given by:

$$P = p_{c,f} - 0,8\ p_c$$

The resultant force F, in kN, acting on a corrugation is given by:

$$F = F_{c,f} - 0,8\ F_c$$

502. **Non homogeneous loading conditions**

At each point of the bulkhead structures, the resultant pressure p, in kN/m2, to be considered for the scantlings of the bulkhead is given by:

$$p = p_{c,f}$$

The resultant force F, in kN, acting on a corrugation is given by:

$$F = F_{c,f}$$

K3. BENDING MOMENT AND SHEAR FORCE IN THE BULKHEAD CORRUGATIONS

100. Bending moment

101. The bending moment M and the shear force Q in the bulkhead corrugations are obtained using the formulae given in K3.100 and K3.200. The M and Q values are to be used for the checks in K3.800.

102. The design bending moment M, in kNm, for the bulkhead corrugations is given by:

$$M = \frac{F*l}{8}$$

where:

F = resultant force, in kN, as given in K2.500

ℓ = span of the corrugation, in m, to be taken according to Figure F.K2.301.1A and F.K2.301.1B

FIGURE F.K2.301.1 - A

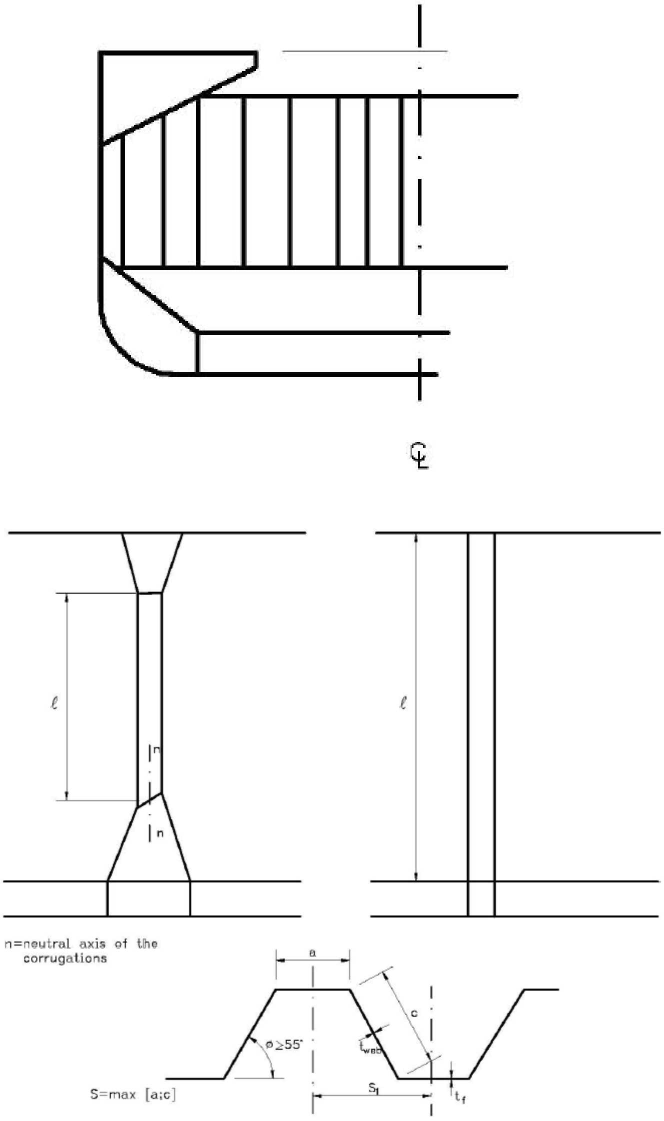
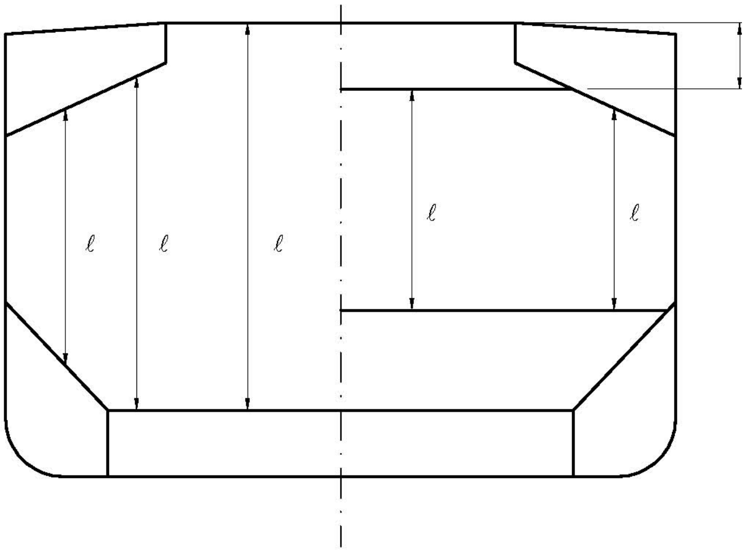


FIGURE F.K2.301-B



Note For the definition of ℓ, the internal end of the upper stool is not to be taken more than a distance from the deck at the centre line equal to:
- 3 times the depth of corrugations, in general
- 2 times the depth of corrugations, for rectangular stool

200. Shear force

201. The shear force Q, in kN, at the lower end of the bulkhead corrugations is given by:

*Q = 0,8*F*

where:

F = as given in K2.500

K4. STRENGTH CRITERIA

100. General

101. The following criteria are applicable to transverse bulkheads with vertical corrugations (see Figure F.K2.201.1). For ships of 190 m of length and above, these bulkheads are to be fitted with a lower stool, and generally with an upper stool below deck. For smaller ships, corrugations may extend from inner bottom to deck; if the stool is fitted, it is to comply with the requirements in K4.100.

102. The corrugation angle φ shown in Figure F.K2.301.1 is not to be less than 55°.

103. Requirements for local net plate thickness are given in K4.700

104. In addition, the criteria as given in K2.100 and K4.500 are to be complied with.

105. The thicknesses of the lower part of corrugations considered in the application of K4.500 and K4.600 are to be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than 0.15l.

106. The thicknesses of the middle part of corrugations as considered in the application of K4.500 and K4.700 are to be maintained to a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than 0.3l.

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

200. Lower stool

201. The height of the lower stool is generally to be not less than 3 times the depth of the corrugations. The thickness and material of the stool top plate is not to be less than those required for the bulkhead plating above.

The thickness and material of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top is not to be less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at lower end of corrugation. The thickness of the stool side plating and the section modulus of the stool side stiffeners is not to be less than those required by each Society on the basis of the load model in Chapter K2. The ends of stool side vertical stiffeners are to be attached to brackets at the upper and lower ends of the stool.

202. The distance from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with Figure F.K4.202.1. The stool bottom is to be installed in line with double bottom floors and is to have a width not less than 2.5 times the mean depth of the corrugation. The stool is to be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate are to be avoided.

203. Where corrugations are cut at the lower stool, corrugated bulkhead plating is to be connected to the stool top plate by full penetration welds. The stool side plating is to be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds (see F.K4.203.1). The supporting floors are to be connected to the inner bottom by either full penetration or deep penetration welds (see F.K4.203.1).

FIGURE F.K4.202.1 PERMITTED DISTANCE, D, FROM EDGE OF STOOL TOP PLATE TO SURFACE OF CORRUGATION FLANGE

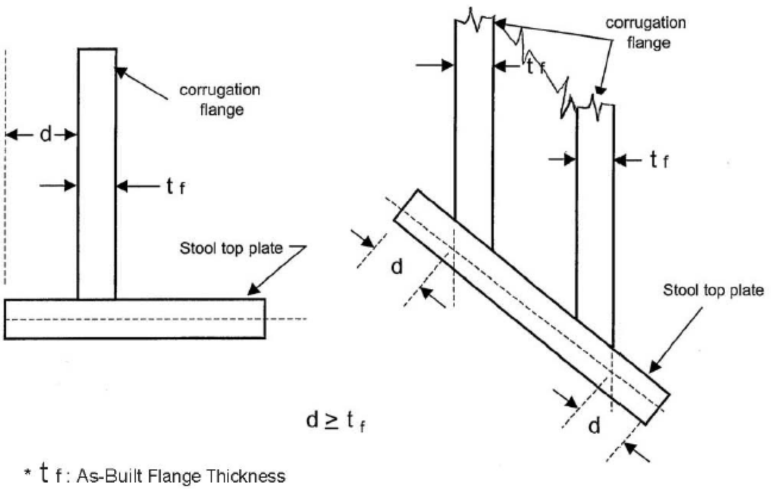
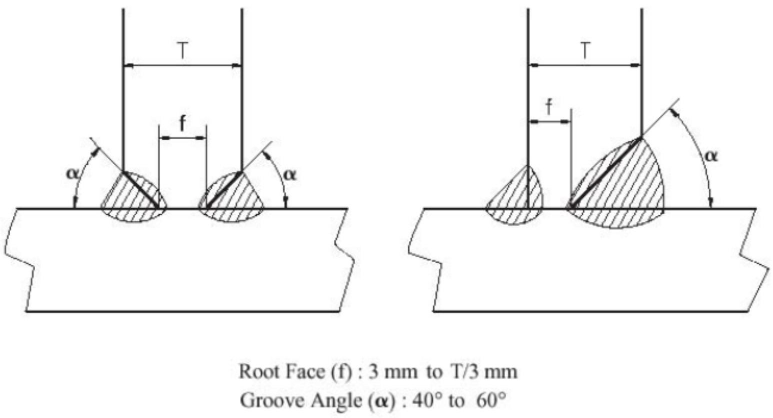


FIGURE F.K4.203.1 – AS BUILT FLANGE THICKNESS



300. Upper stool

301. The upper stool, where fitted, is to have a height generally between 2 and 3 times the depth of corrugations. Rectangular stools are to have a height generally equal to 2 times the depth of corrugations, measured from the deck level and at hatch side girder. The upper stool is to be properly supported by girders or deep brackets between the adjacent hatch-end beams.

302. The width of the stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non-rectangular stools is to have a width not less than 2 times the depth of corrugations. The thickness and material of the stool bottom plate are to be the same as those of the bulkhead plating below. The thickness of the lower portion of stool side plating is not to be less than 80% of that required for the upper part of the bulkhead plating where the same material is used. The thickness of the stool side plating and the section modulus of the stool side stiffeners is not to be less than those required by each Society on the basis of the load model in Chapter K2. The ends of stool side stiffeners are to be attached to brackets at upper and lower end of the stool. Diaphragms are to be fitted inside the stool in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

400. Alignment

401. At deck, if no stool is fitted, two transverse reinforced beams are to be fitted in line with the corrugation flanges.

402. At bottom, if no stool is fitted, the corrugation flanges are to be in line with the supporting floors.

403. Corrugated bulkhead plating is to be connected to the inner bottom plating by full penetration welds. The plating of supporting floors is to be connected to the inner bottom by either full penetration or deep penetration welds (see F.K4.203.1).

404. The thickness and material properties of the supporting floors are to be at least equal to those provided for the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinals to double bottom floors are to be closed by collar plates. The supporting floors are to be connected to each other by suitably designed shear plates, as deemed appropriate by the Classification Society.

4305. Stool side plating is to align with the corrugation flanges and stool side vertical stiffeners and their brackets in lower stool are to align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Stool side plating is not to be knuckled anywhere between the inner bottom plating and the stool top.

500. Bending capacity and shear stress τ

501. The bending capacity is to comply with the following relationship:

$$10^3 * \frac{M}{0,5*ZIE*\sigma\ a,ie + Zm*\sigma\ a,m} \leq 0,95$$

where:

M = bending moment, in kNm, as given in S18.3.1.

Z_{le} = section modulus of one half pitch corrugation, in cm^3, at the lower end of corrugations, to be calculated according to K4.600.

Z_m = section modulus of one half pitch corrugation, in cm^3, at the mid-span of corrugations, to be calculated according to K4.700.

$\sigma a_{,le}$ = allowable stress, in N/mm^2, as given in K4.800, for the lower end of corrugations

$\sigma_{a,m}$ = allowable stress, in N/mm^2, as given in K4.800, for the mid-span of corrugations

502. In no case Z_m is to be taken greater than the lesser of $1.15Z'_{le}$ and $1.15Z_{le}$ for calculation of the bending capacity, $Z'_{,le}$ being defined below.

503. In case shedders plates are fitted which:

a. are not knuckled;

b. are welded to the corrugations and the top of the lower stool by one side penetration welds or equivalent;

c. are fitted with a minimum slope of 45° and their lower edge is in line with the stool side plating;

d. have thicknesses not less than 75% of that provided by the corrugation flange;

e. and material properties at least equal to those provided by the flanges.

or gusset plates are fitted which:

f. are in combination with shedder plates having thickness, material properties and welded connections in accordance with the above requirements;

g. have a height not less than half of the flange width;

h. are fitted in line with the stool side plating;

i. are generally welded to the top of the lower stool by full penetration welds, and to the

j. corrugations and shedder plates by one side penetration welds or equivalent.

k. have thickness and material properties at least equal to those provided for the flanges.

the section modulus Zle, in cm3, is to be taken not larger than the value Z'le, in cm3, given by:

$$Z'_{ie} = Z_g + 10^3 \frac{Qhg - 0,5hg^2 * S1 * pg}{\sigma a}$$

where:

Z_g = section modulus of one half pitch corrugation, in cm3, of the corrugations calculated, according to K4.700, in way of the upper end of shedder or gusset plates, as applicable

Q = shear force, in kN, as given in K3.200

h_g = height, in m, of shedders or gusset plates, as applicable (see Figures F.K4.601.1A and F.K4.601.B, and F,.F2.601.2A and F.F2.601.2B)

s1 = as given in K2.300

p_g = resultant pressure, in kN/m^2, as defined in K2.500 calculated in way of the middle of the shedders or gusset plates, as applicable

σ_a = allowable stress, in N/mm^2, as given in.K4.800.

504. Stresses τ are obtained by dividing the shear force Q by the shear area. The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin φ), φ being the angle between the web and the flange.

505. When calculating the section modulus and the shear area, the net plate thicknesses are to be used.

506. The section modulus of corrugations are to be calculated on the basis of the following requirements given in K4.600 and K4.700.

600. Section modulus at the lower end of corrugations

601. The section modulus is to be calculated with the compression flange having an effective flange width, but, not larger than as given in K4.900.

602. If the corrugation webs are not supported by local brackets below the stool top (or below the inner bottom) in the lower part, the section modulus of the corrugations is to be calculated considering the corrugation webs 30% effective.

a. Provided that effective shedder plates, as defined in S18.4.2, are fitted (see F.K4.601.2A and F.K4.601.2B), when calculating the section modulus of corrugations at the lower end (cross-section 1 in see F.K4.601.2A and F.K4.601.2B), the area of flange plates, in cm2, may be increased by:

$$(2,5a\sqrt{tf * tsh}$$

(not to be taken greater than $2.5at_f$)

where:

a = width, in m, of the corrugation flange (see F.K2.301.1A)

t_{sh} = net shedder plate thickness, in mm

t_f = net flange thickness, in mm

FIGURE F.K4.601.1A

Symmetric shedder plates

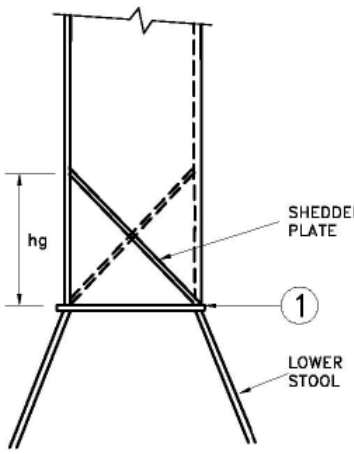


FIGURE F.K4.601.1B

Asymmetric shedder plates

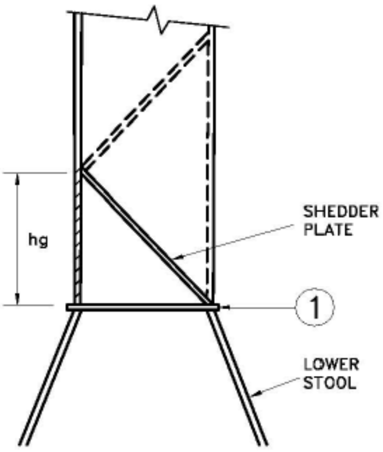


FIGURE F.K4.601.2A

Symmetric gusset / shedder plates

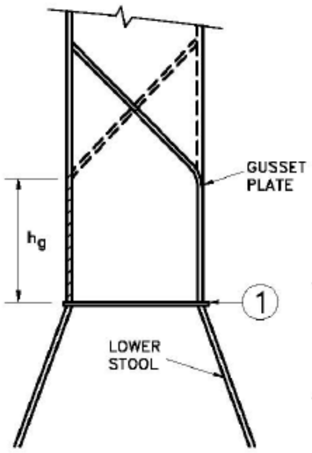
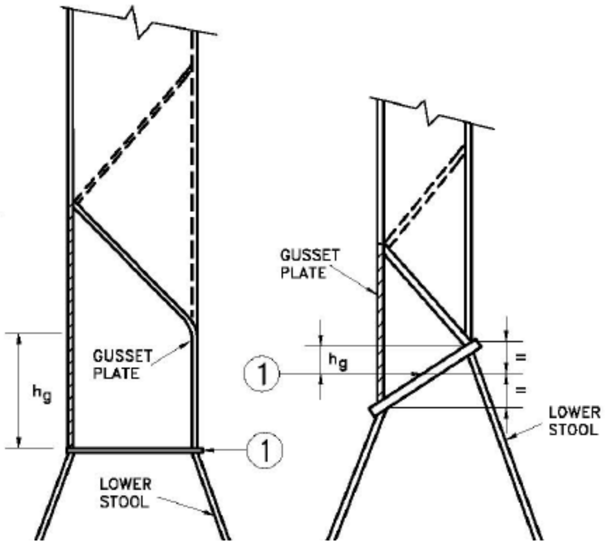


FIGURE F.K4.601.2B

Asymmetric gusset / shedder plates



b. Provided that effective gusset plates, as defined in K4.500, are fitted (see Figures F.K4.601.2A and F.K4.601.2B), when calculating the section modulus of corrugations at the lower end (crosssection 1 in F.K4.601.2A and F.K4.601.2B), the area of flange plates, in cm2, may be increased by (7*hgtf*) where:

h_g = height of gusset plate in m, see Figures 4a and 4b, not to be taken greater than

$$\left(\frac{20}{7}.Sgu\right)$$

s_{gu} = width of the gusset plates, in m

t_f = net flange thickness, in mm, based on the as built condition.

c. If the corrugation webs are welded to a sloping stool top plate which have an angle not less than 45º with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in b) above. No credit can be given to shedder plates only. For angles less than 45º, the effectiveness of the web may be obtained by linear interpolation between 30% for 0º and 100% for 45º.

700. Section modulus of corrugations at cross-sections other than the lower end

701. The section modulus is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, but, not larger than as given in K4.901.

800. Allowable stress check

801. The normal and shear stresses σ and τ are not to exceed the allowable values σa and τa, in N/mm2, given by:

$$\sigma a = \sigma F$$

$$Ta = 0{,}5 * \sigma F$$

σ_F = the minimum upper yield stress, in N/mm^2, of the material.

900. Effective compression flange width and shear buckling check

901. **Effective width of the compression flange of corrugations**

The effective width b_{ef}, in m, of the corrugation flange is given by:

$$bef = Ce * a$$

where:

$Ce = \frac{2{,}25}{\beta} - \frac{1{,}25}{\beta^2}$ for $\beta > 1{,}25$

$Ce = 1{,}0$ for $\beta \leq 1{,}25$

$$\beta = 10^3 . \frac{a}{tf}\sqrt{\frac{\sigma f}{E}}$$

t_f = net flange thickness, in mm

a = width, in m, of the corrugation flange (see Figure F.K2.301.1A)

σ_F = minimum upper yield stress, in N/mm^2, of the material

E = modulus of elasticity of the material, in N/mm2, to be assumed equal to 2.06 × 105 for steel

902. **Shear**

The buckling check is to be performed for the web plates at the corrugation ends.

The shear stress τ is not to exceed the critical value τc, in N/mm2 obtained by the following:

$\tau_C = \tau_E$ when $\tau E \leq \frac{\tau F}{2}$

$= \tau_E\left(1 - \frac{\sigma F}{4\tau E}\right)$

where

$$\tau F = \frac{\sigma F}{\sqrt{3}}$$

σ_F = minimum upper yield stress, in N/mm^2, of the material

$\tau_E = 0{,}9 * k_t * E * \left(\frac{t}{1000c}\right)^2$ (N/mm²)

k_t, E, t and c are given by:

$k_t = 6{,}34$

E = modulus of elasticity of material as given in K4.901

t = net thickness, in mm, of corrugation web

c = width, in m, of corrugation web (See F.K2.301.1A)

903. **Local net plate thickness**

The bulkhead local net plate thickness t, in mm, is given by:

$$T = 14{,}9 * S_w\sqrt{\frac{1{,}05p}{\sigma F}}$$

where:
s_w = plate width, in m, to be taken equal to the width of the corrugation flange or web, whichever is the greater (see Figure F.K2.301.1A)

p = resultant pressure, in kN/m^2, as defined in K2.500, at the bottom of each strake of plating; in all cases, the net thickness of the lowest strake is to be determined using the resultant pressure at the top of the lower stool, or at the inner bottom, if no lower stool is fitted or at the top of shedders, if shedder or gusset/shedder plates are fitted.

σ_F = minimum upper yield stress, in N/mm^2, of the material.

For built-up corrugation bulkheads, when the thicknesses of the flange and web are different, the net thickness of the narrower plating is to be not less than t_n, in mm, given by:

$$tn = 14{,}9 . Sn . \sqrt{\frac{1{,}05p}{\sigma F}}$$

s_n being the width, in m, of the narrower plating.

The net thickness of the wider plating, in mm, is not to be taken less than the maximum of the following

$$tw = 14{,}9.Sw.\sqrt{\frac{1{,}05p}{\sigma F}}$$

and

$$tw = \sqrt{\frac{440.Sw^2 1{,}05.p}{\sigma F} - tnp^2}$$

where t_{np} ≤ actual net thickness of the narrower plating and not to be greater than

$$14{,}9.Sw\sqrt{\frac{1{,}05.p}{\sigma F}}$$

K5. LOCAL DETAILS, CORROSION ADDITION AND STEEL RENEWAL

100. Local details

101. As applicable, the design of local details is to comply with the Society requirements for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures.

102. In particular, the thickness and stiffening of effective gusset and shedder plates, as defined in K4.600, is to comply with the Society requirements, on the basis of the load model in Chapter K2.

200. Corrosion addition and steel renewal

201. The corrosion addition t_s is to be taken equal to 3.5 mm.

202. Steel renewal is required where the gauged thickness is less than t_{net} + 0.5 mm.

203. Where the gauged thickness is within the range t_{net} + 0.5 mm and t_{net} + 1.0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal.

CHAPTER L
EVALUATION OF SCANTLINGS OF THE TRANSVERSE WATERTIGHT CORRUGATED BULKHEAD BETWEEN CARGO HOLDS NOS. 1 AND 2, WITH CARGO HOLD NO. 1 FLOODED, FOR EXISTING BULK CARRIERS
[IACS UR S19]

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L1. APPLICATION AND DEFINITIONS

100. Applications and definitions

101. These requirements apply to all bulk carriers of 150 m in length and above, in the foremost hold, intending to carry solid bulk cargoes having a density of 1,78 t/m3, or above, with single deck, topside tanks and hopper tanks, fitted with vertically corrugated transverse watertight bulkheads between cargo holds No. 1 and 2 where:

a. the foremost hold is bounded by the side shell only for ships which were contracted for construction prior to 1 July 1998, and have not been constructed in compliance with Part II, Title 14, Section 2, Chapter K,

b. the foremost hold is double side skin construction of less than 760 mm breadth measured perpendicular to the side shell in ships, the keels of which were laid, or which were at a similar stage of construction, before 1 July 1999 and have not been constructed in compliance with Part II, Title 14, Section 2, Chapter K.

102. The net scantlings of the transverse bulkhead between cargo holds Nos. 1 and 2 are to be calculated using the loads given in Chapter L2, the bending moment and shear force given in Chapter L3 and the strength criteria given in Chapter L4.

103. Where necessary, steel renewal and/or reinforcements are required as per Chapter I6.

L2. LOAD MODEL

100. General

101. The loads to be considered as acting on the bulkhead are those given by the combination of the cargo loads with those induced by the flooding of cargo hold No.1.

102. The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of the bulkhead, depending on the loading conditions included in the loading manual:

a. homogeneous loading conditions;

b. non homogeneous loading conditions.

103. Non homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not to be considered according to these requirements.

200. Bulkhead corrugation flooding head

201. The flooding head h_f (see figure F.L2.201.1) is the distance, in m, measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f, in m, from the baseline equal to:

a. in general:

D

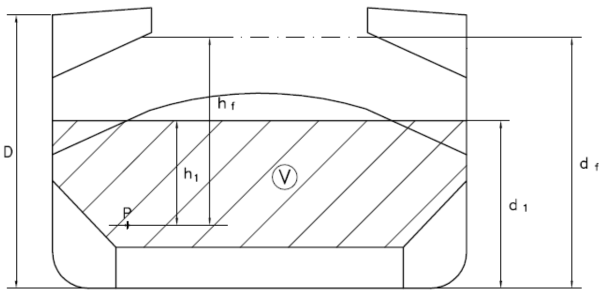
b. for ships less than 50,000 tonnes deadweight with Type B freeboard:

0,95 D

D being the distance, in m, from the baseline to the freeboard deck at side amidship (see Figure F.L2.201.1).

c. for ships to be operated at an assigned load line draught T_r less than the permissible load line draught T, the flooding head defined in a) and b) above may be reduced by T - T_r.

FIGURE F.L2.201.1



V = Volume of cargo

P = Calculation point

300. Pressure in the flooded hold

301. **Bulk cargo loaded hold**

Two cases are to be considered, depending on the values of d_1 and d_f, d_1 (see Figure F.L2.201.1) being a distance from the baseline given, in m, by:

$$d_1 = \frac{Mc}{\rho c * Ic * B} + \frac{Vls}{Ic * B} + (hHT - hDB) * \frac{bHT}{B} + hDB$$

where:

M_c = mass of cargo, in tonnes, in hold No. 1

ρ_c = bulk cargo density, in t/m3

l_c = length of hold No. 1, in m

B = ship's breadth amidship, in m

v_{LS} = volume, in m3, of the bottom stool above the inner bottom

h_{HT} = height of the hopper tanks amidship, in m, from the baseline

h_{DB} = height of the double bottom, in m
b_{HT} = breadth of the hopper tanks amidship, in m.

a. $d_f \geq d_1$

At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure pc,f, in kN/m2, is given by:

$p_{c,f} = \rho . g . h_f$

where:

ρ = sea water density, in t/m3

g = 9,81 m/s2, gravity acceleration

h_f = flooding head as defined in L4.200.

At each point of the bulkhead located at a distance lower than d1 from the baseline, the pressure $p_{c,f,}$ in kN/m^2, is given by:

$$P\ c,f = \rho.g.h_f + [\rho_c\text{-}\rho.(1\text{-}p_{erm})].g.h_1.\tan^2\Upsilon$$

where:

ρ, g, h_f = as given above

ρ_c = bulk cargo density, in t/m3

perm = permeability of cargo, to be taken as 0,3 for ore (corresponding bulk cargo density for iron ore may generally be taken as 3,0 t/m3),

h_1 = vertical distance, in m, from the calculation point to a level located at a distance d1, as defined above, from the base line (see Figure 1)

γ = 48° -(_/2)

Ǿ = angle of repose of the cargo, in degrees, and may generally be taken as 35° for iron ore.

The force $F_{c,f}$, in kN, acting on a corrugation is given by:

$$F_{c,f}=s1*\left[\rho*g\frac{(df-d1)^2}{2}+\frac{\rho*g*(df-di)+(p\ c,f)le}{2}*(d1-hDB-h\ ls)\right]$$

where:

s_1 = spacing of corrugations, in m (see Figure F.L4.101.1A)

ρ, g, d_1, h_{DB} = as given above

d_f = as given in L2.200

$(p_{c,f})_{le}$ = pressure, in kN/m^2, at the lower end of the corrugation

h_{LS} = height of the lower stool, in m, from the inner bottom.

FIGURE F.L4.101.1A

Figure 2a

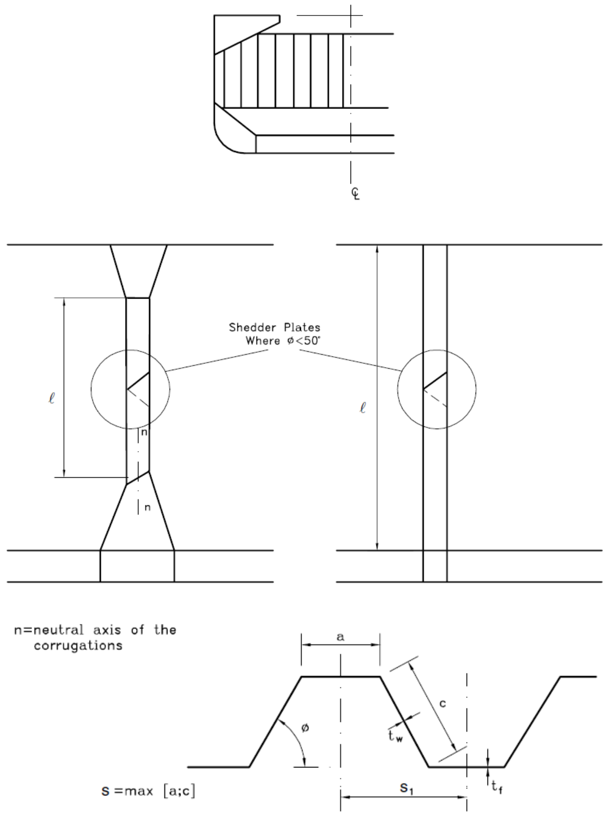
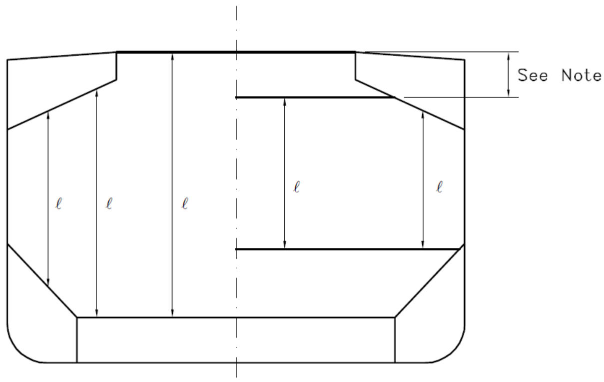


FIGURE F.L4.101.1B

Figure 2b



Note: For the definition of l, the internal end of the upper stool is not to be taken more than a distance from the deck at the centre line equal to:

a. 3 times the depth of corrugations, in general

b. 2 times the depth of corrugations, for rectangular stool

302. **Empty hold**

At each point of the bulkhead, the hydrostatic pressure p_f induced by the flooding head h_f is to be considered.

The force Ff, in kN, acting on a corrugation is given by:

$F_t = s_1.\rho.g.\frac{(df-hDB-hLS)^2}{2}$

where:

s_1, ρ, g, h_{LS} = as given in L2.301.a)

h_{DB} = as given in L2.301

d_f = as given in L2.200.

400. Pressure in the non-flooded bulk cargo loaded hold

401. At each point of the bulkhead, the pressure pc, in kN/m2, is given by:

$P_c = \rho_c.g.h_1.\tan^2\Upsilon$

where:

ρ_c, g, h_1, γ = as given in L2.301.a)

The force Fc, in kN, acting on a corrugation is given by:

$FC = \rho_{C.}g.s_1.\frac{(d1-hDB-hLS)^2}{2}.tan^2\gamma$

where:

ρ_c, g, s_1, h_{LS}, γ = as given in L2.301.a)

d_1, h_{DB} = as given in L2.301

500. Resultant pressure

501. **Homogeneous loading conditions**

At each point of the bulkhead structures, the resultant pressure p, in kN/m2, to be considered for the scantlings of the bulkhead is given by:

$p = p_{c,f}-0,8.p_c$

The resultant force F, in kN, acting on a corrugation is given by:

$F = F_{c,f} – 0,8.F_c$

502. **Non homogeneous loading conditions**

At each point of the bulkhead structures, the resultant pressure p, in kN/m^2, to be considered for the scantlings of the bulkhead is given by:

$p = p_{c,f}$

The resultant force F, in kN, acting on a corrugation is given by:

F = Fc,f

In case hold No.1, in non homogeneous loading conditions, is not allowed to be loaded, the resultant pressure p, in kN/m2, to be considered for the scantlings of the bulkhead is given by:

$p = p_{c,f}$

and the resultant force F, in kN, acting on a corrugation is given by:

$F = F_{c,f}$

L3. BENDING MOMENT AND SHEAR FORCE IN THE BULKHEAD CORRUGATIONS

100. Bending moment and shear force

101. The bending moment M and the shear force Q in the bulkhead corrugations are obtained using the formulae given in L3.100 and L3.200. The M and Q values are to be used for the checks in sub-chapter L4.

102. **Bending moment** The design bending moment M, in kN·m, for the bulkhead corrugations is given by:

$$M = F.\frac{l}{8}$$

where:

F = resultant force, in kN, as given in L2.500

l = span of the corrugation, in m, to be taken according to Figures F.L4.101.1A and F.L4.101.1B.

103. **Shear force**: The shear force Q, in kN, at the lower end of the bulkhead corrugations is given by:

Q = 0,8.F

where:

F = as given in L2.500.

L4. STRENGTH CRITERIA

100. General

101. The following criteria are applicable to transverse bulkheads with vertical corrugations (see Figure F.L4.101.1A).

102. Requirements for local net plate thickness are given in L4.700.

103. In addition, the criteria given in L4.200 and L4.500 are to be complied with.

105. Where the corrugation angle Ǿ shown in Figure F.L4.101.1A if less than 50°, an horizontal row of staggered shedder plates is to be fitted at approximately mid depth of the corrugations (see Figure F.L4.101.1A) to help preserve dimensional stability of the bulkhead under flooding loads. The shedder plates are to be welded to the corrugations by double continuous welding, but they are not to be welded to the side shell.

105. The thicknesses of the middle part of corrugations considered in the application of L4.200 and L4.400 are to be maintained to a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than 0,3·l.

106. The thicknesses of the lower part of corrugations considered in the application of L5.200 and L4.300 are to be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than 0,15·l.

200. Bending capacity and shear stress τ

201. The bending capacity is to comply with the following relationship:

$$10^3 * \frac{M}{0{,}5 * Zie * \sigma\ a{,}ie + Zm * \sigma\ a{,}m} \leq 1{,}0$$

where:

M = bending moment, in kN·m, as given in L3.100.

Z_{le} = section modulus of one half pitch corrugation, in cm^3, at the lower end of corrugations, to be calculated according to L4.300.

Z_m = section modulus of one half pitch corrugation, in cm3, at the mid-span of corrugations, to be calculated according to L4.4004.

$\sigma_{a,le}$ = allowable stress, in N/mm^2, as given in L4.500 for the lower end of corrugations

$\sigma_{a,m}$ = allowable stress, in N/mm^2, as given in L4.500, for the mid-span of corrugations.

202. In no case Z_m is to be taken greater than the lesser of $1{,}15 \cdot Z_{le}$.and $1{,}15 \cdot Z'_{le}$ for calculation of the bending capacity, Z'_{le} being defined below.

203. In case effective shedders plates are fitted which:

a. are not knuckled;

b. are welded to the corrugations and the top of the lower stool by one side penetration welds or equivalent;

or effective gusset plates are fitted which:

c. are fitted in line with the stool side plating;

d. have material properties at least equal to those provided for the flanges,

the section modulus Z_{le}, in cm^3, is to be taken not larger than the value Z'_{le}, in cm^3, given by:

$$Z'io = Zg + 10^3 . \frac{Q.hg - 0{,}5.h^2 g.S1.pg}{\sigma a}$$

where:

Z_g = section modulus of one half pitch corrugation, in cm^3, according to L3.400 in way of the upper end of shedder or gusset plates, as applicable

Q = shear force, in kN, as given in L3.103

h_g = height, in m, of shedders or gusset plates, as applicable (see Figures F.L4.203.1A, F.L4.203.1B, F.L4.203.2A, and F.L4.203.2B)

s_1 = as given in L2.301.a.

p_g = resultant pressure, in kN/m2, as defined in S19.2.5, calculated in way of the middle of the shedders or gusset plates, as applicable

σ_a = allowable stress, in N/mm^2, as given in L4.500.

204. Stresses τ are obtained by dividing the shear force Q by the shear area. The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin ǿ), ǿ being the angle between the web and the flange.

205. When calculating the section moduli and the shear area, the net plate thicknesses are to be used.

206. The section moduli of corrugations are to be calculated on the basis of the requirements given in L4.300 and L4.400.

FIGURE F.L4.203.1A

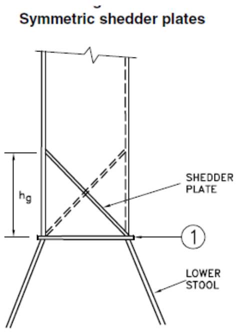


FIGURE F.L4.203.1B

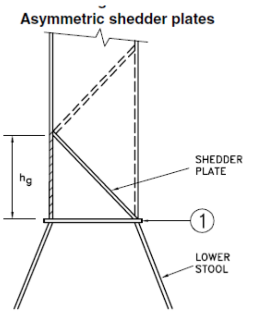


FIGURE F.L4.203.2A

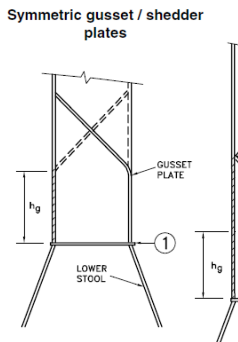
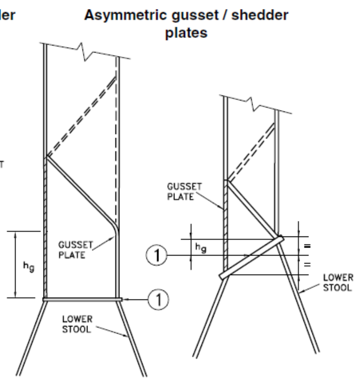


FIGURE F.L4.203.2B



300. Section modulus at the lower end of corrugations

301. The section modulus is to be calculated with the compression flange having an effective flange width, b_{ef}, not larger than as given in L4.601.1.

If the corrugation webs are not supported by local brackets below the stool top (or below the inner bottom) in the lower part, the section modulus of the corrugations is to be calculated considering the corrugation webs 30% effective.

a. Provided that effective shedder plates, as defined in L4.200, are fitted (see Figures F.L4.203.1A and F.L4.203.1B), when calculating the section modulus of corrugations at the lower end (cross-section 1 in Figures F.L4.203.1A and F.L4.203.1B), the area of flange plates, in cm^2, may be increased by:

$$(2,5*a*\sqrt{tf.tsh}\ \sqrt{\frac{\sigma FSH}{\sigma fl}}$$

(not to be taken greater than $2,5*a*t_f$) where:

a = width, in m, of the corrugation flange (see Figure F.L4.201.1A)

t_{sh} = net shedder plate thickness, in mm

t_f = net flange thickness, in mm

σ_{Fsh} = minimum upper yield stress, in N/mm2, of the material used for the shedder plates

σ_{Ffl} = minimum upper yield stress, in N/mm2, of the material used for the corrugation flanges.

b. Provided that effective gusset plates, as defined in L4.200, are fitted (see Figures F.L4.203.2A and F.L4.203.2B), when calculating the section modulus of corrugations at the lower end (cross-section 1 in Figures F.L4.203.2A and F.L4.203.2B), the area of flange plates, in cm^2, may be increased by

$(7*h_g*t_{gu})$

where:

h_g = height of gusset plate in m, see Figures F.L4.203.2A and F.L4.203.2B, not to be taken greater than :

$$\left(\frac{10}{7}.Sgu\right)$$

s_{gu} = width of the gusset plates, in m

tgu = net gusset plate thickness, in mm, not to be taken greater than t_f

t_f = net flange thickness, in mm, based on the as built condition.

c. If the corrugation webs are welded to a sloping stool top plate, which is at an angle not less than 45º with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in b) above. No credit can be given to shedder plates only.

For angles less than 45º, the effectiveness of the web may be obtained by linear interpolation between 30% for 0º and 100% for 45º.

400. Section modulus of corrugations at cross-sections other than the lower end

401. The section modulus is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{ef}, not larger than as given in L4.601.

500. Allowable stress check

501. The normal and shear stresses σ and τ are not to exceed the allowable values σ_a and τ_a, in N/mm^2, given by:
σa = σF

τa = 0,5.σF

σ_F = minimum upper yield stress, in N/mm^2, of the material.

600. Effective compression flange width and shear buckling check

601. **Effective width of the compression flange of corrugations**

The effective width b_{ef}, in m, of the corrugation flange is given by:

$b_{ef} = C_{e.a}$

where:

$Ce = \frac{2,25}{\beta} - \frac{1,25}{\beta^2}$ for $\beta > 1,25$

$Ce = 1$ for $\beta \leq 1,25$

$\beta = 10^3 . \frac{a}{tf}\sqrt{\frac{\sigma f}{E}}$

t_f = net flange thickness, in mm

a = width, in m, of the corrugation flange (see Figure F.L4.203.1A)

σ_F = minimum upper yield stress, in N/mm^2, of the material

E = modulus of elasticity, in N/mm2, to be assumed equal to 2,06•105 N/mm2 for steel

602. **Shear**

The buckling check is to be performed for the web plates at the corrugation ends.

The shear stress τ is not to exceed the critical value τ_c, in N/mm^2 obtained by the following:

$\tau_C = \tau_E$ when $\tau E \leq \frac{\tau F}{2}$

$\tau_C = \tau_E\left(1 - \frac{\tau F}{4\tau E}\right)$ when $\tau E > \frac{\tau F}{2}$

$\tau_F = \frac{\sigma F}{\sqrt{3}}$

σ_F = minimum upper yield stress, in N/mm^2, of the material

$\tau E = 0,9.k_t E\left(\frac{t}{1000c}\right)^2$ (N/mm²)

k_t, E, t and c are given by:

$k_t = 6,34$

E = modulus of elasticity of material as given in L4.601

t = net thickness, in mm, of corrugation web

c = width, in m, of corrugation web (See Figure F.L4.203.1A)

700. Local net plate thickness

701. The bulkhead local net plate thickness t, in mm, is given by:

$t = 14,9.s_w.\sqrt{\frac{p}{\sigma F}}$

where:

s_w = plate width, in m, to be taken equal to the width of the corrugation flange or web, whichever is the greater (see Figure F.L4.203.1A)

p = resultant pressure, in kN/m^2, as defined in L2.500, at the bottom of each strake of plating; in all cases, the net thickness of the lowest strake is to be determined using the resultant pressure at the top of the lower stool, or at the inner bottom, if no lower stool is fitted or at the top of shedders, if shedder or gusset/shedder plates are fitted.

σ_F = minimum upper yield stress, in N/mm^2, of the material.

702. For built-up corrugation bulkheads, when the thicknesses of the flange and web are different, the net thickness of the narrower plating is to be not less than t_n, in mm, given by:

$t = 14,9.s_n.\sqrt{\frac{p}{\sigma F}}$

s_n being the width, in m, of the narrower plating.

703. The net thickness of the wider plating, in mm, is not to be taken less than the maximum of the following values:

$t = 14,9.s_w.\sqrt{\frac{p}{\sigma F}}$

$tw = \sqrt{\frac{440.s^2w*p-t^2np}{\sigma f}}$

where $t_{np} \leq$ actual net thickness of the narrower plating and not to be greater than:

$t = 14,9.s_w.\sqrt{\frac{p}{\sigma F}}$

L5. LOCAL DETAILS

100. Local Details

101. As applicable, the design of local details is to comply with the Society's requirements for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures.

102. In particular, the thickness and stiffening of gusset and shedder plates, installed for strengthening purposes, is to comply with the Society's requirements, on the basis of the load model in sub chapter L2.

103. Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the Society's requirements.

L6. CORROSION ADDITION AND STEEL RENEWAL

100. Corrosion addition and steel renewal

101. Renewal/reinforcement shall be done in accordance with the following requirements and the guidelines contained in sub chapter I7.

a. Steel renewal is required where the gauged thickness is less than t_{net} + 0,5 mm, t_{net} being the thickness used for the calculation of bending capacity and shear stresses as given in L4.200. or the local net plate thickness as given in L4.700. Alternatively, reinforcing doubling strips may be used providing the net thickness is not dictated by shear strength requirements for web plates (see L4.500 and L4.600) or by local pressure requirements for web and flange plates (see L4.7007). Where the gauged thickness is within the range t_{net} + 0,5 mm and t_{net} + 1,0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal.

b. Where steel renewal or reinforcement is required, a minimum thickness of t_{net} + 2,5 mm is to be replenished for the renewed or reinforced parts.

c. When:

$$0{,}8.(\sigma fl.tfl) \geq \Sigma f_s.t_{st}$$

where:

σ_{Ffl} = minimum upper yield stress, in N/mm^2, of the material used for the corrugation flanges

σ_{Fs} = minimum upper yield stress, in N/mm^2, of the material used for the lower stool side plating or floors (if no stool is fitted)

t_{fl} = flange thickness, in mm, which is found to be acceptable on the basis of the criteria specified in a) above or, when steel renewal is required, the replenished thickness according to the criteria specified in b) above. The above flange thickness dictated by local pressure requirements (see L4.700) need not be considered for this purpose

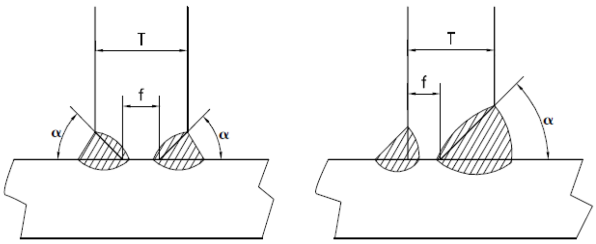
t_{st} = as built thickness, in mm, of the lower stool side plating or floors (if no stool is fitted) gussets with shedder plates, extending from the lower end of corrugations up to 0,1·l, or reinforcing doubling strips (on bulkhead corrugations and stool side plating) are to be fitted.

102. If gusset plates are fitted, the material of such gusset plates is to be the same as that of the corrugation flanges. The gusset plates are to be connected to the lower stool shelf plate or inner bottom (if no lower stool is fitted) by deep penetration welds (see Figure F.I6.101.1).

a. Where steel renewal is required, the bulkhead connections to the lower stool shelf plate or inner bottom (if no stool is fitted) are to be at least made by deep penetration welds (see Figure F.I6.101.1).

b. Where gusset plates are to be fitted or renewed, their connections with the corrugations and the lower stool shelf plate or inner bottom (if no stool is fitted) are to be at least made by deep penetration welds (see Figure F.I6.101.).

FIGURE F.L6.101.1



Root Face (f) : 3 mm to T/3 mm
Groove Angle (α) : 40° to 60°

L7. GUIDANCE ON RENEWAL/ REINFORCEMENT OF VERTICALLY CORRUGATED TRANSVESE WATERTIGHT BULKHEAD BETWEEN CARGO HOLDS No. 1 AND No. 2

100. Guidance on renewal/reinforcement of vertically corrugated transverse watertight bulkhead between cargo holds Nos. 1 and 2

101. The need for renewal or reinforcement of the vertically corrugated transverse watertight bulkhead between cargo holds Nos. 1 and 2 will be determined by the classification society on a case by case basis using the

criteria given in Chapter L in association with the most recent gaugings and findings from survey.

102. In addition to class requirements, the Chapter L assessment of the transverse corrugated bulkhead will take into account the following:-

a. Scantlings of individual vertical corrugations will be assessed for reinforcement/renewal based on thickness measurements obtained in accordance with Part I, Title 02, Section 2 sub chapter F7 at their lower end, at mid-depth and in way of plate thickness changes in the lower 70%. These considerations will take into account the provision of gussets and shedder plates and the benefits they offer, provided that they comply with L4.200 and L4.6006.

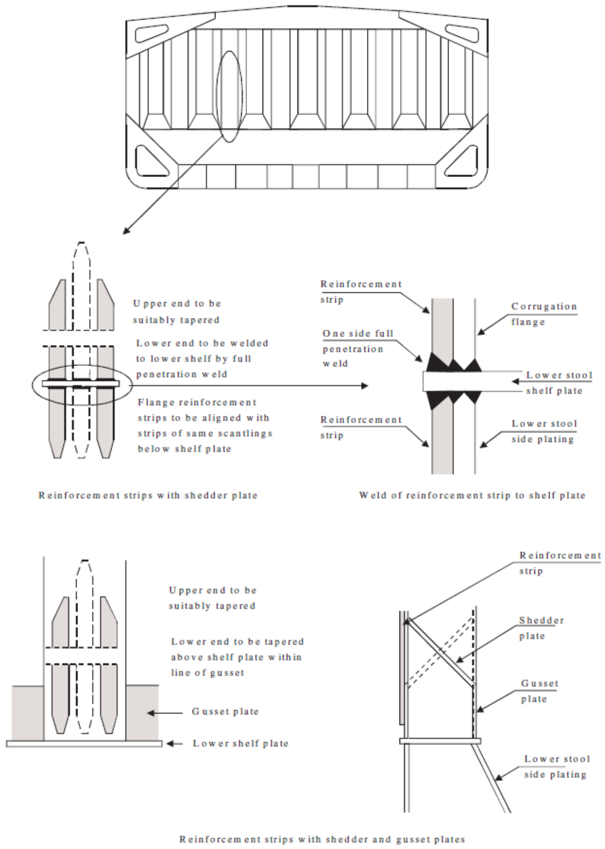
103. Where renewal is required, the extent of renewal is to be shown clearly in plans. The vertical distance of each renewal zone is to be determined by considering Chapter L and in general is to be not less than 15% of the vertical distance between the upper and lower end of the corrugation measured at the ship's centreline.

104. Where the reinforcement is accepted by adding strips, the length of the reinforcing strips is to be sufficient to allow it to extend over the whole depth of the diminished plating. In general, the width and thickness of strips should be sufficient to comply with the Chapter L requirements. The material of the strips is to be the same as that of the corrugation plating. The strips are to be attached to the existing bulkhead plating by continuous fillet welds. The strips are to be suitably tapered or connected at ends in accordance with Class Society practice.

105. Where reinforcing strips are connected to the inner bottom or lower stool shelf plates, one side full penetration welding is to be used. When reinforcing strips are fitted to the corrugation flange and are connected to the lower stool shelf plate, they are normally to be aligned with strips of the same scantlings welded to the stool side plating and having a minimum length equal to the breadth of the corrugation flange.

106. Figure F.L7.106.1 gives a general arrangement of structural reinforcement.

FIGURE F.L7.106.1



Notes to Figure f.l7.106.1 on reinforcement:-

1. Square or trapezoidal corrugations are to be reinforced with plate strips fitted to each corrugation flange sufficient to meet the requirements of Chapter L.

2. The number of strips fitted to each corrugation flange is to be sufficient to meet the requirements of Chapter L.

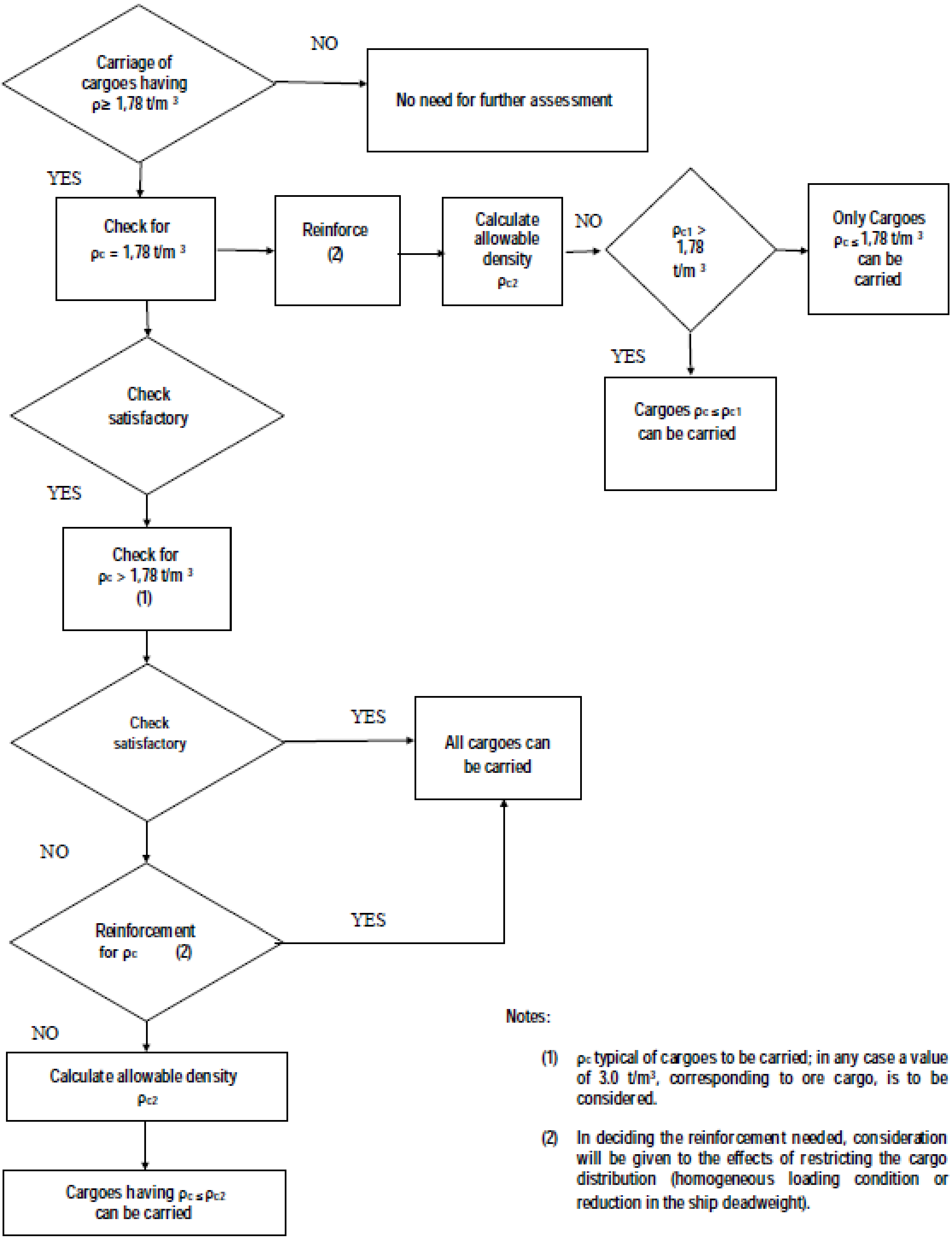
3. The shedder plate may be fitted in one piece or prefabricated with a welded knuckle (gusset plate).

4. Gusset plates, where fitted, are to be welded to the shelf plate in line with the flange of the corrugation, to reduce the stress concentrations at the corrugation corners. Ensure good alignment between gusset plate, corrugation flange and lower stool sloping plate. Use deep penetration welding at all connections. Ensure start and stop of welding is as far away as practically possible from corners of corrugation.
5. Shedder plates are to be attached by one side full penetration welds onto backing bars.

6. Shedder and gusset plates are to have a thickness equal to or greater than the original bulkhead thickness. Gusset plate is to have a minimum height (on the vertical part) equal to half of the width of the corrugation flange. Shedders and gussets are to be same material as flange material.

L8. GUIDANCE TO ASSESS CAPABILITY OF CARRIAGE OF HIGH DENSITY CARGOES ON EXISTING BULK CARRIERS ACCORDING TO THE STRENGTH OF TRANSVERSE BULKEAD BETWEEN CARGO HOLDS No. 1 AND No.

FIGURE F.A1.401.1 - FLOW CHART TO ASSESS THE CAPABILITY OF CARRIAGE OF HIGH DENSITY CARGOES ON EXISTING BULK CARRIERS



Notes:

(1) ρ_c typical of cargoes to be carried; in any case a value of 3.0 t/m³, corresponding to ore cargo, is to be considered.

(2) In deciding the reinforcement needed, consideration will be given to the effects of restricting the cargo distribution (homogeneous loading condition or reduction in the ship deadweight).

CHAPTER M
EVALUATION OF ALLOWWABLE HOLD LOADING FOR BULK CARRIERS CONSIDERING HOLD FLOODING
[IACS UR S20]

CHAPTER CONTENTS

M1. APPLICATION AND DEFINITIONS

M2. INNER BOTTOM FLOODING HEAD

M3. SHEAR CAPACITY OF THE DOUBLE BOTTOM

M4. ALLOWABLE HOLD LOADING

M1. APPLICATION AND DEFINITIONS

100. Application and definitions

101. Chapter M of this Title 14 is to be complied with in respect of the flooding of any cargo hold of bulk carriers of 150m in length and above, with single deck, topside tanks and hopper tanks, and of single side or double side skin construction, intending to carry solid bulk cargoes having a density 1.0 t/m3, or above.

102. The present Chapter M of this Title 14 is to be applied to ships contracted for construction on or after 1 July 2006.

103. The loading in each hold is not to exceed the allowable hold loading in flooded condition, calculated as per sub chapter M4, using the loads given in sub chapter M2 and the shear capacity of the double bottom given in sub chapter M3.

104. In no case is the allowable hold loading, considering flooding, to be greater than the design hold loading in the intact condition.

105. This Chapter M does not apply to CSR Bulk Carriers

M2. LOADING MODEL

100. General

101. The loads to be considered as acting on the double bottom are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of the hold which the double bottom belongs to.

102. The most severe combinations of cargo induced loads and flooding loads are to be used, depending on the loading conditions included in the loading manual:

a. homogeneous loading conditions;

b. non homogeneous loading conditions;

c. packed cargo conditions (such as steel mill products).

103. For each loading condition, the maximum bulk cargo density to be carried is to be considered
in calculating the allowable hold loading limit.

200. Inner bottom flooding head

201. The flooding head h_f (see Figure F.M2;201.1) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance d_f, in m, from the baseline equal to

a. in general:

a.1. D for the foremost hold

a.2. 0.9D for the other holds

b. b. for ships less than 50,000 tonnes deadweight with Type B freeboard:

b.1. 0.95D for the foremost hold

D being the distance, in m, from the baseline to the freeboard deck at side amidship (see Figure F.M2;201.1).

M3. SHEAR CAPACITY OF THE DOUBLE BOTTOM

100. Shear capacity of the double bottom

101. The shear capacity C of the double bottom is defined as the sum of the shear strength at each end of:

a. all floors adjacent to both hoppers, less one half of the strength of the two floors adjacent to each stool, or transverse bulkhead if no stool is fitted (see Figure F.M3.101.1).

b. all double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

102. Where in the end holds, girders or floors run out and are not directly attached to the boundary stool or hopper girder, their strength is to be evaluated for the one end only.

103. Note that the floors and girders to be considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom are not to be included.

104. When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, to the Society's discretion, the shear capacity C of double bottom is to be calculated according to the Society's criteria.

105. In calculating the shear strength, the net thickness of floors and girders is to be used. The net thickness t_{net}, in mm, is given by:

$T_{net} = t – 2,5$

where:

t = thickness, in mm, of floors and girders.

200. Floor shear strength

201. The floor shear strength in way of the floor panel adjacent to hoppers S_{f1}, in kN, and the floor shear strength in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2}, in kN, are given by the following expressions:

$S_{f1} = 10^{-3} Af.\frac{\tau a}{\eta 1}$

$S_{f2} = 10^{-3} Af,h.\frac{\tau a}{\eta 2}$

where:

A_f = sectional area, in mm^2, of the floor panel adjacent to hoppers

$A_{f,h}$ = net sectional area, in mm2, of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper)

τ_a = allowable shear stress, in N/mm^2, to be taken equal to the lesser of

$\tau_a = \frac{162*\sigma F^{0,6}}{(\frac{s}{tnet})^{0,8}}$ and $\frac{\sigma}{\sqrt{3}}$

202. For floors adjacent to the stools or transverse bulkheads as identified in M3, τ_a may be taken as:

$$\frac{\sigma F}{\sqrt{3}}$$

σ_F = minimum upper yield stress, in N/mm^2, of the material
s = spacing of stiffening members, in mm, of panel under consideration
η_1 = 1.10

η_2 = 1.20

η_2 may be reduced, to the Society's discretion, down to 1.10 where appropriate reinforcements are fitted to the Society's satisfaction.

300. Girder shear strength

301. The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g1}, in kN, and the girder shear strength in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2}, in kN, are given by the following expressions:

$S_{g1} = 10^{-3}.Ag.\frac{\tau a}{\eta 1}$

$S_{g2} = 10^{-3}.Ag,h.\frac{\tau a}{\eta 2}$

A_g = minimum sectional area, in mm2, of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted)

$A_{g,h}$ = net sectional area, in mm^2, of the girder panel in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted)

τ_a = allowable shear stress, in N/mm2, as given in M3.200

η_1 = 1.10

η_2 = 1.15

η_2 may be reduced, to the Society's discretion, down to 1.10 where appropriate reinforcements are fitted to the Society's satisfaction

M4. ALLOWABLE HOLD LOADING

100. Allowable hold loading

101. The allowable hold loading W, in tonnes, is given by:

$W = \rho c.V.\frac{1}{F}$

where:

F = 1.1 in general 1.05 for steel mill products
ρ_c = cargo density, in t/m3; for bulk cargoes see S20.2.1; for steel products, ρc is to be taken as the density of steel

V = volume, in m3, occupied by cargo at a level h_1

$h_1 = \frac{X}{\rho c*g}$

X = *for bulk cargoes* the lesser of X_1 and X_2 given by:

$X_1 = \frac{Z+\rho*g(E-hf)}{1+\frac{\rho}{\rho c}(perm-1)}$

$X_2 = Z + \rho g(E - hf * perm)$

X = for steel products, X may be taken as X1, using perm = 0

ρ = sea water density, in t/m3

g = 9.81 m/s2, gravity acceleration

E = ship immersion in m for flooded hold condition = df – 0.1D

df,D = as given in M2.200

hf = flooding head, in m, as defined in M2.200

perm = cargo permeability, (i.e. the ratio between the voids within the cargo mass and the volume occupied by the cargo); it needs not be taken greater than 0.3.

Z = the lesser of Z_1 and Z_2 given by:

$Z_1 = C_h / A_{DB,h}$

$Z_2 = C_e / A_{DB,e}$

C_h = shear capacity of the double bottom, in kN, as defined in M3, considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (see M3.2001) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see M3.300)

C_e = shear capacity of the double bottom, in kN, as defined in M3, considering, for each floor, the shear strength S_{f1} (see M3.200) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see M3.300)

$A_{DB,h} = \sum_{i=1}^{i=n} Si{*}B_{DB,i}$

$A_{DB,e} = \sum_{i=1}^{i=n} (BDB - S1)$

n = number of floors between stools (or transverse bulkheads, if no stool is fitted)

S_i = space of i^{th}-floor, in m

$B_{DB,i} = (B_{DB} – s_1)$ for floors whose shear strength is given by S_{f1} (see M3.200)

$B_{DB,i} = B_{DB,h}$ for floors whose shear strength is given by S_{f2} (see M3.200)

B_{DB} = breadth of double bottom, in m, between hoppers (see Figure F.M4.101.1)

$B_{DB,h}$ = distance, in m, between the two considered opening (see Figure F.M4.101.)

s_1 = spacing, in m, of double bottom longitudinals adjacent to hoppers

FIGURE F.M2.202.1

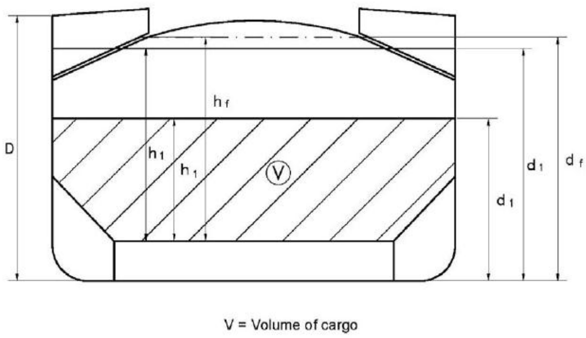


FIGURE F.M3.101.1

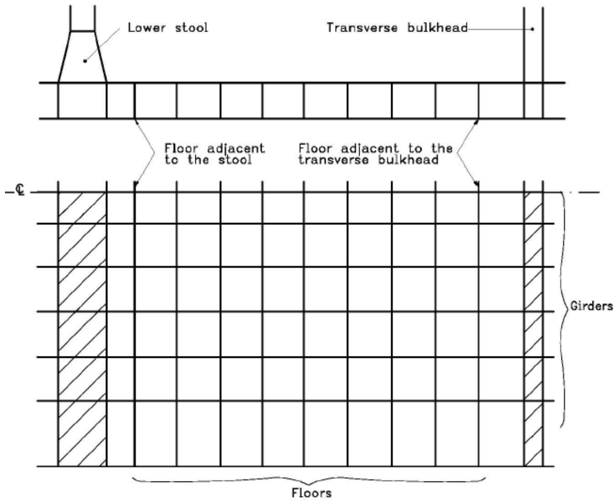
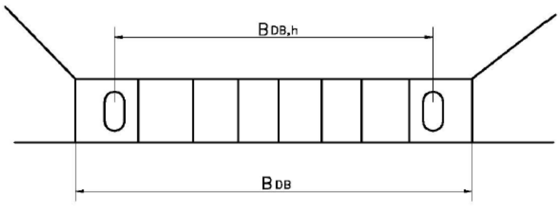


FIGURE F.M4.101.1



CHAPTER N
EVALUATION OF ALLOWABLE HOLD LOADING OF CARGO HOLD No. 1 WITH CARTGO HOLD No. 1 FLOODED, FOR EXISTING BULK CARRIERS [IACS UR S22]

CHAPTER CONTENTS

N1. APPLICATION AND DEVINITIONS

N2. LOADING MODEL

N3. SHEAR CAPACITY OF THE DOUBLE BOTTOM OF HOLD NO. 1

N1. APPLICATION AND DEFINITIONS

100. Application and definitions

101. These requirements apply to all bulk carriers of 150 m in length and above, in the foremost hold, intending to carry solid bulk cargoes having a density of 1,78 t/m3, or above, with single deck, topside tanks and hopper tanks, where:

a. the foremost hold is bounded by the side shell only for ships which were contracted for construction prior to 1 July 1998, and have not been constructed in compliance with Title 14, Chapter M,

b. the foremost hold is double side skin construction less than 760 mm breadth measured perpendicular to the side shell in ships, the keels of which were laid, or which were at a similar stage of construction, before 1 July 1999 and have not been constructed in compliance with IACS Unified Requirement S20 (Rev. 2, Sept. 2000).

102. Early completion of a special survey coming due after 1 July 1998 to postpone compliance is not allowed.

103. The loading in cargo hold No. 1 is not to exceed the allowable hold loading in the flooded condition, calculated as per N3.400, using the loads given in N2 and the shear capacity of the double bottom given in N3.

104. In no case, the allowable hold loading in flooding condition is to be taken greater than the design hold loading in intact condition.

N2. LOADING MODEL

100. General

101. The loads to be considered as acting on the double bottom of hold No. 1 are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of hold No. 1.

102. The most severe combinations of cargo induced loads and flooding loads are to be used, depending on the loading conditions included in the loading manual:

a. homogeneous loading conditions;

b. non homogeneous loading conditions;

c. packed cargo conditions (such as steel mill products).

103. For each loading condition, the maximum bulk cargo density to be carried is to be considered in calculating the allowable hold limit.

200. Inner bottom flooding head

201. The flooding head h_f (see Figure F.N2.201.1) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance df, in m, from the baseline equal to:

a. D in general

b. 0.9D for the other holds

D being the distance, in m, from the baseline to the freeboard deck at side amidship (see Figure F.N2.201.).

N3. SHEAR CAPACITY OF THE DOUBLE BOTTOM OF HOLD NO. 1

100. Shear capacity of the double bottom of hold no. 1

101. The shear capacity C of the double bottom of hold no. 1 is defined as the sum of the shear strength at each end of:

a. all floors adjacent to both hoppers, less one half of the strength of the two floors adjacent to each stool, or transverse bulkhead if no stool is fitted (see Figure F.N3.101.1).

b. all double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

102. The strength of girders or floors which run out and are not directly attached to the boundary stool or hopper girder is to be evaluated for the one end only.

103. Note that the floors and girders to be considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom are not to be included.

104. When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, to the Society's discretion, the shear capacity C of double bottom is to be calculated according to the Society's criteria.

105. In calculating the shear strength, the net thickness of floors and girders is to be used. The net thickness t_{net}, in mm, is given by:

$t_{net} = t - t_c$

where:

t = thickness, in mm, of floors and girders.

t_c = corrosion diminution, equal to 2 mm, in general; a lower value of tc may be adopted, provided that measures are taken, to the Society' s satisfaction, to justify the assumption made.

200. Floor shear strength

The floor shear strength in way of the floor panel adjacent to hoppers S_{f1}, in kN, and the floor shear strength in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2}, in kN, are given by the following expressions:

$S_{f1} = 10^{-3} Af . \frac{\tau a}{\eta 1}$

$S_{f2} = 10^{-3} Af, h . \frac{\tau a}{\eta 2}$

where:

A_f = sectional area, in mm^2, of the floor panel adjacent to hoppers

$A_{f,h}$ = net sectional area, in mm2, of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper)

τ_a = allowable shear stress, in N/mm2, to be taken equal to

$$\frac{\sigma F}{\sqrt{3}}$$

σ_F = minimum upper yield stress, in N/mm^2, of the material

$\eta_1 = 1.10$

$\eta_2 = 1.20$

η_2 may be reduced, to the Society's discretion, down to 1.10 where appropriate reinforcements are fitted to the Society's satisfaction

300. Girder shear strength

301. The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g1}, in kN, and the girder shear strength in way of the largest opening in the outermost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2}, in kN, are given by the following expressions:

$S_{g1} = 10^{-3} Ag . \frac{\tau a}{\eta 1}$

$S_{g2} = 10^{-3} Ag, h . \frac{\tau a}{\eta 2}$

where:

A_g = minimum sectional area, in mm^2, of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted)

$A_{g,h}$ = net sectional area, in mm^2, of the girder panel in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted)

τ_a = allowable shear stress, in N/mm2, as given in S20.3.1

$\eta_1 = 1.10$

$\eta_2 = 1.25$

η_2 may be reduced, to the Society's discretion, down to 1.10 where appropriate reinforcements are fitted to the Society's satisfaction

400. Allowable hold loading

401. The allowable hold loading W, in tonnes, is given by:

$W = \rho_c . V . \frac{1}{F}$

where:

F = 1,05 in general
1,00 for steel mill products

ρ_c = cargo density, in t/m^3; for bulk cargoes see N2.100; for steel products, ρ_c is to be taken as the density of steel

V = volume, in m^3, occupied by cargo at a level h_1

$h_1 = \frac{X}{\rho c . g}$

X = for bulk cargoes the lesser of X_1 and X_2 given by:

$X_1 = \frac{Z + \rho * g(E - hf)}{1 + \frac{\rho}{\rho c}(perm - 1)}$

$X_2 = Z + \rho * g(E - hf * perm)$

X = for steel products, X may be taken as X_1, using

perm = 0

ρ = sea water density, in t/m^3

g = 9.81 m/s^2, gravity acceleration

$E = d_f – 0.1D$

d_f,D = as given in N2.200

hf = flooding head, in m, as defined in S20.2.2

perm = cargo permeability, to be taken greater as 0.3 for ore (corresponding bulk cargo density may generally be taken as 4,0 t/m^3).

Z = the lesser of Z_1 and Z_2 given by:

$Z_1 = \frac{Ch}{ADB,e}$

$Z_2 = \frac{Ce}{ADB,e}$

C_h = shear capacity of the double bottom, in kN, as defined in N3, considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (see N3.200) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see N3.300)

C_e = shear capacity of the double bottom, in kN, considering, for each floor, the shear strength S_{f1} (see N3.200) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see N3.300)

$A_{DB,h} = \sum_{i=1}^{i=n} Si.BDB,i$

$A_{DB,e} = \sum_{i=1}^{i=n} Si.BDB - s$

n = number of floors between stools (or transverse bulkheads, if no stool is fitted)

Si = space of ith-floor, in m

$B_{DB,i} = B_{DB-s}$ for floors whose shear strength is given by S_{f1} (see N3.200)

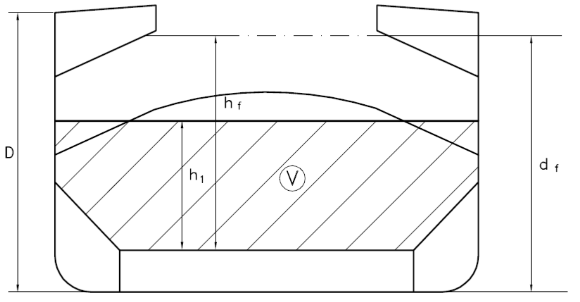
$B_{DB,i} = B_{DB,h}$ for floors whose shear strength is given by Sf2 (see N3.200)

B_{DB} = breadth of double bottom, in m, between hoppers (see Figure F.N3.401.1)

$B_{DB,h}$ = distance, in m, between the two considered opening (see Figure F.N3.401.1)

s = spacing, in m, of double bottom longitudinals adjacent to hoppers

FIGURE F.N2.201.1



V = Volume of cargo

FIGURE F.N3.301.1

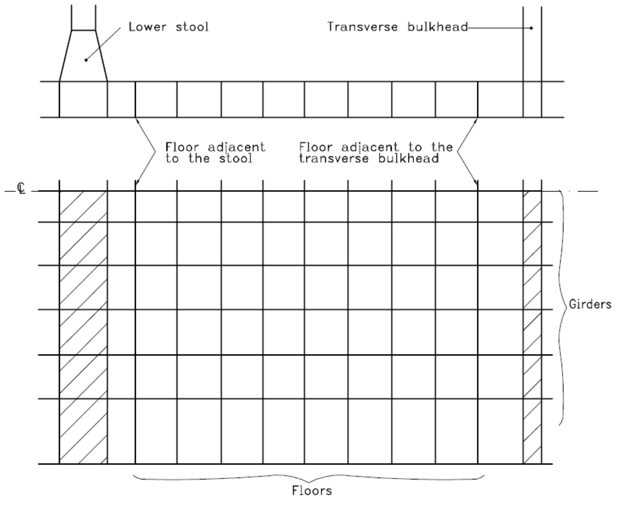
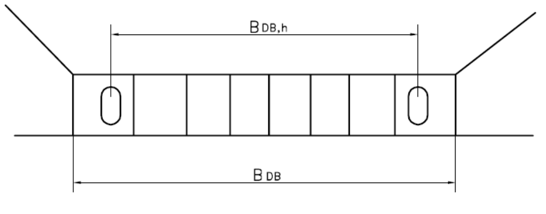


FIGURE F.N3.401.1



CHAPTER O
RENEWAL CRITERIA FOR SIDE SHELL FRAMES AND BRACKETS IN SINGLE SIDE SKIN BULK CARRIERS AND SINGLE SIDE SKIN OBO CARRIERS NOT BUILT IN ACCORDANCE WITH UR S12 (PART II, TITLE 14, SECTION 2 F1)
[IACS UR S31]

CHAPTER CONTENTS

O1. APPLICATION AND DEFINITIOS

O2. RENEWAL OR OTHER MEASURES

O3. STRENGTH CHECK CRITERIA

O1. APPLICATION AND DEFINITIOS

100. Application and definitions

101. These requirements apply to the side shell frames and brackets of cargo holds bounded by the single side shell of bulk carriers constructed with single deck, topside tanks and hopper tanks in cargo spaces intended primarily to carry dry cargo in bulk, which were not built in accordance with Part II, Title 14, Section 2 F1 (UR S12 Rev. 1 or subsequent revisions).

102. In addition, these requirements also apply to the side shell frames and brackets of cargo holds bounded by the single side shell of Oil/Bulk/Ore(OBO) carriers, but of single side skin construction.

103. In the case a vessel as defined above does not satisfy above definition in one or more holds, the requirements in the present Chapter O do not apply to these individual holds.

104. For the purpose of this Chapter O, “ships” means both “bulk carriers” and “OBO carriers” as defined above, unless otherwise specified.

105**.** **Bulk Carriers** subject to these requirements are to be assessed for compliance with the requirements of this Chapter O and steel renewal, reinforcement or coating, where required in accordance with this Chapter O, is to be carried out in accordance with the following schedule and at subsequent intermediate and special surveys.

a. For bulk carriers which will be 15 years of age or more on 1 January 2004 by the due date of the first intermediate or special survey after that date;

b. For bulk carriers which will be 10 years of age or more on 1 January 2004 by the due date of the first special survey after that date;

c. For bulk carriers which will be less than 10 years of age on 1 January 2004 by the date on which the ship reaches 10 years of age.

106. Completion prior to 1 January 2004 of an intermediate or special survey with a due date after 1 January 2004 cannot be used to postpone compliance. However, completion prior to 1 January 2004 of an intermediate survey the window for which straddles 1 January 2004 can be accepted.

107. **OBO carriers** subject to these requirements are to be assessed for compliance with the requirements of this UR and steel renewal, reinforcement or coating, where required in accordance with this UR, is to be carried out in accordance with the following schedule and at subsequent intermediate and special surveys.

a. For OBO carriers which will be 15 years of age or more on 1 July 2005 by the due date of the first intermediate or special survey after that date;

b. For OBO carriers which will be 10 years of age or more on 1 July 2005 by the due date of the first special survey after that date;

c. For OBO carriers which will be less than 10 years of age on 1 July 2005 by the date on which the ship reaches 10 years of age.

108. Completion prior to 1 July 2005 of an intermediate or special survey with a due date after 1 July 2005 cannot be used to postpone compliance. However, completion prior to 1 July 2005 of an intermediate survey the window for which straddles 1 July 2005 can be accepted.

109. These requirements define steel renewal criteria or other measures to be taken for the webs and flanges of side shell frames and brackets as per Part II, Title 14, Section 2 O2.

110. Reinforcing measures of side frames are also defined as per Part II, Title 14, Section 2 O2.300.

111. Finite element or other numerical analysis or direct calculation procedures cannot be used as an alternative to compliance with the requirements of this Chapter, except in cases of unusual side structure arrangements or framing to which the requirements of this Chapter cannot be directly applied. In such cases, the analysis criteria and the strength check criteria are to be in accordance with the Rules.

112. **Ice strengthened ships:** Where ships are reinforced to comply with an ice class notation, the intermediate frames are not to be included when considering compliance with Chapter Q.

The renewal thicknesses for the additional structure required to meet the ice strengthening notation are to be based on the class society’s requirements.

If the ice class notation is requested to be withdrawn, the additional ice strengthening structure, with the exception of tripping brackets (see Part II, Title 14, Section 2 O1.102.a and Part II, Title 14, Section 2 O2.300), is not to be considered to contribute to compliance with Part II, Title 14, Section 2 Chapter F.

O2. RENEWAL OR OTHER MEASURES

100. Criteria for renewal or other measures

101. **Symbols used in O2.100**

t_M = thickness as measured, in mm

t_{REN} = thickness at which renewal is required. See Part II, Title 14, Section 2 O2.102

$t_{REN,d/t}$ = thickness criteria based on d/t ratio. See Part II, Title 14, Section 2 O2.102.a

$t_{REN,S}$ = thickness criteria based on strength. See Part II, Title 14, Section 2 O2.102.b

t_{COAT} = 0.75 tS12

t_{S12} = thickness in mm as required by Part II, Title 14, Section 2 F1 (UR S12 (Rev.3)) in Part II, Title 14, Section 2 F1.300 for frame webs and in Part II, Title 14, Section 2 F1.400 for upper and lower bracket webs

t_{AB} = thickness as built, in mm

t_C = See Table T.O2.101.1 below

TABLE T.O2.101.1 – t_c VALUES IN MM

Ship's length L in m	Holds other than No. 1		Hold No. 1	
	Span and upper brackets	Lower brackets	Span and upper brackets	Lower brackets
≤100	2.0	2.5	2.0	3.0
150	2.0	3.0	3.0	3.5
≥200	2.0	3.0	3.0	4.0
Note: For intermediate ship lengths, t_C is obtained by linear interpolation between the above values.				

102. **Criteria for webs** (Shear and other checks): The webs of side shell frames and brackets are to be renewed when the measured thickness (t_M) is equal to or less than the thickness (t_{REN}) as defined below:

t_{REN} is the greatest of:

a. $t_{COAT} – t_C$

b. 0.75 t_{AB}

c. $t_{REN,d/t}$ (applicable to Zone A and B only)

d. $t_{REN,S}$ (where required by Part II, Title 14, Section 2 O2.102.b)

103. **Thickness criteria based on d/t ratio**

Subject to b) and c) below, $t_{REN,d/t}$ is given by the following equation:

$t_{REN,d/t}$ = (web depth in mm)/R

where:

R = for frames

65 k0.5 for symmetrically flanged frames

55 k0.5 for asymmetrically flanged frames

for lower brackets (see a) below):

87 k0.5 for symmetrically flanged frames

93 k0.5 for asymmetrically flanged frames

k = 1.0 for ordinary hull structural steel and according to Part II, Title 11, Section 2, Chapter C for higher tensile steel.

In no instance is $t_{REN,d/t}$ for lower integral brackets to be taken as less than $t_{REN,d/t}$ for the frames they support.

a. Lower brackets: Lower brackets are to be flanged or face plate is to be fitted, ref. Part II, Title 14, Section 2 O2.102.c. In calculating the web depth of the lower brackets, the following will apply:

a.1. The web depth of lower bracket may be measured from the intersection of the sloped bulkhead of the hopper tank and the side shell plate, perpendicularly to the face plate of the lower bracket (see Figure 3).

a.2. Where stiffeners are fitted on the lower bracket plate, the web depth may be taken as the distance between the side shell and the stiffener, between the stiffeners or between the outermost stiffener and the face plate of the brackets, whichever is the greatest.

b. Tripping bracket alternative: When t_M is less than $t_{REN,d/t}$ at section b of the side frames, tripping brackets in accordance with Part II, Title 14, Section 2 O2.300 may be fitted as an alternative to the requirements for the web depth to thickness ratio of side frames, in which case $t_{REN,d/t}$ may be disregarded in the determination of t_{REN} in accordance with Part II, Title 14, Section 2 O2.102. The value of t_M is to be based on zone B according to UR Z10.2, ANNEX V, see Figure F.O2.102.1.

c. Immediately abaft collision bulkhead: For the side frames, including the lower bracket, located immediately abaft the collision bulkheads, whose scantlings are increased in order that their moment of inertia is such to avoid undesirable flexibility of the side shell, when their web as built thickness t_{AB} is greater than 1.65.$t_{REN,S}$, the thickness $t_{REN,d/t}$ may be taken as the value $t'_{REN,d/t}$ obtained from the following equation:

$$T'_{REN,d/t} = \sqrt[3]{tREN,\frac{d}{t^2}.tREN}$$

where $t_{REN,S}$ is obtained from O3.300

104. **Thickness criteria based on shear strength check:** Where t_M in the lower part of side frames, as defined in Figure F.O2.102.1, is equal to or less than t_{COAT}, $t_{REN,S}$ is to be determined in accordance with Part II, Title 14, Section 2 O3.300.

FIGURE F.O2.102.1 - LOWER PART AND ZONES OF SIDE FRAMES

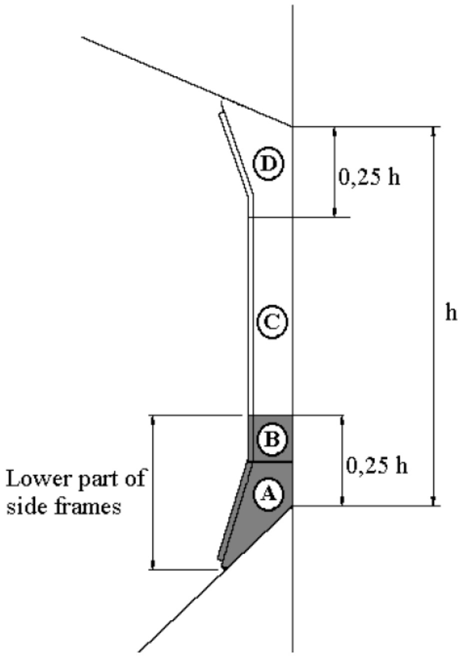


FIGURE FO2.102.2.a – Sections a) and b

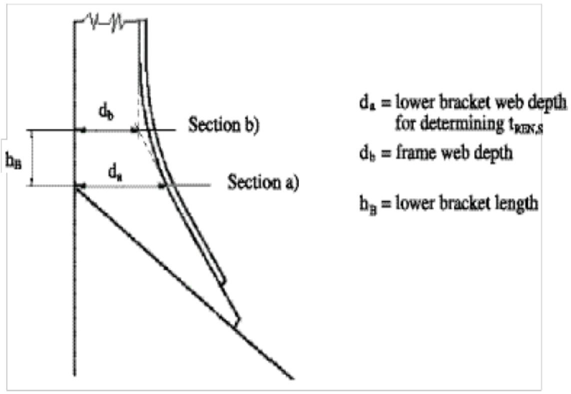


FIGURE FO2.102.2.b – Sections a) and b

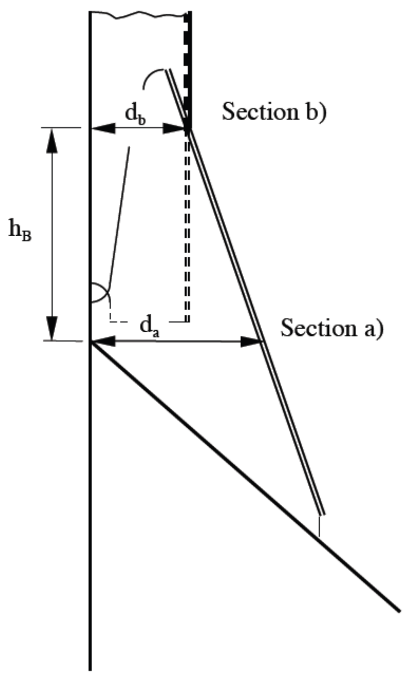
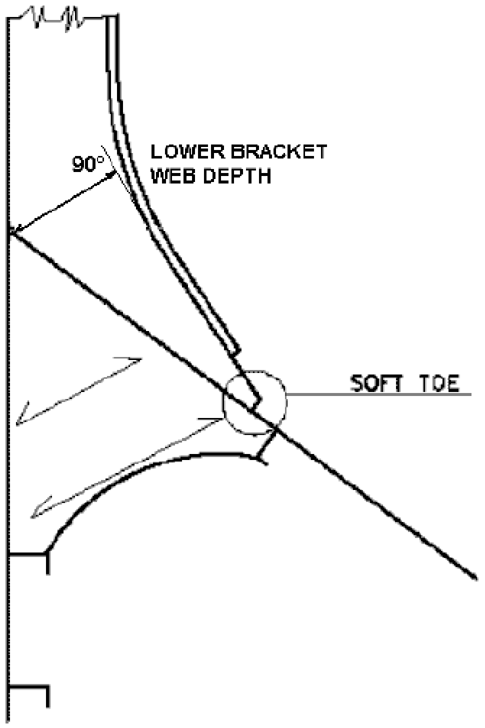


FIGURE FO2.102.3 – DEFINITION OF THE LOWER BRACKET WEB DEPTH FOR DETERMINING t_{REN}, d/t



105. **Thickness of renewed webs of frames and lower brackets**
Where steel renewal is required, the renewed webs are to be of a thickness not less than t_{AB}, $1.2t_{COAT}$ or $1.2t_{REN}$, whichever is the greatest.

106. **Criteria for other measures**
When $t_{REN} < t_M \leq t_{COAT}$, measures are to be taken, consisting of all the following:

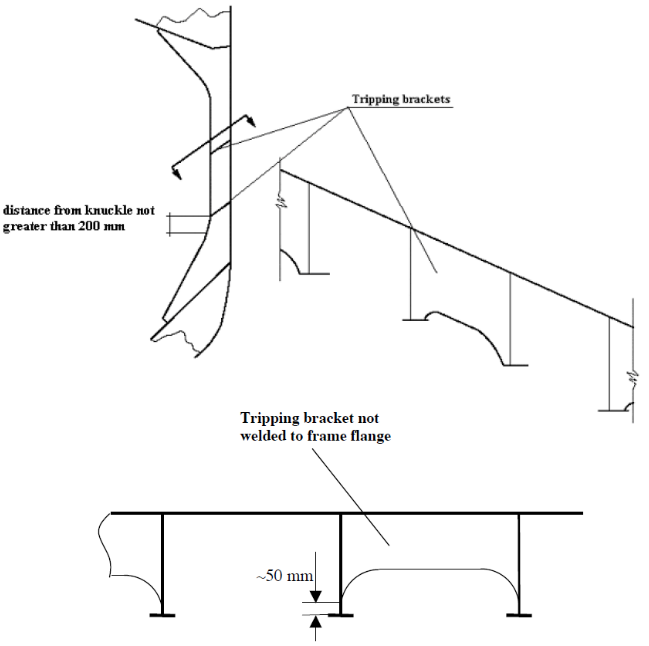
a. Sand blasting, or equivalent, and coating (see Part II, Title 14, Section 2 O2.200).

b. Fitting tripping brackets (see Part II, Title 14, Section 2 O2.300), when the above condition occurs for any of the side frame zones A, B, C and D, shown in Figure F.O2.102.1. Tripping brackets not connected to flanges are to have soft toe, and the distance between the bracket toe and the frame flange is not to be greater than about 50 mm, see Figure F.O2.102.4.

c. Maintaining the coating in "as-new" condition (i.e. without breakdown or rusting) at Special and Intermediate Surveys.

The above measures may be waived if the structural members show no thickness diminution with respect to the as built thicknesses and coating is in "as-new" condition (i.e. without breakdown or rusting). When the measured frame webs thickness t_M is such that $t_{REN} < t_M \leq t_{COAT}$ and the coating is in GOOD condition, sand blasting and coating as required in a) above may be waived even if not found in “as-new” condition, as defined above, provided that tripping brackets are fitted and the coating damaged in way of the tripping bracket welding is repaired

FIGURE F.O2.102.4 – TRIPPING BRACKETS



107. **Criteria for frames and brackets (Bending check)**

108. When lower end brackets were not fitted with flanges at the design stage, flanges are to be fitted so as to meet the bending strength requirements in Part II, Title 14, Section 2 O3.400. The full width of the bracket flange is to extend up beyond the point at which the frame flange reaches full width. Adequate back-up structure in the hopper is to be ensured, and the bracket is to be aligned with the back-up structure. Where the length or depth of the lower bracket does not meet the requirements in Part II, Title 14, Section 2, F.3, a bending strength check in accordance with Part II, Title 14, Section 2 O3.400 is to be carried out and renewals or reinforcements of frames and/or brackets effected as required therein. The bending check needs not to be carried out in the case the bracket geometry is modified so as to comply with Part II, Title 14, Section 2, F.3 requirements.

200. Thickness measurements, steel renewal, sand blasting and coating

201. For the purpose of steel renewal, sand blasting and coating, four zones A, B, C and D are defined, as shown in Figure F.O2.102.11. When renewal is to be carried out, surface preparation and coating are required for the renewed structures as given in Part II, Title 14, Section 2 Chapter R for cargo holds of new buildings.

202. Representative thickness measurements are to be taken for each zone and are to be assessed against the criteria in Part II, Title 14, Section 2, O2.100.

203. When zone B is made up of different plate thicknesses, the lesser thickness is to be used for the

application of the requirements in Part II, Title 14, Section 2, Chapter O

204. In case of integral brackets, when the criteria in Part II, Title 14, Section 2, O2.100 are not satisfied for zone A or B, steel renewal, sand blasting and coating, as applicable, are to be done for both zones A and B.

205. In case of separate brackets, when the criteria in Part II, Title 14, Section 2, O2.1001 are not satisfied for zone A or B, steel renewal, sand blasting and coating is to be done for each one of these zones, as applicable.

206. When steel renewal is required for zone C according to Part II, Title 14, Section 2, O2.100, it is to be done for both zones B and C. When sand blasting and coating is required for zone C according to Part II, Title 14, Section 2, O2.1001, it is to be done for zones B, C and D.

207. When steel renewal is required for zone D according to Part II, Title 14, Section 2, O2.100, it needs only to be done for this zone. When sand blasting and coating is required for zone D according to Part II, Title 14, Section 2, O2.100, it is to be done for both zones C and D.

208. Special consideration may be given by the Society to zones previously renewed or re-coated, if found in “as-new” condition (i.e., without breakdown or rusting).

209. When adopted, on the basis of the renewal thickness criteria in Part II, Title 14, Section 2, O2.100, in general coating is to be applied in compliance with the requirements of Part II, Title 14, Section 2 Chapter R, as applicable.

210. Where, according to the requirements in Part II, Title 14, Section 2 O2.100, a limited number of side frames and brackets are shown to require coating over part of their length, the following criteria apply.

a. The part to be coated includes:

a.1. the web and the face plate of the side frames and brackets,

a.2. - the hold surface of side shell, hopper tank and topside tank plating, as applicable, over a width not less than 100 mm from the web of the side frame.

b. Epoxy coating or equivalent is to be applied.

211. In all cases, all the surfaces to be coated are to be sand blasted prior to coating application.

212. When flanges of frames or brackets are to be renewed according to Part II Title 14, Section 2, Chapter O, the outstanding breadth to thickness ratio is to comply with the requirements in Part II, Title 14, Section 2, F.3.500 (UR S12.5).

300. Reinforcing measures

301. Reinforcing measures are constituted by tripping brackets, located at the lower part and at midspan of side frames (see Figure 4). Tripping brackets may be located at every two frames, but lower and midspan brackets are to be fitted in line between alternate pairs of frames.

302. The thickness of the tripping brackets is to be not less than the as-built thickness of the side frame webs to which they are connected.

303. Double continuous welding is to be adopted for the connections of tripping brackets to the side shell frames and shell plating.

304. Where side frames and side shell are made of Higher Strength Steel (HSS), Normal Strength Steel (NSS) tripping brackets may be accepted, provided the electrodes used for welding are those required for the particular HSS grade, and the thickness of the tripping brackets is equal to the frame web thickness, regardless of the frame web material.

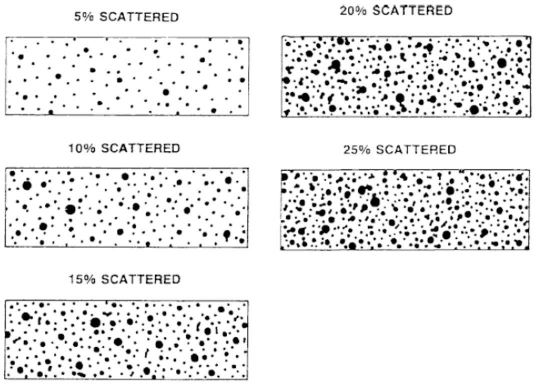
400. Weld throat thickness

401. In case of steel renewal the welded connections are to comply with Part II, Title 14, Section 2, F1 (UR S12.7 of UR S12(Rev.3)).

500. Pitting and grooving

501. If pitting intensity is higher than 15% in area (see Figure F.O2.501.1), thickness measurement is to be taken to check pitting corrosion.

FIGURE F.O2.501.1 - PITTING INTENSITY DIAGRAMS (FROM 5% TO 25% INTENSITY)



502. The minimum acceptable remaining thickness in pits or grooves is equal to:

a. 75% of the as built thickness, for pitting or grooving in the frame and brackets webs and flanges

b. 70% of the as built thickness, for pitting or grooving in the side shell, hopper tank and topside tank plating attached to the side frame, over a width up to 30 mm from each side of it.

600. Renewal of all frames in one or more cargo holds

601. When all frames in one or more holds are required to be renewed according to Part II, Title 14, Section 2, Chapter O, the compliance with the requirements in Part II, Title 14, Section 2, F1 (URS 12 (Rev. 1)) may be accepted in lieu of the compliance with the requirements in Part II, Title 14, Section 2, Chapter O, provided that:

a. It is applied at least to all the frames of the hold(s)

b. The coating requirements for side frames of “new ships” are complied with

c. The section modulus of side frames is calculated according to the Classification Society Rules.

700. Renewal of damaged frames

701. In case of renewal of a damaged frame already complying with Part II, Title 14, Section 2, Chapter O, the following requirements apply:

a. The conditions accepted in compliance with Part II, Title 14, Section 2, Chapter O are to be restored as a minimum.

b. For localised damages, the extension of the renewal is to be carried out according to the standard practice of each Classification Society.

O3. Strength check criteria

100. Load Model

101. In general, loads are to be calculated and strength checks are to be carried out for the aft, middle and forward frames of each hold. The scantlings required for frames in intermediate positions are to be obtained by linear interpolation between the results obtained for the above frames.

102. When scantlings of side frames vary within a hold, the required scantlings are also to be calculated for the mid frame of each group of frames having the same scantlings.

103. The scantlings required for frames in intermediate positions are to be obtained by linear interpolation between the results obtained for the calculated frames.

104. The following **loading conditions** are to be considered:

a. Homogeneous heavy cargo (density greater than 1,78 t/m3)

b. Homogeneous light cargo (density less than 1,78 t/m3)

c. Non homogeneous heavy cargo, if allowed

d. Multi port loading/unloading conditions need not be considered.

105. Forces

a. The forces $P_{fr,a}$ and $P_{fr,b}$, in kN, to be considered for the strength checks at sections a) and b) of side frames (specified in Figure F.O)2.102.2a and F.O2.102.2.b); in the case of separate lower brackets, section b) is at the top of the lower bracket), are given by:

$P_{fr,a} = P_s + \max(P_1,P_2)$

$P_{fr,b} = P_{fr,a}\frac{h-2hB}{h}$

where:

P_s = still water force, in kN

b. When the upper end of the side frame span h (see Figure F.O2.102.1) is below the load water line.

$=sh\left(\frac{ps,u+ps,l}{2}\right)$

c. When the upper end of the side frame span h (see Figure F.O2.102.1) is at or above the load water line,

P_s =

$=sh'\left(\frac{ps,l}{2}\right)$

P_1 = wave force, in kN, in head sea

$=sh\left(\frac{p1,U+p1,L}{2}\right)$

P_2 = wave force, in kN, in beam sea

$=sh\left(\frac{p2,U+p2,L}{2}\right)$

h, h_B = side frame span and lower bracket length, in m, defined in Figure F.O2.102.1 and Figure F.O2.102.2a and 102.2b, respectively

h’ = distance, in m, between the lower end of side frame span h (see Figure F.O2.102.1) and the load water line

s = frame spacing, in m

$p_{S,U}$, $p_{S,L}$ = still water pressure, in kN/m2, at the upper and lower end of the side frame span h (see Figure F.O2.102.1), respectively

$p_{1,U}$, $p_{1,L}$ = wave pressure, in kN/m2, as defined in Part II, Title 14, Section 2, O3.105 for the upper and lower end of the side frame span h, respectively

$p_{2,U}$, $p_{2,L}$ = wave pressure, in kN/m2, as defined in Part II, Title 14, Section 2, O3.106 for the upper and lower end of the side frame span h, respectively

106. Wave Pressure

a. *Wave pressure p1*

a.1. The wave pressure p_1, in kN/m2, at and below the waterline is given by:

$$p_1 = 1{,}5\left[p11 + 135\frac{B}{2(B+75)} - 1{,}2(T-z)\right]$$

$$p_{11} = 3 * ks * C + kf$$

a.2. The wave pressure p_1, in kN/m2, above the water line is given by:

$$p_1 = p_{1wl} - 7{,}5(z-T)$$

b. Wave pressure p_2

b.2. The wave pressure p2, in kN/m^2, at and below the waterline is given by

$$P2 = 13{,}0\left[0{,}5 * B\frac{50cr}{2(B+75)} + CB\frac{0{,}5B+Kf}{14}\left(0{,}7 + 2\frac{z}{T}\right)\right]$$

b.3. - The wave pressure p_2, in kN/m2, above the water line is given by:

$$p_2 = p_{2wl} - 5(z-T)$$

where:

$p_{1wl} = p_1$ wave sea pressure at the waterline

$p_{2wl} = p_2$ wave sea pressure at the waterline

L = Rule length, in m, as defined in UR S2

B = greatest moulded breadth, in m

C_B = block coefficient, as defined in UR S2, but not to be taken less than 0.6

T = maximum design draught, in m

C = coefficient

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

=10,75 for 300 m ‹L

$$C_r = \left(1{,}25 - 0{,}025\frac{2kr}{\sqrt{GM}}\right)k$$

k = 1,2 for ships without bilge keel

= 1.0 for ships with bilge keel

kr = roll radius of gyration. If the actual value of kr is not available

= 0.39 B for ships with even distribution of mass in transverse section (e.g. alternate heavy cargo loading or homogeneous light cargo loading)

= 0.25 B for ships with uneven distribution of mass in transverse section (e.g. homogeneous heavy cargo distribution)

GM = 0.12 B if the actual value of GM is not available

z = vertical distance, in m, from the baseline to the load point

ks = $C_B + \frac{0{,}83}{\sqrt{CB}}$ at aft of L

ks = C_B between 0,2L and 0,6L form end of L

= $C_B + \frac{1{,}33}{CB}$

Between the above specified points, ks is to be interpolated linearly.

$k_f = 0{,}8$ C

200. Allowable stresses

201. The allowable normal and shear stresses a and σ_a, in N/mm2, in the side shell frames and brackets are given by:

$\sigma_a = 0{,}9\ \sigma_F$

$\sigma_a = 0{,}4\ \sigma_F$

where σ_F is the minimum upper yield stress, in N/mm², of the material.

300. Shear strength check

301. Where t_M in the lower part of side frames, as defined in Figure 1, is equal to or less than t_{COAT}, shear strength check is to be carried out in accordance with the following.

The thickness $t_{REN,S}$, in mm, is the greater of the thicknesses $t_{REN,Sa}$ and $t_{REN,Sb}$ obtained from the shear strength check at sections a) and b) (see Figure F.O2.102.2a and 1202.2b2 and Part II, Title 14, Section 2, O3.100) given by the following, but need not be taken in excess of 0.75t $_{S12}$.

At section a): $t_{REN,Sa} = \frac{1000.ks.Pfr,a}{da+sin\phi\tau a}$

At section b): $t_{REN,Sa} = \frac{1000.ks.Pfr,b}{db+sin\phi\tau a}$

where:

k_S = shear force distribution factor, to be taken equal to 0.6

$P_{fr,a}$, $P_{fr,b}$ = pressures forces defined in Part II, Title 14, Section 2, O3.105.

d_a, d_b = bracket and frame web depth, in mm, at sections a) and b), respectively (see Figure F.O2.102.2a and 2b); in case of separate (non integral) brackets, d_b is to be taken as the minimum web depth deducing possible scallops

ϕ= angle between frame web and shell plate

τ_a = allowable shear stress, in N/mm2, defined in S31.3.2.

400. Bending strength check

401. Where the lower bracket length or depth does not meet the requirements in Part II, Title 14, Section 2, F1.(UR S12(Rev.3)), the actual section modulus, in cm3, of the brackets and side frames at sections a) and b) is to be not less than:

at section a): $Z_a = \frac{1000Pfr,a.h}{ma.\sigma a}$

at section b): $Z_a = \frac{1000Pfr,a.h}{mb.\sigma a}$

where:

$P_{fr,a}$ = pressures force defined in Part II, Title 14, Section 2, O3.105.

h = side frame span, in m, defined in Figure F.O2.102.1

σ_a = allowable normal stress, in N/mm2, defined in Part II, Title 14, Section 2, O3.200.

m_a, m_b = bending moment coefficients defined in Table T.O3.401.1

The actual section modulus of the brackets and side frames is to be calculated about an axis parallel to the attached plate, based on the measured thicknesses. For precalculations, alternative thickness values may be used, provided they are not less than:

a. tREN, for the web thickness

b. the minimum thicknesses allowed by the Society renewal criteria for flange and attached plating.

The attached plate breadth is equal to the frame spacing, measured along the shell at midspan of h.

If the actual section moduli at sections a) and b) are less than the values Za and Zb, the frames and brackets are to be renewed or reinforced in order to obtain actual section moduli not less than 1.2 Za and 1.2 Zb, respectively.

In such a case, renewal or reinforcements of the flange are to be extended over the lower part of side frames, as defined in Figure 1.

TABLE T.O3.401.1 - BENDING MOMENT COEFFICIENTS m_a AND m_b

		m_b		
	m_a	$h_B \leq 0.08h$	$h_B = 0.1h$	$h_B \geq 0.125h$
Empty holds of ships approved to operate in non homogeneous loading conditions	10	17	19	22
Other cases	12	20	22	26
Note 1: Non homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, exceeds 1.20 corrected for different cargo densities. Note 2: For intermediate values of the bracket length h_B, the coefficient m_b is obtained by linear interpolation between the table values				

CHAPTER P
REQUIREMENTS FOR THE FITTING OF A FORECASTLE FOR BULK CARRIERS, ORE CARRIERS AND COMBINATION CARRIERS [UR S28]

CHAPTER CONTENTS

P1. APPLICATION AND DEFINITIONS

P2. DIMENSIONS

P1. APPLICATION AND DEFINITIONS

100. Application

101. These requirements apply to all bulk carriers, ore carriers and combination carriers, which are contracted for construction on or after 1 January 2004. Such ships are to be fitted with an enclosed forecastle on the freeboard deck. The required dimensions of the forecastle are defined in P2.

102. The structural arrangements and scantlings of the forecastle are to comply with the relevant Society's requirements.

103. This Chapter does not apply to CSR Bulk Carriers.

P2. DIMENSIONS

100. Dimensions

101. The forecastle is to be located on the freeboard deck with its aft bulkhead fitted in way or aft of the forward bulkhead of the foremost hold, as shown in Figure F.P2.201.1.

102. However, if this requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided the forecastle length is not less than 7% of ship length abaft the forward perpendicular where the ship length and forward perpendicular are defined in the International Convention on Load Line 1966 and its Protocol 1988.

103. The forecastle height HF above the main deck is to be not less than:

a. the standard height of a superstructure as specified in the International Convention on Load Line 1966 and its Protocol of 1988, or

b. HC + 0.5 m, where HC is the height of the forward transverse hatch coaming of cargo hold No.1, whichever is the greater.

103. All points of the aft edge of the forecastle deck are to be located at a distance .F:

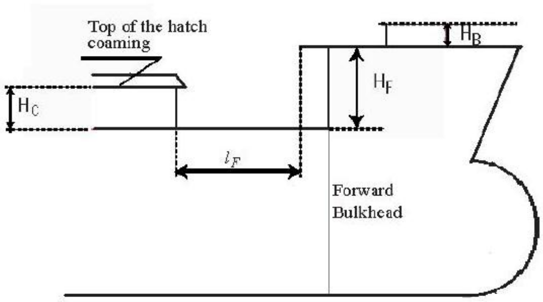
$$L_f = \leq 5\sqrt{HF - HC}$$

from the hatch coaming plate in order to apply the reduced loading to the No.1 forward transverse hatch coaming and No.1 hatch cover .

104. A breakwater is not to be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it is to be located such that its upper edge at centre line is not less than

$H_B/\tan 20°$

forward of the aft edge of the forecastle deck, where HB is the height of the breakwater above the forecastle (see Figure F.P2.201.1).



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