RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

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

Rules for the Survey and Construction of Steel Ships
Part CSR-B&T 2015 AMENDMENT NO.1

Rule No.16 27th February 2015
Resolved by Technical Committee on 2nd February 2015
Approved by Board of Directors on 23rd February 2015

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Rule No.16 27th February 2015
AMENDMENT TO THE RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

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

Part CSR-B&T COMMON STRUCTURAL RULES FOR BULK CARRIERS AND OIL TANKERS

Part 1 GENERAL HULL REQUIREMENTS

Chapter 1 RULE GENERAL PRINCIPLES

Section 1 APPLICATION

3. Class Notations

3.2 Class notation for bulk carriers

Paragraph 3.2.1 has been amended as follows.

3.2.1 Additional service features *BC-A*, *BC-B* and *BC-C*

The following requirements apply to ships, as defined in **1.2.1**, having length L_{CSR} of 150*m* or above.

Bulk carriers are to be assigned one of the following additional service features:

(a) *BC-A*: For bulk carriers designed to carry dry bulk cargoes of cargo density 1.0t/m^3 and above with specified holds empty at maximum draught in addition to *BC-B* conditions.

(b) *BC-B*: For bulk carriers designed to carry dry bulk cargoes of cargo density of 1.0t/m^3 and above with all cargo holds loaded in addition to *BC-C* conditions.

(c) *BC-C*: For bulk carriers designed to carry dry bulk cargoes of cargo density less than 1.0 t/m^3.

The following additional service features are to be provided giving further detailed description of limitations to be observed during operation as a consequence of the design loading condition applied during the design in the following cases:

- {*Maximum cargo density in* t/m^3} for additional service features *BC-A* and *BC-B* if the maximum cargo density is less than 3.0t/m^3, see also **Ch 4, Sec 8, 4.1**.
- {*No MP*} for all additional service features when the ship has not been designed for loading and unloading in multiple ports in accordance with the conditions specified in **Ch 4, Sec 8, 4.2.2**.
- {*Holds a, b, … may be empty*} for additional service feature *BC-A*, see also **Ch 4, Sec 8, 4.1**.
- {*Block loading*} for additional service feature *BC-A*, when the ship is intended to operate in alternate block load condition, see also **Ch 4, Sec 8, 4.2.3 (d)**.

Section 3 VERIFICATION OF COMPLIANCE

2. Documents to be Submitted

2.2 Submission of plans and supporting calculations

Paragraph 2.2.3 has been amended as follows.

2.2.3 Plans and instruments to be supplied onboard the ship

As a minimum, the following plans and instrument are to be supplied onboard:

(a) One copy of the following plans indicating the newbuilding and renewal thickness for each structural item is to be supplied onboard the ship: plans of midship sections, construction profiles, shell expansion, transverse bulkheads, aft and fore part structures, machinery space structures ~~and casing~~.
One copy of the following plans indicating the newbuilding thickness for each structural item is to be supplied onboard the ship: plans of superstructures, ~~and~~ deckhouses and casing.

(b) One copy of the final approved loading manual, see **2.1.1**.

(c) One copy of the final approved loading instrument, see **2.1.1**.

(d) Welding.

(e) Details of the extent and location of higher tensile steel together with details of the specification and mechanical properties, and any recommendations for welding, working and treatment of these steels.

(f) Details and information on use of special materials, such as an aluminium alloy, used in the hull construction.

(g) Towing and mooring arrangements plan, see **Ch 11**, **Sec 3**.

(h) Structural access manual.

(i) Structural details for which post weld treatment methods are applied, showing the description of the details and their locations.

Other plans or instrument may be required by the Society.

Chapter 2 GENERAL ARRANGEMENT DESIGN

Section 3 COMPARTMENT ARRANGEMENT

1. Cofferdams

1.1 Definition

Paragraph 1.1.1 has been amended as follows.

1.1.1
A cofferdam means an empty space arranged so that compartments on each side have no common boundary; a cofferdam may be located vertically or horizontally. As a rule, a cofferdam is to be kept gas-tight and is to be properly ventilated, provided with drainage arrangement, and of sufficient size to allow proper inspection, maintenance and safe evacuation.

1.2 Arrangement of cofferdams

Paragraph 1.2.1 has been amended as follows.

1.2.1
Cofferdams are to be provided between compartments intended for liquid hydrocarbons (including fuel oil, lubricating oil) and those intended for fresh water (~~drinking water,~~ water for propelling machinery and boilers) as well as tanks intended for the carriage of liquid foam for fire extinguishing.

Paragraph 1.2.4 has been added as follows.

1.2.4
The cofferdams specified in **1.2.1** may be waived when deemed impracticable or unreasonable by the Society in relation to the characteristics and dimensions of the spaces containing such tanks, provided that:

- the thickness of common boundary plates of adjacent tanks is increased, with respect to the thickness obtained according to **Ch 6, Sec 4**, by 2 *mm* in the case of tanks carrying fresh water or boiler feed water, and by 1*mm* in all other cases,
- the sum of the throats of the weld fillets at the edges of these plates is not less than the thickness of the plates themselves,
- the structural test is carried out with a test pressure increased by 1 *m* with respect to **Ch 1, Sec 2, 3.8.4**.

Chapter 3 STRUCTURAL DESIGN PRINCIPLES

Section 1 MATERIALS

2. Hull Structural Steel

2.3 Steel grades

Paragraph 2.3.1 has been amended as follows.

2.3.1

Materials in the various strength members are not to be of lower grade than those corresponding to the material classes and grades specified in **Table 3** to **Table ~~8~~7**. General requirements are given in **Table 3**, while additional minimum requirements for ships with length exceeding 150*m* and 250*m*, single side bulk carriers with length exceeding 150*m*~~, and ships with ice strengthening~~ are given in **Table 4** to **Table ~~7~~6**. The material grade requirements for hull members of each class depending on the thickness are defined in **Table ~~8~~7**.

Table 7 has been deleted.

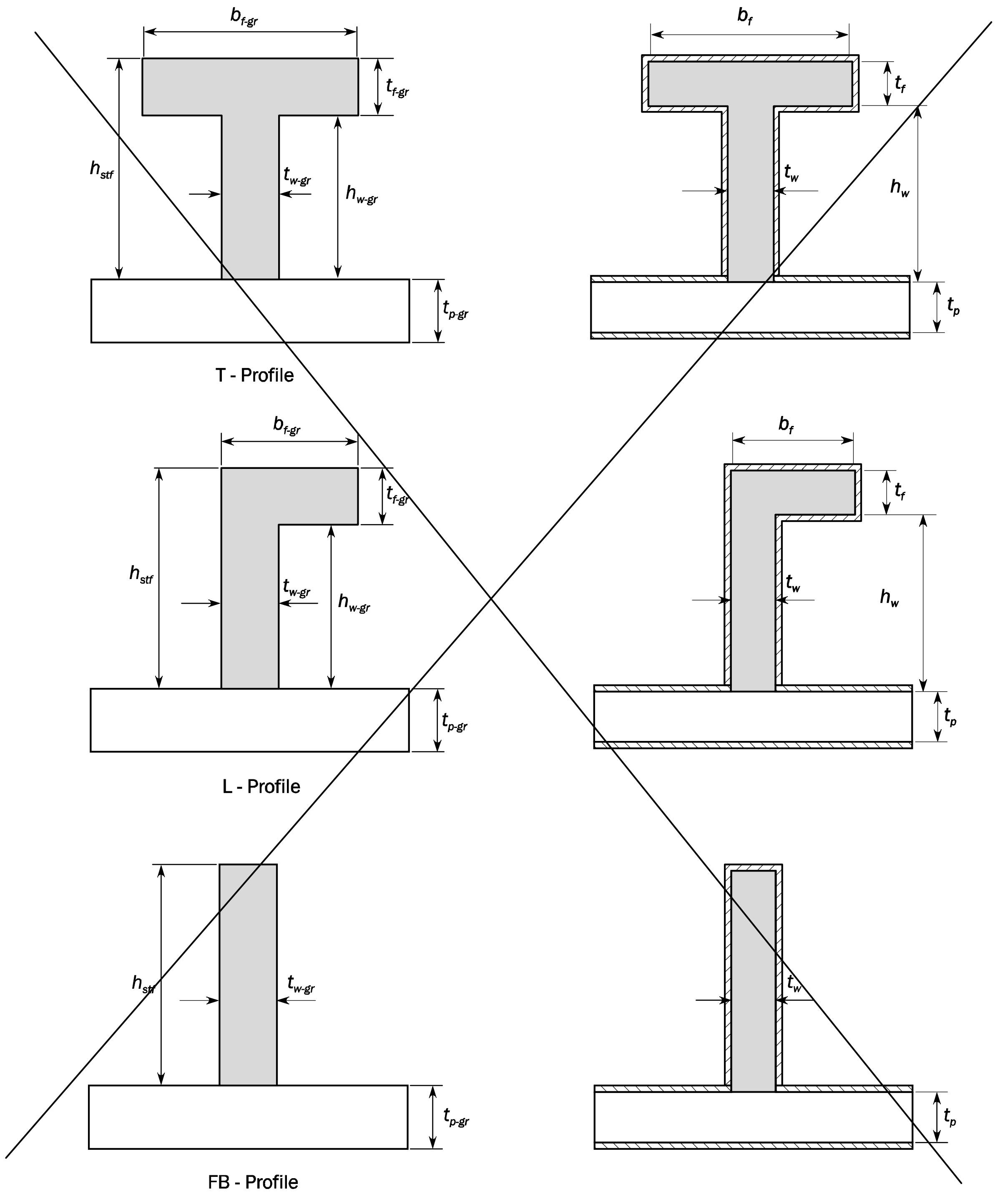
~~Table 7 Minimum material grades for ships with ice strengthening~~

~~Structural member category~~	~~Material grade~~
~~Shell strakes in way of ice strengthening area for plates~~	~~Grade *B/AH*~~

Section 2 NET SCANTLING APPROACH

Fig. 2 has been amended as follows.

Fig. 2 Net sectional properties of local supporting members



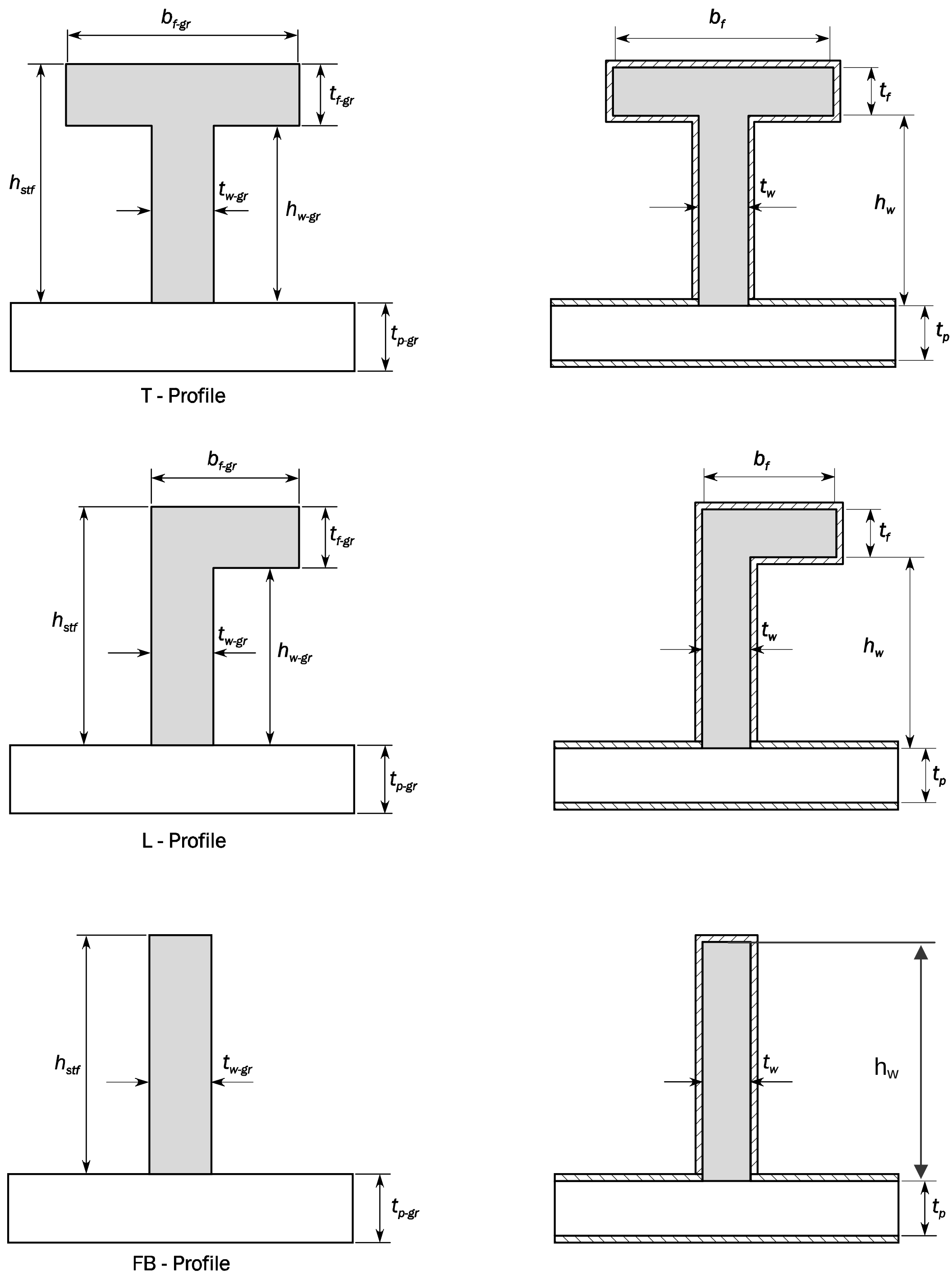
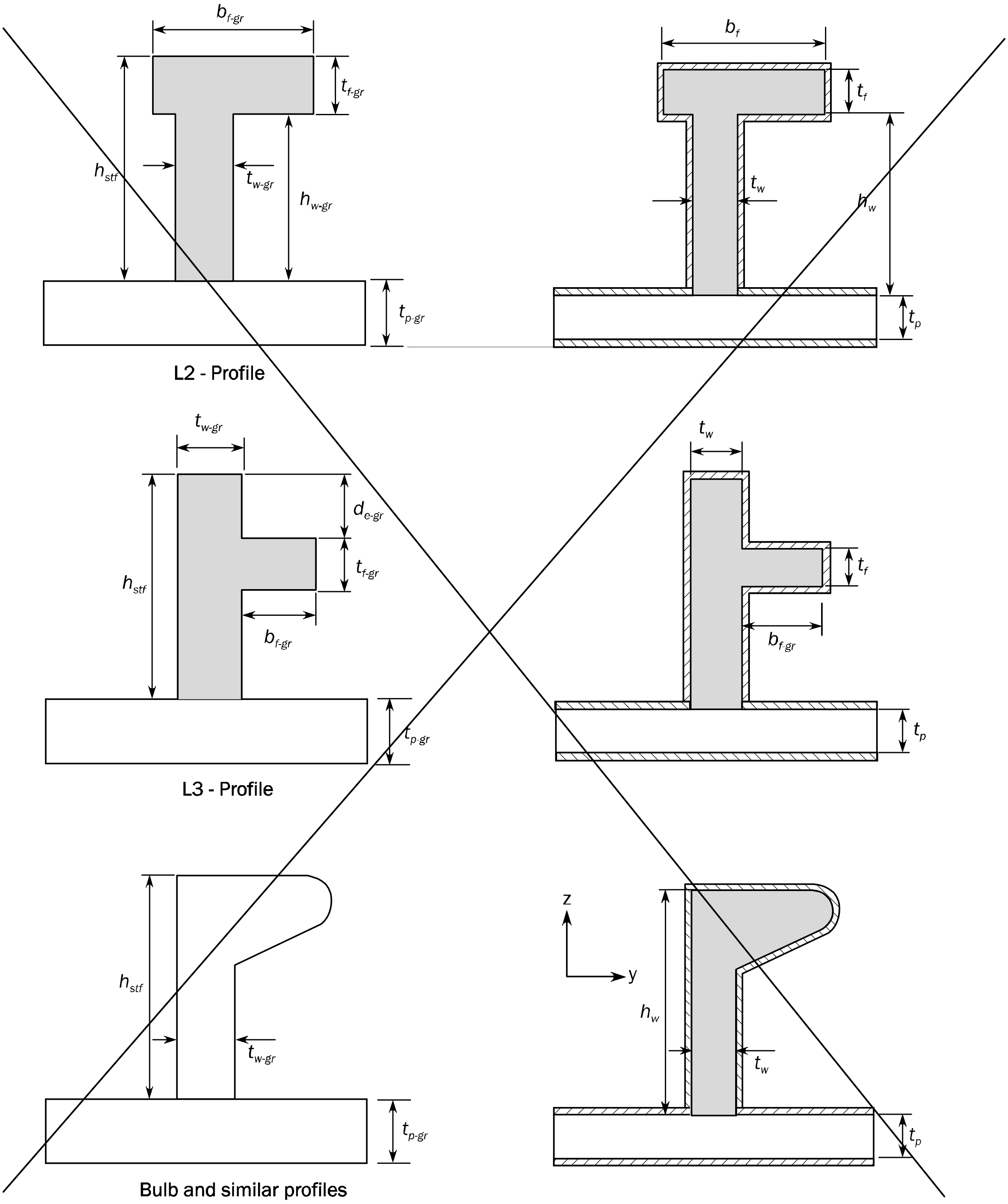
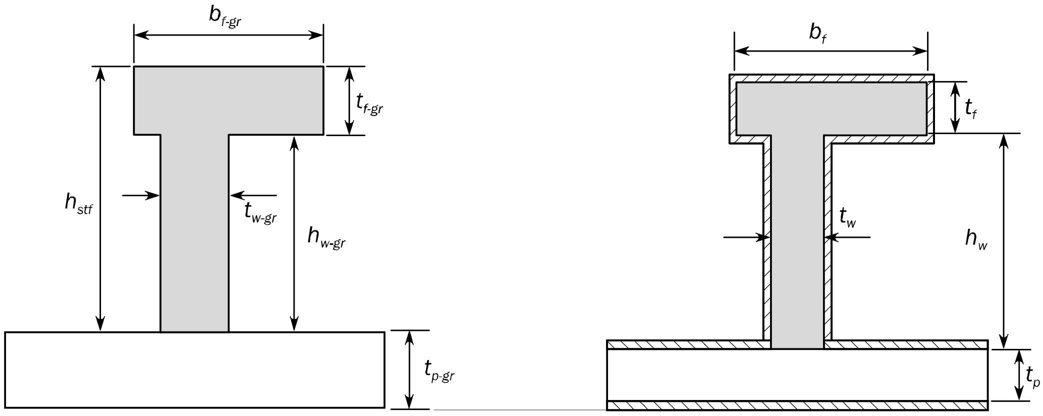

b_f-gr
t_f-gr
h_stf
t_w-gr
h_w-gr
t_p-gr
T - Profile
b_f
t_f
t_w
h_w
t_p
b_f-gr
t_f-gr
h_stf
t_w-gr
h_w-gr
t_p-gr
L - Profile
b_f
t_f
t_w
h_w
t_p
h_stf
t_w-gr
t_p-gr
FB - Profile
t_w
h_W
t_p

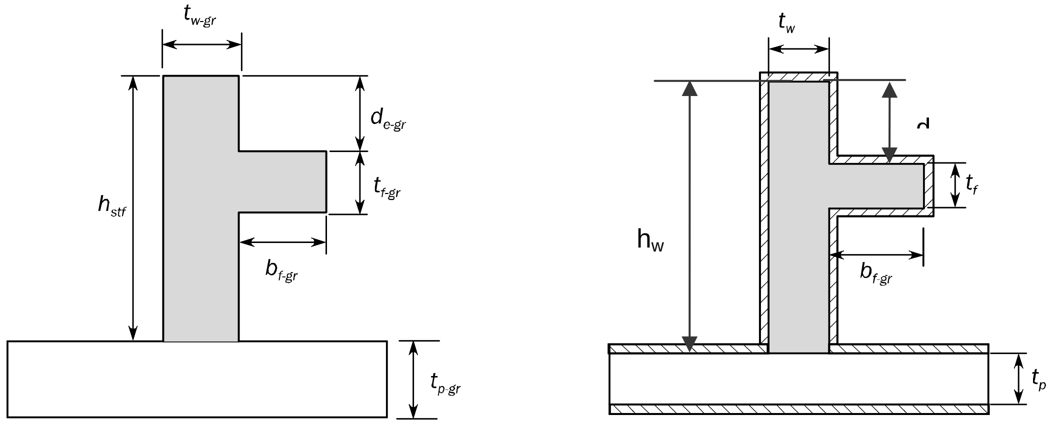
Fig. 3 has been amended as follows.

Fig. 3 Net sectional properties of local supporting members (continued)

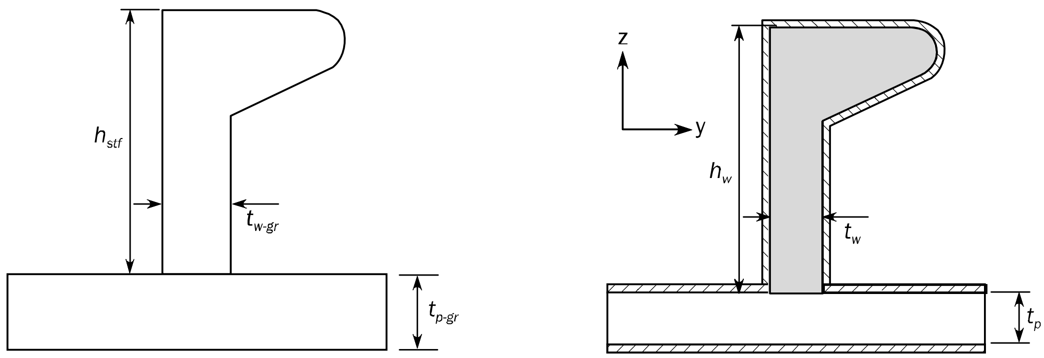




L2 - Profile



L3 - Profile



Bulb and similar profiles

Section 3 CORROSION ADDITIONS

1. General

1.2 Corrosion addition determination

1.2.1

Note (7) of Table 1 has been amended as follows.

(7) If there is no lower stool fitted (i.e. engine room bulkhead or fore peak bulkhead) or if a plane bulkhead is fitted, then this corrosion addition should be applied up to a height level with the opposing bulkhead stool in that hold. In the case where a stool is not fitted on the opposing bulkhead, the vertical extent of this zone is to be from the inner bottom to a height level with the top of the adjacent hopper sloping plate, but need not be taken as more than 3 *m*.

Section 6 STRUCTURAL DETAIL PRINCIPLES

4. Primary Supporting Members (PSM)

4.4 End connections

Paragraph 4.4.2 has been amended as follows.

4.4.2 Scantling of end brackets

In general, the arm lengths of brackets connecting PSMs, as shown in **Fig. 5** are not to be less than the web depth of the member, and need not be taken greater than 1.5 times the web depth.

Within the cargo hold region the ~~The~~ thickness of the bracket is, in general, not to be less than that of the adjoining PSM web plate. Outside of the cargo hold region the thickness of the bracket is not to be less than that of the PSM web plate.

Scantlings of the end brackets are to be such that the section modulus of the PSM with end bracket, excluding face plate where it is sniped, is not to be less than that of the primary supporting member at mid-span.

The net cross sectional area, A_f, in cm^2, of face plates of brackets is not to be less than:

$$A_f = \ell_b t_b$$

where:

ℓ_b: Length of bracket edge, in *m*, see **Fig. 5**. For brackets that are curved, the length of the bracket edge may be taken as the length of the tangent at the midpoint of the edge.

t_b: Minimum net bracket thickness, in *mm*, as defined in **3.2.4**.

Moreover, the net thickness of the face plate is to be not less than that of the bracket web.

5. Intersection of Stiffeners and Primary Supporting Members

5.1 Cut-outs

Paragraph 5.1.6 has been amended as follows.

5.1.6

~~In general, c~~Cut-outs are to have rounded corners and the corner radii, *R*, are to be as large as practicable, with a minimum of 20% of the breadth, *b*, of the cut-out or 25*mm*, whichever is greater. The corner radii, *R*, does not need to be greater than 50*mm*, see **Fig. 7**. Consideration is to be given to other shapes on the basis of maintaining equivalent strength and minimising stress concentration.

6. Openings

6.1 Openings and scallops in stiffeners

Paragraph 6.1.3 has been amended as follows.

6.1.3

Closely spaced scallops or drain holes, i.e. where the distance between scallops/drain holes is less than twice the width *b* as shown in **Fig. 11**, are not permitted in stiffeners contributing to the longitudinal strength. For other stiffeners, closely spaced scallops/drain holes are not permitted within 20% of the stiffener span measured from the end of the stiffener. Widely spaced air or drain holes may be permitted provided that they are of elliptical shape or equivalent to minimise stress concentration and are~~, in general,~~ cut clear of the welds.

7. Double Bottom Structure

7.1 General

Paragraph 7.1.2 has been amended as follows.

7.1.2 Variation in height of double bottom

Any variation in the height of the double bottom is ~~generally~~ to be made gradually and over an adequate length; the knuckles of inner bottom plating are to be located in way of plate floors. Where such arrangement is not possible, suitable longitudinal structures such as partial girders, longitudinal brackets, fitted across the knuckle are to be arranged.

7.5 Bilge keel

Paragraph 7.5.2 has been amended as follows.

7.5.2 Design

The design of single web bilge keels is to be such that failure to the web occurs before failure of the ground bar. ~~In general, t~~This may be achieved by ensuring the web thickness of the bilge keel does not exceed that of the ground bar.

Bilge keels of a different design, from that shown in **Fig. 18**, are to be specially considered by the Society.

10. Bulkhead Structure

10.4 Corrugated bulkheads

Paragraph 10.4.1 has been amended as follows.

10.4.1 General

For ~~bulk carriers of 190*m* of length L_{CSR} and above and for oil tankers~~ ships of 18 *m* moulded depth and above, the transverse vertically corrugated watertight bulkheads are to be fitted with a lower stool, and generally with an upper stool below deck. For ship of 16*m* moulded depth and above, the transverse vertically corrugated watertight bulkheads subject to liquid pressure, e.g. tank bulkheads and ballast hold bulkheads, are to be fitted with a lower stool, and generally with an upper stool below deck. ~~For bulk carriers having length L_{CSR} less than 190*m* and for oil tankers having a moulded depth less than 16*m*,~~ Otherwise corrugations may extend from inner bottom to deck.

10.5 Non-tight bulkheads

Paragraph 10.5.1 has been amended as follows.

10.5.1 General

In general, openings in wash bulkheads are to have generous radii and their aggregate area is not to be less than 10% of the area of the bulkhead. The area of non-tight bulkhead is the whole cross sectional area in one plane that covers the tank boundaries.

11. Pillars

11.2 Connections

Paragraph 11.2.1 has been amended as follows.

11.2.1

Heads and heels of pillars are to be secured by thick doubling plates and brackets as necessary. Alternative arrangements for doubling plates may be accepted, provided that they are considered equivalent as deemed appropriate by the Society. Where the pillars are likely to be subjected to tensile loads, the head and heel of pillars are to be efficiently secured to withstand the tensile loads and the doubling plates replaced by insert plate.

~~In general, t~~The net thickness of doubling plates, when fitted, is to be not less than 1.5 times the net thickness of the pillar. Pillars are to be attached at their heads and heels by continuous welding.

Section 7 STRUCTURAL IDEALISATION

1. Structural Idealisation of Stiffeners and Primary Supporting Members

1.1 Effective spans

Paragraphs 1.1.3 and 1.1.8 have been amended as follows.

1.1.3 Effective shear span of stiffeners

(Omitted)

For curved and/or long brackets (high length/height ratio), the effective bracket length is to be taken as the maximum inscribed 1:1.5 right angled triangle as shown in item **(c)** of both **Fig. 4** and **Fig. 5**.

(Omitted)

1.1.8 Effective bracket definition

The effective bracket is defined as the maximum size of right angled triangular bracket with a length to height ratio of 1.5 that fits inside the fitted bracket. See **Fig. 9** for examples.

1.4 Geometrical properties of stiffeners and primary supporting members

Paragraphs 1.4.3, 1.4.4 and 1.4.6 have been amended as follows.

1.4.3 Effective shear depth of stiffeners

The effective shear depth of stiffeners, d_{shr}, in *mm*, is to be taken as:

$$d_{shr} = \left(h_{stf} + t_p\right)\sin\varphi_w$$

where:

h_{stf}: Height of stiffener, in *mm*, as defined in **Ch 3**, **Sec 2**, **Fig.2**.

t_p: Net thickness of the stiffener attached plating, in *mm*, as defined in **Ch 3**, **Sec 2**, **Fig. 2**.

φ_w: Angle, in *deg*, as defined in **Fig. 14**. φ_w is to be taken as 90 degrees if the angle is greater than or equal to 75 degrees.

1.4.4 Elastic net section modulus of stiffeners

The elastic net section modulus, Z of stiffeners, in cm^3, is to be taken as:

$$Z = Z_{stf}\sin\varphi_w$$

where:

Z_{stf}: Net section modulus of the stiffener, in cm^3, considered perpendicular to its attached plate, i.e. with $\varphi_w = 90$ *deg*.

φ_w: Angle, in *deg*, as defined in **Fig. 14**. φ_w is to be taken as 90 degrees if the angle is greater than or equal to 75 degrees.

1.4.6 Effective net plastic section modulus of stiffeners

(Omitted)

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

- For *T*, *L* (rolled and built-up) ~~and *L2*~~ profiles and flat bar, as defined in **Ch 3**, **Sec 2**, **Fig. 2**,
  ~~$h_w = h_{stf} - t_{f\text{-}net}$.~~
- For ~~flat bar~~ *L2* and *L3* profiles as defined in **Ch 3**, **Sec 2**, **Fig. ~~2~~3**, ~~$h_w = h_{stf}$.~~
- For bulb profiles, to be taken ~~as given in **Table 1** and **Table 2**~~ as defined in **Ch 3, Sec 2, Fig. 3**.

(Omitted)

2. Plates

2.2 Load calculation point

2.2.2 Buckling

For the prescriptive buckling check of the *EPP* according to **Ch 8**, **Sec 3**, the *LCP* for the pressure and for the hull girder stresses are defined in **Table 5**.

For the FE buckling check, **Ch 8, Sec 4** is applicable.

Table 5 has been amended as follows.

Table 5 *LCP* coordinates for plate buckling

LCP coordinates	*LCP* for pressure	*LCP* for hull girder stresses (**Fig. 23**)		
		Bending stresses(1)		Shear stresses
		Non horizontal plate	Horizontal plate	
x coordinate	Same coordinates as *LCP* for yielding See **Table 4**	Mid-length of the *EPP*		
y coordinate		Both upper and lower ends of the *EPP* (points *A*1 and *A*2)	Outboard and inboard ends of the *EPP* (points *A*1 and *A*2)	Mid-point of *EPP* (point *B*)
z coordinate		Corresponding to *x* and *y* values		
(1) the bending stress for curved plate panel is the mean value of the stresses calculated at points *A*1 and *A*2.				

Chapter 4 LOADS

Section 4 HULL GIRDER LOADS

2. Vertical Still Water Hull Girder Loads

2.3 Vertical still water shear force

Paragraph 2.3.4 has been amended as follows.

2.3.4 Permissible still water shear force in harbour/sheltered water and tank testing condition

(Omitted)

Q_{wv}: Vertical wave shear force for strength assessment Q_{wv-pos} and Q_{wv-neg}, as defined in ~~2.3.1~~ **3.2.1** using f_p equal to 1.0.

3. Dynamic Hull Girder Loads

3.4 Wave torsional moment

Paragraph 3.4.1 has been amended as follows.

3.4.1

The wave torsional moment at any longitudinal position with respect to the ship baseline, in *kNm*, is to be taken as:

$$M_{wt} = f_p\left(M_{wt1} + M_{wt2}\right)$$

where:

$$M_{wt1} = 0.4 f_{t1} C_w \sqrt{\frac{L_{CSR}}{T_{LC}}} B^2 D C_B$$

$$M_{wt2} = 0.22 f_{t2} C_w L_{CSR} B^2 C_B$$

f_{t1}, f_{t2}: Distribution factors, taken as:

$f_{t1} = 0$ for $x < 0$

$f_{t1} = \left|\sin\left(\frac{2\pi x}{L_{CSR}}\right)\right|$ for $0 \le x \le L_{CSR}$

$f_{t1} = 0$ for $x > L_{CSR}$

$f_{t2} = 0$ for $x < 0$

$f_{t2} = \sin^2\left(\frac{\pi x}{L_{CSR}}\right)$ for $0 \le x \le L_{CSR}$

$f_{t2} = 0$ for $x > L_{CSR}$

f_p: Coefficient to be taken as:

$f_p = f_{ps}$ for strength assessment.

~~$f_p = 0.9\left[0.24 + \left(6 f_T - 5\right) B \times 10^{-4}\right]$~~ for fatigue assessment.

$f_p = 0.9[0.2 + \left(5 f_T - 4.25\right) B \times 10^{-4}]$

Section 5 EXTERNAL LOADS

Table 22 has been amended as follows.

Table 22 k_p values for ~~*HSM*~~<u>*FSM*</u> load cases

f_{xL}	k_p
0	$-0.75-0.25f_{yB}$
$0.35-0.1f_T$	-1
$0.5-0.2f_T$	1
0.75	1
$0.9-0.1f_T$	-1
1.0	$-0.5-0.5f_{yB}$

Table 29 has been amended as follows.

Table 29 k_p values for *OST* load cases

Transverse position	f_{xL}	*OST-1P - OST-2P*	*OST-1S - OST-2S*
$y \geq 0$	0.0	1.0	$1.0+(0.5-f_T)f_{yB}$
	0.2	1.0	$1.0+3(0.5-f_T)f_{yB}$
	0.4	-1.0	$(2.7-2.4f_T)f_{yB}-1$
	0.5	-1.0	$(2.8-2.6f_T)f_{yB}-1$
	0.7	$(f_T-0.62)f_{yB}-0.38$	$(2.38-3f_T)f_{yB}-0.38$
	0.9	$0.24+0.76f_{yB}$	$0.24-(0.24+f_T)f_{yB}$
	1.0	$-1.0+0.5f_{yB}$	-1.0
~~$y=0$~~ <u>$y<0$</u>	0.0	$1.0+(0.5-f_T)f_{yB}$	1.0
	0.2	$1.0+3(0.5-f_T)f_{yB}$	1.0
	0.4	$(2.7-2.4f_T)f_{yB}-1$	-1.0
	0.5	$(2.8-2.6f_T)f_{yB}-1$	-1.0
	0.7	$(2.38-3f_T)f_{yB}-0.38$	$(f_T-0.62)f_{yB}-0.38$
	0.9	$0.24-(0.24+f_T)f_{yB}$	$0.24+0.76f_{yB}$

Section 6 INTERNAL LOADS

Symbols have been amended as follows.

Symbols

(Omitted)

M : Mass, in t, of the bulk cargo being considered.

M_{Full}: Cargo mass, in t, in a cargo hold corresponding to the volume up to the top of the hatch coaming with a density of the greater of M_H/V_{Full} or 1.0 t/m^3.

$M_{Full} = 1.0\ V_{Full}$ but not less than M_H.

M_H : Cargo mass, in t, in a cargo hold that corresponds to the homogeneously loaded condition at maximum draught with 50% consumables.

M_{HD}: Maximum allowable cargo mass, in t, in a cargo hold according to design loading conditions with specified holds empty at maximum draught with 50% consumables and all ballast water tanks in cargo hold region empty.

$M_{sc\text{-}ib}$: Equivalent mass of a steel coil, in t, on inner bottom, as defined in **4.3.1**

$M_{sc\text{-}hs}$: Equivalent mass of a steel coil, in t, on hopper side, as defined in **4.3.2**.

n_1 : Number of tiers of steel coils.

n_2 : Number of load points per EPP of the inner bottom, see **4.1.3**.

n_3 : Number of dunnages supporting one row of steel coils.

P_{drop}: Overpressure, in kN/m^2, due to sustained liquid flow through air pipe or overflow pipe in case of overfilling or filling during flow through ballast water exchange. It is to be defined by the designer, but not to be less than 25 kN/m^2.

P_{PV} : Setting of pressure relief valve, in kN/m^2, if fitted, but not less than 25 kN/m^2.

$perm$: Permeability of cargo, to be taken as:

$perm$ = 0.3 for iron ore, coal cargoes and cement.

$perm$ = 0 for steel coils and steel packed products.

(Omitted)

1. Pressures Due to Liquids

1.1 Application

Paragraph 1.1.2 has been amended as follows.

1.1.2 Pressures for the strength assessments of flooded conditions

The internal pressure in flooded condition, in kN/m^2, acting on any load point of the watertight boundary of a hold, tank or other space for the flooded static (S) design load scenarios, given in **Ch 4, Sec 7**, is to be taken as:

$$P_{in} = P_{fs} \text{ but not less than } \rho g d_0$$

The internal pressure in flooded condition, in kN/m^2, acting on any load point of the watertight boundary of a hold, tank or other space for the flooded static plus dynamic (S+D) design load scenarios, is to be derived for each dynamic load case and is to be taken as:

$$P_{in} = P_{fs} + P_{fd} \text{ but not less than } \rho g d_0$$

where:

P_{fs}: Static pressure of seawater in flooded condition in the compartment, in kN/m^2, as defined in **1.4**.

P_{fd}: Dynamic inertial pressure of seawater in flooded condition in the compartment, in kN/m^2, as defined in **1.5**.

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

$d_0 = 0.02 L_{CSR}$ for $L_{CSR} < 120m$

$d_0 = 2.4$ for $L_{CSR} \geq 120m$

For corrugations of vertically corrugated bulkheads of bulk carrier cargo holds, the flooded pressures and forces specified in **3** for bulk cargoes are to be applied.

~~For cargo holds carrying steel products, the requirements for pressures and forces in **4** are to be applied.~~

3. Pressures and Forces Due to Dry Cargoes in Flooded Conditions

3.1 Vertically corrugated transverse watertight bulkheads

3.1.3 Flooded level

The flooded level z_F is the distance, in *m*, measured vertically from the baseline with the ship in the upright position, and obtained from **Table 4**.

Table 4 has been amended as follows.

Table 4 Flooded level z_F, in *m*, for vertically corrugated transverse bulkheads

~~Bulk carrier type~~	~~Vertically corrugated transverse bulkhead position~~	
	~~Foremost~~	~~Others~~
~~Bulk carriers less than 50,000 *t* deadweight with Type B freeboard~~	~~$z_F = 0.95\ D_1$~~	~~$z_F = 0.85\ D_1$~~
	~~$z_F = 0.9\ D_1$ (1)~~	~~$z_F = 0.8\ D_1$ (1)~~
~~Other bulk carriers~~	~~$z_F = D_1$~~	~~$z_F = 0.9\ D_1$~~
	~~$z_F = 0.95\ D_1$ (1)~~	~~$z_F = 0.85\ D_1$ (1)~~
~~(1) For ships carrying cargoes having bulk density less than 1.78 t/m^3 in non-homogeneous loading conditions.~~		

Bulk carrier type	Loading Condition	Vertically corrugated transverse bulkhead position	
		Foremost	Others
Bulk carriers less than 50,000 *t* deadweight with Type B freeboard	Non-homogeneous loading conditions with cargo density less than 1.78 t/m^3	$z_F = 0.9\ D_1$	$z_F = 0.8\ D_1$
	Other cases	$z_F = 0.95\ D_1$	$z_F = 0.85\ D_1$
Other bulk carriers	Non-homogeneous loading conditions with cargo density less than 1.78 t/m^3	$z_F = 0.95\ D_1$	$z_F = 0.85\ D_1$
	Other cases	$z_F = D_1$	$z_F = 0.9\ D_1$

Section 8 LOADING CONDITIONS

2. Common Design Loading Conditions

2.2 Partially filled ballast tanks

Paragraph 2.2.1 has been amended as follows.

2.2.1 Partially filled ballast tanks in ballast loading conditions

Ballast loading conditions involving partially filled peak and/or other ballast tanks in any departure, arrival or intermediate condition are not permitted to be used as design loading conditions unless:

- ~~Stress levels are within the Rule acceptance criteria for~~ Longitudinal strength of hull girder given in **Ch 5, Sec 1** and **Ch 8, Sec 3** is to comply with loading conditions with the considered tanks full, empty and partially filled at intended level in any departure, arrival or intermediate condition.
- For bulk carriers having a length L_{CSR} of 150*m* or above, longitudinal strength of hull girder in flooded condition given in **Ch 5**, **Sec 1** is to comply with loading conditions with the considered tanks full, empty and partially filled at intended level in any departure, arrival or intermediate condition.

The corresponding full, empty and partially filled tank conditions are to be considered as design conditions for calculation of the still water bending moment and shear force, but these do not need to comply with propeller immersion and trim requirements as specified in **2.3.1**, **3.1.1** or **4.1.1**.

Where multiple tanks are intended to be partially filled, all combinations of empty, full and partially filled at intended levels for those tanks are to be investigated. These requirements are not applicable to ballast water exchange using the sequential method.

2.4 Harbour and sheltered water conditions

2.4.1

Sub paragraph 2.4.1(c) has been amended as follows.

The following harbour and sheltered water conditions are to be included in the loading manual:

(a) Conditions representing typical complete loading and unloading operations.

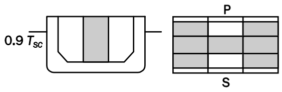
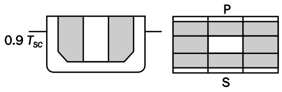
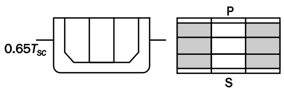
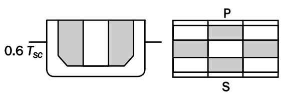
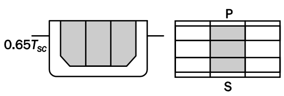
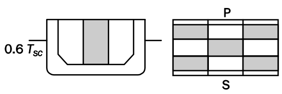
(b) Docking condition afloat.

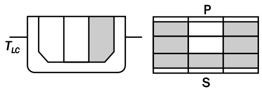
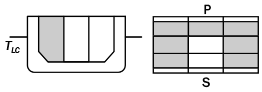
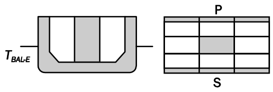
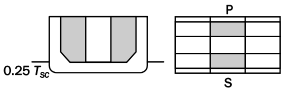
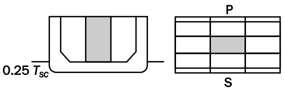
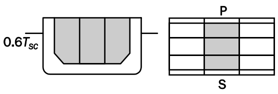
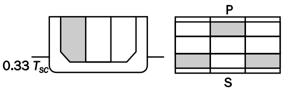
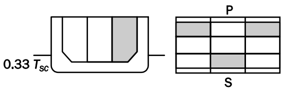
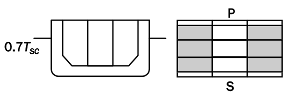
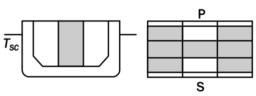
(c) Propellers inspection afloat condition, in which the propeller shaft centreline is at least $D_p/4$ above the waterline in way of the propeller. Ships with podded propulsion system arrangements are to be individually considered by the Society.

3. Oil Tankers

Table 2 has been amended as follows.

Table 2 Load combinations for FE analysis for two oil-tight bulkheads oil tankers applicable to midship cargo hold region

No.	Loading pattern	Still water loads			Dynamic load cases		
		Draught	$C_{BM\text{-}LC}$: % of perm. SWBM	$C_{SF\text{-}LC}$: % of perm. SWSF	Midship cargo region		
Seagoing conditions							
A1		$0.9T_{SC}$	100% (sagging)	100%	HSM-1	~~BSR-1P/S~~ BSP-1P/S	~~OST-1P/S~~ N/A
			100% (hogging)	100%	HSM-2 FSM-2	BSP-1P/S	OST-2P/S OSA-1P/S
A2		$0.9T_{SC}$	100% (sagging)	100%	HSM-1 ~~HSA-1~~	BSR-1P/S BSP-1P/S	~~OSA-1P/S~~ N/A
			100% (hogging)	100%	HSM-2 FSM-2	BSR-1P/S BSP-1P/S	N/A
A3		$0.65T_{SC}$	100% (hogging)	100% (4) Max SFLC	HSM-2	N/A	N/A
				100% (5) Max SFLC	HSM-2	N/A	N/A
				100%	N/A	~~BSR-1P/S~~ BSP-1P/S	~~OSA-2P/S~~ N/A
			0%	100% (6) Max SFLC	HSM-1	N/A	N/A
				100%	N/A	BSP-1P/S	N/A
A4		$0.6T_{SC}$	100% (sagging)	100%	HSM-1	BSR-1P/S BSP-1P/S	~~OST-2P/S~~ OSA-2P/S
A5		$0.65T_{SC}$	100% (sagging)	100% (4) Max SFLC	HSM-1	N/A	N/A
				100% (5) Max SFLC	HSM-1	N/A	N/A
				100%	N/A	~~BSR-1P/S~~ BSP-1P/S	~~OSA-2P/S~~ N/A
			0%	100% (6) Max SFLC	HSM-2	N/A	N/A
				100%	N/A	BSP-1P/S	N/A
A6		$0.6T_{SC}$	100% (hogging)	100%	HSM-2 ~~FSM-2~~	BSR-1P/S BSP-1P/S	OSA-~~2~~1P/S

A7a		T_{LC}	100% (hogging)	100%	HSM-2 FSM-2	BSR-1P/S BSP-1P/S	OST-2P/S OSA-1P/S OSA-2P/S
A7b		T_{LC}	100% (hogging)	100%	HSM-2 FSM-2	BSR-1P/S BSP-1P/S	OST-2P/S OSA-1P/S OSA-2P/S
A8		T_{BAL-E}	100% (sagging)	100%	HSM-1	BSR-1P/S BSP-1P/S	OSA-2P/S
Harbour and testing conditions							
A9		$0.25T_{SC}$	100% (sagging)	100%	N/A		
A10		$0.25T_{SC}$	100% (sagging)	100%	N/A		
A11		$0.6T_{SC}$	100% (sagging)	100% (2) Max SFLC	N/A		
				100% (3) Max SFLC	N/A		
A12a(1)		0.33 T_{SC}	N/A	N/A	N/A		
A12b(1)		$0.33T_{SC}$	N/A	N/A	N/A		
A13		$0.7T_{SC}$	100% (hogging)	100% (2) Max SFLC	N/A		
				100% (3) Max SFLC	N/A		
A14		T_{SC}	100% (hogging)	100%	N/A		

(1) The actual shear force and bending moment that results from the application of local loads to the FE model are to be used. Adjusting vertical loads and bending moments are not applied.

(2) The shear force is to be adjusted to target value at aft bulkhead of the mid-hold.

(3) The shear force is to be adjusted to target value at forward bulkhead of the mid-hold.

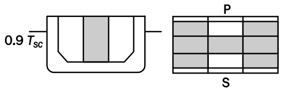
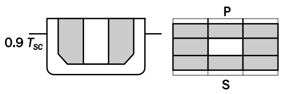
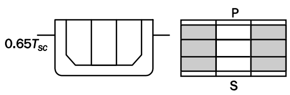
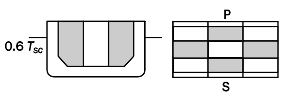
(4) For the mid-hold where $x_{b-aft} \le 0.5L_{CSR}$ and $x_{b-fwd} \ge 0.5L_{CSR}$, the shear force is to be adjusted to target value at aft bulkhead of the mid-hold.

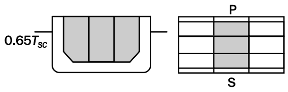
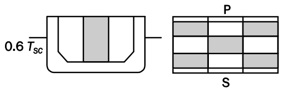
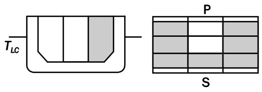
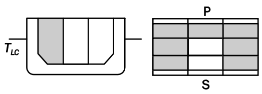
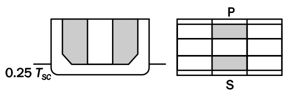
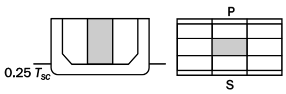
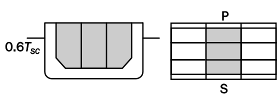
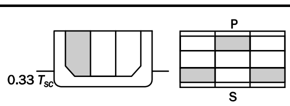
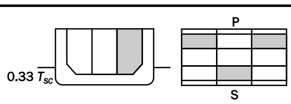
(5) For the mid-hold where $x_{b-aft} \le 0.5L_{CSR}$ and $x_{b-fwd} \ge 0.5L_{CSR}$, the shear force is to be adjusted to target value at forward bulkhead of the mid-hold.

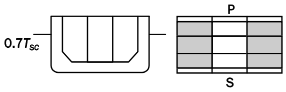
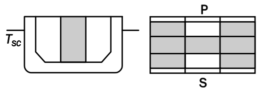
(6) This load combination is to be considered only for the mid-hold where $x_{b-aft} > 0.5L_{CSR}$ or $x_{b-fwd} < 0.5L_{CSR}$.

Table 4 has been amended as follows.

Table 4 Load combinations for FE analysis for two oil-tight bulkheads oil tankers applicable to outside midship cargo hold region

No.	Loading pattern	Still water loads			Dynamic load cases	
		Draught	C_{BM-LC} : % of perm. SWBM	C_{SF-LC} : % of perm. SWSF	Aft region	Forward region
Seagoing conditions						
A1		$0.9T_{SC}$	100% (sagging)	100%	HSM-1 BSP-1P/S ~~BSR-1P/S~~ ~~OST-1P/S~~	HSM-1 ~~FSM-1~~ BSP-1P/S ~~BSR-1P/S~~ ~~OST-1P/S~~
			100% (hogging)	100%	HSM-2 FSM-2 BSP-1P/S OST-2P/S OSA-1P/S	HSM-2 FSM-2 BSP-1P/S
A2		$0.9T_{SC}$	100% (sagging)	100%	HSM-1 BSP-1P/S	HSM-1 FSM-1 BSP-1P/S ~~BSR-1P/S~~ OSA-~~1~~2P/S
			100% (hogging)	100%	HSM-2 FSM-2 ~~HSA-2~~ BSP-1P/S ~~BSR-1P/S~~ ~~OST-2P/S~~ OSA-1P/S	HSM-2 ~~FSM-2~~ BSP-1P/S ~~BSR-1P/S~~ ~~OST-2P/S~~
A3		$0.65T_{SC}$	100% (hogging)	100% Max SFLC	HSM-2	HSM-2 FSM-2
				100%	BSP-1P/S	BSP-1P/S OSA-2P/S
			0%	100% Max SFLC	HSM-1	HSM-1
				100%	~~BSP-1P/S~~ N/A	BSP-1P/S OSA-2P/S
A4		$0.6T_{SC}$	100% (sagging)	100%	HSM-1 BSP-1P/S BSR-1P/S	HSM-1 BSP-1P/S BSR-1P/S OSA-2P/S

A5		$0.65T_{SC}$	100% (sagging)	100% Max SFLC	HSM-1 FSM-1	HSM-1
				100%	BSP-1P/S	BSP-1P/S OSA-2P/S
			0%	100% Max SFLC	HSM-2	HSM-2
				100%	BSP-1P/S	BSP-1P/S OSA-2P/S
A6		$0.6T_{SC}$	100% (hogging)	100%	HSM-2 BSP-1P/S BSR-1P/S	HSM-2 ~~FSM-2~~ BSP-1P/S BSR-1P/S OSA-2P/S
A7a		T_{LC}	100% (hogging)	100%	HSM-2 FSM-2 BSP-1P/S BSR-1P BSR-2S OSA-1P/S OSA-2P/S ~~OST-1S~~ OST-2P	HSM-2 FSM-2 BSP-1P/S BSR-1P BSR-2S OSA-2P/S ~~OST-2P/S~~
A7b		T_{LC}	100% (hogging)	100%	HSM-2 FSM-2 BSP-1P/S BSR-2P BSR-1S OSA-1P/S OSA-2P/S ~~OST-1P~~ OST-2S	HSM-2 FSM-2 BSP-1P/S BSR-2P BSR-1S OSA-2P/S ~~OST-2P/S~~
Harbour and testing conditions						
A9		$0.25T_{SC}$	100% (sagging)	100%	N/A	
A10		$0.25T_{SC}$	100% (sagging)	100%	N/A	
A11		$0.6T_{SC}$	100% (sagging)	100% (2) Max SFLC	N/A	
				100% (3) Max SFLC	N/A	
A12a(1)		$0.33T_{SC}$	N/A	N/A	N/A	
A12b(1)		$0.33T_{SC}$	N/A	N/A	N/A	

A13		0.7T_{SC}	100% (hogging)	100% (2) Max SFLC	N/A
				100% (3) Max SFLC	N/A
A14		T_{SC}	100% (hogging)	100%	N/A

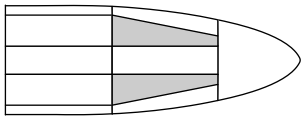
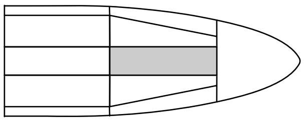
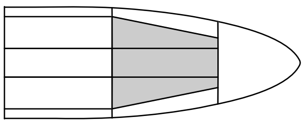
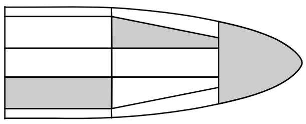
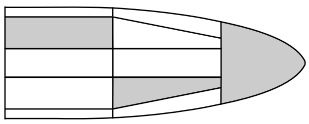
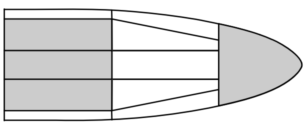
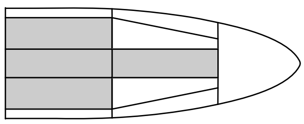
(1) The actual shear force and bending moment that results from the application of local loads to the FE model are to be used. Adjusting vertical loads and bending moments are not applied.

(2) The shear force is to be adjusted to target value at aft bulkhead of the mid-hold.

(3) The shear force is to be adjusted to target value at forward bulkhead of the mid-hold.

Table 6 has been amended as follows.

Table 6 Load combinations for FE analysis for two oil-tight bulkheads oil tankers applicable for foremost cargo hold

No.	Loading pattern	Still water loads			Dynamic load cases
		Draught	C_{BM-LC} : % of perm. SWBM	C_{SF-LC} : % of perm. SWSF	Foremost cargo hold
(Omitted)					
Harbour and testing conditions					
A9		$0.25T_{SC}$	100% (hogging)	100%	N/A
A10		$0.25T_{SC}$	100% (hogging)	100%	N/A
A11		$0.6T_{SC}$	100% (hogging)	100% (2) Max SFLC	N/A
				100% (3) Max SFLC	N/A
A12-a (1) <u>(4)</u>		$0.33T_{SC}$	N/A	N/A	N/A
A12-b (1), <u>(4)</u>		$0.33T_{SC}$	N/A	N/A	N/A
A13 (1)		$0.7T_{SC}$	100% (sagging)	100% (2) Max SFLC	N/A
				100% (3) Max SFLC	N/A
A14		T_{SC}	100% (sagging)	100%	N/A

(1) 100% filling of all fore peak water ballast tanks.

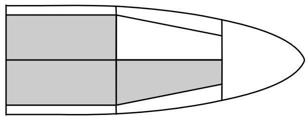
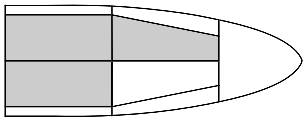
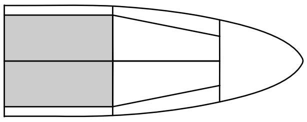
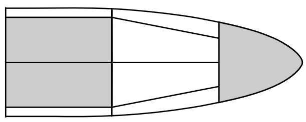
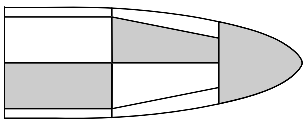
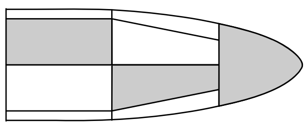
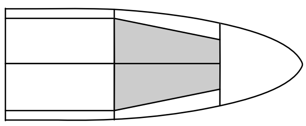
(2) The shear force is to be adjusted to target value at aft bulkhead of the mid-hold.

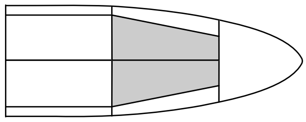
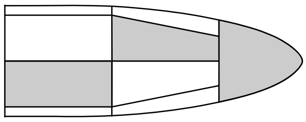
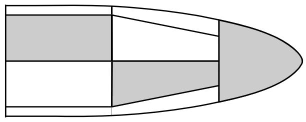
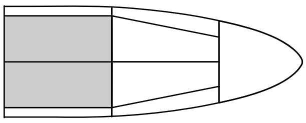
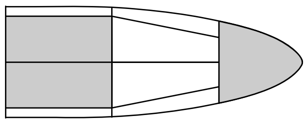
(3) The shear force is to be adjusted to target value at forward bulkhead of the mid-hold.

<u>(4) The actual shear force and bending moment that results from the application of local loads to the FE model are to be used. Adjusting vertical loads and bending moments are not applied.</u>

Table 7 has been amended as follows.

Table 7 Load combination for FE analysis for one centreline oil-tight bulkheads oil tankers applicable for foremost cargo hold

No.	Loading pattern	Still water loads			Dynamic load cases
		Draught	C_{BM-LC} : % of perm. SWBM	C_{SF-LC} : % of perm. SWSF	Foremost cargo hold
Seagoing conditions					
B1		$0.9T_{SC}$	100% (sagging)	100%	HSM-1 BSP-1P/S OSA-2P/S
B2		$0.9T_{SC}$	100% (sagging)	100%	HSM-1 BSP-1P/S OSA-2P/S
B3-1		$0.9T_{SC}$	100% (sagging)	100%	BSP-1P/S OSA-2P/S HSM-1
B3-2 [(1)]		$0.9T_{SC}$	0%	100% Max SFLC	HSM-2 ~~BSP-1P/S~~ ~~OSA-2P/S~~
				<u>100%</u>	<u>BSP-1P/S</u> <u>OSA-2P/S</u>
			100% (sagging)	100% Max SFLC	HSM-1 FMS-1
				100%	BSP-1P/S OST-1P/S OSA-2P/S
B4 [(1)]		$0.6T_{SC}$	100% (hogging)	75%	BSP-1P/S OSA-2P/S
B5 [(1)]		$0.6T_{SC}$	100% (hogging)	75%	BSP-1P/S OSA-2P/S
B6		$0.6T_{SC}$	0%	100% Max SFLC	HSM-1
				100%	OSA-2P/S
			100% (hogging)	100% Max SFLC	HSM-2 FSM-2 ~~OSA-2P/S~~
				<u>100%</u>	<u>OSA-2P/S</u>
Harbour and testing conditions					

B8		$0.33T_{SC}$	100% (hogging)	100% [(2)] Max SFLC	N/A
				100% [(3)] Max SFLC	N/A
B9 [(1)]		$0.33T_{SC}$	100% (hogging)	75%	N/A
B10 [(1)]		$0.33T_{SC}$	100% (hogging)	75%	N/A
B11-1		T_{SC}	100% (sagging)	100%	N/A
B11-2 [(1)]		T_{SC}	100% (sagging)	100% [(2)] Max SFLC	N/A
				100% [(3)] Max SFLC	N/A

(1) 100% filling of all fore end water ballast tanks.

(2) The shear force is to be adjusted to target value at aft bulkhead of the mid-hold.

(3) The shear force is to be adjusted to target value at forward bulkhead of the mid-hold.

4. Bulk Carriers

4.2 Design load combinations for direct strength analysis

Paragraph 4.2.4 has been amended as follows.

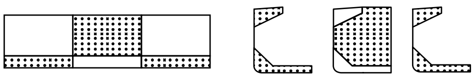
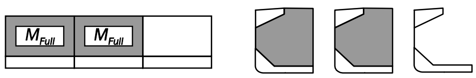
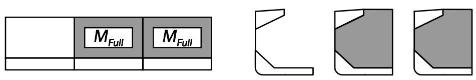
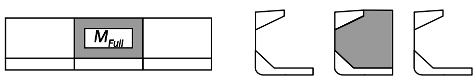
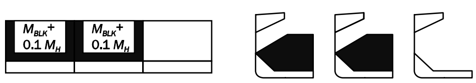
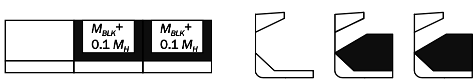
4.2.4 Heavy ballast condition

The following condition applies to ballast holds only:

- Cargo holds which are designed as ballast water holds, being 100% full of ballast water including hatchways, with all double bottom tanks in way of the cargo hold being 100% full, at any heavy ballast draught. For ballast holds adjacent to topside wing, hopper and double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when the topside wing, hopper stool and double bottom tanks are empty ~~except if this loading condition is explicitly prohibited in the loading manual~~.

Table 12 has been amended as follows.

Table 12 FE Load combinations applicable to empty hold in alternate condition of *BC-A* (EA) - midship cargo hold region

No.	Description Reqt ref	Loading pattern Aft Mid Fore	Draught	C_{BM-LC} : % of perm. SWBM	C_{SF-LC} : % of perm. SWSF	Dynamic load case
Seagoing conditions						
(Omitted)						
15[7] ~~[8]~~	Heavy ballast **4.2.4**		T_{Bal-H}	0%	100%	BSR-1P/S
				100% (sag.)	100%	BSR-1P/S
Harbour conditions						
16	Harbour condition **4.2.5 items a and c**		T_{H1}	100% (hog.)	100%	N/A
				100% (sag.)	100%	N/A
17	Harbour condition **4.2.5 items a and c**		T_{H1}	100% (hog.)	100%	N/A
				100% (sag.)	100%	N/A
18	Harbour condition **4.2.5 items a and b**		T_{H2}	100% (hog.)	100% [12] Max SFLC	N/A
					100% [13] Max SFLC	N/A
				100% (sag.)	100% [12] Max SFLC	N/A
					100% [13] Max SFLC	N/A
19[14]	Alt-block harbour condition **4.2.3 item d**		T_{H3}	100% (hog.)	100%	N/A
				100% (sag.)	100%	N/A
20[14]	Alt-block harbour condition **4.2.3 item d**		T_{H3}	100% (hog.)	100%	N/A
				100% (sag.)	100%	N/A

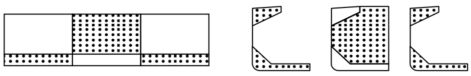
((1) to (7) are omitted)

(8) ~~This condition is not required when this loading condition is explicitly prohibited in the loading manual.~~(Void)

((9) to (14) are omitted)

Table 13 has been amended as follows.

Table 13 FE Load combinations applicable to loaded hold in alternate condition of *BC-A* (FA) - midship cargo hold region

No.	Description Reqt ref	Loading pattern Aft Mid Fore	Draught	C_{BM-LC} : % of perm. SWBM	C_{SF-LC} : % of perm. SWSF	Dynamic load case
Seagoing conditions						
(Omitted)						
15 (7) ~~(8)~~	Heavy ballast **4.2.4**		T_{Bal-H}	0%	100%	BSR-1P/S
				100% (sag.)	100%	BSR-1P/S
Harbour conditions						
(Omitted)						

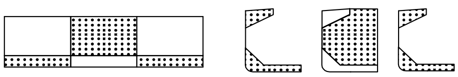
((1) to (7) are omitted)

(8) ~~This condition is not required when this loading condition is explicitly prohibited in the loading manual.~~ (Void)

((9) to (14) are omitted)

Table 14 has been amended as follows.

Table 14 FE Load combinations applicable for *BC-B* & *BC-C* - midship cargo hold region

No.	Description Reqt ref	Loading pattern Aft Mid Fore	Draught	C_{BM-LC} : % of perm. SWBM	C_{SF-LC} : % of perm. SWSF	Dynamic load case
Seagoing conditions						
(Omitted)						
11(6) ~~(7)~~	Heavy ballast **4.2.4**		T_{Bal-H}	0%	100%	BSR-1P/S
				100% (sag.)	100%	BSR-1P/S
Harbour conditions						
(Omitted)						

((1) to (6) are omitted)

(7) ~~This condition is not required when this loading condition is explicitly prohibited in the loading manual.~~ (Void)

((8) to (12) are omitted)

Chapter 5 HULL GIRDER STRENGTH

Section 1 HULL GIRDER YIELDING STRENGTH

1. Strength Characteristics of Hull Girder Transverse Sections

1.2 Hull girder transverse sections

Paragraphs 1.2.9 and 1.2.10 have been amended as follows.

1.2.9 Definitions of openings

The following definitions of opening are to be applied:

(a) Large openings are:
- Elliptical openings exceeding 2.5 *m* in length or 1.2 *m* in breadth.
- Circular openings exceeding 0.9 *m* in diameter.

(b) Small openings (i.e. ~~manholes,~~ lightening holes, etc.) are openings that are not large ones.

(c) Manholes

(~~c~~d) Isolated openings are openings spaced not less than 1 *m* apart in the ship's transverse/vertical direction.

1.2.10 Large openings, manholes and nearby small openings

Large openings and manholes are to be deducted from the sectional area used in hull girder moment of inertia and section modulus. When small openings are spaced less than 1 *m* apart in the ship's transverse/vertical direction to large openings or manholes, the total breadth of them is to be deducted from the sectional area.

Additionally, isolated small openings which do not comply with the arrangement requirements given in **Ch 3, Sec 6, 6.3.2** are to be deducted from the sectional areas included in the hull girder transverse sections.

3. Hull Girder Shear Strength Assessment

3.4 Effective net thickness for longitudinal bulkheads between cargo tanks of oil tankers

Paragraph 3.4.5 has been amended as follows.

3.4.5 Vertical force on double bottom

The maximum vertical resulting force on the double bottom in a tank, F_{db} is in no case to be less than that given by the minimum conditions given in **Table 6**.

The maximum resulting force on the double bottom in a tank, F_{db} in *kN*, is to be taken as:

$$F_{db} = g\left|W_{CT} + W_{CTBT} - \rho b_2 \ell_{tk} T_{mean}\right|$$

where:

W_{CT}: Weight of cargo, in tonnes, as defined in **Table 7**.

W_{CWBT}: Weight of ballast, in tonnes, as defined in **Table 7**.

b_2: Breadth, in *m*, as defined in **Table 7**.

ℓ_{tk} : Length of cargo tank~~, between watertight transverse bulkheads in the wing cargo tank~~, in *m*.

T_{mean}: Draught at the mid length of the tank for the loading condition considered, in *m*.

3.5 Effective net thickness for longitudinal bulkheads between cargo tanks of oil tankers - Correction due to loads from transverse bulkhead stringers

Paragraph 3.5.1 has been amended as follows.

3.5.1

In way of transverse bulkhead stringer connections, within areas as specified in **Fig. 7**, the equivalent net thickness of plate, $t_{sti\text{-}k\text{-}n50}$ in *mm*, where the index *k* refers to the identification number of the stringer, is not to be taken greater than:

$$t_{sti-k-n50} = t_{sfi-n50}\left(1-\frac{\tau_{sti-k}}{\tau_{i-perm}}\right)$$

where:

τ_{sti-k} : Shear stress in plate *i*, in N/mm^2, in the longitudinal bulkhead due to the stringer force in way of stringer *k*, taken as:

$$\tau_{sti-k} = \frac{Q_{st-k}}{l_{st-k}t_{sfi-n50}}$$

$t_{sfi-n50}$: Effective net plating thickness, in *mm*, calculated at the transverse bulkhead for the height corresponding to the level of the stringer.

τ_{t-perm} : permissible hull girder shear stress, in N/mm^2, ~~as defined in **Table 4**~~ for the plate *i*.

$$\tau_{i-perm} = 120/k$$

ℓ_{st-k} : Connection length of stringer *k*, in *m*, as defined in **Fig. 7**.

$Q_{st\text{-}k}$: Shear force on the longitudinal bulkhead from the stringer in loaded condition with tanks abreast full in *kN*, taken as:

$$Q_{st-k} = 0.8F_{st-k}\left(1-\frac{Z_{st-k}-h_{db}}{h_{blk}}\right)$$

$F_{st\text{-}k}$: Total stringer supporting force in way of a longitudinal bulkhead, in *kN*, taken as:

$$F_{st-k} = \frac{P_{st-k}b_{st-k}(h_k+h_{k-1})}{2}$$

h_{db}: Double bottom height, in *m*.

h_{blk}: Height of bulkhead, in *m*, defined as the distance from inner bottom to the deck at the top of the bulkhead.

$z_{st\text{-}k}$: *Z* coordinate of the stringer *k*, in *m*.

$P_{st\text{-}k}$: Pressure on stringer *k*, in kN/m^2, taken as:

$$P_{st-k} = g\rho_L h_{tt-k}$$

ρ_L : Density of the liquid in cargo tank, in t/m^3, ad defined in **Ch 4, Sec 6**.

$h_{tt\text{-}k}$: Height from the top of the tank to the midpoint of the load area between $h_k/2$ below and

$h_{k-1}/2$ above the stringer k, in m.

h_k: Vertical distance from the considered stringer k to the stringer $k+1$ below. For the lowermost stringer, it is to be taken as 80% of the average vertical distance to the inner bottom, in m.

h_{k-1}: Vertical distance from the considered stringer k to the stringer k-1 above. For the uppermost stringer, it is to be taken as 80% of the average vertical distance to the upper deck, in m.

$b_{st\text{-}k}$: Load breadth acting on stringer k, in m, as defined in **Fig.9** and **Fig.10**.

Section 2 HULL GIRDER ULTIMATE STRENGTH

2. Checking Criteria

2.1 General

Paragraph 2.1.2 has been amended as follows.

2.1.2

The vertical hull girder ultimate bending capacity at any hull transverse section is to satisfy the following criteria:

$$M \le \frac{M_U}{\gamma_R}$$

where:

M: Vertical bending moment, in *kNm*, to be obtained as specified in **2.2.1**.

M_U: Vertical hull girder ultimate bending capacity, in *kNm*, to be obtained as specified in **2.3**.

γ_R : Partial safety factor for the vertical hull girder ultimate bending capacity to be taken equal to:

$$\gamma_R = \gamma_M \gamma_{DB}$$

γ_M : Partial safety factor for the vertical hull girder ultimate bending capacity, covering material, geometric and strength prediction uncertainties; in general, to be taken equal to:

$$\gamma_M = 1.1$$

γ_{DB}: Partial safety factor for the vertical hull girder ultimate bending capacity, covering the effect of double bottom bending, to be taken equal to:

- For hogging condition, except flooded conditions:
  - $\gamma_{DB} = 1.25$ for empty cargo holds in alternate condition of *BC-A* bulk carriers,
  - $\gamma_{DB} = 1.10$ for oil tankers, for *BC-B* and *BC-C* bulk carriers and loaded cargo holds in alternate condition of *BC-A* bulk carriers,
- For sagging condition, except flooded conditions: $\gamma_{DB} = 1.0$
- For hogging and sagging condition, for flooded condition: $\gamma_{DB} = 1.0$

Section 3 HULL GIRDER RESIDUAL STRENGTH

2. Checking Criteria

2.2 Damage conditions

Paragraph 2.2.1 has been amended as follows.

2.2.1 General

The damage conditions specified for collision in **2.2.2** and for grounding in **2.2.3** are to be considered. The damage extents specified in **2.2.2** and **2.2.3** are to be measured from the moulded lines of the ship.

~~Plates of inner bottom and inner hull longitudinal bulkhead are to be considered intact unless the damage extent exceeds the distance from inner bottom and inner hull longitudinal bulkhead plate respectively, to the hull envelope plate.~~

Stiffener element is to be considered intact unless the connection of stiffener with attached plate is included in the damaged extent.

Plates and stiffeners of inner bottom and inner hull longitudinal bulkhead are to be considered intact unless the damage extent exceeds the moulded distance from inner bottom and inner hull longitudinal bulkhead plate respectively, to the hull envelope plate.

Appendix 2 HULL GIRDER ULTIMATE CAPACITY

2. Incremental-Iterative Method

2.2 Procedure

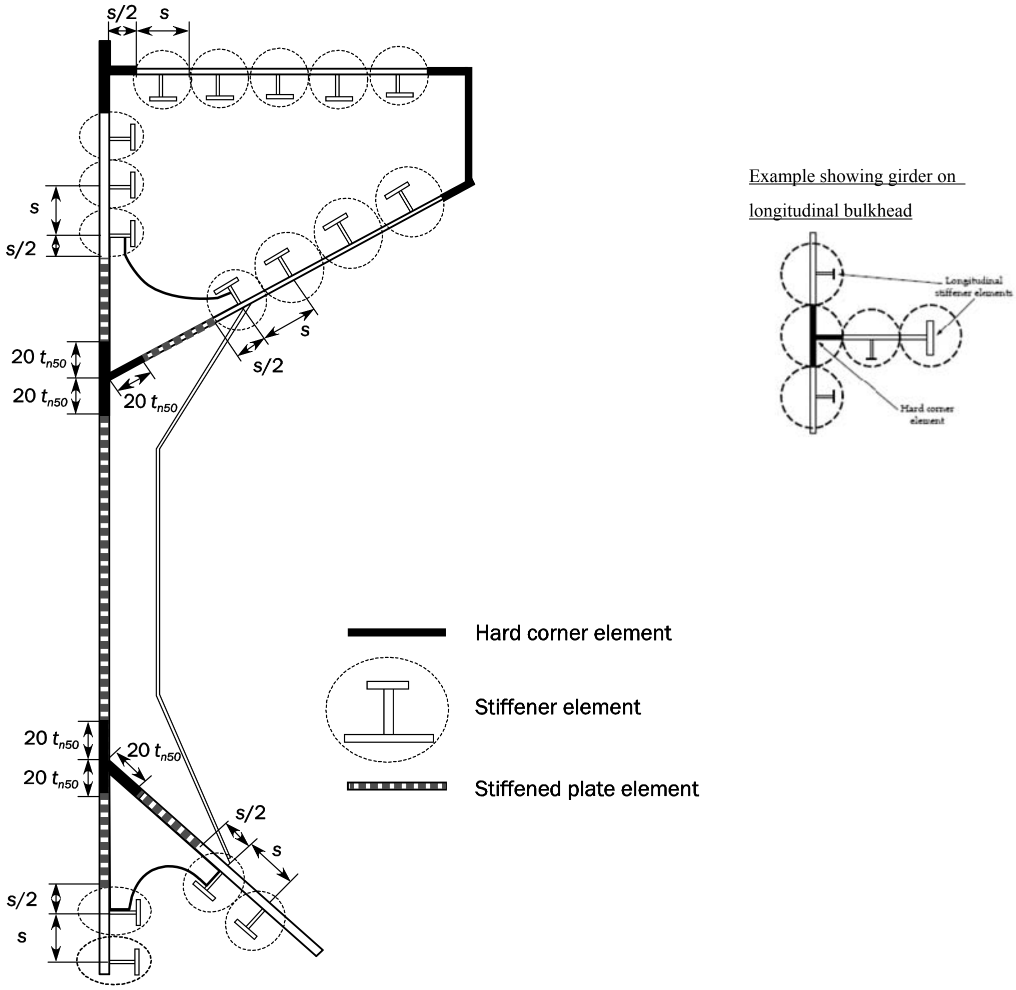
2.2.2 Modelling of the hull girder cross section

Sub-paragraph 2.2.2(a) has been amended as follows.

(a) Hard corner element:
Hard corner 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 $20t_{n50}$ on transversely stiffened panel and to $0.5s$ on a longitudinally stiffened panel, see **Fig. 2**.
where:
t_{n50} : Net 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. Enlarged stiffeners, with or without web stiffening, used for Permanent Means of Access (*PMA*) are not to be considered as a large girder so the attached plate/web connection is only considered as a hard corner, see **Fig. 3**.

Fig.3 has been amended as follows.

Fig.3 Examples of the configuration of stiffened plate elements, stiffener elements and hard corner elements on a hull section



Chapter 6 HULL LOCAL SCANTLING

Section 2 LOAD APPLICATION

2. Design Load Sets

2.1 Application of load components

Table 1 has been amended as follows.

Table 1 Design load sets

Item	Design load set	Load component	Draught	Design load	Loading condition
(Omitted)					
Other tanks (fuel oil tank, fresh water tank)	TK-1	$P_{in} - P_{ex}$ (3)	T_{BAL}	$S+D$	Normal ballast condition
	TK-2	$P_{in} - P_{ex}$ (3)	0.25 T_{SC}	S	Harbour/test condition
Compartments not carrying liquids	FD-1 (6)	P_{in}	T_{SC}	$S+D$	Flooded condition
	FD-2 (6)	P_{in}	-	S	Flooded condition
Exposed deck, internal decks or platforms	DL-1 (8)	P_{dl}, F_U	~~T_{BAL}~~ <u>T_{SC}</u>	$S+D$	~~Normal ballast~~ <u>Full load</u> condition
	DL-2 (8)	P_{dl}, F_U	-	S	Harbour condition

(1) For bulk carrier *BC-A* and *BC-B*, full load condition means 'homogeneous heavy cargo'.
(2) For external shell only.
(3) P_{ex} is to be considered for external shell only.
(4) Not to be applied to bulk cargo hold assigned as ballast hold.
(5) Bulk cargo hold only.
(6) FD-1 and FD-2 are not applicable to external shell and corrugations of transverse vertically corrugated bulkhead separating cargo holds. Requirement in flooded conditions of transverse corrugated bulkhead are given in **Pt 2, Ch 1, Sec 3, 3**.
(7) Minimum draught among heavy ballast conditions is to be used.
(8) Distributed or concentrated loads only. Need not be combined with simultaneously occurring green sea pressure.

Section 4 PLATING

1. Plating Subjected to Lateral Pressure

1.2 Plating of corrugated bulkheads

Title of paragraph 1.2.1 has been amended as follows.

1.2.1 Cold ~~and~~ , hot formed <u>and built up</u> corrugations

2. Special Requirements

2.2 Bilge plating

Paragraph 2.2.2 has been amended as follows.

2.2.2 Bilge plate thickness within $0.4L_{CSR}$ amidships

The net thickness of bilge plating is not to be taken less than the offered net thickness for the adjacent bottom shell or adjacent side shell plating, whichever is greater.

The net thickness of curved bilge plating, t, in *mm*, is not to be taken less than:

$$t = 6.45 \times 10^{-4} (P_{ex} s_b)^{0.4} R^{0.6}$$

where:

P_{ex} : Design sea pressure for the design load set SEA-1 as defined in **Ch 6, Sec 2, 2.1.3** calculated at the lower turn of the bilge, in kN/m^2.

R: Effective bilge radius in *mm*.

$$R = R_0 + 0.5(\Delta s_1 + \Delta s_2)$$

R_0 : Radius of curvature, in *mm*. See **Fig.1**.

Δs_1 : Distance between the lower turn of bilge and the outermost bottom longitudinal, in *mm*, see **Fig.1**. Where the outermost bottom longitudinal is within the curvature, this distance is to be taken as zero.

Δs_2 : Distance between the upper turn of bilge and the lowest side longitudinal, in *mm*, see **Fig.1**. Where the lowest side longitudinal is within the curvature, this distance is to be taken as zero.

s_b : Distance between transverse stiffeners, webs or bilge brackets, in *mm*.

Longitudinally stiffened bilge plating is to be assessed as regular stiffened plating. The bilge thickness is not to be less than the ~~minimum~~ <u>lesser of the</u> value obtained by **1.1.1** and **2.2.2**. A bilge keel is not considered as an effective 'longitudinal stiffening' member and unless other longitudinal stiffeners are fitted, this requirement has to be applied.

Paragraph 2.2.3 has been amended as follows.

2.2.3 Bilge plate thickness outside 0.4L_{CSR} amidships

For ~~transversely stiffened~~ bilge plating outside 0.4L_{CSR} amidships, the bilge plate thickness requirement <u>in **2.2.2**</u> is <u>applicable.</u> ~~to be s~~<u>S</u>pecial~~ly~~ consider<u>ation</u>~~ed based on~~ <u>is to be made in</u> evaluation of support provided by the hull form and internal stiffening arrangements. Outside of 0.4L_{CSR} amidships, the bilge plating thickness and arrangement are to comply with the requirements to side shell or bottom plating in the same region. ~~Effect of increased loading in the forward region is to be specially considered.~~

2.6 Supporting structure in way of corrugated bulkheads

Sub-paragraph 2.6.2(c) has been amended as follows.

2.6.2 Lower stool

(c) <u>For oil tankers, c</u>~~C~~ontinuity between corrugation web and lower stool supporting brackets is to be maintained inside the stool. Alternatively, lower stool supporting brackets inside the stool are to be aligned with every knuckle point of corrugation web.

Chapter 7 DIRECT STRENGTH ANALYSIS

Section 1 STRENGTH ASSESSMENT

2. Net Scantling

2.1 Net scantling application

Paragraph 2.1.1 has been amended as follows.

2.1.1

FE models for cargo hold FE analyses, local fine mesh FE analysis and very fine mesh FE analyses, are to be based on the net scantling approach, applying a corrosion addition ~~of 0.5t_c~~ as defined in **Ch 3**, **Sec 2**, **Table 1**.

All buckling capacity assessment are to be based on corrosion addition ~~t_c,~~ as defined in **Ch 3**, **Sec 2**, **Table 1**.

Section 2 CARGO HOLD STRUCTURAL STRENGTH ANALYSIS

2. Structural Model

2.4 Structural modelling

Paragraph 2.4.9 has been amended as follows.

2.4.9 Openings

Methods of representing openings and manholes in webs of primary supporting members are to be in accordance with **Table 1**. Regardless of size, manholes are to be modelled by removing the appropriate elements. ~~except for manholes which are to be modelled by removing the adequate elements~~.

Table 1 has been amended as follows.

Table 1 Representation of openings in primary supporting member webs

Criteria	Modelling decision	Analysis
$h_o/h < 0.5$ and $g_o < 2.0$	Openings do not need to be modelled	To be evaluated by the screening procedure as given in **Ch 7, Sec 3, 3.1.1**
manholes	The geometry of the opening is to be modelled by removing the adequate elements	To be evaluated by the screening procedure as given in **Ch 7, Sec 3, 3.1.1**
$h_o/h \geq 0.5$ or $g_o \geq 2.0$	The geometry of the opening is to be modelled	To be evaluated by fine mesh as given in **Ch 7, Sec 3, 2.1.1**

$$g_o = \left(1 + \frac{\ell_o^{\,2}}{2.6(h - h_o)^2}\right)$$

ℓ_o : Length of opening parallel to primary supporting member web direction, in *m*, see **Fig. 15**. For sequential openings where the distance, d_o between openings is less than 0.25 *h*, the length ℓ_o is to be taken as the length across openings as shown in **Fig. 16**.

h_o : Height of opening parallel to depth of web, in *m*, see **Fig. 15** and **Fig. 16**.

h : Height of web of primary supporting member in way of opening, in *m*, see **Fig. 15** and **Fig. 16**.

Section 3 LOCAL STRUCTURAL STRENGTH ANALYSIS

2. Local Areas to be Assessed by Fine Mesh Analysis

2.1 List of mandatory structural details

2.1.1 List of structural details

In the midship cargo hold region, the following structural details are to be assessed according to the fine mesh analysis procedure defined in **1.1.3**:

(a) Hopper knuckles for ship with double side as given in **2.1.2**,

(b) Side frame end brackets and lower hopper knuckle for single side bulk carrier as given in **2.1.3**,

(c) Large openings as given in **2.1.4**,

(d) Connections of deck and double bottom longitudinal stiffeners to transverse bulkhead as given in **2.1.5**,

(e) Connections of corrugated bulkhead to adjoining structure as given in **2.1.6**.

For each above mentioned structural detail, one fine mesh model is required within all the cargo hold models covering the midship cargo hold region. The selection of the location of this fine mesh model is to be based on requirements given from **2.1.2** to **2.1.6** from all cargo hold analyses in the midship cargo hold region.

3. Screening Procedure

3.2 List of structural details

Sub-paragraph 3.2.1(a) has been amended as follows.

3.2.1 Cargo hold region

The following structural details and areas in the cargo hold region are to be evaluated by screening:

(a) Openings <u>which do not require modelling and manholes, see **Ch 7, Sec 2, 2.4.9**,</u> in way of web of primary supporting members, such as transverse web frame as indicated in **Table 1** and **Table 2**, horizontal stringers as indicated in **Table 3**, floors and longitudinal girders in double bottom.

(Omitted)

Table 1, Table 2 and Table 3 have been amended as follows.

Table 1 Screening areas of transverse web frame in oil tanker

(Omitted)		
	Bracket toes	
	Openings and manholes (shaded regions)	
	~~Other~~ Openings and manholes (unshaded regions)	Screening check to be performed for openings except if: $h_o/h < 0.35$ and $g_o < 1.2$, and, each end of the opening forms a semi circle arc (i.e. radius of opening equal to *b*/2). This criterion does not apply to manholes which are to be evaluated by screening irrespective of size. h_o, *h* and g_o is defined in **Ch 7, Sec 2, 2.4.9**, *b* is the smallest of the length and breadth of the opening.

Table 2 Screening areas for transverse web frame in bulk carrier

(Omitted)		
	Bracket toes	
	Openings and manholes (shaded regions)	
	Other Openings and manholes (unshaded regions)	Screening check to be performed for openings except if: *ho*/*h* < 0.35 and *go* < 1.2, and, each end of the opening forms a semi circle arc (i.e. radius of opening equal to *b*/2). This criterion does not apply to manholes which are to be evaluated by screening irrespective of size. *ho*, *h* and *go* is defined in **Ch 7, Sec 2, 2.4.9**, *b* is the smallest of the length and breadth of the opening.

Table 3 Screening areas for horizontal stringer and transverse bulkhead to double bottom connections in oil tanker

(Omitted)		
	Bracket toes and heels	
	Openings and manholes (shaded regions)	
	~~Other~~ Openings and manholes (unshaded regions)	Screening check to be performed for openings except if: $h_o/h < 0.35$ and $g_o < 1.2$, and, each end of the opening forms a semi circle arc (i.e. radius of opening equal to *b*/2). This criterion does not apply to manholes which are to be evaluated by screening irrespective of size. h_o, *h* and g_o is defined in **Ch 7, Sec 2, 2.4.9**, *b* is the smallest of the length and breadth of the opening.

Paragraph 3.2.2 has been amended as follows.

3.2.2 Outside midship cargo hold region

The following structural details outside midship cargo hold region are to be evaluated by screening:

(a) Hopper knuckle, as defined in **2.1.2** and **2.1.3**,

(b) Side frame end bracket, as defined in **2.1.3**,

(c) Large openings, as defined in **2.1.4**,

(d) Connections of corrugation to adjoining structure, as defined in **2.1.6**,

The ~~above mentioned structural details~~ connections of corrugation to adjoining structure to be screened are to be similar in its geometry, its proportion and its relative location to the corresponding detail modelled in fine mesh in the midship cargo hold region.

When the ~~above mentioned structural details~~ connections of corrugation to adjoining structure outside the midship cargo hold region are different from the corresponding detail modelled in fine mesh in the midship cargo hold region, a fine mesh analysis is to be performed for the detail located where the yield utilisation factor, λ_y, is maximum for structural details having the same geometry and the same relative location,

When it is deemed necessary, the Society may request a fine mesh analysis to be performed according to **1.1.3**.

3.3 Screening criteria

3.3.1 Screening factors and permissible screening factors

The screening factors, λ_{sc} and the permissible screening factors, λ_{scperm}, are given in **Table 4** for the screening areas defined in **3.1**.

Table 4 has been amended as follows.

Table 4 Screening factors and permissible screening factors

Type of Details	Screening factors, λ_{sc}	Permissible screening factors, λ_{scperm}	
Within the whole cargo hold region		*S+D*	*S*
Openings for which their geometry is not required to be represented in the cargo hold model in accordance with **Ch 7, Sec 2, 2.4.9** in way of webs of primary supporting members, such as transverse web frame as indicated in **Table 1** and **Table 2**, horizontal stringers as indicated in **Table 3**, floors and longitudinal girders in double bottom.	**Table 5**	1.70	1.36
Manholes (2)	λ_y	$0.85\,\lambda_{yperm}$	
Bracket toes on transverse web frames as indicated in **Table 1** and **Table 2**, horizontal stringers and transverse plane bulkhead to double bottom connection or buttress structure specified in **Table 3**.	**Table 6**	1.50	1.20
Heels of transverse bulkhead horizontal stringers specified in **Table 3**.	**Table 7**	1.50	1.20

Connections of transverse lower stool to double bottom girders and longitudinal lower stool to double bottom floors as indicated in **Fig. 5**. The connection of lower hopper to transverse lower stool structure as indicated in **Fig. 5**. The connection of topside tank to inner side as indicated in **Fig. 6**. The connection of corrugation and upper supporting structure to upper stool as indicated in **Fig. 7**.	λ_y	0.75 λ_{yperm}	
Hatch corner area.	λ_y	0.95 λ_{yperm}	
Outside midship cargo hold region			
Hopper knuckle	λ_y	0.65 λ_{yperm}	
Side frame end bracket ~~(2)~~		0.85 λ_{yperm}	
Large openings(2)		0.85 λ_{yperm}	
~~Hopper knuckle~~	$\lambda_{sc} = \dfrac{K_{sc} \cdot \sigma_c}{R_y}$ (1)	~~1.50 f_f~~	~~1.20 f_f~~
~~Side frame end bracket (2)~~		~~1.50 f_f~~	~~1.20 f_f~~
~~Large openings~~		~~1.70 f_f~~	~~1.36 f_f~~
Connections of corrugation to adjoining structure		1.50 f_f	1.20 f_f

where:

λ_y : Coarse mesh yield utilisation factor, as defined in **Ch 7, Sec 2, 5.2.4**.

λ_{yperm} : Coarse mesh permissible yield utilisation factor, as defined in **Ch 7, Sec 2, 5.2.4**.

K_{sc}: Screening stress concentration factor, taken as:

$$K_{sc} = \frac{\sigma_{FM}}{\sigma_{CM}}$$

σ_{FM} : Von Mises fine mesh stress, in N/mm^2, for the considered detail calculated in the midship cargo hold region according to **2**.

σ_{CM} : Von Mises coarse mesh stress, in N/mm^2, for the considered detail calculated in the midship cargo hold region according to **Ch 7, Sec 2**.

σ_C : Von Mises coarse mesh stress, in N/mm^2, for the area in way of considered detail.

f_f : Fatigue factor defined in **6.2.1**.

(1) For each screened detail, σ_{FM} and σ_{CM} are to be taken from the corresponding elements in the same plane position.

(2) ~~For the side frame end brackets of single side bulk carrier, σ_{FM} and σ_{CM} are to be taken at the corresponding elements representing the flange of the end brackets.~~ The representative element which has maximum yield utilisation factor around the manhole and the large opening is to be verified against criterion.

Table 6 and Table 7 have been amended as follows.

Table 6 Screening factor for bracket toes of primary supporting members

λ_{sc} :	Screening factor taken as: ~~$\lambda_{sc} = C_a \left(0.75 \left(\frac{b_2}{b_1} \right)^{0.5} \sigma_{vm} + 0.55 \left(\frac{A_{beam-n50}}{b_1 t_{n50}} \right)^{0.5} \lvert \sigma_{beam} \rvert \right) \frac{k}{235}$~~ $\underline{\lambda_{sc} = C_a \left(0.68 \left(\frac{b_2}{b_1} \right)^{0.5} \sigma_{vm} + 0.50 \left(\frac{A_{beam-n50}}{b_1 t_{n50}} \right)^{0.5} \lvert \sigma_{beam} \rvert \right) \frac{k}{235}}$
C_a:	Coefficient taken as: $C_a = 1.0 - 0.2 \left(\frac{R_a}{1400} \right)^2$
b_1, b_2:	Height of shell element in way of bracket toe in cargo hold FE model, in *mm*.
$A_{beam-n50}$:	Sectional area of beam or rod element in cargo hold FE model representing the face plate of bracket, in mm^2.
σ_{beam} :	Beam or rod element axial stress determined from cargo hold FE analysis, in N/mm^2.
σ_{vm} :	Von Mises stress of shell element in way of bracket toe determined from cargo hold FE analysis, in N/mm^2.
t_{n50}:	Net thickness of shell element in way of bracket toe, in *mm*.
R_a:	Leg length, in *mm*, not to be taken as greater than 1400*mm*.
(Omitted)	

Table 7 Screening factor for heels of transverse bulkhead horizontal stringers

λ_{sc} :	Screening factor taken as: • For heels at side horizontal girder and transverse bulkhead horizontal stringer, at the locations 1, 2 and 3 in figure below. ~~$\lambda_{sc} = 3.0 \sigma_{vm} \frac{k}{235}$~~ $\underline{\lambda_{sc} = 1.67 \sigma_{vm} \frac{k}{235}}$ • For heel at longitudinal bulkhead horizontal stringer, at the location 4 in figure below. ~~$\lambda_{sc} = 5.2 \lvert \sigma_x \rvert \frac{k}{235}$~~ $\underline{\lambda_{sc} = 3.2 \lvert \sigma_x \rvert \frac{k}{235}}$
σ_x :	Axial stress in element *x* direction determined from cargo hold FE analysis in accordance with the coordinate system shown, in N/mm^2.
σ_{vm} :	Von Mises stress of shell element in way of heel determined from cargo hold FE analysis, in N/mm^2.
(Omitted)	

4. Structural Modelling

4.8 Corrugated bulkheads

Paragraphs 4.8.4 and 4.8.5 have been amended as follows.

4.8.4

Diaphragm webs, brackets inside the lower stool and ~~vertical~~ all stiffeners on the stool ~~side~~ plate and diaphragm are to be modelled at their actual positions within the extent of the local model. Shell elements are to be used for modelling of diaphragm, ~~bracket and stiffener webs. Shell elements are be used to represent the flange of stiffeners~~ web and flange of vertically orientated stiffeners, and brackets in the fine mesh zone.

4.8.5

~~Stiffeners on the lower stool plate are to be represented by beam elements.~~ Horizontally orientated stiffeners within the fine mesh zone are to be represented by either shell or beam elements.

5. FE Load Combinations

5.2 Application of loads and boundary conditions

Paragraph 5.2.1 has been amended as follows.

5.2.1 General

Where a separate local model is used for the fine mesh detailed stress analysis, the nodal displacements from the cargo tank model are to be applied to the corresponding boundary nodes on the local model as prescribed displacements. Alternatively, equivalent nodal forces from the cargo tank model may be applied to the boundary nodes.

Where there are nodes on the local model boundaries which are not coincident with the nodal points on the cargo tank model, it is acceptable to impose prescribed displacements on these nodes using multi-point constraints. The use of linear multi-point constraint equations connecting two neighbouring coincident nodes is considered sufficient.

All local loads, including any loads applied for hull girder bending moment and/or shear force ~~corrections~~ adjustments, in way of the structure represented by the separate local finite element model are to be applied to the model.

6. Analysis Criteria

6.2 Acceptance criteria

Paragraph 6.2.1 has been amended as follows.

6.2.1

Verification of stress results against the acceptance criteria is to be carried out in accordance with **6.1**.

The structural assessment is to demonstrate that the stress complies with the following criteria:

(Omitted)

f_f : Fatigue factor, taken as:

- f_f = 1.0 in general,
- f_f = 1.2 for details ~~defined in **Ch 9, Sec 2, Table 1**,~~ assessed by very fine mesh analysis complying with the fatigue assessment criteria given in **Ch 9, Sec 2**.

(Omitted)

Chapter 8 BUCKLING

Section 1 GENERAL

2. Application

2.1 Scope

Paragraph 2.1.1 has been amended as follows.

2.1.1

The buckling checks are to be performed according to:

- **Ch 8**, **Sec 2** for the slenderness requirements of plates, longitudinal and transverse stiffeners, primary supporting members and brackets.
- **Ch 8**, **Sec 3** for the prescriptive buckling requirements of plates, longitudinal and transverse stiffeners, primary supporting members and other structures.
- **Ch 8**, **Sec 4** for the buckling requirements of the FE analysis for the plates, stiffened panels and other structures.
- **Ch 8**, **Sec 5** for the buckling capacity of prescriptive and FE buckling requirements.

3. Definitions

3.2 Buckling utilisation factor

Paragraph 3.2.2 has been amended as follows.

3.2.2

For combined loads, the utilisation factor, η_{act}, is to be defined as the ratio of the applied equivalent stress and the corresponding buckling capacity, as shown in **Fig. 1**, and is to be taken as:

$$\eta_{act} = \frac{W_{act}}{W_u} = \frac{1}{\gamma_c}$$

where:

W_{act}: Applied equivalent stress ~~due to the combined membrane stresses~~, in *N/mm*^{2}:

$$W_{act} = \sqrt{\sigma_x^2 + \sigma_y^2 + \tau^2} \quad \text{for plate}$$

$$W_{act} = \sigma_a + \sigma_b + \sigma_w \quad \text{for stiffener}$$

~~σ_x : Membrane stress applied in *x* direction, in *N/mm*^{2}.~~

~~σ_y : Membrane stress applied in *y* direction, in *N/mm*^{2}.~~

~~τ : Membrane shear stress applied in *xy* plane, in *N/mm*^{2}.~~

~~σ_a : Actual stress in the stiffener as defined in **Ch 8**, **Sec 5**, **2.3**, in *N/mm*^{2}.~~

~~σ_b : Bending stress in the stiffener as defined in **Ch 8**, **Sec 5**, **2.3**, in *N/mm*^{2}.~~

~~σ_w : Warping stress in the stiffener as defined in **Ch 8**, **Sec 5**, **2.3**, in *N/mm*^{2}.~~

W_u: Equivalent buckling capacity, in *N/mm*^{2}, to be taken as:

$$W_u = \sqrt{\sigma_{cx}^2 + \sigma_{cy}^2 + \tau_c^2} \quad \text{for plate}$$

$$W_u = \frac{R_{eH-S}}{S} \quad \text{for stiffener}$$

~~σ_{cx}, σ_{cy}, τ_c : Critical stress, in *N/mm*^{2}, defined in **Ch 8**, **Sec 5**, **2.2** for plates and in **Ch 8**, **Sec 5**, **2.3** for stiffeners.~~

~~R_{eH-S}: Specified minimum yield stress of the stiffener, in *N/mm*^{2}.~~

~~S : Partial safety factor as defined in **Ch 8**, **Sec 5**.~~

γ_c : Stress multiplier factor at failure.

For each typical failure mode, the corresponding capacity of the panel is calculated by applying the actual stress combination and then increasing or decreasing the stresses proportionally until collapse.

Fig. 1 illustrates the buckling capacity and the buckling utilisation factor of a structural member subject to σ_x and σ_y stresses.

Section 2 SLENDERNESS REQUIREMENTS

Symbol ℓ has been amended as follows.

Symbols

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

$b_{f\text{-}out}$: Maximum distance, in *mm*, from mid thickness of the web to the flange edge, as shown in **Fig. 1**.

h_w : Depth of stiffener web, in *mm*, as shown in **Fig. 1**.

ℓ_b : Effective length of edge of bracket, in *mm*, as defined in **Table 3**.

~~ℓ : Length of stiffener between effective supports, in *m*.~~

s_{eff} : Effective width of attached plate of stiffener, in *mm*, taken equal to:

$$s_{eff} = 0.8s$$

t_f : Net flange thickness, in *mm*.

t_p : Net thickness of plate, in *mm*.

t_w : Net web thickness, in *mm*.

2. Plates

2.1 Net thickness of plate panels

Paragraph 2.1.1 has been amended as follows.

2.1.1

The net thickness of plate panels is to satisfy the following criteria:

$$t_p \geq \frac{b}{C}\sqrt{\frac{R_{eH}}{235}}$$

where:

C: Slenderness coefficient taken as:

$C = 100$ for hull envelope and cargo and tank boundaries.

$C = 125$ for other structures.

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

~~The mild steel value~~ A lower specified minimum yield stress may be used in this slenderness criterion provided the requirements specified in **Sec 3** and **Sec 4** are satisfied for the strake assumed in the same lower specified minimum yield stress value ~~in mild steel material~~.

This requirement does not apply to ~~transversely stiffened~~ the bilge plates within the cylindrical part of the ship and radius gunwale.

3. Stiffeners

3.1 Proportions of stiffeners

Paragraph 3.1.3 has been amended as follows.

3.1.3 Bending stiffness of stiffeners

The net moment of inertia, in cm^4, of the stiffener with the effective width of attached plate, about the neutral axis parallel to the attached plating ~~about the neutral axis parallel to the effective attached plate of stiffener, s_{eff},~~ is not to be less than the minimum value given by:

$$I_{st} \geq C\ell^2 A_{eff} \frac{R_{eH}}{235}$$

where

A_{eff}: Net sectional area of stiffener including effective attached plate, s_{eff}, in cm^2.

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

C: Slenderness coefficient taken as:

$C = 1.43$ for longitudinal stiffeners including sniped stiffeners.

$C = 0.72$ for other stiffeners.

6. Other Structures

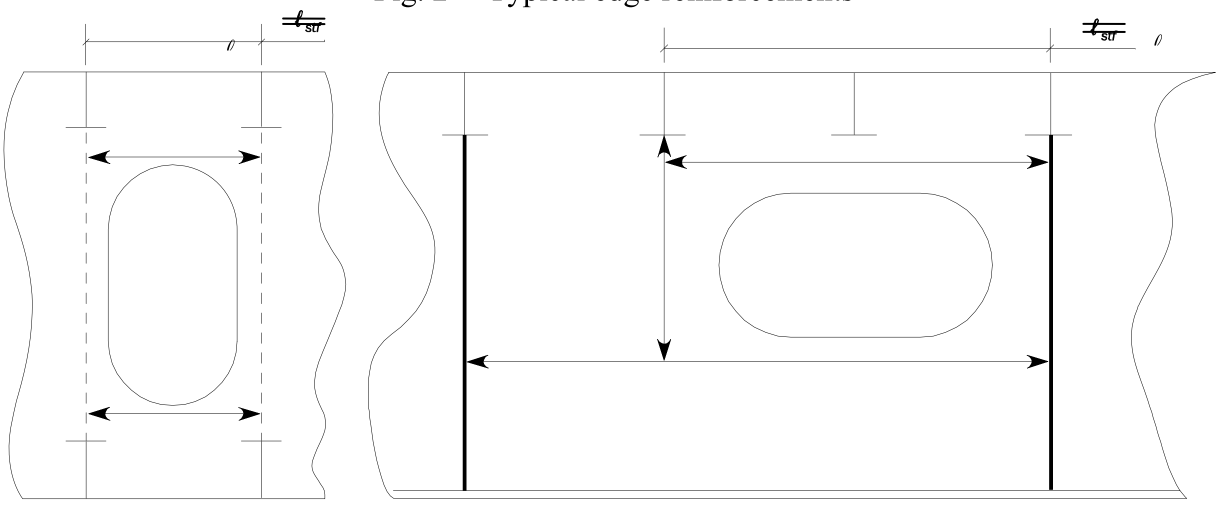
6.2 Edge reinforcement in way of openings

6.2.2 Proportions of edge stiffeners

The net thickness of the web plate and flange of the edge stiffener is to satisfy the requirements specified in **3.1.1** and **3.1.2**.

Fig. 2 has been amended as follows.

Fig. 2 Typical edge reinforcements



Section 3 PRESCRIPTIVE BUCKLING REQUIREMENTS

1. General

1.1 Scope

Paragraph 1.1.1 has been amended as follows.

1.1.1

This section applies to plate panels <u>including curved plate panels</u> and stiffeners subject to hull girder compression and shear stresses. In addition the following structural members subject to compressive stresses are to be checked:

- Corrugation of transverse vertically corrugated bulkhead.
- Corrugation of longitudinal corrugated bulkhead.
- Strut.
- Pillar.
- Cross tie.

1.2 Equivalent plate panel

Paragraph 1.2.2 has been amended as follows.

1.2.2

In transverse stiffening arrangement, when ~~a~~ <u>an</u> *EPP* is made with different thicknesses, the buckling check of the plate and stiffeners is to be made for each thickness considered constant on the *EPP*, the stresses and pressures being estimated for the *EPP* at the *LCP*.

3. Buckling Criteria

3.2 Plates

Paragraph 3.2.1 has been amended as follows.

3.2.1

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

$\eta_{Plate} \le \eta_{all}$

where:

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

For the determination of η_{Plate} of the vertically stiffened side shell plating of single side skin bulk carrier between hopper and topside tanks, the cases ~~9~~12 and ~~12~~16 of **Ch 8**, **Sec 5**, **Table 3** corresponding to the shorter edge of the plate panel clamped are to be considered together with a mean σ_y stress and $\psi_y = 1$.

Section 4 BUCKLING REQUIREMENTS FOR DIRECT STRENGTH ANALYSIS

1. General

1.1 Scope

1.1.1

The requirements of this Section apply for the buckling assessment of direct strength analysis subjected to compressive stress, shear stress and lateral pressure.

Paragraph 1.1.2 has been amended as follows.

1.1.2

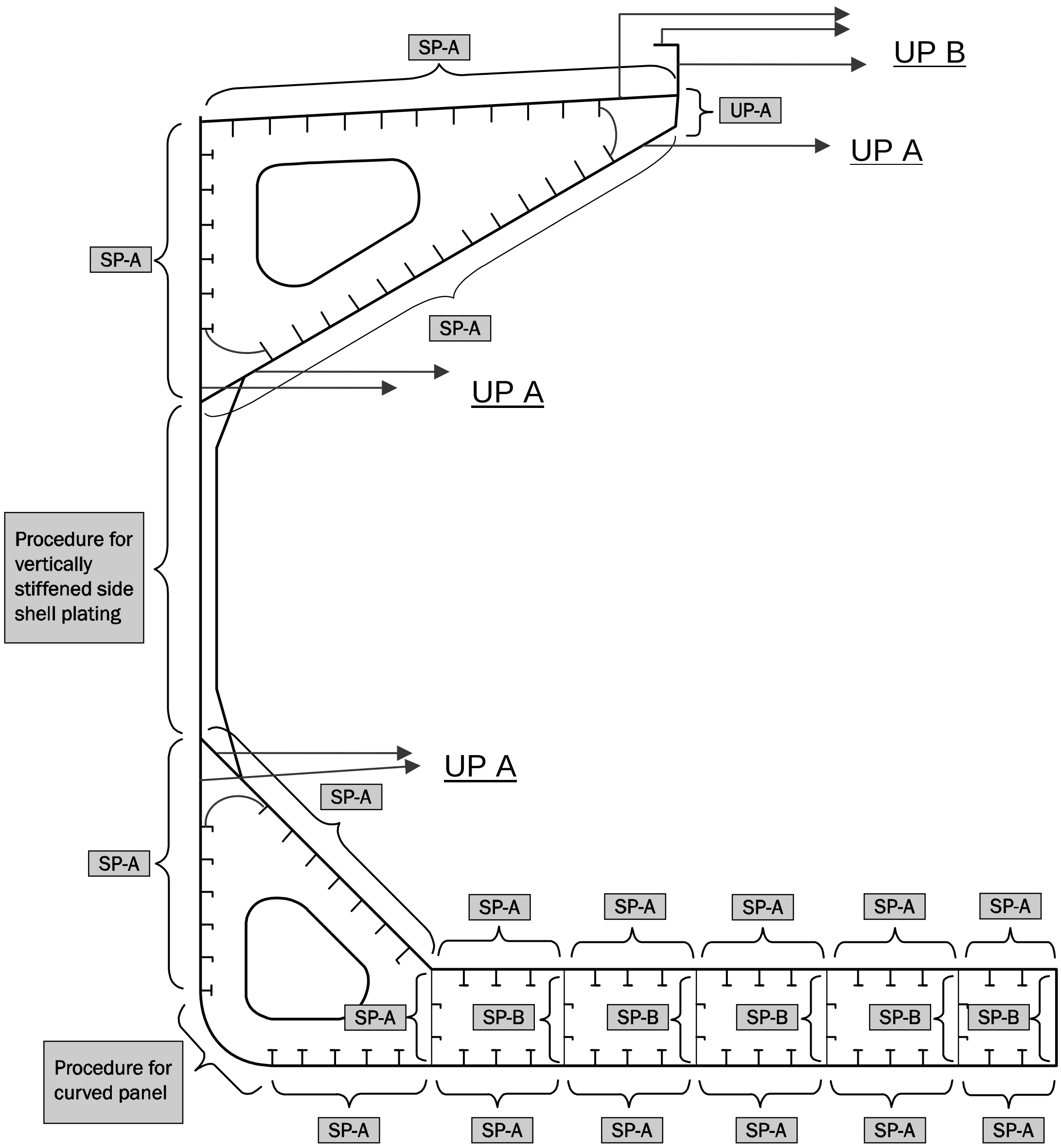
All structural elements in the FE analysis carried out according to **Ch 7** are to be assessed individually. The buckling checks have to be performed for the following structural elements:

- Stiffened and unstiffened panels, inclusive curved panels.
- Web plate in way of openings.
- Corrugated bulkhead.
- Vertically stiffened side shell of single side skin bulk carrier.
- Struts, pillars and cross ties.

2. Stiffened and Unstiffened Panels

Fig. 5 has been amended as follows.

Fig. 5 Longitudinal plates for single hull bulk



4. Vertically Stiffened Side Shell of Single Side Skin Bulk Carrier

4.1 Buckling criteria

Paragraph 4.1.1 has been amended as follows.

4.1.1 Side shell plating

The compressive buckling strength of the vertically stiffened side shell plating of single side skin bulk carrier is to satisfy the following criterion:

$\eta_{Stiffener} \leq \eta_{all}$

where:

$\eta_{Stiffener}$: Maximum vertically stiffened side shell plating utilisation factor calculated according to Method A as defined in **Ch 8**, **Sec 5**, **2.2.1** ~~and for the cases 8, 9 and 12 of **Ch 8**, **Sec 5**, **Table 3** corresponding to the shorter edge of the plate panel clamped,~~ considering the following <u>boundary conditions and</u> stress combinations:

- <u>4 edges simply supported (cases 1, 2 and 15 of **Ch 8, Sec 5, Table 3**):</u>
  - Pure vertical stress:
    - The maximum vertical stress of stress elements is used with $\alpha = 1$ and $\psi_x = 1$
  - Maximum vertical stress combined with longitudinal and shear stress:
    - The maximum vertical stress in the buckling panel plus the shear and longitudinal stresses at the location where the maximum vertical stress occurs is used with $\alpha = 2$ and $\psi_x = \psi_y = 1$
    - The plate thickness to be considered in the buckling strength check is the one where the maximum vertical stress occurs.
  - Maximum shear stress combined with longitudinal and vertical stress:
    - The maximum shear stress in the buckling panel plus the longitudinal and vertical stresses at the location where maximum shear stress occurs is used with $\alpha = 2$ and $\psi_x = \psi_y = 1$
    - The plate thickness to be considered in the buckling strength check is the one where the maximum shear stress occurs.
- <u>The 2 shorter edges of the plate panel clamped (cases 11, 12 and 16 of **Ch 8, Sec 5, Table 3**):</u>
  - Distributed longitudinal stress associated with vertical and shear stress:
    - The actual size of the buckling panel is used to define α .
    - The average values for longitudinal, vertical and shear stresses are to be used.
    - $\psi_x = \psi_y = 1$
    - The plate thickness to be considered in the buckling strength check is the minimum thickness of the buckling panel.

Section 5 BUCKLING CAPACITY

Symbols have been amended as follows.

Symbols

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

A_s : Net sectional area of the stiffener without attached plating, in *mm*^{2}.

a : Length of the longer side of the plate panel ~~as defined in **Table 3**~~, in *mm*.

b : Length of the shorter side of the plate panel ~~as defined in **Table 3**~~, in *mm*.

d : Length of the side parallel to the axis of the cylinder corresponding to the curved plate panel as shown in **Table 4**, in *mm*.

σ_E : Elastic buckling reference stress, in *N/mm*^{2} to be taken as:

- For the application of plate limit state according to **2.2.1**:

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_p}{b}\right)^2$$

- For the application of curved plate panels according to **2.2.6**

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_p}{d}\right)^2$$

Title of paragraph 2 has been amended as follows.

2. ~~Interaction Formulae~~ Buckling Capacity of Plates and Stiffeners

2.2 Plate capacity

Paragraph 2.2.1 has been amended as follows.

2.2.1 Plate limit state

The plate limit state is based on the following interaction formulae:

$$\left(\frac{\gamma_{c1}\sigma_x S}{\sigma_{cx}'}\right)^{e_0} - B\left(\frac{\gamma_{c1}\sigma_x S}{\sigma_{cx}'}\right)^{e_0/2}\left(\frac{\gamma_{c1}\sigma_y S}{\sigma_{cy}'}\right)^{e_0/2} + \left(\frac{\gamma_{c1}\sigma_y S}{\sigma_{cy}'}\right)^{e_0} + \left(\frac{\gamma_{c1}|\tau| S}{\tau_c'}\right)^{e_0} = 1$$

~~$\frac{\gamma_{c1}\sigma_x S}{\sigma_{cx3}} = 1$~~ $\left(\frac{\gamma_{c2}\sigma_x S}{\sigma_{cx}'}\right)^{2/\beta_p^{0.25}} + \left(\frac{\gamma_{c2}|\tau| S}{\tau_c'}\right)^{2/\beta_p^{0.25}} = 1$ for $\sigma_x \ge 0$

~~$\frac{\gamma_{c2}\sigma_y S}{\sigma_{cy3}} = 1$~~ $\left(\frac{\gamma_{c3}\sigma_y S}{\sigma_{cy}'}\right)^{2/\beta_p^{0.25}} + \left(\frac{\gamma_{c3}|\tau| S}{\tau_c'}\right)^{2/\beta_p^{0.25}} = 1$ for $\sigma_y \ge 0$

~~$\frac{\gamma_{c3}|\tau| S}{\tau_c} = 1$~~ $\frac{\gamma_{c4}|\tau| S}{\tau_c'} = 1$

~~$\left[\left(\frac{\gamma_{c4}\sigma_x S}{\sigma_{cx1}}\right)^2 + \left(\frac{\gamma_{c4}\sigma_y S}{\sigma_{cy1}}\right)^2 - \left(\frac{\gamma_{c4}\sigma_x S}{\sigma_{cx1}}\right)\left(\frac{\gamma_{c4}\sigma_y S}{\sigma_{cy1}}\right)\right]\varsigma + \left(\frac{\gamma_{c4}|\sigma_x| S}{\sigma_{cx2}} + \frac{\gamma_{c4}|\sigma_y| S}{\sigma_{cy2}}\right)(1-\varsigma) = 1$~~

with

$\gamma_c = \min(\gamma_{c1}, \gamma_{c2}, \gamma_{c3}, \gamma_{c4})$

where:

σ_x, σ_y: Applied normal stress to the plate panel, in *N/mm*^{2}, to be taken as defined in **2.2.7**.

τ: Applied shear stress to the plate panel, in *N/mm*^{2}.

~~ς: Weighting factor to be taken as given in **Table 1**.~~

σ_{cx}' ~~σ_{cx1}, σ_{cx2}, σ_{cx3}~~: Ultimate ~~critical~~ buckling stresse~~s~~, in *N/mm*^{2}, in direction parallel to the longer edge of the buckling panel as defined in **2.2.3**.

σ_{cy}' ~~σ_{cy1}, σ_{cy2}, σ_{cy3}~~: Ultimate ~~critical~~ buckling stresse~~s~~, in *N/mm*^{2}, in direction parallel to the shorter edge of the buckling panel as defined in **2.2.3**.

τ_c: Ultimate critical shear stresses, in *N/mm*^{2}, as defined in **2.2.3**.

γ_{c1}, γ_{c2}, γ_{c3}, γ_{c4}: Stress multiplier factors at failure for each of the above different limit states. γ_{c1} and γ_{c2} are only to be considered when $\sigma_x \ge 0$ and $\sigma_y \ge 0$ respectively.

B: Coefficient given in **Table 1**

e_0: Coefficient given in **Table 1**

β_p: Plate slenderness parameter taken as:

$$\beta_p = \frac{b}{t_p}\sqrt{\frac{R_{eH\_P}}{E}}$$

Table 1 has been amended as follows.

Table 1 Definition of weighting factor ζ and coefficients $\kappa_{x1}, \kappa_{x2}, \kappa_{y1}, \kappa_{y2}$ coefficients B and e_0

Applied Stress		ζ	κ_{x1}	κ_{x2}	κ_{y1}	κ_{y2}
$\sigma_x \geq 0$	$\sigma_y \geq 0$	$\min\left[1, 0.6\frac{\min(5,\alpha)^{0.2}}{\beta_p^{1/\min(5,\alpha)}}\right]$	κ_{x3}		κ_{y3}	
$\sigma_x < 0$ or $\sigma_y < 0$		1.0	κ_{x4}	-	κ_{y4}	-

Applied Stress	B	e0
$\sigma_x \geq 0$ and $\sigma_y \geq 0$	$0.7 - 0.3\beta_p/\alpha^2$	$2/\beta_p^{0.25}$
$\sigma_x < 0$ or $\sigma_y < 0$	1.0	2.0

Paragraph 2.2.3 has been amended as follows.

2.2.3 Ultimate critical buckling stresses

The ultimate critical buckling stresses of plate panels , in *N/mm*^{2}, are to be taken as:

$$\sigma_{cx1} = \kappa_{x1}R_{eH\_P} \quad \sigma_{cx2} = \kappa_{x2}R_{eH\_P} \quad \sigma_{cx3} = \kappa_{x3}R_{eH\_P}$$

$$\sigma_{cy1} = \kappa_{y1}R_{eH\_P} \quad \sigma_{cy2} = \kappa_{y2}R_{eH\_P} \quad \sigma_{cy3} = \kappa_{y3}R_{eH\_P}$$

$$\sigma_{cx}' = C_x R_{eH\_P}$$

$$\sigma_{cy}' = C_y R_{eH\_P}$$

The ultimate critical buckling stress of plate panels subject to shear , in *N/mm*^{2}, is to be taken as:

$$\tau_c = C_\tau \frac{R_{eH\_P}}{\sqrt{3}} \quad \tau_c' = C_\tau \frac{R_{eH\_P}}{\sqrt{3}}$$

where:

$\kappa_{x1}, \kappa_{x2}, \kappa_{y1}, \kappa_{y2}$: Coefficients defined in **Table 1**.

$\kappa_{x3}, \kappa_{x4}, \kappa_{y3}, \kappa_{y4}$: Coefficients to be taken as:

$$\kappa_{x3} = \frac{C_x^2}{2\varsigma_{x\tau}}\left\{\sqrt{\left(\frac{1-\varsigma_{x\tau}}{C_x}\right)^2 - \frac{4\varsigma_{x\tau}}{C_x^2}\left[\varsigma_{x\tau}\left(\frac{\gamma_c|\tau|S}{\tau_c}\right)^2 + (1-\varsigma_{x\tau})\frac{\gamma_c|\tau|S}{\tau_c} - 1\right]} - \frac{1-\varsigma_{x\tau}}{C_x}\right\}$$

$$\kappa_{y3} = \frac{C_y^2}{2\varsigma_{y\tau}} \left\{ \sqrt{\left(\frac{1-\varsigma_{y\tau}}{C_y}\right)^2 - \frac{4\varsigma_{y\tau}}{C_y^2}\left[\varsigma_{y\tau}\left(\frac{\gamma_c|\tau|S}{\tau_c}\right)^2 + (1-\varsigma_{y\tau})\frac{\gamma_c|\tau|S}{\tau_c} - 1\right]} - \frac{1-\varsigma_{y\tau}}{C_y} \right\}$$

$$\kappa_{x4} = \kappa_{y4} = \sqrt{1-3\left(\frac{\gamma_c|\tau|S}{R_{eH\_P}}\right)^2}$$

$$\varsigma_{x\tau} = \frac{1}{\sqrt{\beta_p}}$$

$$\varsigma_{y\tau} = \frac{\min(5,\alpha)^{0.3}}{\sqrt{\beta_p}}$$

$$\beta_p = \frac{b}{t_p}\sqrt{\frac{R_{eH\_P}}{E}}$$

C_x, C_y, C_τ : Reduction factors, as defined in **Table 3** ~~and **Table 4**~~.

- For the 1st Equation of **2.2.1**, when $\sigma_x < 0$ or $\sigma_y < 0$, the reduction factors are to taken as:

  $C_x = C_y = C_\tau = 1.$

- For the other cases:
  - For SP-A and UP-A, C_y is calculated according to **Table 3** by using

    $c_1 = \left(1 - \frac{1}{\alpha}\right) \geq 0$
  - For SP-B and UP-B, C_y is calculated according to **Table 3** by using

    $c_1 = 1$
  - For vertically stiffened single side skin of bulk carrier, C_y is calculated according to **Table 3** by using

    $c_1 = \left(1 - \frac{1}{\alpha}\right) \geq 0$
  - For corrugation of corrugated bulkheads, C_y is calculated according to **Table 3** by using

    $c_1 = \left(1 - \frac{1}{\alpha}\right) \geq 0$

The boundary conditions for plates are to be considered as simply supported, see cases 1, 2 and ~~11~~15 of **Table 3**. If the boundary conditions differ significantly from simple support, a more appropriate boundary condition can be applied according to the different cases of **Table 3** subject to the agreement of the Society.

2.2.4 Correction factor F_{long}

The correction factor F_{long} depending on the edge stiffener types on the longer side of the buckling panel is defined in **Table 2**. An average value of F_{long} is to be used for plate panels having different edge stiffeners. For stiffener types other than those mentioned in **Table 2**, the value of *c* is to be agreed by the Society. In such a case, value of *c* higher than those mentioned in **Table 2** can be used, provided it is verified by buckling strength check of panel using non-linear FE analysis and deemed appropriate by the Society.

Table 2 has been amended as follows.

Table 2 Correction factor F_{long}

<table>
<tr><th colspan="3">Structural element types</th><th>F_{long}</th><th>c</th></tr>
<tr><td colspan="3">Unstiffened Panel</td><td>1.0</td><td>N/A</td></tr>
<tr><td rowspan="8">Stiffened Panel</td><td colspan="2">Stiffener not fixed at both ends</td><td>1.0</td><td>N/A</td></tr>
<tr><td rowspan="7">Stiffener fixed at both ends</td><td>Flat bar [1]</td><td rowspan="4">$\frac{t_w}{t_p} > 1$ for $F_{long} = c + 1$
$\frac{t_w}{t_p} \leq 1$ for $F_{long} = c\left(\frac{t_w}{t_p}\right)^3 + 1$</td><td>0.10</td></tr>
<tr><td>Bulb profile</td><td>0.30</td></tr>
<tr><td>Angle profile</td><td>0.40</td></tr>
<tr><td>T profile</td><td>0.30</td></tr>
<tr><td>Girder of high rigidity (e.g. bottom transverse)</td><td>1.4</td><td>N/A</td></tr>
<tr><td>U type profile fitted on hatch cover [2]</td><td>・ Plate on which the U type profile is fitted
・ For $b_2 < b_2$: F_{long} =1
・ For $b_2 \geq b_2$:
$F_{long} = \left(1.55 - 0.55\frac{b_1}{b_2}\right)\left[1 + c\left(\frac{t_w}{t_p}\right)^3\right]$
・ Other plate of the U type profile: F_{long} =1</td><td>0.2</td></tr>
<tr><td colspan="5">(1) t_w is the net web thickness, in *mm*, without the correction defined in **2.3.2**.
(2) b_1 and b_2 are defined in **Pt 2, Ch 1, Sec 5, Fig. 1**.</td></tr>
</table>

Paragraph 2.2.6 has been amended as follows.

2.2.6 Curved plate panels

~~**Table 4** applies to curved plate panels with $R/t_p \le 2500$. Otherwise, **Table 3** is applicable.~~

~~For the application of **Table 4**, the stresses and coefficients are to be taken as:~~

- ~~For d $d \ge g$: $\sigma_{ax} = \sigma_x$, $\sigma_{tg} = \sigma_y$, $C_x = C_{ax}$ and $C_y = C_{tg}$.~~
- ~~Otherwise : $\sigma_{ax} = \sigma_y$, $\sigma_{tg} = \sigma_x$, $C_x = C_{tg}$ and $C_y = C_{ax}$.~~

This requirement for curved plate limit state is applicable when $R/t_p \le 2500$. Otherwise, the requirement for plate limit state given in **2.2.1** is applicable.

The curved plate limit state is based on the following interaction formula:

$$\left(\frac{\gamma_c \sigma_{ax} S}{C_{ax} R_{eH\_P}}\right)^{1.25} - 0.5 \cdot \left(\frac{\gamma_c \sigma_{ax} S}{C_{ax} R_{eH\_P}}\right)\left(\frac{\gamma_c \sigma_{tg} S}{C_{tg} R_{eH\_P}}\right) + \left(\frac{\gamma_c \sigma_{tg} S}{C_{tg} R_{eH\_P}}\right)^{1.25} + \left(\frac{\gamma_c \tau \sqrt{3} S}{C_\tau R_{eH\_P}}\right)^{2} = 1.0$$

where:

σ_{ax} : Applied axial stress to the cylinder corresponding to the curved plate panel, in N/mm^2. In case of tensile axial stresses, σax = 0.

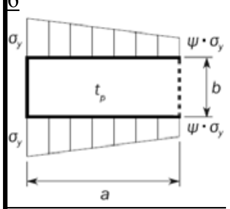
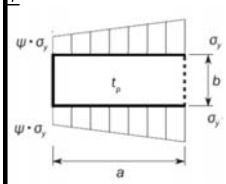
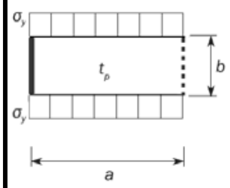
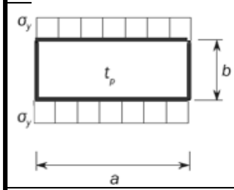
σ_{tg} : Applied tangential stress to the cylinder corresponding to the curved plate panel, in N/mm^2. In case of tensile tangential stresses, σtg = 0.

C_{ax}, C_{tg}, C_τ : Buckling reduction factor of the curved plate panel, as defined in **Table 4**.

The stress multiplier factor, γ_c, of the curved plate panel need not be taken less than the stress multiplier factor, γ_c, for the expanded plane panel according to **2.2.1**.

Case 6 to 10 and Case 11 to 13 of Table 3 have been renumbered to Case 9 to 13 and Case 15 to 17, and Case 6 to 8, 14, 18 and 19 have been added as follows.

Table 3 Buckling factor and reduction factor for plane plate panels

Case	Stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor C
(Omitted)				
6 	$1 \geq \psi \geq 0$		$K_y = \frac{4(0.425+\alpha^2)}{(3\psi+1)\alpha^2}$	$C_y = 1$ for $\lambda \leq 0.7$ $C_y = (\frac{1}{\lambda^2+0.51})$ for $\lambda > 0.7$
	$0 > \psi \geq -1$		$K_y = 4(0.425+\alpha^2)(1+\psi)\frac{1}{\alpha^2} - 5\psi(1-3.42\psi)\frac{1}{\alpha^2}$	
7 	$1 \geq \psi \geq -1$		$K_y = 4(0.425+\alpha^2)\frac{(3-\psi)}{2\alpha^2}$	
8 	=		$K_y = 1 + \frac{0.56}{\alpha^2} + \frac{0.13}{\alpha^4}$	
(Omitted)				
14 	–		$K_y = \frac{6.97}{\alpha^2} + \frac{3.1}{\alpha^2}\left[\frac{4-1/\alpha}{3}\right]^4$	$C_y = 1$ for $\lambda \leq 0.83$ $C_y = 1.13\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda > 0.83$
(Omitted)				

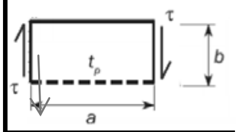
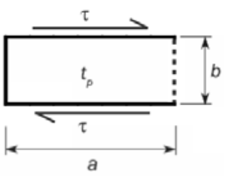
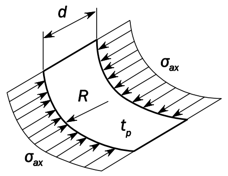
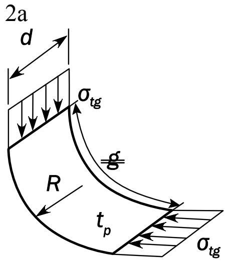
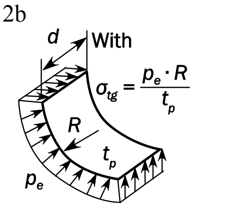
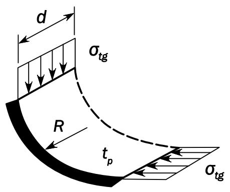
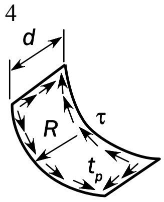
18 	–	$K_\tau = 3^{0.5}(0.6 + 4/\alpha^2)$	$C_\tau = 1$ for $\lambda \le 0.84$ $C_\tau = \dfrac{0.84}{\lambda}$ for $\lambda > 0.84$
19 	–	$K_\tau = 8$	

Table 4 has been amended as follows.

Table 4 Buckling and reduction factor for curved plate panel with $R/t_p \leq 2500$

Case	Aspect ratio	Buckling factor K	Reduction factor C
1 	$\frac{d}{R} \leq 0.5\sqrt{\frac{R}{t_p}}$	$K = 1 + \frac{2}{3}\frac{d^2}{Rt_p}$	For general application: $C_{ax} = 1$ for $\lambda \leq 0.25$ $C_{ax} = 1.233 - 0.933\lambda$ for $0.25 < \lambda \leq 1$ $C_{ax} = 0.3/\lambda^3$ for $1 < \lambda \leq 1.5$ $C_{ax} = 0.2/\lambda^2$ for $\lambda > 1.5$ For curved single fields, e.g. bilge strake, which are bounded by plane panels as shown in **Ch 6**, **Sec 4, Fig.1**: $C_{ax} = \frac{0.65}{\lambda^2} \leq 1.0$
	$\frac{d}{R} > 0.5\sqrt{\frac{R}{t_p}}$	$K = 0.267\frac{d^2}{Rt_p}\left[3 - \frac{d}{R}\sqrt{\frac{t_p}{R}}\right] \geq 0.4\frac{d^2}{Rt_p}$	
2a  2b  p_e = external pressure in [N/mm²]	$\frac{d}{R} \leq 1.63\sqrt{\frac{R}{t_p}}$	$K = \frac{d}{\sqrt{Rt_p}} + 3\frac{(Rt_p)^{0.175}}{d^{0.35}}$	For general application: $C_{tg} = 1$ for $\lambda \leq 0.4$ $C_{tg} = 1.274 - 0.686\lambda$ for $0.4 < \lambda \leq 1.2$ $C_{tg} = \frac{0.65}{\lambda^2}$ for $\lambda > 1.2$ For curved single fields, e.g. bilge strake, which are bounded by plane panels as shown in **Ch 6**, **Sec 4**, **Fig.1**: $C_{ax} = \frac{0.8}{\lambda^2} \leq 1.0$
	$\frac{d}{R} > 1.63\sqrt{\frac{R}{t_p}}$	$K = 0.3\frac{d^2}{R^2} + 2.25\left(\frac{R^2}{dt_p}\right)^2$	
3 	$\frac{d}{R} \leq \sqrt{\frac{R}{t_p}}$	$K = \frac{0.6d}{\sqrt{Rt_p}} + \frac{\sqrt{Rt_p}}{d} - 0.3\frac{Rt_p}{d^2}$	As in load case 2a.
	$\frac{d}{R} > \sqrt{\frac{R}{t_p}}$	$K = 0.3\frac{d^2}{R^2} + 0.291\left(\frac{R^2}{dt_p}\right)^2$	
4 	$\frac{d}{R} \leq 8.7\sqrt{\frac{R}{t_p}}$	$K = \sqrt{3}\sqrt{28.3 + \frac{0.67d^3}{R^{1.5}t_p^{1.5}}}$	$C_\tau = 1$ for $\lambda \leq 0.4$ $C_\tau = 1.274 - 0.686\lambda$ for $0.4 < \lambda \leq 1.2$ $C_\tau = \frac{0.65}{\lambda^2}$ for $\lambda > 1.2$
	$\frac{d}{R} > 8.7\sqrt{\frac{R}{t_p}}$	$K = \sqrt{3}\frac{0.28d^2}{R\sqrt{Rt_p}}$	
Explanations for boundary conditions: - - - - - - - - - - Plate edge free. ———— Plate edge simply supported. ▬▬▬▬ Plate edge clamped.			
~~Note 1 : For curved plate panels, the C-value need not be taken less than for the expanded plane panel.~~			

2.3 Stiffeners

Paragraph 2.3.5 has been amended as follows.

2.3.5 Effective width of attached plating

The effective ~~breadth~~ width of attached plating of stiffeners, b_{eff}, in *mm*, is to be taken as:

- For $\sigma_x > 0$:
  - For FE analysis,

    $$b_{eff} = \min(C_x b, \chi_s s)$$

  - For prescriptive assessment,

    $$b_{eff} = \min(\frac{C_{x1} b_1 + C_{x2} b_2}{2}, \chi_s s)$$

- For $\sigma_x \le 0$:
  - $b_{eff} = \chi_s s$

where:

χ_s: Effective ~~breadth~~ width coefficient to be taken as:

$$\chi_s = \min\left[\frac{1.12}{1 + \frac{1.75}{\left(\frac{\ell_{eff}}{s}\right)^{1.6}}} ; 1.0\right] \quad \text{for} \quad \frac{\ell_{eff}}{s} \ge 1$$

$$\chi_s = 0.407 \frac{\ell_{eff}}{s} \quad \text{for} \quad \frac{\ell_{eff}}{s} < 1$$

(Omitted)

2.4 Primary supporting members

Paragraph 2.4.1 has been amended as follows.

2.4.1 Web plate in way of openings

The web plate of primary supporting members with openings is to be assessed for buckling based on the combined axial compressive and shear stresses.

The web plate adjacent to the opening on both sides is to be considered as individual unstiffened plate panels as shown in **Table 6**.

The interaction formula of **2.2.1** is to be used with:

- $\sigma_x = \sigma_{av}$
- $\sigma_y = 0$
- $\tau = \tau_{av}$

where:

σ_{av} : Weighted average compressive stress, in N/mm^2, in the area of web plate being considered according to case 1, 2 or 3 in **Table 3**, i.e. $P1$, $P2$,or $P3$ as shown in **Table 6** in N/mm^2.

τ_{av} : Weighted average shear stress in the area of web plate being considered according to case 11 or 13 in **Table 3**, in N/mm^2.

For the application of the **Table 6**, the weighted average shear stress is to be taken as:

- Opening modelled in primary supporting members:

  τ_{av} : Weighted average shear stress, in N/mm^2, in the area of web plate being considered , i.e. $P1$, $P2$,or $P3$ as shown in **Table 6**.

  - Configuration a) when using case 13:
    - In $P1$: $\tau_{av} = \tau_{av}(P1)(h - h_0)/h$
    - In $P2$: $\tau_{av} = \tau_{av}(P2)(h - h_0)/h$
  - Configuration b) when using case 11:
    - In $P1$: $\tau_{av} = \tau_{av}(P1)$
    - In $P2$: $\tau_{av} = \tau_{av}(P2)$
  - Configuration c):
    - In $P1$ when using case 13: $\tau_{av} = \tau_{av}(P1)(h - h_0)/h$
    - In $P2$ when using case 13: $\tau_{av} = \tau_{av}(P2)(h - h_0)/h$
    - In $P3$ when using case 11: $\tau_{av} = \tau_{av}(P3)$

- Opening not modelled in primary supporting members:

  τ_{av} : Weighted average shear stress, in N/mm^2, given in **Table 6**.

  - Configuration a) when using case 13:
    - $\tau_{av} = \tau_{av}(web)$
  - Configuration b) when using case 11:
    - In $P1$: $\tau_{av} = \tau_{av}(P1)h/(h - h_0)$
    - In $P2$: $\tau_{av} = \tau_{av}(P2)h/(h - h_0)$
  - Configuration c):
    - In $P1$ when using case 13: $\tau_{av} = \tau_{av}(web)$
    - In $P2$ when using case 13: $\tau_{av} = \tau_{av}(web)$
    - In $P3$ when using case 11: $\tau_{av} = \tau_{av}(P3)h/(h - h_0)$

where:

h: Height, in m, of the web of the primary supporting member in way of the opening.

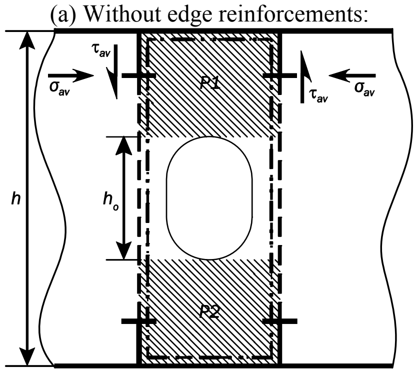
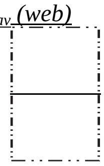
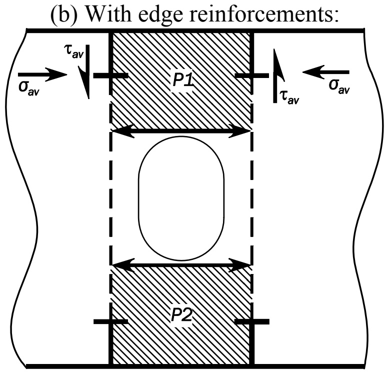
h_0: Height in m, of the opening measured in the depth of the web.

$\tau_{av}(P1)$, $\tau_{av}(P2)$, $\tau_{av}(P3)$: Weighted average shear stress, in N/mm^2, within the areas $P1$, $P2$ and $P3$, as shown in **Table 6**.

$\tau_{av}(web)$: Weighted average shear stress, in N/mm^2, in the area of the web marked with a dash rectangular shape, as shown in **Table 6**.

Table 6 has been amended as follows.

Table 6 Reduction factors

Configuration	C_x, C_y	C_τ	
		Opening modelled in PSM	Opening not modelled in PSM
(a) Without edge reinforcements: 	Separate reduction factors are to be applied to areas *P*1 and *P*2 using case 3 or case 6 in **Table 3**, with edge stress ratio: $\psi = 1.0$	Separate reduction factors are to be applied to areas *P*1 and *P*2 using case 18 or case 19 in **Table 3**	・ When case 17 of **Table 3** is applicable: A common reduction factor is to be applied to areas *P*1 and *P*2 using case ~~13~~17 in **Table 3** ~~for area marked~~ with: $\tau_{av} = \tau_{av}$ *(web)*  ・ When case 17 of Table 3 is not applicable: Separate reduction factors are to be applied to areas *P*1 and *P*2 using case 18 or case 19 in **Table 3** with: $\tau_{av} = \tau_{av}$ *(web) h/(h-h$_0$)*
(b) With edge reinforcements: 	Separate reduction factors are to be applied for areas *P*1 and *P*2 using C_x for case 1 or C_y for case 2 in **Table 3** with stress ratio: $\psi = 1.0$	Separate reduction factors are to be applied for areas *P*1 and *P*2 using case ~~11~~15 in **Table 3**.	Separate reduction factors are to be applied to areas *P*1 and *P*2 using case 15 in **Table 3** with: $\tau_{av} = \tau_{av}$ *(web)* $h/(h-h_0)$
(Omitted)			
Note 1: Web panels to be considered for buckling in way of openings are shown shaded and numbered *P*1, *P*2, etc.			
Where: *h* : Height, in *m*, of the web of the primary supporting member in way of the opening. h_0: Height in *m*, of the opening measured in the depth of the web. τ_{av} *(web)*: Weighted average shear stress, in N/mm^2, over the web height *h* of the primary supporting member.			

Title of paragraph 3 has been amended as follows.

3. Buckling capacity of o~~O~~ther Structures

Appendix 1 STRESS BASED REFERENCE STRESSES

1. Stress Based Method

1.2 Stress application

Paragraph 1.2.2 has been amended as follows.

1.2.2 Irregular panel <u>and curved panel</u>

The reference stresses of an irregular panel <u>or of a curved panel</u> are to be taken as defined in **2.2**.

2. Reference Stresses

Title of paragraph 2.2 has been amended as follows.

2.2 Irregular panel <u>and curved panel</u>

Chapter 9 FATIGUE

Section 1 GENERAL CONSIDERATIONS

1. Rule Application for Fatigue Requirements

1.1 Scope

Paragraph 1.1.8 has been added as follows.

1.1.8 Special consideration for the application of the Rules

Notwithstanding the provisions in this chapter, relevant rule changes adopted by *IACS* may be applicable from their effective dates.

Section 2 STRUCTURAL DETAILS TO BE ASSESSED

2. Finite Element Analysis

2.1 Structural details to be assessed

Paragraph 2.1.3 has been amended as follows.

2.1.3 Details to be checked by screening fatigue assessment

The structural details listed in **Table 2** for which FE fine mesh models have been analysed according to yielding requirements given in **Ch 7, Sec 3** are to be assessed using the screening fatigue procedure as given in **Ch 9, Sec 5, 6** or to be assessed by very fine mesh analysis according to **Ch 9, Sec 5, 1** to **4**.

Table 3 has been amended as follows.

Table 3 Structural details to be assessed by very fine mesh analysis if not designed in accordance with detail design standard

No	Critical detail	Corresponding detail design standard	Applicability	
			Oil tanker	Bulk carrier
1	Radiused upper hopper knuckle connection (intersection of knuckled inner side plate, side girder and transverse web) at the most critical frame location.(1)	**Ch 9, Sec 6, 4**	One cargo tank(4)	Ballast hold of double side bulk carrier
2	~~Corrugated transverse bulkhead~~ Corrugations of transverse bulkheads to lower stool or inner bottom plating connection.(2)(3)	**Ch 9, Sec 6, 6** and **Ch 9, Sec 6, 7**	One cargo tank(4)	Ballast hold
3	~~Corrugated transverse bulkhead~~ Corrugations of transverse bulkheads to upper stool.(2)(3)	**Ch 9, Sec 6, 6**	N/A	Ballast hold
4	Cruciform heel connections between side stringers in double side and transverse bulkhead horizontal stringers, for the stringer closest to the mid depth and for the uppermost one.	**Ch 9, Sec 6, 5**	One cargo tank(4)	N/A
5	Lower and upper side frame bracket toes at the most critical frame position.(1)	**Ch 9, Sec 6, 8**	N/A	*FA* hold(4), *EA* hold(4) and ballast hold of single skin bulk carrier
(Omitted)				

Section 3 FATIGUE EVALUATION

3. Reference Stresses for Fatigue Assessment

3.1 Fatigue stress range

Paragraph 3.1.2 has been amended as follows.

3.1.2 Welded joints

For welded joints, the fatigue stress range $\Delta\sigma_{FS,i(j)}$, in N/mm^2, corrected for mean stress effect, thickness effect and warping effect, is taken as:

- For simplified stress analysis:

  $\Delta\sigma_{FS,i(j)} = f_{mean,i(j)} \cdot f_{thick} \cdot f_{warp} \cdot \Delta\sigma_{HS,i(j)}$

- For FE analysis:
  - For web-stiffened cruciform joints:

    ~~$\Delta\sigma_{FS,i(j)} = \max\left(\Delta\sigma_{FS1,i(j)}, \Delta\sigma_{FS2,i(j)}\right)$~~

    $\Delta\sigma_{FS,i(j)} = f_w \cdot f_s \cdot \max\left(\Delta\sigma_{FS1,i(j)}, \Delta\sigma_{FS2,i(j)}\right)$

  - For other joints:

    $\Delta\sigma_{FS,i(j)} = \max_{(SideL,SideR)}\left[\max\left(\Delta\sigma_{FS1,i(j)}, \Delta\sigma_{FS2,i(j)}\right)\right]$

where:

$\Delta\sigma_{HS,i(j)}$: Hot spot stress range, in N/mm^2, due to dynamic loads in load case (i) of loading condition (j) given in **Ch 9, Sec 4, 2.1.1**.

$\Delta\sigma_{FS1,i(j)}$: Fatigue stress range, in N/mm^2, due to the principal hot spot stress range $\Delta\sigma_{HS1,i(j)}$

$\Delta\sigma_{FS2,i(j)}$: Fatigue stress range, in N/mm^2, due to the principal hot spot stress range $\Delta\sigma_{HS2,i(j)}$

SideL, *SideR* : Left and right side respectively of the line A-A as shown in **Ch 9, Sec 5, Fig. 15** and **Ch 9, Sec 5**, **Fig. 16**.

$f_{mean1,\ i(j)}$: Correction factor for mean stress effect given in **3.2**.

$f_{mean2,\ i(j)}$: Correction factor for mean stress effect given in **3.2**.

f_w : correction factor for the effect of stress gradient along weld line given as 0.96

f_s : correction factor for the effect of supporting member given as 0.95

f_{warp} : Correction factor due to warping effect, taken as:

- f_{warp} = 1.07 for the deck longitudinal stiffener of bulk carrier, the closest to the longitudinal hatch coaming in way of the hatch corner as shown in **Fig. 1**, except f_{warp} =1.0 when OST is not the dominant load case for all loading conditions
- f_{warp} = 1.04 for following deck longitudinal stiffeners of bulk carrier, except f_{warp} =1.0 when OST is not the dominant load case for all loading conditions:
  - The closest stiffener to the longitudinal hatch coaming at one web

frame away from the hatch corner, in way of the hatch opening as shown in **Fig. 1**,

- The second closest stiffener away from the longitudinal hatch coaming in way of the hatch corner as shown in **Fig. 1**,

- f_{warp} = 1.0 for the other cases.

4. *S*-*N* Curves

4.1 Basic *S*-*N* curves

Paragraph 4.1.5 has been amended as follows.

4.1.5 Corrosive environment

The basic design curves for corrosive environment shown in **Fig. 4** are represented by linear relationships between log($\Delta\sigma$) and log(N) as follows:

$$\log(N) = \log(K_2) - m \cdot \log(\Delta\sigma)$$

N : Predicted number of cycles to failure under stress range $\Delta\sigma$.

K_2 : Constant related to design S-N curve as given in **Table 3**.

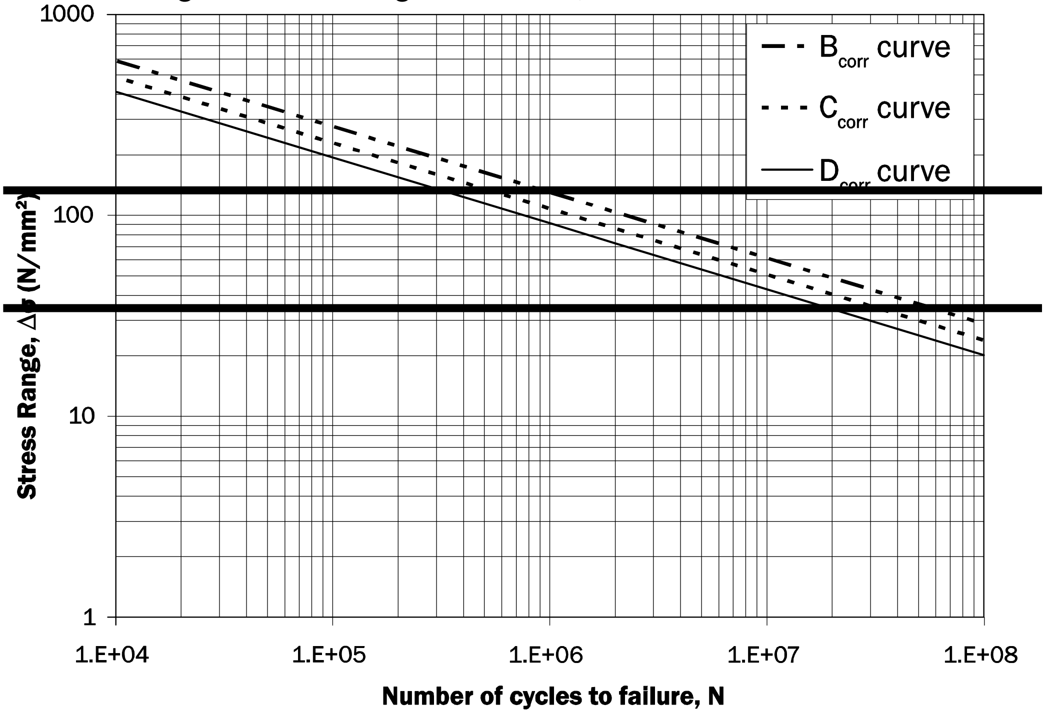
Table 3 has been amended as follows.

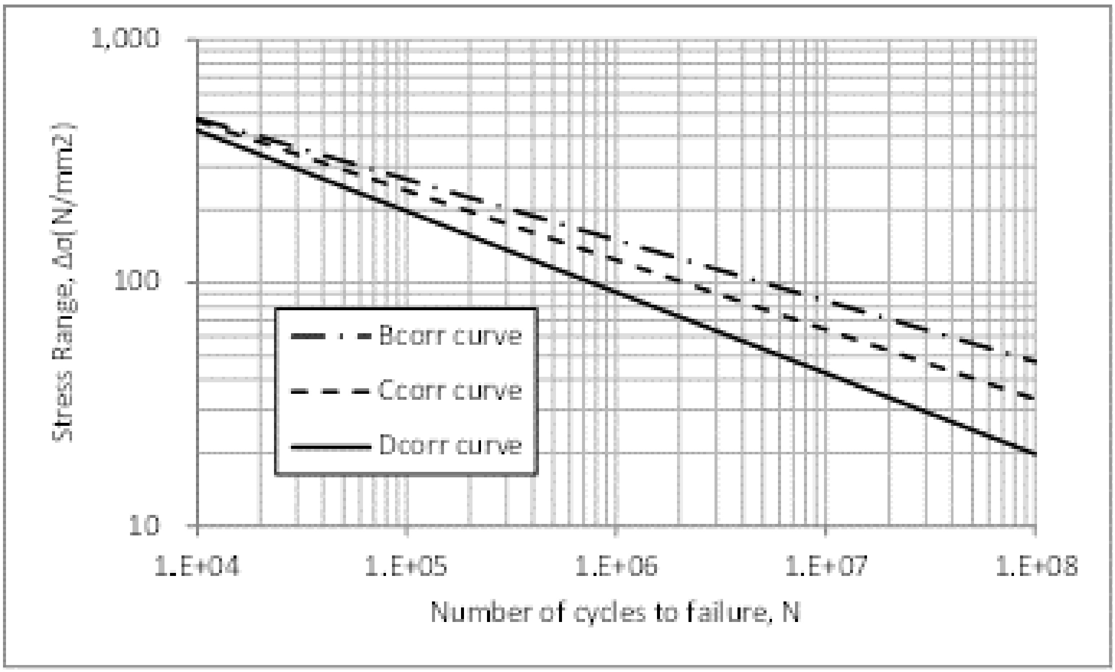
Table 3 Basic *S*-*N* curve data, corrosive environment

Class	K_2	m	Design stress range at 2×10^6 cycles, N/mm^2
B_{corr}	~~2.246E12~~ 5.05×10^{14}	3.0	~~103.9~~ 126.1
C_{corr}	~~1.267E12~~ 2.12×10^{13}	3.0	~~85.9~~ 101.6
D_{corr}	~~7.600E11~~ 7.60×10^{11}	3.0	72.4

Fig. 4 has been amended as follows.

Fig. 4 Basic design S-N curves, corrosive environment





4.2 Selection of *S*-*N* curves

Paragraph 4.2.3 has been amended as follows.

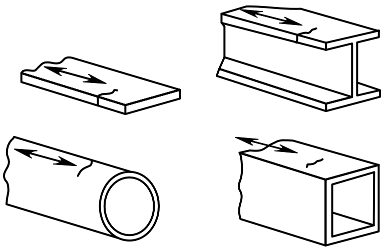
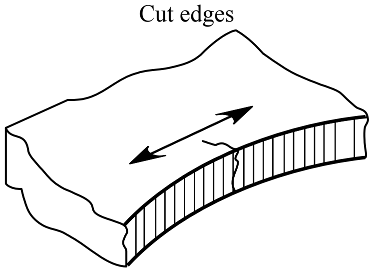
4.2.3 Surface finishing factor

The *S*-*N* curve *C* is applicable to most of non-welded locations taking into account the likelihood of some notching from corrosion, wear and tear in service with surface finishing factor as given in **Table 4**.

Higher surface finishing quality may be applied in using *S*-*N* curve *B* as given in **Table 4**, provided adequate protective measures are taken against wear, tear and corrosion <u>and finite element analysis according **Sec 5, 2** is carried out</u>.

Table 4 has been amended as follows.

Table 4 Non-welded joints: thickness exponent and surface finishing factor

	Joint config.uration, fatigue crack location and stress direction	Edge cutting process	Edge treatment	Surface finishing	n	K_{sf}	*S-N* curve
1	Rolled or extruded plates and sections as well as seamless pipes, no surface or rolling defects 	N/A	N/A	No surface nor roll defect[(1),(2)]	0	0.94	*B*
2	Cut edges 	Machine-cutting e.g. by a thermal process~~.~~ ~~S~~ or sheared edge cutting.	Cutting edges chamfered or rounded by means of Smooth grinding, groove direction parallel to the loading direction.	Smooth surface free of cracks and notches.[(1),(2)]	0.1	1.00	*B*
			~~Edges machined or ground smooth~~ Cutting edges broken or rounded.	Smooth surface free of cracks and notches [(1),(2)]	0.1	1.07	*B*
			No edge treatment	Surface free of cracks and severe notches (inspection procedure) [(1),(2)]	0.1	1.0	*C*
		Manually thermally cut e.g. by flame cutting	No edge treatment	Surface free of cracks and severe notches (inspection procedure) [(1),(2)]	0.1	1.24	*C*

Note 1 : Stress increase due to geometry of cut-outs to be considered.

Note 2 : Fine mesh FE analysis according to **Sec 5, 2**.

Section 4 SIMPLIFIED STRESS ANALYSIS

4. Local Stiffener Stress

4.1 Stress due to stiffener bending

Paragraph 4.1.1 has been amended as follows.

4.1.1 Stress due to dynamic pressure

The hot spot stress, in N/mm^2, due to local dynamic pressure in load case $i1$ and $i2$ for loading condition (j) is obtained from the following formula：

$$\sigma_{LD,ik(j)} = \frac{K_b K_n\, s\, \ell_{bdg}^2 \left(\eta_W\, f_{NL} P_{W,ik(j)} + \eta_{Id} P_{Id,ik(j)} + \eta_{bd} P_{bd,ik(j)}\right)\left(1 - \frac{6x_e}{\ell_{bdg}} + \frac{6x_e^2}{\ell_{bdg}^2}\right)}{12 Z_{eff-n50}}$$

where：

$P_{W,\,ik(j)}$： Dynamic wave pressure, at the mid span, in kN/m^2, specified in **Ch 4, Sec 5, 1.4**, in load case $i1$ and $i2$ for loading condition (j).

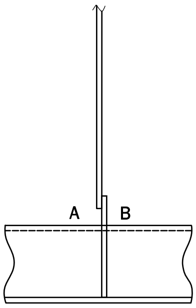
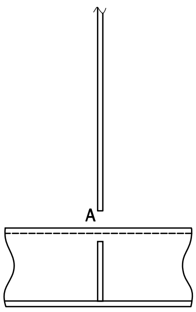
$P_{ld,\,ik(j)}$： Dynamic liquid tank pressure, at the mid span, in kN/m^2, as specified in **Ch 4, Sec 6, 1.1.1**, in load case $i1$ and $i2$ for loading condition (j).
Pressure acting on both sides of the stiffener, i.e. applied on the attached plate on stiffener side or on opposite side to the stiffener, could be simultaneously considered if relevant in the loading condition.
For the deck longitudinal stiffeners of bulk carriers, no internal pressure from the topside tank is considered.

(Omitted)

5. Stress Concentration Factors

Table 4 has been amended as follows.

Table 4 Stress concentration factors (continued)

ID	Connection type [(2) (3)]	Point '*A*'		Point '*B*'	
		K_a	K_b	K_a	K_b
(Omitted)					
31 [(4)]		~~1.34~~ 1.13	~~1.47~~ 1.20	~~1.34~~ 1.13	~~1.47~~ 1.20
32 [(4) (5) (6)]		~~1.34~~ 1.13	1.14	N/A	N/A

(1) The attachment length *d*, in *mm*, is defined as the length of the welded attachment on the longitudinal stiffener flange without deduction of scallop.

(2) Where the longitudinal stiffener is a flat bar and there is a web stiffener/bracket welded to the flat bar stiffener, the stress concentration factor listed in the table is to be multiplied by a factor of 1.12 when the thickness of attachment is thicker than the 0.7 times thickness of flat bar stiffener. This also applies to unsymmetrical profiles where there is less than 8*mm* clearance between the edge of the stiffener flange and the attachment, e.g. bulb or angle profiles where the clearance of 8 *mm* cannot be achieved.

(3) Designs with overlapped connection / attachments, see **5.2.3**.

(4) *ID*. 31 and 32 refer to details where web stiffeners are omitted or not connected to the longitudinal stiffener flange. See **5.2.4**

(5) For connection type *ID*. 32 with no collar and/or web plate welded to the flange, the stress concentration factors provided in this table are to be used irrespective of slot config.uration.

(6) The fatigue assessment point '*A*' is located at the connection between the stiffener web and the transverse web frame or lug plate.

5.3 Alternative design

Sub-paragraph 5.3.1(d) has been amended as follows.

5.3.1

Upon agreement by the Society, the geometrical stress concentration factors for alternative designs are to be calculated by a very fine mesh FE analysis according to the requirements given in **Ch 9, Sec 5**. Additional requirements for derivation of geometrical stress concentration factors for stiffener end connections using very fine mesh FE analysis are given below：

(a) FE model extent：the FE model, as shown in **Fig. 10**, is to cover at least four web frame spacings in the longitudinal stiffener direction with the detail to be considered located at the middle frame. The same type of end connection is to be modelled at all the web frames. In the transverse direction, the model may be limited to one stiffener spacing.

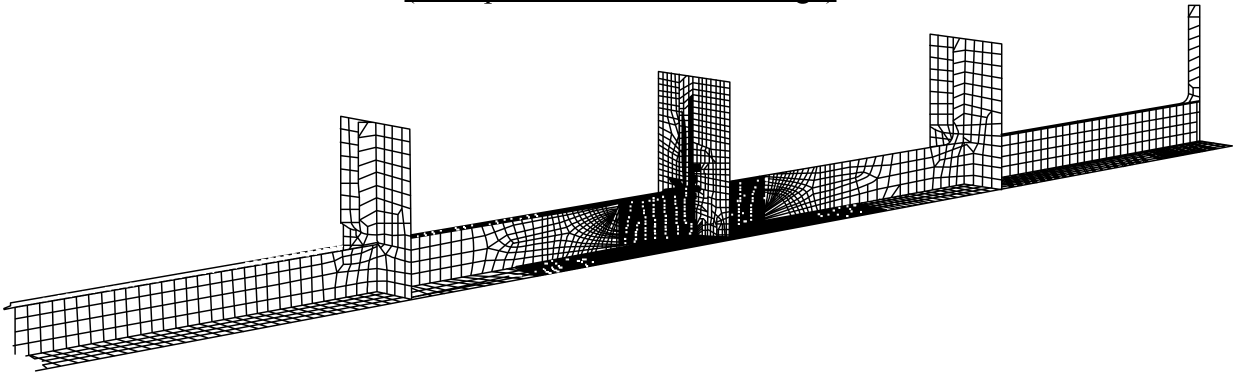
(b) Load application：in general, two loading cases are to be considered：
- Axial loading by enforced displacement applied to the model ends and
- Lateral loading by unit pressure load applied to the shell plating.

(c) Boundary conditions：
- Symmetry conditions are applied along the longitudinal cut of the plate flange, along transverse and vertical cuts on web frames and on top of the web stiffener.
- For lateral pressure loading：the model is to be fixed in all degrees of freedom at both forward and aft ends.
- For axial loading：the model is to be fixed for displacement in the longitudinal direction at the aft end of the model while enforced axial displacement is applied at the forward end, or vice versa.

(d) FE mesh density：At the location of the hot spots under consideration, the element size is to be in the order of the thickness of the stiffener flange <u>or 10 *mm* depending on the type of stiffener</u>. In the remaining part of the model, the element size is to be in the order of $s/10$, where s is the stiffener spacing.

Title of Fig. 10 has been amended as follows.

Fig. 10 Fine mesh finite element model for derivation of geometrical stress concentration factor <u>(example of stiffener with flange)</u>



Section 5 FINITE ELEMENT STRESS ANALYSIS

4. Hot Spot Stress for Web-Stiffened Cruciform Joint

4.2 Calculation of hot spot stress at the flange

Paragraph 4.2.1 has been amended as follows.

4.2.1

For hot spot at the flange of web-stiffened cruciform joints, the surface principal stress is to be read out from a point shifted away from the intersection line between the considered member and abutting member to the position of the actual weld toe and multiplied by 1.12. The intersection line is taken at the mid-thickness of the cruciform joint assuming a median alignment.

The hot spot stress, in N/mm^2, is to be obtained as:

$$\sigma_{HS} = 1.12\sigma_{shift}$$

where:

σ_{shift} : Surface principal stress, in N/mm^2, at shifted stress read out position.

The stress read out point shifted away from the intersection line is obtained as:

$$x_{shift} = \frac{t_{1-n50}}{2} + x_{wt}$$

where:

t_{1-n50} : Net plate thickness of the plate number 1, in *mm*, as shown in **Fig. 18**

x_{wt} : Extended fillet weld leg length, in *mm*, as defined in **Fig. 18**, not taken larger than ~~$t_{1-n50}/2$~~ t_{1-n50}.

Table 2 has been amended as follows.

Table 2 Stress magnification factor

~~Ship type~~	~~Structural details category~~	~~Stress magnification factor,~~ η
~~Oil tanker~~	~~Toe of stringer~~	~~2.45~~
	~~Bracket toe of transverse web frame~~	~~1.65~~
~~Bulk carrier~~	~~Lower hopper knuckle~~	~~2.10 for *FA*(1)~~ ~~2.00 for *EA*(1)~~
	~~Lower stool – inner bottom~~ ~~(for knuckle angle = 90 deg)~~	~~1.66~~
	~~Lower stool – inner bottom~~ ~~(for knuckle angle > 90 deg)~~	~~1.45 for *FA*(1)~~ ~~1.75 for *EA*(1)~~

~~(1) *FA* and *EA* mean full and empty cargo hold in alternate loading condition respectively.~~

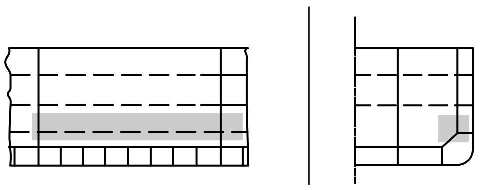
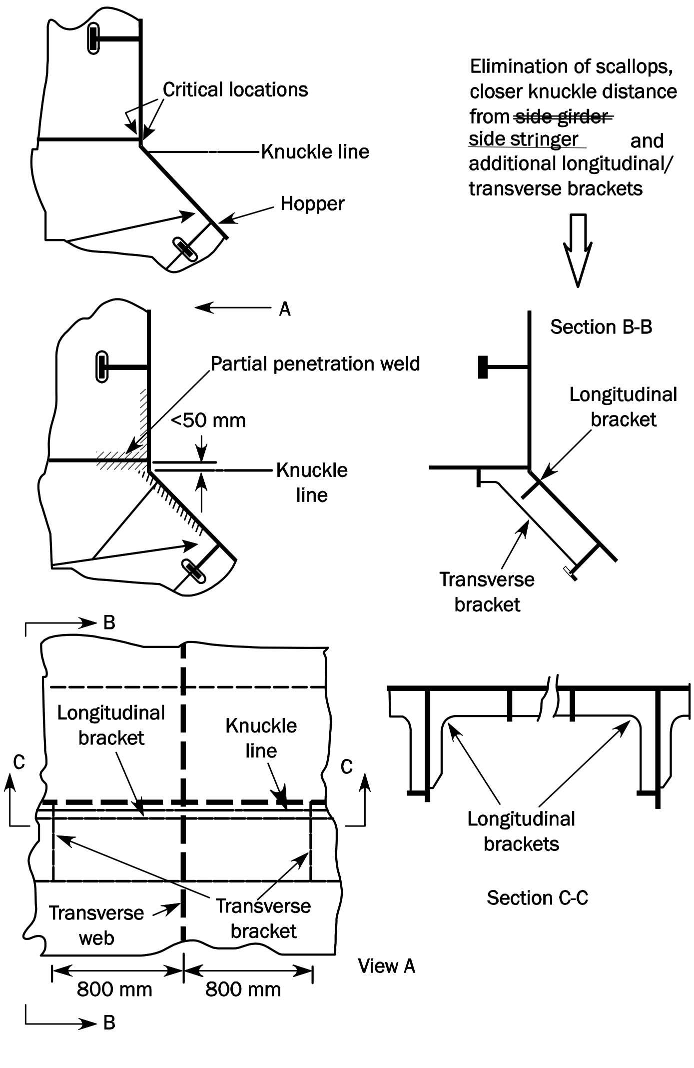
Ship type	Structural detail category		Bulk hold	Stress magnification factor
Oil tanker	Toe of stringer		-	2.45
	Bracket toe of transverse web frame		-	1.65
Bulk carrier	Lower hopper welded knuckle		FA(1)	2.28
			EA or C(1)	2.00
	Lower stool - Inner bottom	Non vertical (knuckle angle > 90°)	FA(1)	1.81
			EA or C(1)	1.47
		Vertical (knuckle angle = 90°)	FA(1)	2.09
			EA or C(1)	2.75

(1) FA and EA means "full cargo hold in alternate loading condition" and "empty cargo hold in alternate loading condition" respectively, *C* means cargo hold of *BC-B* and *BC-C* bulk carriers.

Section 6 DETAIL DESIGN STANDARD

Table 8 has been amended as follows.

Table 8 Design standard H – upper hopper knuckle connection detail, radiused type, oil tankers and double side bulk carrier

<table>
<tr><td colspan="2">Connections of transverse webs in double side tanks to hopper tanks
Hopper corner connections employing radiused knuckle between side longitudinal bulkhead and hopper sloping plating</td></tr>
<tr><td>Critical areas</td><td>Design standard H</td></tr>
<tr><td></td><td rowspan="3">

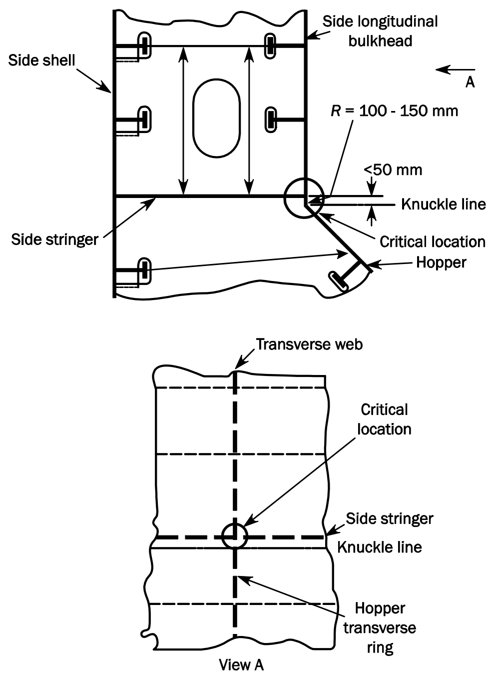
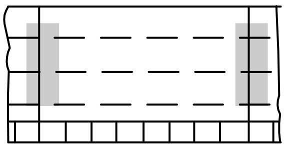
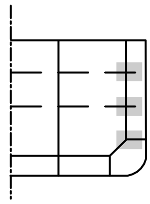
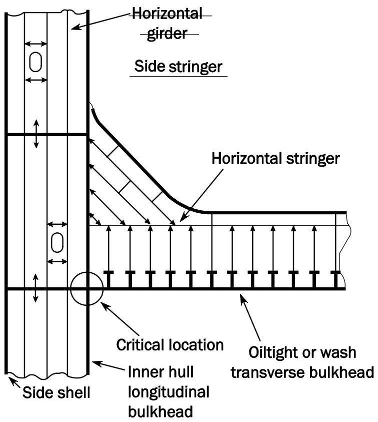
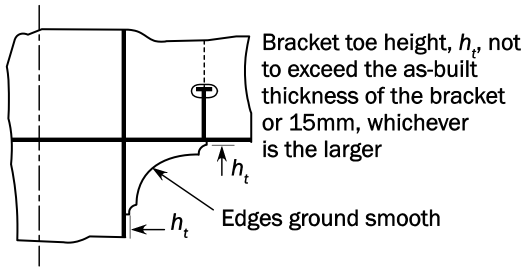
(Omitted)</td></tr>
<tr><td>Critical locations</td></tr>
<tr><td>
</td></tr>
<tr><td colspan="2">(Omitted)</td></tr>
</table>

Table 9 has been amended as follows.

Table 9 Design Standard I – transverse bulkhead horizontal stringer heel

<table>
<tr><td colspan="2">Connections of horizontal stringer on plane oil-tight transverse bulkheads or
wash bulkheads to inner hull longitudinal bulkheads</td></tr>
<tr><td>Critical areas</td><td>Design standard I</td></tr>
<tr><td> 
Critical locations

</td><td>

Note 1: Where a face plate is considered necessary, it is recommended that design features be adopted to reduce the stress concentration at the face plate termination (e.g. taper and soft nose). Adequate fatigue life of the weld on the bracket edge in way of such terminations is to be confirmed.
Note 2: ‘Slit type cut-outs are to be adopted in way of the bracket toe as shown. Alternatively, cut-outs with insert type collars will be accepted. Scallops are to be avoided.’</td></tr>
<tr><td>Critical location</td><td>Intersections of webs of transverse bulkhead horizontal stringer and double side tank ~~horizontal girder~~ side stringer forming square corners.</td></tr>
<tr><td>Detail design standard</td><td>A soft toe backing bracket is to be fitted. The following bracket sizes are recommended:
・ VLCC: 800×800×30, *R*600 with soft toe as shown in figure above,
・ Other tankers: 800×600×25, *R*550 with soft toe as shown in figure above, where the longer arm length is in way of the inner skin.
The specified minimum yield stress for the bracket is not to be less than 315 N/mm^2. The free edge is to be ground smooth with corners rounded.</td></tr>
<tr><td>Building tolerances</td><td>The nominal distance between the centres of thickness of the two abutting members should not exceed 1/3 of the as-built plate thickness of the inner hull longitudinal bulkhead.</td></tr>
<tr><td>Welding requirements</td><td>Vertical weld between the inner hull plating and transverse bulkhead plating, fillet welding having minimum weld factor 0.44.
Welding between the backing bracket and the adjoining plates is to be double sided fillet welding having minimum weld factor 0.44 except in way of the bracket toes. Full penetration welding is to be used for the connection of bracket toes to the inner hull and transverse bulkhead plating for a distance of 200 *mm* from the toes and the weld toes are to be ground smooth in way.</td></tr>
</table>

Chapter 10 OTHER STRUCTURES

Section 1 FORE PART

Symbol n_s has been amended as follows.

Symbols

n_s = 1 for one end ~~equivalent to built in~~ fixed and one end simply supported.

Section 4 TANKS SUBJECT TO SLOSHING

1. General

1.3 Application of sloshing pressure

Sub-paragraph 1.3.5(c) has been amended as follows.

1.3.5 Application of design sloshing pressure due to transverse liquid motion

The design sloshing pressure due to transverse liquid motion, $P_{shl\text{-}t}$, as defined in **Ch 4, Sec 6, 6.4.3**, is to be applied to the following members as shown in **Fig. 2**.

(a) Longitudinal tight bulkhead.
(b) Longitudinal wash bulkhead.
(c) Horizontal stringers ~~and vertical webs~~ on longitudinal tight and wash bulkheads.
(d) Plating and stiffeners on the transverse tight bulkheads including stringers and deck within a distance from the longitudinal bulkhead taken as:
- 0.25 b_{slh},
- The distance between the longitudinal bulkhead and the first girder if located inside the tank at the considered level,

whichever is less.

In addition, the first girder next to the longitudinal tight or wash bulkhead if the girder is located within $0.25b_{slh}$ from the longitudinal bulkhead, as shown in **Fig. 2**, is to be assessed for the reflected sloshing pressure,
$P_{slh\text{-}grd}$ as defined in **Ch 4, Sec 6, 6.4.4**.

The minimum sloshing pressure, $P_{slh\text{-}min}$, as defined in **Ch 4, Sec 6, 6.2**, is to be applied to all other members.

Chapter 11 SUPERSTRUCTURES, DECKHOUSES AND HULL OUTFITTING

Section 2 BULWARK AND GUARD RAILS

2. Bulwarks

2.2 Construction of bulwarks

2.2.1 Plating

The gross thickness of bulwark plating, at the boundaries of exposed freeboard and superstructure decks, is not to be less than that given in **Table 1**.

Table 1 has been amended as follows.

Table 1 Thickness of bulwark plates

Height of bulwark	Gross thickness
1.8*m* or more	~~Thickness required for a superstructure in the same position, obtained from **Ch 11, Sec 1, 3.1**~~ Thickness required for a superstructure side in the same position, obtained from **Ch11, Sec 1 3.2.1**, but not to be less than 6.5 *mm*
1.0 *m*	6.5 *mm*
Intermediate height	To be determined by linear interpolation

Section 3 EQUIPMENT

3. Anchoring Equipment

Paragraph 3.9 has been added as follows.

3.9 Tow lines and mooring line

3.9.1 General

Mooring lines and towlines are not required as a condition of Classification. The hawsers and towlines listed in **Table 2** are intended as a guide. Where the tabular breaking strength is greater than 490*kN*, the breaking strength and the number of individual hawsers given in **Table 2** may be modified, provided that their product is not less than that of the breaking strength and the number of hawsers given in the **Table 2**.

Table 2 has been added as follows.

Table 2 Towline and hawsers

Equipment Number		Towline wire or rope		Hawsers		
Greater than	Equal to or less than	Length, in *m*	Breaking strength, in *kN*	Number	Length of each, in *m*	Breaking strength, in *kN*
150	175	180	98.0	3	120	54.0
175	205	180	112.0	3	120	59.0
205	240	180	129.0	4	120	64.0
240	280	180	150.0	4	120	69.0
280	320	180	174.0	4	140	74.0
320	360	180	207.0	4	140	78.0
360	400	180	224.0	4	140	88.0
400	450	180	250.0	4	140	98.0
450	500	180	277.0	4	140	108.0
500	550	190	306.0	4	160	123.0
550	600	190	338.0	4	160	132.0
600	660	190	371.0	4	160	147.0
660	720	190	406.0	4	160	157.0
720	780	190	441.0	4	170	172.0
780	840	190	480.0	4	170	186.0
840	910	190	518.0	4	170	201.0
910	980	190	559.0	4	170	216.0
980	1060	200	603.0	4	180	230.0
1060	1140	200	647.0	4	180	250.0
1140	1220	200	691.0	4	180	270.0
1220	1300	200	738.0	4	180	284.0
1300	1390	200	786.0	4	180	309.0
1390	1480	200	836.0	4	180	324.0
1480	1570	220	888.0	5	190	324.0
1570	1670	220	941.0	5	190	333.0
1670	1790	220	1024.0	5	190	353.0
1790	1930	220	1109.0	5	190	378.0
1930	2080	220	1168.0	5	190	402.0

Equipment Number		Towline wire or rope		Hawsers		
		Length, in *m*	Breaking strength, in *kN*	Number	Length of each, in *m*	Breaking strength, in *kN*
Greater than	Equal to or less than					
2080	2230	240	1259.0	5	200	422.0
2230	2380	240	1356.0	5	200	451.0
2380	2530	240	1453.0	5	200	480.0
2530	2700	260	1471.0	6	200	480.0
2700	2870	260	1471.0	6	200	490.0
2870	3040	260	1471.0	6	200	500.0
3040	3210	280	1471.0	6	200	520.0
3210	3400	280	1471.0	6	200	554.0
3400	3600	280	1471.0	6	200	588.0
3600	3800	300	1471.0	6	200	618.0
3800	4000	300	1471.0	6	200	647.0
4000	4200	300	1471.0	7	200	647.0
4200	4400	300	1471.0	7	200	657.0
4400	4600	300	1471.0	7	200	667.0
4600	4800	300	1471.0	7	200	677.0
4800	5000	300	1471.0	7	200	686.0
5000	5200	300	1471.0	8	200	686.0
5200	5500	300	1471.0	8	200	696.0
5500	5800	300	1471.0	8	200	706.0
5800	6100	300	1471.0	8	200	706.0
6100	6500	300	1471.0	9	200	716.0
6500	6900	300	1471.0	9	200	726.0
6900	7400	300	1471.0	10	200	726.0
7400	7900	300	1471.0	11	200	726.0
7900	8400	300	1471.0	11	200	735.0
8400	8900	300	1471.0	12	200	735.0
8900	9400	300	1471.0	13	200	735.0
9400	10000	300	1471.0	14	200	735.0
10000	10700	-	-	15	200	735.0
10700	11500	-	-	16	200	735.0
11500	12400	-	-	17	200	735.0
12400	13400	-	-	18	200	735.0
13400	14600	-	-	19	200	735.0
14600	16000	-	-	21	200	735.0

Section 4 SUPPORTING STRUCTURE FOR DECK EQUIPMENT AND FITTINGS

Symbols have been amended as follows.

Symbols

For symbols not defined in this section, refer to **Ch 1, Sec 4**.
SWL: Safe working load as defined in **4.1.4**.
Normal stress : The sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress

3. Mooring Winches

3.1 General

Paragraph 3.1.5 has been amended as follows.

3.1.5 Supporting structure

The supporting structure is to be dimensioned to ensure that for each of the load cases specified in ~~**2.1.5**~~**3.1.7**, the stresses do not exceed the permissible values given in **2.1.12** ~~to **2.1.15**~~**.**

For mooring winches situated within the forward $0.25L_{CSR}$, the supporting structure is to be dimensioned to ensure that for the load case specified in ~~**3.1.7**~~**2.1.6**, the stresses do not exceed the permissible values given in ~~**2.1.12**~~**2.1.13** to **2.1.15**.

3.1.6 Corrosion model

These requirements are to be assessed based on gross scantlings.

Paragraph 3.1.7 has been amended as follows.

3.1.7

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

(a) Mooring winch at maximum pull: 100% of the Rated Pull.
(b) Mooring winch with brake effective: 100% of the Holding Load.
(c) Line strength: 125% of the breaking strength of the mooring line (hawser) according to **Ch 11, Sec 3**, **Table** ~~**1**~~**2** for the ship's corresponding equipment number.

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

5. Bollards and Bitts, Fairleads, Stand Rollers, Chocks and Capstans

5.1 General

Paragraph 5.1.6 has been amended as follows.

5.1.6

Design loads for the supporting structure for shipboard fittings are to be according to:

(a) In the case of normal towing in harbour or manoeuvring operations, 125% of the maximum towline load as indicated on the towing and mooring arrangement plan.

(b) In the case of towing service other than that experienced in harbour or manoeuvring operations, such as escort service, the nominal breaking strength of towline.

(c) In the case of mooring operations, 125% of the nominal breaking strength of the mooring line (hawser) ~~or towline~~ according to **Ch 11, Sec 3**, **Table ~~1~~2** for the ship's corresponding equipment number.

Chapter 12 CONSTRUCTION

Section 1 CONSTRUCTION AND FABRICATION

3. Cold Forming

3.3 Low bending radius

Sub-paragraph 3.3.1(b) has been amended as follows.

3.3.1

When the inside bending radius is reduced below 10 times or 4.5 times the as-built plate thickness according to **3.1** and **3.2** respectively, supporting data is to be provided. The bending radius is in no case to be less than 2 times the as-built plate thickness. As a minimum, the following additional requirements are to be complied with:

(a) For all bent plates:

- 100% visual inspection of the bent area is to be carried out.
- Random checks by magnetic particle testing are to be carried out.

(b) In addition to **(a)**, for bent plates ~~subject to lateral liquid pressure~~ at boundaries to tanks or ballast holds:

- The steel is to be of Grade *D*/*DH* or higher.
- The material is impact tested in the strain-aged condition and satisfies the requirements stated herein. The deformation is to be equal to the maximum deformation to be applied during production, calculated by the formula $t_{as\text{-}built} /(2r_{bdg} + t_{as\text{-}built})$, where $t_{as\text{-}built}$ is the as-built thickness of the plate material and r_{bdg} is the bending radius. One sample is to be plastically strained at the calculated deformation or 5%, whichever is greater and then artificially aged at 250°*C* for one hour then subject to Charpy *V*-notch testing. The average impact energy after strain ageing is to meet the impact requirements specified for the grade of steel used.

Section 3 DESIGN OF WELD JOINTS

2. Tee or Cross Joint

2.3 Intermittent fillet welds

2.3.1

Where continuous welding is not required, intermittent welding may be applied.

Paragraph 2.3.2 has been amended as follows.

2.3.2

Where beams, stiffeners, frames, etc, are intermittently welded and pass through slotted girders, shelves or stringers, there is to be a pair of matched intermittent welds on each side of every intersection. In addition, the beams, stiffeners and frames are to be efficiently attached to the girders, shelves and stringers.

Where intermittent welding or one side continuous welding is permitted, double continuous welds are to be applied for one-tenth of their shear span at each end, in accordance with **2.5.2** and **2.5.3**.

2.4 Partial and full penetration welds

Paragraph 2.4.6 has been amended as follows.

2.4.6 Locations required for full or partial penetration welding

Partial penetration welding as defined in **2.4.2**, is to be used in the following locations. Additional locations may be required based on other criteria, such as fatigue assessment as given in **Ch 9** (see **Fig. 3**):

(a) Connection of hopper sloping plate to longitudinal bulkhead (inner hull).
(b) Longitudinal/transverse bulkhead primary supporting member end connections to the double bottom.
(c) Corrugated bulkhead lower stool side plating to lower stool top plate.
(d) Corrugated bulkhead lower stool side plating to inner bottom.
(e) Corrugated bulkhead lower stool supporting floors to inner bottom.
(f) Corrugated bulkhead gusset and shedder plates.
(g) Lower 15% of the length of built-up corrugation of vertical corrugated bulkheads
(~~g~~h) Structural elements in double bottom below bulkhead primary supporting members and stool plates.
(~~h~~i) Lower hopper plate to inner bottom.
(~~i~~j) Horizontal stringers on bulkheads in way of their bracket toe and the heel.

2.5 Weld size criteria

Paragraph 2.5.2 has been amended as follows.

2.5.2

The leg length, ℓ_{leg} in *mm*, of continuous, lapped or intermittent fillet welds is not to be taken less than the greater of the following values:

$\ell_{leg} = f_1 f_2 t_{as-built}$

$\ell_{leg} = f_{yd} f_{weld} f_2 f_3 t_{as-built} + t_{gap}$

ℓ_{leg} as given in **Table 1**.

where:

f_1: Coefficient depending on welding type:

$f_1 = 0.30$ for double continuous welding.

$f_1 = 0.38$ for intermittent welding.

f_2: Coefficient depending on the edge preparation:

$f_2 = 1.0$ for double continuous welding without bevelling.

~~$f_2 = 0.85$ for partial penetration welds with one side bevelling and $f = t_{as-built}/2$.~~

$f_2 = 0.70$ for partial penetration welds with one side bevelling and $f = t_{as-built}/3$.

f_{yd}: Coefficient not to be taken less than the following:

$$f_{yd} = \left(\frac{1}{K}\right)^{0.5}\left(\frac{235}{R_{eH\_weld}}\right)^{0.75}$$

$f_{yd} = 0.71$

R_{eH_weld}: Specified minimum yield stress for the weld deposit in N/mm^2, not to be less than:

$R_{eH\_weld} = 305\ N/mm^2$ for welding of normal strength steel with $R_{eH} = 235\ N/mm^2$.

$R_{eH\_weld} = 375\ N/mm^2$ for welding of higher strength steels with R_{eH} from 265 to 355 N/mm^2.

$R_{eH\_weld} = 400\ N/mm^2$ for welding of higher strength steel with $R_{eH} = 390\ N/mm^2$.

f_{weld}: Weld factor dependent on the type of the structural member, see **Table 2** ~~and~~, **Table 3** and **Table 4**.

k: Material factor of the abutting member.

f_3: Correction factor for the type of weld:

$f_3 = 1.0$ for double continuous weld.

$f_3 = s_{ctr}/\ell_{weld}$ for intermittent or chain welding.

s_{ctr}: Distance between successive fillet welds, in *mm*.

Table 2 has been amended as follows.

Table 2 Weld factors for different structural members

Hull area	Connection		f_{weld}
	Of	To	
(Omitted)			
~~Hatch cover~~	~~Watertight/oil-tight joints~~		~~0.48~~
	~~Hatch cover~~	~~At ends of stiffeners~~	~~0.38 (1)~~
		~~Elsewhere~~	~~0.24 (1)~~
~~Ventilator~~	~~Coaming~~	~~Deck~~	~~0.48~~

(1) ~~For bulk carrier hatch covers use weld factor of 0.38 for watertight joints and 0.24 at ends of stiffeners.~~(Void)

(2) f_{weld} =0.43 for hatch coaming other than in cargo holds.

(3) Continuous welding.

(4) PPW: Partial penetration welding in accordance with **2.4.2**.

(5) FPW: Full penetration welding in accordance with **2.4.2**.

Table 3 has been added as follows.

Table 3 Weld factors for miscellaneous fittings and equipment

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

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

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

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

Paragraph 2.5.4 has been amended as follows.

2.5.4

For primary supporting members connections not listed in **Table 2** and **Table 3**, the weld factors from **Table ~~3~~4** are to be used.

Table 3 has been renumbered to Table 4.

Table ~~3~~4 Weld factors for primary supporting members

Hull structural member	Connection			f_{weld}
	Of	To		
Primary supporting member	Web plate	Shell plating, deck plating, inner bottom plating, bulkhead	Within 15% of shear span at ends	0.48
			Elsewhere	0.38
		Face plate	In tanks/holds Members located within 0.125 L_{CSR} from fore peak	0.38
			Elsewhere if cross section area of face plate exceeds 65 cm^2	0.38
			Elsewhere	0.24
	End connections		In way of boundaries of ballast and cargo tanks	0.48
			Elsewhere	0.38

3. Butt Joint

3.2 Thickness difference

Paragraph 3.2.1 has been amended as follows.

3.2.1 Taper

In the case of welding of plates with difference in as-built thickness ~~equal to or~~ greater than 4 *mm*, the thicker plate is normally to be tapered. The taper has to have a length of not less than 3 times the difference in as-built thickness. If the width of groove is not less than 3 times the difference the transition taper is to be avoided.

Chapter 13 SHIP IN OPERATION – RENEWAL CRITERIA

Section 2 ACCEPTANCE CRITERIA

1. General

1.2 Definition

Paragraph 1.2.1 has been amended as follows.

1.2.1 Deck zone

The deck zone includes all the following items contributing to the hull girder strength:

- For bulk carriers: elements above or crossed by the 0.9 *D* level line above the baseline such as:
  - Strength deck plating.
  - Deck stringer.
  - Sheer strake.
  - Side shell plating.
  - Inner hull and other longitudinal bulkhead plating, if any.
  - Topside tank sloped plating, including horizontal and vertical strakes.
  - Longitudinal stiffeners, girders and stringers connected to the above mentioned plating.
- For oil tankers:
  - Strength deck plating.
  - Deck stringer.
  - Sheer strake.
  - Inner hull and other longitudinal bulkheads upper most strake.
  - Longitudinal stiffeners, girders and stringers connected to the above mentioned plating.

Part 2 SHIP TYPES

Chapter 1 BULK CARRIERS

Section 2 STRUCTURAL DESIGN PRINCIPLES

3. Structural Detail Principles

3.3 Deck structures

Paragraph 3.3.4 has been amended as follows.

3.3.4 Openings in strength deck - Corner of hatchways
(a) Within the cargo hold region

For hatchways located within the cargo hold region, insert plates, whose thicknesses are to be determined according to the formula given after, are to be fitted in way of corners where the plating cut-out has a circular profile.

The radius of circular corners is not to be less than 5% of the hatch width, where a continuous longitudinal deck girder is fitted below the hatch coaming.

Corner radius, in the case of the arrangement of two or more hatchways athwartship, is considered by the Society on a case-by-case basis.

For hatchways located within the cargo hold region, insert plates are, in general, not required in way of corners where the plating cut-out has an elliptical or parabolic profile and the half axes of elliptical openings, or the half lengths of the parabolic arch, are not less than:

- 1/20 of the hatchway width or 600 *mm*, whichever is the lesser, in the transverse direction.
- Twice the transverse dimension, in the fore and aft direction.

Where insert plates are required, their net thickness is to be obtained, in *mm*, from the following formula:

$$t_{INS} = \left(0.8 + 0.4\frac{b}{\ell}\right)t_{off}$$

without being taken less than t_{off} or greater than 1.6 t_{off}.

where:

ℓ: Width, in *m*, in way of the corner considered, of the cross deck strip between two consecutive hatchways, measured in the longitudinal direction, see **Pt 1**, **Ch 3**, **Sec 6**, **Fig. 15**.

b: Width, in *m*, of the hatchway considered, measured in the transverse direction, see **Pt 1**, **Ch 3**, **Sec 6**, **Fig. 15**.

t_{off}: Offered net thickness, in *mm*, of the deck at the side of the hatchways.

For the extreme corners of end hatchways, insert plates are required. The net thickness of these insert plates is to be 60% greater than the net offered thickness of the adjacent deck plating. A lower thickness may be accepted by the Society on the basis of calculations showing that stresses at hatch corners are lower than permissible values.

Where insert plates are required, the arrangement is shown in **Pt 1**, **Ch 9**, **Sec 6**, **Table 15**, in which d_1, d_2, d_3 and d_4 are to be greater than the stiffener spacing.

~~For hatchways located outside the cargo hold region, a reduction in the thickness of the insert plates in way of corners may be considered by the Society on a case-by-case basis.~~

For ships having length L_{CSR} of 150 *m* or above, the corner radius, the thickness and the extent of insert plate may be determined by the results of a direct strength assessment according to **Pt 1**, **Ch 7**, including buckling check and fatigue strength assessment of hatch corners according to **Pt 1**, **Ch 8** and **Pt 1**, **Ch 9** respectively. For such type of ships it is recommended to arrange circular hatch corners.

(b) Outside the cargo hold region

For hatchways located outside the cargo hold region, a reduction in the thickness of the insert plates in way of corners may be considered by the Society on a case-by-case basis.

Section 3 HULL LOCAL SCANTLING

Symbols have been amended as follows.

Symbols

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

C_{XG}, C_{YS}, C_{YR}, C_{YG}, C_{ZP}, C_{ZR} : Load combination factors, as defined in **Pt 1**, **Ch 4**, **Sec 2**.

d_{shr} : Effective shear depth of the stiffener as defined in Pt 1, **Ch 3**, **Sec 7**, **1.4.3**.

F_R : Resultant force, in *kN*, as defined in **Pt 1**, **Ch 4**, **Sec 6**, **Table 7**.

$F_{sc-ib-s}$: Static load, in *kN*, as defined in **Pt 1**, **Ch 4**, **Sec 6**, **4.3.1**. ℓ is to be substituted by ℓ_{bdg} for stiffeners.

F_{sc-ib}: Total load, in *kN*, as defined in **Pt 1**, **Ch 4**, **Sec 6**, **4.2.1**. ℓ is to be substituted by ℓ_{bdg} for stiffeners.

$F_{sc-hs-s}$: Static load, in *kN*, as defined in **Pt 1**, **Ch 4**, **Sec 6**, **4.3.2**. ℓ is to be substituted by ℓ_{bdg} for stiffeners.

F_{sc-hs}: Total load, in *kN*, as defined in **Pt 1**, **Ch 4**, **Sec 6**, **4.2.2**. ℓ is to be substituted by ℓ_{bdg} for stiffeners.

ℓ : Distance, in *m*, as defined in **Pt 1**, **Ch 4**, **Sec 6**.

ℓ_{lp} : Distance, in *m*, as defined in **Pt 1**, **Ch 4**, **Sec 6**.

ℓ_{bdg} : Effective bending span, in *m*, as defined in **Ch 3, Sec 7, 1.1.2**.

ℓ_{SF} : Side frame span ℓ, in *m*, as defined in **Ch 1**, **Sec 2**, **Fig. 2**, not to be taken less than 0.25 *D*.

P : Design pressure in kN/m^2, for the design load set being considered according to **Pt 1**, **Ch 6**, **Sec 2**, **2** and calculated at the load calculation point defined in **Pt 1**, **Ch 3**, **Sec 7**, **3.2**.

P_R : Resultant pressure, in kN/m^2, as defined in **Pt 1**, **Ch 4**, **Sec 6**, **Table 7**.

s_{CW} : Plate width, in *mm*, taken as the width of the corrugation flange a or the web *c*, whichever is greater, see **Pt 1**, **Ch 3**, **Sec 6**, **Fig. 21**.

s_C : Half pitch, in *mm*, of the corrugation flange as defined in **Pt 1**, **Ch 3**, **Sec 6**, **Fig. 21**.

1. Cargo Hold Side Frames of Single Side Bulk Carriers

1.1 Strength criteria

Paragraph 1.1.1 has been amended as follows.

1.1.1 Net section modulus and net shear sectional area

The net section modulus Z, in cm^3, and the net shear sectional area A_{shr}, in cm^2, in the mid-span area of side frames subjected to lateral pressure are not to be taken less than:

$$Z = 1.125 \alpha_m \frac{P\, s\, \ell_{SF}^2}{f_{bdg}\, C_s\, R_{eH}}$$

~~$A_{shr} = 5.5 \alpha_S \frac{P\, s\, \ell_{SF}}{C_t\, \tau_{eH}} \left(\frac{\ell_{SF} - 2\ell_B}{\ell_{SF}} \right) 10^{-3}$~~ $A_{shr} = 5.0 \alpha_S \frac{P\, s\, \ell_{SF}}{C_t\, \tau_{eH}} \left(\frac{\ell_{SF} - 2\ell_B}{\ell_{SF}} \right) 10^{-3}$

where:

α_m : Coefficient taken as:

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

$\alpha_m = 0.36$ for other ships.

f_{bdg}: Bending coefficient taken as 10.

C_s: Permissible bending stress coefficient for the design load set being considered taken as:

$Cs = 0.75$ for acceptance criteria set *AC-S*.

$Cs = 0.90$ for acceptance criteria set *AC-SD*.

α_S : Coefficient taken as:

$\alpha_s = 1.1$ for side frames of empty holds in alternate condition of *BC-A* ships.

$\alpha_s = 1.0$ for other side frames.

ℓ_B : Lower bracket length, in *m*, as defined in **Fig. 1**.

P: Design pressures, in kN/m^2, for design load sets as defined in **Pt 1**, **Ch 6**, **Sec 2**, **Table 1**~~,~~ ~~excluding the design load sets *WB-4* to *WB-6*~~.

C_t: Permissible shear stress coefficient for the design load set being considered, taken as:

$C_t = 0.75$ for acceptance criteria set *AC-S*.

$C_t = 0.90$ for acceptance criteria set *AC-SD*.

2. Structure Loaded by Steel Coils on Wooden Dunnage

2.3 Inner bottom

Paragraph 2.3.2 has been amended as follows.

2.3.2 Stiffeners of inner bottom plating

The net section modulus Z, in cm^3, and the net web thickness, t_w, in mm, of single span stiffeners located on inner bottom plating are not to be taken less than:

$Z = K_3 \dfrac{F_{sc-ib-s}}{8 C_s R_{eH}} 10^3$ and $t_w = \dfrac{0.5 F_{sc-ib-s}}{d_{shr} C_t \tau_{eH}} 10^3$, for design load set *BC-9*.

$Z = K_3 \dfrac{F_{sc-ib}}{8 C_s R_{eH}} 10^3$ and $t_w = \dfrac{0.5 F_{sc-ib}}{d_{shr} C_t \tau_{eH}} 10^3$, for design load set *BC-10*.

where:

K_3 : Coefficient as defined in **Table 2**.

~~$K_3 = 2\ell/3$~~ $K_3 = 2\ell_{bdg}/3$, when $n_2 > 10$.

C_s : Permissible bending stress coefficient, as defined in **Pt 1**, **Ch 6**, **Sec 5**, **1.1.2**.

C_t : Permissible shear stress coefficient for the design load set being considered, to be taken as:

$C_t = 0.85$ for acceptance criteria set *AC-S*.

$C_t = 1.00$ for acceptance criteria set *AC-SD*.

n_2 : Number of load points per *EPP* of the inner bottom, see **Pt 1**, **Ch 4**, **Sec 6**, **4.1.3**.

Table 2 has been amended as follows.

Table 2 Coefficient K_3

~~n_2~~	~~1~~	~~2~~	~~3~~	~~4~~	~~5~~	~~6~~	~~7~~	~~8~~	~~9~~	~~10~~
~~K_3~~	~~ℓ~~	~~$\ell - \frac{\ell_{lp}^2}{\ell}$~~	~~$\ell - \frac{2\ell_{lp}^2}{3\ell}$~~	~~$\ell - \frac{5\ell_{lp}^2}{9\ell}$~~	~~$\ell - \frac{\ell_{lp}^2}{2\ell}$~~	~~$\ell - \frac{7\ell_{lp}^2}{15\ell}$~~	~~$\ell - \frac{4\ell_{lp}^2}{9\ell}$~~	~~$\ell - \frac{3\ell_{lp}^2}{7\ell}$~~	~~$\ell - \frac{5\ell_{lp}^2}{12\ell}$~~	~~$\ell - \frac{11\ell_{lp}^2}{27\ell}$~~

n_2	1	2	3	4	5	6	7	8	9	10
K_3	ℓ_{bdg}	$\ell_{bdg} - \frac{\ell_{IP}^2}{\ell_{bdg}}$	$\ell_{bdg} - \frac{2\ell_{IP}^2}{3\ell_{bdg}}$	$\ell_{bdg} - \frac{5\ell_{IP}^2}{9\ell_{bdg}}$	$\ell_{bdg} - \frac{\ell_{IP}^2}{2\ell_{bdg}}$	$\ell_{bdg} - \frac{7\ell_{IP}^2}{15\ell_{bdg}}$	$\ell_{bdg} - \frac{4\ell_{IP}^2}{9\ell_{bdg}}$	$\ell_{bdg} - \frac{3\ell_{IP}^2}{7\ell_{bdg}}$	$\ell_{bdg} - \frac{5\ell_{IP}^2}{12\ell_{bdg}}$	$\ell_{bdg} - \frac{11\ell_{IP}^2}{27\ell_{bdg}}$

2.4 Hopper tank and inner hull

Title of paragraph 2.4.1 has been amended as follows.

2.4.1 Hopper ~~side~~ sloping plating and inner hull plating
(Omitted)

Paragraph 2.4.2 has been amended as follows.

2.4.2 Stiffeners of hopper ~~side~~ sloping plating and inner hull plating

The net section modulus Z, in cm^3, and the net web thickness, t_w, in mm, of single span ordinary stiffeners located on bilge hopper sloping plate and inner hull plate are not to be taken less than:

$Z = K_3 \frac{F_{sc-hs-s}}{8C_s R_{eH}} 10^3$ and $t_w = \frac{0.5F_{sc-hs-s}}{d_{shr} C_t \tau_{eH}} 10^3$, applicable for design load set *BC-9*.

$Z = K_3 \frac{F_{sc-hs}}{8C_s R_{eH}} 10^3$ and $t_w = \frac{0.5F_{sc-hs}}{d_{shr} C_t \tau_{eH}} 10^3$, applicable for design load set *BC-10*.

where:

K_3 : Coefficient as defined in **Table 2**.

~~$K_3 = 2\ell/3$~~ $K_3 = 2\ell_{bdg}/3$ when $n_2 > 10$.

C_s, C_t : As defined in **2.3.2**.

3. Transverse Vertically Corrugated Watertight Bulkheads Separating Cargo Holds in Flooded Condition

3.3 Net section modulus at the lower end of the corrugations

Paragraph 3.3.3 has been amended as follows.

3.3.3 Effective shedder plates

Provided that effective shedder plates are fitted as shown in **Fig. 4**, when calculating the section modulus at the lower end of the corrugations (Sections '1' in **Fig. 4**), the net area, in cm^2, of flange plates may be increased by the factor I_{SH} to be taken as:

$I_{SH} = 2.5 \cdot 10^{-3}\, a \sqrt{t_f\, t_{SH}}$ without being taken greater than $2.5\, a t_f\, 10^{-3}$

where:

a : Width, in *mm*, of the corrugation flange as shown in **Pt 1**, **Ch 3**, **Sec 6**, **Fig. 21**.

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

t_f : Net flange thickness, in *mm*.

Effective shedder plates are those which:

- are not knuckled,
- are welded to the corrugations and the lower stool top plate according to **Pt 1**, **Ch 12**,
- are fitted with a minimum slope of 45°, their lower edge being in line with the lower stool side plating,
- have net thickness not less than 75% of ~~that~~ the net required for the corrugation flanges,
- have material properties not less than those required for the flanges.

Paragraph 3.3.4 has been amended as follows.

3.3.4 Effective gusset plates

Provided that effective gusset plates are fitted, when calculating the section modulus at the lower end of the corrugations (Sections '1' in **Fig. 5** and **Fig. 6**), the net area, in cm^2, of flange plates may be increased by the factor I_G to be taken as:

$I_G = 7 h_G\, t_f$

where:

h_g : Height, in *m*, of gusset plates as shown in **Fig. 5** and **Fig. 6** but not to be taken greater than:

$$\frac{10 S_{GU}}{7}$$

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

t_f : Net flange thickness, in *mm*.

Effective gusset plates are those which:

- are in combination with shedder plates having thickness, material properties and welded connections as requested for shedder plates in **3.3.3**,
- have a height not less than half of the flange width,
- are fitted in line with the lower stool side plating,

- are welded to the lower stool top plate, corrugations and shedder plates according to **Pt 1**, **Ch 12**, **Sec 3**, **2.4.6**,
- have net thickness and material properties not less than those net required for the flanges.

3. Transverse Corrugated Bulkheads of Ballast Holds

3.2 Net section modulus

3.2.1

The net section modulus *Z*, in *cm*^{3}, of corrugated bulkhead of ballast holds, subjected to lateral pressure are not to be less than the values obtained from the following formula:

$$Z = K \frac{P s_C \ell^2}{f_{bdg} C_s R_Y}$$

where:

K: Coefficient given in **Table 1** and **Table 2**, according to the type of end connection. When $d_H < 2.5\ d_0$, both section modulus per half pitch of corrugated bulkhead and section modulus of lower stool at inner bottom are to be calculated.

P: Design pressure for the design load set as defined in **Pt 1, Ch 6, Sec 2, Table 1** and calculated at the load calculation point defined in **Pt 1, Ch 3, Sec 7, 3.2**, in *kN/m*^{2}.

s_C: Half pitch length, in *mm*, of the corrugation, as defined in **Pt 1, Ch 3, Sec 6, Fig. 21**.

ℓ: Length, in *m*, between the supports, as indicated in **Fig. 1**.

C_s: Coefficient defined in **Pt 1, Ch 6, Sec 5, 1.1.2**.

f_{bdg}: Coefficient defined in **Pt 1, Ch 6, Sec 5, 1.1.2**.

The effective width of the corrugation flange in compression is to be considered according to **Ch 1, Sec 3, 3.3.1** when the net section modulus of corrugated bulkhead is calculated.

Table 1 and Table 2 have been amended as follows.

Table 1 Values of *K*, in case $d_H \geq 2.5\ d_0$

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 2 Values of *K*, in case $d_H < 2.5\ d_0$

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

4. Primary Supporting Members

4.3 Centre girders and side girders

Paragraph 4.3.1 has been amended as follows.

4.3.1 Net web thickness

The net thickness of girders in double bottom structure, in *mm*, is not to be less than the greater of the value

t_1 and t_2 specified in the followings according to each location:

$$t_1 = C_1 \frac{|P|\, S\, |x - x_c|}{(d_0 - d_1) C_{t-pr}\, \tau_{eH}} \left\{ 1 - 4 \left(\frac{y}{B_{DB}} \right)^2 \right\}$$

~~in which $|x - x_c|$ is to be taken less than or equal to 0.25 ℓ_{DB}.~~ where $|x - x_c|$ is less than 0.25 ℓ_{DB}, $|x - x_c|$ is to be taken as 0.25 ℓ_{DB}.

$$t_2 = 1.75 \sqrt[3]{\frac{H^2\, a^2\, C_{t-pr}\, \tau_{eH}}{C_1'}} \cdot t_1$$

where:

P: Design pressure in kN/m^2, for the design load set being considered according to **Pt 1, Ch 6, Sec 2, 2.1.3**, calculated at mid-point of a floor located midway between transverse bulkheads or transverse bulkhead and toe of stool, where fitted.

S: Distance between the centres of the two spaces adjacent to the centre or side girder under consideration, in *m*.

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

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

C_1: Coefficient given in **Table 4** depending on B_{DB} / ℓ_{DB}. For intermediate values of B_{DB} / ℓ_{DB}, C_1 is to be obtained by linear interpolation.

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

S_1: Spacing, in *m*, of vertical stiffeners or floors.

C'_1: Coefficient given in **Table 5** depending on S_1/a. For intermediate values of S_1/a, C'_1 is to be determined by linear interpolation.

H: Value obtained from the following formulae:

- Where the girder is provided with an unreinforced opening:

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

- In other cases:

$$H = 1.0$$

4.4 Floors

Paragraph 4.4.1 has been amended as follows.

4.4.1 Net web thickness

The net thickness of floors in the double bottom structure, in *mm*, is not to be less than the greatest of values t_1 and t_2 specified in the following according to each location:

$$t_1 = C_2 \frac{|P| S B_{DB}}{(d_0 - d_1) C_{t-pr} \tau_{eH}} \left(\frac{2|y|}{B'_{DB}} \right) \left\{ 1 - 2 \left(\frac{x - x_c}{\ell_{DB}} \right)^2 \right\}$$

~~in which $|x - x_c|$ is to be taken less than or equal to $0.25\ell_{DB}$ and $|y|$ is to be taken less than or equal to $B'_{DB}/4$.~~ where $|x - x_c|$ is less than $0.25\ell_{DB}$, $|x - x_c|$ is to be taken as $0.25\ell_{DB}$, and where $|y|$ is less than $B'_{DB}/4$, $|y|$ is to be taken as $B'_{DB}/4$.

~~$t_2 = 1.75 \sqrt[3]{\frac{H^2 a^2 C_{t-pr} \tau_{eH}}{C'_2} - t_1}$~~ $t_2 = 1.75 \sqrt[3]{\frac{H^2 a^2 C_{t-pr} \tau_{eH}}{C'_2} t_1}$

(Omitted)

4.5 Stringer of double side structure

Paragraph 4.5.1 has been amended as follows.

4.5.1 Net web thickness

The net thickness of stringers in double side structure, in *mm*, is not to be less than the greater of the value t_1 and t_2 specified in the followings according to each location:

$$t_1 = C_3 \frac{|P| S |x - x_c|}{(d_0 - d_1) C_{t-pr} \tau_{eH}}$$

~~in which $|x - x_c|$ is to be taken less than or equal to $0.25\ell_{DS}$.~~ where $|x - x_c|$ is under $0.25\ell_{DS}$, $|x - x_c|$ is to be taken as $0.25\ell_{DS}$.

~~$t_2 = 1.75 \sqrt[3]{\frac{H^2 a^2 C_{t-pr} \tau_{eH}}{C'_3} - t_1}$~~ $t_2 = 1.75 \sqrt[3]{\frac{H^2 a^2 C_{t-pr} \tau_{eH}}{C'_3} t_1}$

(Omitted)

4.6 Transverse web in double side structure

Paragraph 4.6.1 has been amended as follows.

4.6.1 Net web thickness

The net thickness of transverse webs in double side structure, in *mm*, is not to be less than the greater of the value t_1 and t_2 specified in the followings according to each location:

$$t_1 = C_4 \frac{|P|\, S\, h_{DS}}{(d_0 - d_1)\, C_{t-pr}\ \tau_{eH}} \left(1 - 1.75 \frac{z - z_{BH}}{h'_{DS}} \right)$$

~~in which z - z_{BH} is to be taken greater than or equal to 0.4 h'_{DS}.~~ where z - z_{BH} is greater than 0.4 h'_{DS}, z - z_{BH} is to be taken as 0.4 h'_{DS}.

$$t_2 = 1.75 \sqrt[3]{\frac{H^2\ \mathrm{a}^2\, C_{t-pr}\, \tau_{eH}}{C'_4}\, t_1}$$

(Omitted)

Section 5 CARGO HATCH COVERS

3. Width of Attached Plating

3.2 Primary supporting members

Paragraph 3.2.1 has been amended as follows.

3.2.1

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

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

  ~~$b_p = b_{p1} + b_{p2}$~~ $b_p = b_{eff}$

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

  ~~$b_p = b_{p1}$~~ $b_p = 0.5b_{eff}$

  where:

  ~~$b_{p1} = \min(0.165\ell_p, S_{p1})$~~

  ~~$b_{p2} = \min(0.165\ell_p, S_{p2})$~~

  ~~ℓ_p : Span, in *m*, of the considered primary supporting member.~~

  ~~S_{p1}, S_{p2}: Half distance, in *m*, between the considered primary supporting member and the adjacent ones, S_{p1} for one side, S_{p2} for the other side.~~

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

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

5. Strength Check

5.1 General

Paragraph 5.1.1 has been amended as follows.

5.1.1 Application

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

In the latter case, i.e. when the hatch cover is arranged as a grillage of longitudinal and transverse primary supporting members, or when the Society deems it necessary, the stresses in the primary supporting members are to be determined by a grillage or a finite element analysis.

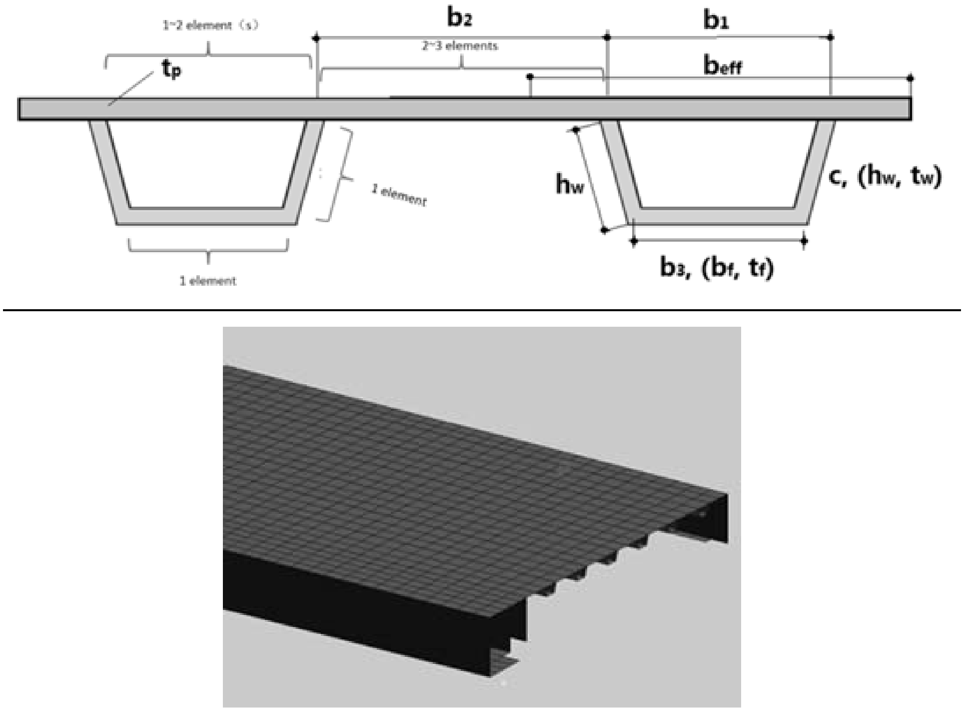
It is to be checked that stresses induced by concentrated loads are in accordance with the criteria in **5.4.4**.

When FE analysis is carried out, the buckling assessment as described in **5.2.3**, **5.3.4** and **5.4.6** can be made considering only the stresses given by the FE analysis

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

Fig. 1 has been added as follows.

Fig. 1 Example of hatch cover fitted with U type stiffener



5.2 Plating

Paragraph 5.2.3 has been amended as follows.

5.2.3 Buckling strength

The buckling strength of the hatch cover plating subjected to loading conditions as defined in **4.1** is to comply with the following formula:

$\eta_{Plate} \le \eta_{all}$

where:

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

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

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

For hatch covers fitted with U type stiffeners, the buckling panels b_1,b_2 and c (see **Fig. 1**) are to be assessed separately.

5.3 Stiffeners

Paragraph 5.3.4 has been amended as follows.

5.3.4 Buckling strength

The buckling strength of the hatch cover stiffeners subjected to loading conditions as defined in **4.1** is to comply with the following formula:

$\eta_{Stiffener} \le \eta_{all}$

where:

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

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

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

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

- Web height taken equal to d as defined in **Pt 1, Ch 3, Sec 6, Fig. 21**.
- Web thickness equal to 2 t_w.
- Flange breadth taken as b_3, as shown on **Fig. 1**.
- Flange thickness taken as t_f, as shown on **Fig. 1**.
- Effective width of the attached plating, b_{eff}, taken as:

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

Where:

C_{x1}, C_{x2} : Reduction factor defined in **Pt 1, Ch 8, Sec 5, Table 3** calculated for the EPP b1 and b2 according to case 1.

5.4 Primary supporting members

Paragraph 5.4.3 has been amended as follows.

5.4.3 Normal and shear stress for isolated beam

In case that grillage analysis or finite element analysis are not carried out, according to the requirements in **5.1.1**, the maximum normal stress σ and shear stress τ, in N/mm^2, in the primary supporting members are to be taken as given by the following formulae:

$$\sigma = \frac{s(F_S P_S + F_W P_W)\ell_m^2}{f_{bc} Z} \quad \sigma = \frac{S(F_S P_S + F_W P_W)\ell_m^2}{f_{bc} Z}$$

$$\tau = \frac{5s(F_S P_S + F_W P_W)\ell_m}{A_{shr}} \quad \tau = \frac{5S(F_S P_S + F_W P_W)\ell_m}{A_{shr}}$$

where:

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

Chapter 2 OIL TANKERS

Section 2 STRUCTURAL DESIGN PRINCIPLES

1. Corrosion Protection

1.3 Paint containing aluminium

Paragraph 1.3.1 has been amended as follows.

1.3.1

The use of aluminium coatings containing greater than 10% aluminium by weight in the dry film is prohibited in cargo tanks, cargo tank deck area, pump rooms, cofferdams or any other area where cargo vapour may accumulate ~~unless it has been shown by appropriate tests that the paint to be used does not increase the incendiary sparking hazard. Tests need not be performed for coatings with less than 10% aluminium by weight.~~

Section 4 HULL OUTFITTING

1. Supporting Structures for Components Used in Emergency Towing Arrangements

1.5 Loads

Paragraph 1.5.1 has been amended as follows.

1.5.1 Safe working loads

Safe working load of emergency towing arrangements is not to be taken less than:

・ 1,000 *kN* for tankers having a deadweight greater than or equal to 20,000 *t*, but less than 50,000 *t*.

・ 2,000 *kN* for tankers having a deadweight greater than or equal to 50,000 *t*.

~~The position and direction of load actions to be ascertained is to be submitted for reference.~~

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 1 July 2015.

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.0, July 2009)

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

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

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

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

Note:
This Procedural Requirement applies from 1 July 2009.