Common Structural Rules for Bulk Carriers and Oil Tankers

Draft Rule Change Proposal 1 to 01 JAN 2021 version

Notes: (1) These Rule Changes enter into force on 1st July 2022.

COMMON STRUCTURAL RULES FOR BULK CARRIERS AND OIL TANKERS

RULE CHANGE PROPOSAL 1

This document contains amendments within the following Parts and chapters of the Common Structural Rules for Bulk Carriers and Oil Tankers, 1 January 2021. The amendments are effective on 1 July 2022.

The technical background document containing explanation for the amendments in this document can be found in "Technical Background for Rule Change Proposal 1 to 01 JAN 2021 version".

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2 SYMBOLS

2.4 Scantlings

2.4.1

Unless otherwise specified, symbols regarding scantlings and their units used in these Rules are those defined in Table 5.

Table 5: Scantlings

~~d_e~~	~~Distance from the upper edge of the web to the top of the flange for L3 profiles~~	~~mm~~

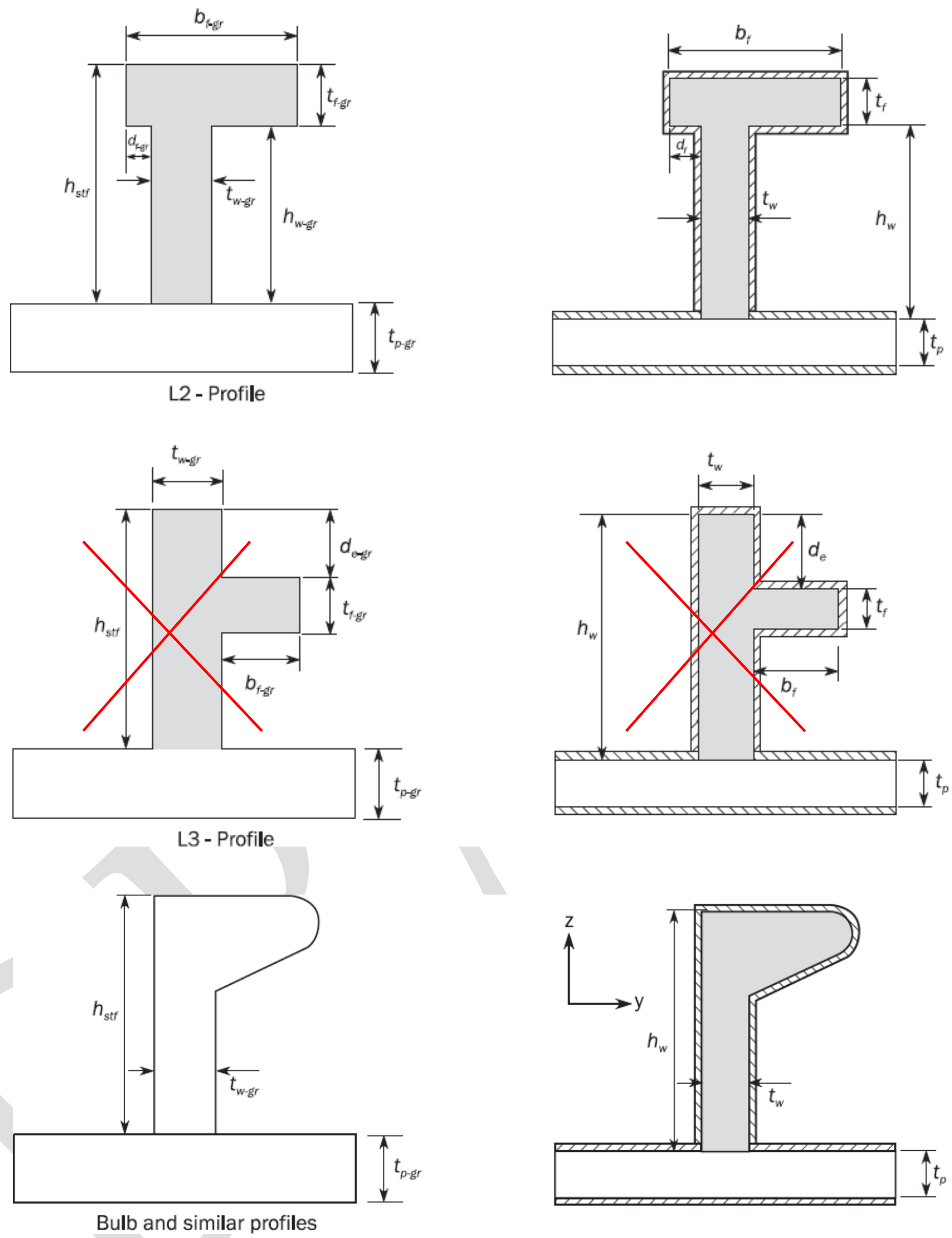
CHAPTER 3
STRUCTURAL DESIGN PRINCIPLES

SECTION 2 NET SCANTLING APPROACH

SYMBOLS

~~d_e : Distance in mm, from the upper edge of the web to the top of the flange for *L3* profiles, see Figure 3.~~
d_f : Distance in mm, for the extension of flange for L2 profiles, see Figure 3.

Figure 3: Net sectional properties of local supporting members (continued)



SECTION 3 CORROSION ADDITIONS

1 GENERAL

1.2.4

When a local structural member/plate is affected by more than one value of corrosion addition, the most onerous value is to be applied to the entire strake.

However, for the vertical corrugations arranged by vertical seams in oil tankers, the actual corrosion additions above and below the line 3m below top of tank (as defined in Table 1) can be used for the parts above and below the line, respectively.

SECTION 7 STRUCTURAL IDEALISATION

1.4 Geometrical properties of stiffeners and primary supporting members

1.4.6 Effective net plastic section modulus of stiffeners

…

h_w : Depth of stiffener web, in mm, taken equal to:

- For T, L (rolled and built-up) profiles and flat bar, as defined in Ch 3, Sec 2, Figure 2.
- For L2 ~~and L3~~ profile~~s~~ as defined in Ch 3, Sec 2, Figure 3.
- For bulb profiles, to be taken as defined in [1.4.1].

$h_{f\text{-}ctr}$: Height of stiffener measured to the mid thickness of the flange:

- $h_{f\text{-}ctr} = h_w + 0.5\, t_f$ for profiles with flange of rectangular shape ~~except for L3 profiles~~ and for bulb profiles.
- ~~$h_{f\text{-}ctr} = h_w - d_e - 0.5$ tf for L3 profiles as defined in Ch 3, Sec 2, Figure 3.~~

~~d_e : Distance from upper edge of web to the top of the flange, in mm, for L3 profiles, see Ch 3, Sec 2, Figure 3.~~

…

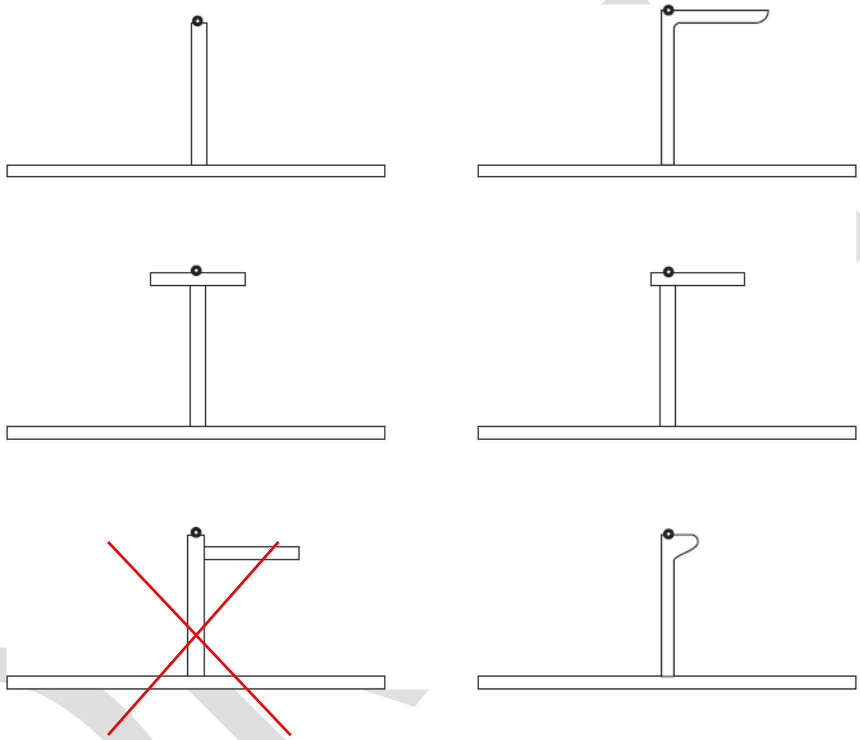
3 STIFFENERS

3.1 Reference point

3.1.1

The requirements of section modulus for stiffeners relate to the reference point giving the minimum section modulus. This reference point is generally located as shown in Figure 23 for typical profiles.

Figure 23: Reference point for calculation of section modulus and hull girder stress for local scantling assessment



CHAPTER 4
LOADS

SECTION 5 EXTERNAL LOADS

3. EXTERNAL IMPACT PRESSURES FOR THE BOW AREA

3.3 Bow impact pressure

3.3.1 Design pressures

The bow impact pressure P_{FB}, in kN/m^2, to be considered for the bow impact design load scenario is to be taken as:

$$P_{FB} = 1.025\, f_{FB} C_{FB} V_{im}^2 \sin \gamma_{wl}$$

γ_{wl} : Local bow impact angle, in deg, measured in a vertical plane containing the normal to the shell, from the horizontal to the tangent line at the considered position but not less than 50 deg, as shown in Figure 12. Where this value is not available, it may be taken as:

$$\gamma_{wl} = \tan^{-1}\left(\frac{\tan \beta_{pl}}{\cos \alpha_{wl}}\right)$$

For ships with bow impact angle less than 50 deg, the impact pressure is to be individually considered by the Society.

SECTION 8 LOADING CONDITIONS

3 OIL TANKERS

3.1.1 Seagoing conditions

The following seagoing loading conditions are to be included, as a minimum, in the loading manual:
…

e) Design ballast condition in which all segregated ballast tanks in the cargo tank region are full and all other tanks are empty including fuel oil and fresh water tanks. This design condition is for assessment of hull strength and is not intended for ship operation. ~~This condition will also be covered by the IMO 73/78 SBT condition provided the corresponding condition in the loading manual only includes ballast in segregated ballast tanks in the cargo tank region.~~

CHAPTER 8
BUCKLING

SECTION 2 SLENDERNESS REQUIREMENTS

Figure 1 : Stiffener scantling parameters

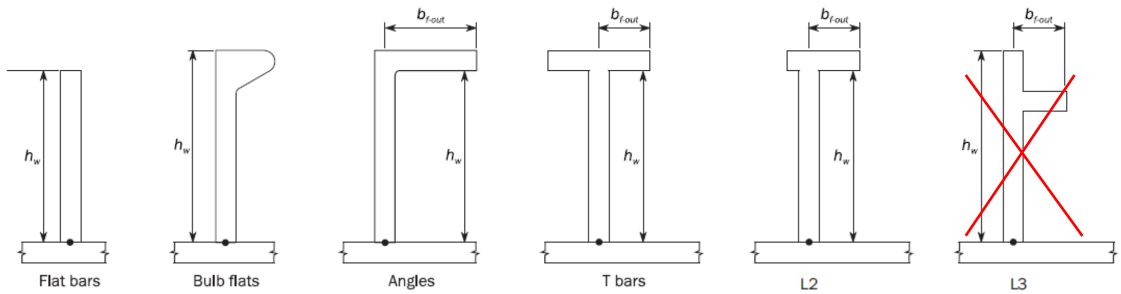


Table 1: Slenderness coefficients

Type of Stiffener	C_w	C_f
Angle and L2 ~~and L3~~ bars	75	12
T-bars	75	12
Bulb bars	45	-
Flat bars	22	-

SECTION 5 BUCKLING CAPACITY

SYMBOLS

…

A_p : Net sectional area of the stiffener attached plating, in mm^2, taken as:

$$A_p = st_p$$

…

d_f : Distance in mm, for the extension of flange for L2 profiles, as defined in Ch3, Sec2, Figure 3.

~~d_e : Distance from upper edge of web to the top of the flange, in mm, as defined in Ch 3, Sec 2, Figure 3.~~

e_f : Distance from attached plating to centre of flange, in mm, as shown in Figure 1 to be taken as:

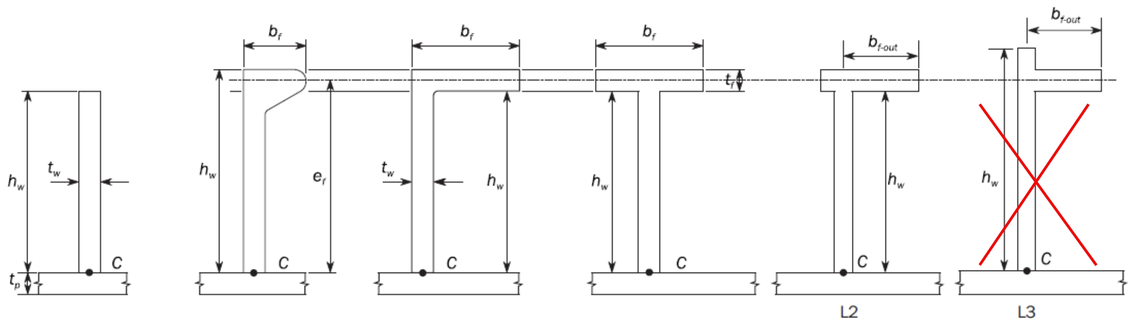
$e_f = h_w$ for flat bar profile.

$e_f = h_w - 0.5\ t_f$ for bulb profile.

$e_f = h_w + 0.5\ t_f$ for angle, L2 and Tee profiles.

~~$e_f = h_w - d_e - 0.5\ t_f$ for L3 profile.~~

Figure 1 : Stiffener cross sections



2 BUCKLING CAPACITY OF PLATES AND STIFFENERS

2.1 Overall stiffened panel capacity

2.1.2

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

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

where:

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

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

$N_x = \sigma_{x,av}(A_p + A_s)/s$

For stiffened panels fitted with U-type stiffeners, stiffener spacing s is taken as:

$s = b_1 + b_2$

where b_1 and b_2 are as defined in Pt 2, Ch 1, Sec 5, Figure 1.

……

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

$$D_{11} = \frac{EI_{eff}10^4}{s}$$

$$D_{12} = \frac{Et_p^3 \nu}{12(1-\nu^2)}$$

$$D_{22} = \frac{Et_p^3}{12(1-\nu^2)}$$

$$D_{33} = \frac{Et_p^3}{12(1+\nu)}$$

For stiffened panels fitted with U-type stiffeners, D_{12} and D_{22} are defined as:

$$D_{22} = \frac{E t_p^3}{12(1-\nu^2)}\left[1.2 + 4.8 \times Min\left(1.0, \frac{b_1^2}{h_w(b_1+b_2)}\right) \times Min\left(1.0, \left(\frac{t_w}{t_p}\right)^3\right)\right]$$

$D_{12} = \nu D_{22}$

h_w: Breadth of U-type stiffener web as defined in Pt 2, Ch 1, Sec 5, Figure 1.

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].

2.2.4 Correction factor F_{long}

Table2: Correction factor F_{long}

<table>
<tr><th colspan="3">Structural element types</th><th>F_{long}</th><th>c</th></tr>
<tr><td colspan="3">Unstiffened Panel</td><td>1.0</td><td>N/A</td></tr>
<tr><td rowspan="8">Stiffened Panel</td><td colspan="2">Stiffener not fixed at both ends</td><td>1.0</td><td>N/A</td></tr>
<tr><td rowspan="6">Stiffener fixed at both ends</td><td>Flat bar (1)</td><td rowspan="4">$F_{long} = c + 1$ for $\frac{t_w}{t_p} > 1$
$F_{long} = c\left(\frac{t_w}{t_p}\right)^3 + 1$ for $\frac{t_w}{t_p} \le 1$</td><td>0.10</td></tr>
<tr><td>Bulb profile</td><td>0.30</td></tr>
<tr><td>Angle and L2 ~~and L3~~ profiles</td><td>0.40</td></tr>
<tr><td>T profile</td><td>0.30</td></tr>
<tr><td>Girder of high rigidity (e.g. bottom transverse)</td><td>1.4</td><td>N/A</td></tr>
<tr><td>U-type profile fitted on hatch cover (2)</td><td>• Plate on which the U type profile is fitted, including EPP b_1 and EPP b_2
  • For $b_2 < b_1$: $F_{long} = 1$
  • For $b_2 \ge b_1$:
$$F_{long} = \left(1.55 - 0.55\frac{b_1}{b_2}\right)\left[1 + c\left(\frac{t_w}{t_p}\right)^3\right]$$
• Other plate of the U type profile: $F_{long} = 1$</td><td>0.2</td></tr>
<tr><td colspan="5">(1) t_w is the net web thickness, in mm, without the correction defined in [2.3.2].
(2) b_1, b_2, and t_w are defined in Pt 2, Ch 1, Sec 5, Figure 1..</td></tr>
</table>

2.2.5 Correction factor F_{tran}

The correction factor F_{tran} is to be taken as:

- For transversely framed EPP of single side skin bulk carrier, between the hopper and top wing tank:
  - F_{tran} = 1.25 when the two adjacent frames are supported by one tripping bracket fitted in way of the adjacent plate panels.
  - F_{tran} = 1.33 when the two adjacent frames are supported by two tripping brackets each fitted in way of the adjacent plate panels.
  - F_{tran} = 1.15 elsewhere.
- For the attached plate of a U-type stiffener fitted on a hatch cover:

$$F_{tran} = Max(3 - 0.08(F_{tran0} - 6)^2, 1.0) \leq 2.25$$

where,

$$F_{tran0} = Min\left(\frac{b_2}{b_1} + \frac{6b_2^2}{\pi^2 h_w(b_1 + b_2)}\left(\frac{t_w}{t_p}\right)^3, 6\right) \text{ for EPP } b_2$$

$$F_{tran0} = Min\left(\frac{b_1}{b_2} + \frac{6b_1^2}{\pi^2 h_w(b_2 + b_1)}\left(\frac{t_w}{t_p}\right)^3, 6\right) \text{ for EPP } b_1$$

with b_1, b_2 and h_w as defined in Pt 2, Ch 1, Sec 5, Figure 1.

Coefficient F defined in Case 2 of Table 3 is to be replaced by the following formula:

$$F = \left[1 - \left(\frac{K_y}{0.91F_{tran}} - 1\right)/\lambda_p^2\right] c_1 \geq 0$$

- For other cases: F_{tran} = 1

2.3.4 Ultimate buckling capacity

When $\sigma_a + \sigma_b + \sigma_w > 0$ while initially setting $\gamma = 1$, the ultimate buckling capacity for stiffeners is to be checked according to the following interaction formula:

…

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

~~$$\sigma_w = E y_w \left(\frac{t_f}{2} + h_w\right) \Phi_0 \left(\frac{m_{tor}\pi}{l_{tor}}\right)^2 \left(\frac{1}{1 - \frac{\gamma\sigma_a}{\sigma_{ET}}} - 1\right)$$~~

~~*with precondition* $\sigma_{ET} - \gamma\sigma_a > 0$ *for stiffener induced failure (SI).*~~

- For stiffener induced failure (*SI*)
  - For $\sigma_a > 0$

$$\sigma_w = E y_w e_f \Phi_0 \left(\frac{m_{tor}\pi}{l_{tor}}\right)^2 \left(\frac{1}{1-\frac{\gamma\sigma_a}{\sigma_{ET}}} - 1\right) \text{ with precondition } \sigma_{ET} - \gamma\sigma_a > 0$$

- For $\sigma_a \le 0$

  $\sigma_w = 0$

- For plate induced failure (*PI*)

  $\sigma_w = 0$

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

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

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

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

Table 5: Moments of inertia

	Flat bars(1)	Bulb, angle, L2~~, L3~~ and T profiles
I_P	$\frac{h_w^3 t_w}{3\cdot 10^4}$	$\left(\frac{A_w(e_f - 0.5t_f)^2}{3} + A_f e_f^2\right)10^{-4}$
I_T	$\frac{h_w t_w^3}{3\cdot 10^4}\left(1 - 0.63\frac{t_w}{h_w}\right)$	$\frac{(e_f - 0.5t_f)t_w^3}{3\cdot 10^4}\left(1 - 0.63\frac{t_w}{e_f - 0.5t_f}\right) + \frac{b_f t_f^3}{3\cdot 10^4}\left(1 - 0.63\frac{t_f}{b_f}\right)$
I_ω	$\frac{h_w^3 t_w^3}{36\cdot 10^6}$	For bulb, angle and L2 ~~and L3~~ profiles(2): $\frac{A_f^3 + A_w^3}{36\cdot 10^6} + \frac{e_f^2}{10^6}\left(\frac{A_f b_f^2 + A_w t_w^2}{3} - \frac{\left(A_f(b_f - 2d_f) + A_w t_w\right)^2}{4(A_f + A_w)} - A_f d_f(b_f - d_f)\right)$ For T profile: $\frac{b_f^3 t_f e_f^2}{12\cdot 10^6}$

(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.
(2) d_f is to be taken as 0 for bulb and angle profiles.

CHAPTER 11
SUPERSTRUCTURE, DECKHOUSES AND HULL OUTFITTING

SECTION 4 SUPPORTING STRUCTURE FOR DECK EQUIPMENT AND FITTINGS

3 MOORING WINCHES

~~3.1.3 Rated pull~~

~~The Rated Pull is defined as the maximum load which the mooring winch is designed to exert during operation.~~

~~3.1.4 Holding load~~

~~The Holding Load is defined as the maximum load which the mooring winch is designed to resist during operation and is to be taken as the design brake holding load or equivalent.~~

~~3.1.5~~ 3.1.3 Supporting structure

The supporting structure is to be dimensioned to ensure that for each of the load cases specified in [~~3.1.7~~ 5.3.1], the stresses do not exceed the permissible values given in [2.1.12].

For mooring winches situated within the forward 0.25 L, the supporting structure is to be dimensioned to ensure that for the load case specified in [2.1.6], the stresses do not exceed the permissible values given in [2.1.13] to [2.1.15].

~~3.1.6~~ 3.1.4 Corrosion model

These requirements are to be assessed based on net scantlings.

~~3.1.7 Each of the following load cases are to be examined for design loads due to mooring operation:~~

~~a) Mooring winch at maximum pull: 100% of the Rated Pull.~~
~~b) Mooring winch with brake effective: 100% of the Holding Load.~~
~~c) Line strength: 125% of the breaking strength of the mooring line provided by the designer (refer to Ch 11, Sec 3, [3.9]).~~

~~Rated pull and holding load are defined in [3.1.3] and [3.1.4]. The design load is to be applied through the mooring line according to the arrangement shown on the mooring arrangement plan.~~

~~3.1.8~~ 3.1.5

For mooring winches situated within the forward 0.25 L, the resultant forces in the bolts obtained from green sea design loads are to be calculated in accordance with [2.1.6] to [2.1.9].

~~3.1.9~~ 3.1.6

Where a separate foundation is provided for the mooring winch brake, the distribution of resultant forces is to take into account of the different load path. The brake is only to be considered in relation to the forces in [~~3.1.7~~ 5.3.1] ~~item (b)~~.

PART 2 SHIP TYPES

CHAPTER 1
BULK CARRIERS

SECTION 5 CARGO HATCH COVERS

SYMBOLS

~~b_p : Effective breadth, in mm, of the plating attached to the stiffener or primary supporting member, as defined in [3].~~

1 GENERAL

1.5 Allowable stresses

1.5.1

The allowable stresses σ_a ~~and τ_a~~, in N/mm^2, are to be obtained from Table 2.

Table 2 : Allowable stresses~~, in N/mm^2~~

Members of	Subjected to	σ_a, in N/mm^2	~~τ_a, in N/mm^2~~
Weathertight hatch cover	External pressure, as defined in [4.1.2]	0.80 R_{eH}	~~0.46 R_{eH}~~
Weathertight hatch cover	Other loads, as defined in [4.1.3] to [4.1.6]	0.90 R_{eH}	~~0.51 R_{eH}~~

The allowable buckling utilisation factors are given in Table 3:

Table 3 : Allowable buckling utilisation factors

Structural component	Subject to	η_{all}, Allowable buckling utilisation factor
Plates and stiffeners Web of PSM	External pressure, as defined in [4.1.2]	0.80 for load combination: S+D
	Other loads, as defined in [4.1.3] to [4.1.6]	~~0.80~~ 0.90 for load combination: S+D ~~0.64 for load combination: S~~

3 WIDTH OF ATTACHED PLATING

3.1 Stiffeners

3.1.1

The width of the attached plating b_p, in mm, to be considered for the check of stiffeners is to be taken as:

- Where the attached plating extends on both sides of the stiffener:

  $b_p = s$

- Where the attached plating extends on one side of the stiffener:

  $b_p = 0.5\, s$

3.2 Primary supporting members

3.2.1

The effective breadth, in mm, of the attached plating to be considered for the yielding and buckling checks of primary supporting members analysed through isolated beam or grillage model is to be taken as:

- Where the plating extends on both sides of the primary supporting member:

  $b_p = b_{eff}$

- Where the plating extends on one side of the primary supporting member:

  $b_p = 0.5 b_{eff}$

where:

b_{eff} : Effective breadth of attached plating, in m, as defined in Pt 1 Ch 3 Sec 7 [1.3.2]

For structural evaluations based on isolated beam or grillage models, the areas of stiffeners are not to be included in the idealisation of the attached plating of the primary members.

5 STRENGTH CHECK

5.1 General

5.1.1 Application

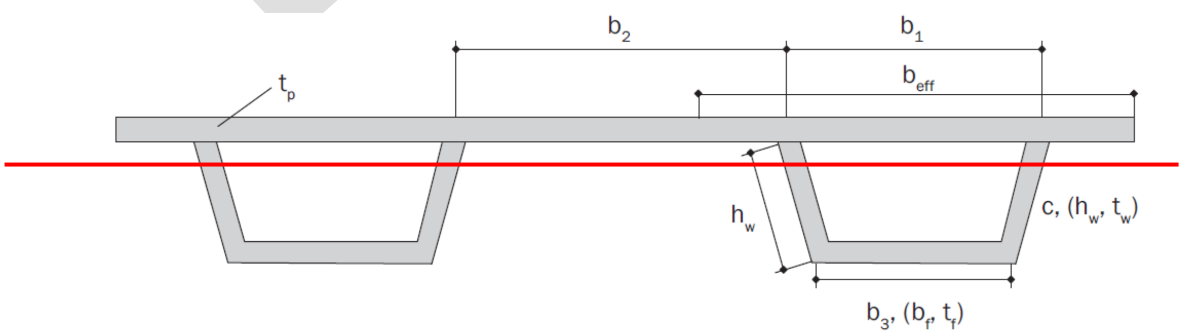
The strength check is applicable to rectangular hatch covers subjected to ~~a uniform~~ lateral pressure and/or concentrated loads, designed with primary supporting members arranged in one direction or as a grillage of longitudinal and transverse primary supporting members.

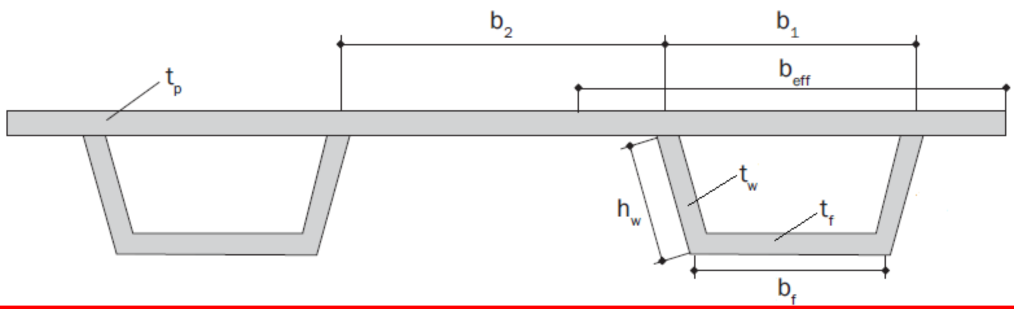
It is also applicable for hatch covers fitted with U-type stiffeners as shown in Figure 1. ~~In the latter case, i.e. when the hatch cover is arranged as a grillage of longitudinal and transverse primary supporting members, or when the Society deems it necessary, t~~The stresses in ~~the primary supporting~~ all structural members are to be determined by ~~a grillage or~~ a finite element analysis with the modelling requirements as described in [5.6.1].

It is to be checked that the stresses of all structural members ~~induced by concentrated loads are in accordance with the criteria in [5.4.4]~~ comply with the yield strength assessment requirement in [5.6.2]~~.~~ ~~When FE analysis is carried out,~~ and the buckling strength assessment requirements as described in [5.2.3], [5.3.4] ~~and~~, [5.4.6], [5.6.3] and [5.6.4] ~~can be made considering only the stresses given by the FE analysis~~.

~~The hatch covers fitted with U-type stiffeners as shown in Figure 1 are to be checked by means of FE analysis. In transverse section of the stiffener, nodes are to be located at the connection between the web of the U-type stiffener and the hatch cover plate as well as at the connection between the web and the flange of the U-type stiffener. The buckling assessment as described in [5.2.3], [5.3.4] and [5.4.6] can be made considering only the stresses given by the FE analysis.~~

Figure 1: Example of hatch cover fitted with U-type stiffener





5.2 Plating

5.2.3 Buckling strength

The buckling strength of the hatch cover plating subjected to loading conditions as defined in [4.1] is to comply with the requirements in [5.6.3]. ~~following formula:~~

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

~~where:~~

~~η_{Plate} : Maximum plate utilisation factor calculated according to Method A, as defined in Pt 1, Ch 8, Sec 5, [2.2].~~

- ~~For stresses obtained from beam theory, i.e. not calculated by means of finite element analysis:~~
  - ~~x or y is selected for the uniaxial check of the plate in the direction parallel to the primary supporting member,~~
  - ~~$\tau = 0$.~~
- ~~For stresses calculated by means of finite element analysis: σ_x, σ_y, τ obtained from FE analysis.~~

~~η_{all} : Allowable utilisation factor, as given in Table 3.~~

For hatch covers fitted with U-type stiffeners, it is to comply with the requirements in [5.6.4]. ~~the buckling panels b_1, b_2, b_3 and c (see Figure 1) are to be assessed separately~~

5.3 Stiffeners

5.3.1

~~For flat bar stiffeners, the ratio hw /tw is to comply with the following formula:~~

Stiffeners are to comply with the applicable slenderness and proportion requirements given in Pt 1, Ch 8, Sec 2, [3.1.1] and [3.1.2].

$$\frac{h_w}{t_w} \leq 15\sqrt{\frac{235}{R_{eH}}}$$

5.3.4 Buckling strength

The buckling strength of the hatch cover stiffeners subjected to loading conditions as defined in [4.1] is to comply with the requirements in [5.6.3]. ~~following formula:~~

~~$\eta_{stiffener} \leq \eta_{all}$~~

~~where:~~

~~$\eta_{stiffener}$: Maximum stiffener utilisation factor calculated according to Pt 1, Ch 8, Sec 5, [2.3].~~

- ~~For uniaxial stresses obtained by beam theory, i.e. not calculated by means of finite element analysis:~~
  - ~~σ_x: stiffener axial stress,~~
  - ~~$\sigma_y = 0$,~~
  - ~~$\tau = 0$.~~
- ~~For stresses calculated by means of finite element analysis:~~
  - ~~σ_x: stiffener axial stress from FE analysis,~~
  - ~~σ_y : stress perpendicular to the stiffener,~~
  - ~~τ□: shear stress in the attached plate.~~

~~η_{all} : Allowable utilisation factor, as given in Table 3.~~

The buckling strength of the hatch cover fitted with U-type stiffeners subjected to loading conditions as defined in [4.1] is to comply with the requirements in [5.6.4]. ~~is to be checked as detailed above, considering the U-type as an equivalent T-bar profile as follows:~~

- ~~Web height taken equal to d as defined in Pt 1, Ch 3, Sec 6, Figure 21.~~
- ~~Web thickness equal to $2t_w$.~~

- Flange breadth taken as b_3, as shown on Figure 1.
- Flange thickness taken as t_f, as shown on Figure 1.
- Effective width of the attached plating, b_{eff}, taken as:

  $b_{eff} = C_{x1}b_1 + C_{x2}b_2$

  Where:

  C_{x1}, C_{x2} : Reduction factor defined in Pt 1, Ch 8, Sec 5, Table 3 calculated for the EPP b_1 and b_2 according to Case 1

5.4 Primary supporting members

5.4.1 Application

The requirements in [5.4.3] to [5.4.5] apply to primary supporting members which may be analysed through isolated beam models.

Primary supporting members whose arrangement is of a grillage type and which cannot be analysed through isolated beam models are to be checked by direct calculations, using the checking criteria in [5.4.4] with the requirements in [5.4.2] to [5.4.7].

5.4.2 Minimum net thickness of web

The web net thickness of primary supporting members, in mm, is not to be less than 6 mm.

5.4.3

Void.

5.4.3 Normal and shear stress for isolated beam

In case that grillage analysis or finite element analysis are not carried out, according to the requirements in [5.1.1], the maximum normal stress σ and shear stress τ, in N/mm², in the primary supporting members are to be taken as given by the following formulae:

$$\sigma = \frac{S(F_s P_s + F_w P_w) l_m^2}{f_{bc} Z}$$

$$\tau = \frac{5S(F_s P_s + F_w P_w) l_m}{A_{shr}}$$

where:

l_m : Bending span, in m, of the primary supporting member.

5.4.4

Void.

~~5.4.4 Checking criteria~~

~~The normal stress σ and the shear stress τ, calculated according to [5.4.3] or determined through a grillage analysis or finite element analysis, as the case may be, are to comply with the following formulae:~~

~~$\sigma \leq \sigma_a$~~
~~$\tau \leq \tau_a$~~

5.4.6 Buckling strength of the web panels of the primary supporting members

The web of primary supporting members subject to loading conditions as defined in [4.1] is to comply with the requirements in [5.6.3].~~be taken as:~~

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

~~where:~~

~~η_{Plate} : Maximum plate utilisation factor calculated according to Method A, as defined in Pt 1, Ch 8, Sec 5, [2.4].~~

- ~~Shear stress obtained by beam theory (i.e. calculated according to [5.4.3] or determined through a grillage analysis), or~~
- ~~σ_x, σ_y, τ obtained by FE analysis.~~

~~η_{all} : Allowable utilisation factor, as given in Table 3.~~

5.6 Finite element model and buckling assessment

5.6.1 Finite element model

For the strength assessments of hatch covers subjected to loading conditions as defined in [4.1], by means of FE analysis, the hatch cover geometry shall be idealized as realistically as possible. In no case shall the element width be larger than stiffener spacing. In way of force transfer points and cutouts the mesh is to be refined where applicable. The ratio of element length to width shall not exceed 4.

The element size along the height of webs of primary supporting member is not to exceed one-third of the web height. Stiffeners, which support plates subjected to lateral pressure loads, are to be included in the FE model idealization. Stiffeners may be modelled by using beam elements, or shell/plate elements. Buckling stiffeners may be disregarded for the stress calculation.

Hatch covers fitted with U-type stiffeners as shown in Figure 1 are to be assessed by means of FE analysis. The geometry of the U-type stiffeners is to be accurately modelled using shell/plate elements. Nodal points are to be properly placed on the intersections between the webs of a U-type stiffener and the hatch cover plate, and between the webs and flange of the U-type stiffener.

5.6.2 Yield strength assessment

All hatch cover structural members are to comply with the following formula

$\sigma_{vm} \leq \sigma_a$ for shell elements in general.
$\sigma_{axial} \leq \sigma_a$ for rod or beam elements in general.

where,

σ_a: Allowable stress as defined in [1.5.1], Table 2.
σ_{vm}: Von Mises stress, in N/mm², to be taken as follows:

$$\sigma_{vm} = \sqrt{\sigma_x{}^2 - \sigma_x\sigma_y + \sigma_y{}^2 + 3\tau_{xy}^2}$$

σ_x: Normal stress, in N/mm², in *x*-direction.

σ_y: Normal stress, in N/mm², in *y*-direction.

τ_{xy} : Shear stress, in N/mm², in the *x*-*y* plane.

σ_{axial} : Axial stress in rod or beam element, in N/mm².

Indices *x* and *y* are coordinates of a two-dimensional Cartesian system in the plane of the considered structural element.

In case of FEM calculations using shell (or plate) elements, the stresses are to be read from the centre of the individual element. It is to be observed that, in particular, at flanges of unsymmetrical girders, the evaluation of stress from element centre may lead to non-conservative results. Thus, a sufficiently fine mesh is to be applied in these cases or, the stress at the element edges shall not exceed the allowable stress. Where shell elements are used, the stresses are to be evaluated at the mid plane of the element.

5.6.3 Buckling strength assessment

The plate panel of a hatch cover structure is to be modelled as stiffened panel (SP) or unstiffened panel (UP). Assessment Method A (-A) and Method B (-B) as defined in Pt 1, Ch 8, Sec 1, [3] are to be used in accordance with Table 4, Figure 3 and Figure 4. For a web panel with opening, the procedure for opening should be used for its buckling assessment.

Wherever necessary, the following corresponding buckling requirements for direct strength anaslysis in Pt 1, Ch 8, Sec 4 can be referred to:

(1) Average thickness of plate panel, in Pt 1, Ch 8, Sec 4, [2.1.2].

(2) Irregular plate panel, in Pt 1, Ch 8, Sec 4, [2.3].

(3) Reference stress, in Pt 1, Ch 8, Sec 4, [2.4].

(4) Lateral pressure, in Pt 1, Ch 8, Sec 4, [2.5].

(5) Buckling criteria, in Pt 1, Ch 8, Sec 4, [2.6], but using allowable buckling utilisation factors as defined in Pt 2, Ch 1, Sec 5, Table 3.

Table 4 : Structural members and assessment methods

Structural elements	**Assessment method**[1,2]	**Normal panel definition**
Hatch cover top/bottom plating structures, see Figure 3		
Hatch cover top/bottom plating	SP-A	Length: between web frames Width: between primary supporting members
Irregularly stiffened panels	UP-B	Plate between local stiffeners/PSM
Hatch cover webs of primary supporting members, see Figure 4		
Web of transverse/longitudinal girder (single skin type)	UP-B	Plate between local stiffeners/face plate/PSM
Web of transverse/longitudinal girder (double skin type)	SP-B[3]	Length: between web frames Width: full web depth
Web panel with opening	Procedure for opening	Plate between local stiffeners/face plate/PSM
Irregularly stiffened panels	UP-B	Plate between local stiffeners/face

Note 1: SP and UP stand for stiffened and unstiffened panel respectively.

Note 2: A and B stand for Method A and Method B respectively.

Note 3: In case that the buckling carlings/brackets are irregularly arranged in the web of transverse/longitudinal girder, UP-B method may be used.

Figure 3 : Hatch cover top/bottom plating structures

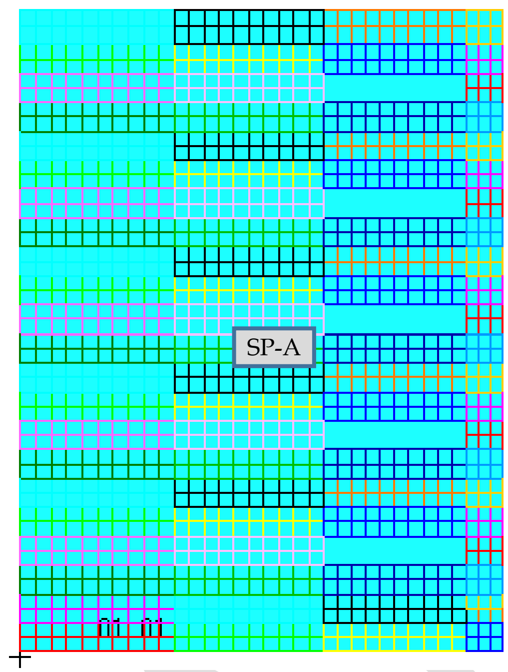
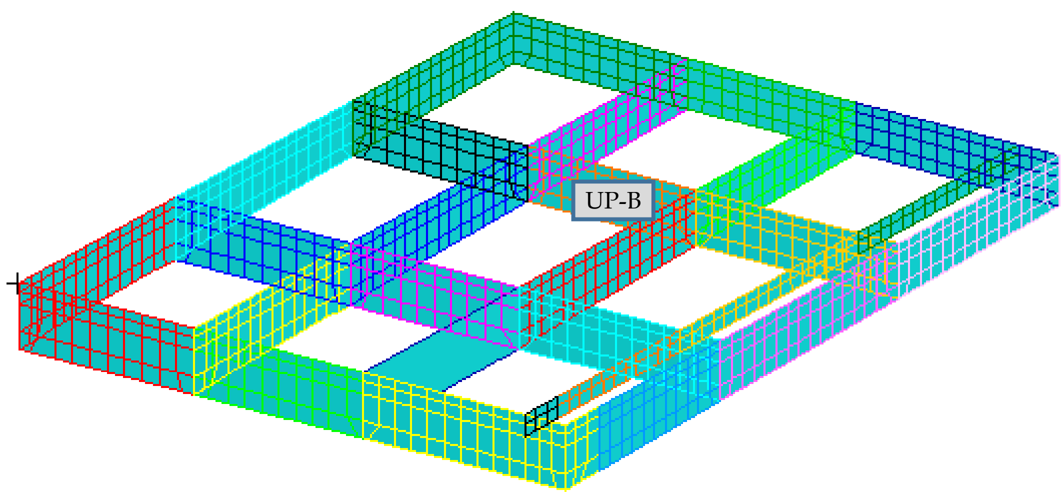


Figure 4 : Hatch cover webs of primary supporting members



5.6.4 Buckling assessment of stiffened panels with U-type stiffeners

For hatch covers fitted with U-type stiffeners, local plate buckling is to be checked for each of the plate panels EPP b_1, b_2, b_f and h_w (see Figure 1) separately as follows:

- The attached plate panels EPP b_1 and b_2 are to be assessed using SP-A model, where in the calculation of buckling factors K_x as defined in Pt 1, Ch 8, Sec 5, Table 3, the correction factor F_{long} for U-type stiffeners as defined in Pt 1, Ch 8, Sec 5, Table 2 is to be used; and in the calculation of K_y as defined in Pt 1, Ch 8, Sec 5, Table 3, the F_{tran} for U-type stiffeners as defined in Pt 1, Ch 8, Sec 5, [2.2.5] is to be used.
- The face plate and web plate panels EPP b_f and h_w are to be assessed using UP-B model with F_{long}=1 and F_{tran}=1.

The overall stiffened panel capacity and ultimate capacity of stiffeners of the hatch cover fitted with U-type stiffeners are to be checked with warping stress σ_w = 0, and with bending moment of inertia including effective width of attached plating being calculated based on the following assumptions:

- The two web panels of a U-type stiffener are to be taken as perpendicular to the attached plate with thickness equal to t_w and height equal to the distance between the attached plate and the face plate of the stiffener.
- Effective width of the attached plating, b_{eff}, taken as the sum of the b_{eff} calculated for the EPP b_1 and b_2 respectively according to SP-A model.
- Effective width of the attached plating of a stiffener without the shear lag effect, b_{eff1}, taken as the sum of the b_{eff1} calculated for the EPP b_1 and b_2 respectively.

6 HATCH COAMINGS

6.3 Scantlings

6.3.3 Coaming stays

…(examples shown in Figure ~~3~~ 5 and Figure ~~4~~ 6)…

Figure ~~3~~ 5 : Coaming stay (example 1)

Figure ~~4~~ 6 : Coaming stay (example 2)