08-391

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part CSR-B Common Structural Rules for Bulk Carriers

Rules for the Survey and Construction of Steel Ships
Part CSR-B 2008 AMENDMENT NO.4

Rule No.60 5th September 2008

Resolved by Technical Committee on 25th June 2008

Approved by Board of Directors on 22nd July 2008

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Rule No.60 5th September 2008
AMENDMENT TO THE RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Rules for the survey and construction of steel ships" has been partly amended as follows:

Part CSR-B Common Structural Rules for Bulk Carriers

Chapter 1 GENERAL PRINCIPLES

Section 4 SYMBOLS AND DEFINITIONS

2. Symbols

2.1 Ship's main data

2.1.1

Definition of symbol, V, has been amended as follows.

V : Maximum ahead service speed, in *knots*, means the greatest speed which the ship is designed to maintain in service at her deepest seagoing draught at the maximum propeller *RPM* and corresponding engine *MCR* (Maximum Continuous Rating).

Chapter 3 STRUCTURAL DESIGN PRINCIPLES

Section 1 MATERIAL

2. Hull structural steel

2.3 Grades of steel

Table 4 has been amended as follows.

Table 4 Application of material classes and grades

Structural member category	Material class	
	Within 0.4*L* amidship	Outside 0.4*L* amidship
SECONDARY		
Longitudinal bulkhead strakes, other than that belonging to the Primary category	I	*A*/*AH*
Deck Plating exposed to weather, other than that belonging to the Primary or Special category		
Side plating[7]		
PRIMARY		
Bottom plating, including keel plate	II	*A*/*AH*
Strength deck plating, excluding that belonging to the Special category		
Continuous longitudinal members above strength deck, excluding hatch coamings		
Uppermost strake in longitudinal bulkhead		
Vertical strake (hatch side girder) and uppermost sloped strake in top wing tank		
SPECIAL		
Sheer strake at strength deck[1,6]	III	II (I outside 0.6*L* amidships)
Stringer plate in strength deck[1,6]		
Deck strake at longitudinal bulkhead[6]		
Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers, combination carriers and other ships with similar hatch openings configuration[2]		
Bilge strake[3,4,6]		
Longitudinal hatch coamings of length greater than 0.15*L*[5]		
Web of lower bracket of side frame of single side bulk carriers having additional service feature *BC-A* or *BC-B*[5]		
End brackets and deck house transition of longitudinal cargo hatch coamings[5]		

Notes:

(1) Not to be less than grade *E*/*EH* within 0.4*L* amidships in ships with length exceeding 250 *m*.
(2) Not to be less than class III within 0.6*L* amidships and class II within the remaining length of the cargo region.
(3) May be of class II in ships with a double bottom over the full breadth and with length less than 150*m*.
(4) Not to be less than grade *D*/*DH* within 0.4*L* amidships in ships with length exceeding 250*m*.
(5) Not to be less than grade *D*/*DH*.
(6) Single strakes required to be of class III or of grade *E*/*EH* and within 0.4*L* amidships are to have breadths, in m, not less than 0.8 + 0.005*L*, need not be greater than 1.8 *m*, unless limited by the geometry of the ship's design.
(7) For *BC-A* and *BC-B* ships with single side skin structures, side shell strakes included totally or partially between the two points located to 0.125ℓ above and below the intersection of side shell and bilge hopper sloping plate are not to be less than grade *D/DH*, ℓ being the frame span.

Paragraph 2.3.7 has been amended as follows.

2.3.7

In specific cases, such as ~~**2.3.6**~~**2.3.8**, with regard to stress distribution along the hull girder, the classes required within 0.4*L* amidships may be extended beyond that zone, on a case by case basis.

Section 6 STRUCTURAL ARRANGEMENT PRINCIPLES

8. Single side structure

8.3 Side frames

Paragraph 8.3.1 has been amended as follows.

8.3.1 General

Frames are to be built-up symmetrical sections with integral upper and lower brackets and are to be arranged with soft toes.

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:

$$\cancel{r = \frac{0.3 b_f^2}{t_f + t_C}} \quad \underline{r = \frac{0.4 b_f^2}{t_f + t_C}}$$

where:

t_C : Corrosion addition, in mm, specified in **Ch 3**, **Sec 3**

b_f and t_f: Flange width and net thickness of the curved flange, in mm. The end of the flange is to be sniped.

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.

The dimensions of side frames are defined in **Fig. 19**.

10. Bulkhead structure

10.4 Corrugated bulkheads

Paragraph 10.4.4 has been amended as follows.

10.4.4 Span of corrugations

The span ℓ_C of the corrugations is to be taken as the distance shown in **Fig. 29**.

For the definition of ℓ_C, ~~the height of the upper and lower stools may not be taken smaller than the values specified in **10.4.7 and 10.4.8**.~~ <u>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:</u>

<u>- 3 times the depth of corrugation, in general</u>

<u>- 2 times the depth of corrugation, for rectangular stool</u>

Paragraph 10.4.7 has been amended as follows.

10.4.7 Lower stool

The lower stool, when fitted, is to have a height in general not less than 3 *times* the depth of the corrugations.

The net thickness and material of the stool top plate are to be not less than those required for the bulkhead plating above. The net thickness and material properties of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top are to be not less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at the lower end of the corrugation.

The ends of stool side ordinary stiffeners, when fitted in a vertical plane, are to be attached to brackets at the upper and lower ends of the stool.

The distance *d* from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with **Fig. 30**.

The stool bottom is to be installed in line with double bottom floors or girders as the case may be, 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 or floors as the case may be, 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.

Where corrugations are cut at the lower stool, ~~the weld of corrugations and stool side plating to the stool top plate are to be full penetration one. The weld of stool side plating and supporting floors to the inner bottom plating are to be full penetration or deep penetration welds.~~ 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. The supporting floors are to be connected to the inner bottom by either full penetration or deep penetration weld.

Chapter 4 DESIGN LOADS

Section 5 EXTERNAL PRESSURES

3. External pressures on superstructure and deckhouses

3.2 Exposed wheel house tops

Paragraph 3.2.1 has been amended as follows.

3.2.1

The lateral pressure for exposed wheel house tops, in kN/m^2, is not to be taken less than:

~~$p = 2.5$~~ <u>$p = 12.5$</u>

Title of 3.4 has been amended as follows.

~~3.4 Superstructure end bulkheads and deckhouse walls~~

<u>3.4 End bulkhead of superstructure and deckhouse</u>

Paragraph 3.4.1 has been amended as follows.

3.4.1

The lateral pressure, in kN/m^2, for determining the scantlings is to be obtained from the greater of the following formulae:

$$p_A = nc\left[bC - (z - T)\right]$$

$$p_A = p_{A\min}$$

where:

n : Coefficient defined in **Table 7**, depending on the tier level.
The lowest tier is normally that tier which is directly situated above the uppermost continuous deck to which the depth D is to be measured. However, where the actual distance <u>$(D\text{-}T)$</u> exceeds the minimum non-corrected tabular freeboard according to *ILLC* as amended by at least one standard superstructure height as defined in **Ch 1**, **Sec 4**, **3.18.1**, this tier may be defined as the 2nd tier and the tier above as the 3rd tier

c : Coefficient taken equal to:

$$c = 0.3 + 0.7\frac{b_1}{B_1}$$

For exposed parts of machinery casings, c is not to be taken less than 1.0

b_1: Breadth of deckhouse at the position considered

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

b_1 / B_1 is not to be taken less than 0.25

b : Coefficient defined in **Table 8**

x : X co-ordinate, in m, of the calculation point for the bulkhead considered. When determining sides of a deckhouse, the deckhouse is to be subdivided into parts of approximately equal length, not exceeding $0.15L$ each, and x is to be taken as the X co-ordinate of the centre of each part considered.

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

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

$p_{A\min}$: Minimum lateral pressure, in kN/m^2, defined in **Table 9**.

Table 9 has been amended as follows.

Table 9 Minimum lateral pressure $p_{A\min}$

	$p_{A\min}$, in kN/m^2	
L	Lowest tier of unprotected fronts	Elsewhere(1)
$90 < L \leq 250$	$25 + \dfrac{L}{10}$	$12.5 + \dfrac{L}{20}$
$L > 250$	50	25

(1) For the 4th tier and above, $p_{A\min}$ is to be taken equal to ~~2.5~~ 12.5kN/m^2.

4. Pressure in bow area

4.1 Bow flare area pressure

Paragraph 4.1.1 has been amended as follows.

4.1.1

The bow pressure, in kN/m^2, to be considered for the reinforcement of the bow flare area is to be obtained from the following formula:

$$p_{FB} = K(p_S + p_W)$$

where:

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

K : Coefficient taken equal to:

$$K = \frac{c_{FL}\left(0.2V + 0.6\sqrt{L}\right)^2}{42C(C_B + 0.7)\left(1 + \dfrac{20}{C_B}\left(\dfrac{x}{L} - 0.7\right)^2\right)}(10 + z - T_B) \quad \text{to be taken not less than 1.0}$$

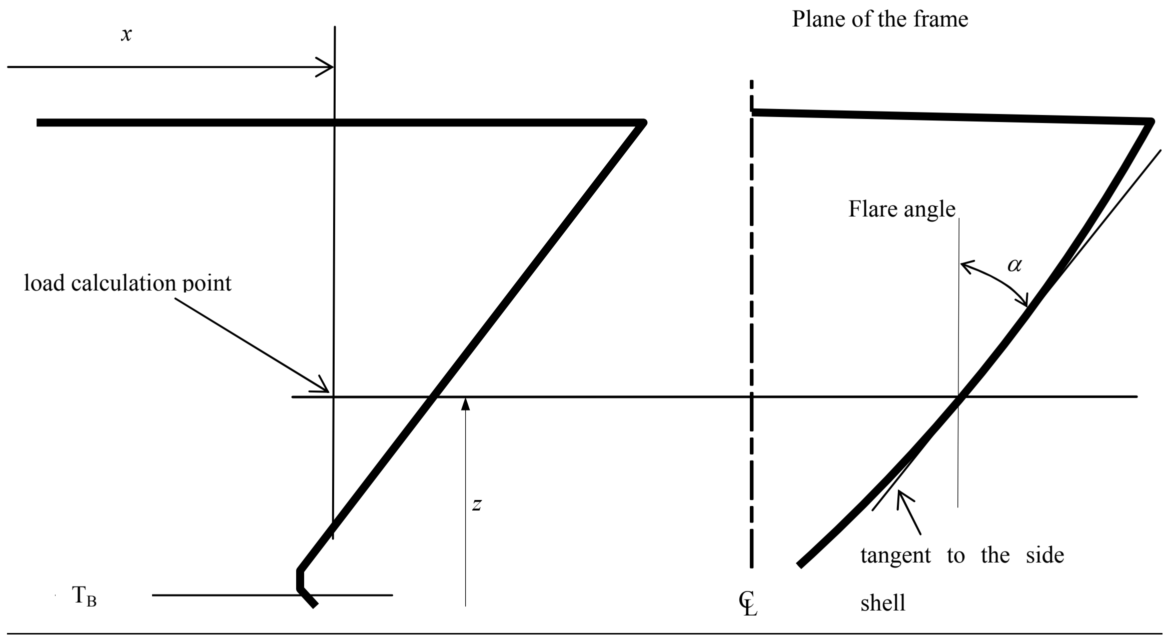
c_{FL} : Coefficient taken equal to:

$c_{FL} = 0.8$ in general

$$c_{FL} = \frac{0.4}{1.2 - 1.09\sin\alpha} \quad \text{where the flare angle } \alpha \text{ is greater than } 40°$$

Where, the flare angle α at the load calculation point is to be measured in plane of the frame between a vertical line and the tangent to the side shell plating. (see **Fig. 7**)

Fig. 7 The definition of the flare angle



Chapter 5 HULL GIRDER STRENGTH

Section 1 YIELDING CHECK

3. Checking criteria

3.1 Normal stresses

Paragraph 3.1.1 has been amended as follows.

3.1.1

It is to be checked that the normal stresses σ_1 calculated according to **2.1.2** and, when applicable, **2.1.3** are in compliance with the following formula:

$\sigma_1 \le \sigma_{1,ALL}$

where:

$\sigma_{1,ALL}$: Allowable normal stress, in N/mm^2, obtained from the following formulae:

$$\sigma_{1,ALL} = \frac{130}{k} \quad \text{for} \quad \frac{x}{L} \le 0.1$$

$$\sigma_{1,ALL} = \frac{190}{k} - \frac{1500}{k}\left(\frac{x}{L} - 0.3\right)^2 \quad \text{for} \quad 0.1 < \frac{x}{L} < 0.3$$

$$\sigma_{1,ALL} = \frac{190}{k} \quad \text{for} \quad 0.3 \le \frac{x}{L} \le 0.7$$

$$\cancel{\sigma_{1,ALL} = \frac{190}{k} - \frac{1500}{k}\left(\frac{x}{L} - 0.7\right)^2} \quad \underline{\sigma_{1,ALL} = \frac{190}{k} - \frac{1500}{k}\left(\frac{x}{L} - 0.7\right)^2} \quad \text{for} \quad 0.7 < \frac{x}{L} < 0.9$$

$$\sigma_{1,ALL} = \frac{130}{k} \quad \text{for} \quad \frac{x}{L} \ge 0.9$$

4. Section modulus and moment of inertia

4.5 Extent of higher strength steel

Paragraph 4.5.1 has been amended as follows.

4.5.1

When a material factor for higher strength steel is used in calculating the required section modulus at bottom or deck according to **4.2** or **4.3**, the relevant higher strength steel is to be adopted for all members contributing to the longitudinal strength (see **1**), at least up to a vertical distance, in *m*, obtained from the following formulae:

- above the baseline (for section modulus at bottom):

$$V_{HB} = \frac{\sigma_{1B} - k\sigma_{1,ALL}}{\sigma_{1B} + \sigma_{1D}} z_D$$

- below a horizontal line located at a distance V_D (see **1.4.2**) above the neutral axis of the hull transverse section (for section modulus at deck):

$$V_{HD} = \frac{\sigma_{1D} - k\sigma_{1,ALL}}{\sigma_{1B} + \sigma_{1D}}\left(N + V_D\right)$$

where:

σ_{1B}, σ_{1D}: Normal stresses, in N/mm^2, at bottom and deck, respectively, calculated according to ~~**2.1.2**~~ **2.1**

z_D: Z co-ordinate, in m, of the strength deck defined in **1.3**, with respect to the reference co-ordinate system defined in **Ch 1**, **Sec 4**, **4**

Appendix 1 HULL GIRDER ULTIMATE STRENGTH

Symbols have been amended as follows.

Symbols

For symbols not defined in this Appendix, refer to **Ch 1**, **Sec 4**.

I_Y : Moment of inertia, in m^4, of the hull transverse section around its horizontal neutral axis, to be calculated according to **Ch 5**, **Sec 1**, **1.5.1**

Z_{AB}, Z_{AD} : Section moduli, in ~~cm^3~~ m^3, at bottom and deck, respectively, defined in **Ch 5**, **Sec 1**, **1.4.2**.

2. Criteria for the calculation of the curve *M-χ*

2.1 Simplified method based on a incremental-iterative approach

Paragraph 2.1.2 has been amended as follows.

2.1.2 Assumption

In applying the procedure described in **2.1.1**, the following assumptions are generally to be made:

- the ultimate strength is calculated at hull transverse sections between two adjacent transverse webs.
- the hull girder transverse section remains plane during each curvature increment.
- the hull material has an elasto-plastic behaviour.
- the hull girder transverse section is divided into a set of elements, which are considered to act independently.
  These elements are:
  - transversely framed plating panels and/or ordinary stiffeners with attached plating, whose structural behaviour is described in **2.2.1**
  - hard corners, constituted by plating crossing, whose structural behaviour is described in **2.2.2**.
- according to the iterative procedure, the bending moment M_i acting on the transverse section at each curvature value χ_i is obtained by summing the contribution given by the stress σ acting on each element. The stress σ, corresponding to the element strain ε, is to be obtained for each curvature increment from the non-linear load-end shortening curves σ- ε - of the element.
  These curves are to be calculated, for the failure mechanisms of the element, from the formulae specified in **2.2**. The stress σ is selected as the lowest among the values obtained from each of the considered load-end shortening curves σ- ε.
- The procedure is to be repeated until the value of the imposed curvature reaches the value χ_F, in m^{-1}, in hogging and sagging condition, obtained from the following formula:

$$\chi_F = \pm 0.003 \frac{M_Y}{EI_Y}$$

where:

M_Y : the lesser of the values M_{Y1} and M_{Y2}, in *kN-m*:

$\cancel{M_{Y1} = 10^{-3} R_{eH} Z_{AB}}$ $\underline{M_{Y1} = 10^{3} R_{eH} Z_{AB}}$

$\cancel{M_{Y2} = 10^{-3} R_{eH} Z_{AD}}$ $\underline{M_{Y2} = 10^{3} R_{eH} Z_{AD}}$

If the value χ_F is not sufficient to evaluate the peaks of the curve M-χ, the procedure is to be repeated until the value of the imposed curvature permits the calculation of the maximum bending moments of the curve.

2.2 Load-end shortening curves σ–ε

Paragraph 2.2.6 has been amended as follows.

2.2.6 Web local buckling of ordinary stiffeners made of flanged profiles

The equation describing the load-end shortening curve $\cancel{\sigma_{CR1}-\varepsilon}$ $\underline{\sigma_{CR3}-\varepsilon}$ for the web local buckling of flanged ordinary stiffeners composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR3} = \Phi R_{eH} \frac{10^3 b_E t_p + h_{we} t_w + b_f t_f}{10^3 s t_p + h_w t_w + b_f t_f}$$

where

Φ : Edge function defined in **2.2.3**

b_E : Effective width, in *m*, of the attached shell plating, defined in **2.2.4**

h_{we} : Effective height, in *mm*, of the web, equal to:

$$h_{we} = \left(\frac{2.25}{\beta_w} - \frac{1.25}{\beta_w^2} \right) h_w \quad \text{for } \beta_w > 1.25$$

$$h_{we} = h_w \quad \text{for } \beta_w \le 1.25$$

$$\beta_w = \frac{h_w}{t_w} \sqrt{\frac{\varepsilon R_{eH}}{E}}$$

ε : Relative strain defined in **2.2.3**

Paragraph 2.2.8 has been amended as follows.

2.2.8 Plate buckling

The equation describing the load-end shortening curve σ_{CR5}-ε for the buckling of transversely stiffened panels composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR5} = \min \begin{cases} R_{eH}\,\Phi \\ \Phi R_{eH} \left[\frac{s}{\ell} \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2} \right) + 0.1 \left(1 - \frac{s}{\ell} \right) \left(1 + \frac{1}{\beta_E^2} \right)^2 \right] \end{cases}$$

where:

Φ : Edge function defined in **2.2.3**.

~~β_E : Coefficient defined in **2.2.4**.~~

$$\beta_E = 10^3 \frac{s}{t_p}\sqrt{\frac{\varepsilon R_{eH}}{E}}$$

s : plate breadth, in *m*, taken as the spacing between the ordinary stiffeners.

ℓ : longer side of the plate, in *m*.

Chapter 6 HULL SCANTLINGS

Section 1 PLATING

2. General requirements

2.5 Sheerstrake

Paragraph 2.5.3 has been amended as follows.

2.5.3 Net thickness of the sheerstrake in way of breaks of ~~long~~ effective superstructures

The net thickness of the sheerstrake is to be increased in way of breaks of ~~long~~ effective superstructures occurring within 0.5*L* amidships, over a length of about one sixth of the ship's breadth on each side of the superstructure end.

This increase in net thickness is not to be less than 40% of the net thickness of sheerstrake other than those in way of such breaks, but need not exceed 4.5 *mm*.

Where the breaks of superstructures occur outside 0.5*L* amidships, the increase in net thickness may be reduced to 30%, but need not exceed 2.5 *mm*.

Paragraph 2.5.4 has been amended as follows.

2.5.4 Net thickness of the sheerstrake in way of breaks of ~~short~~ non-effective superstructures

The net thickness of the sheerstrake is to be increased in way of breaks of ~~short~~ non-effective superstructures occurring within 0.6*L* amidships, over a length of about one sixth of the ship's breadth on each side of the superstructure end.

This increase in net thickness is to be equal to 15%, but need not exceed 4.5 *mm*.

3. Strength check of plating subjected to lateral pressure

3.1 Load model

Paragraph 3.1.3 has been amended as follows.

3.1.3 Lateral pressure in flooded conditions

The lateral pressure in flooded conditions p_F is defined in **Ch 4, Sec 6, ~~3~~ 3.2.1**.

Section 2 ORDINARY STIFFENERS

3. Yielding check

3.1 Load model

Paragraph 3.1.3 has been amended as follows.

3.1.3 Lateral pressure in flooded conditions

The lateral pressure in flooded conditions p_F is defined in **Ch 4, Sec 6, ~~3~~ 3.2.1**.

3.4 Upper and lower connections of side frames of single side bulk carriers

Paragraph 3.4.1 has been amended as follows.

3.4.1

The section moduli of the:

- side shell and hopper tank longitudinals that support the lower connecting brackets,
- side shell and topside tank longitudinals that support the upper connecting brackets

are to be such that the following relationship is separately satisfied for each lower and upper connecting bracket (see also **Ch 3**, **Sec 6**, **Fig 22**):

$$\sum_n w_i d_i \geq \alpha_T \frac{(p_S + p_W)\ell^2 \ell_1^2}{16 R_Y}$$

where:

n : Number of the longitudinal stiffeners of side shell and hopper / topside tank that support the lower / upper end connecting bracket of the side frame, as applicable

w_i : Net section modulus, in cm^3, of the i-th longitudinal stiffener of the side shell or hopper / topside tank that support the lower / upper end connecting bracket of the side frame, as applicable

d_i : Distance, in m, of the above i-th longitudinal stiffener from the intersection point of the side shell and hopper /topside tank

ℓ_1 : Spacing, in m, of transverse supporting webs in hopper / topside tank, as applicable

R_y : Lowest value of equivalent yield stress, in N/mm^2, among the materials of the longitudinal stiffeners of side shell and hopper / topside tanks that support the lower / upper end connecting bracket of the side frame

α_T : Coefficient taken equal to:

$\alpha_T = 150$ for the longitudinal stiffeners supporting the lower connecting brackets

$\alpha_T = 75$ for the longitudinal stiffeners supporting the upper connecting brackets

ℓ : Side frame span, in m, as defined in **3.3.1**.

p_S , p_W : Still water and wave pressures as those for the side frame.

4. Web stiffeners of primary supporting members

4.1 Net scantlings

Paragraph 4.1.3 has been amended as follows.

4.1.3 Connection ends of web stiffeners

Where the web stiffeners of primary supporting members are welded to ordinary stiffener face plates, the stress at ends of web stiffeners of primary supporting members in water ballast tanks, in N/mm^2, is to comply with the following formula when no bracket is fitted:

$$\sigma \leq 175$$

where:

$$\sigma = 1.1 K_{con} K_{longi} K_{stiff} \frac{\Delta\sigma}{\cos\theta}$$

K_{con} : Coefficient considering stress concentration, taken equal to:

$K_{con} = 3.5$ for stiffeners in the double bottom or double side space (see **Fig. 8**)

$K_{con} = 4.0$ for other cases (e.g. hopper tank, top side tank, etc.) (see **Fig. 8**)

K_{longi} : Coefficient considering shape of cross section of the longitudinal, taken equal to:

$K_{longi} = 1.0$ for symmetrical profile of stiffener (e.g. *T*-section, flat bar)

$K_{longi} = 1.3$ for asymmetrical profile of stiffener (e.g. angle section, bulb profile)

K_{stiff} : Coefficient considering the shape of the end of the stiffener, taken equal to:

$K_{stiff} = 1.0$ for standard shape of the end of the stiffener (see **Fig. 9**)

$K_{stiff} = 0.8$ for the improved shape of the end of the stiffener (see **Fig. 9**)

θ : As given in **Fig. 10**

$\Delta\sigma$: Stress range, in N/mm^2, transferred from longitudinals into the end of web stiffener, as obtained from the following formula:

$$\Delta\sigma = \frac{2W}{0.322h'\left[\left(A_{w1}/\ell_1\right) + \left(A_{w2}/\ell_2\right)\right] + A_{s0}}$$

W : Dynamic load, in N, as obtained from the following formula:

$$W = 1000(\ell - 0.5s)sp$$

p : Maximum inertial pressure due to liquid <u>in the considered compartment where the web stiffener is located</u> according to **Ch 4**, **Sec 6**, **2.2.1**, in kN/m^2, of the probability level of 10^{-4}. , calculated at mid-span of the ordinary stiffener

ℓ : Span of the longitudinal, in *m*

s : Spacing of the longitudinal, in *m*

A_{s0}, A_{w1}, A_{w2} : Geometric parameters as given in **Fig. 10**, in mm^2

ℓ_1, ℓ_2 : Geometric parameters as given in **Fig. 10**, in *mm*

h' : As obtained from following formula, in *mm*:

$$h' = h_s + h_0'$$

h_s : As given in **Fig. 10**, in *mm*

h_0' : As obtained from the following formula, in *mm*

$h_0' = 0.636b'$ for $b' \leq 150$

$h_0' = 0.216b' + 63$ for $150 < b'$

b' : Smallest breadth at the end of the web stiffener, in *mm*, as shown in **Fig. 10**

Section 3 BUCKLING & ULTIMATE STRENGTH OF ORDINARY STIFFENERS AND STIFFENED PANELS

Symbols have been amended as follows.

Symbols

For symbols not defined in this Section, refer to **Ch 1**, **Sec 4**.

In this section, compressive and shear stresses are to be taken positive, tension stresses are to be taken negative.

~~*a* : Length of single or partial plate panel, in *mm*~~

~~*b* : Breadth of elementary plate panel, in *mm*~~

<u>*a* : Length in *mm* of the longer side of the partial plate field in general or length in *mm* of the side of the partial plate field according **Table 2**, BLC 3 – 10</u>

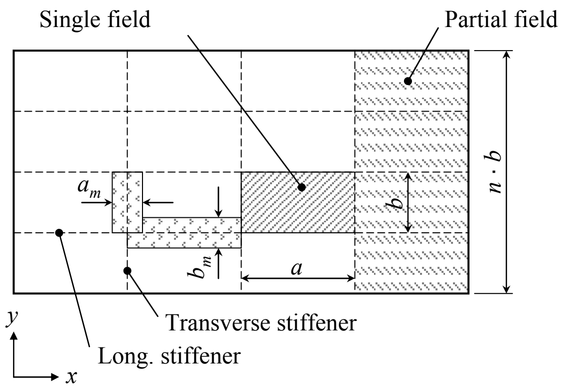
<u>*b* : Length in *mm* of the shorter side of the partial plate field in general or length in *mm* of the side of the partial plate field according **Table 2**, BLC 3 – 10</u>

α : Aspect ratio of elementary plate panel, taken equal to:

$$\alpha = \frac{a}{b}$$

n : Number of elementary plate panel breadths within the partial or total plate panel

Fig. 1 General arrangement of panel



Longitudinal : stiffener in the direction of the length *a*

Transverse : stiffener in the direction of the breath *b*

t : Net plate thickness, in *mm*

σ_n : Normal stress resulting from hull girder bending, in N/mm^2

τ_{SF} : Shear stress induced by the shear forces as defined in **2.1.3**, in N/mm^2

σ_x : Membrane stress in x-direction, in N/mm^2

σ_y : Membrane stress in y-direction, in N/mm^2

τ : Shear stress in the x-y plane, in N/mm^2

λ : Reference degree of slenderness, taken equal to:

$$\lambda = \sqrt{\frac{R_{eH}}{K\sigma_e}}$$

K : Buckling factor according to **Table 2** and **Table 3**

Reference stress, to be the following for BLC 1 and 2:

σ_e : Reference stress, taken equal to:

$$\sigma_e = 0.9E\left(\frac{t}{b'}\right)^2$$

b' : Shorter side of elementary plate panel

Reference stress, to be the following for BLC 3 through 10:

σ_e : Reference stress, taken equal to:

$$\sigma_e = 0.9E\left(\frac{t}{b}\right)^2$$

ψ : Edge stress ratio taken equal to:

$\psi = \sigma_2 / \sigma_1$

where:

σ_1 : maximum compressive stress

σ_2 : minimum compressive stress or tensile stress

S : Safety factor, taken equal to:

$S = 1.0$ except for the case mentioned below

$S = 1.1$ for structures which are exclusively exposed to local loads (e.g. hatch covers, foundations)

$S = 1.15$ for the ultimate strength in lateral buckling mode of longitudinal and transverse ordinary stiffeners of the hatchway coamings, sloping plating of the topside tanks and hopper tanks, inner bottom, inner side if any, side shell of single side skin construction and top and bottom stools of transverse bulkheads, assessed according to **4.2**.

For constructions of aluminium alloys the safety factors are to be increased in each case by 0.1

F_1 : Correction factor for boundary condition of stiffeners on the longer side of elementary plate panels according to **Table 1**. If the clamping is unequal on the longitudinal sides of the panel, the minimum value of the appropriate F_1-parameter has to be used.

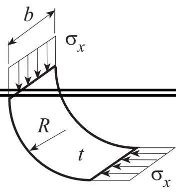
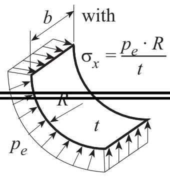
Table 1 Correction factor F_1

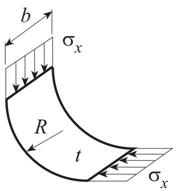
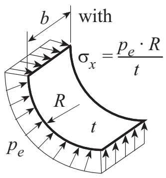
	F_1 (2)	Edge stiffener
Stiffeners sniped at both ends	1.00	
Guidance values where both ends are effectively connected to adjacent structures(1)	1.05	Flat bar
	1.10	Bulb section
	1.20	Angle and tee-sections
	1.30	Girders of high rigidity (e.g. bottom transverses)

(1) Exact values may be determined by direct calculations.
(2) An average value of F_1 is to be used for plate panels having different edge stiffeners.

Table 3 Buckling and reduction factor for curved plate panel with $R/t \leq 2500$[1]

BLC 1a and 1b have been amended as follows.

Buckling-Load Case	Aspect ratio b/R	Buckling factor K	Reduction factor κ
1a 	$\frac{b}{R} \leq 1.63\sqrt{\frac{R}{t}}$	$K = \frac{b}{\sqrt{R\,t}} + 3\frac{(R\,t)^{0.175}}{b^{0.35}}$	$\kappa_x = 1$ for $\lambda \leq 0.4$[2] $\kappa_x = 1.274 - 0.686 \cdot \lambda$ for $0.4 < \lambda \leq 1.2$ $\kappa_x = \frac{0.65}{\lambda^2}$ for $\lambda > 1.2$
1b  p_e = external pressure in [N/mm²]	$\frac{b}{R} > 1.63\sqrt{\frac{R}{t}}$	$K = 0.3\frac{b^2}{R^2} + 2.25\left(\frac{R^2}{b\,t}\right)^2$	

Buckling-Load Case	Aspect ratio b/R	Buckling factor K	Reduction factor κ
1a 	$\frac{b}{R} \leq 1.63\sqrt{\frac{R}{t}}$	$K = \frac{b}{\sqrt{R\,t}} + 3\frac{(R\,t)^{0.175}}{b^{0.35}}$	$\kappa_x = 1$ for $\lambda \leq 0.4$[2] $\kappa_x = 1.274 - 0.686 \cdot \lambda$ for $0.4 < \lambda \leq 1.2$ $\kappa_x = \frac{0.65}{\lambda^2}$ for $\lambda > 1.2$
1b  p_e = external pressure in [N/mm²]	$\frac{b}{R} > 1.63\sqrt{\frac{R}{t}}$	$K = 0.3\frac{b^2}{R^2} + 2.25\left(\frac{R^2}{b\,t}\right)^2$	

Section 4 PRIMARY SUPPORTING MEMBERS

1. General

1.1 Application

Paragraph 1.1.1 has been amended as follows.

1.1.1

The requirements of this Section apply to the strength check of pillars and primary supporting members, subjected to lateral pressure ~~and~~ and/or hull girder normal stresses for such members contributing to the hull girder longitudinal strength.

The yielding check is also to be carried out for such members subjected to specific loads, such as concentrated loads.

1.3 Primary supporting members for ships of 150 *m* or more in length (*L*)

Paragraph 1.3.1 has been amended as follows.

1.3.1

For primary supporting members for ships having a length (*L*) of 150 *m* or more, the direct strength analysis is to be carried out according to the provisions specified in **Ch 7**, and the requirements in **4** are also to be complied with. In addition, the primary supporting members for *BC-A* and *BC-B* ships are to comply with the requirements in **3** ~~**and 4**~~.

2. Scantling of primary supporting members for ships of less than 150 *m* in length (*L*)

2.3 Floors

Paragraph 2.3.1 has been amended as follows.

2.3.1 Net web thickness

The net thickness of floors in the double bottom structure, in *mm*, is not to be less than the greatest of ~~either of the value~~ values t_1 to t_3 specified in the ~~followings~~ following according to each location:

$$t_1 = C_2 \frac{pSB_{DB}}{(d_0 - d_1)\tau_a} \left(\frac{2|y|}{B'_{DB}} \right) \left\{ 1 - 2\left(\frac{x - x_c}{l_{DB}} \right)^2 \right\}$$

where $|x - x_c|$ is less than $0.25\ell_{DB}$, $|x - x_c|$ is to be taken as $0.25\ell_{DB}$, and where $|y|$ is less than $B'_{DB}/4$, $|y|$ is to be taken as $\cancel{b'/4}$ $\underline{B'_{DB}/4}$

$$t_2 = 1.75 \sqrt[3]{\frac{H^2 a^2 \tau_a}{C'_2} t_1}$$

$$t_3 = \frac{8.5 S_2}{\sqrt{k}}$$

where:

S : Spacing of solid floors, in m

d_0 : Depth of the solid floor at the point under consideration in m

d_1 : Depth of the opening, if any, at the point under consideration in m

B'_{DB} : Distance between toes of hopper tanks at the position of the solid floor under consideration, in m

C_2 : Coefficient obtained from **Table 5** depending on B_{DB} / ℓ_{DB}. For intermediate values of B_{DB} / ℓ_{DB}, C_2 is to be obtained by linear interpolation

p, B_{DB}, x_c, ℓ_{DB} : As defined in **2.2.1**

a : Depth of the solid floor at the point under consideration, in m. However, where horizontal stiffeners are fitted on the floor, a is the distance from the horizontal stiffener under consideration to the bottom shell plating or the inner bottom plating or the distance between the horizontal stiffeners under consideration

S_1 : Spacing, in m, of vertical ordinary stiffeners or girders

C_2' : Coefficient given in **Table 6** depending on S_1/d_0. For intermediate values of S_1/d_0, C_2' is to be determined by linear interpolation.

H : Value obtained from the following formulae:

(a) where openings with reinforcement or no opening are provided on solid floors:

i) where slots without reinforcement are provided:

$$H = \sqrt{4.0 \frac{d_2}{S_1} - 1.0}$$, without being taken less than 1.0

ii) where slots with reinforcement are provided: $H = 1.0$

(b) where openings without reinforcement are provided on solid floors:

i) where slots without reinforcement are provided:

$$H = \left(1 + 0.5 \frac{\phi}{d_0}\right) \sqrt{4.0 \frac{d_2}{S_1} - 1.0}$$, without being taken less than $1 + 0.5 \frac{\phi}{d_0}$

ii) where slots with reinforcement are provided:

$$H = 1 + 0.5 \frac{\phi}{d_0}$$

d_2 : Depth of slots without reinforcement provided at the upper and lower parts of solid floors, in m, whichever is greater

ϕ : Major diameter of the openings, in m

S_2 : The smaller of S_1 or a, in m.

Table 5 Coefficient C_2

$\frac{B_{DB}}{\ell_{DB}}$	0.4 and under	0.6	0.8	1.0	1.2	1.4	1.6 and over
C_2	0.48	0.47	0.45	0.43	0.40	0.37	0.34

Table 6 Coefficient C_2'

S_1 / d_0	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4 and over
C_2'	64	38	25	19	15	12	10	9	8	7

Chapter 7 DIRECT STRENGTH ANALYSIS

Section 4 HOT SPOT STRESS ANALYSIS FOR FATIGUE STRENGTH ASSESSMENT

3. Hot spot stress

3.3 Simplified method for the bilge hopper knuckle part

3.3.3

Table 1 has been amended as follows.

Table 1 Stress concentration factor K_0

~~Plate thickness~~ Plate net thickness in FE model t (mm)	Angle of hopper slope plate to the horizontal θ (deg)			
	40	45	50	90
16	3.0	3.2	3.4	4.2
18	2.9	3.1	3.3	4.0
20	2.8	3.0	3.2	3.8
22	2.7	2.9	3.1	3.6
24	2.6	2.8	3.0	3.5
26	2.6	2.7	2.9	3.4
28	2.5	2.7	2.8	3.3
30	2.4	2.6	2.7	3.2

Note: Alternatively, K_0 can be determined by the following formula.

$$K_0 = \frac{0.14\theta \cdot (1.15 - 0.0033\theta)}{(0.5t)^{(0.2+0.0028\theta)}}$$

Chapter 8 FATIGUE CHECK OF STRUCTURAL DETAILS

Section 5 STRESS ASSESSMENT OF HATCH CORNERS

2. Nominal stress range

2.1 Nominal stress range due to wave torsional moment

Paragraph 2.1.1 has been amended as follows.

2.1.1

The nominal stress range, in N/mm^2, due to cross deck bending induced by wave torsion to be obtained from the following formula:

$$\Delta\sigma_{WT} = \frac{2}{1000} F_S F_L \frac{Q \cdot B_H}{W_Q}$$

where:

$$Q = \frac{1000\,u}{\dfrac{(B_H + b_S)^3}{12 E I_Q} + \dfrac{2.6 B_H}{E A_Q}}$$

u : Displacement of hatch corner in longitudinal direction, in m, taken equal to:

$$u = \frac{31.2}{1000} \frac{M_{WT}\ \omega}{I_T E\ DOC}$$

DOC : Deck opening coefficient, taken equal to:

$$DOC = \frac{L_C B}{\sum_{i=1}^{n} L_{H,i} B_{H,i}}$$

M_{WT} : Maximum wave torsional moment, in $kN\text{-}m$, defined in **Ch 4**, **Sec 3**, **3.4.1**, with $f_p = 0.5$

F_S : Stress correction factor, taken equal to:

$F_s = 5$

F_L : Correction factor for longitudinal position of hatch corner, taken equal to:

$$F_L = 1.75 \frac{x}{L} \qquad \text{for} \quad 0.57 \le x/L \le 0.85$$

$$F_L = 1.0 \qquad \text{for} \quad x/L < 0.57 \text{ and } x/L > 0.85$$

B_H : Breadth of hatch opening, in m

W_Q : Section modulus of the cross deck about z-axis, in m^3, including upper stool, near hatch corner (see **Fig. 2**)

I_Q : Moment of inertia of the cross deck about z-axis, in m^4, including upper stool, near the hatch corner (see **Fig. 2**)

A_Q : ~~Shear area~~ Effective shear area of the whole section of the cross deck, in m^2, including upper stool, near the hatch corner (see **Fig. 2**). For the determination of the effective shear area the consideration of only the plate elements is sufficient, and the stiffeners can be neglected.

b_S : Breadth of remaining deck strip on one side, in m, beside the hatch opening

I_T : Torsion moment of inertia of ships cross section, in m^4, calculated within cross deck area by neglecting upper and lower stool of the bulkhead (see **Fig. 1**). It may be calculated according to **App1**

ω : Sector coordinate, in m^2, calculated at the same cross section as I_T and at the Y and Z location of the hatch corner (see **Fig. 1**) It may be calculated according to **App1**

L_C : Length of cargo area, in m, being the distance between engine room bulkhead and collision bulkhead

$B_{H,i}$: Breadth of hatch opening of hatch i, in m

$L_{H,i}$: Length of hatch opening of hatch i, in m

n : Number of hatches.

3. Hot spot stress

3.1 Hot spot stress range

Paragraph 3.1.1 has been amended as follows.

3.1.1

The hot spot stress range, in N/mm^2, is to be obtained from the following formula:

$$\Delta\sigma_W = K_{gh}\,\Delta\sigma_{WT}$$

where:

K_{gh} : Stress concentration factor for the hatch corner, taken equal to:

~~$K_{gh} = \frac{r_a + 2r_b}{3r_a}\left[1+\left(\frac{b}{1.23\ell_{CD}+0.8b}\frac{0.22\ell_{CD}}{r_a}\right)^{0.65}\right]$, to be taken not less than 1.0~~

$$K_{gh} = \frac{r_a + 2r_b}{3r_a}\cdot\left\{1+\left(\frac{2b}{1.23l_{CD}+1.6b}\frac{0.22l_{CD}}{r_a}\right)^{0.65}\right\}$$, to be taken not less than 1.0

r_a : Radius, in m, in major axis

r_b : Radius, in m, in minor axis (if the shape of corner is a circular arc, r_b is to be equal to r_a)

ℓ_{CD} : Length of cross deck, in m, in longitudinal direction

b : Distance, in m, from the edge of hatch opening to the ship's side.

Chapter 9 OTHER STRUCTURES

Section 1 FORE PART

3. Load model

3.2 Pressure in bow area

Paragraph 3.2.1 has been amended as follows.

3.2.1 Lateral pressure in intact conditions

The pressure in bow area, in kN/m^2, is to be taken equal to:

$(p_S + p_W)$

where:

p_S, p_W : Hydrostatic ~~pressure~~ and ~~maximum~~ hydrodynamic pressures ~~among load cases H, F, R and P,~~ according to **Ch 4**, **Sec 5**, <u>or internal still water and inertial pressures according to **Ch 4, Sec 6, 2**, to be considered among load cases H, F, R and P.</u>

5. Strengthening of flat bottom forward area

5.4 Primary supporting members

Paragraph 5.4.1 has been amended as follows.

5.4.1 Girders

The net thickness of girders in double bottom forward area, in *mm*, is not to be less than the greatest of either of the value t_1 to t_3 specified in the followings according to each location:

$$t_1 = \frac{c_A p_{SL} S \ell}{2(d_0 - d_1)\tau_a}$$

$$t_2 = 1.75 \sqrt[3]{\frac{H^2 a^2 \tau_a}{C_1'} t_1}$$

$$t_3 = \frac{C_1'' a}{\sqrt{k}}$$

where:

c_A : Coefficient taken equal to:

$c_A = 3/A$, with $0.3 \le c_A \le 1.0$

A : Loaded area, in m^2, between the supports of the structure considered<u>, obtained from the following formula:</u>

<u>$A = S\,\ell$</u>

p_{SL} : As defined in **3.4**

S : Spacing of centre or side girders under consideration, in *m*

~~ℓ : Spacing of floors under consideration, in m~~

ℓ : Span of centre or side girders between floors under consideration, in m

d_0 : Depth of the centre or side girder under consideration, in m

d_1 : Depth of the opening, if any, at the point under consideration, in m

H : Value obtained from the following formulae:

(a) Where the girder is provided with an unreinforced opening : $H = 1 + 0.5\dfrac{\phi}{\alpha}$

(b) In other cases: $H = 1.0$

ϕ : Major diameter of the openings, in m

α : The greater of a or S_1, in m.

a : Depth of girders at the point under consideration, in m, Where, however, if horizontal stiffeners are fitted on the girder, a is the distance from the horizontal stiffener under consideration to the bottom shell plating or inner bottom plating, or the distance between the horizontal stiffeners under consideration

S_1 : Spacing, in m, of vertical ordinary stiffeners or floors

C_1' : Coefficient obtained from **Table 5** depending on S_1/a. For intermediate values of S_1/a, C_1' is to be determined by linear interpolation.

C_1'' : Coefficient obtained from **Table 6** depending on S_1/a. For intermediate values of S_1/a, C_1'' is to be obtained by linear interpolation.

Table 5 Coefficient C_1'

$\frac{S_1}{a}$	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4 and over
C_1'	64	38	25	19	15	12	10	9	8	7

Table 6 Coefficient C_1''

$\frac{S_1}{a}$		0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6 and over
C_1''	Centre girder	4.4	5.4	6.3	7.1	7.7	8.2	8.6	8.9	9.3	9.6	9.7
	Side girder	3.6	4.4	5.1	5.8	6.3	6.7	7.0	7.3	7.6	7.9	8.0

Paragraph 5.4.2 has been amended as follows.

5.4.2 Floors

The net thickness of floors in double bottom forward area, in mm, is not to be less than the greatest of either of the value t_1 to t_3 specified in the followings according to each location:

$$t_1 = \frac{c_A p_{SL} S\ell}{2(d_0 - d_1)\tau_a}$$

$$t_2 = 1.75\sqrt[3]{\frac{H^2 a^2 \tau_a}{C_2'} t_1}$$

$$t_3 = \frac{8.5S_2}{\sqrt{k}}$$

where :

~~c_A : As defined in **5.4.1**~~

c_A : Coefficient taken equal to:

$c_A = 3/A$, with $0.3 \le c_A \le 1.0$

A : Loaded area, in m^2, between the supports of the structure considered, obtained from the following formula:

$A = S\,\ell$

p_{SL} : As defined in **3.4**

S : Spacing of solid floors under consideration, in *m*

~~ℓ : Spacing of girders under consideration, in *m*~~

ℓ : Span of floors between centre girder and side girder or side girders under consideration, in *m*

d_0 : Depth of the solid floor at the point under consideration in *m*

d_1 : Depth of the opening, if any, at the point under consideration in *m*

H : Value obtained from the following formulae:

a) Where openings with reinforcement or no opening are provided on solid floors:

1) Where slots without reinforcement are provided:

$$H = \sqrt{4.0\frac{d_2}{S_1} - 1.0}$$, without being taken less than 1.0

2) Where slots with reinforcement are provided: $H = 1.0$

b) Where openings without reinforcement are provided on solid floors:

1) Where slots without reinforcement are provided:

$$H = \left(1 + 0.5\frac{\phi}{d_0}\right)\sqrt{4.0\frac{d_2}{S_1} - 1.0}$$, without being taken less than $1 + 0.5\frac{\phi}{d_0}$

2) Where slots with reinforcement are provided:

$$H = 1 + 0.5\frac{\phi}{d_0}$$

d_2 : Depth of slots without reinforcement provided at the upper and lower parts of solid floors, in *m*, whichever is greater

S_1 : Spacing, in *m*, of vertical ordinary stiffeners or girders

ϕ : Major diameter of the openings, in *m*.

a : Depth of the solid floor at the point under consideration, in *m*, Where, however, if horizontal stiffeners are fitted on the floor, a is the distance from the horizontal stiffener under consideration to the bottom shell plating or the inner bottom plating or the distance between the horizontal stiffeners under consideration

S_2 : The smaller of S_1 or a, in *m*

C_2' : Coefficient given in **Table 7** depending on S_1/d_0. For intermediate values of S_1/d_0, C_2' is to be determined by linear interpolation.

Table 7 Coefficient C_2'

S_1/d_0	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4 and over
C_2'	64	38	25	19	15	12	10	9	8	7

Section 2 AFT PART

2. Load model

2.2 Lateral pressures

Paragraph 2.2.1 has been amended as follows.

2.2.1 Lateral pressure in intact conditions

The aft part lateral pressure in intact conditions, in kN/m^2, is to be taken equal to:

$(p_S + p_W)$

where:

p_S, p_W : Hydrostatic ~~pressure~~ and ~~maximum~~ hydrodynamic pressures ~~among load cases H, F, R and P,~~ according to **Ch 4**, **Sec 5**, or internal still water and inertial pressures according to **Ch 4, Sec 6, 2**, to be considered among load cases H, F, R and P.

4. Scantlings

Title of 4.1 has been amended as follows.

4.1 ~~Side plating~~ Plating

Section 3 MACHINERY SPACE

1. General

1.2 Scantlings

Paragraph 1.2.1 has been amended as follows.

1.2.1 Net scantlings

As specified in **Ch 3**, **Sec 2** all scantlings referred to in this Section are net, i.e. they do not include any margin for corrosion.

The gross scantlings are obtained as specified in ~~**Ch 3**, **Sec 3**~~ <u>**Ch 3**, **Sec 2, 3.1**</u>.

Section 4 SUPERSTRUCTURES AND DECKHOUSES

1. General

1.1 Definitions

Paragraph 1.1.3 has been amended as follows.

1.1.3 Long deckhouse

A long deckhouse is a deckhouse the length of which within 0.4*L* amidships exceeds 0.2*L*~~ or 12 *m*, whichever is the greater~~. The strength of a long deckhouse is to be specially considered.

Paragraph 1.1.5 has been amended as follows.

1.1.5 Non-effective superstructure

For the purpose of this section, all superstructures being located beyond 0.4*L* amidships or having a length of less than 0.15*L*~~ or less than 12 *m*~~ are considered as non-effective superstructures.

Paragraph 1.1.7 has been amended as follows.

<u>1.1.7 Effective superstructure</u>

<u>Effective superstructure is a superstructure not covered by the definition given in **1.1.5**.</u>

Chapter 10 HULL OUTFITTING

Section 1 RUDDER AND MANOEUVRING ARRANGEMENT

3. Scantlings of the rudder stock

3.1 Rudder stock diameter

Paragraph 3.1.1 has been amended as follows.

3.1.1

The diameter of the rudder stock, in ~~m~~ mm, for transmitting the rudder torque is not to be less than:

$$D_t = 4.2\,\sqrt[3]{Q_R\,k_r}$$

where:

Q_R : As defined in **2.1.2**, **2.2.2** and **2.2.3**

The related torsional stress, in N/mm^2, is:

$$\tau_t = \frac{68}{k_r}$$

where:

k_r : As defined in **1.4.2** and **1.4.3**.

3.3 Analysis

Paragraph 3.3.2 has been amended as follows.

3.3.2 Data for the analysis

ℓ_{10} ,.., ℓ_{50} : Lengths, in m, of the individual girders of the system

I_{10} ,.., I_{50} : Moments of inertia of these girders, in cm^4

For rudders supported by a sole piece the length ℓ_{20} is the distance between lower edge of rudder body and centre of sole piece, and I_{20} is the moment of inertia of the pintle in the sole piece.

Load on rudder body, in kN/m, (general):

$$p_R = \frac{C_R}{\ell_{10}\cdot 10^3}$$

Load on semi-spade rudders, in kN/m:

$$p_{R10} = \frac{C_{R2}}{\ell_{10}\cdot 10^3}$$

$$p_{R20} = \frac{C_{R1}}{\ell_{20}\cdot 10^3}$$

C_R, C_{R1}, C_{R2} : As defined in **2.1** and **2.2**

Z : Spring constant, in kN/m, of support in the sole piece or rudder horn respectively: for the support in the sole piece (see **Fig. 3**):

$$Z = \frac{6.18\, I_{50}}{\ell_{50}^3}$$

for the support in the rudder horn (see **Fig. 4**):

$$Z = \frac{1}{f_b + f_t}$$

f_b : Unit displacement of rudder horn, in *m/kN*, due to a unit force of 1*kN* acting in the centre of support

$$f_b = \frac{1.3\, d^3\, 10^8}{3\, E\, I_n}$$

$$f_b = 0.21 \frac{d^3}{I_n} \qquad \text{(guidance value for steel)}$$

I_n : Moment of inertia of rudder horn, in cm^4, around the *x*-axis at *d*/2 (see **Fig. 4**)

f_t : Unit displacement due to a torsional moment of the amount 1, in *m/kN*

$$f_t = \frac{d\, e^2}{G\, J_t}$$

$$\cancel{f_t = \frac{d\, e^2 \sum u_i / t_i}{3.17 \cdot 10^8\, F_T^2}} \quad \underline{f_t = \frac{d\, e^2 \sum u_i / t_i}{3.14 \cdot 10^8\, F_T^2}} \quad \text{for steel}$$

G : Modulus of rigity, kN/m^2:

$G = 7.92 \cdot 10^7$ for steel

J_t : Torsional moment of inertia, in m^4

F_T : Mean sectional area of rudder horn, in m^2

u_i : Breadth, in *mm*, of the individual plates forming the mean horn sectional area

t_i : Plate thickness of individual plate having breadth u_i, in *mm*

e, d : Distances, in *m*, according to **Fig. 4**

K_{11}, K_{22}, K_{12} : Rudder horn compliance constants calculated for rudder horn with 2-conjugate elastic supports (**Fig.5**).The 2-conjugate elastic supports are defined in terms of horizontal displacements, y_i, by the following equations:

at the lower rudder horn bearing:

$\cancel{y_1 = - K_{12}\, F_{A2} - K_{22}\, F_{A1}}$ $\quad \underline{y_1 = - K_{12}\, B_2 - K_{22}\, B_1}$

at the upper rudder horn bearing:

$\cancel{y_2 = - K_{11}\, F_{A2} - K_{12}\, F_{A1}}$ $\quad \underline{y_2 = - K_{11}\, B_2 - K_{12}\, B_1}$

where

y_1, y_2 : Horizontal displacements, in *m*, at the lower and upper rudder horn bearings, respectively

$\cancel{F_{A1}, F_{A2}}$ $\underline{B_1, B_2}$: Horizontal support forces, in *kN*, at the lower and upper rudder horn bearings, respectively

K_{11}, K_{22}, K_{12} : Obtained, in *m/kN*, from the following formulae:

$$K_{11} = 1.3 \frac{\lambda^3}{3EJ_{1h}} + \frac{e^2 \lambda}{GJ_{th}}$$

$$K_{12} = 1.3 \left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2 (d - \lambda)}{2EJ_{1h}} \right] + \frac{e^2 \lambda}{GJ_{th}}$$

$$K_{22} = 1.3\left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2(d-\lambda)}{EJ_{1h}} + \frac{\lambda(d-\lambda)^2}{EJ_{1h}} + \frac{(d-\lambda)^3}{3EJ_{2h}}\right] + \frac{e^2 d}{GJ_{th}}$$

d : Height of the rudder horn, in *m*, defined in **Fig. 5**. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, till the mid-line of the lower rudder horn pintle

λ : Length, in *m*, as defined in **Fig. 5**. This length is measured downwards from the upper rudder horn end, at the point of curvature transition, till the mid-line of the upper rudder horn bearing. For $\lambda = 0$, the above formulae converge to those of spring constant *Z* for a rudder horn with 1-elastic support, and assuming a hollow cross section for this part

e : Rudder-horn torsion lever, in *m*, as defined in **Fig. 5** (value taken at $z = d/2$)

J_{1h} : Moment of inertia of rudder horn about the *x* axis, in m^4, for the region above the upper rudder horn bearing. Note that J_{1h} is an average value over the length λ (see **Fig. 5**)

J_{2h} : Moment of inertia of rudder horn about the *x* axis, in m^4, for the region between the upper and lower rudder horn bearings. Note that J_{2h} is an average value over the length $d - \lambda$ (see **Fig. 5**)

J_{th} : Torsional stiffness factor of the rudder horn, in m^4

For any thin wall closed section

$$J_{th} = \frac{4F_T^2}{\sum_i \frac{u_i}{t_i}}$$

F_T : Mean of areas enclosed by outer and inner boundaries of the thin walled section of rudder horn, in m^2

u_i : Length, in *mm*, of the individual plates forming the mean horn sectional area

t_i : Thickness, in *mm*, of the individual plates mentioned above.

Note that the J_{th} value is taken as an average value, valid over the rudder horn height.

3.4 Rudder trunk supporting rudder stock

Paragraph 3.4.4 has been amended as follows.

3.4.4

The weld at the connection between the rudder trunk and the shell or the bottom of the skeg is to be full penetration.

The fillet shoulder radius *r*, in *mm*, is to be as large as practicable and to comply with the following formulae:

$r = 60$ when $\sigma \geq 40 / k$ N/mm^2

$r = 0.1D_1$, without being less than 30, when $\sigma < 40 / k$ N/mm^2

~~without being less than 30,~~

where D_1 is defined in **3.2.1**.

The radius may be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld.

The radius is to be checked with a template for accuracy. Four profiles at least are to be checked. A report is to be submitted to the Surveyor.

5. Rudder body, rudder bearings

5.1 Strength of rudder body

Paragraph 5.1.3 has been amended as follows.

5.1.3

For rudder bodies without cut-outs the permissible stress are limited to:

- bending stress, in N/mm^2, due to M_R defined in **3.3.3**:
  $\sigma_b = 110$
- shear stress, in N, due to Q_1 defined in **3.3.3**:
  $\tau_t = 50$
- equivalent stress due to bending and shear:
  $\cancel{\sigma_v = \sqrt{\sigma^2_b + 3\tau^2} = 120}$ $\underline{\sigma_v = \sqrt{\sigma_b{}^2 + 3\tau^2} = 120}$

In case of openings in the rudder plating for access to cone coupling or pintle nut the permissible stresses according to **5.1.4** apply. Smaller permissible stress values may be required if the corner radii are less than $0.15h_o$, where h_o is the height of opening.

5.2 Rudder plating

Paragraph 5.2.1 has been amended as follows.

5.2.1

The thickness of the rudder plating, in *mm*, is to be determined according to the following formula:

$$\cancel{t_P = 1.74a\sqrt{p_R k} + 2.5} \quad \underline{t_P = 1.74a\beta\sqrt{p_R k} + 2.5}$$

where:

$p_R = 10T + \dfrac{C_R}{10^3 A}$, in kN/m^2

a : Smaller unsupported width of a plate panel, in *m*.

~~The influence of the aspect ratio of the plate panels may be taken into account according to **Ch 3**.~~

$$\underline{\beta = \sqrt{1.1 - 0.5\left(\frac{a}{b}\right)^2} \quad \text{max, 1.0, if } \frac{b}{a} \geq 2.5}$$

<ins>b : greatest unsupported width of a plate panel, in *m*.</ins>

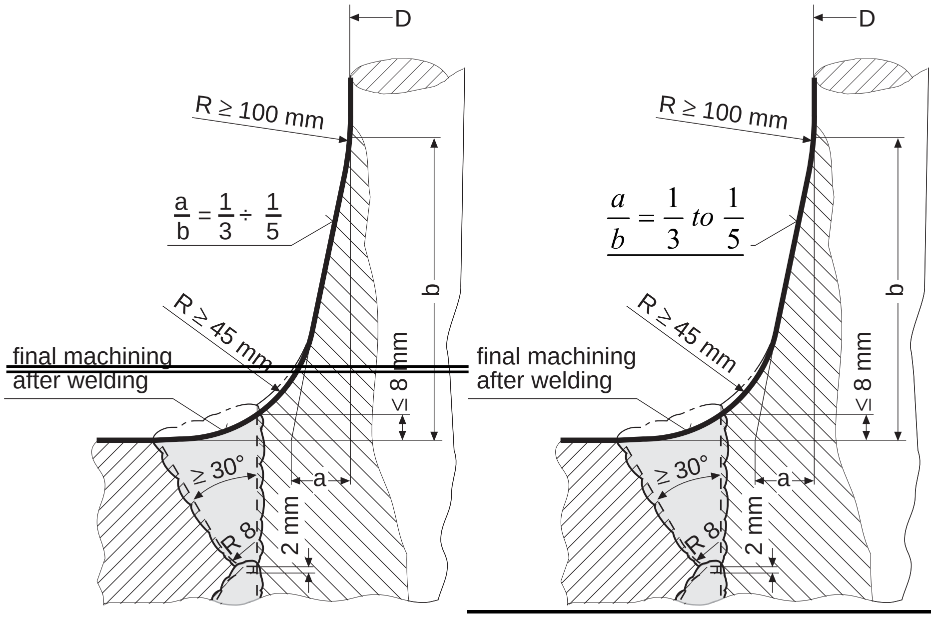
However, the thickness is to be not less than the thickness of the shell plating at aft part according to **Ch 9**, **Sec 2**.

Regarding dimensions and welding, **10.1.1** is to be comply with.

10. Rudder coupling flanges

Fig. 21 has been amended as follows.

Fig. 21 Welded joint between rudder stock and coupling flange



Chapter 11 CONSTRUCTION AND TESTING

Section 2 WELDING

2. Types of welded connections

2.6 Fillet welds

Table 1 has been amended as follows.

Table 1 Categories of fillet welds

Category	Kinds of fillet welds	As-built thickness of abutting plate, t, in *mm*(1)	Leg length of fillet weld, in *mm*(2)	Length of fillet welds, in *mm*	Pitch, in *mm*
$F0$	Double continuous weld	t	$0.7t$	-	-
$F1$	Double continuous weld	$t \leq 10$	$0.5t + 1.0$	-	-
		$10 \leq t < 20$	$0.4t + 2.0$	-	-
		$20 \leq t$	$0.3t + 4.0$	-	-
$F2$	Double continuous weld	$t \leq 10$	$0.4t + 1.0$	-	-
		$10 \leq t < 20$	$0.3t + 2.0$	-	-
		$20 \leq t$	$0.2t + 4.0$	-	-
$F3$	Double continuous weld	$t \leq 10$	$0.3t + 1.0$	-	-
		$10 \leq t < 20$	$0.2t + 2.0$		
		$20 \leq t$	$0.1t + 4.0$		
$F4$	Intermittent weld	$t \leq 10$	$0.5t + 1.0$	75	300
		$10 \leq t < 20$	$0.4t + 2.0$		
		$20 \leq t$	$0.3t + 4.0$		

(1) t is as-built thickness of the thinner of two connected members

(2) Leg length of fillet welds is made fine adjustments corresponding to the corrosion addition t_C specified in **Ch 3**, **Sec 3**, **Table 1** as follows:

+ 1.0 *mm* for $t_C > 5$
+ 0.5 *mm* for $5 \geq t_C > 4$
+ 0.0 *mm* for $4 \geq t_C > 3$
- 0.5 *mm* for $t_C \leq 3$

(3) The weld sizes are to be rounded to the nearest half millimeter.

Paragraph 2.6.2 has been amended as follows.

2.6.2 Intermittent welds

Where double continuous fillet welds in lieu of intermittent welds are applied, leg length of fillet welds is to be of category ~~$F2$~~ $F3$.

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 1 April 2006.

2. Notwithstanding the amendments to the Rules, the current requirements may apply to ships for which the date of contract for construction* is before the effective date.
*“contract for construction” is defined in the latest version of IACS Procedural Requirement(PR) No.29.

IACS PR No.29 (Rev.4)

1. The date of “contract for construction” of a vessel is the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the vessels included in the contract are to be declared to the classification society by the party applying for the assignment of class to a newbuilding.

2. The date of “contract for construction” of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.
For the purpose of this Procedural Requirement, vessels built under a single contract for construction are considered a “series of vessels” if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:
(1) such alterations do not affect matters related to classification, or
(2) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval.
The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

3. If a contract for construction is later amended to include additional vessels or additional options, the date of “contract for construction” for such vessels is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract is to be considered as a “new contract” to which **1.** and **2.** above apply.

4. If a contract for construction is amended to change the ship type, the date of “contract for construction” of this modified vessel, or vessels, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

Notes:
1. This Procedural Requirement applies to all IACS Members and Associates.
2. This Procedural Requirement is effective for ships “contracted for construction” on or after 1 January 2005.
3. Revision 2 of this Procedural Requirement is effective for ships “contracted for construction” on or after 1 April 2006.
4. Revision 3 of this Procedural Requirement was approved on 5 January 2007 with immediate effect.
5. Revision 4 of this Procedural Requirement was adopted on 21 June 2007 with immediate effect.