21-393

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part CSR-B&T Common Structural Rules for Bulk Carriers and Oil Tankers

Rules for the Survey and Construction of Steel Ships
Part CSR-B&T 2021 AMENDMENT NO.1

Rule No.2 10 March 2021
Resolved by Technical Committee on 27 January 2021

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NIPPON KAIJI KYOKAI

Rule No.2 10 March 2021
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&T COMMON STRUCTURAL RULES FOR BULK CARRIERS AND OIL TANKERS

Part 1 GENERAL HULL REQUIREMENTS

Chapter 2 GENERAL ARRANGEMENT DESIGN

Section 2 SUBDIVISION ARRANGEMENT

1. Watertight Bulkhead Arrangement

Paragraph 1.2 has been deleted.

1.2 ~~Openings in Watertight Bulkheads~~(Deleted)

~~1.2.1~~

~~The number of openings in watertight bulkheads is to be kept a minimum, where penetrations of watertight bulkheads and internal decks are necessary for access, piping, ventilation, electrical cables. Arrangements are to be made to maintain the watertight integrity.~~

~~1.2.2~~

~~The tightness, operability and indication of the doors in watertight bulkheads are to be in accordance with *Ch II-1, Reg 13-1 of SOLAS Convention*, as amended.~~

3. Aft Peak Bulkhead

3.1 General

Paragraph 3.1.2 has been amended as follows.

3.1.2

The aft peak bulkhead may be stepped below the ~~bulkhead~~ freeboard deck, provided that the degree of safety of the ship as regards subdivision is not thereby diminished.

Paragraph 3.1.4 has been amended as follows.

3.1.4

~~The aft peak bulkhead may terminate at the first deck above the deepest draught at the aft perpendicular, provided that this deck is made watertight to the stern or to the transom.~~ Provided that the aft peak bulkhead extends above the deepest load line, termination of the afterpeak bulkhead on a watertight deck lower than the freeboard deck can be accepted. In order to provide such a watertight deck a tight sealing of the rudder stock shall be fitted in way of this deck or above.

Section 3 COMPARTMENT ARRANGEMENT

Paragraph 4 has been deleted.

4. ~~Fore End Compartments~~(Deleted)

~~4.1 General~~

~~4.1.1~~

~~The fore peak and other compartments located forward of the collision bulkhead may not be arranged for the carriage of fuel oil or other flammable products.~~

Paragraph 5 has been deleted.

5. ~~Fuel Oil Tanks~~(Deleted)

~~5.1 Arrangement of Fuel Oil Tanks~~

~~5.1.1~~

~~Fuel oil tanks are to be arranged in accordance with the requirements in *SOLAS Ch II-2, Reg 4.2* and *MARPOL, Annex I, Ch 3, Reg 12A*.~~

Paragraph 6 has been deleted.

6. ~~Aft End Compartments~~(Deleted)

~~6.1 Sterntube~~

~~6.1.1~~

~~Sterntubes are to be enclosed in a watertight space (or spaces) of moderate volume. Other measures to minimise the danger of water penetrating into the ship in case of damage to the sterntube arrangement may be taken at the discretion of the Society.~~

Chapter 4 LOADS

Section 5 EXTERNAL LOADS

Symbols

Symbols has been amended as follows.

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

λ : Wave length, in m.

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

x, y, z : X, Y and Z coordinates, in m, of the load point with respect to the reference coordinate system defined in **Ch 4, Sec 1, 1.2.1**.

f_{xL} : Ratio as defined in **Ch 4, Sec 2**.

f_{yB} : Ratio between Y-coordinate of the load point and B_x, to be taken as:

$f_{yB} = \frac{|2y|}{B_x}$, but not greater than 1.0.

~~$f_{yB} = 0$~~ $f_{yB} = 1.0$ when $B_x = 0$.

(Omitted)

Section 6 INTERNAL LOADS

2. Pressures and Forces Due to Dry Bulk Cargo

2.5 Shear Load

Paragraph 2.5.1 has been amended as follows.

2.5.1 Application

For FE strength assessment and FE fatigue assessment, the following shear load pressures are to be considered in addition to the dry bulk cargo pressures defined in **2.4** when the load point elevation, z, is lower or equal to z_C:

(Omitted)

Section 8 LOADING CONDITIONS

5. Standard Loading Conditions for Fatigue Assessment

5.1 Oil Tanker

Paragraph 5.1.1 has been amended as follows.

5.1.1

The standard loading conditions to be applied to oil tankers for fatigue assessment as required in **Ch 9**, **Sec 1**, **6.2**, are defined in **Table 22** to **Table 24**. Where fuel oil tanks, other oil tanks or fresh water tanks are arranged in way of the cargo hold region, the filling level of them are to be taken as full for both simplified stress analysis according to **Ch 9, Sec 4** and direct strength analysis according to **Ch 7** and **Ch 9, Sec 5**. ~~For simplified stress analysis according to **Ch 9, Sec 4**, the filling level of them are to be taken as half height, measured from z_{top} to the lowest point of tank.~~

5.2 Bulk Carriers

Paragraph 5.2.1 has been amended as follows.

5.2.1

The standard loading conditions to be applied to bulk carriers for fatigue assessment as required in **Ch 9**, **Sec 1**, **6.3** are defined in **Table 25**, to **Table 31** according to their additional service feature notations and the location of the assessed details. Where fuel oil tanks, other oil tanks or fresh water tanks are arranged in way of the cargo hold region, the filling level of them are to be taken as full for both simplified stress analysis according to **Ch 9, Sec 4** and direct strength analysis according to **Ch 7** and **Ch 9, Sec 5**. ~~For simplified stress analysis according to **Ch 9, Sec 4**, the filling level of them are to be taken as half height, measured from z_{top} to the lowest point of tank.~~

Chapter 8 BUCKLING

Section 4 BUCKLING REQUIREMENTS FOR DIRECT STRENGTH ANALYSIS

5. Struts, Pillars and Cross Ties

5.1 Buckling Criteria

Paragraph 5.1.1 has been amended as follows.

5.1.1

The compressive buckling strength of struts, pillars and cross ties is to satisfy the following criterion:

$\eta_{Pillar} \leq \eta_{all}$

The buckling strength of elementary plate panels of cross ties is to satisfy the following criterion:

$\eta_{Plate} \leq \eta_{all}$

where:

η_{Pillar}: Maximum utilisation factor of struts, pillars or cross ties, as defined in **Ch 8**, **Sec 5**, **3.1**.

η_{Plate}: Maximum plate utilisation factor calculated according to UP-B, as defined in **Ch 8, Sec 5, 2.2.**

Section 5 BUCKLING CAPACITY

Symbols

Symbols has been amended as follows.

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

(Omitted)

γ_{GEB} : Stress multiplier factor of global elastic buckling capacity.

2. Buckling Capacity of Plates and Stiffeners

Paragraph 2.1 has been amended as follows.

2.1 Overall Stiffened Panel Capacity

2.1.1

The elastic stiffened panel limit state is based on the following interaction formula, which sets a precondition for the buckling check of stiffeners in accordance with **2.3.4**:

$$\frac{P_z}{c_f} = 1$$

$$\frac{\gamma}{\gamma_{GEB}} = 1$$

where c_f and P_z are defined in 2.3.4. where the stress multiplier factor corresponding to global elastic buckling capacity, γ_{GEB}, is to be calculated based on the following formulae:

$$\gamma_{GEB} = \gamma_{GEB,bi+\tau} \quad for\ \ \tau \neq 0\ and\ (\sigma_x > 0\ or\ \sigma_y > 0)$$

$$\gamma_{GEB} = \gamma_{GEB,bi} \quad for\ \ \tau = 0\ and\ (\sigma_x > 0\ or\ \sigma_y > 0)$$

$$\gamma_{GEB} = \gamma_{GEB,\tau} \quad for\ \ \tau \neq 0\ and\ (\sigma_x \leq 0\ and\ \sigma_y \leq 0)$$

where $\gamma_{GEB,bi+\tau}$, $\gamma_{GEB,bi}$ and $\gamma_{GEB,\tau}$ are stress multiplier factors for different load combinations as defined in **2.1.2**, **2.1.3** and **2.1.4**, respectively. For the calculation of $\gamma_{GEB,bi+\tau}$, $\gamma_{GEB,bi}$ and $\gamma_{GEB,\tau}$, neither σ_x nor σ_y shall be taken less than 0.

σ_x, σ_y : Applied normal stresses to the plate panel, in *N/mm*[2], to be taken as defined in **2.2.7.**

τ : Applied shear stress, in *N/mm*[2], to be taken as defined in **2.2.7**.

2.1.2

The stress multiplier factor $\gamma_{GEB,bi}$ for the stiffened panel subjected to biaxial loads is taken as:

$$\gamma_{GEB,bi} = \frac{\pi^2}{L_{B1}^2 L_{B2}^2} \frac{\left[D_{11}L_{B2}^4 + 2(D_{12}+D_{33})n^2L_{B1}^2L_{B2}^2 + n^4D_{22}L_{B1}^4\right]}{L_{B2}^2N_x + n^2L_{B1}^2K_{tran}N_y}$$

where:

N_x: Load per unit length applied on the edge along x axis of the stiffened panel, in *N/mm*, taken as

$$N_x = \sigma_{x,av}(t_p s + t_w h_w + t_f b_f)/s$$

N_y: Load per unit length applied on the edge along y axis of the stiffened panel, in N/mm, taken as

$$N_y = c\sigma_y t_p$$

L_{B1}: Stiffener span, in *mm*, equal to spacing between primary supporting members, i.e. $L_{B1} = \ell$. For vertically stiffened side shell of single side skin bulk carriers, $L_{B1} = 0.8\ell$.

L_{B2}: Width of the stiffened panel, in *mm*, taken as 6 times of the stiffener spacing, i.e. 6*s*.

n: Number of half waves along the direction perpendicular to the stiffener axis. The factor $\gamma_{GEB,bi}$ is to be minimized with respect to the wave parameter *n*, i.e. to be taken as the smallest value larger than zero.

K_{tran}: Coefficient taken as 0.9.

c: Factor taking into account the stresses in the attached plating acting perpendicular to the stiffener axis:

$$c = 0.5(1+\Psi) \ \text{ for } \ 0 \leq \Psi \leq 1$$

$$c = \frac{1}{2(1-\Psi)} \ \text{ for } \ \Psi < 0$$

Ψ: Edge stress ratio for case 2 according to **Table 3**.

$\sigma_{x,av}$: Average stress for both plate and stiffener with Poisson correction, taken as:

$$\sigma_{x,av} = \sigma_x - \nu\sigma_y A_s/(A_p + A_s) \geq 0 \ \text{ for } \ \sigma_x > 0 \ \text{ and } \ \sigma_y > 0$$

$\sigma_{x,av} = \sigma_x$ for $\sigma_x \leq 0$ and $\sigma_y \leq 0$

$D_{11}, D_{12}, D_{22}, D_{33}$: Bending stiffness coefficients, in *Nmm*, of the stiffened panel, defined as:

$$\left.\begin{aligned} D_{11} &= \frac{EI_{eff}10^4}{s} \\ D_{12} &= \frac{Et_p^3\nu}{12(1-\nu^2)} \\ D_{22} &= \frac{Et_p^3}{12(1-\nu^2)} \\ D_{33} &= \frac{Et_p^3}{12(1+\nu)} \end{aligned}\right\}$$

I_{eff} : Moment of inertia, in *cm*^{4}, of the stiffener including effective width of attached plating, the same as *I* defined in **2.3.4**.

2.1.3

The stress multiplier factor $\gamma_{GEB,\tau}$ for the stiffened panel subjected to pure shear load is taken as:

$$\gamma_{GEB,\tau} = \frac{\sqrt[4]{D_{11}^3 D_{22}}}{(L_{B1}/2)^2 N_{xy}}\left[8.125 + 5.64\sqrt{\frac{(D_{12}+D_{33})^2}{D_{11}D_{22}}} - 0.6\frac{(D_{12}+D_{33})^2}{D_{11}D_{22}}\right] \quad \text{for} \quad D_{11}D_{22} \geq (D_{12}+D_{33})^2$$

$$\gamma_{GEB,\tau} = \frac{\sqrt{2D_{11}(D_{12}+D_{33})}}{(L_{B1}/2)^2 N_{xy}}\left[8.3 + 1.525\frac{D_{11}D_{22}}{(D_{12}+D_{33})^2} - 0.493\frac{D_{11}^2 D_{22}^2}{(D_{12}+D_{33})^4}\right] \quad \text{for}$$

$D_{11}D_{22} < (D_{12}+D_{33})^2$

where:

$N_{xy} = \tau t$

2.1.4

The stress multiplier factor $\gamma_{GEB,bi+\tau}$ for the stiffened panel subjected to combined loads is taken as:

$$\gamma_{GEB,bi+\tau} = \frac{1}{2}\gamma_{GEB,\tau}{}^2\left[-\frac{1}{\gamma_{GEB,bi}} + \sqrt{\frac{1}{\gamma_{GEB,bi}{}^2} + 4\frac{1}{\gamma_{GEB,\tau}{}^2}}\right]$$

where $\gamma_{GEB,bi}$ and $\gamma_{GEB,\tau}$ are as defined in **2.1.2** and **2.1.3**, respectively.

2.2 Plate capacity

Paragraph 2.2.7 has been amended as follows.

2.2.7 Applied normal and shear stresses to plate panels

The normal stress, σ_x and σ_y, in *N/mm*^{2}, to be applied for the overall stiffened panel capacity and the plate panel capacity calculations, as given in **2.1.1** and **2.2.1** respectively, are to be taken as follows:

- For FE analysis, the reference stresses as defined in **Ch 8**, **Sec 4**, **2.4**.
- For prescriptive assessment, the axial or transverse compressive stresses calculated according to **Ch 8**, **Sec 3**, **2.2.1**, at load calculation points of the considered elementary

plate panel, as defined in **Ch 3**, **Sec 7**, **2**.

- For grillage analysis where the stresses are obtained based on beam theory, the stresses taken as:

$$\sigma_x = \frac{\sigma_{xb} + \nu\sigma_{yb}}{1-\nu^2}$$

$$\sigma_y = \frac{\sigma_{yb} + \nu\sigma_{xb}}{1-\nu^2}$$

where:

σ_{xb}, σ_{yb}: Stress, in *N/mm*^{2}, from grillage beam analysis respectively along *x* or *y* axis of the attached ~~buckling panel~~ plate of girders.

The shear stress τ, in *N/mm*^{2}, to be applied for the overall stiffened panel capacity and the plate panel capacity calculations, as given in **2.1.1** and **2.2.1** respectively, are to be taken as follows:

- For FE analysis, the reference shear stresses as defined in **Ch 8**,**Sec 4**, **2.4**.
- For prescriptive assessment of the plate panel capacity, the shear stresses calculated according to **Ch 8**, **Sec 3**, **2.2.1**, at load calculation points of the considered elementary plate panel, as defined in **Ch 3**, **Sec 7**, **2**.
- For prescriptive assessment of the overall stiffened panel capacity, the shear stresses calculated according to **Ch 8**, **Sec 3**, **2.2.1**, at the following load calculation point:
  - At the middle of the full span, ℓ, of the considered stiffener.
  - At the intersection point between the stiffener and its attached plating.
- For grillage beam analysis, $\tau = 0$ in the attached ~~buckling panel~~ plate of girders.

2.3 Stiffeners

Paragraph 2.3.2 has been amended as follows.

2.3.2 Web thickness of flat bar

For accounting the decrease of the stiffness due to local lateral deformation, the effective web thickness of flat bar stiffener, in mm, is to be used in **2.1** and **2.3.4** for the calculation of the net sectional area, *A*$_s$, the net section modulus, *Z*, and the moment of inertia, *I*, of the stiffener and is taken as:

$$t_{w\_red} = t_w \left(1 - \frac{2\pi^2}{3}\left(\frac{h_w}{s}\right)^2 \left(1 - \frac{b_{eff1}}{s}\right)\right)$$

Paragraph 2.3.4 has been amended as follows.

2.3.4 Ultimate buckling capacity

When $\sigma_a + \sigma_b + \sigma_w > 0$, the ultimate buckling capacity for stiffeners is to be checked according to the following interaction formula:

$$\frac{\gamma_c\sigma_a + \sigma_b + \sigma_w}{R_{eH}} S = 1$$

where:

σ_a: Effective axial stress, in *N/mm*^{2}, at mid span of the stiffener, acting on the stiffener with its attached plating.

$$\sigma_a = \sigma_x \frac{st_p + A_s}{b_{eff1}t_p + A_s}$$

σ_x: Nominal axial stress, in N/mm^2, acting on the stiffener with its attached plating.

- For FE analysis, σ_x is the FE corrected stress as defined in **2.3.6** in the attached plating in the direction of the stiffener axis.
- For prescriptive assessment, σ_x is the axial stress calculated according to **Ch 8**, **Sec 3**, **2.2.1** at load calculation point of the stiffener, as defined in **Ch 3**, **Sec 7**, **3**.
- For grillage beam analysis, σ_x is the stress acting along the x axis of the attached buckling panel.

R_{eH}: Specified minimum yield stress of the material, in N/mm^2:

$R_{eH} = R_{eH\_S}$ for stiffener induced failure (SI).

$R_{eH} = R_{eH\_P}$ for plate induced failure (PI).

σ_b: Bending stress in the stiffener, in N/mm^2:

$$\sigma_b = \frac{M_0 + M_1}{1000Z}$$

Z: Net section modulus of stiffener, in cm^3, including effective width of plating according to **2.3.5**, to be taken as:

- The section modulus calculated at the top of stiffener flange for stiffener induced failure (SI).
- The section modulus calculated at the attached plating for plate induced failure (PI).

C_{PI}: Plate induced failure pressure coefficient:

$C_{PI} = 1$ if the lateral pressure is applied on the side opposite to the stiffener.

$C_{PI} = -1$ if the lateral pressure is applied on the same side as the stiffener.

C_{SI}: Stiffener induced failure pressure coefficient:

$C_{SI} = -1$ if the lateral pressure is applied on the side opposite to the stiffener.

$C_{SI} = 1$ if the lateral pressure is applied on the same side as the stiffener.

M_1: Bending moment, in Nmm, due to the lateral load P:

$M_1 = C_i \frac{|P|s\ell^2}{24\times10^3}$ for continuous stiffener

$M_1 = C_i \frac{|P|s\ell^2}{8\times10^3}$ for sniped stiffener

$M_1 = C_i \frac{|P|s\ell^2}{14.2\times10^3}$ for stiffener sniped at one end and continuous at the other end

P: Lateral load, in kN/m^2.

For FE analysis, P is the average pressure as defined in **Ch 8**, **Sec 4**, **2.5.2** in the attached plating.

For prescriptive assessment, P is the pressure calculated at load calculation point of the stiffener, as defined in **Ch 3**, **Sec 7**, **3**.

C_i: Pressure coefficient:

$C_i = C_{SI}$ for stiffener induced failure (SI).

$C_i = C_{PI}$ for plate induced failure (PI).

M_0: Bending moment, in Nmm, due to the lateral deformation w of stiffener:

~~$M_0 = F_E \left(\frac{P_z w}{c_f - P_z}\right)$ with $c_f - P_z > 0$~~

$M_0 = F_E \frac{\gamma}{\gamma_{GEB} - \gamma} w_0$ with precondition $\gamma_{GEB} - \gamma > 0$

where γ_{GEB} is the stress multiplier factor of global elastic buckling capacity as defined in **2.1.**

F_E: Ideal elastic buckling force of the stiffener, in *N*.

$$F_E = \left(\frac{\pi}{\ell}\right)^2 EI10^4$$

I: Moment of inertia, in cm^4, of the stiffener including effective width of attached plating according to **2.3.5**. *I* is to comply with the following requirement:

$$I \geq \frac{st_p^3}{12 \times 10^4}$$

t_p: Net thickness of plate, in *mm*, to be taken as

- For prescriptive requirements: the mean thickness of the two attached plating panels,
- For FE analysis: the thickness of the considered EPP on one side of the stiffener.

~~P_z: Nominal lateral load, in N/mm^2, acting on the stiffener due to stresses, σ_x, σ_y and τ, in the attached plating in way of the stiffener mid span:~~

$$P_z = \frac{t_p}{s}\left(\sigma_{xl}\left(\frac{\pi s}{\ell}\right)^2 + 2c\gamma\sigma_y + \sqrt{2}\tau_1\right)$$

$$\sigma_{xl} = \gamma\sigma_x\left(1 + \frac{A_s}{st_p}\right) \text{ but not less than 0}$$

$$\tau_1 = \gamma|\tau| - t_p\sqrt{R_{eH\_p}E\left(\frac{m_1}{a^2} + \frac{m_2}{b^2}\right)} \text{ but not less than 0}$$

~~σ_y: Stress applied on the edge along *y* axis of the buckling panel, in N/mm^2, but not less than 0.~~

- ~~For FE analysis, σ_y is the FE corrected stress as defined in **2.3.6** in the attached plating in the direction perpendicular to the stiffener axis.~~
- ~~For prescriptive assessment, σ_y is the maximum compressive stress calculated according to **Ch 8, Sec 3, 2.2.1**, at load calculation points of the stiffener attached plating, as defined in **Ch 3, Sec 7, 2**.~~
- ~~For grillage beam analysis, σ_y is the stress acting along the *y* axis of the attached buckling panel.~~

~~τ : Applied shear stress, in N/mm^2.~~

- ~~For FE analysis, τ is the reference shear stress as defined in **Ch 8, Sec 4, 2.4.2** in the attached plating.~~
- ~~For prescriptive assessment, τ is the shear stress at the attached plate calculated according to **Ch 8, Sec 3, 2.2.1** at the following load calculation point:~~
  - ~~At the middle of the full span, ℓ, of the considered stiffener~~
  - ~~At the intersection point between the stiffener and its attached plate.~~
- ~~For grillage beam analysis, $\tau = 0$ in the attached buckling panel.~~

~~m_1, m_2: Coefficients taken equal to:~~

$m_1 = 1.47, m_2 = 0.49$ for $\alpha \geq 2$

$m_1 = 1.96, m_2 = 0.37$ for $\alpha < 2$

~~*c*: Factor taking into account the stresses in the attached plating acting perpendicular to the stiffener's axis:~~

$c = 0.5(1 + \psi)$ for $0 \leq \psi \leq 1$

$c = \frac{1}{2(1-\psi)}$ for $\psi < 0$

~~ψ: Edge stress ratio for case 2 according to **Table 3**.~~

~~w: Deformation of stiffener, in mm:~~

~~$w = w_0 + w_1$~~

w_0: Assumed imperfection, in mm, to be taken as:

$w_0 = \ell/1000$ in general.

$w_0 = -w_{na}$ for stiffeners sniped at one or both ends considering stiffener induced failure (*SI*).

$w_0 = w_{na}$ for stiffeners sniped at one or both ends considering plate induced failure (*PI*).

w_{na}: Distance from the mid-point of attached plating to the neutral axis of the stiffener calculated with the effective width of the attached plating according to **2.3.5**.

~~w_1: Deformation of stiffener, in *mm*, at mid-point of stiffener span due to lateral load *P*. In case of uniformly distributed load, w_1 is to be taken as:~~

~~$w_1 = C_i \frac{|P| s \ell^4}{384 \times 10^7 EI}$ in general~~

~~$w_1 = C_i \frac{5|P| s \ell^4}{384 \times 10^7 EI}$ for stiffeners sniped at both ends~~

~~$w_1 = C_i \frac{2|P| s \ell^4}{384 \times 10^7 EI}$ for stiffeners sniped at one end and continuous at the other end.~~

~~c_f: Elastic support provided by the stiffener, in *N/mm*^2:~~

~~$c_f = F_E \left(\frac{\pi}{\ell}\right)^2 (1 + c_p)$~~

~~$c_p = \frac{1}{1 + \frac{0.91}{c_{xa}}\left(\frac{12I}{s t_p^3} 10^4 - 1\right)}$~~

~~c_{xa}: Coefficient to be taken as:~~

~~$c_{xa} = \left(\frac{\ell}{2s} + \frac{2s}{\ell}\right)^2$ for $\ell \geq 2s$~~

~~$c_{xa} = \left(1 + \left(\frac{\ell}{2s}\right)^2\right)^2$ for $\ell < 2s$~~

σ_w: Stress due to torsional deformation, in *N/mm*^2, to be taken as:

~~$\sigma_w = E y_w \left(\frac{t_f}{2} + h_w\right) \Phi_0 \left(\frac{\pi}{\ell}\right)^2 \left(\frac{1}{1 - \frac{0.4 R_{eH\_S}}{\sigma_{ET}}} - 1\right)$ for stiffener induced failure (*SI*).~~

$\sigma_w = E y_w \left(\frac{t_f}{2} + h_w\right) \Phi_0 \left(\frac{m_{tor}\pi}{\ell_{tor}}\right)^2 \left(\frac{1}{1 - \frac{\gamma \sigma_a}{\sigma_{ET}}} - 1\right)$ with precondition $\sigma_{ET} - \gamma\sigma_a > 0$ for stiffener induced failure (*SI*).

$\sigma_w = 0$ for plate induced failure (*PI*).

ℓ_{tor}: Stiffener span, distance equal to spacing between primary supporting members, i.e. $\ell_{tor} = \ell$. When the stiffener is supported by tripping brackets, ℓ_{tor} should be taken as the maximum spacing between the adjacent primary supporting members and fitted tripping brackets.

y_w: Distance, in *mm*, from centroid of stiffener cross section to the free edge of stiffener flange, to be taken as:

$y_w = \frac{t_w}{2}$ for flat bar.

$y_w = b_f - \frac{h_w t_w^2 + t_f b_f^2}{2A_s}$ for angle and bulb profiles.

$y_w = b_{f-out} + 0.5t_w - \frac{h_w t_w^2 + t_f\left(b_f^2 - 2b_f d_f\right)}{2A_s}$ for L2 profile

$y_w = b_{f-out} + 0.5t_w - \frac{(h_w - t_f)t_w^2 + t_f\left(b_f + t_w\right)^2}{2A_s}$ for L3 profile

$y_w = \frac{b_f}{2}$ for T profile.

Φ_0: Coefficient taken as:

~~$\Phi_0 = \frac{\ell}{h_w} 10^{-3}$~~

$$\Phi_0 = \frac{\ell_{tor}}{m_{tor} h_w} 10^{-4}$$

σ_{ET}: Reference stress for torsional buckling, in N/mm^2:

~~$\sigma_{ET} = \frac{E}{I_p}\left(\frac{\varepsilon\pi^2 I_\omega 10^2}{\ell^2} + 0.385 I_T\right)$~~

$$\sigma_{ET} = \frac{E}{I_p}\left[\left(\frac{m_{tor}\pi}{\ell_{tor}}\right)^2 I_w \cdot 10^2 + \frac{1}{2(1+\nu)} I_T + \left(\frac{\ell_{tor}}{m_{tor}\pi}\right)^2 \varepsilon \cdot 10^{-4}\right]$$

I_P: Net polar moment of inertia of the stiffener, in cm^4, about point C as shown in **Fig. 1**, as defined in **Table 5**.

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

I_ω: Net ~~sectional~~ sectorial moment of inertia of the stiffener, in cm^6, about point C as shown in **Fig.1**, as defined in **Table 5**.

m_{tor}: Number of half waves within ℓ_{tor}, taken as a positive integer so as to give smallest reference stress for torsional buckling.

ε: Degree of fixation.

~~$\varepsilon = 1 + \frac{\left(\frac{\ell}{\pi}\right)^2 10^{-3}}{\sqrt{I_\omega\left(\frac{0.75s}{t_p^3} + \frac{e_f - 0.5t_f}{t_w^3}\right)}}$~~

$\varepsilon = \left(\frac{3b}{t_p^3} + \frac{2h_w}{t_w^3}\right)^{-1}$ for bulb, angle, L2, L3 and T profiles;

$\varepsilon = \left(\frac{t_p^3}{3b}\right)$ for flat bars.

A_w: Net web area, in mm^2.

A_f: Net flange area, in mm^2.

Table 5 has been amended as follows.

Table 5 Moments of Inertia

	Flat bars [(1)]	Bulb, angle, L2, L3 and T profiles
I_P	$\frac{h_w^3 t_w}{3\times10^4}$	$\left(\frac{A_w\left(e_f-0.5t_f\right)^2}{3}+A_f e_f^2\right)10^{-4}$
I_T	$\frac{h_w t_w^3}{3\times10^4}\left(1-0.63\frac{t_w}{h_w}\right)$	$\frac{\left(e_f-0.5t_f\right)t_w^3}{3\times10^4}\left(1-0.63\frac{t_w}{e_f-0.5t_f}\right)+\frac{b_f t_f^3}{3\times10^4}\left(1-0.63\frac{t_f}{b_f}\right)$
I_ω	$\frac{h_w^3 t_w^3}{36\times10^6}$	~~$\frac{A_f e_f^2 b_f^2}{12\times10^6}\left(\frac{A_f+2.6A_w}{A_f+A_w}\right)$~~ $\frac{A_f^3+A_w^3}{36\cdot10^6}+\frac{e_f^2}{10^6}\left(\frac{A_f b_f^2+A_w t_w^2}{3}-\frac{\left(A_f b_f+A_w t_w\right)^2}{4\left(A_f+A_w\right)}\right)$ for bulb, angle, L2 and L3 profiles. $\frac{b_f^3 t_f e_f^2}{12\times10^6}$ for T profiles.
(1) t_w is the net web thickness, in *mm*. t_{w_red} as defined in **2.3.2** is not to be used in this table.		

Paragraph 2.3.6 has been amended as follows.

2.3.6 FE corrected stresses for stiffener capacity

When the reference stresses σ_x and σ_y obtained by FE analysis according to **Ch 8**, **Sec 4**, **2.4** are both compressive, ~~they are~~ σ_x is to be corrected according to the following ~~formulae~~ formula:

- If $\sigma_x < \nu\sigma_y$:

  $\sigma_{xcor} = 0$

  ~~$\sigma_{ycor} = \sigma_y$~~
- ~~If $\sigma_y < \nu\sigma_x$:~~

  ~~$\sigma_{xcor} = \sigma_x$~~

  ~~$\sigma_{ycor} = 0$~~
- ~~In the other cases:~~

  ~~$\sigma_{xcor} = \sigma_x - \nu\sigma_y$~~

  ~~$\sigma_{ycor} = \sigma_y - \nu\sigma_x$~~
- If $\sigma_x \geq \nu\sigma_y$:

  $\sigma_{xcor} = \sigma_x - \nu\sigma_y$

Appendix 1 STRESS BASED REFERENCE STRESSES

2. Reference Stresses

2.1 Regular Panel

Paragraph 2.1.1 has been amended as follows.

2.1.1 Longitudinal stress

The longitudinal stress σ_x applied on the shorter edge of the buckling panel is to be calculated as follows:

(Omitted)

- For overall stiffened panel buckling and stiffener buckling assessments, $\sigma_x(x)$ applied on the shorter edge of the attached plate is to be taken as:

  $$\sigma_x = \frac{\sum_1^n A_i \sigma_{xi}}{\sum_1^n A_i}$$

  The edge stress ratio ψ_x for the stress σ_x is equal to 1.0.

Chapter 9 FATIGUE

Section 3 FATIGUE EVALUATION

6. Weld Improvement Methods

6.1 General

Paragraph 6.1.1 has been amended as follows.

6.1.1

Post-weld fatigue strength improvement methods are to be considered as a supplementary means of achieving the required fatigue life, and subjected to quality control procedures and corrosion protection in accordance with **Pt 1, Ch 3, Sec 4**. ~~The benefit from post-weld treatment can only be applied for corrosion free condition and may only be considered provided that a protective coating is applied after the post-weld treatment and maintained during the design life time.~~

6.4 Applicability

Paragraph 6.4.1 has been amended as follows.

6.4.1

The application of post-weld improvement and fatigue improvement factor provided in this section is subject to following limitations:

- The weld type complies with **6.1.5**.
- The weld improvement is effective in improving the fatigue strength of structural details under high cycle fatigue conditions therefore the fatigue improvements factors do not apply to low-cycle fatigue conditions, i.e. when $N \leq 5\times10^4$, where N is the number of life cycles to failure.
- Unless otherwise specifically stated, the fatigue improvement factor is to be used for welds, joining steel plates which are between 6 and 50 *mm* thick.
- ~~This benefit can only be achieved in a corrosion free condition and may only be considered provided that a suitable protective coating is applied after the post-weld treatment and maintained during the design life time.~~
- Fatigue improvement factor is to be applied to as-welded transverse butt welds, as-welded *T*-joint and cruciform welds and as-welded longitudinal attachment welds excluding longitudinal end connections.
- In way of areas prone to mechanical damage, fatigue improvement may only be granted if these are adequately protected.
- Treatment of inter-bead toes is required for large multi-pass welds as shown in **Fig. 6**.
- The builder is to provide the list of details and their locations on the ship for which the post-weld treatment has been applied.

Chapter 12 CONSTRUCTION

Section 3 DESIGN OF WELD JOINTS

2. Tee or Cross Joint

2.4 Partial or Full Penetration Welds

Paragraph 2.4.6 has been amended as follows.

2.4.6 Locations required for partial penetration welding

Partial penetration welding as defined in **2.4.2**, is to be used in the following locations. (see examples in **Fig. 3**):

(a) Connection of hopper sloping plate to longitudinal bulkhead (inner hull).
(b) End connection of ~~L~~longitudinal/transverse bulkhead primary supporting member including buttress structure ~~end connections~~ to the double bottom and both end connections of backing bracket, where it is fitted.
(c) Corrugated bulkhead lower stool supporting floors to inner bottom.
(d) Corrugated bulkhead gusset and shedder plates.
(e) Lower 15% of the length of built-up corrugation of vertical corrugated bulkheads
(f) Structural elements in double bottom below bulkhead primary supporting members and stool plates, except in way of **2.4.5(i)**.
(g) Lower hopper plate to inner bottom.
(h) Horizontal stringers on bulkheads in way of their bracket toe and the heel.

2.5.2

Table 3 has been amended as follows.

Table 3 Weld Factors for Miscellaneous Fittings and Equipment

Item	Connection to	f_{weld}
Hatch cover	Watertight/oil-tight joints	0.48 (1)
	At ends of stiffeners	0.38 (2)
	Elsewhere	0.24
Mast, derrick post, crane pedestal, etc.	Deck / Underdeck reinforced structure	0.43
Deck machinery seat	Deck	0.24
Mooring equipment seat	Deck	0.43
Ring for access hole type cover	Anywhere	0.43
Stiffening of side shell doors and weathertight doors	Anywhere	0.24
Frames of shell and weathertight doors	Anywhere	0.43
Coaming of ventilator and air pipe	Deck	0.43
Ventilators, etc., fittings	Anywhere	0.24
Ventilators, air pipes, etc., coaming to deck	Deck	0.43
Scupper and discharge	Deck	0.55
Bulwark stay	Deck	0.24
Bulwark plating	Deck	0.43
Guard rail, stanchion	Deck	0.43
Cleats and fittings	Hatch coaming and hatch cover	~~0.60~~ 0.24 (3)

(1) For bulk carrier hatch covers f_{weld} = 0.38 for watertight joints

(2) For bulk carrier hatch covers f_{weld} = 0.24 at ends of stiffeners

(3) Minimum weld factor. Where $t_{as\text{-}built}$ >11.5 *mm* l_{leg} need not exceed $0.62t_{as\text{-}built}$. Penetration welding may be required depending on design.

Part 2 SHIP TYPES

Chapter 1 BULK CARRIERS

Section 2 STRUCTURAL DESIGN PRINCIPLES

3. Structural Detail Principles

3.3 Deck Structures

Paragraph 3.3.5 has been amended as follows.

3.3.5 Protection against wire rope

Wire rope grooving in way of cargo holds openings is to be prevented by fitting suitable protection such as half-round bar on the hatch side girders (i.e. upper portion of topside tank plates) ~~or~~ and hatch end beams in cargo hold and upper portion of hatch coamings.

Paragraph 3.3.6 has been added as follows.

3.3.6 Protection of cargo hatch opening corners against mechanical damage

Specific measures are to be arranged to prevent the hatch opening corners from mechanical damage incurred by coming into direct contact with the vertical grab wire under normal operations.

Section 5 CARGO HATCH COVERS

2. Arrangements

Paragraph 2.1 has been deleted.

2.1 ~~Height of Hatch Coamings~~(Deleted)

~~2.1.1~~

~~The height of hatch coamings is not to be less than:~~

- ~~600 *mm* in position 1.~~
- ~~450 *mm* in position 2.~~

~~2.1.2~~

~~The height of hatch coamings in positions 1 and 2 closed by steel covers provided with gaskets and securing devices may be reduced with respect to the above values or the coamings may be omitted entirely, on condition that the Administration is satisfied that the safety of the ship is not thereby impaired in any sea conditions.~~

~~In such cases the scantlings of the covers, their gasketing, their securing arrangements and the drainage of recesses in the deck are considered by the Society on a case-by-case basis.~~

Chapter 2 OIL TANKERS

Section 1 GENERAL ARRANGEMENT DESIGN

2. Separation of Cargo Tanks

2.1 General

Paragraph 2.1.1 has been amended as follows.

2.1.1

~~The cargo pump room, cargo tanks, slop tanks and cofferdams are to be positioned forward of machinery spaces. Main cargo control stations, control stations, accommodation and service spaces are to be positioned aft of cargo tanks, slop tanks and spaces which isolate cargo or slop tanks from machinery spaces, but not necessary aft of the oil fuel bunker tanks and ballast tanks.~~

The designer's attention is to be drawn on the arrangement of the cargo pump room, cargo tanks, slop tanks and cofferdams, main cargo control stations, control stations, accommodation and service spaces as well as on the need to separate the cargo tanks from the machinery space.

Paragraph 2.1.2 has been deleted.

~~2.1.2~~

~~A cofferdam is to be provided to separate the cargo tanks from the machinery space. Pump room, ballast tanks or fuel oil tanks may be considered as cofferdam for this purpose.~~

Section 4 HULL OUTFITTING

1. Supporting Structures for Components Used in Emergency Towing Arrangements

1.1 General

Paragraph 1.1.1 and 1.1.2 have been amended as follows.

1.1.1

It is the responsibility of the designer to provide ~~E~~emergency towing arrangements ~~are to be~~ fitted at both the bow and stern of every tanker with a deadweight of 20,000 tonnes or more, as required by *SOLAS*, as amended.

1.1.2

The designer is reminded that design and construction of the towing arrangements ~~is~~ are to be approved by the Flag Administration or the Society on their behalf.

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 1 July 2021.

2. Notwithstanding the amendments to the Rules, the current requirements apply to ships for which the date of contract for construction* is before the effective date.

3. Notwithstanding the provision of preceding **2.**, the amendments to the Rules may apply to ships for which the date of contract for construction* is before the effective date upon request.

* "contract for construction" is defined in the latest version of IACS Procedural Requirement (PR) No.29.

IACS PR No.29 (Rev.0, July 2009)

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.

Note:
This Procedural Requirement applies from 1 July 2009.