09-391

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part CSR-B Common Structural Rules for Bulk Carriers

Rules for the Survey and Construction of Steel Ships
Part CSR-B 2009 AMENDMENT NO.1

Rule No.19 15th April 2009
Resolved by Technical Committee on 4th February 2009
Approved by Board of Directors on 24th February 2009

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Rule No.19 15th April 2009
AMENDMENT TO THE RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

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

Part CSR-B Common Structural Rules for Bulk Carriers

Amendment 1-1

Chapter 8 FATIGUE CHECK OF STRUCTURAL DETAILS

Section 2 FATIGUE STRENGTH ASSESSMENT

2. Equivalent notch stress range

Paragraph 2.3 has been amended as follows.

2.3 Equivalent notch stress range

2.3.1 Equivalent notch stress range

The equivalent notch stress range, in N/mm^2, for each loading condition is to be calculated with the following formula:

$$\Delta\sigma_{eq,\,j} = K_f \Delta\sigma_{equiv,\,j}$$

where:

$\Delta\sigma_{equiv,\,j}$: Equivalent hot spot stress range, in N/mm^2, in loading condition "*j*" obtained by **[2.3.2]**.

K_f: Fatigue notch factor defined in **Table 1**.

Table 1 Fatigue notch factors K_f

Subject	~~K_f~~ Without weld grinding	With weld grinding (not applicable for ordinary stiffeners and boxing fillet welding *1)
Butt welded joint	1.25	1.10
Fillet welded joint	1.30	1.15 *2
Non welded part	1.00	-

Note:
*1 Boxing fillet welding is defined as a fillet weld around a corner of a member as an extension of the principal weld.
*2 This is applicable for deep penetration welding, or full penetration welding only.

In case where grinding is performed, full details regarding grinding standards including the extent, smoothness particulars, final welding profiles, and grinding workmanship as well as quality acceptance criteria are to be submitted to the Society for approval.
It is preferred that any grinding is carried out by rotary burrs, is to extend below plate surfaces in order to remove any toe defects and ground areas are to have sufficient corrosion protection.
Such treatments are to procedure smooth concave profiles at weld toes with the depth of these depressions penetrating into plate surfaces to at least 0.5*mm* below the bottom of any visible undercuts.

The depth of any grooves produced is to be kept to a minimum and, in general, kept to a maximum of 1*mm*. Under no circumstances is grinding depth to exceed 2*mm* or 7 % of plate gross thickness, whichever is smaller. Grinding has to extend to 0.5 longitudinal spacing or 0.5 frame spacing at the each side of hot spot locations.

2.3.2 Equivalent hot spot stress range

The equivalent hot spot stress range, in N/mm^2, is to be calculated for each loading condition with the following formula:

$$\Delta\sigma_{equiv,\,j} = f_{mean,\,j}\,\Delta\sigma_{W,\,j}$$

where:

$f_{mean\,,\,j}$: Correction factor for mean stress :

- for hatch corners $f_{mean\,,\,j} = 0.77$
- for primary members and longitudinal stiffeners connections, $f_{mean\,,\,j}$ corresponding to the condition "*j*" taken equal to:

$$f_{mean,\,j} = \max\left\{0.4,\left[\max\left(0,\frac{1}{2}+\frac{-\ln\left(10^{-4}\right)}{4}\frac{\sigma_{m,\,j}}{\Delta\sigma_{W,\,j}}\right)\right]^{0.25}\right\}$$

$\sigma_{m,\,1}$: Local hot spot mean stress, in N/mm^2, in the condition "1", obtained from the following formulae:

- if $0.6\Delta\sigma_{W,1} \geq 2.5R_{eH}$:

  $\sigma_{m,1} = -0.18\Delta\sigma_{W,1}$
- if $0.6\Delta\sigma_{W,1} < 2.5R_{eH}$:

  $\sigma_{m,1} = R_{eH} - 0.6\Delta\sigma_{W,1}$ for $0.6\Delta\sigma_{W,1} > R_{eH} - \sigma_{res} - \sigma_{mean,1}$

  $\sigma_{m,1} = \sigma_{mean,1} + \sigma_{res}$ for $0.6\Delta\sigma_{W,1} \leq R_{eH} - \sigma_{res} - \sigma_{mean,1}$

$\sigma_{m\,,\,j}$: Local hot spot mean stress, in N/mm^2, in the condition "*j*", obtained from the following formulae:

- if $0.24\Delta\sigma_{W,\,j} \geq R_{eH}$:

  $\sigma_{m,\,j(j\neq1)} = -0.18\Delta\sigma_{W,\,j}$
- if $0.24\Delta\sigma_{W,\,j} < R_{eH}$:

  $\sigma_{m,\,j(j\neq1)} = -R_{eH} + 0.24\Delta\sigma_{W,\,j}$ for

  $0.24\Delta\sigma_{W,\,j} > R_{eH} + \sigma_{m,1} - \sigma_{mean,1} + \sigma_{mean,\,j}$

  $\sigma_{m,\,j(j\neq1)} = \sigma_{m,1} - \sigma_{mean,1} + \sigma_{mean,\,j}$ for

  $0.24\Delta\sigma_{W,\,j} \leq R_{eH} + \sigma_{m,1} - \sigma_{mean,1} + \sigma_{mean,\,j}$

$\sigma_{mean\,,\,j}$: Structural hot spot mean stress, in N/mm^2, corresponding to the condition "*j*"

σ_{res} : Residual stress, in N/mm^2, taken equal to : ~~obtained from the following formulae:~~

$\cancel{\sigma_{res} = \max\{\sigma_{res,j}\ ,\ j=1,2,}3,4\}$

$\sigma_{res} = 0.25R_{eH}$ for stiffener end connection

$\sigma_{res} = 0$ for non welded part and primary members(cruciform joint or butt weld)

$$\cancel{\sigma_{res,j} = \begin{cases}\max\left[-R_{eH},\min\left\{R_{eH},\sigma_{res0}+\sigma_{mean,j}+0.6\Delta\sigma_{W,j}\right\}-\sigma_{mean,j}-0.6\Delta\sigma_{W,j}\right] & \text{for } \sigma_{mean,j}\geq 0\\ \min\left[R_{eH},\max\left\{-R_{eH},\sigma_{res0}+\sigma_{mean,j}-0.24\Delta\sigma_{W,j}\right\}-\sigma_{mean,j}+0.24\Delta\sigma_{W,j}\right] & \text{for } \sigma_{mean,j}<0\end{cases}}$$

$$\sigma_{res0} = \begin{cases} 0.25 R_{eH} & \text{for} \quad \text{welded joint} \\ 0 & \text{for} \quad \text{non welded part} \end{cases}$$

EFFECTIVE DATE AND APPLICATION (Amendment 1-1)

1. The effective date of the amendments is 12 September 2008.

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

IACS PR No.29 (Rev.4)

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

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

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

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

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

Amendment 1-2

Chapter 1 GENERAL PRINCIPLES

Section 1 APPLICATION

1. General

1.1 Structural requirements

Paragraph 1.1.2 has been amended as follows.

1.1.2

This Part applies to the hull structures of single side skin and double side skin bulk carriers with unrestricted worldwide navigation, having length $\cancel{L}\underline{L_{CSR-B}}$ of 90 *m* or above.

(Omitted)

Paragraph 1.1.3 has been amended as follows.

1.1.3

This Part contains the *IACS* requirements for hull scantlings, arrangements, welding, structural details, materials and equipment applicable to all types of bulk carriers having the following characteristics:

- $\cancel{L}\underline{L_{CSR-B}} < 350\ m$
- $\cancel{L}\underline{L_{CSR-B}} / B > 5$
- $B / D < 2.5$
- $C_B \geq 0.6$

Section 4 SYMBOLS AND DEFINITIONS

1. Primary symbols and units

1.1

Table 1 has been amended as follows.

Table 1 Primary symbols

Symbol	Meaning	Units
(Omitted)		
$\cancel{L}\underline{L_{CSR-B}}$	Length of ship (see [**2**])	*m*
(Omitted)		

2. Symbols

2.1 Ship's main data

Paragraph 2.1.1 has been amended as follows.

2.1.1

~~L~~ L_{CSR-B} : Rule length, in m, defined in **3.1**

(Omitted)

C_B : Total block coefficient

$$\cancel{C_B = \frac{\Delta}{1.025LBT}} \quad C_B = \frac{\Delta}{1.025L_{CSR-B}BT}$$

(Omitted)

2.3 Loads

Paragraph 2.3.1 has been amended as follows.

2.3.1

(Omitted)

C : Wave parameter, taken equal to:

$$\cancel{C = 10.75 - \left(\frac{300-L}{100}\right)^{1.5} \quad \text{for } 90 \le L < 300\ m}$$

$$\cancel{C = 10.75 \quad \text{for } 300 \le L < 350\ m}$$

$$C = 10.75 - \left(\frac{300-L_{CSR-B}}{100}\right)^{1.5} \quad \text{for } 90m \le L_{CSR-B} < 300m$$

$$C = 10.75 \quad \text{for } 300m \le L_{CSR-B} < 350m$$

(Omitted)

3. Definitions

Paragraph 3.1 has been amended as follows.

3.1 Rule length

3.1.1

The rule length ~~L~~ L_{CSR-B} is the distance, in m, measured on the summer load waterline, from the forward side of the stem to the after side of the rudder post, or to the centre of the rudder stock where there is no rudder post. ~~L~~ L_{CSR-B} is to be not less than 96% and need not exceed 97% of the extreme length on the summer load waterline.

3.1.2

In ships without rudder stock (e.g. ships fitted with azimuth thrusters), the rule length ~~L~~ L_{CSR-B} is to be taken equal to 97% of the extreme length on the summer load waterline.

3.1.3

In ships with unusual stem or stern arrangements, the rule length ~~L~~L_{CSR-B} is considered on a case by case basis.

Paragraph 3.3 has been amended as follows.

3.3 Ends of rule length ~~L~~L_{CSR-B} and midship

3.3.1 Fore end

The fore end (*FE*) of the rule length ~~L~~L_{CSR-B}, see **Fig. 2**, is the perpendicular to the summer load waterline at the forward side of the stem.

The aft end (*AE*) of the rule length ~~L~~L_{CSR-B}, see **Fig. 2**, is the perpendicular to the waterline at a distance ~~L~~L_{CSR-B} aft of the fore end.

3.3.2 Midship

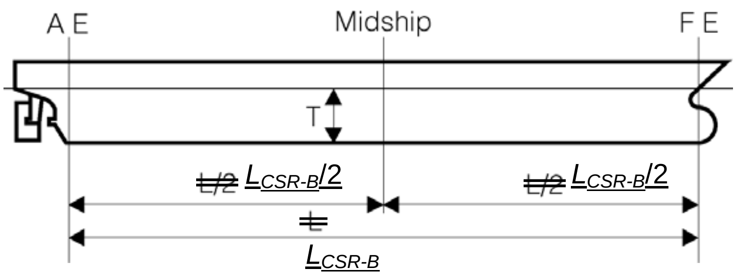
The midship is the perpendicular to the waterline at a distance 0.5~~L~~L_{CSR-B} aft of the fore end.

3.3.3 Midship part

The midship part of a ship is the part extending 0.4~~L~~L_{CSR-B} amidships, unless otherwise specified.

Fig. 2 has been amended as follows.

Fig.2 Ends and midship



4. Reference co-ordinate system

4.1

Paragraph 4.1.1 has been amended as follows.

4.1.1

The ship's geometry, motions, accelerations and loads are defined with respect to the following right-hand co-ordinate system (see **Fig. 4**):

- Origin: at the intersection among the longitudinal plane of symmetry of ship, the aft end of ~~L~~L_{CSR-B} and the baseline
- *X* axis: longitudinal axis, positive forwards
- *Y* axis: transverse axis, positive towards portside
- *Z* axis: vertical axis, positive upwards.

Chapter 2 GENERAL ARRANGEMENT DESIGN

Section 1 SUBDIVISION ARRANGEMENT

1. Number and arrangement of transverse watertight bulkheads

Table 1 has been amended as follows.

Table 1 Number of bulkheads

Length (m)	Number of bulkheads for ships with aft machinery[1]	Numbers of bulkheads for other ships
~~$90 \le L < 105$~~ $\underline{90 \le L_{CSR-B} < 105}$	4	5
~~$105 \le L < 120$~~ $\underline{105 \le L_{CSR-B} < 120}$	5	6
~~$120 \le L < 145$~~ $\underline{120 \le L_{CSR-B} < 145}$	6	7
~~$145 \le L < 165$~~ $\underline{145 \le L_{CSR-B} < 165}$	7	8
~~$165 \le L < 190$~~ $\underline{165 \le L_{CSR-B} < 190}$	8	9
~~$L \ge 190$~~ $\underline{L_{CSR-B} \ge 190}$	To be defined on a case by case basis	
(1) After peak bulkhead and aft machinery bulkhead are the same.		

Section 2 COMPARTMENT ARRANGEMENT

5. Minimum bow height

5.1 General

Paragraph 5.1.1 has been amended as follows.

5.1.1

Ref. ILLC, as amended (Resolution MSC.143(77) Reg. 39(1))

The bow height F_b, defined as the vertical distance at the forward perpendicular between the waterline corresponding to the assigned summer freeboard and the designed trim and the top of the exposed deck at side, is to be not less than:

$$F_b = (6075(L_{LL}/100) - 1875(L_{LL}/100)^2 + 200(L_{LL}/100)^3)(2.08 + 0.609C_B - 1.603C_{wf} - 0.0129(\cancel{L}\underline{L_{LL}}/T_1))$$

(Omitted)

Paragraph 5.1.2 has been amended as follows.

5.1.2

Ref. ILLC, as amended (Resolution MSC.143(77) Reg. 39.(2))

Where the bow height required in paragraph **5.1.1** is obtained by sheer, the sheer is to extend for at least 15% of the length of the ship measured from the forward perpendicular. Where it is obtained by fitting a superstructure, such superstructure is to extend from the stem to a point at least 0.07~~L~~L_{LL} abaft the forward perpendicular, and is to be enclosed as defined **Ch 9**, **Sec 4**.

Paragraphs 5.1.4 and 5.1.5 have been amended as follows.

5.1.4

Ref. ILLC, as amended (Resolution MSC.143(77) Reg. 39(4, a))

The sheer of the forecastle deck may be taken into account, even if the length of the forecastle is less than 0.15~~L~~$\underline{L_{LL}}$, but greater than 0.07~~L~~$\underline{L_{LL}}$, provided that the forecastle height is not less than one half of standard height of superstructure between 0.07~~L~~$\underline{L_{LL}}$ and the forward perpendicular.

5.1.5

Ref. ILLC, as amended (Resolution MSC.143(77) Reg. 39(4, b))

Where the forecastle height is less than one half of the standard height of superstructure, the credited bow height may be determined as follows:

a) Where the freeboard deck has sheer extending from abaft 0.15~~L~~$\underline{L_{LL}}$, by a parabolic curve having its origin at 0.15~~L~~$\underline{L_{LL}}$ abaft the forward perpendicular at a height equal to the midship depth of the ship, extended through the point of intersection of forecastle bulkhead and deck, and up to a point at the forward perpendicular not higher than the level of the forecastle deck (as illustrated in **Fig. 1**). However, if the value of the height denoted h_t in **Fig. 1** is smaller than the value of the height denoted h_b then h_t may be replaced by h_b in the available bow height, where:

$$\cancel{h_t = Z_b\left(\frac{0.15L}{x_b}\right)^2 - Z_t} \quad \underline{h_t = Z_b\left(\frac{0.15L_{LL}}{x_b}\right)^2 - Z_t}$$

Z_b: As defined in **Fig. 1**

Z_t : As defined in **Fig. 1**

h_f : Half standard height of superstructure

b) Where the freeboard deck has sheer extending for less than 0.15~~L~~$\underline{L_{LL}}$ or has no sheer, by a line from the forecastle deck at side at 0.07~~L~~$\underline{L_{LL}}$ extended parallel to the base line to the forward perpendicular (as illustrated in **Fig. 2**).

Fig.1 and Fig.2 have been amended as follows.

Fig. 1 Credited bow height where the freeboard deck has sheer extending from abaft 0.15~~*L*~~<u>L_{LL}</u>

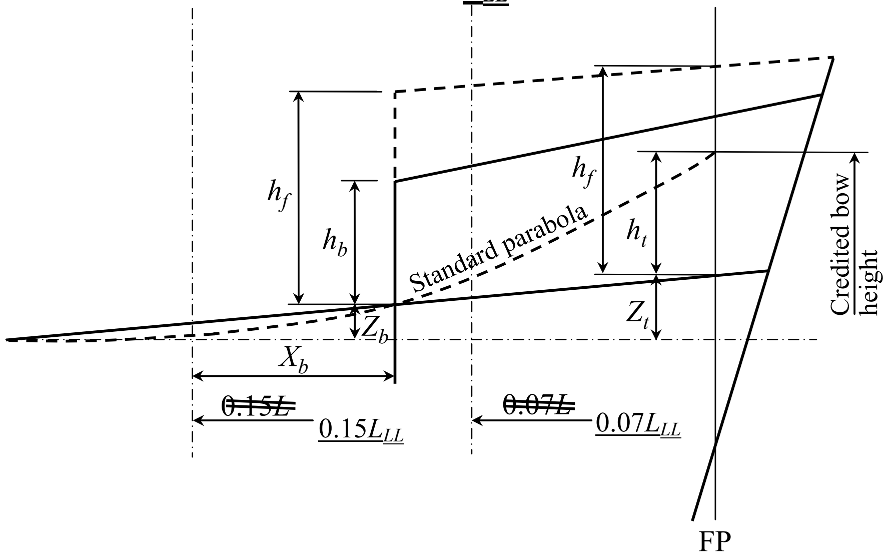
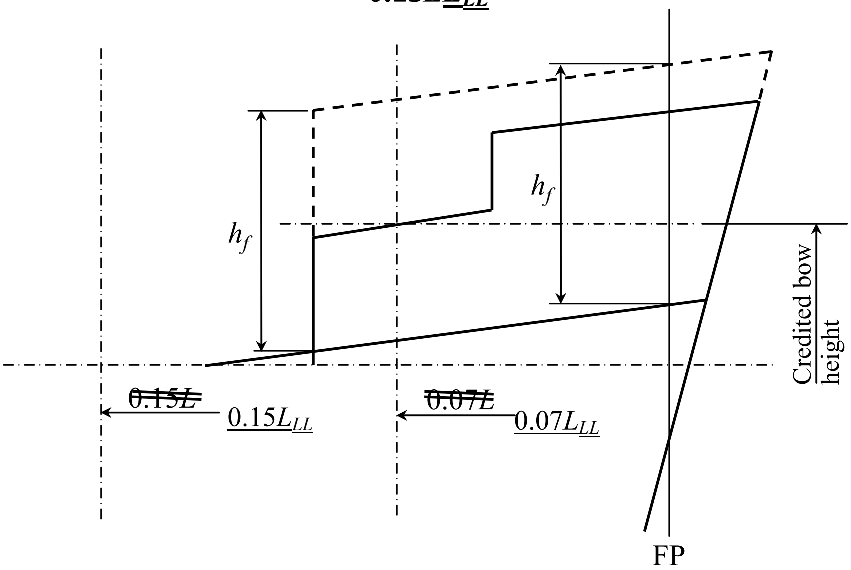


Fig. 2 Credited bow height where the freeboard deck has sheer extending for less than 0.15~~*L*~~<u>L_{LL}</u>



Chapter 3 STRUCTURAL DESIGN PRINCIPLES

Section 1 MATERIAL

2. Hull structural steel

2.3 Grades of steel

Table 4 has been amended as follows.

Table 4 Application of material classes and grades

<table>
<tr><td rowspan="2">Structural member category</td><td colspan="2">Material class</td></tr>
<tr><td>Within $0.4\cancel{L}\underline{L_{CSR-B}}$ amidship</td><td>Outside $0.4\cancel{L}\underline{L_{CSR-B}}$ amidship</td></tr>
<tr><td colspan="3">(Omitted)</td></tr>
<tr><td colspan="3">SPECIAL</td></tr>
<tr><td>(Omitted)</td><td rowspan="4">III</td><td rowspan="4">II
(I outside $0.6\cancel{L}\underline{L_{CSR-B}}$ amidships)</td></tr>
<tr><td>Longitudinal hatch coamings of length greater than $0.15\cancel{L}\underline{L_{CSR-B}}$ (5)</td></tr>
<tr><td>Web of lower bracket of side frame of single side bulk carriers having additional service feature BC-A or BC-B(5)</td></tr>
<tr><td>End brackets and deck house transition of longitudinal cargo hatch coamings(5)</td></tr>
<tr><td colspan="3">Notes:
(1) Not to be less than grade E/EH within $0.4\cancel{L}\underline{L_{CSR-B}}$ amidships in ships with length exceeding 250 m.
(2) Not to be less than class III within $0.6\cancel{L}\underline{L_{CSR-B}}$ amidships and class II within the remaining length of the cargo region.
(3) May be of class II in ships with a double bottom over the full breadth and with length less than 150 m.
(4) Not to be less than grade D/DH within $0.4\cancel{L}\underline{L_{CSR-B}}$ amidships in ships with length exceeding 250 m.
(5) Not to be less than grade D/DH.
(6) Single strakes required to be of class III or of grade E/EH and within $0.4\cancel{L}\underline{L_{CSR-B}}$ amidships are to have breadths, in m, not less than $0.8 + 0.005\cancel{L}\underline{L_{CSR-B}}$, need not be greater than 1.8 m, unless limited by the geometry of the ship's design.
(7) For BC-A and BC-B ships with single side skin structures, side shell strakes included totally or partially between the two points located to 0.125ℓ above and below the intersection of side shell and bilge hopper sloping plate are not to be less than grade D/DH, ℓ being the frame span.</td></tr>
</table>

Paragraphs 2.3.7 and 2.3.8 have been amended as follows.

2.3.7

In specific cases, such as **2.3.8**, with regard to stress distribution along the hull girder, the classes required within $0.4\cancel{L}\underline{L_{CSR-B}}$ amidships may be extended beyond that zone, on a case by case basis.

2.3.8

The material classes required for the strength deck plating, the sheerstrake and the upper strake of longitudinal bulkheads within $0.4\cancel{L}\underline{L_{CSR-B}}$ amidships are to be maintained for an adequate length across the poop front and at the ends of the bridge, where fitted.

2.4 Structures exposed to low air temperature

Paragraph 2.4.6 has been amended as follows.

2.4.6

Single strakes required to be of class III or of grade *E*/*EH* and *FH* are to have breadths not less than the values, in m, given by the following formula, but need not to be greater than 1.8 *m*:

$b = 0.005\cancel{L}\underline{L_{CSR-B}} + 0.8$

Table 5 has been amended as follows.

Table 5 Application of material classes and grades - Structures exposed at low temperature

<table>
<tr><td rowspan="2">Structural member category</td><td colspan="2">Material class</td></tr>
<tr><td>Within 0.4$\cancel{L}\underline{L_{CSR-B}}$ amidship</td><td>Outside 0.4$\cancel{L}\underline{L_{CSR-B}}$ amidship</td></tr>
<tr><td colspan="3">(Omitted)</td></tr>
<tr><td colspan="3">Notes:
(1) Plating at corners of large hatch openings to be specially considered. Class III or grade E/EH to be applied in positions where high local stresses may occur.
(2) Not to be less than grade E/EH within 0.4$\cancel{L}\underline{L_{CSR-B}}$ amidships in ships with length exceeding 250 m.
(3) In ships with a breadth exceeding 70 m at least three deck strakes to be class III.
(4) Not to be less than grade D/DH.</td></tr>
</table>

Section 2 NET SCANTLING APPROACH

3. Net scantling approach

3.2 Considered net scantling

Paragraph 3.2.7 has been amended as follows.

3.2.7 Check of primary supporting members for ships less than 150*m* in length $\cancel{L}\underline{L_{CSR-B}}$

The net thickness of plating which constitutes primary supporting members for ships less than 150*m* in length $\cancel{L}\underline{L_{CSR-B}}$, to be checked according to Ch 6, Sec 4, 2, is to be obtained by deducting t_C from the gross thickness.

Section 5 CORROSION PROTECTION

1. General

1.2 Protection of seawater ballast tanks and void double side skin spaces

Paragraph 1.2.1 has been amended as follows.

1.2.1

All dedicated seawater ballast tanks anywhere on the ship (excluding ballast hold) for vessels having a length ($\cancel{L}\underline{L_{CSR-B}}$) of not less than 90*m* and void double side skin spaces in the cargo length area for vessels having a length (L_{LL}) of not less than 150*m* are to have an efficient corrosion prevention system, such as hard protective coatings or equivalent, applied in accordance with the manufacturer's recommendation.

The coatings are to be of a light colour, i.e. a colour easily distinguishable from rust which facilitates inspection.

Where appropriate, sacrificial anodes, fitted in accordance with **2**, may also be used.

Section 6 STRUCTURAL ARRANGEMENT PRINCIPLES

6. Double bottom

6.1 General

Paragraph 6.1.6 has been amended as follows.

6.1.6 Continuity of strength

Where the framing system changes from longitudinal to transverse, special attention is to be paid to the continuity of strength by means of additional girders or floors. Where this variation occurs within $0.6\cancel{L}\underline{L_{CSR-B}}$ amidships, the inner bottom is generally to be maintained continuous by means of inclined plating.

(Omitted)

6.2 Keel

Paragraph 6.2.1 has been amended as follows.

6.2.1

The width of the keel is to be not less than the value obtained, in *m*, from the following formula:

$$b = 0.8 + \cancel{L}\underline{L_{CSR-B}}/200$$

6.5 Bilge strake and bilge keel

Paragraph 6.5.2 has been amended as follows.

6.5.2 Bilge keel

(Omitted)

The bilge keel and the intermediate flat are to be made of steel with the same yield stress as the one of the bilge strake. The bilge keel with a length greater than $0.15\cancel{L}\underline{L_{CSR\text{-}B}}$ is to be made with the same grade of steel as the one of bilge strake.

(Omitted)

7. Double Side structure

7.3 Structural arrangement

Paragraph 7.3.3 has been amended as follows.

7.3.3 Primary supporting member fitting

(Omitted)

Unless otherwise specified, horizontal side girders are to be fitted aft of the collision bulkhead up to $0.2\cancel{L}\underline{L_{CSR\text{-}B}}$ aft of the fore end, in line with fore peak girders.

Paragraph 7.3.6 has been amended as follows.

7.3.6 Sheer strake

The width of the sheer strake is to be not less than the value obtained, in *m*, from the following formula:

$$b = 0.715 + 0.425\cancel{L}\underline{L_{CSR\text{-}B}} / 100$$

(Omitted)

9. Deck structure

9.2 General arrangement

Paragraph 9.2.5 has been amended as follows.

9.2.5 Stringer plate

The width of the stringer plate is to be not less than the value obtained, in *m*, from the following formula:

$$b = 0.35 + 0.5\cancel{L}\underline{L_{CSR\text{-}B}} / 100$$

Rounded stringer plate, where adopted, are to have a radius complying with the requirements in **7.3.6**.

Chapter 4 DESIGN LOADS

Section 2 SHIP MOTIONS AND ACCELERATIONS

Definition of symbol, a_0, has been amended as follows.

Symbols

a_0 : Acceleration parameter, taken equal to:

$$\cancel{a_0 = f_p(1.58 - 0.47C_B)\left(\frac{2.4}{\sqrt{L}} + \frac{34}{L} - \frac{600}{L^2}\right)}$$

$$\underline{a_0 = f_p(1.58 - 0.47C_B)\left(\frac{2.4}{\sqrt{L_{CSR-B}}} + \frac{34}{L_{CSR-B}} - \frac{600}{L_{CSR-B}{}^2}\right)}$$

2. Ship absolute motions and accelerations

2.2 Pitch

Paragraph 2.2.1 has been amended as follows.

2.2.1

The pitch period T_P, in s, and the single pitch amplitude Φ, in deg, are given by:

$$T_P = \sqrt{\frac{2\pi\lambda}{g}}$$

$$\cancel{\Phi = f_p \frac{960}{L}\sqrt[4]{\frac{V}{C_B}}} \quad \underline{\Phi = f_p \frac{960}{L_{CSR-B}}\sqrt[4]{\frac{V}{C_B}}}$$

where:

$$\cancel{\lambda = 0.6\left(1 + \frac{T_{LC}}{T_S}\right)L} \quad \underline{\lambda = 0.6\left(1 + \frac{T_{LC}}{T_S}\right)L_{CSR-B}}$$

3. Ship relative accelerations

3.2 Accelerations

Paragraph 3.2.1 has been amended as follows.

3.2.1

The reference values of the longitudinal, transverse and vertical accelerations at any point are obtained from the following formulae:

(Omitted)

- In vertical direction:

$$a_Z = C_{ZH} a_{heave} + C_{ZR} a_{roll\,z} + C_{ZP} a_{pitch\,z}$$

where:

C_{XG}, C_{XS}, C_{XP}, C_{YG}, C_{YS}, C_{YR}, C_{ZH}, C_{ZR} and C_{ZP} : Load combination factors defined in **Ch 4, Sec 4, 2.2**

(Omitted)

$a_{pitch\,z}$: Vertical acceleration due to pitch, in *m/s*^{2}

$$\cancel{a_{pitch\,z} = \Phi \frac{\pi}{180}\left(\frac{2\pi}{T_P}\right)^2 \left|(x - 0.45L)\right|} \quad \underline{a_{pitch\,z} = \Phi \frac{\pi}{180}\left(\frac{2\pi}{T_P}\right)^2 \left|(x - 0.45L_{CSR-B})\right|}$$

where $\cancel{\left|(x - 0.45L)\right|}$ $\underline{\left|(x - 0.45L_{CSR-B})\right|}$ is to be taken not less than 0.2~~L~~$\underline{L_{CSR-B}}$

(Omitted)

Section 3 HULL GIRDER LOADS

2. Still water loads

2.2 Still water bending moment

Paragraph 2.2.2 has been amended as follows.

2.2.2

If the design still water bending moments are not defined, at a preliminary design stage, at any hull transverse section, the longitudinal distributions shown in **Fig. 2** may be considered.

In **Fig. 2**, M_{SW} is the design still water bending moment amidships, in hogging or sagging conditions, whose values are to be taken not less than those obtained, in *kN-m*, from the following formulae:

- hogging conditions:

$$\cancel{M_{SW,H} = 175CL^2B(C_B + 0.7)10^{-3} - M_{WV,H}} \quad \underline{M_{SW,H} = 175CL_{CSR-B}{}^2B(C_B + 0.7)10^{-3} - M_{WV,H}}$$

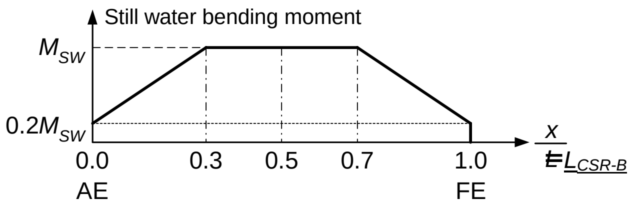
- sagging conditions:

$$\cancel{M_{SW,S} = 175CL^2B(C_B + 0.7)10^{-3} - M_{WV,S}} \quad \underline{M_{SW,S} = 175CL_{CSR-B}{}^2B(C_B + 0.7)10^{-3} - M_{WV,S}}$$

where $M_{WV,H}$ and $M_{WV,S}$ are the vertical wave bending moments, in *kN-m*, defined in **3.1**.

Fig. 2 has been amended as follows.

Fig. 2 Preliminary still water bending moment distribution



3. Wave loads

3.1 Vertical wave bending moments

Paragraph 3.1.1 has been amended as follows.

3.1.1 Intact condition

The vertical wave bending moments in intact condition at any hull transverse section are obtained, in *kN-m*, from the following formulae:

- hogging conditions:

$$\cancel{M_{WV,H} = 190 F_M f_p C L^2 B C_B 10^{-3}} \quad \underline{M_{WV,H} = 190 F_M f_p C L_{CSR-B}{}^2 B C_B 10^{-3}}$$

- sagging conditions:

$$\cancel{M_{WV,S} = 110 F_M f_p C L^2 B (C_B + 0.7) 10^{-3}} \quad \underline{M_{WV,S} = 110 F_M f_p C L_{CSR-B}{}^2 B (C_B + 0.7) 10^{-3}}$$

where:

F_M : Distribution factor defined in **Table 1** (see also **Fig. 3**).

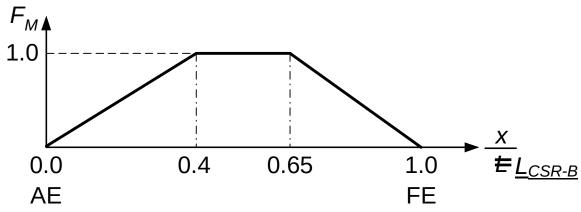
Table 1 has been amended as follows.

Table 1 Distribution factor F_M

Hull transverse section location	Distribution factor F_M
$\cancel{0 \le x < 0.4L}$ $\underline{0 \le x < 0.4L_{CSR-B}}$	$\cancel{2.5\frac{x}{L}}$ $\underline{2.5\frac{x}{L_{CSR-B}}}$
$\cancel{0.4L \le x \le 0.65L}$ $\underline{0.4L_{CSR-B} \le x \le 0.65L_{CSR-B}}$	1.0
$\cancel{0.65L < x \le L}$ $\underline{0.65L_{CSR-B} < x \le L_{CSR-B}}$	$\cancel{2.86\left(1-\frac{x}{L}\right)}$ $\underline{2.86\left(1-\frac{x}{L_{CSR-B}}\right)}$

Fig. 3 has been amended as follows.

Fig. 3 Distribution factor F_M



3.2 Vertical wave shear force

Paragraph 3.2.1 has been amended as follows.

3.2.1 Intact condition

The vertical wave shear force in intact condition at any hull transverse section is obtained, in kN, from the following formula:

$$Q_{WV} = 30 F_Q f_p C \cancel{L}\underline{L_{CSR-B}} B(C_B + 0.7)10^{-2}$$

(Omitted)

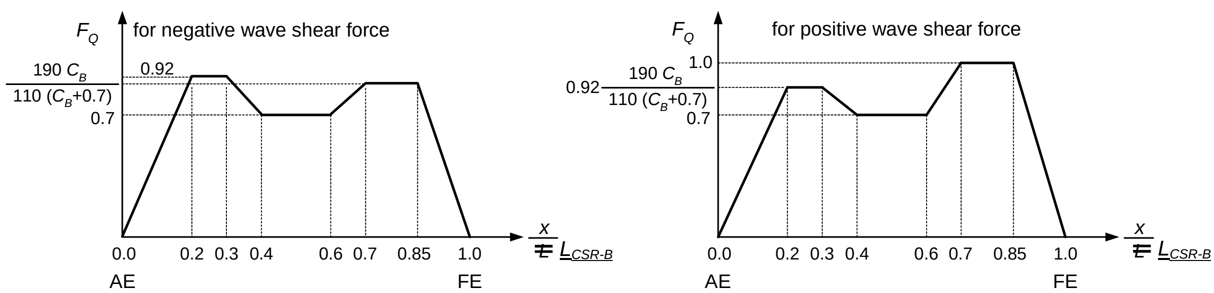
Table 2 has been amended as follows.

Table 2 Distribution factor F_Q

Hull transverse section location	Distribution factor F_Q	
	Positive wave shear force	Negative wave shear force
$\cancel{0 \le x < 0.2L}$ $\underline{0 \le x < 0.2L_{CSR-B}}$	$\cancel{4.6A\frac{x}{L}}$ $\underline{4.6A\frac{x}{L_{CSR-B}}}$	$\cancel{4.6\frac{x}{L}}$ $\underline{4.6\frac{x}{L_{CSR-B}}}$
$\cancel{0.2L \le x \le 0.3L}$ $\underline{0.2L_{CSR-B} \le x \le 0.3L_{CSR-B}}$	$0.92A$	0.92
$\cancel{0.3L < x < 0.4L}$ $\underline{0.3L_{CSR-B} < x < 0.4L_{CSR-B}}$	$\cancel{(9.2A-7)\left(0.4-\frac{x}{L}\right)+0.7}$ $\underline{(9.2A-7)\left(0.4-\frac{x}{L_{CSR-B}}\right)+0.7}$	$\cancel{2.2\left(0.4-\frac{x}{L}\right)+0.7}$ $\underline{2.2\left(0.4-\frac{x}{L_{CSR-B}}\right)+0.7}$
$\cancel{0.4L \le x \le 0.6L}$ $\underline{0.4L_{CSR-B} \le x \le 0.6L_{CSR-B}}$	0.7	0.7
$\cancel{0.6L < x < 0.7L}$ $\underline{0.6L_{CSR-B} < x < 0.7L_{CSR-B}}$	$\cancel{3\left(\frac{x}{L}-0.6\right)+0.7}$ $\underline{3\left(\frac{x}{L_{CSR-B}}-0.6\right)+0.7}$	$\cancel{(10A-7)\left(\frac{x}{L}-0.6\right)+0.7}$ $\underline{(10A-7)\left(\frac{x}{L_{CSR-B}}-0.6\right)+0.7}$
$\cancel{0.7L \le x \le 0.85L}$ $\underline{0.7L_{CSR-B} \le x \le 0.85L_{CSR-B}}$	1	A
$\cancel{0.85L < x \le L}$ $\underline{0.85L_{CSR-B} < x \le L_{CSR-B}}$	$\cancel{6.67\left(1-\frac{x}{L}\right)}$ $\underline{6.67\left(1-\frac{x}{L_{CSR-B}}\right)}$	$\cancel{6.67A\left(1-\frac{x}{L}\right)}$ $\underline{6.67A\left(1-\frac{x}{L_{CSR-B}}\right)}$
Note : $A = \dfrac{190C_B}{110(C_B+0.7)}$		

Fig. 4 has been amended as follows.

Fig. 4 Distribution factor F_Q



3.3 Horizontal wave bending moment

Paragraph 3.3.1 has been amended as follows.

3.3.1

The horizontal wave bending moment at any hull transverse section, in *kN-m*, is given by:

$$\cancel{M_{WH} = (0.3 + \frac{L}{2000}) F_M f_p C L^2 T_{LC} C_B} \quad M_{WH} = \left(0.3 + \frac{L_{CSR-B}}{2000}\right) F_M f_b C L_{CSR-B}{}^2 T_{LC} C_B$$

where F_M is the distribution factor defined in **3.1.1**.

3.4 Wave torsional moment

Paragraph 3.4.1 has been amended as follows.

3.4.1

The wave torsional moment at any hull transverse section, in *kN-m*, is given by:

$$M_{WT} = f_p (|M_{WT1}| + |M_{WT2}|)$$

where:

$$\cancel{M_{WT1} = 0.4 \cdot C \sqrt{\frac{L}{T}} \cdot B^2 D \cdot C_B \cdot F_{T1}} \quad M_{WT1} = 0.4 C \sqrt{\frac{L_{CSR-B}}{T}} B^2 D C_B F_{T1}$$

$$\cancel{M_{WT2} = 0.22 \cdot C L B^2 C_B \cdot F_{T2}} \quad M_{WT2} = 0.22 \cdot C L_{CSR-B} B^2 C_B \cdot F_{T2}$$

F_{T1}, F_{T2} : Distribution factors, defined as follows:

$$\cancel{F_{T1} = \sin\left(\frac{2\pi x}{L}\right)} \quad F_{T1} = \sin\left(\frac{2\pi x}{L_{CSR-B}}\right)$$

$$\cancel{F_{T2} = \sin^2\left(\frac{\pi x}{L}\right)} \quad F_{T2} = \sin^2\left(\frac{\pi x}{L_{CSR-B}}\right)$$

Section 4 LOAD CASES

2. Load cases

2.2 Load combination factors

Table 3 has been amended as follows.

Table 3 Load combination factors *LCF*

	LCF	H1	H2	F1	F2	R1	R2	P1	P2
(Omitted)									
a_{heave}	C_{ZH}	$0.6\frac{T_{LC}}{T_S}$	$-0.6\frac{T_{LC}}{T_S}$	0	0	$\cancel{\frac{\sqrt{L}}{40}}$ $\underline{\frac{\sqrt{L_{CSR-B}}}{40}}$	$\cancel{\frac{\sqrt{L}}{40}}$ $\underline{-\frac{\sqrt{L_{CSR-B}}}{40}}$	1	-1
$a_{roll\ z}$	C_{ZR}	0	0	0	0	1	-1	0.3	-0.3
$a_{pitch\ z}$	C_{ZP}	1	-1	0	0	0	0	0	0
(1) The *LCF* for C_{QW} is only used for the aft part of midship section. The inverse value of it should be used for the forward part of the midship section.									

Section 5 EXTERNAL PRESSURES

Definition of symbol, L_2, has been amended as follows.

Symbols

L_2 : Rule length ~~L~~ $\underline{L_{CSR-B}}$, but to be taken not greater than 300 *m*

1. External sea pressures on side shell and bottom

1.3 Hydrodynamic pressures for load cases H1, H2, F1 and F2

Paragraph 1.3.1 has been amended as follows.

1.3.1

The hydrodynamic pressures p_H and p_F, for load cases H1, H2, F1 and F2, at any point of the hull below the waterline are to be obtained, in kN/m^2, from **Table 2**.

The distribution of pressure p_{F2} is schematically given in **Fig. 2**.

Table 2 Hydrodynamic pressures for load cases H1, H2, F1 and F2

Load case	Hydrodynamic pressure, in kN/m^2
H1	$p_{H1} = - k_\ell \, k_p \, p_{HF}$
H2	$p_{H2} = k_\ell \, k_p \, p_{HF}$
F1	$p_{F1} = - p_{HF}$
F2	$p_{F2} = p_{HF}$

where:

$$\cancel{p_{HF} = 3 f_p f_{nl} C \sqrt{\frac{L + \lambda - 125}{L}} \left(\frac{z}{T_{LCi}} + \frac{|2y|}{B_i} + 1 \right)}$$

$$\underline{p_{HF} = 3 f_p f_{nl} C \sqrt{\frac{L_{CSR-B} + \lambda - 125}{L_{CSR-B}}} \left(\frac{z}{T_{LCi}} + \frac{|2y|}{B_i} + 1 \right);}$$

with $\frac{|2y|}{B_i} \le 1.0$ and z is to be taken not greater than T_{LCi}

f_{nl} : Coefficient considering nonlinear effect, taken equal to:

$f_{nl} = 0.9$ for the probability level of 10^{-8}

$f_{nl} = 1.0$ for the probability level of 10^{-4}

k_ℓ : Amplitude coefficient in the longitudinal direction of the ship, taken equal to:

$$\cancel{k_\ell = 1 + \frac{12}{C_B} \left(1 - \sqrt{\frac{|2y|}{B}} \right) \left| \frac{x}{L} - 0.5 \right|^3} \qquad \cancel{\text{for } 0.0 \le x/L \le 0.5}$$

$$\underline{k_\ell = 1 + \frac{12}{C_B} \left(1 - \frac{|2y|}{B} \right) \left| \frac{x}{L_{CSR-B}} - 0.5 \right|^3} \qquad \underline{\text{for } 0.0 \le x/L_{CSR-B} \le 0.5}$$

$$\cancel{k_\ell = 1 + \frac{6}{C_B} \left(3 - \frac{|4y|}{B} \right) \left| \frac{x}{L} - 0.5 \right|^3} \qquad \cancel{\text{for } 0.5 \le x/L \le 1.0}$$

$$\underline{k_\ell = 1 + \frac{6}{C_B} \left(3 - \frac{|4y|}{B} \right) \left| \frac{x}{L_{CSR-B}} - 0.5 \right|^3} \qquad \underline{\text{for } 0.5 \le x/L_{CSR-B} \le 1.0}$$

k_p : Phase coefficient in the longitudinal direction of the ship, taken equal to:

$$\cancel{k_p = \left(1.25 - \frac{T_{LC}}{T_S} \right) \cos\left(\frac{2\pi |x - 0.5L|}{L} \right) - \frac{T_{LC}}{T_S} + 0.25}$$

$\underline{k_p = \left(1.25 - \frac{T_{LC}}{T_S} \right) \cos\left(\frac{2\pi |x - 0.5L_{CSR-B}|}{L_{CSR-B}} \right) - \frac{T_{LC}}{T_S} + 0.25}$, for local strength analysis in conditions other than full load condition, for direct strength analysis and for fatigue strength assessments

$k_p = -1.0$, for local strength analysis in full load condition

λ : Wave length, in m, taken equal to:

$\cancel{\lambda = 0.6 \left(1 + \frac{T_{LC}}{T_S} \right) L}$ $\underline{\lambda = 0.6 \left(1 + \frac{T_{LC}}{T_S} \right) L_{CSR-B}}$ for load cases H1 and H2

$\cancel{\lambda = 0.6\left(1+\frac{2}{3}\frac{T_{LC}}{T_S}\right)L}$ $\underline{\lambda = 0.6\left(1+\frac{2}{3}\frac{T_{LC}}{T_S}\right)L_{CSR-B}}$ for load cases F1 and F2

1.4 Hydrodynamic pressures for load cases R1 and R2

Paragraph 1.4.1 has been amended as follows.

1.4.1

The hydrodynamic pressures p_R, for load cases R1 and R2, at any point of the hull below the waterline are to be obtained, in kN/m^2, from the following formulae. The distribution of pressure p_{R1} is schematically given in **Fig. 3**.

$$\cancel{p_{R1} = f_{nl}\left(10y\sin\theta + 0.88 f_p C\sqrt{\frac{L+\lambda-125}{L}}\left(\frac{|2y|}{B}+1\right)\right)}$$

$$\underline{p_{R1} = f_{nl}\left(10y\sin\theta + 0.88 f_p C\sqrt{\frac{L_{CSR-B}+\lambda-125}{L_{CSR-B}}}\left(\frac{|2y|}{B}+1\right)\right)}$$

$$p_{R2} = -p_{R1}$$

where:

f_{nl} : Coefficient considering nonlinear effect, taken equal to:

$f_{nl} = 0.8$ for the probability level of 10^{-8}

$f_{nl} = 1.0$ for the probability level of 10^{-4}

$$\lambda = \frac{g}{2\pi}T_R^2$$

y : Y co-ordinate of the load point, in m, taken positive on the portside.

1.5 Hydrodynamic pressures for load cases P1 and P2

Paragraph 1.5.1 has been amended as follows.

1.5.1

The hydrodynamic pressures p_P, for the load cases P1 and P2, at any point of the hull below the waterline are to be obtained, in kN/m^2, from **Table 3**. The distribution of pressure p_{P1} is schematically given in **Fig. 4**.

Table 3 Hydrodynamic pressures for load cases P1 and P2

Load case	Hydrodynamic pressure, in kN/m^2	
	weather side	lee side
P1	$p_{P1} = p_P$	$p_{P1} = p_P/3$
P2	$p_{P2} = -p_P$	$p_{P2} = -p_P/3$

where:

$$\cancel{p_P = 4.5 f_p f_{nl} C\sqrt{\frac{L+\lambda-125}{L}}\left(2\frac{|z|}{T_{LCi}}+3\frac{|2y|}{B}\right)}$$

$$\underline{p_P = 4.5 f_p f_{nl} C \sqrt{\frac{L_{CSR-B}+\lambda-125}{L_{CSR-B}}}\left(2\frac{|z|}{T_{LCi}}+3\frac{|2y|}{B}\right)}$$

f_{nl} : Coefficient considering nonlinear effect, taken equal to:

$f_{nl} = 0.65$ for the probability level of 10^{-8}

$f_{nl} = 1.0$ for the probability level of 10^{-4}

$\cancel{\lambda = \left(0.2+0.4\frac{T_{LC}}{T_S}\right)L}$ $\underline{\lambda = \left(0.2+0.4\frac{T_{LC}}{T_S}\right)L_{CSR-B}}$

y : Y co-ordinate of the load point, in m, as defined in **1.4.1**

3. External pressures on superstructure and deckhouses

3.3 Sides of superstructures

Table 6 has been amended as follows.

Table 6 Distribution factor c_F

Location	c_F
$\cancel{0 \le \frac{x}{L} < 0.2}$ $\underline{0 \le \frac{x}{L_{CSR-B}} < 0.2}$	$\cancel{1.0+\frac{5}{C_B}\left(0.2-\frac{x}{L}\right)}$ $\underline{1.0+\frac{5}{C_B}\left(0.2-\frac{x}{L_{CSR-B}}\right)}$, without taking $x/\cancel{L}\underline{L_{CSR-B}}$ less than 0.1
$\cancel{\frac{x}{L} \ge 0.2}$ $\underline{\frac{x}{L_{CSR-B}} \ge 0.2}$	1.0

3.4 End bulkhead of superstructure and deckhouse

Paragraph 3.4.1 has been amended as follows.

3.4.1

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

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

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

(Omitted)

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

(Omitted)

Table 8 and Table 9 have been amended as follows.

Table 8 Coefficient *b*

Location of bulkhead	b
$\cancel{\frac{x}{L} < 0.45}$ $\frac{x}{L_{CSR-B}} < 0.45$	$\cancel{1.0 + \left(\frac{\frac{x}{L} - 0.45}{C_B + 0.2}\right)^2}$ $1.0 + \left(\frac{\frac{x}{L_{CSR-B}} - 0.45}{C_B + 0.2}\right)^2$
$\cancel{\frac{x}{L} \geq 0.45}$ $\frac{x}{L_{CSR-B}} \geq 0.45$	$\cancel{1.0 + 1.5\left(\frac{\frac{x}{L} - 0.45}{C_B + 0.2}\right)^2}$ $1.0 + 1.5\left(\frac{\frac{x}{L_{CSR-B}} - 0.45}{C_B + 0.2}\right)^2$
Where: C_B :Block coefficient with $0.6 \leq C_B \leq 0.8$. When determining scantlings of aft ends forward of amidships, C_B need not be taken less than 0.8.	

Table 9 Minimum lateral pressure p_{Amin}

	p_{Amin}, in kN/m^2	
$\cancel{L}$ L_{CSR-B}	Lowest tier of unprotected fronts	Elsewhere(1)
$\cancel{90 < L \leq 250}$ $90 < L_{CSR-B} \leq 250$	$\cancel{25 + \frac{L}{10}}$ $25 + \frac{L_{CSR-B}}{10}$	$\cancel{12.5 + \frac{L}{20}}$ $12.5 + \frac{L_{CSR-B}}{20}$
$\cancel{L > 250}$ $L_{CSR-B} > 250$	50	25
(1) For the 4th tier and above, $p_{A\min}$ is to be taken equal to $12.5kN/m^2$.		

4. Pressure in bow area

4.1 Bow flare area pressure

Paragraph 4.1.1 has been amended as follows.

z

4.1.1

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

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

where:

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

K : Coefficient taken equal to:

$$\cancel{K = \frac{c_{FL}\left(0.2V + 0.6\sqrt{L}\right)^2}{42C(C_B + 0.7)\left(1 + \frac{20}{C_B}\left(\frac{x}{L} - 0.7\right)^2\right)}(10 + z - T_B)}$$

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

(Omitted)

4.2 Design bottom slamming pressure

Paragraph 4.2.1 has been amended as follows.

4.2.1

The bottom slamming pressure, in kN/m^2, to be considered for the reinforcement of the flat bottom forward is to be obtained from the following formula:

- $\cancel{p_{SL} = 162c_1c_{SL}\sqrt{L}}$ $\underline{p_{SL} = 162c_1c_{SL}\sqrt{L_{CSR-B}}}$ for ~~L~~$\underline{L_{CSR-B}} \leq 150m$
- $\cancel{p_{SL} = 1984c_1c_{SL}(1.3 - 0.002L)}$ $\underline{p_{SL} = 1984c_1c_{SL}(1.3 - 0.002L_{CSR-B})}$ for ~~L~~$\underline{L_{CSR-B}} > 150m$

where:

c_1 : Coefficient taken equal to:

$$\cancel{c_1 = 3.6 - 6.5\left(\frac{T_{BFP}}{L}\right)^{0.2}} \quad \underline{c_1 = 3.6 - 6.5\left(\frac{T_{BFP}}{L_{CSR-B}}\right)^{0.2}}$$, to be taken not greater than 1.0

T_{BFP} : Smallest design ballast draught, in m, defined at forward perpendicular for normal ballast conditions. Where the sequential method for ballast water exchange is intended to be applied, T_{BFP} is to be considered for the sequence of exchange.

c_{SL} : Distribution factor taken equal to (see **Fig 6**):

$c_{SL} = 0$ for $\cancel{\frac{x}{L} \leq 0.5}$ $\underline{\frac{x}{L_{CSR-B}} \leq 0.5}$

$\cancel{c_{SL} = \frac{\frac{x}{L} - 0.5}{c_2}}$ ~~for~~ $\cancel{0.5 < \frac{x}{L} < 0.5 + c_2}$

$\underline{c_{SL} = \frac{\frac{x}{L_{CSR-B}} - 0.5}{c_2}}$ for $\underline{0.5 < \frac{x}{L_{CSR-B}} \leq 0.5 + c_2}$

$\cancel{c_{SL} = 1.0}$ ~~for~~ $\cancel{0.5 + c_2 < \frac{x}{L} \leq 0.65 + c_2}$

$$\underline{c_{SL} = 1.0} \qquad \underline{\text{for } 0.5 + c_2 < \frac{x}{L_{CSR-B}} \le 0.65 + c_2}$$

$$\cancel{c_{SL} = 0.5\left(1 + \frac{1 - \frac{x}{L}}{0.35 - c_2}\right) \qquad \text{for } \frac{x}{L} > 0.65 + c_2}$$

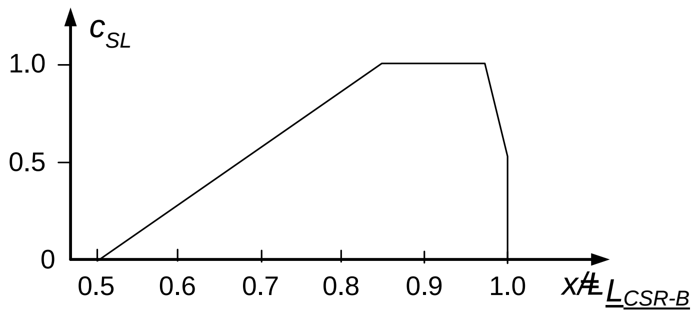
$$\underline{c_{SL} = 0.5\left(1 + \frac{1 - \frac{x}{L_{CSR-B}}}{0.35 - c_2}\right)} \qquad \underline{\text{for } \frac{x}{L_{CSR-B}} > 0.65 + c_2}$$

c_2 : Coefficient taken equal to:

$\cancel{c_2 = 0.33C_B + \frac{L}{2500}}$ $\underline{c_2 = 0.33C_B + \frac{L_{CSR-B}}{2500}}$, to be taken not greater than 0.35.

Fig.6 has been amended as follows.

Fig 6 Distribution factor c_{SL}



Section 6 INTERNAL PRESSURES AND FORCES

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

Symbols

ρ_C : Density of the dry bulk cargo, in t/m^3, taken equal to:

- the value given in **Table 1** for ships having a length ($\cancel{L}\underline{L_{CSR-B}}$) of 150 *m* and above
- the maximum density from the loading manual for ships having a length ($\cancel{L}\underline{L_{CSR-B}}$) less than 150 *m*

3. Lateral pressures and forces in flooded condition

3.2 General

Paragraph 3.2.1 has been amended as follows.

3.2.1

The pressure p_F to be considered as acting on plating (excluding bottom and side shell plating) which constitute boundaries of compartments not intended to carry liquids is to be obtained, in kN/m^2, from the following formula:

$$p_F = \rho g\left(1 + 0.6\frac{a_Z}{g}\right)(z_F - z), \text{ without being less than } gd_0$$

where:

z_F : Z co-ordinate, in m, of the freeboard deck at side in way of the transverse section considered. Where the results of damage stability calculations are available, the deepest equilibrium waterline may be considered in lieu of the freeboard deck; in this case, the Society may require transient conditions to be taken into account

d_0 : Distance, in m, to be taken equal to:

$d_0 = 0.02\cancel{L}L_{CSR-B}$	for $90\ m \leq \cancel{L}L_{CSR-B} < 120\ m$
$d_0 = 2.4$	for $\cancel{L}L_{CSR-B} \geq 120\ m$

Section 7 LOADING CONDITIONS

1. Application

Title of 1.1 has been amended as follows.

1.1 Ships having a length ($\cancel{L}L_{CSR-B}$) less than 150 *m*

Title of 1.2 has been amended as follows.

1.2 Ships having a length ($\cancel{L}L_{CSR-B}$) of 150 *m* and above

Paragraph 1.2.1 has been amended as follows.

1.2.1

The requirements in **2** to **4** are applicable to ships having a length ($\cancel{L}L_{CSR-B}$) of 150 *m* and above.

Section 8 LOADING MANUAL AND LOADING INSTRUMENT

1. General

Title of 1.2 has been amended as follows.

1.2 Ships equal to or greater than 150 *m* in length (~~L~~$\underline{L_{CSR-B}}$)

2. Loading manual

2.1 Definitions

Title of 2.1.2 has been amended as follows.

2.1.2 Ships equal to or greater than 150 *m* in length (~~L~~$\underline{L_{CSR-B}}$)

2.2 Conditions of approval

Title of 2.1.2 has been amended as follows.

2.2.2 Ships equal to or greater than 150 *m* in length (~~L~~$\underline{L_{CSR-B}}$)

3. Loading instrument

3.1 Definitions

Title of 3.1.2 has been amended as follows.

3.1.2 Ships equal to or greater than 150 *m* in length (~~L~~$\underline{L_{CSR-B}}$)

3.2 Conditions of approval

Title of 3.2.2 has been amended as follows.

3.2.2 Ships equal to or greater than 150 *m* in length (~~L~~$\underline{L_{CSR-B}}$)

Appendix 1 HOLD MASS CURVES

1. General

1.1 Application

Paragraph 1.1.1 has been amended as follows.

1.1.1
The requirements of this Appendix apply to ships of 150 *m* in length (~~L~~$\underline{L_{CSR-B}}$) and above.

Chapter 5 HULL GIRDER STRENGTH

Section 1 YIELDING CHECK

1. Strength characteristics of the hull girder transverse sections

1.3 Strength deck

Paragraph 1.3.2 has been amended as follows.

1.3.2

A superstructure extending at least 0.15~~L~~$L_{CSR\text{-}B}$ within 0.4~~L~~$L_{CSR\text{-}B}$ amidships may generally be considered as contributing to the longitudinal strength.

For other superstructures and for deckhouses, their contribution to the longitudinal strength is to be assessed on a case by case basis, to evaluate their percentage of participation to the longitudinal strength.

3. Checking criteria

3.1 Normal stresses

Paragraph 3.1.1 has been amended as follows.

3.1.1

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

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

where:

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

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

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

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

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

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

$$\sigma_{1,ALL} = \frac{130}{k} \quad \text{for} \quad \frac{x}{L_{CSR-B}} \leq 0.1$$

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

$$\sigma_{1,ALL} = \frac{190}{k} \ \underline{\text{ for }} \ 0.3 \le \frac{x}{L_{CSR-B}} \le 0.7$$

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

$$\sigma_{1,ALL} = \frac{130}{k} \ \underline{\text{ for }} \ \frac{x}{L_{CSR-B}} \ge 0.9$$

4. Section modulus and moment of inertia

Paragraph 4.2 has been amended as follows.

4.2 Section modulus within 0.4~~L~~$\underline{L_{CSR-B}}$ amidships

4.2.1

The net section moduli Z_{AB} and Z_{AD} at the midship section are to be not less than the value obtained, in m^3, from the following formula:

- $Z_{R,MIN} = 0.9C\cancel{L}\underline{L_{CSR-B}}^2B(C_B + 0.7)k10^{-6}$

4.2.2

In addition, the net section moduli Z_{AB} and Z_{AD} within 0.4~~L~~$\underline{L_{CSR-B}}$ amidships are to be not less than the value obtained, in m^3, from the following formula:

- $Z_R = \frac{M_{SW} + M_{WV}}{\sigma_{1,ALL}} 10^{-3}$
- in addition, for *BC-A* and *BC-B* ships:

$$Z_R = \frac{M_{SW,F} + M_{WV,F}}{\sigma_{1,ALL}} 10^{-3}$$

(Omitted)

4.2.4

Scantlings of members contributing to the longitudinal strength (see **1**), based on the section modulus requirement in **4.2.1**, are to be maintained within 0.4~~L~~$\underline{L_{CSR-B}}$ amidships.

Paragraph 4.3 has been amended as follows.

4.3 Section modulus outside 0.4~~L~~$\underline{L_{CSR-B}}$ amidships

4.3.1

The net section moduli Z_{AB} and Z_{AD} outside 0.4~~L~~$\underline{L_{CSR-B}}$ amidships are to be not less than the value obtained, in m^3, from the following formula:

- $Z_R = \frac{M_{SW} + M_{WV}}{\sigma_{1,ALL}} 10^{-3}$
- in addition, for *BC-A* and *BC-B* ships:

$$Z_R = \frac{M_{SW,F} + M_{WV,F}}{\sigma_{1,ALL}} 10^{-3}$$

4.3.2

Scantlings of members contributing to the hull girder longitudinal strength (see **1**) may be gradually reduced, outside 0.4~~L~~$L_{CSR\text{-}B}$ amidships, to the minimum required for local strength purposes at fore and aft parts, as specified in **Ch 9**, **Sec 1** or **Ch 9**, **Sec 2**, respectively.

4.4 Midship section moment of inertia

Paragraph 4.4.1 has been amended as follows.

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 m^4, from the following formula:

$$\cancel{I_{YR} = 3Z'_{R,MIN} L\ 10^{-2}} \quad \underline{I_{YR} = 3Z'_{R,MIN} L_{CSR-B} 10^{-2}}$$

where $Z'_{R,MIN}$ is the required net midship section modulus $Z_{R,MIN}$, in m^3, calculated as specified in **4.2.1**, but assuming $k = 1$.

4.5 Extent of higher strength steel

Paragraph 4.5.2 has been amended as follows.

4.5.2

The higher strength steel is to extend in length at least throughout 0.4~~L~~$L_{CSR\text{-}B}$ amidships where it is required for strength purposes according to the provision of this Part.

Section 2 ULTIMATE STRENGTH CHECK

1. Application

1.1 General

Paragraph 1.1.1 has been amended as follows.

1.1.1

The requirements of this Section apply to ships equal to or greater than 150 *m* in length (~~L~~$L_{CSR\text{-}B}$).

Chapter 6 HULL SCANTLINGS

Section 1 PLATING

2. General requirements

2.1 Corrugated bulkhead

Table 2 has been amended as follows.

Table 2 Minimum net thickness of plating

Plating	Minimum net thickness, in *mm*
Keel	$7.5 + 0.03\cancel{L}\underline{L_{CSR-B}}$
Bottom, inner bottom	$5.5 + 0.03\cancel{L}\underline{L_{CSR-B}}$
Weather strength deck and trunk deck, if any	$4.5 + 0.02\cancel{L}\underline{L_{CSR-B}}$
Side shell, bilge	$0.85\cancel{L}\underline{L_{CSR-B}}^{1/2}$
Inner side, hopper sloping plate and topside sloping plate	$0.7\cancel{L}\underline{L_{CSR-B}}^{1/2}$
Transverse and longitudinal watertight bulkheads	$0.6\cancel{L}\underline{L_{CSR-B}}^{1/2}$
Wash bulkheads	6.5
Accommodation deck	5.0

2.5 Sheerstrake

Paragraphs 2.5.3 and 2.5.4 have been amended as follows.

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

The net thickness of the sheerstrake is to be increased in way of breaks of effective superstructures occurring within $0.5\cancel{L}\underline{L_{CSR-B}}$ amidships, over a length of about one sixth of the ship's breadth on each side of the superstructure end.

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

Where the breaks of superstructures occur outside $0.5\cancel{L}\underline{L_{CSR-B}}$ amidships, the increase in net thickness may be reduced to 30%, but need not exceed 2.5 *mm*.

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

The net thickness of the sheerstrake is to be increased in way of breaks of non-effective superstructures occurring within $0.6\cancel{L}\underline{L_{CSR-B}}$ amidships, over a length of about one sixth of the ship's breadth on each side of the superstructure end.

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

2.6 Stringer plate

Paragraphs 2.6.2 and 2.6.3 have been amended as follows.

2.6.2 Net thickness of the stringer plate in way of breaks of long superstructures

The net thickness of the stringer plate is to be increased in way of breaks of long superstructures occurring within 0.5~~L~~$\underline{L_{CSR-B}}$ amidships, over a length of about one sixth of the ship's breadth on each side of the superstructure end.

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

Where the breaks of superstructures occur outside 0.5~~L~~$\underline{L_{CSR-B}}$ amidships, the increase in net thickness may be reduced to 30%, but need not exceed 2.5 *mm*.

2.6.3 Net thickness of the stringer plate in way of breaks of short superstructures

The net thickness of the stringer plate is to be increased in way of breaks of short superstructures occurring within 0.6~~L~~$\underline{L_{CSR-B}}$ amidships, over a length of about one sixth of the ship breadth on each side of the superstructure end.

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

Section 2 ORDINARY STIFFENERS

Definition of symbol, L_2, has been amended as follows.

Symbols

L_2 : Rule length ~~L~~$\underline{L_{CSR-B}}$, but to be taken not greater than 300 *m*

2. General requirements

2.2 Minimum net thicknesses of webs of ordinary stiffeners

Paragraph 2.2.2 has been amended as follows.

2.2.2 Side frames of single side bulk carriers

The net thickness of side frame webs within the cargo area, in *mm*, is to be not less than the value obtained from the following formula:

$t_{MIN} = 0.75\alpha\,(7 + 0.03\cancel{L}\underline{L_{CSR-B}})$

where:

α : Coefficient taken equal to:

$\alpha = 1.15$ for the frame webs in way of the foremost hold

$\alpha = 1.00$ for the frame webs in way of other holds.

3. Yielding check

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

Paragraph 3.2.4 has been amended as follows.

3.2.4 Net section modulus of corrugated bulkhead of ballast hold for ships having a length

($\cancel{L}\underline{L_{CSR-B}}$) less than 150$m$

The net section modulus w, in cm^3, of corrugated bulkhead of ballast hold for ships having a length ($\cancel{L}\underline{L_{CSR-B}}$) less than 150$m$ subjected to lateral pressure are to be not less than the values obtained from the following formula:

(Omitted)

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

2. Application

2.1 Load model for hull transverse section analysis

Paragraph 2.1.3 has been amended as follows.

2.1.3 Shear stress

The shear stress τ_{SF} to be considered for each of the mutually exclusive load cases as referred in **2.1.1** is the shear stress induced by the shear forces, in kN, equal to:

(Omitted)

If the design still water shear force is not available at preliminary design stage, the following default value, in kN, may be used:

$$Q_{SW0} = 30\ C\ \cancel{L}\underline{L_{CSR-B}}\ B\ (C_B + 0.7)10^{-2}$$

Section 4 PRIMARY SUPPORTING MEMBERS

Definition of symbol, L_2, has been amended as follows.

Symbols

L_2 : Rule length $\cancel{L}\underline{L_{CSR-B}}$, but to be taken not greater than 300 m

1. General

Title of 1.2 has been amended as follows.

1.2 Primary supporting members for ships less than 150 *m* in length ($\cancel{L}\underline{L_{CSR-B}}$)

Paragraph 1.2.1 has been amended as follows.

1.2.1

For primary supporting members for ships having a length ($\cancel{L}\underline{L_{CSR-B}}$) less than 150 m, the strength check of such members is to be carried out according to the provisions specified in **2** and **4**.

Paragraph 1.3 has been amended as follows.

1.3 Primary supporting members for ships of 150 *m* or more in length (~~L~~$\underline{L_{CSR-B}}$)

1.3.1

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

Title of 2. has been amended as follows.

2. Scantling of primary supporting members for ships of less than 150 *m* in length (~~L~~$\underline{L_{CSR-B}}$)

Chapter 8 FATIGUE CHECK OF STRUCTURAL DETAILS

Section 1 GENERAL CONSIDERATION

1. General

1.1 Application

Paragraph 1.1.1 has been amended as follows.

1.1.1

The requirements of this Chapter are to be applied to ships having length ~~L~~$L_{CSR\text{-}B}$ of 150 *m* or above, with respect to 25 *years* operation life in North Atlantic.

Section 2 FATIGUE STRENGTH ASSESSMENT

3. Calculation of fatigue damage

3.3 Elementary fatigue damage

Paragraph 3.3.1 has been amended as follows.

3.3.1

The elementary fatigue damage for each loading condition is to be calculated with the following formula:

(Omitted)

N_L : Total number of cycles for the design ship's life, taken equal to:

$$\cancel{N_L = \frac{0.85 T_L}{4 \log L}} \quad N_L = \frac{0.85 T_L}{4 \log L_{CSR-B}}$$

(Omitted)

Table 2 has been amended as follows.

Table 2 Coefficient α_j depending on the loading condition

	Loading Conditions	*BC-A*	*BC-B*, *BC-C*
~~$L < 200\ m$~~ $\underline{L_{CSR-B} < 200\ m}$	Homogeneous	0.6	0.7
	Alternate	0.1	---
	Normal ballast	0.15	0.15
	Heavy ballast	0.15	0.15
~~$L \geq 200\ m$~~ $\underline{L_{CSR-B} \geq 200\ m}$	Homogeneous	0.25	0.5
	Alternate	0.25	---
	Normal ballast	0.2	0.2
	Heavy ballast	0.3	0.3

Section 3 STRESS ASSESSMENT OF PRIMARY MEMBERS

3. Hot spot mean stress

3.2 Mean stress according to the superimposition method

Paragraph 3.2.2 has been amended as follows.

3.2.2 Stress due to still water hull girder moment

The hot spot stress, in *N/mm*^{2}, due to still water bending moment in loading condition "(*k*)" is to be obtained from the following formula:

(Omitted)

heavy ballast condition ; $\cancel{M_{S,(4)} = \begin{cases} 2.66\dfrac{x}{L}M_{SW,H} & ; \quad 0 < x \leq 0.15L \\ 2.66\left(0.3 - \dfrac{x}{L}\right)M_{SW,H} & ; \quad 0.15L < x \leq 0.3L \\ 3.5\left(\dfrac{x}{L} - 0.3\right)M_{SW,S} & ; \quad 0.3L < x \leq 0.5L \\ -3.5\left(0.7 - \dfrac{x}{L}\right)M_{SW,S} & ; \quad 0.5L < x \leq 0.7L \\ 2.66\left(\dfrac{x}{L} - 0.7\right)M_{SW,H} & ; \quad 0.7L < x \leq 0.85L \\ 2.66\left(1 - \dfrac{x}{L}\right)M_{SW,H} & ; \quad 0.85L < x \leq L \end{cases}}$

$$
M_{S,(4)} = \begin{cases} 2.66\dfrac{x}{L_{CSR-B}}M_{SW,H} & ; \quad 0 < x \le 0.15L_{CSR-B} \\ 2.66\left(0.3 - \dfrac{x}{L_{CSR-B}}\right)M_{SW,H} & ; \quad 0.15L_{CSR-B} < x \le 0.3L_{CSR-B} \\ -3.5\left(\dfrac{x}{L_{CSR-B}} - 0.3\right)M_{SW,S} & ; \quad 0.3L_{CSR-B} < x \le 0.5L_{CSR-B} \\ -3.5\left(0.7 - \dfrac{x}{L_{CSR-B}}\right)M_{SW,S} & ; \quad 0.5L_{CSR-B} < x \le 0.7L_{CSR-B} \\ 2.66\left(\dfrac{x}{L_{CSR-B}} - 0.7\right)M_{SW,H} & ; \quad 0.7L_{CSR-B} < x \le 0.85L_{CSR-B} \\ 2.66\left(1 - \dfrac{x}{L_{CSR-B}}\right)M_{SW,H} & ; \quad 0.85L_{CSR-B} < x \le L_{CSR-B} \end{cases}
$$

(Omitted)

Section 5 STRESS ASSESSMENT OF HATCH CORNERS

2. Nominal stress range

2.1 Nominal stress range due to wave torsional moment

Paragraph 2.1.1 has been amended as follows.

2.1.1

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

(Omitted)

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

$\cancel{F_L = 1.75\dfrac{x}{L}}$ $\underline{F_L = 1.75\dfrac{x}{L_{CSR-B}}}$ for $\cancel{0.57 \le x/L \le 0.85}$ $\underline{0.57 \le x/L_{CSR-B} \le 0.85}$

$F_L = 1.0$ for $x/$ ~~L~~$\underline{L_{CSR-B}} < 0.57$ and $x/$ ~~L~~$\underline{L_{CSR-B}} > 0.85$

(Omitted)

Chapter 9 OTHER STRUCTURES

Section 1 FORE PART

Definition of symbol, L_2, has been amended as follows.

Symbols

L_2 : Rule length $\cancel{L}\underline{L_{CSR\text{-}B}}$, but to be taken not greater than 300 *m*

2. Arrangement

2.1 Structural arrangement principles

Paragraph 2.1.1 has been amended as follows.

2.1.1 General

(Omitted)

Where the brackets are provided to ensure the structural continuity from the forward end to $0.15\cancel{L}\underline{L_{CSR\text{-}B}}$ behind fore perpendicular, flanged brackets have to be used.

4. Scantlings

4.1 Bow flare reinforcement

Paragraph 4.1.1 has been amended as follows.

4.1.1

The bow flare area to be reinforced is that extending forward of $0.9\cancel{L}\underline{L_{CSR\text{-}B}}$ from the aft end and above the normal ballast waterline according to the applicable requirements in **4.2** to **4.4**.

4.2 Plating

Table 1 has been amended as follows.

Table 1 Net minimum thickness of plating

Minimum net thickness, in *mm*	
Bottom,	$5.5 + 0.03\cancel{L}\underline{L_{CSR\text{-}B}}$
Side	$0.85\cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$
Inner bottom	$5.5 + 0.03\cancel{L}\underline{L_{CSR\text{-}B}}$
Strength deck	$4.5 + 0.02\cancel{L}\underline{L_{CSR\text{-}B}}$
Platform and wash bulkhead	6.5

5. Strengthening of flat bottom forward area

5.1 Application

Paragraph 5.1.1 has been amended as follows.

5.1.1

The flat bottom forward area to be reinforced is the flat part of the ship's bottom extending forward of $\cancel{0.2V\sqrt{L}}$ $\underline{0.2V\sqrt{L_{CSR-B}}}$ from the fore perpendicular end, up to a height of $0.05T_B$ or 0.3 *m* above base line, whichever is the smaller.

6. Stem

6.1 Bar stem

Paragraph 6.1.1 has been amended as follows.

6.1.1

The gross cross sectional area, in cm^2, of a bar stem below the load waterline is not to be less than:

$A_b = 1.25\cancel{L}\underline{L_{CSR-B}}$

6.2 Plate stem and bulbous bows

Paragraph 6.2.1 has been amended as follows.

6.2.1

The gross thickness, in *mm*, is not to be less than the values obtained from the following formula:

$\cancel{t = (0.6 + 0.4s_B)(0.08L + 6)\sqrt{k}}$ $\underline{t = (0.6 + 0.4s_B)(0.08L_{CSR-B} + 6)\sqrt{k}}$, without being taken greater than $22\sqrt{k}$

(Omitted)

Section 2 AFT PART

Definition of symbols, L_1 and L_2, have been amended as follows.

Symbols

L_1 : Rule length $\cancel{L}\underline{L_{CSR-B}}$, but to be taken not greater than 200 *m*
L_2 : Rule length $\cancel{L}\underline{L_{CSR-B}}$, but to be taken not greater than 300 *m*

4. Scantlings

4.1 Plating

Table 1 has been amended as follows.

Table 1 Net minimum thickness of plating

Minimum net thickness, in *mm*	
Bottom	$5.5 + 0.03\cancel{L}\underline{L_{CSR-B}}$
Side and transom	$0.85\cancel{L^{1/2}}\underline{L_{CSR-B}{}^{1/2}}$
Inner bottom	$5.5 + 0.03\cancel{L}\underline{L_{CSR-B}}$
Strength deck	$4.5 + 0.02\cancel{L}\underline{L_{CSR-B}}$
Platform and wash bulkhead	6.5

6. Sternframes

6.2 Connections

Paragraph 6.2.1 has been amended as follows.

6.2.1 Connection with hull structure

Sternframes are to be effectively attached to the aft structure and the lower part of the sternframe is to be extended forward of the propeller post to a length not less than $1500 + 6\cancel{L}\underline{L_{CSR-B}}$ *mm*, in order to provide an effective connection with the keel. However, the sternframe need not extend beyond the aft peak bulkhead.

The net thickness of shell plating connected with the sternframe is to be not less than that obtained, in *mm*, from the following formula:

$$t = 8.5 + 0.045\cancel{L}\underline{L_{CSR-B}}$$

6.4 Propeller shaft bossing

Table 5 and Table 6 have been amended as follows.

Table 5 Single screw ships - Gross scantlings of propeller posts

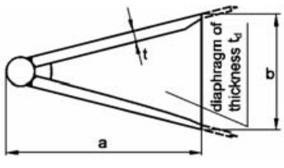
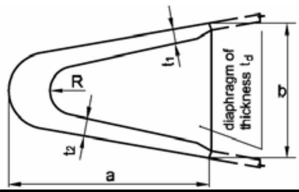
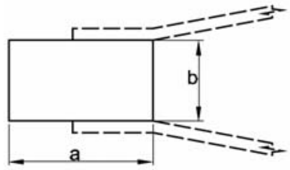
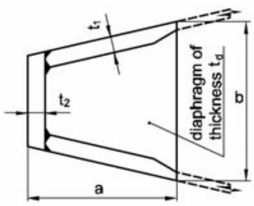
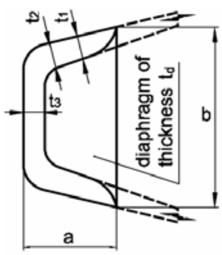
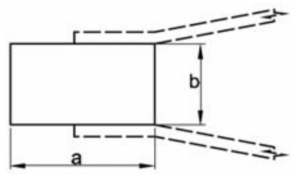
Gross scantlings of propeller posts, in *mm*	Fabricated propeller post 	Cast propeller post 	Bar propeller post, cast or forged, having rectangular section 
a	$50\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$33\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$\cancel{10\sqrt{7.2L-256}}$ $\underline{10\sqrt{7.2L_{CSR-B}-256}}$
b	$35\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$23\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$\cancel{10\sqrt{4.6L-164}}$ $\underline{10\sqrt{4.6L_{CSR-B}-164}}$
$t_1{}^{(1)}$	$2.5\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$3.2\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$ to be taken not less than 19 *mm*	-
$t_2{}^{(1)}$	-	$4.4\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$ to be taken not less than 19 *mm*	-
t_D	$1.3\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$2.0\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	-
R	-	$50\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	-
(1) Propeller post thicknesses t_1, and t_2 are, in any case, to be not less than $(0.05\cancel{L}\underline{L_{CSR\text{-}B}} + 9.5)$ *mm*.			

Table 6 Twin screw ships - Gross scantlings of propeller posts

Gross scantlings of propeller posts, in *mm*	Fabricated propeller post 	Cast propeller post 	Bar propeller post, cast or forged, having rectangular section 
a	$25\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$12.5\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$2.4\cancel{L}\underline{L_{CSR\text{-}B}}+6$
b	$25\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$25\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$0.8\cancel{L}\underline{L_{CSR\text{-}B}}+2$
$t_1{}^{(1)}$	$2.5\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$2.5\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	-
$t_2{}^{(1)}$	$3.2\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$3.2\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	-
t_3	-	$4.4\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	-
t_D	$1.3\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	$2.0\ \cancel{L^{1/2}}\underline{L_{CSR\text{-}B}{}^{1/2}}$	-
(1) Propeller post thicknesses t_1, t_2 and t_3 are, in any case, to be not less than $(0.05\cancel{L}\underline{L_{CSR\text{-}B}} + 9.5)$ *mm*.			

Section 3 MACHINERY SPACE

2. Double bottom

2.2 Minimum thicknesses

Table 1 has been amended as follows.

Table 1 Double bottom - Minimum net thicknesses of inner bottom, floor and girder webs

Element	Minimum net thickness, in *mm*
Inner bottom	$6.6 + 0.024\cancel{L}\underline{L_{CSR-B}}$ The Society may require the thickness of the inner bottom in way of the machinery seatings and on the main thrust blocks to be increased, on a case by case basis.
Margin plate	$0.9\cancel{L^{1/2}}\underline{L_{CSR-B}^{1/2}} + 1$
Centre girder	$1.55\cancel{L^{1/3}}\ \underline{L_{CSR-B}^{1/3}} + 3.5$
Floors and side girders	$1.7\cancel{L^{1/3}}\underline{L_{CSR-B}^{1/3}} +1$
Girder bounding a duct keel	$0.8\cancel{L^{1/2}}\underline{L_{CSR-B}^{1/2}} + 2.5$, to be taken not less than that required for the centre girder.

7. Main machinery seating

7.1 Arrangement

Paragraph 7.1.6 has been amended as follows.

7.1.6 Number of girders in way of machinery seatings

At least two girders are to be fitted in way of main machinery seatings.

One girder may be fitted only where the following three formulae are complied with:

$\cancel{L}\underline{L_{CSR-B}} < 150\ m$

$P < 7100\ kW$

$P < 2.3\ n_r\ L_E$

Section 4 SUPERSTRUCTURES AND DECKHOUSES

Definition of symbol, L_2, has been amended as follows.

Symbols

L_2 : Rule length $\cancel{L}\underline{L_{CSR-B}}$, but to be taken not greater than 300 *m*

1. General

1.1 Definitions

Paragraph 1.1.3 has been amended as follows.

1.1.3 Long deckhouse

A long deckhouse is a deckhouse the length of which within $0.4\cancel{L}\underline{L_{CSR\text{-}B}}$ amidships exceeds $0.2\ \cancel{L}\underline{L_{CSR\text{-}B}}$. The strength of a long deckhouse is to be specially considered.

Paragraph 1.1.5 has been amended as follows.

1.1.5 Non-effective superstructure

For the purpose of this section, all superstructures being located beyond $0.4\cancel{L}\underline{L_{CSR\text{-}B}}$ amidships or having a length of less than $0.15\cancel{L}\underline{L_{CSR\text{-}B}}$ are considered as non-effective superstructures.

2. Arrangement

2.1 Strengthening at the ends of superstructures

Paragraphs 2.1.1 and 2.1.2 have been amended as follows.

2.1.1

In way of end bulkheads of superstructures located within $0.4\cancel{L}\underline{L_{CSR\text{-}B}}$ amidships, the thickness of the strength deck in a breadth of $0.1B$ from the shell, the thickness of the sheerstrake, and the thickness of the superstructure side plating are to be increased by the percentage of strengthening specified in **Table 1**. The strengthening is to be extended over a region from 4 frame spacings abaft the end bulkhead to 4 frame spacings forward of the end bulkhead.

2.1.2

Under strength decks in way of $0.6\cancel{L}\underline{L_{CSR\text{-}B}}$ amidships, girders are to be fitted in alignment with longitudinal walls, which are to extend at least over three frame spacings beyond the end points of the longitudinal walls. The girders are to overlap with the longitudinal walls by at least two frame spacings.

4. Scantlings

4.1 Side plating of non-effective superstructures

Paragraph 4.1.1 has been amended as follows.

4.1.1

The thickness, in *mm*, of the side plating of non-effective superstructures is not to be less than the greater of the following values:

$$t = 1.21 s\sqrt{k p_{SI}} + t_C$$

$$\cancel{t = 0.8\sqrt{kL}} \quad t = 0.8\sqrt{kL_{CSR-B}}$$

4.2 Deck plating of non-effective superstructures

Paragraph 4.2.1 has been amended as follows.

4.2.1

The thickness, in *mm*, of deck plating of non-effective superstructures is not to be less than the greater of the following values:

$$t = 1.21 s\sqrt{k p_D} + t_C$$

$$\cancel{t = (5.5 + 0.02L)\sqrt{k}} \quad t = (5.5 + 0.02 L_{CSR-B})\sqrt{k}$$

where ~~L~~ L_{CSR-B} is not to be taken greater than 200 *m*.

Section 5 HATCH COVERS

1. General

1.1 Application

Paragraph 1.1.1 has been amended as follows.

1.1.1

The requirements in **1** to **8** apply to steel hatch covers in positions 1 and 2 on weather decks, defined in **Ch 1**, **Sec 4**, **3.20**.

The requirements in **9** apply to steel hatch covers of small hatches fitted on the exposed fore deck over the forward 0.25~~L~~L_{CSR-B}.

9. Small hatches fitted on the exposed fore deck

9.1 Application

Paragraph 9.1.1 has been amended as follows.

9.1.1

The requirements of this article apply to steel covers of small hatches fitted on the exposed fore deck over the forward 0.25~~L~~L_{CSR-B}, where the height of the exposed deck in way of the hatch is less than 0.1~~L~~L_{CSR-B} or 22 *m* above the summer load waterline, whichever is the lesser.

Small hatches are hatches designed for access to spaces below the deck and are capable to be closed weather-tight or watertight, as applicable. Their opening is generally equal to or less than 2.5 m^2.

Section 6 ARRANGEMENT OF HULL AND SUPERSTRUCTURE OPENINGS

4. Discharges

4.2 Arrangement of garbage chutes

Paragraph 4.2.1 has been amended as follows.

4.2.1 Inboard end above the waterline

Ref. ILLC, as amended (Resolution MSC.143(77) Reg. 22-1(1, b))

The inboard end is to be located above the waterline formed by an 8.5° heel, to port or starboard, at a draft corresponding to the assigned summer freeboard, but not less than 1000 *mm* above the summer load waterline.

Where the inboard end of the garbage chute exceeds 0.01~~L~~$\underline{L_{LL}}$ above the summer load waterline, valve control from the freeboard deck is not required, provided the inboard gate valve is always accessible under service conditions.

Chapter 10 HULL OUTFITTING

Section 1 RUDDER AND MANOEUVRING ARRANGEMENT

1. General

Paragraph 1.3 has been amended as follows.

1.3 Size of rudder area

In order to achieve sufficient manoeuvring capability the size of the movable rudder area A is recommended to be not less than obtained, in m^2, from the following formula:

$$\cancel{A = c_1 c_2 c_3 c_4 \frac{1.75LT}{100}} \quad \underline{A = c_1 c_2 c_3 c_4 \frac{1.75 L_{CSR-B} T}{100}}$$

(Omitted)

9. Rudder horn and sole piece scantlings

9.2 Rudder horn of semi spade rudders (case of 1-elastic support)

Paragraph 9.2.5 has been amended as follows.

9.2.5

When determining the thickness of the rudder horn plating the provisions of **5.2** to **5.4** are to be complied with. The thickness, in mm, is, however, not to be less than $\cancel{2.4\sqrt{LK}}$ $\underline{2.4\sqrt{L_{CSR-B}K}}$.

Section 2 BULWARKS AND GUARD RAILS

2. Bulwarks

2.1 General

Paragraph 2.1.2 has been amended as follows.

2.1.2

In type B-60 and B-100 ships, the spacing forward of 0.07~~L~~$\underline{L_{CSR-B}}$ from the fore end of brackets and stays is to be not greater than 1.2 m.

Section 3 EQUIPMENT

2. Equipment number

2.1 Equipment number

Paragraph 2.1.2 has been amended as follows.

2.1.2 Equipment number

The equipment number EN is to be obtained from the following formula:

$$EN = \Delta^{2/3} + 2\,h\,B + 0.1\,A$$

where:.

Δ : Moulded displacement of the ship, in t, to the summer load waterline

h : Effective height, in m, from the summer load waterline to the top of the uppermost house, to be obtained in accordance with the following formula:

$$h = a + \Sigma\, h_n$$

When calculating h, sheer and trim are to be disregarded

a : Freeboard amidships from the summer load waterline to the upper deck, in m

h_n : Height, in m, at the centreline of tier "n" of superstructures or deckhouses having a breadth greater than $B/4$. Where a house having a breadth greater than $B/4$ is above a house with a breadth of $B/4$ or less, the upper house is to be included and the lower ignored

A : Area, in m^2, in profile view, of the parts of the hull, superstructures and houses above the summer load waterline which are within the length $\cancel{L}\underline{L_{CSR-B}}$ and also have a breadth greater than $B/4$

3. Equipment

3.7 Windlass

Paragraph 3.7.8 has been amended as follows.

3.7.8 Green sea loads

Where the height of the exposed deck in way of the item is less than $0.1\cancel{L}\underline{L_{CSR-B}}$ or 22 m above the summer load waterline, whichever is the lesser, the securing devices of windlasses located within the forward quarter length of the ship are to resist green sea forces.

(Omitted)

Chapter 11 CONSTRUCTION AND TESTING

Section 2 WELDING

2. Types of welded connections

2.4 Full penetration welds

Paragraph 2.4.1 has been amended as follows.

2.4.1 Application

(Omitted)

- edge reinforcement or pipe penetrations both to strength deck, sheer strake and bottom plating within $0.6\cancel{L}\underline{L_{CSR-B}}$ amidships, when the dimension of the opening exceeds 300 *mm*
- abutting plate panels forming boundaries to sea below summer load waterline.

2.6 Fillet welds

Table 2 has been amended as follows.

Table 2 Application of fillet welds

<table>
<tr><td rowspan="2">Hull area</td><td colspan="4">Connection</td><td>Category</td></tr>
<tr><td colspan="2">Of</td><td colspan="2">To</td><td></td></tr>
<tr><td colspan="6">(Omitted)</td></tr>
<tr><td rowspan="4">Deck</td><td rowspan="3">Strength deck</td><td rowspan="2">$t \geq 13$</td><td colspan="2">Side shell plating within $0.6\cancel{L}\underline{L_{CSR-B}}$ midship</td><td>Deep penetration</td></tr>
<tr><td colspan="2">Elsewhere</td><td>F 1</td></tr>
<tr><td>$t < 13$</td><td colspan="2">Side shell plating</td><td>F 1</td></tr>
<tr><td colspan="5">(Omitted)</td></tr>
<tr><td colspan="6">(Omitted)</td></tr>
<tr><td rowspan="5">Primary supporting members</td><td colspan="2" rowspan="5">Web plate and girder plate</td><td rowspan="2">Shell plating, deck plating, inner bottom plating, bulkhead</td><td>At end (15% of span)</td><td>F 1</td></tr>
<tr><td>Elsewhere</td><td>F 2</td></tr>
<tr><td rowspan="3">Face plate</td><td>In tanks, and located within $0.125\cancel{L}\underline{L_{CSR-B}}$ from fore peak</td><td>F 2</td></tr>
<tr><td>Face area exceeds 65 cm^2</td><td>F 2</td></tr>
<tr><td>Elsewhere</td><td>F 3</td></tr>
<tr><td colspan="6">(Omitted)</td></tr>
</table>

2.8 Slot welds

Paragraph 2.8.1 has been amended as follows.

2.8.1 General

Slot welds may be adopted in very specific cases subject to the approval of the Society. However, slot welds of doublers on the outer shell and strength deck are not permitted within 0.6~~L~~$\underline{L_{CSR-B}}$ amidships.

EFFECTIVE DATE AND APPLICATION (Amendment 1-2)

1. The effective date of the amendments is 15 April 2009.

Amendment 1-3

Chapter 3 Structural design principles

Section 3 Corrosion additions

1. Corrosion additions

1.2 Corrosion addition determination

Table 1 has been amended as follows.

Table 1 Corrosion addition on one side of structural members

<table>
<tr><th rowspan="2">Compartment Type</th><th rowspan="2" colspan="2">Structural member</th><th colspan="2">Corrosion addition, t_{C1} or t_{C2}, in mm</th></tr>
<tr><th>$BC\text{-}A$ or $BC\text{-}B$ ships with $L \geq 150\ m$</th><th>Other</th></tr>
<tr><td rowspan="4">Ballast water tank(2)</td><td rowspan="2">Face plate of primary members</td><td>Within 3 m below the top of tank(3)</td><td colspan="2">2.0</td></tr>
<tr><td>Elsewhere</td><td colspan="2">1.5</td></tr>
<tr><td rowspan="2">Other members</td><td>Within 3 m below the top of tank(3)</td><td colspan="2">1.7</td></tr>
<tr><td>Elsewhere</td><td colspan="2">1.2</td></tr>
<tr><td rowspan="9">Dry bulk cargo hold(1)</td><td rowspan="3">Transverse bulkhead</td><td>Upper part(4)</td><td>2.4</td><td>1.0</td></tr>
<tr><td>Lower stool : sloping <s>and top</s> plate, vertical plate and top plate</td><td>5.2</td><td>2.6</td></tr>
<tr><td>Other parts</td><td>3.0</td><td>1.5</td></tr>
<tr><td rowspan="4">Other members</td><td>Upper part(4)</td><td rowspan="2">1.8</td><td rowspan="2">1.0</td></tr>
<tr><td>Webs and flanges of the upper end brackets of side frames of single side bulk carriers</td></tr>
<tr><td>Webs and flanges of lower brackets of side frames of single side bulk carriers</td><td>2.2</td><td>1.2</td></tr>
<tr><td>Other parts</td><td>2.0</td><td>1.2</td></tr>
<tr><td rowspan="2">Sloped plating of hopper tank, inner bottom plating</td><td>Continuous wooden ceiling</td><td>2.0</td><td>1.2</td></tr>
<tr><td>No continuous wooden ceiling</td><td>3.7</td><td>2.4</td></tr>
<tr><td rowspan="2">Exposed to atmosphere</td><td colspan="2">Horizontal member and weather deck(5)</td><td colspan="2">1.7</td></tr>
<tr><td colspan="2">Non horizontal member</td><td colspan="2">1.0</td></tr>
<tr><td colspan="3">Exposed to sea water(7)</td><td colspan="2">1.0</td></tr>
<tr><td colspan="3">Fuel oil tanks and lubricating oil tanks(2)</td><td colspan="2">0.7</td></tr>
<tr><td colspan="3">Fresh water tanks</td><td colspan="2">0.7</td></tr>
<tr><td>Void spaces(6)</td><td colspan="2">Spaces not normally accessed, e.g. access only through bolted manholes openings, pipe tunnels, etc.</td><td colspan="2">0.7</td></tr>
<tr><td>Dry spaces</td><td colspan="2">Internal of deck houses, machinery spaces, stores spaces, pump rooms, steering spaces, etc.</td><td colspan="2">0.5</td></tr>
<tr><td colspan="3">Other compartments than above</td><td colspan="2">0.5</td></tr>
</table>

Notes
(1) Dry bulk cargo hold includes holds, intended for the carriage of dry bulk cargoes, which may carry water ballast.
(2) The corrosion addition of a plating between water ballast and heated fuel oil tanks is to be increased by 0.7 *mm*.
(3) ~~This is not to be applied to structural members of inner bottom and located below inner bottom.~~ This is only applicable to ballast tanks with weather deck as the tank top.
(4) Upper part of the cargo holds corresponds to an area above the connection between the top side and the inner hull or side shell. If there is no top side, the upper part corresponds to the upper one third of the cargo hold height.
(5) Horizontal member means a member making an angle up to 20° as regard as a horizontal line.
(6) The corrosion addition on the outer shell plating in way of pipe tunnel is to be considered as water ballast tank.
(7) Outer side shell between normal ballast draught and scantling draught is to be increased by 0.5 *mm*.

Section 6 STRUCTURAL ARRANGEMENT PRINCIPLES

6. Double bottom

6.4 Floors

Paragraph 6.4.2 has been amended as follows.

6.4.2 Floors in way of transverse bulkheads

Where transverse bulkhead is provided with lower stool, solid floors are to be fitted in line with both sides of lower stool. Where transverse bulkhead is not provided with lower stool, solid floors are to be fitted in line with both flanges of the vertically corrugated transverse bulkhead or in line of plane transverse bulkhead.

~~The net thickness and material properties of the supporting floors and pipe tunnel beams are to be not less than those required for the bulkhead plating or, when a stool is fitted, of the stool side plating.~~

10. Bulkhead structure

10.4 Corrugated bulkheads

Paragraph 10.4.2 has been amended as follows.

10.4.2 Construction

The main dimensions a, R, c, d, t, φ and s_C of corrugated bulkheads are defined in **Fig. 28**.

The bending radius is not to be less than the following values, in *mm*:

$R = 3.0t$

where:

t :As-built thickness, in *mm*, of the corrugated plate.

The corrugation angle φ shown in **Fig. 28** is to be not less than 55°.

~~The thickness of the lower part of corrugations is to be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than 0.15~~$\cancel{\ell_C}$~~.~~

~~The thickness of the middle part of corrugations is to be maintained for a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than $0.3\ell_C$.~~
~~The section modulus of the corrugations in the remaining upper part of the bulkhead is to be not less than 75% of that required for the middle part, corrected for different minimum yield stresses.~~
When welds in a direction parallel to the bend axis are provided in the zone of the bend, the welding procedures are to be submitted to the Society for approval.

Paragraph 10.4.5 has been amended as follows.

10.4.5 Structural arrangements

The strength continuity of corrugated bulkheads is to be ensured at the ends of corrugations.
Where corrugated bulkheads are cut in way of primary supporting members, attention is to be paid to ensure correct alignment of corrugations on each side of the primary member.
Where vertically corrugated transverse bulkheads or longitudinal bulkheads are welded on the inner bottom plate, floors or girders are to be fitted in way of flanges of corrugations, respectively~~ and the net thickness and materials of floors and girders are to be not less than those adjacent corrugation face plate~~.
In general, the first vertical corrugation connected to the boundary structures is to have a width not smaller than typical width of corrugation flange.
~~Where stools are fitted at the lower part of transverse bulkheads, the net thickness of adjacent floors is to be not less than that of the stool plating.~~

Paragraph 10.4.6 has been amended as follows.

10.4.6 Bulkhead stools

Plate diaphragms or web frames are to be fitted in bottom stools in way of the double bottom longitudinal girders or plate floors, as the case may be.
Brackets or deep webs are to be fitted to connect the upper stool to the deck transverse or hatch end beams, as the case may be.
~~The continuity of the corrugated bulkhead with the stool plating is to be adequately ensured. In particular, upper strake of the lower stool is to be of the same net thickness and yield stress as those of the lower strake of the bulkhead.~~

Paragraph 10.4.7 has been amended as follows.

10.4.7 Lower stool

The lower stool, when fitted, is to have a height in general not less than 3 *times* the depth of the corrugations.
~~The net thickness and material of the stool top plate are to be not less than those required for the bulkhead plating above. The net thickness and material properties of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top are to be not less than the required flange plate thickness and material to~~

~~meet the bulkhead stiffness requirement at the lower end of the corrugation.~~
The ends of stool side ordinary stiffeners, when fitted in a vertical plane, are to be attached to brackets at the upper and lower ends of the stool.
The distance *d* from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with **Fig. 30**.
The stool bottom is to be installed in line with double bottom floors or girders as the case may be, and is to have a width not less than 2.5 *times* the mean depth of the corrugation.
The stool is to be fitted with diaphragms in line with the longitudinal double bottom girders or floors as the case may be, for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate are to be avoided.
Where corrugations are cut at the lower stool, corrugated bulkhead plating is to be connected to the stool top plate by full penetration welds. The stool side plating is to be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds. The supporting floors are to be connected to the inner bottom by either full penetration or deep penetration weld.

Paragraph 10.4.8 has been amended as follows.

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 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.

Paragraph 10.4.9 has been amended as follows.

10.4.9 Alignment

At deck, if no upper stool is fitted, two transverse or longitudinal reinforced beams as the case may be, are to be fitted in line with the corrugation flanges.
At bottom, if no lower stool is fitted, the corrugation flanges are to be in line with the supporting floors or girders.
The weld of corrugations and floors or girders to the inner bottom plating are to be full penetration ones. ~~The thickness and material properties of the supporting floors or girders are~~

~~to be not less than those of the corrugation flanges. Moreover, t~~The cut-outs for connections of the inner bottom longitudinals to double bottom floors are to be closed by collar plates. The supporting floors or girders are to be connected to each other by suitably designed shear plates.
Stool side plating is to be aligned with the corrugation flanges. Lower stool side vertical stiffeners and their brackets in the stool are to be aligned with the inner bottom structures as longitudinals or similar, to provide appropriate load transmission between these stiffening members.
Lower stool side plating is not to be knuckled anywhere between the inner bottom plating and the stool top plate.

Paragraph 10.4.13 has been deleted.

10.4.13 ~~Section modulus at the lower end of corrugations~~ (void)

~~a) The section modulus at the lower end of corrugations (**Fig. 31** to **Fig. 35**) is to be calculated with the compression flange having an effective flange width b_{ef} not larger than that indicated in **10.4.10**.~~

~~b) Webs not supported by local brackets~~
~~Except in case e), if the corrugation webs are not supported by local brackets below the stool top plate (or below the inner bottom) in the lower part, the section modulus of the corrugations is to be calculated considering the corrugation webs 30% effective.~~

~~c) Effective shedder plates~~
~~Provided that effective shedder plates, as defined in **10.4.11**, are fitted (see **Figs. 31** and **32**), when calculating the section modulus of corrugations at the lower end (cross sections 1 in **Figs. 31** and **32**), the area of flange plates may be increased by the value obtained, in cm^2, from the following formula:~~

$$\cancel{I_{SH} = 2.5a\sqrt{t_f t_{SH}}}$$

~~without being taken greater than $2.5at_f$,~~
~~where:~~
~~a : Width, in m, of the corrugation flange (see **Fig. 28**)~~
~~t_{SH} : Net shedder plate thickness, in mm~~
~~t_f : Net flange thickness, in mm.~~

~~d) Effective gusset plates~~
~~Provided that effective gusset plates, as defined in **10.4.12**, are fitted (see **Figs. 33** to **35**), when calculating the section modulus of corrugations at the lower end (cross-sections 1 in **Figs. 33** to **35**), the area of flange plates may be increased by the value obtained, in cm^2, from the following formula:~~

$$\cancel{I_G = 7h_G t_f}$$

~~where:~~
~~h_G : Height, in m, of gusset plates (see **Figs 33** to **35**), to be taken not greater than $(10/7)S_{GU}$~~
~~S_{GU} : Width, in m, of gusset plates~~
~~t_f : Net flange thickness, in mm, based on the as-built condition.~~

~~e) Sloping stool top plate~~
~~If the corrugation webs are welded to a sloping stool top plate which has an angle not less than 45° with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. For angles less than 45°, the~~

~~effectiveness of the web may be obtained by linear interpolation between 30% for 0° and 100% for 45°.~~
~~Where effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in d) above. No credit may be given to shedder plates only.~~

Fig. 31 to Fig. 35 have been deleted.

Fig. 31 ~~Symmetrical shedder plates~~ (void)

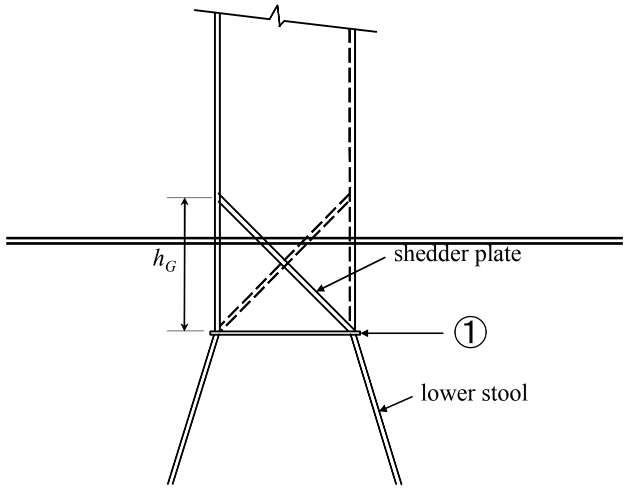


Fig. 32 ~~Asymmetrical shedder plates~~ (void)

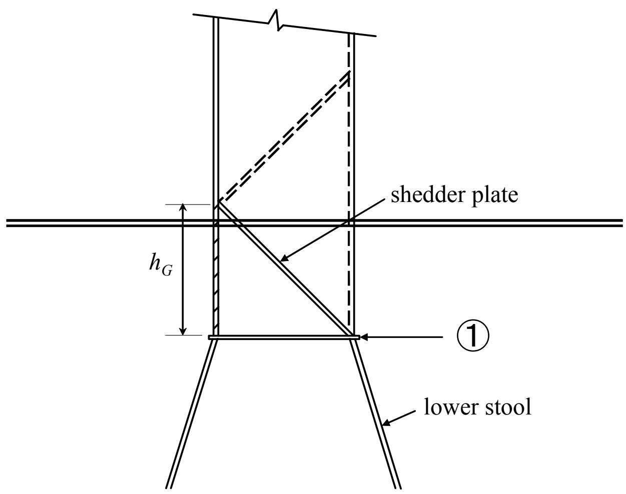


Fig. 33 ~~**Symmetrical gusset/shedder plates**~~ **(void)**

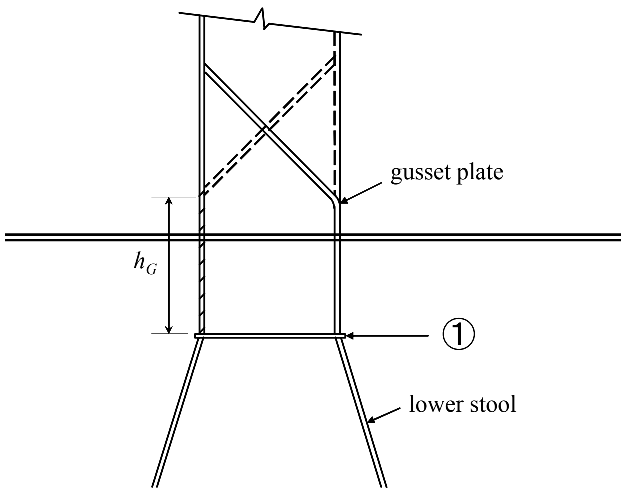


Fig. 34 ~~**Asymmetrical gusset/shedder plates**~~ **(void)**

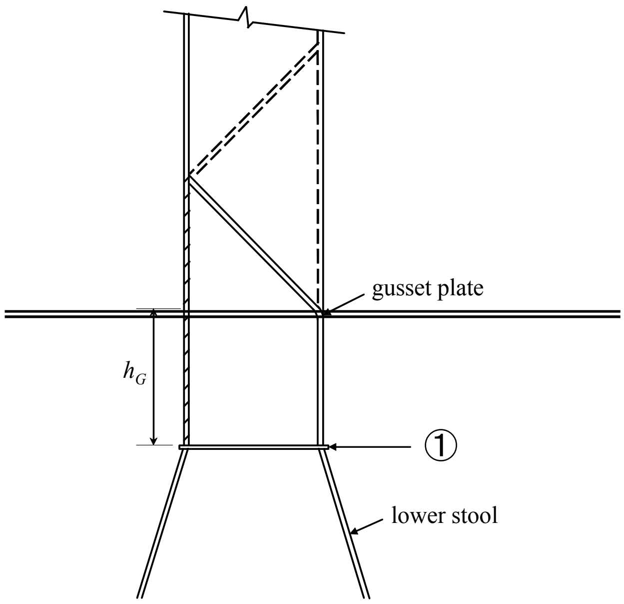
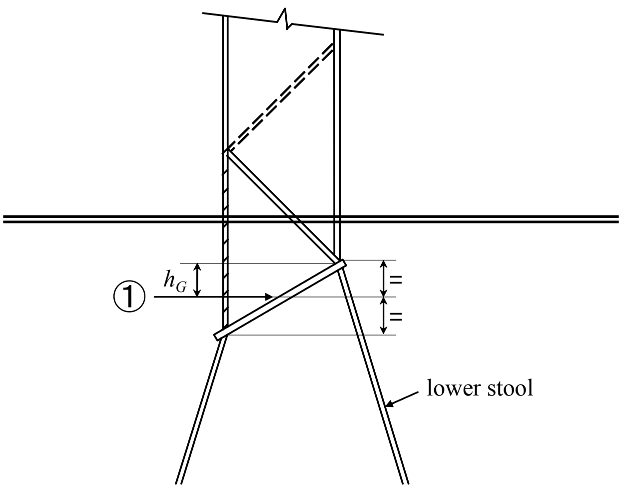


Fig. 35 ~~Asymmetrical gusset/shedder plates~~ (void)



Paragraph 10.4.14 has been deleted.

10.4.14 ~~Section modulus at sections other than the lower end of corrugations~~ (void)

~~The section modulus is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{ef}, not larger than that obtained in **10.4.10**.~~

Paragraph 10.4.15 has been deleted.

10.4.15 ~~Shear area~~ (void)

~~The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by ($\sin\varphi$), φ being the angle between the web and the flange (see **Fig. 28**).~~

Chapter 4 DESIGN LOADS

Section 2 SHIP MOTIONS AND ACCELERATIONS

2. Ship absolute motions and accelerations

2.1 Roll

Table 1 has been amended as follows.

Table 1 Values of k_r and GM

Loading condition		k_r	GM
Full load condition	Alternate or homogeneous loading	$0.35B$	$0.12B$
	Steel coil loading	$0.42B$	$0.24B$
Normal ballast condition		$0.45B$	$0.33B$
Heavy ballast condition		$0.40B$	$0.25B$

Section 5 EXTERNAL PRESSURES

2. External pressures on exposed decks

2.1 General

Paragraph 2.1.1 has been amended as follows.

2.1.1

The external pressures on exposed decks are to be applied for the local scantling check of the structures on exposed deck but not applied for fatigue strength assessment.

If a breakwater is fitted on the exposed deck, no reduction in the external pressures defined in **2.2** and **2.3** is allowed for the area of the exposed deck located aft of the breakwater.

Section 6 INTERNAL PRESSURES AND FORCES

2. Lateral pressure due to liquid

2.1 Pressure due to liquid in still water

Paragraph 2.1.3 has been added as follows.

2.1.3

For fatigue strength assessment, the liquid pressure in still water p_{BS} in kN/m^2, is given by the following formula.

$$p_{BS} = \rho_L g (z_{TOP} - z)$$

If the p_{BS} is negative, p_{BS} is to be taken equal to 0.

Where the considered load point is located in the fuel oil, other oils or fresh water tanks, liquids are assumed to be fulfilled up to the half height of the tanks and z_{TOP} is taken to the z coordinate of the liquid surface at the upright condition.

Chapter 5 HULL GIRDER STRENGTH

Section 1 YIELDING CHECK

2. Hull girder stresses

2.2 Shear stresses

Paragraph 2.2.2 has been amended as follows.

2.2.2 Simplified calculation of shear stresses induced by vertical shear forces

The shear stresses induced by the vertical shear forces in the calculation point are obtained, in N/mm^2, from the following formula:

$$\tau_1 = \left(Q_{SW} + Q_{WV} - \varepsilon \Delta Q_C\right) \frac{S}{I_Y t} \delta$$

where:

t : Minimum net thickness, in *mm*, of side and inner side plating, as applicable according to **Table 1**

δ : Shear distribution coefficient defined in **Table 1**

$\varepsilon = \operatorname{sgn}\left(Q_{SW}\right)$

ΔQ_C : Shear force correction (see **Fig. 2**)~~, which~~ at the section considered. The shear force correction is to be considered independently forward and aft of the transverse bulkhead for the hold considered. The shear force correction takes into account, when applicable, the portion of loads transmitted by the double bottom girders to the transverse bulkheads:

- for ships with any non-homogeneous loading conditions, such as alternate hold loading conditions and heavy ballast conditions carrying ballast in hold(s):

$\cancel{\Delta Q_C = \alpha \left| \frac{M}{B_H \ell_H} - \rho T_{LC} \right|}$ $\Delta Q_C = \alpha \left| \frac{M}{B_H \ell_H} - \rho T_{LC,mh} \right|$ for each non-homogeneous loading condition

- for other ships and homogeneous loading conditions:

$\Delta Q_C = 0$

$$\alpha = g \frac{\ell_0 b_0}{2 + \varphi \frac{\ell_0}{b_0}}$$

$\varphi = 1.38 + 1.55 \frac{\ell_0}{b_0}$, to be taken not greater than 3.7

ℓ_0, b_0 : Length and breadth, respectively, in *m*, of the flat portion of the double bottom in way of the hold considered; b_0 is to be measured on the hull transverse section at the middle of the hold

ℓ_H: Length, in *m*, of the hold considered, measured between the middle of the transverse corrugated bulkheads depth

B_H : Ship's breadth, in *m*, measured at the level of inner bottom on the hull transverse section at the middle of the hold considered

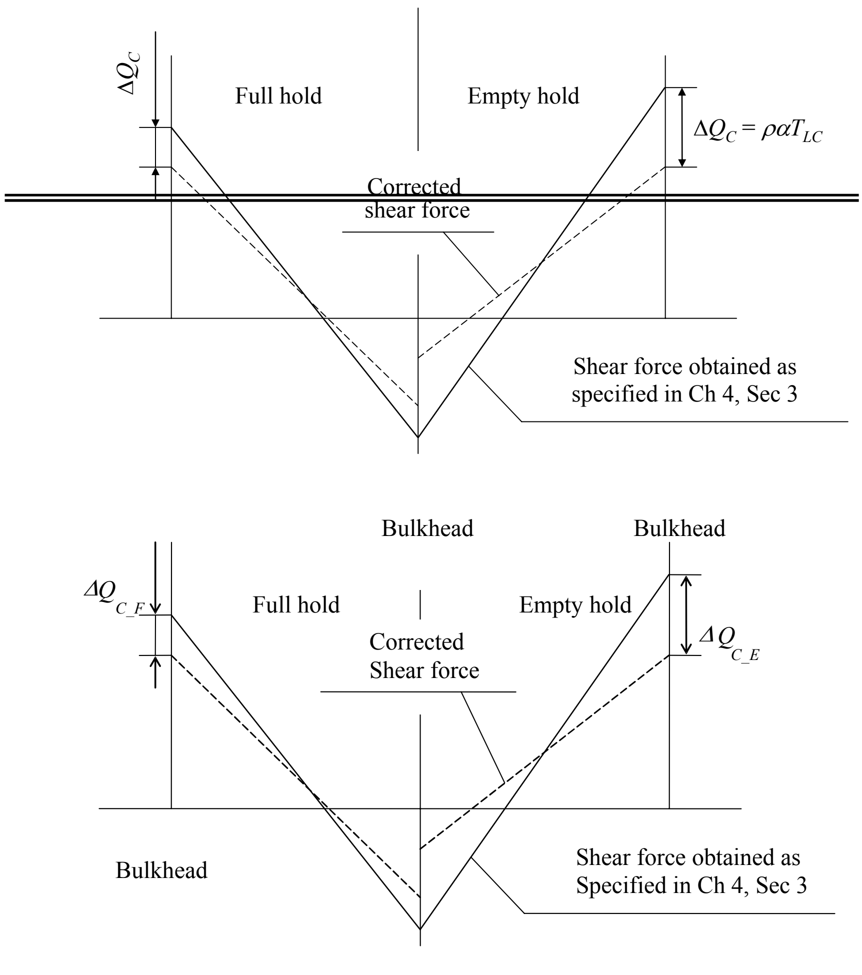
M: ~~Total mass of cargo, in *t*, in the hold of the section considered~~ Mass, in *t*, in the considered section.

- Adjacent cargo hold is loaded for the non homogeneous loading condition for the condition under consideration
  M is to include the total mass in the hold and the mass of water ballast in double bottom tank, bounded by side girders in way of hopper tank plating or longitudinal bulkhead.
- Other cases
  M is the total mass in the hold.

~~T_{LC}~~ $T_{LC,mh}$: Draught, in *m*, measured vertically on the hull transverse section at the middle of the hold considered, from the moulded baseline to the waterline in the loading condition considered.

Fig.2 has been amended as follows.

Fig. 2 Shear force correction ΔQ_C



Note:

ΔQ_{C_F}: shear force correction for the full hold.

ΔQ_{C_E}: shear force correction for the empty hold.

Paragraph 2.2.3 has been amended as follows.

2.2.3 Shear stresses in flooded conditions of *BC-A* or *BC-B* ships

This requirement applies to *BC-A* or *BC-B* ships, in addition to **2.2.1** and **2.2.2**.

The shear stresses, in the flooded conditions specified in **Ch 4**, **Sec 3**, are to be obtained at ~~any~~ the calculation point, in N/mm^2, from the following formula:

$$\tau_1 = \left(Q_{SW,F} + Q_{WV,F} - \varepsilon \Delta Q_C\right)\frac{S}{I_Y t}\delta$$

$$\varepsilon = \operatorname{sgn}(Q_{SW,F})$$

ΔQ_C : Shear force correction, to be calculated according to **2.2.2**, where the mass ~~M is to include the mass~~ of the ingressed water ~~in the hold considered~~ is to be added to M and where the draught ~~T_{LC}~~ $T_{LC,mh}$ is to be measured up to the equilibrium waterline

t : Net thickness, in *mm*, of the side plating.

5. Permissible still water bending moment and shear force

5.1 Permissible still water bending moment and shear force in intact condition

Paragraph 5.1.3 has been amended as follows.

5.1.3 Permissible still water shear force - Simplified calculation

Where the shear stresses are obtained through the simplified procedure in **2.2.2**, the permissible positive or negative still water shear force in intact condition at any hull transverse section is obtained, in *kN*, from the following formula:

$$Q_P = \varepsilon\left(\frac{120}{k\delta}\frac{I_Y t}{S} + \Delta Q_C\right) - Q_{WV}$$

where:

$$\varepsilon = \operatorname{sgn}(Q_{SW})$$

δ : Shear distribution coefficient defined in **Table 1**

t : Minimum net thickness, in *mm*, of side and inner side plating, as applicable according to **Table 1**

ΔQ_C : Shear force corrections defined in **2.2.2**, to be considered independently forward and aft of the transverse bulkhead.

A lower value of the permissible still water shear force may be considered, if requested by the Shipbuilder.

Appendix 1 HULL GIRDER ULTIMATE STRENGTH

Symbols have been amended as follows.

Symbols

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

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

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

$\underline{R_{eHs}}$:<u>Minimum yield stress, in *N/mm*^{2}, of the material of the considered stiffener.</u>

$\underline{R_{eHp}}$:<u>Minimum yield stress, in *N/mm*^{2}, of the material of the considered plate.</u>

$\underline{A_S}$:<u>Net sectional area, in *cm*^{2}, of stiffener, without attached plating.</u>

$\underline{A_P}$:<u>Net sectional area, in *cm*^{2}, of attached plating.</u>

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

2.1 Simplified method based on a incremental-iterative approach

Paragraph 2.1.1 has been amended as follows.

2.1.1 Procedure

The curve M-χ is to be obtained by means of an incremental-iterative approach, summarised in the flow chart in **Fig. 1**.

In this approach, the ultimate hull girder bending moment capacity M_U is defined as the peak value of the curve with vertical bending moment M versus the curvature χ of the ship cross section as shown in **Fig. 1.** The curve is to be obtained through an incremental-iterative approach.

Each step of the incremental procedure is represented by the calculation of the bending moment M_i which acts on the hull transverse section as the effect of an imposed curvature χ_i.

For each step, the value χ_i is to be obtained by summing an increment of curvature $\Delta\chi$ to the value relevant to the previous step χ_{i-1}.This increment of curvature corresponds to an increment of the rotation angle of the hull girder transverse section around its horizontal neutral axis.

This rotation increment induces axial strains ε in each hull structural element, whose value depends on the position of the element. In hogging condition, the structural elements above the neutral axis are lengthened, while the elements below the neutral axis are shortened. Vice-versa in sagging condition.

The stress σ induced in each structural element by the strain ε is to be obtained from the load-end shortening curve σ-ε of the element, which takes into account the behaviour of the element in the non-linear elasto-plastic domain.

The distribution of the stresses induced in all the elements composing the hull transverse section determines, for each step, a variation of the neutral axis position, since the relationship σ-ε is non-linear. The new position of the neutral axis relevant to the step considered is to be obtained by means of an iterative process, imposing the equilibrium among the stresses acting in all the hull elements.

Once the position of the neutral axis is known and the relevant stress distribution in the section structural elements is obtained, the bending moment of the section M_i around the new position of the neutral axis, which corresponds to the curvature χ_i imposed in the step considered, is to be obtained by summing the contribution given by each element stress.

The main steps of the incremental-iterative approach described above are summarised as follows (see also **Fig. 1**):

Step 1 Divide the transverse section of hull into stiffened plate elements

Step 2 Define stress-strain relationships for all elements as shown in **Table 1**

Step 3 Initialize curvature χ_1 and neutral axis for the first incremental step with the value of incremental curvature (curvature that induces a stress equal to 1% of yield strength in strength deck) as:

$$\chi_1 = \Delta\chi = \frac{0.01\dfrac{R_{eH}}{E}}{z_D - N}$$

where:

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

Step 4 Calculate for each element the corresponding strain $\cancel{\varepsilon_i = \chi\ z_i}$ $\varepsilon_i = \chi(z_i - z_{NA})$ and the corresponding stress σ_i

Step 5 Determine the neutral axis z_{NA_cur} at each incremental step by establishing force equilibrium over the whole transverse section as:

$\Sigma A_i\ \sigma_i = \Sigma A_j\ \sigma_j$ (i-th element is under compression, j-th element under tension)

Step 6 Calculate the corresponding moment by summing the contributions of all elements as:

$$M_U = \sum \sigma_{Ui} A_i \left|\left(z_i - z_{NA\_cur}\right)\right|$$

Step 7 Compare the moment in the current incremental step with the moment in the previous incremental step. If the slope in M-χ relationship is less than a negative fixed value, terminate the process and define the peak value of M_U. Otherwise, increase the curvature by the amount of $\Delta\chi$ and go to **Step 4**.

Paragraph 2.1.3 has been added as follows.

2.1.3 Modeling of the hull girder cross section

Hull girder transverse sections are to be considered as being constituted by the members contributing to the hull girder ultimate strength.

Sniped stiffeners are also to be modeled imaginarily, taking account that they doesn't contribute to the hull girder strength.

The structural members are categorized into an ordinary stiffener element, a stiffened plate element or a hard corner element.

The plate panel including web plate of girder or side stringer is idealized into either a stiffened plate element, an attached plate of an ordinary stiffener element or a hard corner element.

The plate panel is categorized into the following two kinds:

- longitudinally stiffened panel of which the longer side is in the longitudinal direction, and
- transversely stiffened panel of which the longer side is in the perpendicular direction to the longitudinal direction.

・ Hard corner element

Hard corners elements are sturdier elements composing the hull girder transverse section, which collapse mainly according to an elasto-plastic mode of failure (material yielding); they are generally constituted by two plates not lying in the same plane.

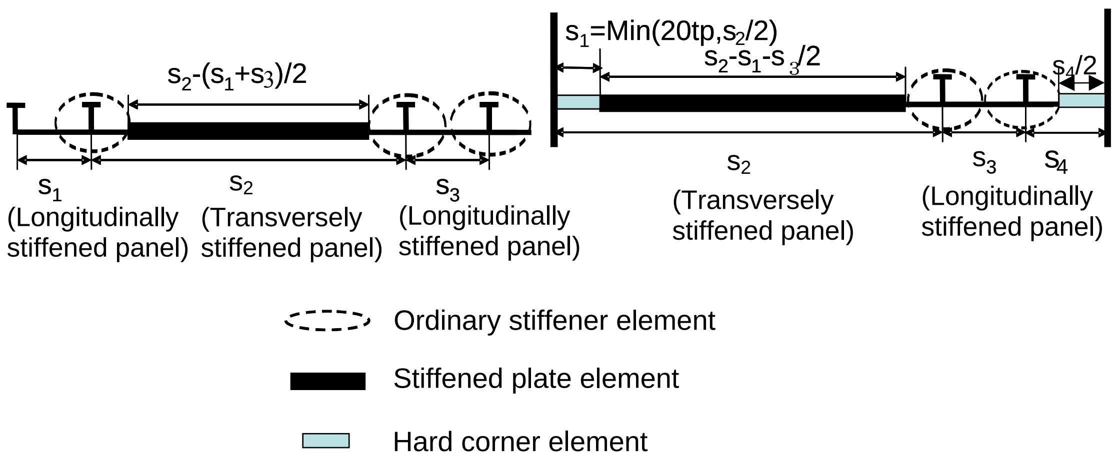
The extent of a hard corner element from the point of intersection of the plates is taken equal to

$20t_p$ on transversely stiffened panel and to 0.5 *s* on a longitudinally stiffened panel. (See **Fig. 6**)
where:
t_p : Gross offered thickness of the plate, in *mm*
s : Spacing of the adjacent longitudinal stiffener, in *m*
Bilge, sheer strake-deck stringer elements, girder-deck connections and face plate-web connections on large girders are typical hard corners.

- Ordinary stiffener element
  The ordinary stiffener constitutes an ordinary stiffener element together with the attached plate. The attached plate width is in principle:
  - equal to the mean spacing of the ordinary stiffener when the panels on both sides of the stiffener are longitudinally stiffened, or
  - equal to the width of the longitudinally stiffened panel when the panel on one side of the stiffener is longitudinally stiffened and the other panel is of the transversely stiffened. (See **Fig. 6**)
- Stiffened plate element
  The plate between ordinary stiffener elements, between an ordinary stiffener element and a hard corner element or between hard corner elements is to be treated as a stiffened plate element. (See **Fig. 6**)

Fig.6 to Fig. 10 have been added as follows.

Fig. 6 Extension of the breadth of the attached plating and hard corner element



The typical examples of modeling of hull girder section are illustrated in **Figs. 7** and **8**. Notwithstanding the foregoing principle these figures are to be applied to the modeling in the vicinity of upper deck, sheer strake and hatch side girder.

Fig. 7 Extension of the breadth of the attached plating and hard corner element

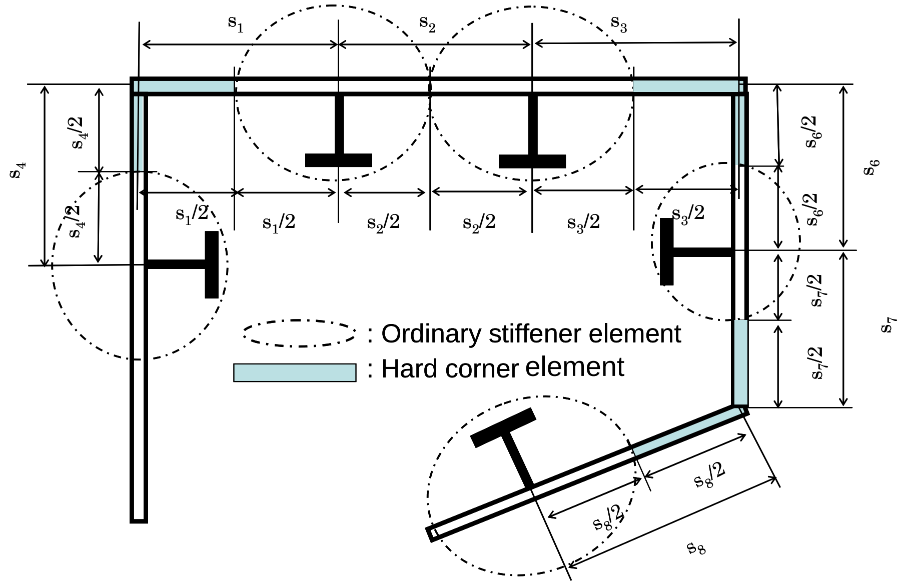
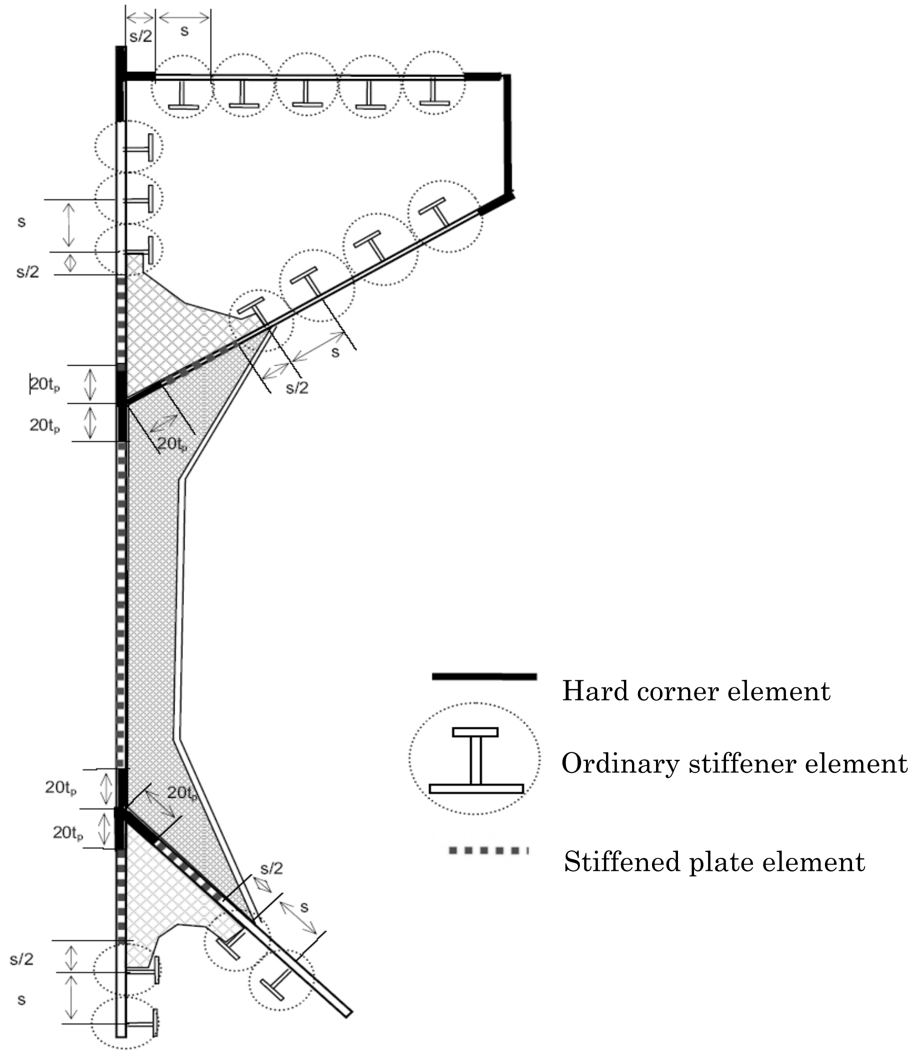


Fig. 8 Examples of the configuration of stiffened plate elements, ordinary stiffener elements and hard corner elements on a hull section



Note:

(1) In case of the knuckle point as shown in **Fig. 9**, the plating area adjacent to knuckles in the plating with an angle greater than 30 degrees is defined as a hard corner. The extent of one side of the corner is taken equal to 20 t_p on transversely framed panels and to 0.5*s* on longitudinally framed panels from the knuckle point.

(2) Where the plate members are stiffened by non-continuous longitudinal stiffeners, the non-continuous stiffeners are considered only as dividing a plate into various elementary plate panels.

(3) Where the opening is provided in the stiffened plate element, the openings are to be considered in accordance with **Ch 5 Sec 1, 1.2.7, 1.2.8** and **1.2.9**.

(4) Where attached plating is made of steels having different thicknesses and/or yield stresses, an average thickness and/or average yield stress obtained by the following formula are to be used for the calculation.

$$t = \frac{t_1 s_1 + t_2 s_2}{s} \quad , \quad R_{eHp} = \frac{R_{eHp1} t_1 s_1 + R_{eHp2} t_2 s_2}{ts}$$

Where,

R_{eH1}, R_{eH2}, t_1, t_2, s_1, s_2 and s are shown in **Fig. 10**.

Fig. 9 The case of plating with knuckle point

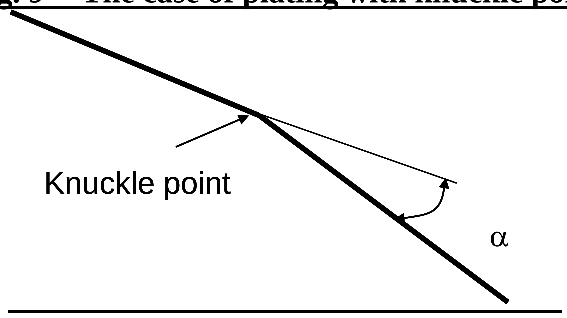
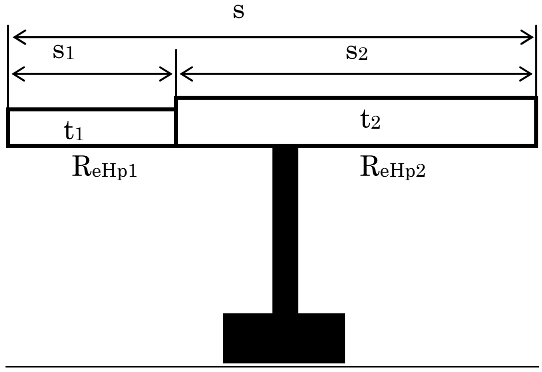


Fig. 10 Element with different thickness and yield strength



2.2 Load-end shortening curves σ–ε

Paragraph 2.2.1 has been amended as follows.

2.2.1 ~~Plating panels~~ Stiffened plate element and ordinary stiffener~~s~~ element

~~Plating panels~~ Stiffened plate element and ordinary stiffener~~s~~ element composing the hull girder transverse sections may collapse following one of the modes of failure specified in **Table 1**.

- Where the plate members are stiffened by non-continuous longitudinal stiffeners, the stress of the element is to be obtained in accordance with **2.2.3** to **2.2.7**, taking into account the non-continuous longitudinal stiffener.

  In calculating the total forces for checking the hull girder ultimate strength, the area of non-continuous longitudinal stiffener is to be assumed as zero.
- Where the opening is provided in the stiffened plate element, the considered area of the stiffened plate element is to be obtained by deducting the opening area from the plating in calculating the total forces for checking the hull girder ultimate strength. The consideration of the opening is in accordance with the requirement in **Ch 5 Sec 1, 1.2.7** to **1.2.9**.
- For stiffened plate element, the effective breadth of plate for the load shortening portion of the stress-strain curve is to be taken as full plate breadth, i.e. to the intersection of other plate or

longitudinal stiffener – not from the end of the hard corner element nor from the attached plating of ordinary stiffener element, if any. In calculating the total forces for checking the hull girder ultimate strength, the area of the stiffened plate element is to be taken between the hard corner element and the ordinary stiffener element or between the hard corner elements, as applicable.

Paragraph 2.2.2 has been amended as follows.

2.2.2 Hard corner~~s~~ element

~~Hard corners are sturdier elements composing the hull girder transverse section, which collapse mainly according to an elasto-plastic mode of failure (material yielding). These elements are generally constituted of two plates not lying in the same plane. Bilge, sheer strake-deck stringer elements, girder-deck connections and face plate-web connections on large girders are typical hard corners.~~

The relevant load-end shortening curve σ-ε is to be obtained for lengthened and shortened hard corners according to **2.2.3**.

Table 1 has been amended as follows.

Table 1 Modes of failure of ~~plating panel~~ stiffened plate element and ordinary stiffeners element

Element	Mode of failure	Curve σ–ε defined in
Lengthened ~~transversely framed plating panel~~ stiffened plate element or ordinary stiffener~~s~~ element	Elasto-plastic collapse	**2.2.3**
Shortened ordinary stiffener~~s~~ element	Beam column buckling Torsional buckling Web local buckling of flanged profiles Web local buckling of flat bars	**2.2.4** **2.2.5** **2.2.6** **2.2.7**
Shortened ~~transversely framed plating panel~~ stiffened plate element	Plate buckling	**2.2.8**

Paragraph 2.2.3 has been amended as follows.

2.2.3 Elasto-plastic collapse of structural elements

The equation describing the load-end shortening curve σ-ε for the elasto-plastic collapse of structural elements composing the hull girder transverse section is to be obtained from the following formula, valid for both positive (shortening) and negative (lengthening) strains (see **Fig. 2**):

$\cancel{\sigma = \Phi R_{eH}}$

$\sigma = \Phi R_{eHA}$

where:

R_{eHA}: Equivalent minimum yield stress, in N/mm^2, of the considered element, obtained by the following formula

$$R_{eHA} = \frac{R_{eHp} A_p + R_{eHs} A_s}{A_p + A_s}$$

Φ: Edge function, equal to:

Φ = -1 for ε < -1

$\Phi = \varepsilon$ for $-1 \leq \varepsilon \leq 1$

Φ = 1 for ε > 1

ε : Relative strain, equal to:

$$\varepsilon = \frac{\varepsilon_E}{\varepsilon_Y}$$

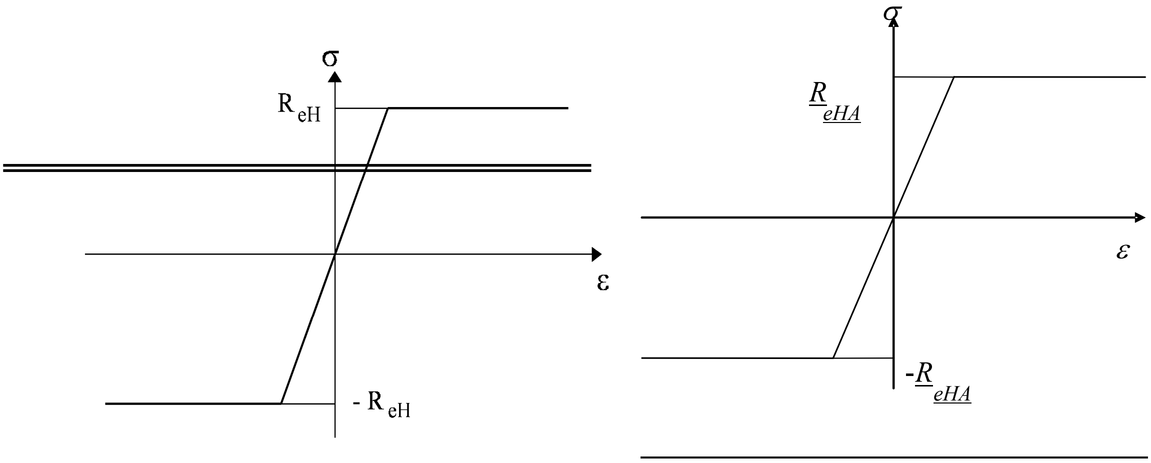
ε_E : Element strain

ε_Y : Strain at yield stress in the element, equal to:

$$\cancel{\varepsilon_Y = \frac{R_{eH}}{E}} \qquad \underline{\varepsilon_Y = \frac{R_{eHA}}{E}}$$

Fig.2 has been amended as follows.

Fig. 2 Load-end curve σ–ε for elasto plastic collapse



Paragraph 2.2.4 has been amended as follows.

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**):

$$\cancel{\sigma_{CR1} = \Phi\sigma_{C1}\frac{A_{Stif} + 10 b_E t_p}{A_{Stif} + 10 s t_p}} \qquad \underline{\sigma_{CR1} = \Phi\sigma_{C1}\frac{A_S + A_{pE}}{A_S + A_p}}$$

where:

Φ: Edge function defined in **2.2.3**

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

σ_{C1} : Critical stress, in N/mm^2, equal to:

$$\sigma_{C1} = \frac{\sigma_{E1}}{\varepsilon} \qquad \text{for} \quad \cancel{\sigma_{E1} \leq \frac{R_{eH}}{2}\varepsilon} \quad \underline{\sigma_{E1} \leq \frac{R_{eHB}}{2}\varepsilon}$$

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

R_{eHB} : Equivalent minimum yield stress, in N/mm^2, of the considered element, obtained by the following formula

$$R_{eHB} = \frac{R_{eHp} A_{pE1} l_{pE} + R_{eHs} A_s l_{sE}}{A_{pE1} l_{pE} + A_s l_{sE}}$$

A_{pE1} : Effective area, in cm^2, equal to

$$A_{pE1} = 10 b_{E1} t_p$$

l_{pE} : Distance, in mm, measured from the neutral axis of the stiffener with attached plate of width b_{E1} to the bottom of the attached plate

l_{sE} : Distance, in mm, measured from the neutral axis of the stiffener with attached plate of width b_{E1} to the top of the stiffener

ε : Relative strain defined in **2.2.3**

σ_{E1} : Euler column buckling stress, in N/mm^2, 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 cm^4, with attached shell plating of width b_{E1}

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

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

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

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

~~A_E~~ A_{pE} : Net sectional area, in cm^2, of ~~ordinary stiffeners with~~ attached shell plating of width b_E, equal to:

$$A_{pE} = 10 b_E t_p$$

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

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

$$b_E = s \quad \text{for } \beta_E \le 1.25$$

Paragraph 2.2.5 has been amended as follows.

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**).

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

where:

Φ: Edge function defined in **2.2.3**

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

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

$$\sigma_{C2} = \frac{\sigma_{E2}}{\varepsilon} \qquad \text{for} \quad \cancel{\sigma_{E2} \le \frac{R_{eH}}{2}\varepsilon} \qquad \underline{\sigma_{E2} \le \frac{R_{eHs}}{2}\varepsilon}$$

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

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:

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

$$\cancel{\sigma_{CP} = R_{eH}} \qquad \underline{\sigma_{CP} = R_{eHp}} \qquad \text{for} \quad \beta_E \le 1.25$$

β_E : Coefficient defined in **2.2.4**

Paragraph 2.2.6 has been amended as follows.

2.2.6 Web local buckling of ordinary stiffeners made of flanged profiles

The equation describing the load-end shortening curve σ_{CR3}–ε for the web local buckling of flanged ordinary stiffeners composing the hull girder transverse section is to be obtained from the following formula:

$$\cancel{\sigma_{CR3} = \Phi R_{eH} \frac{10^3 b_E t_p + h_{we} t_w + b_f t_f}{10^3 s t_p + h_w t_w + b_f t_f}} \qquad \underline{\sigma_{CR3} = \Phi \frac{10^3 b_E t_p R_{eHp} + (h_{we} t_w + b_f t_f) R_{eHs}}{10^3 s t_p + h_w t_w + b_f t_f}}$$

where

Φ: Edge function defined in **2.2.3**

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

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

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

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

$$\cancel{\beta_w = \frac{h_w}{t_w}\sqrt{\frac{\varepsilon\, R_{eH}}{E}}} \qquad \underline{\beta_w = \frac{h_w}{t_w}\sqrt{\frac{\varepsilon\, R_{eHs}}{E}}}$$

ε : Relative strain defined in **2.2.3**

Paragraph 2.2.7 has been amended as follows.

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**):

$$\cancel{\sigma_{CR4} = \Phi \frac{10 s t_P \sigma_{CP} + A_{Stif}\sigma_{C4}}{A_{Stif} + 10 s t_P}} \qquad \underline{\sigma_{CR4} = \Phi \frac{A_p \sigma_{CP} + A_s \sigma_{C4}}{A_p + A_s}}$$

where:

Φ: Edge function defined in **2.2.3**

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

σ_{CP}: Buckling stress of the attached plating, in N/mm^2, defined in **2.2.5**

σ_{C4}: Critical stress, in N/mm^2, equal to:

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

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

σ_{E4}: Local Euler buckling stress, in N/mm^2, equal to:

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

ε : Relative strain defined in **2.2.3**.

Paragraph 2.2.8 has been amended as follows.

2.2.8 Plate buckling

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

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

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

where:

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

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

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

ℓ : longer side of the plate, in m.

Chapter 6 HULL SCANTLINGS

Section 1 PLATING

2. General requirements

Paragraph 2.7 has been amended as follows.

2.7 Inner bottom loaded by steel coils on a wooden support

2.7.1 General

The net thickness of inner bottom, bilge hopper sloping plate and inner hull for ships intended to carry steel coils is to comply with **2.7.2** to **2.7.4**.

The provision is determined by assuming **Fig 2** as the standard means of securing steel coils. ~~In case where steel coils are lined up two or more tier, formulae in **2.7.2** and **2.7.3** can be applied to the case that only lowest tier of steel coils is in contact with hopper sloping plate or inner hull plate. In other cases, scantlings of plate thickness are calculated by direct strength analysis or other procedures deemed as appropriate by the Society.~~

2.7.1 bis1 Accelerations

In order to calculate the accelerations, the following coordinates are to be used for the center of gravity.

x_{G-sc} = 0.75 ℓ_H forward of aft bulkhead, where the hold of which the mid position is located forward from 0,45L from A.E.

x_{G-sc} = 0.75 ℓ_H afterward of fore bulkhead, where the hold of which the mid position is located afterward from 0,45L from A.E.

$$y_{G-sc} = \varepsilon \frac{B_h}{4}$$

$$z_{G-sc} = h_{DB} + \left\{1 + (n_1 - 1)\frac{\sqrt{3}}{2}\right\}\frac{d_{sc}}{2}$$

where:

ε : 1.0 when a port side structural member is considered , or -1.0 when a starboard side structural member is considered.

B_h: breadth in *m*, at the mid of the hold, of the cargo hold at the level of connection of bilge hopper plate with side shell or inner hull

d_{sc} : diameter of steel coils, in *m*

h_{DB} : height of inner bottom, in *m*

ℓ_H: Cargo hold length, in *m*

Vertical acceleration a_Z , in *m/s*^{2},are to be calculated by the formulae defined in **Ch 4, Sec 2, 3.2** and tangential acceleration a_R due to roll, in *m/s*^{2} is to be calculated by the following formula:

$$a_R = \theta \frac{\pi}{180}\left(\frac{2\pi}{T_R}\right)^2 \sqrt{{y_{G\_SC}}^2 + R^2}$$

Where:

θ, T_R and R: as defined in **Ch 4 Sec 2, 3.2**.

2.7.2 Inner bottom plating

The net thickness of plating of longitudinally framed inner bottom is to be not less than the value obtained, in *mm*, from the following formula:

$$\cancel{t = K_1\sqrt{\frac{(g + a_Z)F}{\lambda_P R_Y}}} \quad t = K_1\sqrt{\frac{\{g(\cos(C_{ZP}\Phi)\cos(C_{ZR}\theta)) + a_z\}F}{\lambda_P R_Y}}$$

where:

K_1 : Coefficient taken equal to:

$$K_1 = \sqrt{\frac{1.7s\ell K_2 - 0.73s^2K_2^2 - (\ell - \ell')^2}{2\ell'(2s + 2\ell K_2)}}$$

a_Z : Vertical acceleration, in m/s^2, defined in ~~**Ch 4, Sec2, 3.2**~~ **2.7.1 bis1**,

Φ : Single pitch amplitude, in deg, defined in **Ch 4, Sec2, 2.2**,

θ : Single roll amplitude, in deg, defined in **Ch 4, Sec2, 2.1**,

C_{ZP}, C_{ZR} : Load combination factor defined in **Ch 4, Sec4, 2.2**

F : Force, in *kg*, taken equal to:

$$F = K_S \frac{Wn_1n_2}{n_3} \quad \text{for } n_2 \le 10 \text{ and } n_3 \le 5$$

$$F = K_S n_1 W \frac{l}{l_S} \quad \text{for } n_2 > 10 \text{ or } n_3 > 5$$

λ_P : Coefficient defined in **Table 6**

K_S : Coefficient taken equal to:

$K_S = 1.4$ when steel coils are lined up in one tier with a key coil

$K_S = 1.0$ in other cases

W : Mass of one steel coil, in *kg*

n_1 : Number of tiers of steel coils

n_2 : Number of load points per elementary plate panel ~~of inner bottom, taken equal to:~~ (See **Figs 3** and **4**). When $n_3 \le 5$, n_2 can be obtained from **Table 3** according to the values of n_3 and ℓ / ℓ_S

- ~~in case of steel coils loaded as shown in **Fig 3**, n_2 is obtained from **Table 3** according to the values of n_3 and ℓ / ℓ_S~~
- ~~in case of steel coils loaded as shown in **Fig 4**, $n_2 = n_3$~~

n_3 : Number of dunnages supporting one steel coil

ℓ_S : Length of a steel coil, in *m*

K_2 : Coefficient taken equal to:

$$K_2 = -\frac{s}{\ell} + \sqrt{\left(\frac{s}{\ell}\right)^2 + 1.37\left(\frac{\ell}{s}\right)^2\left(1 - \frac{\ell'}{\ell}\right)^2 + 2.33}$$

ℓ' : Distance, in *m*, between outermost load points per elementary plate panel ~~of inner bottom plate~~ in ship length~~, taken equal to:~~ (See **Figs 3** and **4**). When $n_2 \le 10$ and

$n_3 \le 5$, l' can be obtained from **Table 4** according to the values of ℓ, ℓ_S, n_2 and n_3. When $n_2 > 10$ or $n_3 > 5$, ℓ' is to be taken equal to ℓ.

- ~~in case of steel coils loaded as shown in **Fig 3**, ℓ' is obtained from **Table 4** according to the values of ℓ, ℓS, n2 and n3~~
- ~~in case of steel coils loaded as shown in **Fig 4**, ℓ' is the actual value.~~

2.7.3 ~~H~~ Bilge hopper sloping plate and inner hull plat~~inge~~e

The net thickness of plating of longitudinally framed bilge hopper sloping plate and inner hull is to be not less than the value obtained, in *mm*, from the following formula:

$$\cancel{t = K_1 \sqrt{\frac{[g\cos(\theta_1 - \theta_2) + a_Y \sin\theta_1]F'}{\lambda_P R_Y}}}$$

$$t = K_1 \sqrt{\frac{a_{hopper} F'}{\lambda_p R y}}$$

where:

K_1 : Coefficient defined in **2.7.2**

$\cancel{\theta_1}$ θ_h : Angle, in *deg*, between inner bottom plate and bilge hopper sloping plate or inner hull plat~~inge~~e

~~θ_2 : Single roll amplitude, in *deg*, defined in **Ch 4, Sec 2, 2.1**~~

~~a_Y : Transverse acceleration, in *m/s²*, defined in **Ch 4, Sec2, 3.2**~~

$$a_{hopper} = -C_{YR} a_R \sin\left(\tan^{-1}\left|\frac{y_{G\_SC}}{R}\right| - \theta_h\right) + g\cos(\theta_h - C_{YG}\theta)\cos(C_{XG}\Phi) + C_{YS} a_{sway} \sin\theta_h$$

a_R : tangential acceleration defined in **2.7.1 bis1**.

a_{sway} : Transverse acceleration due to sway, in m/s^2, defined in **Ch 4, Sec 2, 2.4**

C_{XG}, C_{YS}, C_{YR}, C_{YG}: Load combination factors defined in **Ch 4, Sec 4, 2.2**

y_{G_sc} : Centre of gravity in transverse direction, in *m*, defined in **2.7.1 bis1**

R : Coefficient defined in **Ch 4, Sec 2, 3.2.1**

F' : Force, in *kg*, taken equal to:

$$F' = \frac{W n_2 C_k}{n_3} \quad \text{for } n_2 \le 10 \text{ and } n_3 \le 5$$

$$F' = C_k W \frac{l}{l_S} \quad \text{for } n_2 > 10 \text{ or } n_3 > 5,$$

λ_P : Coefficient defined in **Table 6**

W, n_2, n_3, Φ and θ : As defined in **2.7.2**

C_k : Coefficient taken equal to:

C_k = ~~4.0~~ 3.2 when steel coils are lined up two or more tier, or when steel coils are lined up one tier and key coil is located second or third from bilge hopper sloping plate or inner hull plate

C_k = ~~2.5~~ 2.0 for other cases

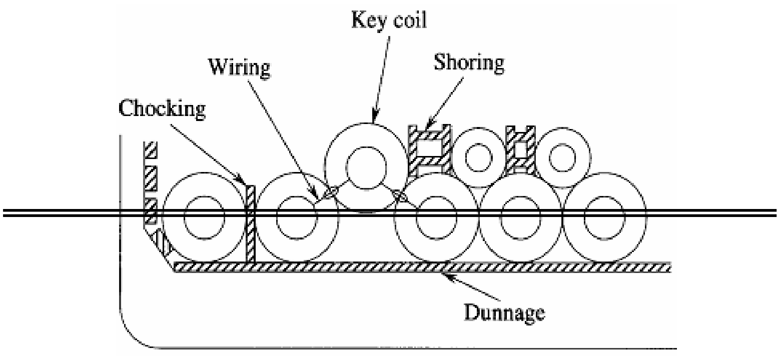
2.7.4

~~Where the number of load points per elementary plate panel n2 is greater than 10 and/or the~~

~~number of dunnages n_3 is greater than 5, the inner bottom may be considered as loaded by a uniform distributed load. In such a case, the thickness of the inner bottom plating is to be obtained according to **3.2.1**~~. (void)

Fig.2 to Fig.4 have been amended as follows.

Fig. 2 Inner bottom loaded by steel coils



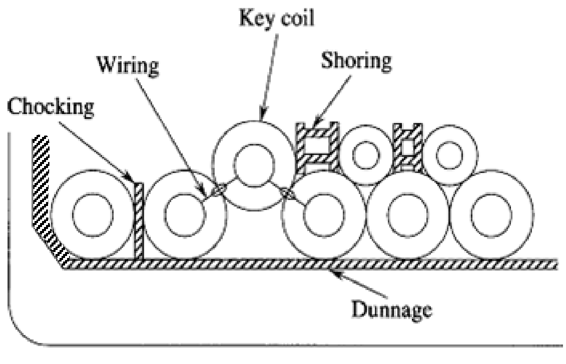


Fig. 3 Loading condition of steel coils (Example of $n_2 = 4$, $n_3 = 3$)

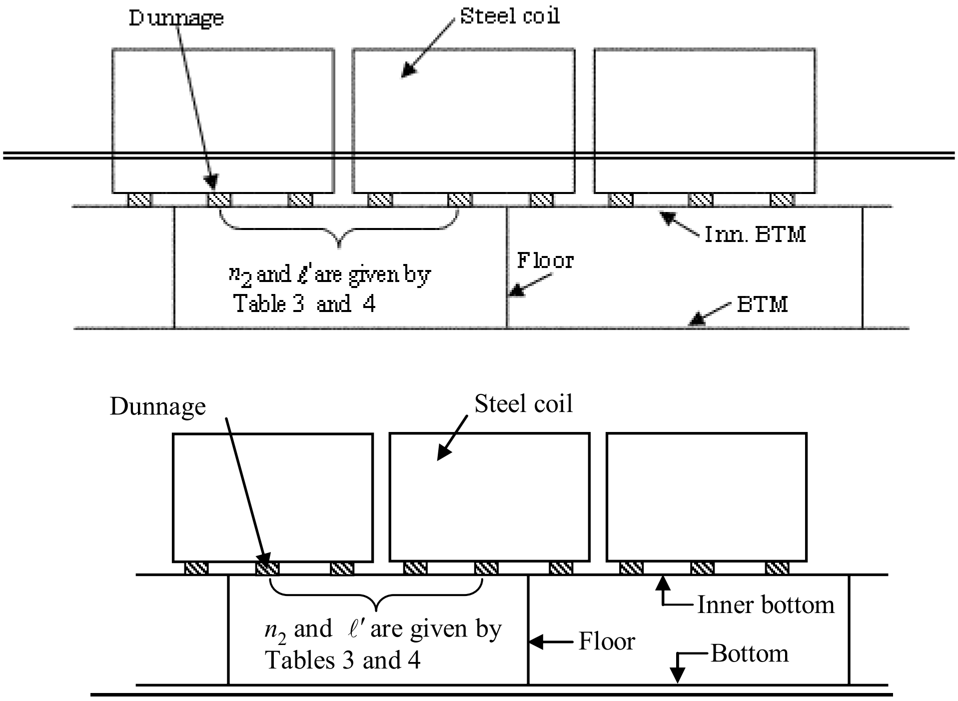
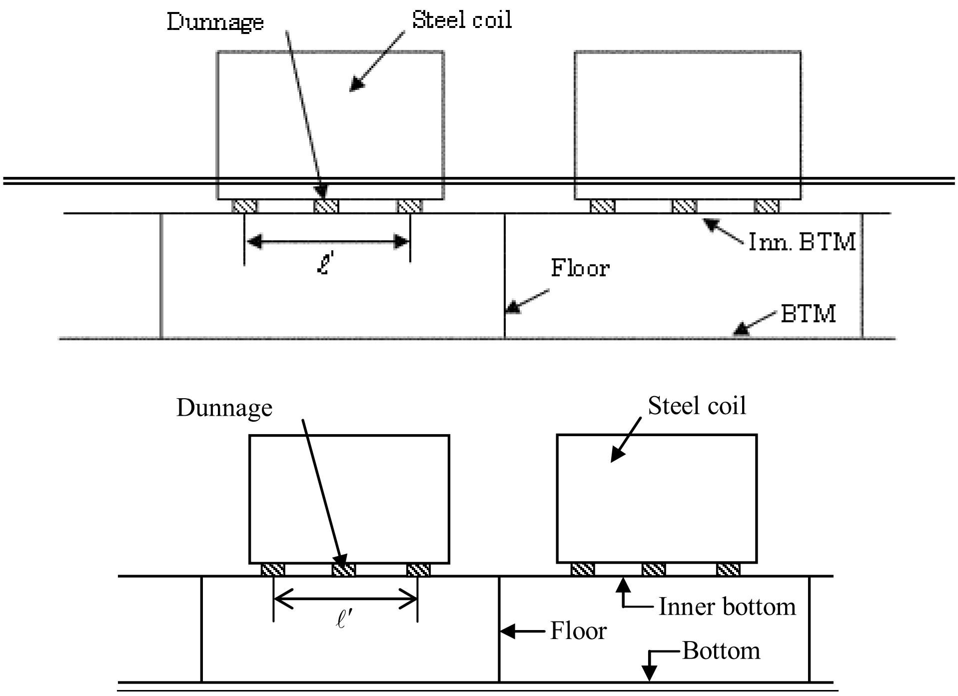


Fig. 4 Loading condition of steel coils (Example of $n_2 = 3$, $n_3 = 3$)



3. Strength check of plating subjected to lateral pressure

3.2 Plating thickness

Paragraph 3.2.3 has been amended as follows.

3.2.3 Net thickness of the corrugations of transverse vertically corrugated watertight bulkheads separating cargo holds for flooded conditions

The net plate thickness *t*, in *mm*, of transverse vertically corrugated watertight bulkheads separating cargo holds is to be not less than that obtained from the following formula:

$$t = 14.9s\sqrt{\frac{1.05p}{R_{eH}}}$$

p : Resultant pressure, in kN/m^2, as defined in **Ch 4, Sec 6, 3.3.7**

s : plate width, in *m*, to be taken equal to the width of the corrugation flange or web, whichever is greater.

For built-up corrugation bulkheads, when the thicknesses of the flange and web are different:

- the net thickness of the narrower plating is to be not less than that obtained, in *mm*, from the following formula:

$$t_N = 14.9s\sqrt{\frac{1.05p}{R_{eH}}}$$

s : plate width, in *m*, of the narrower plating

- the net thickness of the wider plating is not to be less than the greater of those obtained, in *mm*, from the following formulae:

$$t_W = 14.9s\sqrt{\frac{1.05p}{R_{eH}}}$$

$$t_W = \sqrt{\frac{462s^2 p}{R_{eH}} - t_{NP}^2}$$

where:

t_{NP} : Actual net thickness of the narrower plating, in *mm*, to be not taken greater than:

$$t_{NP} = 14.9s\sqrt{\frac{1.05p}{R_{eH}}}$$

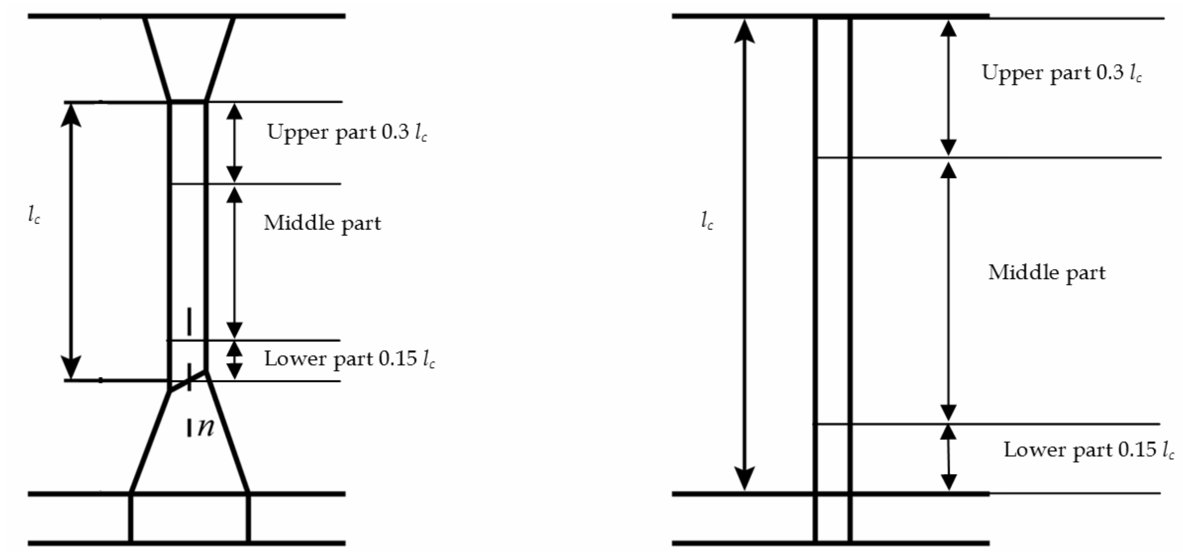
s : plate width, in *m*, to be taken equal to the width of the corrugation flange or web, whichever is greater.

The net thickness of the lower part of corrugations is to be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than $0.15\ell_C$, where ℓ_C is the span of the corrugations, in *m*, to be obtained according to **Ch 3, Sec 6, 10.4.4**. The net thickness is also to comply with the requirements in **3.2.1**, **Sec 2**, **3.6.1** and **3.6.2**, and **Sec 3, 6**.

The net thickness of the middle part of corrugations is to be maintained for a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than $0.3\ell_C$. The net thickness is also to comply with the requirements in **3.2.1** and **Sec 2, 3.6.1** and **3.6.2**.

Fig.5 has been added as follows.

Fig. 5 Parts of Corrugation



Paragraph 3.2.3 bis1 has been added as follows.

3.2.3 bis1 Net thickness of lower stool and upper stool

The net thickness and material of the stool top plate of lower stool are to be not less than those for the corrugated bulkhead plating above required by **3.2.3**.

The net thickness and material of the upper portion of vertical or sloping stool side plating of lower stool within the depth equal to the corrugation flange width from the stool top are to be not less than the flange plate at the lower end of the corrugation required by **3.2.3**, as applicable, whichever is the greater.

The net thickness and material of the stool bottom plate of upper stool are to be the same as those of the bulkhead plating below required by **3.2.3**, as applicable, whichever is the greater.

The net thickness of the lower portion of stool side plating is to be not less than 80% of the upper part of the bulkhead plating required by **3.2.3**, as applicable, whichever is the greater, where the same material is used.

The net thicknesses of lower stool and upper stool are to be not less than those required by **3.2.1**, **3.2.3** and **3.2.4**.

Paragraph 3.2.3 bis2 has been added as follows.

3.2.3 bis2 Net thickness of supporting floors of corrugated bulkhead

The net thickness and material of the supporting floors and pipe tunnel beams of corrugated bulkhead, when no stool is fitted, are to be not less than those of the corrugation flanges required by **3.2.3**.

When a lower stool is fitted, the net thickness of supporting floors are to be not less than that of the stool side plating required by the first sentence of **3.2.2**.

Section 2 ORDINARY STIFFENERS

2. General requirements

Paragraph 2.1 has been deleted.

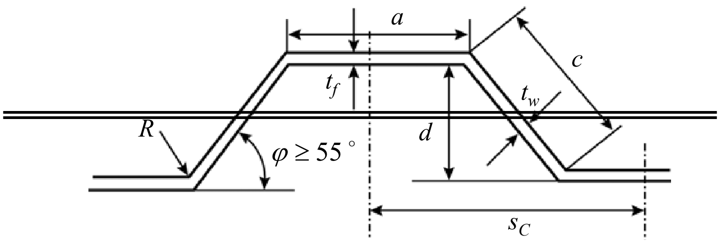
2.1 ~~Corrugated bulkhead~~ (void)

~~2.1.1~~

~~Unless otherwise specified, the net section modulus and the net shear sectional area of a corrugation are to be not less than those obtained for an ordinary stiffener with s equal s_C, as defined in **Fig. 2**.~~ (void)

Fig.2 has been deleted.

Fig. 2 ~~Corrugated bulkhead~~ (void)



Paragraph 2.2 has been amended as follows.

2.2 ~~Minimum n~~Net thicknesses of webs of ordinary stiffeners

2.2.1 Minimum net thicknesses of webs of ~~O~~ordinary stiffeners other than side frames of single side bulk carriers

The net thickness of the web of ordinary stiffeners, in *mm*, is to be not less than the greater of:

- $t = 3.0 + 0.015L_2$
- 40% of the net ~~offered~~ required thickness of the attached plating, to be determined according to **Ch.6, Sec.1**.

~~and is to be less than 2 *times* the net offered thickness of the attached plating~~

2.2.2 Minimum net thicknesses of ~~S~~side frames of single side bulk carriers

The net thickness of side frame webs within the cargo area, in *mm*, is to be not less than the value obtained from the following formula:

$t_{MIN} = 0.75\alpha(7 + 0.03L)$

where:

α : Coefficient taken equal to:

$\alpha = 1.15$ for the frame webs in way of the foremost hold

$\alpha = 1.00$ for the frame webs in way of other holds.

2.2.3 Maximum net thickness of web of ordinary stiffener

The net thickness of the web of ordinary stiffeners, in *mm*, is to be less than 2 times the net offered thickness of the attached plating.

Paragraph 2.5 has been amended as follows.

2.5 Ordinary stiffeners of inner bottom loaded by steel coils on a wooden support

2.5.1 General

The requirements of this sub-article apply to the ordinary stiffeners located on inner bottom plate, bilge hopper sloping plate and inner hull plate when loaded by steel coils on a wooden support (dunnage), as indicated in **Fig 2** of **Ch 6**, **Sec 1**.

~~In case where steel coils are lined up two or more tier, formulae in **2.5.2** and **2.5.3** can be applied to the case that only lowest tier of steel coils is in contact with hopper sloping plate or inner hull plate. In other cases, scantlings of net section modulus and net shear section area are calculated by direct strength analysis or other procedures.~~

2.5.2 Ordinary stiffeners located on inner bottom plating

The net section modulus w, in cm^3, and the net shear sectional area A_{sh}, in cm^2, of single span ordinary stiffeners located on inner bottom plating are to be not less than the values obtained from the following formulae:

$$\cancel{w = K_3 \frac{(g + a_Z)F}{8\lambda_S R_Y}}$$

$$\cancel{A_{sh} = \frac{5(g + a_Z)F}{\tau_a \sin\phi} 10^{-3}}$$

$$w = K_3 \frac{\{g(\cos(C_{ZP}\Phi)\cos(C_{ZR}\theta)) + a_Z\}F}{8\lambda_S R_Y}$$

$$A_{sh} = \frac{5\{g(\cos(C_{ZP}\Phi)\cos(C_{ZR}\theta)) + a_Z\}F}{\tau_a \sin\phi} 10^{-3}$$

where:

K_3 : Coefficient defined in **Table 1**. When n_2 is greater than 10, K_3 is to be taken equal to 2 ℓ /3

a_Z : Vertical acceleration, in m/s^2, defined in ~~**Ch 4, Sec2, 3.2**~~ **Ch 6, Sec1, 2.7.1 bis1**

Φ : Single pitch amplitude, in *deg*, defined in **Ch 4, Sec 2, 2.2**

θ : Single roll amplitude, in *deg*, defined in **Ch 4, Sec 2, 2.1**

C_{ZP}, C_{ZR} : Load combination factor defined in **Ch 4, Sec 4, 2.2**

F : Force, in *kg*, defined in **Ch 6**, **Sec 1**, **2.7.2**

λ_S : Coefficient defined in **Table 3**

ϕ : Angle, in *deg*, defined in **3.2.3**.

2.5.3 Ordinary stiffeners located on bilge hopper sloping plate or inner hull plat~~ing~~e

The net section modulus w, in cm^3, and the net shear sectional area A_{sh}, in cm^2, of single span ordinary stiffeners located on bilge hopper sloping plate and inner hull plate are to be not less than the values obtained from the following formulae:

$$\cancel{w = K_3 \frac{[g\cos(\theta_1 - \theta_2) + a_Y \sin\theta_1]F'}{8\lambda_S R_Y}}$$

$$\cancel{A_{sh} = \frac{5a_Y F'}{\tau_a \sin\varphi \sin\phi} 10^{-3}}$$

$$w = K_3 \frac{a_{hopper} F'}{8 \lambda_S R_Y}$$

$$A_{sh} = \frac{5 a_{hopper} F'}{\tau_a \sin\phi} 10^{-3}$$

where:

K_3 : Coefficient defined in **Table 1**. When $n_2 > 10$, K_3 is taken equal to 2 ℓ /3

~~θ_1, θ_2 : Angles, in *deg*, defined in **Ch 6**, **Sec 1**, **2.7.3**~~

θ_h : Angle, in *deg*, between inner bottom plate and bilge hopper sloping plate or inner hull plate

~~a_T : Transverse acceleration, in *m/s*^{2}, defined in **Ch 4, Sec 2, 3.2**~~

a_{hopper} : Acceleration, in *m/s*^{2}, defined in **Ch 6, Sec 1, 2.7.3**

F' : Force, in *kg*, defined in **Ch 6**, **Sec 1**, **2.7.3**

λ_S : Coefficient defined in **Table 3**

ϕ : Angle, in *deg*, defined in **3.2.3**

~~φ : Angle, in *deg*, between inner bottom plating and hopper sloping plate or inner hull plating.~~

~~ℓ' : Distance, in *m*, between load points per elementary plate panel of inner bottom plate in ship length, sloping plate or inner hull plating, as defined in **Ch 6, Sec 1, 2.7.2**.~~

ℓ' : Distance, in *m*, between between outermost load points per elementary plate panel in ship length

2.5.4

~~Where the number of load points per elementary plate panel n_2 is greater than 10 and/or the number of dunnages n_3 is greater than 5, the inner bottom may be considered as loaded by a uniform distributed load. In such a case, the scantling of the inner bottom ordinary stiffeners is to be obtained according to **3.2.3**.~~ (void)

3. Yielding check

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

Paragraph 3.2.4 has been amended as follows.

3.2.4 Net section modulus of corrugated bulkhead of ballast hold for ships having a length (L) less than 150*m*

The net section modulus *w*, in *cm*^{3}, of corrugated bulkhead of ballast hold for ships having a length (L) less than 150*m* subjected to lateral pressure are to be not less than the values obtained from the following formula:

$$w = K \frac{(p_S + p_W) s_C \ell^2}{m \lambda_S R_Y} 10^3$$

where:

K : Coefficient given in **Table 4** and **5**, according to the type of end connection. When $d_H < 2.5d_0$, both section modulus per half pitch of corrugated bulkhead and section modulus of lower stool at inner bottom are to be calculated.

s_C : Half pitch length, in *m*, of the corrugation, defined in ~~**2.1.1**~~ **Ch 3, Sec 6, Fig. 28**

ℓ : Length, in *m*, between the supports, as indicated in **Fig. 6**

λ_S: Coefficient defined in **Table 3**.

The effective width of the corrugation flange in compression is to be considered according to **Ch3, Sec 6**, **10.4.10** when the net section modulus of corrugated bulkhead is calculated.

Table 4 has been amended as follows.

Table 4 Values of *K*, in case $d_H \geq 2.5 d_0$

~~Lower end~~	~~Upper end~~		
	~~Supported by girders~~	~~Welded directly to deck~~	~~Welded to stool efficiently supported by ship structure~~
~~Supported by girders or welded directly to decks or inner bottoms~~	~~0.83~~	~~1.25~~	~~1.25~~
~~Welded to stool efficiently supported by ship structure~~	~~1.25~~	~~1.00~~	~~0.83~~

Upper end support		
Supported by girders	Welded directly to deck	Welded to stool efficiently supported by ship structure
1.25	1.00	0.83

Table 5 has been amended as follows.

Table 5 Values of *K*, in case $d_H < 2.5 d_0$

~~Upper end support~~	~~Supported by girders~~	~~Connected to deck~~	~~Connected to stool~~
~~Section modulus of corrugated bulkhead~~	~~0.83~~	~~0.71~~	~~0.65~~
~~Section modulus of stool at bottom~~	~~0.83~~	~~1.25~~	~~1.13~~

Section modulus of	Upper end support		
	Supported by girders	Connected to Deck	Connected to stool
Corrugated bulkhead	0.83	0.71	0.65
Stool at bottom	0.83	1.25	1.13

Paragraph 3.2.6 has been deleted.

3.2.6 ~~Bending capacity and shear capacity of the corrugations of transverse vertically corrugated watertight bulkheads separating cargo holds for flooded conditions~~ (void)

~~The bending capacity and the shear capacity of the corrugations of watertight bulkheads between separating cargo holds are to comply with the following formulae:~~

$$\cancel{0.5W_{LE} + W_M \geq \frac{M}{0.95R_{eH}} 10^3}$$

$$\cancel{\tau \leq \frac{R_{eH}}{2}}$$

~~where:~~

~~M : Bending moment in a corrugation, to be obtained, in $kN\text{-}m$, from the following formula:~~

$$\cancel{M = F\ell_C / 8}$$

~~F : Resultant force, in kN, to be calculated according to **Ch 4**, **Sec 6**, **3.3.7**~~

~~ℓ_C: Span of the corrugations, in m, to be obtained according to **Ch 3**, **Sec 6**, **10.4.4**~~

~~W_{LE} : Net section modulus, in cm^3, of one half pitch corrugation, to be calculated at the lower end of the corrugations according to **Ch 3**, **Sec 6**, **10.4.13**, without being taken greater than the value obtained from the following formula:~~

$$\cancel{W_{LE,M} = W_G + \left(\frac{Q\, h_G - 0.5 h_G^2\, s_C\, p_G}{R_{eH}} \right) 10^3}$$

~~W_G: Net section modulus, in cm^3, of one half pitch corrugation, to be calculated in way of the upper end of shedder or gusset plates, as applicable, according to **Ch 3**, **Sec 6**, **10.4.14**~~

~~Q : Shear force in a corrugation, to be obtained, in kN, from the following formula:~~

$$\cancel{Q = 0.8F}$$

~~h_G : Height, in m, of shedders or gusset plates, as applicable (see **Ch 3**, **Sec 6**, **Fig 31** to **Fig 35**)~~

~~p_G : Resultant pressure, in kN/m^2, to be calculated in way of the middle of the shedders or gusset plates, as applicable, according to **Ch 4**, **Sec 6**, **3.3.7**~~

~~s_C: Spacing of the corrugations, in m, to be taken according to **Fig. 2**~~

~~W_M: Net section modulus, in cm^3, of one half pitch corrugation, to be calculated at the mid-span of corrugations according to **Ch 3**, **Sec 6**, **10.4.14**, without being taken greater than $1.15W_{LE}$~~

~~τ : Shear stress in the corrugation, in N/mm^2, to be obtained from the following formula:~~

$$\cancel{\tau = 10\frac{Q}{A_{sh}}}$$

~~A_{sh} : Shear area, in cm^2, calculated according to **Ch 3**, **Sec 6**, **10.4.15**.~~

3.3 Strength criteria for side frames of single side bulk carriers

Paragraph 3.3.1 has been amended as follows.

3.3.1 Net section modulus and net shear sectional area of side frames

The net section modulus w, in cm^3, and the net shear sectional area A_{sh}, in cm^2, of side frames subjected to lateral pressure are to be not less, in the mid-span area, than the values obtained from the following formulae:

$$w = 1.125\alpha_m \frac{(p_S + p_W)s\ell^2}{m\lambda_S R_Y} 10^3$$

$$A_{sh} = 1.1\alpha_S \frac{5(p_S + p_W)s\ell}{\tau_a \sin\phi}\left(\frac{\ell - 2\ell_B}{\ell}\right)$$

where:

α_m : Coefficient taken equal to:

$\alpha_m = 0.42$ for *BC-A* ships

$\alpha_m = 0.36$ for other ships

λ_S: Coefficient taken equal to 0.9

ℓ : Side frame span, in m, defined in **Ch 3**, **Sec 6**, **Fig. 19**, to be taken not less than $0.25D$

α_S : Coefficient taken equal to:

$\alpha_S = 1.1$ for side frames of holds specified to be empty in *BC-A* ships

$\alpha_S = 1.0$ for other side frames

ℓ_B: Lower bracket length, in *m*, defined in **Fig 7**

p_s , p_w : Still water and wave pressures, in kN/m^2, in intact conditions calculated as defined in **1.3** and **1.4.2**.

In addition ~~to the above provision~~, for side frames of holds intended to carry ballast water in heavy ballast condition, the net section modulus w, in cm^3, and the net shear sectional area A_{sh}, in cm^2, ~~of side frames subjected to lateral pressure in holds intended to carry ballast water~~ all along the span are to be in accordance with **3.2.3** , ℓ being the span of the side frame as defined in **Ch.3, Sec.6, 4.2**, with consideration to brackets at ends.

Paragraph 3.3.3 has been amended as follows.

3.3.3 Lower bracket of side frame

~~In addition, a~~ At the level of lower bracket as shown in **Ch 3**, **Sec 6**, **Fig. 19**, the net section modulus of the frame and bracket, or integral bracket, with associated shell plating, is to be not less than twice the net section modulus w required for the frame mid-span area obtained from **3.3.1**.

In addition, for holds intended to carry ballast water in heavy ballast condition, the net section modulus w, in cm^3, at the level of lower bracket is to be not less than twice the greater of the net sections moduli obtained from **3.2.3** and **3.3.1**.

The net thickness t_{LB} of the frame lower bracket, in *mm*, is to be not less than the net thickness of the side frame web plus 1.5 *mm*.

Moreover, the net thickness t_{LB} of the frame lower bracket is to comply with the following formula:

- for symmetrically flanged frames: $\frac{h_{LB}}{t_{LB}} \le 87\sqrt{k}$
- for asymmetrically flanged frames : $\frac{h_{LB}}{t_{LB}} \le 73\sqrt{k}$

The web depth h_{LB} of lower bracket may be measured from the intersection between the sloped bulkhead of the hopper tank and the side shell plate, perpendicularly to the face plate of the lower bracket (see **Ch 3, Sec 6, Fig. 22**).

For the 3 side frames located immediately abaft the collision bulkhead, whose scantlings are increased according to **3.3.2**, when t_{LB} is greater than $1.73t_w$, the thickness t_{LB} may be taken as the value t'_{LB} obtained from the following formula:

$$t'_{LB} = \left(t_{LB}^2 \cdot t_w\right)^{1/3}$$

where t_w is the net thickness of the side frame web, in *mm*, corresponding to A_{sh} determined in accordance to **3.3.1**.

The flange outstand is not to exceed $12k^{0.5}$ *times* the net flange thickness.

Paragraph 3.3.4 has been amended as follows.

3.3.4 Upper bracket of side frame

~~In addition, a~~ At the level of upper bracket as shown in **Ch 3**, **Sec 6**, **Fig 19**, the net section modulus of the frame and bracket, or integral bracket, with associated shell plating, is to be not less than twice the net section modulus w required for the frame mid-span area obtained from **3.3.1**.

In addition, for holds intended to carry ballast water in heavy ballast condition, the net section modulus w, in cm^3, at the level of upper bracket is not to be less than twice the greater of the net sections moduli obtained from **3.2.3** and **3.3.1**.

The net thickness t_{UB} of the frame upper bracket, in mm, is to be not less than the net thickness of the side frame web.

Paragraph 3.6 has been added as follows.

3.6 Scantlings of transverse vertically corrugated watertight bulkheads separating cargo holds for flooded conditions

3.6.1 Bending capacity and shear capacity of the corrugations of transverse vertically corrugated watertight bulkheads separating cargo holds

The bending capacity and the shear capacity of the corrugations of watertight bulkheads between separating cargo holds are to comply with the following formulae:

$$0.5W_{LE} + W_M \geq \frac{M}{0.95R_{eH}}10^3$$

$$\tau \leq \frac{R_{eH}}{2}$$

where:

M: Bending moment in a corrugation, to be obtained, in $kN.m$, from the following formula:

$$M = F\ell_C / 8$$

F : Resultant force, in kN, to be calculated according to **Ch 4**, **Sec 6**, **3.3.7**

ℓ_C: Span of the corrugations, in m, to be obtained according to **3.6.2**

W_{LE} : Net section modulus, in cm^3, of one half pitch corrugation, to be calculated at the lower end of the corrugations according to **3.6.2**, without being taken greater than the value obtained from the following formula:

$$W_{LE,M} = W_G + \left(\frac{Q\,h_G - 0.5h_G^2\,s_C\,p_G}{R_{eH}}\right)10^3$$

W_G: Net section modulus, in cm^3, of one half pitch corrugation, to be calculated in way of the upper end of shedder or gusset plates, as applicable, according to **3.6.2**

Q : Shear force at the lower end of a corrugation, to be obtained, in kN, from the following formula:

$$Q = 0.8F$$

h_G : Height, in m, of shedders or gusset plates, as applicable (see **Fig. 11** to **Fig. 15**)

p_G : Resultant pressure, in kN/m^2, to be calculated in way of the middle of the shedders or gusset plates, as applicable, according to **Ch 4**, **Sec 6**, **3.3.7**

s_C: Spacing of the corrugations, in m, to be taken according to **Ch 3, Sec 6, Fig.28**

W_M: Net section modulus, in cm^3, of one half pitch corrugation, to be calculated at the mid-span of corrugations according to **3.6.2**, without being taken greater than $1.15W_{LE}$

τ : Shear stress in the corrugation, in N/mm^2, to be obtained from the following formula:

$$\tau = 10\frac{Q}{A_{sh}}$$

A_{sh} : Shear area, in cm^2, calculated according to the followings.

The shear area is to be reduced in order to account for possible non-perpendicular between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin φ), φ being the angle between the web and the flange (see **Ch 3, Sec 6, Fig. 28**). The actual net section modulus of corrugations is to be calculated according to **3.6.2**. The net section modulus of the corrugations upper part of the bulkhead, as defined in **Sec 1, Fig. 5**, is to be not less than 75% of that of the middle part complying with this requirement and **Sec 1, 3.2.1**, corrected for different minimum yield stresses.

3.6.2 Net Section modulus at the lower end of corrugations

a) The net section modulus at the lower end of corrugations (**Fig. 11** to **Fig. 15**) is to be calculated with the compression flange having an effective flange width b_{ef} not larger than that indicated in **Ch 3, Sec 6, 10.4.10**

b) Webs not supported by local brackets

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

c) Effective shedder plates

Provided that effective shedder plates, as defined in **Ch 3, Sec 6, 10.4.11** are fitted (see **Fig. 11** and **Fig. 12**), when calculating the section modulus of corrugations at the lower end (cross sections 1 in **Fig. 11** and **Fig. 12**), the net area of flange plates may be increased by the value obtained, in cm^2, from the following formula:

$I_{SH} = 2.5a\sqrt{t_f t_{SH}}$ without being taken greater than $2.5at_f$.

where:

a : Width, in m, of the corrugation flange (see **Ch 3, Sec 6, Fig. 28**)

t_{SH} : Net shedder plate thickness, in mm

t_f : Net flange thickness, in mm.

d) Effective gusset plates

Provided that effective gusset plates, as defined in **Ch 3, Sec 6, 10.4.12**, are fitted (see **Fig. 13** to **Fig. 15**), when calculating the net section modulus of corrugations at the lower end (cross-sections 1 in **Fig. 13** to **Fig. 15**), the area of flange plates may be increased by the value obtained, in cm^2, from the following formula:

$I_G = 7h_G t_f$

where:

h_G : Height, in m, of gusset plates (see **Fig. 13** to **Fig. 15**), to be taken not greater than (10/7) S_{GU}.

S_{GU}: Width, in m, of gusset plates.

t_f : Net flange thickness, in mm.

e) Sloping stool top plate

If the corrugation webs are welded to a sloping stool top plate which has an angle not less than 45° with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. For angles less than 45°, the effectiveness of the web may be obtained by linear interpolation between 30% for 0° and 100% for 45°.

Where effective gusset plates are fitted, when calculating the net section modulus of corrugations the net area of flange plates may be increased as specified in **d)** above. No credit may be given to shedder plates only.

3.6.3 Stiffeners in lower stool and upper stool

The net section modulus of stiffeners in lower stool and upper stool is to be greater of the values obtained from the following formula or required by **3.2.5**.

$$w = \frac{ps\ell^2}{16\alpha\lambda_s R_Y} 10^3$$

where:

p : Pressure, in kN/m^2, as defined in **Ch 4 Sec 6, 3.3.7**.

α and λ_S :defined in **3.2.5**.

Fig.11 to Fig.15 have been added as follows.

Fig. 11 Symmetrical shedder plates

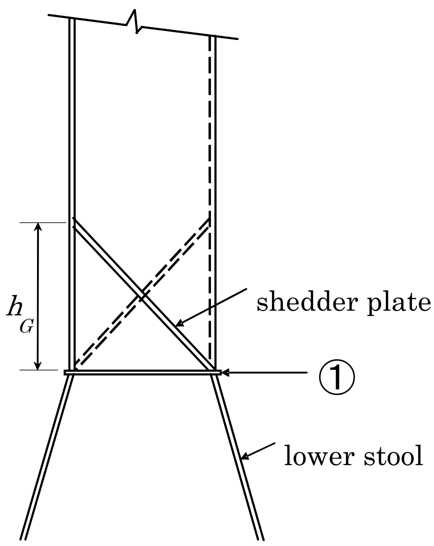


Fig. 12 Asymmetrical shedder plates

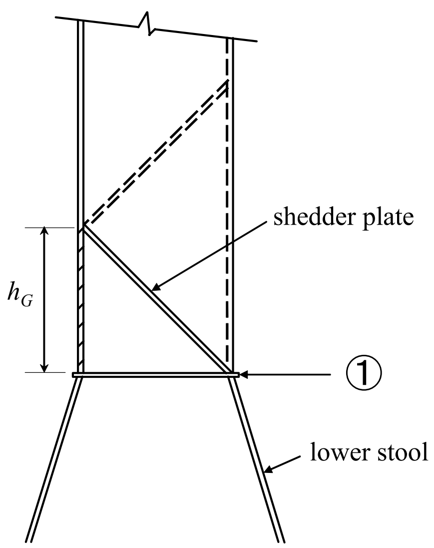


Fig. 13 Symmetrical gusset/shedder plates

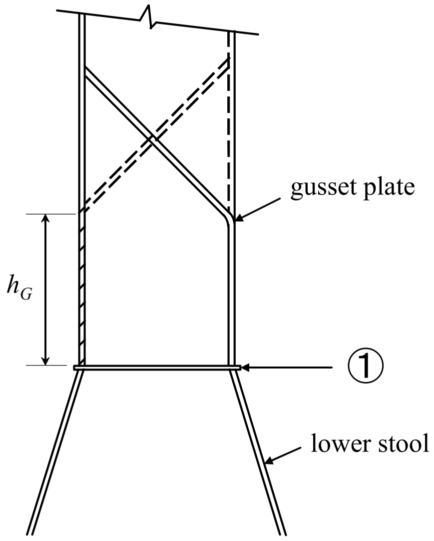


Fig. 14 Asymmetrical gusset/shedder plates

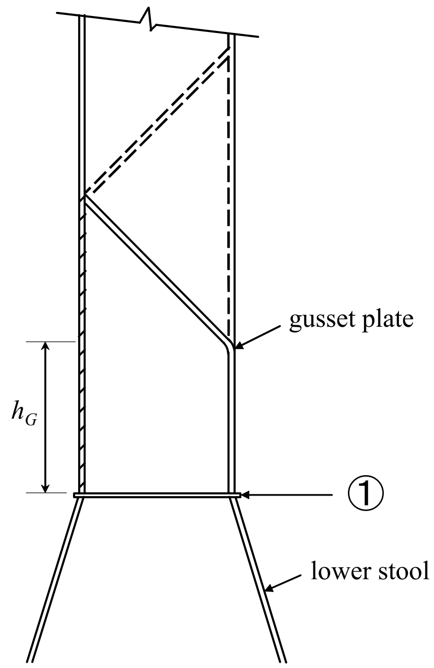
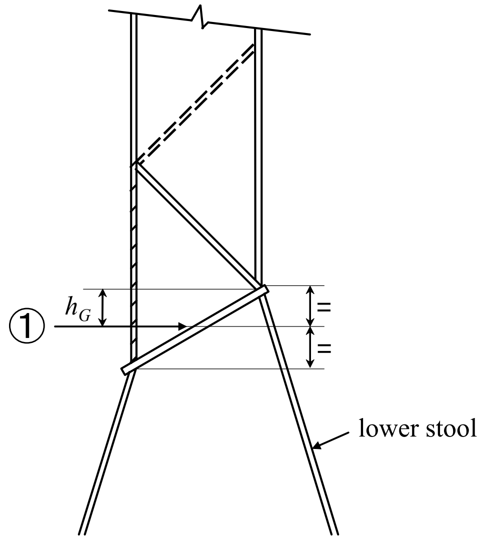


Fig. 15 Asymmetrical gusset/shedder plates



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

6.1 General

Paragraph 6.1.1 has been amended as follows.

6.1.1 Shear buckling check of the bulkhead corrugation webs

The shear stress τ, calculated according to **Ch 6**, **Sec 2**, ~~3.2.6~~**3.6.1**, is to comply with the following formula:

$$\tau \le \tau_C$$

where:

τ_C : Critical shear buckling stress to be obtained, in *N/mm*^{2}, from the following formulae:

$$\tau_c = \tau_E \quad \text{for} \quad \tau_E \le \frac{R_{eH}}{2\sqrt{3}}$$

$$\tau_c = \frac{R_{eH}}{\sqrt{3}}\left(1 - \frac{R_{eH}}{4\sqrt{3}\tau_E}\right) \quad \text{for} \quad \tau_E > \frac{R_{eH}}{2\sqrt{3}}$$

τ_E : Euler shear buckling stress to be obtained, in *N/mm*^{2}, from the following formula:

$$\tau_E = 0.9 k_t E \left(\frac{t_w}{10^3 c}\right)^2$$

k_t : Coefficient, to be taken equal to 6.34

t_W: Net thickness, in *mm*, of the corrugation webs

c : Width, in *m* of the corrugation webs (see ~~Ch 6, Sec 2, Fig 2~~**Ch 3, Sec 6, Fig. 28**).

Chapter 7 DIRECT STRENGTH ANALYSIS

Section 2 GLOBAL STRENGTH FE ANALYSIS OF CARGO HOLD STRUCTURES

2. Analysis model

2.2 Finite element modeling

Paragraph 2.2.4 has been amended as follows.

2.2.4

When orthotropic elements are not used in *FE* model:

- mesh size is to be equal to or less than the representative spacing of longitudinal stiffeners or transverse side frames
- stiffeners are to be modeled by using rod and/or beam/bar elements
- ~~where a double hull is fitted,~~ webs of primary supporting members are to be divided at least three elements height-wise However, for transverse primary supporting members inside hopper tank and top side tank, which are less in height than the space between ordinary longitudinal stiffeners, two elements on the height of primary supporting members are accepted.
- ~~where no double hull construction is fitted,~~ side shell frames and their end brackets are to be modeled by using shell elements for web and shell/beam/rod elements for face plate. Webs of side shell frames need not be divided along the direction of depth
- aspect ratio of elements is not to exceed 1:4.

An example of typical mesh is given in **App 1**.

2.3 Boundary conditions

Paragraph 2.3.1 has been amended as follows.

2.3.1

Both ends of the model are to be simply supported according to **Table 1** and **Table 2**. The nodes on the longitudinal members at both end sections are to be rigidly linked to independent points at the neutral axis on the centreline as shown in **Table 1**. The independent points of both ends are to be fixed as shown in **Table 2**.

Table 2 has been amended as follows.

Table 2 Support condition of the independent point

Location of the independent point	Translational			Rotational		
	Dx	Dy	Dz	Rx	Ry	Rz
Independent point on aft end of model	-	Fix	Fix	~~-~~ Fix	-	-
Independent point on fore end of model	Fix	Fix	Fix	Fix	-	-

3. Analysis criteria

3.2 Yielding strength assessment

Paragraph 3.2.1 has been amended as follows.

3.2.1 Reference stresses

Reference stress is Von Mises equivalent stress at the centre of a plane element (shell or membrane) or axial stress of a line element (bar, beam or rod) obtained by *FE* analysis through considering hull girder loads according to **2.5.4** or **2.5.5**.

Where the effects of openings are not considered in the *FE* model, the reference stresses in way of the openings are to be properly modified with adjusting shear stresses in proportion to the ratio of web height and opening height.

Where elements under assessment are smaller than the standard mesh size specified in **2.2.4** or **2.2.5**, the reference stress may be obtained from the averaged stress over the elements within the standard mesh size.

Paragraph 3.4 has been amended as follows.

3.4 Deflection of primary supporting members

~~The maximum relative deflection between the double bottom and the forward (or afterward) transverse bulkhead obtained from the *FE* analysis is not to exceed the following criteria:~~

The relative deflection, $\delta_{\max}$ in *mm*, in the outer bottom plate obtained by FEA is not to exceed the following criteria:

$$\delta_{\max} \le \frac{\ell_i}{150}$$

where:

$\delta_{\max}$: Maximum relative deflection, ~~between the double bottom and the forward (or afterward) transverse bulkhead, in *mm*~~ in *mm*, obtained by the following formula, and not including secondary deflection

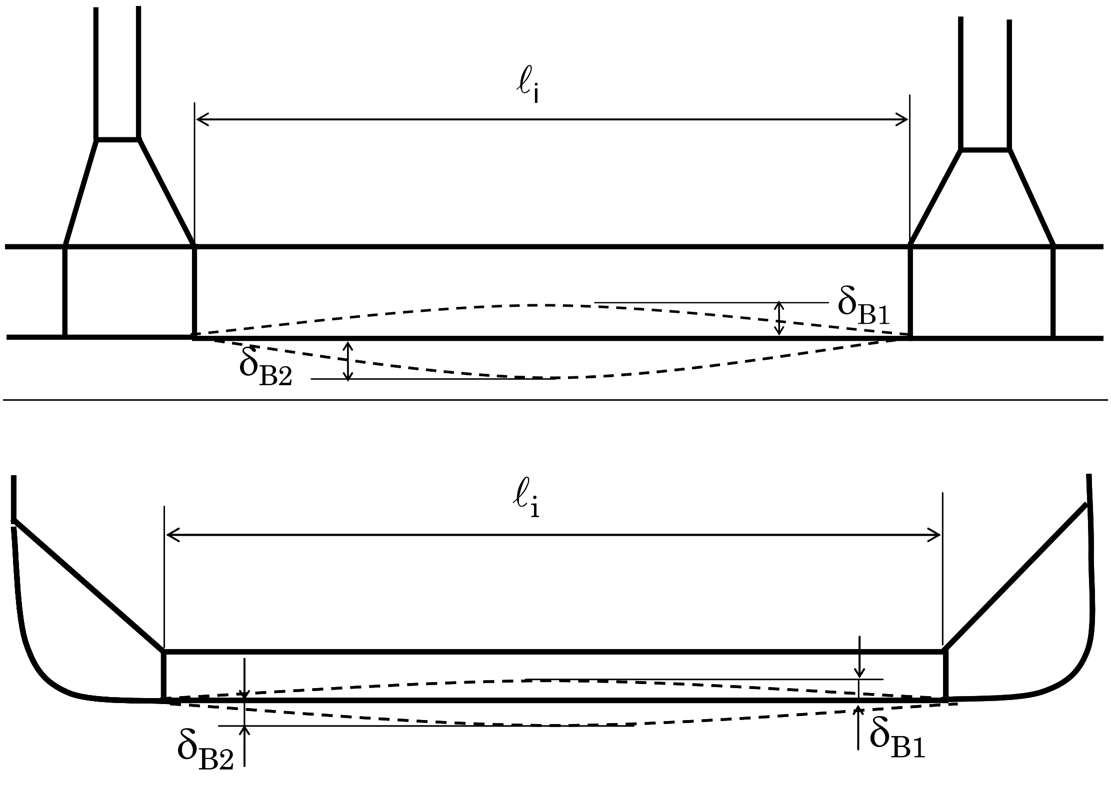
$$\delta_{\max} = \max\left(\left|\delta_{B1}\right|, \left|\delta_{B2}\right|\right)$$

where, δ_{B1} and δ_{B2} are shown in **Fig. 3**.

ℓ_i : Length or breadth of the flat part of the double bottom, in *mm*, whichever is the shorter.

Fig.3 has been added as follows.

Fig. 3 Definition of relative deflection



Section 3 DETAILED STRESS ASSESSMENT

1. General

1.1 Application

Paragraph 1.1.1 has been amended as follows.

1.1.1

This Section describes the procedure for the detailed stress assessment with refined meshes to evaluate highly stressed areas of primary supporting members.

Where the global cargo hold analysis of **Sec 2** is carried out using a model complying with the modelling criteria of **Sec 2, 2.2.4**, the areas listed in Tab 1 are to be refined at the locations whose calculated stresses exceed 95% for non-orthotropic elements or 85 % for orthotropic element but do not exceed 100% of the allowable stress as specified in **Sec 2, 3.2.3**.

Chapter 8 FATIGUE CHECK OF STRUCTURAL DETAILS

Section 1 GENERAL CONSIDERATION

1. General

1.3 Subject members

Table 1 has been amended as follows.

Table 1 Members and locations subjected to fatigue strength assessment

Members	Details
Inner bottom plating	Connection with sloping and /or vertical plate of lower stool
	Connection with sloping plate of hopper tank
Inner side plating	Connection with sloping plate of hopper tank
Transverse bulkhead	Connection with sloping plate of lower stool
	Connection with sloping plate of upper stool
Hold frames of single side bulk carriers	Connection to the upper and lower wing tank
Ordinary stiffeners in double side space	Connection of longitudinal stiffeners with web frames and transverse bulkhead
	Connection of transverse stiffeners with stringer or similar
Ordinary stiffeners in upper and lower wing tank	Connection of longitudinal stiffeners with web frames and transverse bulkhead
Ordinary stiffeners in double bottom	Connection of longitudinal stiffeners with floors <u>and floors</u> in way of <u>lower stool or</u> transverse bulkhead
Hatch corners	Free edges of hatch corners

3. Loading

3.1 Loading condition

Paragraph 3.1.1 has been amended as follows.

3.1.1

The loading conditions to be considered are defined in **Table 2** depending on the ship type. <u>The standard loading conditions illustrated in **Ch 4, App 3** are to be considered.</u>

Section 4 STRESS ASSESSMENT OF STIFFENERS

1. General

1.1 Application

Paragraph 1.1.2 has been added as follows.

1.1.2

The hot spot stress ranges and structural hot spot mean stresses of longitudinal stiffeners are to be evaluated at the face plate of the longitudinal considering the type of longitudinal end connection and the following locations.

(1) Transverse webs or floors other than those at transverse bulkhead of cargo hold or in way of stools, such that additional hot spot stress due to the relative displacement may not be considered. These longitudinal end connections are defined in **Table 1**. When transverse webs or floors are watertight, the coefficients K_{gl} and K_{gh} as defined in **Table 2** are to be considered instead of those defined in **Table 1**.

(2) Transverse webs or floors at transverse bulkhead of cargo hold in way of stools, such that additional hot spot stress due to the relative displacement should be considered. These longitudinal end connections are defined in **Table 2**. When transverse webs or floors at transverse bulkhead of cargo hold or in way of stools are not watertight, the coefficients K_{gl} and K_{gh} as defined in **Table 1** are to be considered instead of those defined in **Table 2**.

2. Hot spot stress range

2.3 Stress range according to the simplified procedure

Paragraph 2.3.1 has been amended as follows.

2.3.1 Hot spot stress ranges

The hot spot stress range, in N/mm^2, due to dynamic loads in load case "*i*" of loading condition "(*k*)" is to be obtained from the following formula:

$$\Delta\sigma_{W,i(k)} = \left|\left(\sigma_{GW,i1(k)} + \sigma_{W1,i1(k)} - \sigma_{W2,i1(k)} + \sigma_{d,i1(k)}\right) - \left(\sigma_{GW,i2(k)} + \sigma_{W1,i2(k)} - \sigma_{W2,i2(k)} + \sigma_{d,i2(k)}\right)\right|$$

where

$\sigma_{GW,i1(k)}$, $\sigma_{GW,i2(k)}$: Stress due to hull girder moment, defined in **2.3.2**

$\sigma_{W1,i1(k)}$, $\sigma_{W1,i2(k)}$: Stress $\sigma_{LW,ij(k)}$, $\sigma_{CW,ij(k)}$ and $\sigma_{LCW,ij(k)}$ due to hydrodynamic or inertial pressure when the pressure is applied on the same side as the ordinary stiffener depending on the considered case

$\sigma_{W2,i1(k)}$, $\sigma_{W2,i2(k)}$: Stress $\sigma_{LW,ij(k)}$, $\sigma_{CW,ij(k)}$ and $\sigma_{LCW,ij(k)}$ due to hydrodynamic or inertial pressure when the pressure is applied on the side opposite to the stiffener depending on the considered case

$\sigma_{LW,i1(k)}$, $\sigma_{LW,i2(k)}$: Stresses due to wave pressure, defined in **2.3.3**

$\sigma_{CW,i1(k)}$, $\sigma_{CW,i2(k)}$: Stresses due to liquid pressure, defined in **2.3.4**

$\sigma_{LCW,\, i1(k)}$, $\sigma_{LCW,\, i2(k)}$: Stresses due to dry bulk cargo pressure, defined in **2.3.5**

$\sigma_{d,\, i1(k)}$, $\sigma_{d,\, i2(k)}$: Stress due to relative displacement of transverse bulkhead or floor in way of stools, defined in **2.3.6**.

Paragraph 2.3.2 has been amended as follows.

2.3.2 Stress due to hull girder moments

The hull girder hot spot stress, in N/mm^2, in load case "i1" and "i2" for loading condition "(k)" is to be obtained from the following formula:

$$\sigma_{GW,\, i\, j(k)} = K_{gh} \cdot \left(C_{WV,\, i\, j}\, \sigma_{WV,\, i\, j} - C_{WH,\, i\, j}\, \sigma_{WH,\, (k)} \right) \qquad (j = 1, 2)$$

where:

K_{gh} : Geometrical stress concentration factor for nominal hull girder stress ~~depending on the detail of end connection as defined in **Table 1**~~ K_{gh} is given in **Table 1** and **Table 2** for the longitudinal end connection specified in **1.1.2 (1)** and **1.1.2 (2)**, respectively. The stress concentration factor can be evaluated directly by the FE analysis.

$C_{WV,\, i1}$, $C_{WV,\, i2}$, $C_{WH,\, i1}$, $C_{WH,\, i2}$: Load combination factors for each load case defined in **Ch 4**, **Sec 4**, **2.2**.

$\sigma_{WV,\, i1}$, $\sigma_{WV,\, i2}$, $\sigma_{WH,\, (k)}$: Nominal hull girder stresses, in N/mm^2, defined in **Sec 3**, **2.2.2**.

Paragraph 2.3.3 has been amended as follows.

2.3.3 Stress due to wave pressure

The hot spot stress, in N/mm^2, due to the wave pressure in load case "i1" and "i2" for loading condition "(k)" is to be obtained from the following formula:

$$\cancel{\sigma_{LW,\, i\, j(k)} = \frac{K_{gl} K_s C_{NE,\, i\, j(k)}\, p_{W,\, i\, j(k)}\, s \ell^2 \left(1 - \frac{6x_f}{\ell} + \frac{6{x_f}^2}{\ell^2} \right)}{12w} 10^3 \qquad (j = 1, 2)}$$

$$\sigma_{LW,\, i\, j(k)} = \frac{K_{gl} K_s\, p_{CW,\, i\, j(k)}\, s \ell^2 \left(1 - \frac{6x_f}{\ell} + \frac{6{x_f}^2}{\ell^2} \right)}{12w} 10^3 \qquad (j = 1, 2)$$

$$p_{CW,i1(k)} = \begin{cases} 2C_{NE,i1(k)}\, p_{W,i1(k)} & ;\ C_{NE,i1(k)} < 0.5 \\ p_{W,i1(k)} & ;\ C_{NE,i1(k)} \geq 0.5 \end{cases}$$

$$p_{CW,i2(k)} = \begin{cases} 0 & ;\ C_{NE,i2(k)} < 0.5 \\ (2C_{NE,i2(k)} - 1)\, p_{W,i2(k)} & ;\ C_{NE,i2(k)} \geq 0.5 \end{cases}$$

where:

$p_{W,\, i\, j(k)}$: Hydrodynamic pressure, in kN/m^2, specified in **Ch 4**, **Sec 5**, **1.3**, **1.4** and **1.5**, with $f_p = 0.5$, in load case "i1" and "i2" for loading condition "(k)". When the location of the considered member is above the waterline, the hydrodynamic pressure is to be taken as the pressure at waterline.

K_{gl} : Geometrical stress concentration factor for stress due to lateral pressure ~~depending on the detail of end connection as defined in **Table 1**.~~ K_{gl} is given in **Table 1** and **Table 2** for the longitudinal end connection specified in **1.1.2 (1)** and **1.1.2 (2)**, respectively.

The stress concentration factor can be evaluated directly by the *FE* ~~analysis when the detail of end connection is not defined in **Table 1**~~.

K_s: Geometrical stress concentration factor due to stiffener geometry

$$K_s = 1 + \left[\frac{t_f(a^2 - b^2)}{2w_b}\right]\left[1 - \frac{b}{b_f}\left(1 + \frac{w_b}{w_a}\right)\right]10^{-3}$$

a, b : Eccentricity, in mm, of the face plate as defined in **Fig. 1**. For angle profile, "b" is to be taken as half the net actual thickness of the web.

t_f, b_f : thickness and breadth of face plate, in *mm*, respectively, as defined in **Fig. 1**.

w_a, w_b : Net section modulus in A and B respectively(see **Fig. 1**), in cm^3, of the stiffener about the neutral axis parallel to Z axis without attached plating.

$C_{NE,\,ij(k)}$: Correction factor for the non linearity of the wave pressure range in load case "$i1$" and "$i2$" of loading condition "(k)"

$$C_{NE,\,ij(k)} = \begin{cases} \exp\left[-\left(\dfrac{z - T_{LC(k)} + \dfrac{|p_{W,\,ij(k),\,WL}|}{\rho g}}{\dfrac{|p_{W,\,ij(k),\,WL}|}{\rho g}(-\ln 0.5)^{-1/2.5}}\right)^{2.5}\right] & \text{for} \quad z > T_{LC(k)} - \dfrac{|p_{W,\,ij(k),\,WL}|}{\rho g} \\ 1.0 & \text{for} \quad z \le T_{LC(k)} - \dfrac{|p_{W,\,ij(k),\,WL}|}{\rho g} \end{cases}$$

$T_{LC(k)}$: Draught, in *m*, of the considered loading condition "(k)"

$p_{W,\,ij(k),\,WL}$: Hydrodynamic pressure, in kN/m^2, at water line in load case "$i1$" and "$i2$" of loading condition "(k)"

z : Z co-ordinate, in *m*, of the point considered

s : Stiffener spacing, in *m*

ℓ : Span, in *m*, to be measured as shown in **Fig. 2**. The ends of the span are to be taken at points where the depth of the end bracket, measured from the face plate of the stiffener is equal to half the depth of the stiffener

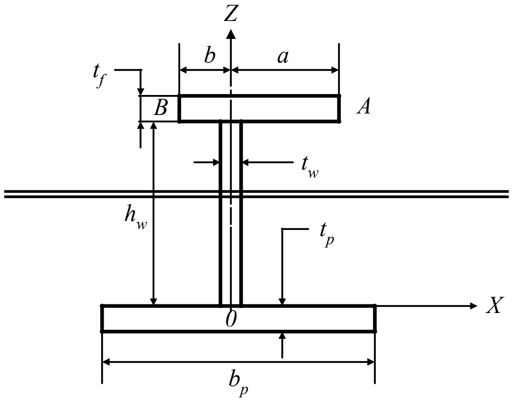
x_f : Distance, in *m*, to the hot spot from the closest end of the span ℓ (see **Fig. 2**)

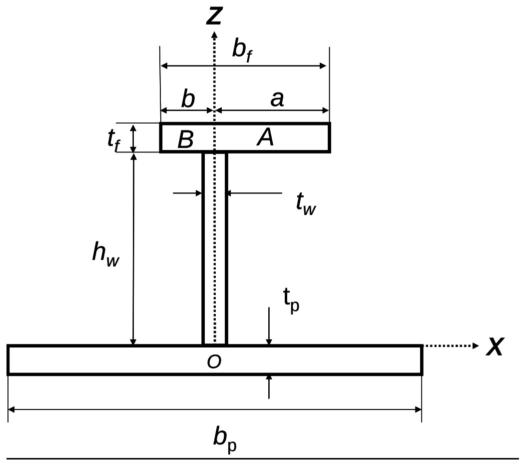
w : Net section modulus, in cm^3, of the considered stiffener. The section modulus w is to be calculated considering an effective breadth s_e, in m, of attached plating obtained from the following formulae:

$$s_e = \begin{cases} 0.67s \cdot \sin\left[\dfrac{\pi}{6}\left(\dfrac{\ell\left(1 - 1/\sqrt{3}\right)}{2s}\right)\right] & \text{for} \quad \dfrac{\ell}{s} \le \dfrac{6}{1 - 1/\sqrt{3}} \\ 0.67s & \text{for} \quad \dfrac{\ell}{s} > \dfrac{6}{1 - 1/\sqrt{3}} \end{cases}$$

Fig.1 has been amended as follows.

Fig. 1 Sectional parameters of a stiffener





Paragraph 2.3.4 has been amended as follows.

2.3.4 Stress due to liquid pressure

The hot spot stress, in N/mm^2, due to the liquid pressure in load case "*i*1" and "*i*2" for loading condition "(*k*)" is to be obtained from the following formula:

$$\sigma_{CW,\,i\,j(k)} = \frac{K_{gl} K_s C_{NI,\,i\,j(k)} p_{BW,\,i\,j(k)} s \ell^2 \left(1 - \dfrac{6x_f}{\ell} + \dfrac{6{x_f}^2}{\ell^2}\right)}{12w} \cdot 10^3 \qquad (j = 1, 2)$$

where:

$p_{BW,\,i\,j(k)}$: Inertial pressure, in kN/m^2, due to liquid specified in **Ch 4**, **Sec 6**, **2.2**, with f_p = 0.5, in load case "*i*1" and "*i*2" for loading condition "(*k*)". <u>Where the considered location is located in fuel oil, other oil or fresh water tanks, no inertial pressure is considered for the tank top longitudinals and when the location of the considered member is above the liquid surface in static and upright condition, the inertial pressure is to be taken at the liquid surface line.</u>

$C_{NI,\,i\,j(k)}$: Correction factor for the non linearity of the inertial pressure range due to liquid in load case "*i*1" and "*i*2" for loading condition "(*k*)"

$$C_{NI,\,i\,j(k)} = \begin{cases} \exp\left[-\left(\dfrac{z - z_{SF} + \dfrac{\left|p_{BW,\,i\,j(k),\,SF}\right|}{\rho g}}{\dfrac{\left|p_{BW,\,i\,j(k),\,SF}\right|}{\rho g}\left(-\ln 0.5\right)^{-1/2.5}}\right)^{2.5}\right] & \text{for} \quad z > z_{SF} - \dfrac{\left|p_{BW,\,i\,j(k),\,SF}\right|}{\rho g} \\ 1.0 & \text{for} \quad z \le z_{SF} - \dfrac{\left|p_{BW,\,i\,j(k),\,SF}\right|}{\rho g} \end{cases}$$

z_{SF} : Z co-ordinate, in m, of the liquid surface. ~~In general, it is taken as the distance to the top of the tank. In case of fuel oil tank, it may be taken as the distance to the half height of the tank~~ In general, it is taken equal to "z_{top}" defined in **Ch 4 Sec 6**. If the considered location is located in fuel oil, other oil or fresh water tanks, it may be taken as the distance to the half height of the tank.

z : Z co-ordinate, in m, of the point considered

$p_{BW,\,i\,j(k),\,SF}$: Inertial pressure due to liquid, in kN/m^2, taken at the liquid surface in load case "i1" and "i2" for loading condition "(k)". In calculating the inertial pressure according to **Ch 4 Sec 6, 2.2.1**, x and y coordinates of the reference point are to be taken as liquid surface instead of tank top.

K_{gl}, K_s : the stress concentration factor defined in **2.3.3**

Paragraph 2.3.6 has been amended as follows.

2.3.6 Stress due to relative displacement of transverse bulkhead or floor in way of transverse bulkhead or stool

For longitudinal end connection specified in **1.1.2 (2)**, ~~T~~the additional hot spot stress, in N/mm^2, due to the relative displacement in the ~~transverse~~ direction perpendicular to the attached plate between the transverse bulkhead or floor in way of stools and the adjacent transverse web or floor in load case "i1" and "i2" for loading condition "(k)" is to be obtained from the following formula:

$$\sigma_{d,\,i\,j(k)} = \begin{cases} K_{dF-a}\sigma_{dF-a,\,i\,j(k)} + K_{dA-a}\sigma_{dA-a,\,i\,j(k)} & \text{for point "}a\text{"} \\ K_{dF-f}\sigma_{dF-f,\,i\,j(k)} + K_{dA-f}\sigma_{dA-f,\,i\,j(k)} & \text{for point "}f\text{"} \end{cases} \qquad (j = 1, 2)$$

where:

a, f : Suffix which denotes the location considered as indicated in **Table ~~1~~2**

A, F : Suffix which denotes the direction, forward (F) and afterward (A), of the transverse web or floor where the relative displacement is occurred as indicated in **Table ~~1~~2** (see **Fig. 3**)

$\sigma_{dF\text{-}a,\,i\,j(k)}$, $\sigma_{dA\text{-}a,\,i\,j(k)}$, $\sigma_{dF\text{-}f,\,i\,j(k)}$, $\sigma_{dA\text{-}f,\,i\,j(k)}$: Additional stress at point "a" and "f", in N/mm^2, due to the relative displacement between the transverse bulkhead or floors in way of stools and the forward (F) and afterward (A) transverse web or floor respectively in load case "i1" and "i2" for loading condition "(k)"

$$\sigma_{dF-a,\,i\,j(k)} = \frac{3.9\delta_{F,\,i\,j(k)} E I_A I_F}{w_A \ell_F \left(\ell_A I_F + \ell_F I_A\right)}\left(1 - 1.15\frac{\left|x_{fA}\right|}{\ell_A}\right)10^{-5}$$

$$\sigma_{dA-a,\,i\,j(k)} = \left[\frac{3.9\delta_{A,\,i\,j(k)} E I_A I_F}{w_A \ell_A (\ell_A I_F + \ell_F I_A)} \left(1 - 1.15 \frac{|x_{fA}|}{\ell_A}\right) - \frac{0.9\delta_{A,\,i\,j(k)} E I_A |x_{fA}|}{w_A \ell_A^{\,3}} \right] 10^{-5}$$

$$\sigma_{dF-f,\,i\,j(k)} = \left[\frac{3.9\delta_{F,\,i\,j(k)} E I_A I_F}{w_F \ell_F (\ell_A I_F + \ell_F I_A)} \left(1 - 1.15 \frac{|x_{fF}|}{\ell_F}\right) - \frac{0.9\delta_{F,\,i\,j(k)} E I_F |x_{fF}|}{w_F \ell_F^{\,3}} \right] 10^{-5}$$

$$\sigma_{dA-f,\,i\,j(k)} = \frac{3.9\delta_{A,\,i\,j(k)} E I_A I_F}{w_F \ell_A (\ell_A I_F + \ell_F I_A)} \left(1 - 1.15 \frac{|x_{fF}|}{\ell_F}\right) 10^{-5}$$

$\delta_{F,\,i\,j(k)}$, $\delta_{A,\,i\,j(k)}$: Relative displacement, in *mm*, in the ~~transverse~~ direction perpendicular to the attached plate between the transverse bulkhead or floor in way of stools and the forward (F) and afterward (A) transverse web or floor in load case "*i*1" and "*i*2" for loading condition "(*k*)" (see **Fig. 3**)

(a) For longitudinals penetrating floors in way of stools
Relative displacement is defined as the displacement of the longitudinal in relation to the line passing through the stiffener end connection at the base of the stool measured at the first floor forward (F) or afterward (A) of the stool.

(a) For longitudinals other than (a)
Relative displacement is defined as the displacement of the longitudinal in relation to its original position measured at the first forward (F) or afterward (A) of the transverse bulkhead.
Where the stress of the face of longitudinal at the assessment point due to relative displacement is tension, the sign of the relative displacement is positive.

I_F, I_A : Net moment of inertia, in cm^4, of forward (F) and afterward (A) longitudinal

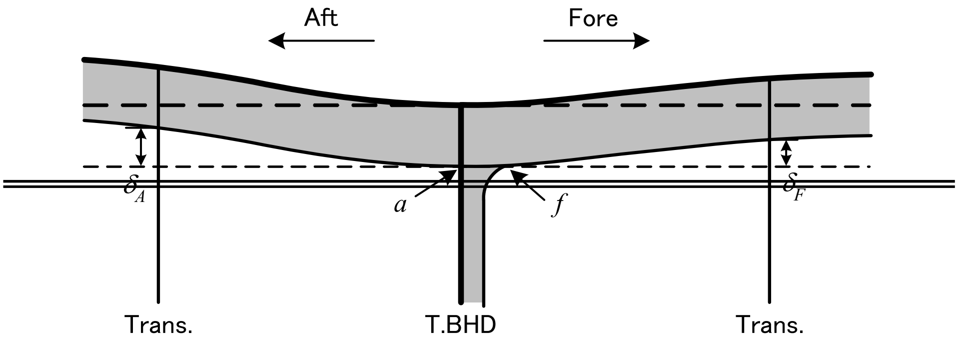
K_{dF-a}, K_{dA-a}, K_{dF-f}, K_{dA-f} : Stress concentration factor for stiffener end connection at point "*a*" and "*f*" subject to relative displacement between the transverse bulkhead and the forward (F) and afterward (A) transverse web or floors in way of stool respectively as defined in **Table ~~1~~2**. The stress concentration can be evaluated directly by the *FE* analysis when the detail of end connection is not defined in **Table ~~1~~2**.

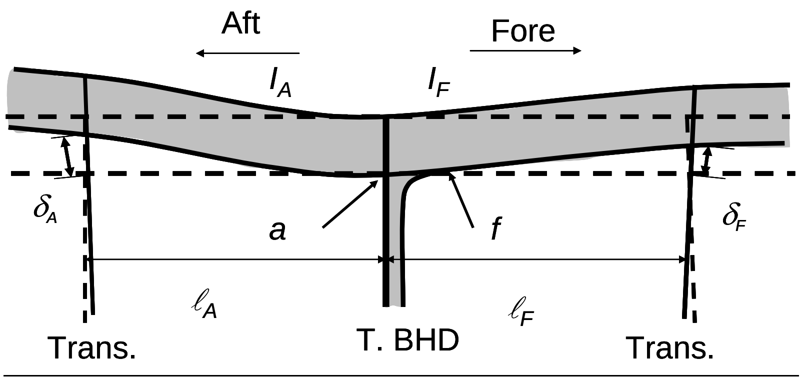
ℓ_F, ℓ_A : Span, in *m*, of forward (F) and afterward (A) longitudinal to be measured as shown in **Fig. 2**

x_{fF}, x_{fA} : Distance, in *m*, to the hot spot from the closest end of ℓ_F and ℓ_A respectively (see **Fig. 2**).

Fig.3 has been amended as follows.

Fig. 3 ~~**Relative displacement between the transverse bulkhead and the transverse web or floor**~~ **Definition of the relative displacement (Example of the side longitudinal)**





3. Hot spot mean stress

3.3 Mean stress according to the simplified procedure

Paragraph 3.3.1 has been amended as follows.

3.3.1 Hot spot mean stresses

The structural hot spot mean stress, in N/mm^2, in loading condition "(k)" regardless of load case "i" is to be obtained from the following formula:

$$\sigma_{mean,(k)} = \sigma_{GS,(k)} + \sigma_{S1,(k)} - \sigma_{S2,(k)} + \sigma_{dS,(k)}$$

where

$\sigma_{GS,(k)}$: Stress due to still water hull girder moment, defined in **3.3.2**

$\sigma_{S1,(k)}$: Stress due to static pressure when the pressure is applied on the same side as the ordinary stiffener depending on the considered case, with consideration of the stresses defined in **3.3.3** to **3.3.5**

$\sigma_{S2,(k)}$: Stress due to static pressure when the pressure is applied on the side opposite to the stiffener depending on the considered case, with consideration of the stresses defined in **3.3.3** to **3.3.5**

~~$\sigma_{LS,(k)}$: Stress due to hydrostatic pressure, defined in **3.3.3**~~

~~$\sigma_{CS,(k)}$: Stress due to liquid pressure in still water, defined in **3.3.4**~~

~~$\sigma_{LCS,(k)}$: Stress due to dry bulk cargo pressure in still water, defined in **3.3.5**~~

$\sigma_{dS,(k)}$: Stress due to relative displacement of transverse bulkhead in still water, defined in **3.3.6**.

Paragraph 3.3.3 has been amended as follows.

3.3.3 Stress due to hydrostatic and hydrodynamic pressure

The hot spot stress due to hydrostatic and hydrodynamic pressure, in N/mm^2, in loading condition "(k)" is to be obtained with the following formula:

$$\cancel{\sigma_{LS,(k)} = \frac{K_{gl} K_s p_{S,(k)} s \ell^2 \left(1 - \frac{6x_f}{\ell} + \frac{6x_f{}^2}{\ell^2}\right)}{12w} 10^3}$$

$$\underline{\sigma_{LS,(k)} = \frac{K_{gl} K_s \left\{ p_{S,(k)} + \frac{p_{CW,i1(k)} + p_{CW,i2(k)}}{2} \right\} s \ell^2 \left(1 - \frac{6x_f}{\ell} + \frac{6x_f{}^2}{\ell^2}\right)}{12w} \cdot 10^3}$$

where:

$p_{S,(k)}$: Hydrostatic pressure, in kN/m^2, in loading condition "(k)" specified in **Ch 4**, **Sec 5**, **1.2**.

<u>$p_{CW,ij\,(k)}$: Corrected hydrodynamic pressure, in kN/m^2, according to **2.3.3**, with f_p = 0.5, in load case "i1" and "i2" for loading condition "(k)".</u>

<u>i : Suffix which denotes the load case specified in **Sec 2 [2.1.1]**, when calculating the mean stress, "I" is to be used.</u>

Paragraph 3.3.4 has been amended as follows.

3.3.4 Stress due to liquid pressure in still water

The structural hot spot mean stress due to liquid pressure in still water, in N/mm^2, in loading condition "(k)" is to be obtained with the following formula:

$$\sigma_{CS,(k)} = \frac{K_{gl} K_s p_{CS,(k)} s \ell^2 \left(1 - \frac{6x_f}{\ell} + \frac{6x_f{}^2}{\ell^2}\right)}{12w} 10^3$$

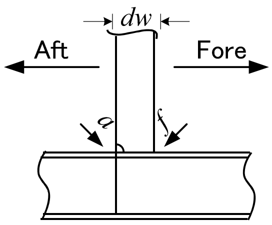
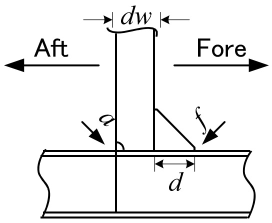
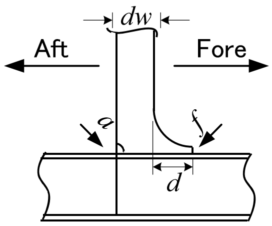
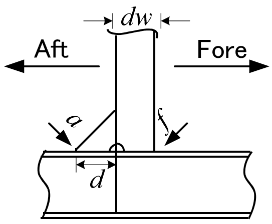
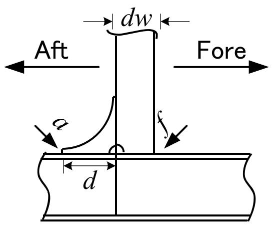
where:

$p_{CS,(k)}$: Liquid pressure in still water, in kN/m^2, in loading condition "(k)" specified in **Ch 4**, **Sec 6**, **2.1**.

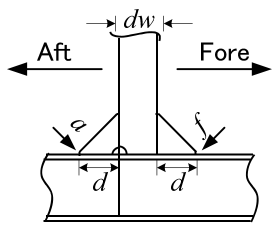
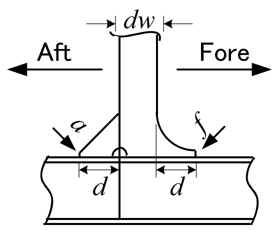
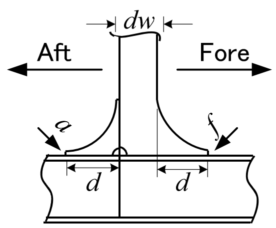
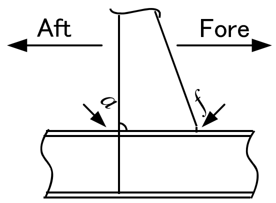
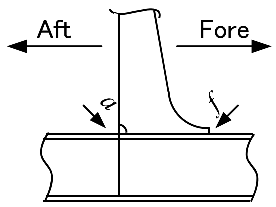
<u>Where the considered location is located in fuel oil, other oil or fresh water tanks, d_{AP} and P_{PV} defined in **Ch 4 Sec 6** are to be taken equal to 0 and z_{TOP} specified in **Ch 4 Sec 6, 2.1** is to be taken equal to z_{SF} specified in **2.3.4**.</u>

Table 1 has been amended as follows.

~~**Table 1 Stress concentration factors for the stiffener end connection**~~

~~Structural type~~	~~Assessed point~~	~~Collar plate~~	~~Bracket size~~	~~Stress concentration factors~~			
				~~K_{gl}~~	~~K_{gh}~~	~~K_{dF}~~	~~K_{dA}~~
~~1~~ 	~~*a*~~	~~watertight~~	~~—~~	~~1.5~~	~~1.1~~	~~1.15~~	~~1.5~~
		~~non-watertight~~	~~—~~	~~1.65~~	~~1.1~~	~~—~~	~~—~~
	~~*f*~~	~~watertight~~	~~—~~	~~1.1~~	~~1.05~~	~~1.55~~	~~1.05~~
~~2~~ 	~~*a*~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.45~~	~~1.1~~	~~1.15~~	~~1.4~~
			~~$1.5dw \le d$~~	~~1.4~~	~~1.05~~	~~1.15~~	~~1.35~~
		~~non-watertight~~	~~$dw \le d < 1.5dw$~~	~~1.55~~	~~1.1~~	~~—~~	~~—~~
			~~$1.5dw \le d$~~	~~1.5~~	~~1.05~~	~~—~~	~~—~~
	~~*f*~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.1~~	~~1.05~~	~~1.15~~	~~1.1~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.1~~	~~1.05~~
~~3~~ 	~~*a*~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.4~~	~~1.1~~	~~1.1~~	~~1.35~~
			~~$1.5dw \le d$~~	~~1.35~~	~~1.05~~	~~1.05~~	~~1.3~~
		~~non-watertight~~	~~$dw \le d < 1.5dw$~~	~~1.5~~	~~1.1~~	~~—~~	~~—~~
			~~$1.5dw \le d$~~	~~1.45~~	~~1.05~~	~~—~~	~~—~~
	~~*f*~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.05~~	~~1.05~~	~~1.1~~	~~1.05~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.05~~
~~4~~ 	~~*a*~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.1~~	~~1.05~~	~~1.05~~	~~1.25~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.2~~
	~~*f*~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.3~~	~~1.1~~	~~1.35~~	~~1.05~~
			~~$1.5dw \le d$~~	~~1.3~~	~~1.05~~	~~1.3~~	~~1.05~~
		~~non-watertight~~	~~$dw \le d < 1.5dw$~~	~~1.4~~	~~1.1~~	~~—~~	~~—~~
			~~$1.5dw \le d$~~	~~1.4~~	~~1.05~~	~~—~~	~~—~~
~~5~~ 	~~*a*~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.1~~	~~1.05~~	~~1.05~~	~~1.2~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.15~~
	~~*f*~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.3~~	~~1.1~~	~~1.55~~	~~1.1~~
			~~$1.5dw \le d$~~	~~1.3~~	~~1.05~~	~~1.5~~	~~1.05~~
		~~non-watertight~~	~~$dw \le d < 1.5dw$~~	~~1.35~~	~~1.1~~	~~—~~	~~—~~
			~~$1.5dw \le d$~~	~~1.35~~	~~1.05~~	~~—~~	~~—~~

~~Table 1 Stress concentration factors for the stiffener end connection (continued)~~

~~Structural type~~	~~Assessed point~~	~~Collar plate~~	~~Bracket size~~	~~Stress concentration factors~~			
				~~K_{gl}~~	~~K_{gh}~~	~~K_{dF}~~	~~K_{dA}~~
~~6~~ 	~~a~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.1~~	~~1.05~~	~~1.05~~	~~1.1~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.05~~
		~~non-watertight~~	~~$dw \le d < 1.5dw$~~	~~1.15~~	~~1.05~~	~~——~~	~~——~~
			~~$1.5dw \le d$~~	~~1.1~~	~~1.05~~	~~——~~	~~——~~
	~~f~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.05~~	~~1.05~~	~~1.1~~	~~1.05~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.05~~
~~7~~ 	~~a~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.1~~	~~1.05~~	~~1.05~~	~~1.2~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.15~~
		~~non-watertight~~	~~$dw \le d < 1.5dw$~~	~~1.15~~	~~1.05~~	~~——~~	~~——~~
			~~$1.5dw \le d$~~	~~1.1~~	~~1.05~~	~~——~~	~~——~~
	~~f~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.05~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.05~~
~~8~~ 	~~a~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.1~~	~~1.1~~	~~1.05~~	~~1.15~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.1~~
		~~non-watertight~~	~~$dw \le d < 1.5dw$~~	~~1.1~~	~~1.1~~	~~——~~	~~——~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~——~~	~~——~~
	~~f~~	~~watertight~~	~~$dw \le d < 1.5dw$~~	~~1.05~~	~~1.05~~	~~1.1~~	~~1.05~~
			~~$1.5dw \le d$~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.05~~
~~9~~ 	~~a~~	~~watertight~~	~~——~~	~~1.4~~	~~1.05~~	~~1.05~~	~~1.75~~
	~~f~~	~~watertight~~	~~——~~	~~1.6~~	~~1.05~~	~~1.7~~	~~1.05~~
~~10~~ 	~~a~~	~~watertight~~	~~——~~	~~1.3~~	~~1.05~~	~~1.05~~	~~1.75~~
	~~f~~	~~watertight~~	~~——~~	~~1.55~~	~~1.05~~	~~1.3~~	~~1.05~~

~~Table 1 Stress concentration factors for the stiffener end connection (continued)~~

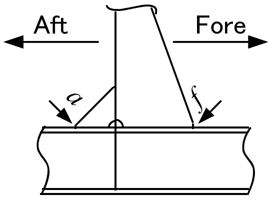
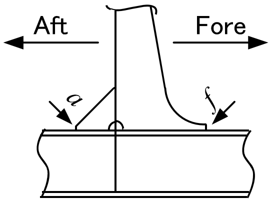
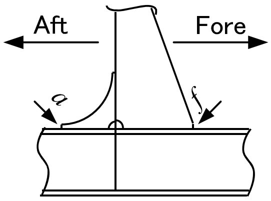
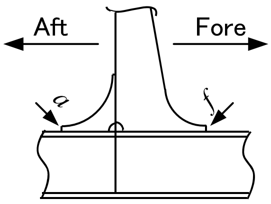
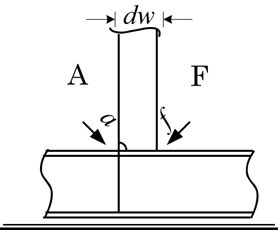
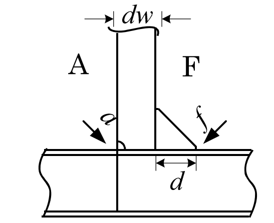
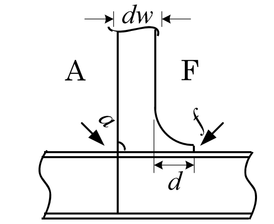
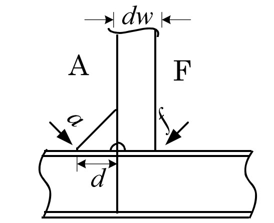
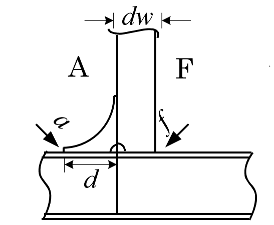
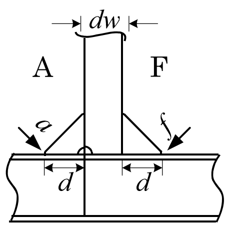
~~Structural type~~	~~Assessed point~~	~~Collar plate~~	~~Bracket size~~	~~Stress concentration factors~~			
				~~K_{gl}~~	~~K_{gh}~~	~~K_{dF}~~	~~K_{dA}~~
~~11~~ 	~~*a*~~	~~watertight~~	~~——~~	~~1.1~~	~~1.05~~	~~1.05~~	~~1.2~~
	~~*f*~~	~~watertight~~	~~——~~	~~1.75~~	~~1.05~~	~~1.4~~	~~1.05~~
~~12~~ 	~~*a*~~	~~watertight~~	~~——~~	~~1.1~~	~~1.05~~	~~1.05~~	~~1.2~~
	~~*f*~~	~~watertight~~	~~——~~	~~1.3~~	~~1.05~~	~~1.05~~	~~1.05~~
~~13~~ 	~~*a*~~	~~watertight~~	~~——~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.15~~
	~~*f*~~	~~watertight~~	~~——~~	~~1.95~~	~~1.05~~	~~1.55~~	~~1.05~~
~~14~~ 	~~*a*~~	~~watertight~~	~~——~~	~~1.05~~	~~1.05~~	~~1.05~~	~~1.15~~
	~~*f*~~	~~watertight~~	~~——~~	~~1.7~~	~~1.05~~	~~1.15~~	~~1.05~~

Table 1 Stress concentration factors for non-watertight longitudinal end connection at transverse webs or floors other than transverse bulkheads or floors in way of stools

Bracket type	Assessed point	Bracket size	Stress concentration factors	
			K_{gl}	K_{gh}
1 	*a*	-----	1.65	1.1
2 	*a*	$dw \leq d < 1.5dw$	1.55	1.1
		$1.5dw \leq d$	1.5	1.05
3 	*a*	$dw \leq d < 1.5dw$	1.5	1.1
		$1.5dw \leq d$	1.45	1.05
4 	*f*	$dw \leq d < 1.5dw$	1.4	1.1
		$1.5dw \leq d$	1.4	1.05
5 	*f*	$dw \leq d < 1.5dw$	1.35	1.1
		$1.5dw \leq d$	1.35	1.05
6 	*a*	$dw \leq d < 1.5dw$	1.15	1.05
		$1.5dw \leq d$	1.1	1.05

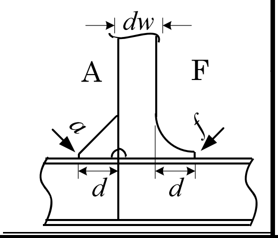
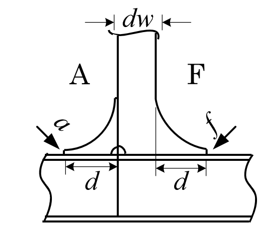
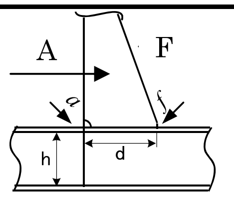
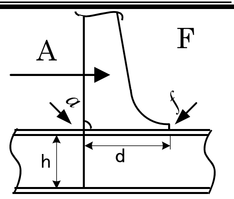
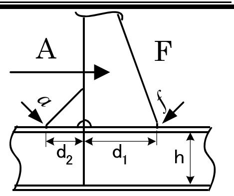
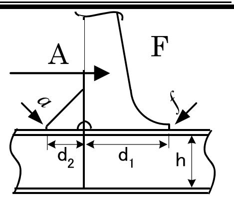
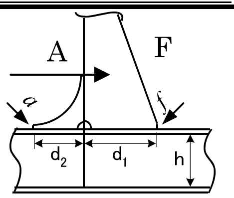
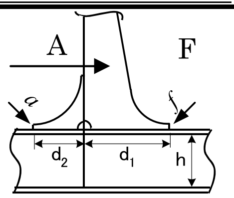
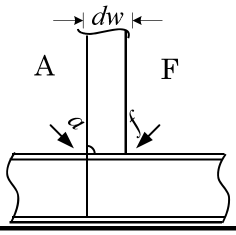
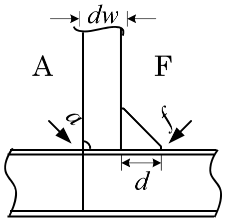
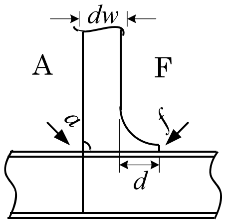
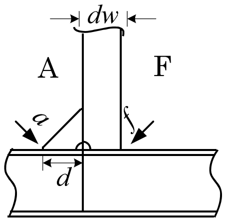
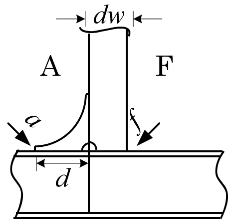
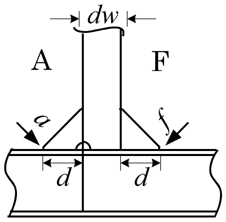
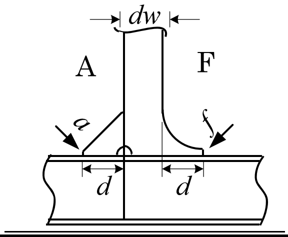
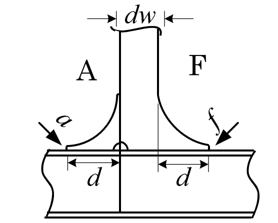
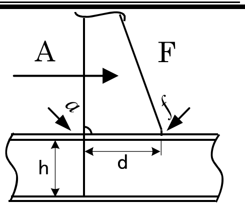
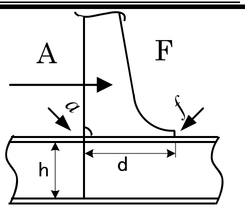
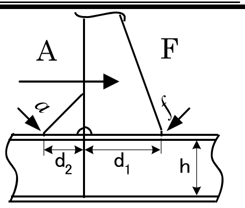
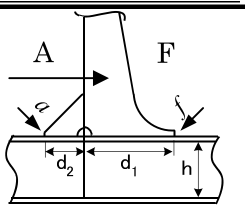
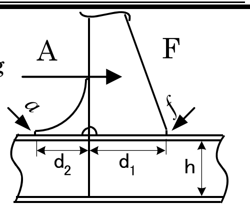
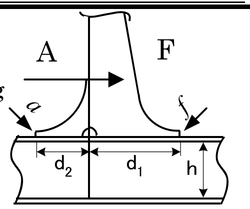
Bracket type	Assessed point	Bracket size	Stress concentration factors	
			K_{gl}	K_{gh}
7 	a	$dw \leq d < 1.5dw$	1.15	1.05
		$1.5dw \leq d$	1.1	1.05
8 	a	$dw \leq d < 1.5dw$	1.1	1.1
		$1.5dw \leq d$	1.05	1.05
9 Tripping bracket 	a	$d \leq 2h$	1.45	1.1
10 Tripping bracket 	a	$d \leq 2.5h$	1.35	1.1
11 Tripping bracket 	a	$d_1 \leq 2h$ and $h \leq d_2$	1.15	1.1
	f		1.85	1.1
12 Tripping bracket 	a	$d_1 \leq 2.5h$ and $h \leq d_2$	1.15	1.1
	f		1.35	1.1
13 Tripping bracket 	a	$d_1 \leq 2h$ and $h \leq d_2$	1.1	1.1
	f		2.05	1.1
14 Tripping bracket 	a	$d_1 \leq 2.5h$ and $h \leq d_2$	1.1	1.1
	f		1.8	1.1

Table 2 has been added as follows.

Table 2 Stress concentration factors for watertight longitudinal end connection at transverse bulkheads and floors in way of stools

Bracket type	Assessed point	Bracket size	Stress concentration factors			
			K_{gl}	K_{gh}	K_{dF}	K_{dA}
1 	a	-----	1.5	1.1	1.15	1.5
	f	-----	1.1	1.05	1.55	1.05
2 	a	$dw \leq d < 1.5dw$	1.45	1.1	1.15	1.4
		$1.5dw \leq d$	1.4	1.05	1.15	1.35
	f	$dw \leq d < 1.5dw$	1.1	1.05	1.15	1.1
		$1.5dw \leq d$	1.05	1.05	1.1	1.05
3 	a	$dw < d < 1.5dw$	1.4	1.1	1.1	1.35
		$1.5dw \leq d$	1.35	1.05	1.05	1.3
	f	$dw \leq d < 1.5dw$	1.05	1.05	1.1	1.05
		$1.5dw \leq d$	1.05	1.05	1.05	1.05
4 	a	$dw \leq d < 1.5dw$	1.1	1.05	1.05	1.25
		$1.5dw \leq d$	1.05	1.05	1.05	1.2
	f	$dw \leq d < 1.5dw$	1.3	1.1	1.35	1.05
		$1.5dw \leq d$	1.3	1.05	1.3	1.05
5 	a	$dw \leq d < 1.5dw$	1.1	1.05	1.05	1.2
		$1.5dw \leq d$	1.05	1.05	1.05	1.15
	f	$dw \leq d < 1.5dw$	1.3	1.1	1.55	1.1
		$1.5dw \leq d$	1.3	1.05	1.5	1.05
6 	a	$dw \leq d < 1.5dw$	1.1	1.05	1.05	1.1
		$1.5dw \leq d$	1.05	1.05	1.05	1.05
	f	$dw \leq d < 1.5dw$	1.05	1.05	1.1	1.05
		$1.5dw \leq d$	1.05	1.05	1.05	1.05

Bracket type	Assessed point	Bracket size	Stress concentration factors			
			K_{gl}	K_{gh}	K_{dF}	K_{dA}
7 	a	$dw \leq d < 1.5dw$	1.1	1.05	1.05	1.2
		$1.5dw \leq d$	1.05	1.05	1.05	1.15
	f	$dw < d < 1.5dw$	1.05	1.05	1.05	1.05
		$1.5dw \leq d$	1.05	1.05	1.05	1.05
8 	a	$dw \leq d < 1.5dw$	1.1	1.1	1.05	1.15
		$1.5dw \leq d$	1.05	1.05	1.05	1.1
	f	$dw \leq d < 1.5dw$	1.05	1.05	1.1	1.05
		$1.5dw \leq d$	1.05	1.05	1.05	1.05
9 Tripping bracket 	a	$d \leq 2h$	1.4	1.05	1.05	1.75
	f		1.6	1.05	1.7	1.05
10 Tripping bracket 	a	$d \leq 2.5h$	1.3	1.05	1.05	1.75
	f		1.55	1.05	1.3	1.05
11 Tripping bracket 	a	$d_1 \leq 2h$ and $h \leq d_2$	1.1	1.05	1.05	1.2
	f		1.75	1.05	1.4	1.05
12 Tripping bracket 	a	$d_1 \leq 2.5h$ and $h \leq d_2$	1.1	1.05	1.05	1.2
	f		1.3	1.05	1.05	1.05
13 Tripping bracket 	a	$d_1 \leq 2h$ and $h \leq d_2$	1.05	1.05	1.05	1.15
	f		1.95	1.05	1.55	1.05
14 Tripping 	a	$d_1 \leq 2.5h$ and $h \leq d_2$	1.05	1.05	1.05	1.15
	f		1.7	1.05	1.15	1.05

Chapter 9 OTHER STRUCTURES

Section 1 FORE PART

4. Scantlings

4.3 Ordinary stiffeners

Paragraph 4.3.3 has been amended as follows.

4.3.3

The net thickness of the web of ordinary stiffeners, in mm, is to be not less than the greater of:

- $t = 3.0 + 0.015L_2$
- 40% of the net ~~offered~~ required thickness of the attached plating, to be determined according to **4.2** and **5.2**.
- ~~and is to be less than twice the net offered thickness of the attached plating.~~

The net dimensions of ordinary stiffeners are to comply with the requirement in **Ch 6, Sec 2, 2.2.2** and **2.3**.

Section 2 AFT PART

4. Scantlings

4.2 Ordinary stiffeners

Paragraph 4.2.3 has been amended as follows.

4.2.3

The net thickness of the web of ordinary stiffeners, in *mm*, is to be not less than the greater of:

- $t = 3.0 + 0.015L_2$
- 40% of the net ~~offered~~ required thickness of the attached plating, to be determined according to **4.1**.

~~and is to be less than twice the net offered thickness of the attached plating.~~

The net dimensions of ordinary stiffeners are to comply with the requirement in **Ch 6, Sec 2, 2.2.2** and **2.3**.

Section 3 MACHINERY SPACE

7. Main machinery seating

7.2 Minimum scantlings

Paragraph 7.2.1 has been amended as follows.

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 **Table 2**. However, the net cross-sectional area of each bedplate of the seatings may be determined by the engine manufacturers, provided the information regarding permissible foundation stiffness considering the engine characteristics and engine room arrangement, etc..

Section 4 SUPERSTRUCTURES AND DECKHOUSES

Symbols have been amended as follows.

Symbols

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

L_2 : Rule length L, but to be taken not greater than 300 m

p_D : Lateral pressure for decks, in kN/m^2, as defined in **3.2.1**

p_{SI} : Lateral pressure for sides of superstructures, in kN/m^2, as defined in **3.2.3**

k : Material factor, defined in **Ch 3**, **Sec 1**, **2.2**

s : Spacing, in m, of ordinary stiffeners, measured at mid-span along the chord

ℓ : Span, in m, of ordinary stiffeners, measured between the supporting members, see **Ch 3**, **Sec 6**, **4.2**

~~t_C : Corrosion addition, defined in **Ch 3**, **Sec 3**~~

c : Coefficient taken equal to:

$c = 0.75$ for beams, girders and transverses which are simply supported on one or both ends

$c = 0.55$ in other cases

m_a : Coefficient taken equal to:

$$m_a = 0.204\frac{s}{\ell}\left[4-\left(\frac{s}{\ell}\right)^2\right], \text{ with } \frac{s}{\ell} \le 1$$

4. Scantlings

4.1 Side plating of non-effective superstructures

Paragraph 4.1.1 has been amended as follows.

4.1.1

The gross thickness, in *mm*, of the side plating of non-effective superstructures is not to be less than the greater of the following values:

$\cancel{t = 1.21s\sqrt{kp_{SI}} + t_C}$ $\underline{t = 1.21s\sqrt{kp_{SI}} + 1.5}$

$t = 0.8\sqrt{kL}$

Paragraph 4.2 has been amended as follows.

4.2 Deck plating of non-effective superstructures

4.2.1

The gross thickness, in *mm*, of deck plating of non-effective superstructures is not to be less than the greater of the following values:

$\cancel{t = 1.21s\sqrt{kp_D} + t_C}$ $\underline{t = 1.21s\sqrt{kp_D} + 1.5}$

$t = (5.5 + 0.02L)\sqrt{k}$

where L is not to be taken greater than 200 *m*.

4.2.2

Where additional superstructures are arranged on non-effective superstructures located on the freeboard deck, the gross thickness required by **4.2.1** may be reduced by 10%.

4.2.3

Where plated decks are protected by sheathing, the gross thickness of the deck plating according to **4.2.1** and **4.2.2** may be reduced by $\cancel{t_C}$ 1.5 *mm*. However, such deck plating is not to be less than 5 *mm*.

Where a sheathing other than wood is used, attention is to be paid that the sheathing does not affect the steel. The sheathing is to be effectively fitted to the deck.

4.5 Decks of short deckhouses

Paragraph 4.5.1 has been amended as follows.

4.5.1 Plating

The thickness, in *mm*, of weather deck of short deckhouses and is not to be less than:

$\cancel{t = 8s\sqrt{k} + t_C}$ $\underline{t = 8s\sqrt{k} + 1.5}$

For weather decks of short deckhouses protected by sheathing and for decks within deckhouses, the gross thickness may be reduced by $\cancel{t_C}$ 1.5 *mm*. However, such deck plating is not to be less than 5 *mm*.

5. End bulkheads of superstructure and deckhouse

5.3 Scantlings

Paragraph 5.3.2 has been amended as follows.

5.3.2 Plate thickness

The gross thickness of the plating, in *mm*, is not to be less than the greater of the values obtained from the following formulae:

$$\cancel{t = 0.9 s \sqrt{k p_A} + t_C} \quad \underline{t = 0.9 s \sqrt{k p_A} + 1.5}$$

$t_{min} = \left(5.0 + \dfrac{L_2}{100}\right)\sqrt{k}$, for the lowest tier

$t_{min} = \left(4.0 + \dfrac{L_2}{100}\right)\sqrt{k}$, for the upper tiers, without being less than 5.0 *mm*.

Section 5 HATCH COVERS

Symbols have been amended as follows.

Symbols

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

p_S : Still water pressure, in kN/m^2, defined in **4.1**

p_W : Wave pressure, in kN/m^2, defined in **4.1**

p_C : Pressure acting on the hatch coaming, in kN/m^2, defined in **6.2**

F_S, F_W: Coefficients taken equal to:

$F_S = 0$ and $F_W = 0.9$ for ballast water loads on hatch covers of the ~~cargo~~ ballast hold

$F_S = 1.0$ and $F_W = 1.0$ in other cases

s : Length, in *m*, of the shorter side of the elementary plate panel

ℓ : Length, in *m*, of the longer side of the elementary plate panel

b_p : Effective width, in *m*, of the plating attached to the ordinary stiffener or primary supporting member, defined in **3**

w : Net section modulus, in cm^3, of the ordinary stiffener or primary supporting member, with an attached plating of width b_p

A_{sh} : Net shear sectional area, in cm^2, of the ordinary stiffener or primary supporting member

m : Boundary coefficient for ordinary stiffeners and primary supporting members, taken equal to:

$m = 8$, in the case of ordinary stiffeners and primary supporting members simply supported at both ends or supported at one end and clamped at the other end

$m = 12$, in the case of ordinary stiffeners and primary supporting members clamped at both ends

t_C : Total corrosion addition, in *mm*, defined in **1.4**

σ_a, τ_a : Allowable stresses, in N/mm^2, defined in **1.5**

1. General

1.5 Allowable stresses

Table 2 has been amended as follows.

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 **Ch 4, sec 5, ~~2~~5.2.1**	0.80 R_{eH}	0.46 R_{eH}
Pontoon hatch cover		0.68 R_{eH}	0.39 R_{eH}
Weathertight hatch cover and pontoon hatch cover	Other loads, as defined in **Ch 4 ,Sec 5, 5.1.1** and **Ch 4, Sec 6, 2**	0.90 R_{eH}	0.51 R_{eH}

5. Strength check

5.2 Plating

Paragraph 5.2.3 has been amended as follows.

5.2.3 Critical buckling stress check

The compressive stress σ in the hatch cover plating, induced by the bending of primary supporting members, parallel to the direction of ordinary stiffeners is to comply with the following formula:

$$\sigma \le \frac{0.88}{S}\sigma_{C1}$$

where:

S : Safety factor defined in **Ch 6**, **Sec 3**

σ_{C1} : Critical buckling stress, in N/mm^2, taken equal to:

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

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

$$\sigma_{E1} = 3.6\,E\left(\frac{t}{1000s}\right)^2$$

t : Net thickness, in *mm*, of plate panel

The compressive stress σ in the hatch cover plating, induced by the bending of primary supporting members, perpendicular to the direction of ordinary stiffeners is to comply with the following formula:

$$\sigma \le \frac{0.88}{S}\sigma_{C2}$$

where:

S : Safety factor defined in **Ch 6**, **Sec 3**

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

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

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

$$\sigma_{E2} = 0.9\, m\, E\left(\frac{t}{1000 s_s}\right)^2$$

m : Coefficient taken equal to:

$$m = c\left[1 + \left(\frac{s_s}{\ell_s}\right)^2\right]^2 \frac{2.1}{\psi + 1.1}$$

t : Net thickness, in *mm*, of plate panel

s_s : Length, in *m*, of the shorter side of the plate panel

ℓ_s : Length, in *m*, of the longer side of the plate panel

ψ : Ratio between smallest and largest compressive stress

c : Coefficient taken equal to:

$c = 1.3$ when plating is stiffened by primary supporting members

$c = 1.21$ when plating is stiffened by ordinary stiffeners of angle or T type

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

$c = 1.05$ when plating is stiffened by flat bar.

$c = 1.30$ when plating is stiffened by ordinary stiffeners of U type. The higher c value but not greater than 2.0 may be taken if it is verified by buckling strength check of panel using non-linear FEA and deemed appropriate by the Society.

An averaged value of c is to be used for plate panels having different edge stiffeners.

~~In addition, t~~The bi-axial compression stress in the hatch cover plating, when calculated by means of finite element analysis, is to comply with the requirements in **Ch 6**, **Sec 3**.

5.3 Ordinary stiffeners

Paragraph 5.3.2 has been amended as follows.

5.3.2 Minimum net thickness of web

The web net thickness of the ordinary stiffener, in *mm*, is to be not less than ~~the minimum values given in **5.2.2**~~ 4*mm*.

5.4 Primary supporting members

Paragraph 5.4.2 has been amended as follows.

5.4.2 Minimum net thickness of web

The web net thickness of primary supporting members, in *mm*, is to be not less than ~~the minimum values given in **5.2.2**~~ 6*mm*.

Chapter 12 ADDITIONAL CLASS NOTATIONS

Section 1 GRAB ADDITIONAL CLASS NOTATION

2. Scantlings

2.1 Plating

Paragraph 2.1.1 has been amended as follows.

2.1.1

The net thickness of plating of inner bottom, ~~lower strake of~~ hopper tank sloping plate ~~and~~ transverse lower stool ~~plating~~, transverse bulkhead plating and inner hull up to a height of 3.0*m* above the lowest point of the inner bottom, excluding bilge wells, is to be taken as the greater of the following values:

- t, as obtained according to requirements in **Ch 6** and **Ch 7**
- t_{GR}, as defined in **2.1.2** and **2.1.3**.

Paragraph 2.1.3 has been amended as follows.

2.1.3

The net thickness t_{GR}, in *mm*, ~~within the lower 3 *m*~~ of hopper tank sloping plate, ~~and of~~ transverse lower stool, transverse bulkhead plating and inner hull up to a height of 3.0*m* above the lowest point of the inner bottom, excluding bilge wells, is to be obtained from the following formula:

$$t_{GR} = 0.28\left(M_{GR} + 42\right)\sqrt{sk}$$

EFFECTIVE DATE AND APPLICATION (Amendment 1-3)

1. The effective date of the amendments is 1 July 2009.

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

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

IACS PR No.29 (Rev.4)

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

2. The date of "contract for construction" of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.

For the purpose of this Procedural Requirement, vessels built under a single contract for construction are considered a "series of vessels" if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:

(1) such alterations do not affect matters related to classification, or

(2) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval.

The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

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

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

Notes:

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