Common Structural Rules for Bulk Carriers, January 2006

Corrigenda 2
Rule Editorials

Notes: (1) These Rule Corrigenda enter into force on 1 April 2006.
(2) This document contains a copy of the affected rule along with the editorial change or clarification noted as applicable.

CHAPTER 3 – STRUCTURAL DESIGN PRINCIPLES

SECTION 6 STRUCTURAL ARRANGEMENT PRINCIPLES

7. Double side structure

7.1 Application

7.1.1

The requirement of this article applies to longitudinally or transversely framed side structure.

The transversely framed side structures are built with transverse frames possibly supported by horizontal side girders.

The longitudinally framed side structures are built with longitudinal ordinary stiffeners supported by vertical primary supporting members.

The side within the hopper and topside tanks is, in general, to be longitudinally framed. It may be transversely framed when this accepted for the double bottom and the deck according to ~~6.1.1~~ **6.1.2** and 9.1.1 respectively.

Reason for the Rule Clarification:

Editorial correction – incorrect reference.

10. Bulkhead structure

10.4 Corrugated bulkheads

10.4.1 General

For ships of 190m of length *L* and above, the transverse vertically corrugated watertight bulkheads are to be fitted with a lower stool, and **generally** with an upper stool below ~~the~~ deck. **For ships less than 190m in length *L*,** ~~In ships less than 150 m in length,~~ corrugations may extend from ~~the~~ inner bottom to ~~the~~ deck **provided the global strength of hull structures are satisfactorily proved for ships having ship length *L* of 150m and above by DSA as required by Ch 7 of the Rules.**

Reason for the Rule Clarification:

The correction is made to be in line with IACS UR S18.

10.4.8 Upper stool

The upper stool, when fitted, is to have a height in general between two and three times the depth of corrugations. Rectangular stools are to have a height in general equal to twice the depth of corrugations, measured from the deck level and at the hatch side girder.

The upper stool of transverse bulkhead is to be properly supported by deck girders or deep brackets between the adjacent hatch end beams.

The width of the upper stool bottom plate is generally to be the same as that of the lower stool top plate. The stool ~~bottom~~ **top** of non-rectangular stools is to have a width not less than twice 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 to be not less than 80% of that required for the upper part of the bulkhead plating where the same material is used.

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

The stool is to be fitted with diaphragms in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders or transverse deck primary supporting members as the case may be, 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.

Reason for the Rule Clarification:

Editorial correction

CHAPTER 4 – DESIGN LOADS

SECTION 3 HULL GIRDER LOADS

1. General

1.1 Sign conversions of bending moments and shear forces

1.1.1

Absolute values are to be taken for bending moments and shear forces introduced in this Section. The sign of bending moments and shear forces is to be considered according to Sec 4, Tab 3. The sign conventions of vertical bending moments, horizontal bending moments and shear forces at any ship transverse section are as shown in Fig 1, namely:

- the vertical bending moments M_{SW} and M_{WV} are positive when they induce tensile stresses in the strength deck (hogging bending moment) and are negative in the opposite case (sagging bending moment)
- the horizontal bending moment M_{WH} is positive when it induces tensile stresses in the starboard and is negative in the opposite case.
- the vertical shear forces ~~Q~~ Q_{SW}, Q_{WV} ~~is~~ **are** positive in the case of downward resulting forces preceding and upward resulting forces following the ship transverse section under consideration, and is negative in the opposite case.

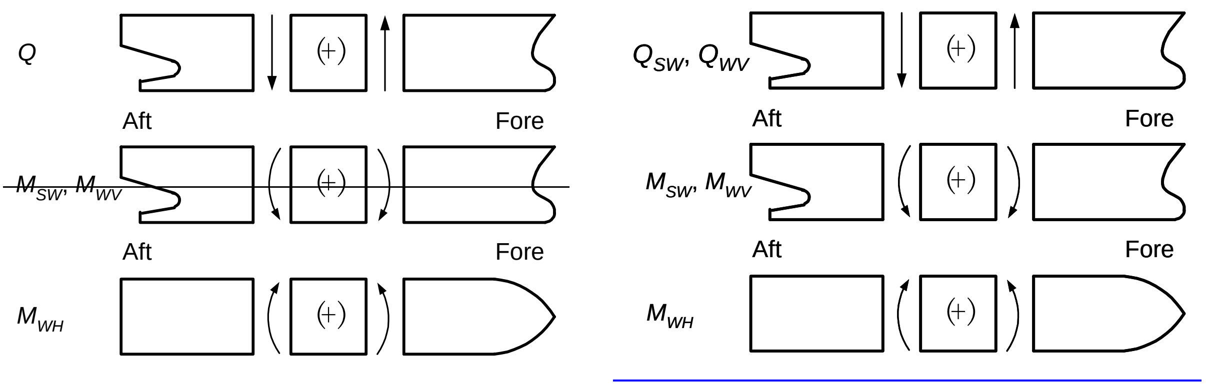

Figure 1: Sign conventions for shear forces ~~Q~~ Q_{SW}, Q_{WV} and bending moments M_{SW}, M_{WV} and M_{WH}

Reason for the Rule Clarification:

Editorial correction

CHAPTER 5 – HULL GIRDER STRENGTH

SECTION 1 YIELDING CHECK

2. Hull girder stresses

2.2 Shear stresses

2.2.2 Simplified calculation of shear stresses induced by vertical shear force

The shear stresses induced by the vertical shear forces in the calculation point are obtained, in N/mm², from the following formula:

…………….

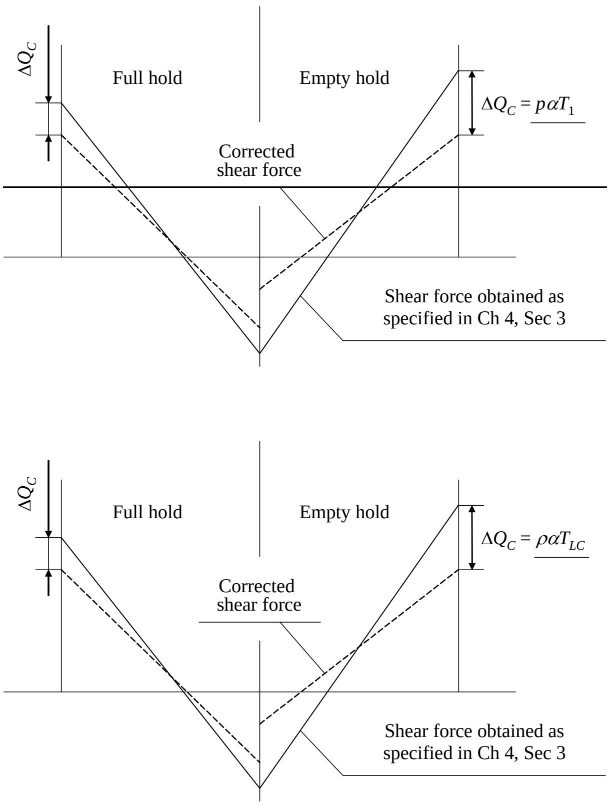

Figure 2 : Shear force correction ΔQ_C

Reason for the Rule Clarification:

Editorial correction – correction of equation in Figure 2

4. Section modulus and moment of inertia

4.4 Midship section moment of inertia

4.4.1

The net midship section moment of inertia about its horizontal neutral axis is to be not less than the value obtained, in m4, from the following formula:

$$I_{YR} = 3Z'_{R,MIN} L \cdot 10^{-2}$$

where $Z'_{R,MIN}$ is the required net midship section modulus $Z_{R,MIN}$, in m3, calculated as specified in **[4.2.1]** ~~or [4.2.2]~~, but assuming $k = 1$.

Reason for the Rule Clarification:

The correction is made to be in line with IACS UR.

CHAPTER 5 – HULL GIRDER STRENGTH

APPENDIX 1 HULL GIRDER ULTIMATE STRENGTH

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

2.2 Load-end shortening curves σ-ε

2.2.4 Beam column buckling

The equation describing the load-end shortening curve σ_{CR1}-ε for the beam column buckling of ordinary stiffeners composing the hull girder transverse section is to be obtained from the following formula (see Fig 3):

$$\sigma_{CR1} = \Phi \sigma_{C1} \frac{A_{Stif} + 10 b_E t_p}{A_{Stif} + 10 s t_p}$$

where:

Φ : Edge function defined in [2.2.3]

A_{Stif}: Net sectional area of the stiffener, in cm², without attached plating

σ_{C1} : Critical stress, in N/mm², equal to:

$$\sigma_{C1} = \frac{\sigma_{E1}}{\varepsilon} \qquad \text{for } \sigma_{E1} \le \frac{R_{eH}}{2}\varepsilon$$

$$\sigma_{C1} = R_{eH}\left(1 - \frac{\Phi R_{eH}\, \varepsilon}{4\sigma_{E1}}\right) \qquad \text{for } \sigma_{E1} > \frac{R_{eH}}{2}\varepsilon$$

ε : Relative strain defined in [2.2.3]

σ_{E1} : Euler column buckling stress, in N/mm², equal to:

$$\sigma_{E1} = \pi^2 E \frac{I_E}{A_E l^2} 10^{-4}$$

I_E : Net moment of inertia of ordinary stiffeners, in cm⁴, with attached shell plating of width b_{E1}

b_{E1} : Effective width, in m, of the attached shell plating, equal to:

$$b_{E1} = \frac{s}{\beta_E} \qquad \text{for } \beta_E > 1.0$$

$$b_{E1} = s \qquad \text{for } \beta_E \le 1.0$$

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

A_E : Net sectional area, in cm², of ordinary stiffeners with attached shell plating of width b_E

b_E : Effective width, in m, of the attached shell plating, equal to:

$$b_E = \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2}\right)s \qquad \text{for } \beta_E > 1.25$$

$b_E = s$ for $\beta_E \leq 1.25$

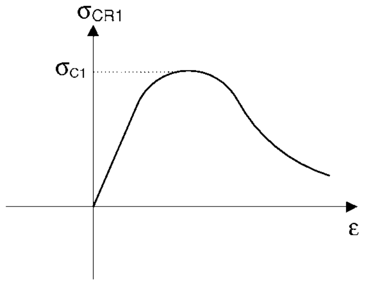

Figure 3 Load-end shortening curve σ_{CR1}-ε for beam column buckling

Reason for the Rule Clarification:

Editorial correction of formula.

2.2.5 Torsional Buckling

The equation describing the load-end shortening curve σ_{CR2}-ε for the flexural-torsional buckling of ordinary stiffeners composing the hull girder transverse section is to be obtained according to the following formula (see Fig 4).

$$\sigma_{CR2} = \Phi \frac{A_{Stif}\sigma_{C2} + 10 s t_p \sigma_{CP}}{A_{Stif} + 10 s t_p}$$

where:

Φ : Edge function defined in [2.2.3]

A_{Stif}: Net sectional area of the stiffener, in cm^2, without attached plating

σ_{C2} : Critical stress, in N/mm^2, equal to:

$$\sigma_{C2} = \frac{\sigma_{E2}}{\varepsilon} \quad \text{for } \sigma_{E2} \leq \frac{R_{eH}}{2}\varepsilon$$

$$\sigma_{C2} = R_{eH}\left(1 - \frac{\Phi R_{eH}\ \varepsilon}{4\sigma_{E2}}\right) \quad \text{for } \sigma_{E2} > \frac{R_{eH}}{2}\varepsilon$$

σ_{E2} : Euler torsional buckling stress, in N/mm^2, defined in Ch 6, Sec 3, [4.3]

ε : Relative strain defined in [2.2.3]

σ_{CP} : Buckling stress of the attached plating, in N/mm^2, equal to:

$$\sigma_{CP} = \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2}\right)R_{eH} \quad \text{for } \beta_E > 1.25$$

$$\sigma_{CP} = R_{eH} \quad \text{for } \beta_E \leq 1.25$$

β_E : Coefficient defined in [2.2.4]

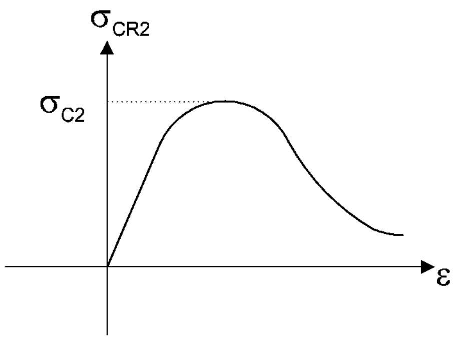

Figure 4 Load-end shortening curve σ_{CR2}-ε for flexural-torsional buckling

Reason for the Rule Clarification:

Editorial correction of formula.

2.2.7 Web local buckling of ordinary stiffeners made of flat bars

The equation describing the load-end shortening curve σ_{CR4}-ε for the web local buckling of flat bar ordinary stiffeners composing the hull girder transverse section is to be obtained from the following formula (see Fig 5):

$$\sigma_{CR4} = \Phi \frac{10 s t_P \sigma_{CP} + A_{Stif} \sigma_{C4}}{A_{Stif} + 10 s t_P}$$

where:

Φ : Edge function defined in [2.2.3]

A_{Stif}: Net sectional area of the stiffener, in cm², without attached plating

σ_{CP} : Buckling stress of the attached plating, in N/mm², defined in [2.2.5]

σ_{C4} : Critical stress, in N/mm², equal to:

$$\sigma_{C4} = \frac{\sigma_{E4}}{\varepsilon} \quad \text{for } \sigma_{E4} \le \frac{R_{eH}}{2}\varepsilon$$

$$\sigma_{C4} = R_{eH}\left(1 - \frac{\Phi R_{eH}\,\varepsilon}{4\sigma_{E4}}\right) \quad \text{for } \sigma_{E4} > \frac{R_{eH}}{2}\varepsilon$$

σ_{E4} : Local Euler buckling stress, in N/mm², equal to:

$$\sigma_{E4} = 160000\left(\frac{t_w}{h_w}\right)^2$$

ε : Relative strain defined in [2.2.3].

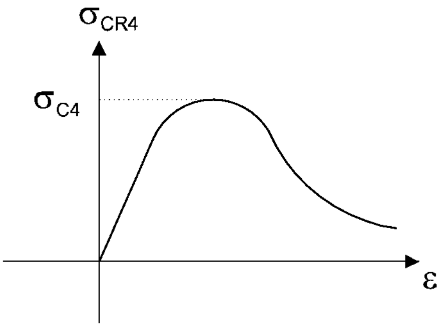

Figure 5 Load-end shortening curve σ_{CR4}-ε for web local buckling

Reason for the Rule Clarification:

Editorial correction of formula.

CHAPTER 6 – HULL SCANTLINGS

SECTION 1 PLATING

2. General requirements

2.5 Sheerstrake

2.5.1 Welded sheerstrake

The net thickness of a welded sheerstrake is to be not less than the actual **net** thicknesses of the adjacent 2 m width side plating, taking into account higher strength steel corrections if needed.

Reason for the Rule Clarification:

Editorial correction

SECTION 2 ORDINARY STIFFENERS

3. Yielding check

3.3 Strength criteria for single span ordinary stiffeners other than side frames of single side bulk carriers

3.3.2 Supplementary strength requirements

In addition to [3.3.1], the net moment of inertia, in cm^4, of the 3 side frames located immediately abaft the collision bulkhead is to be not less than the value obtained from the following formula:

$$I = 0.18 \frac{(p_S + p_W)\ell^4}{n}$$

where:

ℓ : Side frame span, in m

n : Number of frames from the bulkhead to the frame in question, taken equal to 1, 2 or 3

~~s : Frame spacing, in m~~

As an alternative, supporting structures, such as horizontal stringers, are to be fitted between the collision bulkhead and a side frame which is in line with transverse webs fitted in both the topside tank and hopper tank, maintaining the continuity of forepeak stringers within the foremost hold.

Reason for the Rule Clarification:

Editorial correction – definition of frame spacing is deleted.

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

3.4.2

The net connection area, A_i, in cm², of the bracket to the i-th longitudinal stiffener supporting the bracket is to be obtained from the following formula:

$$A_i = 0.4 \frac{w_i s}{\ell_1^2} \frac{k_{bkt}}{k_{lg,i}}$$

where:

w_i : Net section modulus, in cm³, of the i-th longitudinal stiffener of the side or sloped bulkheads that support the lower or the upper end connecting bracket of the side frame, as applicable

ℓ_1 : As defined in [3.4.1]

k_{bkt} : Material factor for the bracket

$k_{lg,i}$: Material factor for the i-th longitudinal stiffener

s : Frame spacing, in m

Reason for the Rule Clarification:

Editorial correction

4. Web stiffeners of primary supporting members

4.1 Net scantlings

4.1.3 Connection ends of web stiffeners

The stress at ends of web stiffeners of primary supporting members in water ballast tanks, in N/mm2, is to comply with the following formula when no bracket is fitted:

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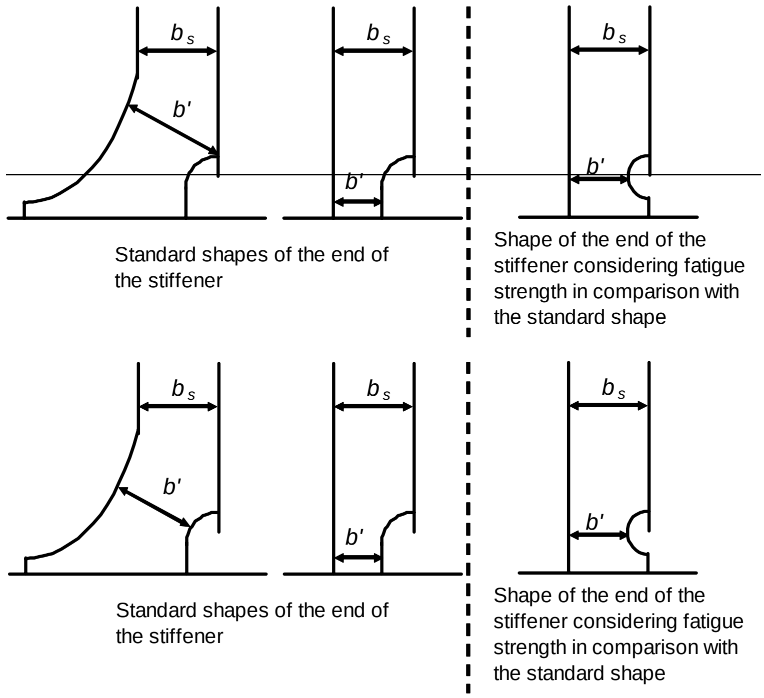

Figure 9 : Shape of the end of the web stiffener

Reason for the Rule Clarification:

Editorial correction – correction of the indication of the smallest breadth (b') shown in the left-hand figure

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

1. General

1.1

1.1.2

The buckling checks have to be performed for the following elements:

a) according to requirements of [2], [3] and [4] and for all load cases as defined in Ch 4, Sec 4 in intact condition:

- Elementary plate panels and ordinary stiffeners in a hull transverse section analysis,
- Elementary plate panels modeled in FEM as requested in Ch 7.

b) according to requirements of [6] and only in flooded condition:

- transverse vertically corrugated watertight bulkheads ~~for BC-A and BC-B ships~~.

Reason for the Rule Clarification:

Editorial correction

4. Buckling criteria of partial and total panels

4.2 Ultimate strength in lateral buckling mode

4.2.2 Evaluation of the bending stress σ_b

The bending stress σ_b, in N/mm², in the stiffeners is equal to:

$$\sigma_b = \frac{M_0 + M_1}{W_{st} 10^3}$$

with:

M_0 : Bending moment, in N.mm, due to the deformation w of stiffener, taken equal to:

$$M_0 = F_{Ki} \frac{p_z w}{c_f - p_z}$$

with $(c_f - p_z) > 0$

M_1 : Bending moment, in N.mm, due to the lateral load p, taken equal to:

$$M_1 = \frac{pba^2}{24 \cdot 10^3} \quad \text{for longitudinal stiffeners}$$

$M_1 = \frac{pa(n \cdot b)^2}{8c_S 10^3}$ for transverse stiffeners, with n equal to 1 for ordinary transverse stiffeners.

W_{st} : Net section modulus of stiffener (longitudinal or transverse), in cm^3, including effective width of plating according to 5, taken equal to:

- if a lateral pressure is applied on the stiffener:

  W_{st} is the net section modulus calculated at flange if the lateral pressure is applied on the same side as the stiffener.

  W_{st} is the net section modulus calculated at attached plate if the lateral pressure is applied on the side opposite to the stiffener.

- if no lateral pressure is applied on the stiffener:

  W_{st} is the minimum net section modulus among those calculated at flange and attached plate

c_S : Factor accounting for the boundary conditions of the transverse stiffener

c_S = 1.0 for simply supported stiffeners

c_S = 2.0 for partially constraint stiffeners

p : Lateral load in kN/m^2, as defined in Ch 4, Sec5 and Ch 4, Sec 6 calculated at the load point as defined in Ch 6, Sec 2, [~~1.4.2~~**1.4**]

F_{Ki} : Ideal buckling force, in N, of the stiffener, taken equal to:

$$F_{Kix} = \frac{\pi^2}{a^2} E I_x 10^4 \quad \text{for longitudinal stiffeners}$$

$$F_{Kiy} = \frac{\pi^2}{(nb)^2} E I_y 10^4 \quad \text{for transverse stiffeners}$$

I_x, I_y : Net moments of inertia, in cm^4, of the longitudinal or transverse stiffener including effective width of attached plating according to 5. I_x and I_y are to comply with the following criteria:

$$I_x \geq \frac{bt^3}{12 \cdot 10^4}$$

$$I_y \geq \frac{at^3}{12 \cdot 10^4}$$

p_z : Nominal lateral load, in N/mm^2, of the stiffener due to σ_x, σ_y and τ

$$p_{zx} = \frac{t_a}{b}\left(\sigma_{xl}\left(\frac{\pi b}{a}\right)^2 + 2c_y\sigma_y + \tau_1\sqrt{2}\right) \quad \text{for longitudinal stiffeners}$$

$$p_{zy} = \frac{t_a}{a}\left(2c_x\sigma_{xl} + \sigma_y\left(\frac{\pi a}{nb}\right)^2\left(1 + \frac{A_y}{at_a}\right) + \tau_1\sqrt{2}\right) \quad \text{for transverse stiffeners}$$

$$\sigma_{xl} = \sigma_x\left(1 + \frac{A_x}{bt_a}\right)$$

t_a : Net thickness offered of attached plate, in mm

c_x, c_y : Factor taking into account the stresses vertical to the stiffener's axis and distributed variable along the stiffener's length taken equal to:

$0.5(1+\psi)$ for $0 \le \psi \le 1$

$\dfrac{0.5}{1-\psi}$ for $\psi < 0$

A_x, A_y : Net sectional area, in mm², of the longitudinal or transverse stiffener respectively without attached plating

$$\tau_1 = \left[\tau - t\sqrt{R_{eH}E\left(\frac{m_1}{a^2}+\frac{m_2}{b^2}\right)}\right] \ge 0$$

m_1, m_2 : Coefficients taken equal to:

for longitudinal stiffeners:

$\dfrac{a}{b} \ge 2.0$: $m_1 = 1.47$ $m_2 = 0.49$

$\dfrac{a}{b} < 2.0$: $m_1 = 1.96$ $m_2 = 0.37$

for transverse stiffeners:

$\dfrac{a}{n \cdot b} \ge 0.5$: $m_1 = 0.37$ $m_2 = \dfrac{1.96}{n^2}$

$\dfrac{a}{n \cdot b} < 0.5$: $m_1 = 0.49$ $m_2 = \dfrac{1.47}{n^2}$

$w = w_0 + w_1$

w_0 : Assumed imperfection, in mm, taken equal to:

$w_0 = \min(\dfrac{a}{250}, \dfrac{b}{250}, 10)$ for longitudinal stiffeners

$w_0 = \min(\dfrac{a}{250}, \dfrac{n \cdot b}{250}, 10)$ for transverse stiffeners

For stiffeners sniped at both ends w_0 must not be taken less than the distance from the midpoint of attached plating to the neutral axis of the stiffener calculated with the effective width of its attached plating.

w_1 : Deformation of stiffener, in mm, at midpoint of stiffener span due to lateral load p. In case of uniformly distributed load the following values for w_1 may be used:

$w_1 = \dfrac{pba^4}{384 \cdot 10^7 EI_x}$ for longitudinal stiffeners

$w_1 = \dfrac{5ap(nb)^4}{384 \cdot 10^7 EI_y c_S^2}$ for transverse stiffeners

c_f : Elastic support provided by the stiffener, in N/mm², taken equal to:

- for longitudinal stiffeners

$$c_f = F_{Kix}\frac{\pi^2}{a^2}(1+c_{px})$$

$$c_{px} = \frac{1}{1 + \dfrac{0.91\left(\dfrac{12 \cdot 10^4 I_x}{t^3 b} - 1\right)}{c_{xa}}}$$

c_{xa} : Coefficient taken equal to :

$$c_{xa} = \left[\frac{a}{2b} + \frac{2b}{a}\right]^2 \quad \text{for} \quad a \geq 2b$$

$$c_{xa} = \left[1 + \left(\frac{a}{2b}\right)^2\right]^2 \quad \text{for} \quad a < 2b$$

- for transverse. stiffeners :

$$c_f = c_S F_{Kiy} \frac{\pi^2}{(n \cdot b)^2}\left(1 + c_{py}\right)$$

$$c_{py} = \frac{1}{1 + \dfrac{0.91\left(\dfrac{12 \cdot 10^4 I_y}{t^3 a} - 1\right)}{c_{ya}}}$$

c_{ya} : Coefficient taken equal to :

$$c_{ya} = \left[\frac{nb}{2a} + \frac{2a}{nb}\right]^2 \quad \text{for} \quad nb \geq 2a$$

$$c_{ya} = \left[1 + \left(\frac{nb}{2a}\right)^2\right]^2 \quad \text{for} \quad nb < 2a$$

Reason for the Rule Clarification:

Editorial correction – error in reference

4.2.3 Equivalent criteria for longitudinal and transverse ordinary stiffeners not subjected to lateral pressure

Longitudinal and transverse ordinary stiffeners not subjected to lateral pressure are considered as complying with the requirement of [4.2.1] if their net moments of inertia I_x and I_y, in cm⁴, are not less than the value obtained by the following formula:

- For longitudinal stiffener :

~~$$I_x = \frac{p_{zx} a^2}{\pi^2 10^4}\left(\frac{w_{0x} h_w}{\frac{R_{eH}}{S} - \sigma_x} + \frac{a^2}{\pi^2 E}\right)$$~~ $$I_x = \frac{p_{zx} a^2}{\pi^2 10^4}\left(\frac{w_0 h_w}{\frac{R_{eH}}{S} - \sigma_x} + \frac{a^2}{\pi^2 E}\right)$$

- For transverse stiffener :

$$\require{cancel}\cancel{I_y = \frac{p_{zy}(nb)^2}{\pi^2 10^4}\left(\frac{w_{0y}h_w}{\frac{R_{eH}}{S}-\sigma_y}+\frac{(nb)^2}{\pi^2 E}\right)} \qquad I_y = \frac{p_{zy}(nb)^2}{\pi^2 10^4}\left(\frac{w_0 h_w}{\frac{R_{eH}}{S}-\sigma_y}+\frac{(nb)^2}{\pi^2 E}\right)$$

Reason for the Rule Clarification:

Editorial correction of symbols in formulae. w_{0y} and w_{0z} corrected to w_0.

4.3 Torsional buckling

4.3.1 Longitudinal stiffeners

The longitudinal ordinary stiffeners are to comply with the following criteria:

$$\frac{\sigma_x S}{\kappa_T R_{eH}} \le 1.0$$

κ_T : Coefficient taken equal to:

$$\kappa_T = 1.0 \text{ for } \lambda_T \le 0.2$$

$$\kappa_T = \frac{1}{\Phi + \sqrt{\Phi^2 - \lambda_T^2}} \text{ for } \lambda_T > 0.2$$

$$\Phi = 0.5\left(1 + 0.21(\lambda_T - 0.2) + \lambda_T^2\right)$$

λ_T : Reference degree of slenderness taken equal to:

$$\lambda_T = \sqrt{\frac{R_{eH}}{\sigma_{KiT}}}$$

$$\sigma_{KiT} = \frac{E}{I_P}\left(\frac{\pi^2 I_\omega 10^2}{a^2}\varepsilon + 0.385 I_T\right) \quad \text{, in N/mm}^2$$

I_P : Net polar moment of inertia of the stiffener, in cm^4, defined in Tab 5, and related to the point C as shown in Fig 2

I_T : Net St. Venant's moment of inertia of the stiffener, in cm^4, defined in Tab 5,

I_ω : Net sectorial moment of inertia of the stiffener, in cm^6, defined in Tab 5, related to the point C as shown in Fig 2

ε : Degree of fixation taken equal to:

$$\varepsilon = 1 + 10^{-3}\sqrt{\frac{a^4}{\frac{3}{4}\pi^4 I_w\left(\frac{b}{t^3} + \frac{4h_w}{3t_w^3}\right)}}$$

A_w : Net web area equal to: $A_w = h_w t_w$

A_f : Net flange area equal to: $A_f = b_f t_f$

$$e_f = h_w + \frac{t_f}{2}\text{, in mm}$$

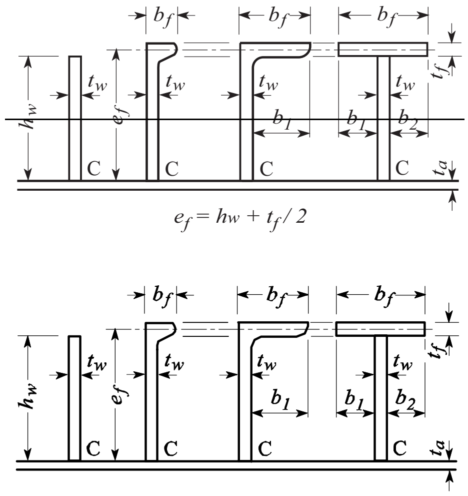

Figure 2: Dimensions of stiffeners

Table 5: Moments of inertia

Profile	I_P	I_T	I_w
Flat bar	$\frac{h_w^3 t_w}{3 \cdot 10^4}$	$\frac{h_w t_w^3}{3 \cdot 10^4}\left(1 - 0.63\frac{t_w}{h_w}\right)$	$\frac{h_w^3 t_w^3}{36 \cdot 10^6}$
Sections with bulb or flange	$\left(\frac{A_w h_w^2}{3} + A_f e_f^2\right)10^{-4}$	$\frac{h_w t_w^3}{3 \cdot 10^4}\left(1 - 0.63\frac{t_w}{h_w}\right)$ + $\frac{b_f t_f^3}{3 \cdot 10^4}\left(1 - 0.63\frac{t_f}{b_f}\right)$	for bulb and angle sections: $\frac{A_f e_f^2 b_f^2}{12 \cdot 10^6}\left(\frac{A_f + 2.6 A_w}{A_f + A_w}\right)$ for tee-sections $\frac{b_f^3 t_f e_f^2}{12 \cdot 10^6}$

Reason for the Rule Clarification:

Editorial correction – delete the definition in the figure.

6. Transverse vertical corrugated watertight bulkhead in flooded conditions ~~for BC-A and BC-B ships~~

Reason for the Rule Clarification:

Editorial correction

SECTION 4 PRIMARY SUPPORTING MEMBERS

3. Additional requirements for primary supporting members of BC-A and BC-B ships

3.1 Evaluation of double bottom capacity and allowable hold loading in flooded conditions

3.1.4 Allowable hold loading

The allowable hold loading is to be obtained, in t, from the following formula:

$$W = \rho_C V \frac{1}{F}$$

where:

F : Coefficient to be taken equal to:
$F = 1.1$ in general
$F = 1.05$ for steel mill products

V : Volume, in m³, occupied by cargo at a level h_B

h_B : Level of cargo, in m², to be obtained from the following formula:

$$h_B = \frac{X}{\rho_C g}$$

X : Pressure, in kN/m², to be obtained from the following formulae:

- for dry bulk cargoes, the lesser of:

$$X = \frac{Z + \rho g (z_F - 0.1 D_1 - h_F)}{1 + \frac{\rho}{\rho_C}(perm - 1)}$$

$$X = Z + \rho g (z_F - 0.1 D_1 - h_F perm)$$

- for steel mill products:

$$X = \frac{Z + \rho g (z_F - 0.1 D_1 - h_F)}{1 - \frac{\rho}{\rho_C}}$$

D_1 : Distance, in m, from the base line to the freeboard deck at side amidships

h_f : Inner bottom flooding head 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 z_F, in m, from the baseline.

z_F : Flooding level, in m, defined in Ch 4, Sec 6, [~~3.3.3~~ **3.4.3**]

perm : Permeability of cargo, which need not be taken greater than 0.3

Z : Pressure, in kN/m², to be taken as the lesser of:

$$Z = \frac{C_H}{A_{DB,H}}$$

$$Z = \frac{C_E}{A_{DB,E}}$$

C_H : Shear capacity of the double bottom, in kN, to be calculated according to [3.1.1], considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (see [3.1.2]) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see [3.1.3])

C_E : Shear capacity of the double bottom, in kN, to be calculated according to [3.1.1], considering, for each floor, the shear strength S_{f1} (see [3.1.2]) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see [3.1.3])

- $A_{DB,H} = \sum_{i=1}^{n} S_i B_{DB,i}$
- $A_{DB,E} = \sum_{i=1}^{n} S_i \left(B_{DB} - s \right)$

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

S_i : Space of i-th floor, in m

$B_{DB,i}$: Length, in m, to be taken equal to :
$B_{DB,i} = B_{DB} - s$ for floors for which $S_{f1} < S_{f2}$ (see [3.1.2])
$B_{DB,i} = B_{DB,h}$ for floors for which $S_{f1} \geq S_{f2}$ (see [3.1.2])

B_{DB} : Breadth, in m, of double bottom between the hopper tanks (see Fig 3)

$B_{DB,h}$: Distance, in m, between the two openings considered (see Fig 3)

s : Spacing, in m, of inner bottom longitudinal ordinary stiffeners adjacent to the hopper tanks.

Reason for the Rule Clarification:

Editorial correction – error in reference

CHAPTER 7 – DIRECT STRENGTH ANALYSIS

SECTION 2 GLOBAL STRENGTH EF ANALYSIS OF CARGO HOLE STRUCTURES

2. Analysis model

2.5 Consideration of hull girder loads

2.5.4 Influence of local loads

The distribution of hull girder shear force and bending moment induced by local loads applied on the model are calculated using a simple beam theory for the hull girder.

Reaction forces at both ends of the model and distributions of shearing forces and bending moments induced by local loads can be determined by following formulae:

$$R_{V\_fore} = -\frac{\sum_i (x_i - x_{aft})\vec{f}_i \cdot \vec{z}}{x_{fore} - x_{aft}} \qquad R_{V\_aft} = \sum_i \vec{f}_i \cdot \vec{z} + R_{V\_fore}$$

$$R_{H\_fore} = \frac{\sum_i (x_i - x_{aft})\vec{f}_i \cdot \vec{y}}{x_{fore} - x_{aft}} \qquad R_{H\_aft} = -\sum_i \vec{f}_i \cdot \vec{y} + R_{H\_fore}$$

$$Q_{V\_FEM}(x) = R_{V\_aft} - \sum_i \vec{f}_i \cdot \vec{z} \qquad \text{when } x_i < x$$

$$Q_{H\_FEM}(x) = R_{H\_aft} + \sum_i \vec{f}_i \cdot \vec{y} \qquad \text{when } x_i < x$$

$$M_{V\_FEM}(x) = (x - x_{aft})R_{V\_aft} - \sum_i (x - x_i)\vec{f}_i \cdot \vec{z} \qquad \text{when } x_i < x$$

$$M_{H\_FEM}(x) = (x - x_{aft})R_{H\_aft} + \sum_i (x - x_i)\vec{f}_i \cdot \vec{y} \qquad \text{when } x_i < x$$

where:

x_{aft} : Location of the aft end support

x_{fore} : Location of the fore end support

x : Considered location

R_{V_aft}, R_{V_fore}, R_{H_aft} and R_{H_fore} : Vertical and horizontal reaction forces at the fore and aft ends

Q_{V_FEM}, Q_{H_FEM}, M_{V_FEM} and M_{H_FEM} : Vertical and horizontal shear forces and bending moments created by the local loads applied on the FE model. **Sign of Q_{V_FEM}, M_{V_FEM} and M_{H_FEM} is in accordance with the sign convention defined in Ch 4, Sec 3. The sign convention for reaction forces is that a positive creates a positive shear force.**

$\vec{f}_i$: Applied force on node i due to all local loads

x_i : Longitudinal coordinate of node *i*

Reason for the Rule Clarification:

Clarification of sign convention

2.5.6 Direct method

In direct method the effect of hull girder loads are directly considered in 3D FE model. The equilibrium loads are to be applied at both model ends in order to consider the hull girder loads as specified in [2.5.2] and [2.5.3] and influence of local loads as specified in [2.5.4].

In order to control the shear force at the target locations, two sets of enforced moments are applied at both ends of the model. These moments are calculated by following formulae:

$$M_{Y\_aft\_SF} = M_{Y\_fore\_SF} = \frac{(x_{fore} - x_{aft})}{2}\left[Q_{V\_T}(x_{eq}) - Q_{V\_FEM}(x_{eq})\right]$$

$$M_{Z\_aft\_SF} = M_{Z\_fore\_SF} = \frac{(x_{fore} - x_{aft})}{2}\left[Q_{H\_T}(x_{eq}) - Q_{H\_FEM}(x_{eq})\right]$$

In order to control the bending moments at the target locations, another two sets of enforced moments are applied at both ends of the model. These moments are calculated by following formulae:

$$M_{Y\_aft\_BM} = -M_{Y\_fore\_BM} = -\left[M_{V\_T}(x_{eq}) - M_{V\_FEM}(x_{eq}) - M_{Y\_aft\_SF}\left(2\frac{x_{eq} - x_{aft}}{x_{fore} - x_{aft}} - 1\right)\right]$$

$$M_{Z\_aft\_BM} = -M_{Z\_fore\_BM} = -\left[M_{H\_T}(x_{eq}) - M_{H\_FEM}(x_{eq}) - M_{Z\_aft\_SF}\left(2\frac{x_{eq} - x_{aft}}{x_{fore} - x_{aft}} - 1\right)\right]$$

where:

x_{eq} : Considered location for the hull girder loads evaluation,

Q_{V_FEM}, Q_{H_FEM}, M_{V_FEM}, M_{H_FEM} : As defined in [2.5.4]

Q_{V_T}, Q_{H_T}, M_{V_T}, M_{H_T} : Target vertical and horizontal shear forces and bending moments, defined in Tab 3 or Tab 4, at the location x_{eq}. **Sign of Q_{V_T}, M_{V_T} and M_{H_T} is in accordance with sign convention defined in Ch 4, Sec 3.**

$M_{Y\_aft\_SF}$, $M_{Y\_fore\_SF}$, $M_{Y\_aft\_BM}$, $M_{Y\_fore\_BM}$: Enforced moments to apply at the aft and fore ends for vertical shear force and bending moment control, positive for clockwise around *y*-axis. **The sign convention for $M_{Y\_aft\_SF}$, $M_{Y\_fore\_SF}$, $M_{Y\_aft\_BM}$ and $M_{Y\_fore\_BM}$ is that of the FE model axis. The sign convention for other bending moment, shear forces and reaction forces is in accordance with the sign convention defined in Ch 4, Sec 3.**

$M_{Z\_aft\_SF}$, $M_{Z\_fore\_SF}$, $M_{Z\_aft\_BM}$, $M_{Z\_fore\_BM}$: Enforced moments to apply at the aft and fore ends for horizontal shear force and bending moment control, positive for clockwise around *z*-axis. **The sign convention for $M_{Z\_aft\_SF}$,**

$M_{Z\_fore\_SF}$, $M_{Z\_aft\_BM}$ and $M_{Z\_fore\_BM}$ is that of the FE model axis. The sign convention for other bending moment, shear forces and reaction forces is in accordance with the sign convention defined in Ch 4, Sec 3.

The enforced moments at the model ends can be generated by one of the following methods:

- to apply distributed forces at the end section of the model, with a resulting force equal to zero and a resulting moment equal to the enforced moment. The distributed forces are applied to the nodes on the longitudinal members where boundary conditions are given according to Tab 1. The distributed forces are to be determined by using the thin wall beam theory
- to apply concentrated moments at the independent points defined in [2.3.1].

Reason for the Rule Clarification:

Clarification of sign conventions

CHAPTER 8 – FATIGUE CHECK OF STRUCTURAL DETAILS

SECTION 2 FATIGUE STRENGTH ASSESSMENT

3. Calculation of fatigue damage

3.2 Long-term distribution of stress range

3.2.1

The cumulative probability density function of the long-term distribution of combined notch stress ranges is to be taken as a two-parameter Weibull distribution:

~~$$F(x) = 1 - \exp\left[-\left(\frac{x}{\Delta\sigma_{W,j}} \right)^{\xi} (\ln N_R)^{1/\xi} \right]$$~~

$$F(x) = 1 - \exp\left[-\left(\frac{x}{\Delta\sigma_{E,j}} \right)^{\xi} (\ln N_R) \right]$$

where:

ξ : Weibull shape parameter, taken equal to 1.0

N_R : Number of cycles, taken equal to 10^4.

Reason for the Rule Clarification:

Editorial correction - correction of error in formula

SECTION 4 STRESS ASSESSMENT OF STIFFENERS

3. Hot spot mean stress

3.3 Mean stress according to the superimposition method

3.3.2

The hot spot stress due to still water bending moment, in N/mm², in loading condition "(*k*)" is to be obtained with the following formula:

$$\sigma_{GS,(k)} = K_{gh} \frac{M_{S,(k)}(z-N)}{I_Y} 10^{-3}$$

where:

$M_{S,(k)}$: Still water vertical bending moment, in kN.m, defined in Sec 3, [~~3.2.1~~**3.2.2**].

Reason for the Rule Clarification:

Editorial correction – error in reference.

APPENDIX1 CROSS SECTIONAL PROPERTIES FOR TORSION

1. Calculation formulae

1.4 Computation of cross sectional properties for the entire cross section

Asymmetric cross section:			Symmetric cross section (only half of the section is modeled)		
A	=	$\sum A$	A	=	$2\sum A$
y_s	=	$\frac{\sum S_z}{\sum A}$			
z_s	=	$\frac{\sum S_y}{\sum A}$	z_s	=	$\frac{\sum S_y}{\sum A}$
I_y	=	$\sum I_y - \sum A z_s^2$	I_y	=	$2\left(\sum I_y - \sum A z_s^2\right)$
I_z	=	$\sum I_z - \sum A y_s^2$	I_z	=	~~$2\left(\sum I_z - \sum A y\right)_s^2$~~ $2\left(\sum I_z - \sum A y_s^2\right)$
I_{yz}	=	$\sum I_{yz} - \sum A y_s z_s$			
I_T	=	$\sum \frac{s t^3}{3}$	I_T	=	$2\left[\sum \frac{s t^3}{3} + \sum_{Cell\ i} \left(2 A_{yi} \Phi_i\right)\right]$
ω_0	=	$\frac{\sum S_\omega}{\sum A}$			
$I_{\omega y}$	=	$\sum I_{\omega y} - \sum A y_s \omega_0$	$I_{\omega y}$	=	$2\sum I_{\omega y}$
$I_{\omega z}$	=	$\sum I_{\omega z} - \sum A z_s \omega_0$			
y_M	=	$\frac{I_{\omega z} I_z - I_{\omega y} I_{yz}}{I_y I_z - I_{yz}^2}$			
z_M	=	$\frac{I_{\omega z} I_{yz} - I_{\omega y} I_y}{I_y I_z - I_{yz}^2}$	z_M	=	$-\frac{I_{\omega y}}{I_z}$
I_ω	=	$\sum I_\omega - \sum A \omega_0^2 + z_m I_{\omega y} - y_M I_{\omega z}$	I_ω	=	$2\sum I_\omega + z_m I_{\omega y}$

Reason for the Rule Clarification:

Editorial correction – correction of error in formula

CHAPTER 9 – OTHER STRUCTURES

SECTION 1 FORE PART

3. Load model

3.2 Pressure in bow area

3.2.2 Lateral pressure in testing conditions

The lateral pressure p_T in testing conditions is ~~defined in Ch 4, Sec 6, [4]~~ **taken equal to:**

- **$p_T = p_{ST} - p_S$ for bottom shell plating and side shell plating**
- **$p_T = p_{ST}$ otherwise**

where:

p_{ST} : Testing pressure defined in Ch 4, Sec 6, [4]

p_S : Pressure taken equal to:

- **if the testing is carried out afloat: hydrostatic pressure defined in Ch 4, Sec 5, [1] for the draught T_1, defined by the Designer, at which the testing is carried out. If T_1 is not defined, the testing is considered as being not carried out afloat.**
- **if the testing is not carried out afloat: $p_S = 0$**

Reason for the Rule Clarification:

Editorial correction – this correction is made to be consistent with Ch 6, Sec 1, [3.1.4] and Ch 6, Sec 2, [3.1.4]

SECTION 2 AFT PART

2. Load model

2.2 Lateral pressures

2.2.2 Lateral pressure in testing conditions

The lateral pressure p_T in testing conditions is ~~defined in Ch 4, Sec 6, [4]~~ **taken equal to:**

- **$p_T = p_{ST} - p_S$ for bottom shell plating and side shell plating**
- **$p_T = p_{ST}$ otherwise**

where:

p_{ST} : Testing pressure defined in Ch 4, Sec 6, [4]

p_S : Pressure taken equal to:

- **if the testing is carried out afloat: hydrostatic pressure defined in Ch 4, Sec 5, [1] for the draught T_1, defined by the Designer, at which the testing is carried out. If T_1 is not defined, the testing is considered as being not carried out afloat.**
- **if the testing is not carried out afloat: $p_S = 0$**

Reason for the Rule Clarification:

Editorial correction – this correction is made to be consistent with Ch 6, Sec 1, [3.1.4] and Ch 6, Sec 2, [3.1.4]

SECTION 3 MACHINERY SPACE

7. Main machinery seating

7.2 Minimum scantlings

7.2.1

The net scantlings of the structural elements in way of the internal combustion engine seatings are to be obtained from the formulae in Tab 2.

Table 1: Minimum scantlings of the structural elements in way of machinery seatings

Scantling minimum value	Scantling minimum value
Net cross-sectional area, in cm², of each bedplate of the seatings	$40 + 70 \dfrac{P}{n_r L_E}$
Bedplate net thickness, in ~~m~~ **mm**	Bedplates supported by two or more girders: $\sqrt{240 + 175 \dfrac{P}{n_r L_E}}$ Bedplates supported by one girder: $5 + \sqrt{240 + 175 \dfrac{P}{n_r L_E}}$
Total web net thickness, in mm, of girders fitted in way of machinery seatings	Bedplates supported by two or more girders: $\sqrt{320 + 215 \dfrac{P}{n_r L_E}}$ Bedplates supported by one girder: $\sqrt{95 + 65 \dfrac{P}{n_r L_E}}$
Web net thickness, in mm, of floors fitted in way of machinery seatings	$\sqrt{55 + 40 \dfrac{P}{n_r L_E}}$

Reason for the Rule Clarification:

Editorial correction – correction of unit

SECTION 5 HATCH COVERS

4. Load model

4.1 Lateral pressures and forces

4.1.2 Sea pressure

The still water and wave lateral pressures are to be considered and are to be taken equal to:

- still water pressure: $p_S = 0$
- wave pressure p_W, as defined in Ch 4, Sec 5 [~~2.2~~5.2].

Reason for the Rule Clarification:

Editorial correction – error in reference

5. Strength check

5.2 Plating

5.2.2 Minimum net thickness

Ref. ILLC, as amended (Resolution MSC.143(77) Reg. 16 (5, c))

In addition to [5.2.1], *the net thickness, in mm, of the plating forming the top of the hatch cover is to be not less than the greater of the following values:*

~~$t = 0.01s$~~

$t = 10s$

$t = 6$

Reason for the Rule Clarification:

Editorial correction – correction of error in formula

CHAPTER 10 – HULL OUTFITTING

SECTION 1 RUDDER AND MANOEUVRING ARRANGEMENT

4. Rudder couplings

4.5 Cone couplings with special arrangements for mounting and dismounting the couplings

4.5.1

Where the stock diameter exceeds 200 mm, the press fit is recommended to be effected by a hydraulic pressure connection. In such cases the cone is to be more slender, ~~$c \approx 1:2$~~ $c \approx 1:12$ to $\approx 1:20$.

Reason for the Rule Clarification:

Editorial correction – correction of error in formula