РОССИЙСКИЙ МОРСКОЙ РЕГИСТР СУДОХОДСТВА

HEAD OFFICE

CIRCULAR LETTER **No.** 314-26-796c dated 12.01.2015

Re:

On coming into force of a new revision of S18 IACS Unified Requirement (UR) S18 (Rev. 9, Apr. 2014) "Evaluation of Scantlings of Corrugated Transverse Watertight Bulkheads in Non-CSR Bulk Carriers Considering Hold Flooding"

Item of technical supervision:

Bulk carriers under construction

Implementation	upon receipt
Valid: till	-
Validity period extended till	-
Cancels / Amends/ Supplements Circular Letter No. -	dated -
Number of pages:	1+14
Appendices:	Amendments to Chapter 3.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships (hereinafter, the Rules) on 14 pages

Technical Director - Head of Classification Directorate Vladimir I. Evenko

Amends	Rules for the Classification and Construction of Sea-Going Ships, 2014 – ND No. 2-020101-077 and 2015 – ND No. 2-020101-085

We hereby inform you that in connection with application in the RS activity of a new revision of IACS UR S18 (Rev. 9, Apr. 2014) "Evaluation of Scantlings of Corrugated Transverse Watertight Bulkheads in Non-CSR Bulk Carriers Considering Hold Flooding" the amendments given in the Appendix to this Circular Letter shall be introduced into Chapter 3.3, Part II "Hull" of the Rules.

The control copy of IACS UR (in English) is posted on the RS internal website in the Section "External Normative Documents/ ND No. №1-0212-018-E".

These amendments will be introduced into a new edition of the Rules.

It is necessary to do the following:

1. Apply the amendments to the Rules during review and approval of technical documentation on bulk s.
2. Bring the content of the Circular Letter to the notice of the RS surveyors, interested organizations and shipowners in the area of the RS Branch Offices' activity.

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DMS "THESIS" No.	internal document 276547 of 19.11.2014		

Amendments to the Rules for the Classification and Construction of Sea-Going Ships,

2014 – ND No. 2-020101-077 and 2015 – ND No. 2-020101-085

PART II. Hull

3.3 BULK CARRIERS AND OIL OR BVULK DRY CARGO CARRIERS

Paras 3.3.4.10 and 3.3.4.11 shall be renumbered 3.3.4.11 and 3.3.4.12 accordingly.

A **new para 3.3.4.10** shall be introduced:

"**3.3.4.10** For ships of 150 m in length and more, intended to carry cargoes having bulk density of 1,0 t/m^3 and more, and with:

single side skin construction;

double side skin, in which any part of longitudinal bulkhead is located within *B*/5 or 11,5 m, whichever is less, inboard from the ship's side at right angle to the centerline at the assigned summer load line;
contracted for construction on or after 1 July 2006,
the strength of transverse, watertight, vertically corrugated bulkheads shall be additionally verified in accordance with a special procedure, described in Annex 3, for the case of each of the holds being flooded.".

New Appendix 3 to Part II "Hull" shall be introduced:

"*APPENDIX 3*

MEMBER SCANTLING ASSESSMENT OF TRANSVERSE WATERTIGHT CORRUGATED BULKHEAD IN NON-CSR BULK CARRIERS WITH CARGO HOLD FLOODED

1 APPLICATION AND DEFINITIONS

This procedure apply for bulk carriers specified in 3.3.4.10.

Uniform loading is the loading for which the maximum-to-minimum filling ratio for each cargo hold does not exceed 1,20 with regard for a correction depending on cargo density.

Net thickness t_{net} is the thickness obtained as a result of applying the strength criteria given in Section 4 of this Appendix.

Required thickness is the sum of net thickness (t_{net}) and the corrosion allowance (ts) given in Section 6 of this Appendix.

2 LOADING MODEL

2.1 General provisions.

Loads considered to act upon the bulkhead are loads due to a combination of cargo loads and those resulting from flooding a hold adjacent to the bulkhead in question. In any case, the pressure of water flooding a hold without cargo shall be considered.

To assess the member scantlings of each bulkhead, the most unfavourable combinations of loading and hold flooding shall be used proceeding from the following loading conditions described in the loading manual:
uniform loading;
non-uniform loading;
loading with regard for individual loaded and empty holds being flooded.

The limits set for design loads in cargo holds shall be taken into consideration by the designer when determining typical loading conditions to be included in the Loading Manual.
Partially non-uniform loading which may occur during cargo-handling operations in port may not be considered where the final typical loading of the ship is uniform.

Holds in which pallet cargo is loaded shall be considered empty.

Except where considered empty. Except where the ship being non-uniformly loaded is intended only for the carriage of iron ore or a cargo with a density of 1,78 t/m^3 or above, it shall be considered that the maximum cargo mass which may be present in a hold will fill it to the upper deck level on the centreline plane.

2.2 Water head applied to a corrugated bulkhead as a result of hold flooding.

Water head, h_f (refer to Fig. 2.2 of this Appendix) is the distance, in m, measured vertically, with the ship in the upright position, from a reference point to a level removed to the distance d_f, in m, from the base line and equal to:

.1 in general case:
D for the forward transverse corrugated bulkhead;
0,9*D* for other bulkheads.

If a ship is non-uniformly loaded with a bulk cargo with the density below 1,78 t/m^3, the following values may be adopted for the calculation:

0,95*D* for the forward transverse corrugated bulkhead;
0,85*D* for other bulkheads;

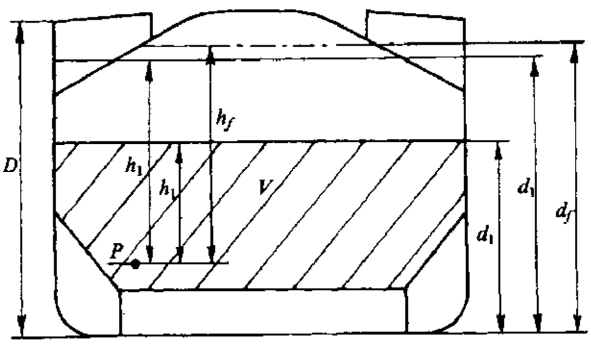


Fig. 2.2:
V – volume of cargo;
P – reference point;

D – distance, in m, from the base line to the freeboard deck measured along the side

.2 for ships with a freeboard of B type and a deadweight below 50000 t:

0,95D for the forward transverse corrugated bulkhead;
0,85D for other bulkheads.

If a ship is non-uniformly loaded with a bulk cargo with the density below 1,78 t/m^3, the following values may be adopted for the calculation:

2.3 Pressure in unflooded holds filled with bulk cargo.
For any point on the bulkhead, the pressure pc, inkN/m^2, shall be determined by the formula

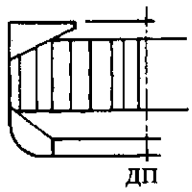
$$p_C = \rho_C g h_1 tan^2\gamma$$

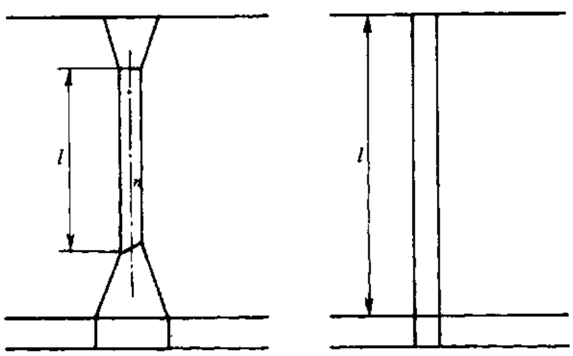
where ρ_C = bulk cargo density, in t/m^3;
g = gravity acceleration equal to 9,81 m/s2;
h_1 = vertical distance, in m, from a reference point to a horizontal plane corresponding to the cargo surface level (refer to Fig. 2.2 of this Appendix) and distanced by d_1, in m, from the base line;
$\gamma = 45° - \left(\frac{\varphi}{2}\right)$;
φ = repose angle generally adopted equal to 35° for iron ore and to 25° for cement.

The force F_C, in kN, acting upon a corrugation shall be determined by the formula

$$F_C = p_C g s_1 \frac{(d_1 - h_{DB} - h_{LS})^2}{2} tan^2 y$$

where s_1 = corrugation spacing, in m (refer to Fig. 2.3 of this Appendix);
h_{LS} =average height, in m, of the lower bulkhead support above the inner bottom;
h_{DB} = double bottom height, in m.





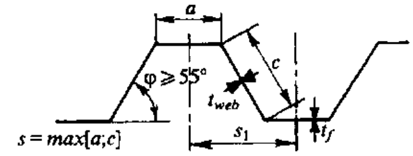


Fig. 2.3:
n – neutral axis of corrugation;
t_f – corrugation face plate thickness;
t_{web} – corrugation web thickness

2.4 Pressure in flooded holds.
2.4.1 Bulk cargo holds.
Two cases of hold loading shall be considered proceeding from the values of d1 and df:

.1 $d_f \geq d_1$.

For any point on the bulkhead lying between d_1 and d_f above the base line, the pressure $p_{c,f}$, in kN/m², shall be determined by the formula

$$p_{c,f} = \rho g h_f,$$

where ρ = seawater density, in t/m³;
g = gravity acceleration (see 2.3 of this Appendix);
h_f = water head (refer to 2.2 of this Appendix).
For any point on the bulkhead lying lower than d_1 above the base line, the pressure $p_{c,f}$ in kN/m², shall be determined by the formula

$$p_{c,f} = \rho g h_f + [\rho_c - \rho(1 - perm]g h_1 tan^2\gamma,$$

where for ρ_c, g, h_1, γ refer to 2.3 of this Appendix;
perm = permeability of cargo, to be taken as 0,3 for ore (corresponding bulk cargo density for iron ore may generally be taken as 3,0 t/m³), coal cargoes and for cement (corresponding bulk cargo density for cement may generally be taken as 1,3 t/m³.

The force $F_{c,f}$, in kN, applied to a corrugation shall be determined by the formula:

$$F_{c,f} = s_1[\rho g \frac{(d_f - d_1)}{2} + \frac{\rho g(d_f - d_1) + (p_{c,f})_{le}}{2}(d_1 - h_{DB} - h_{LS})],$$

where for $s_1, g, d_1, h_{DB}, h_{LS}$ refer to 2.3 of this Appendix;
for d_f, refer to 2.2 of this Appendix;
$(p_{c,f})_{le}$ = pressure on the level of the lower support section of the bulkhead, in kN/m²;

.2 $d_f < d_1$.

For any point on the bulkhead lying between d_1 and d_f above the base line, the pressure $p_{c,f}$, in kN/m², shall be determined by the formula

$$p_{c,f} = \rho_c g h_1 tan^2\gamma$$

where for p_c, g, h_1, γ, refer to 2.3 of this Appendix.

For any point on the bulkhead lying below d_f above the base line, the pressure $p_{c,f}$, in kN/m², shall be determined by the formula:

$$p_{c,f} = \rho g h_f + [\rho_c h_1 - \rho(1 - perm) h_f] g \cdot tan^2\gamma,$$

where for $\rho, h_f, perm$, refer to 2.4.1.1 of this Appendix;
for p_c, g, h_1, γ refer to 2.3 of this Appendix.
The force $F_{c,f}$, in kN, applied to a corrugation shall be determined by the formula

$$F_{c,f} = s_1[\rho_c g \frac{(d_1 - d_f)^2}{2} tan^2\gamma + \frac{p_c g(d_1 - d_f) tan^2\gamma + (p_{c,f})_{le}}{2}(d_f - h_{DB} - h_{LS})],$$

where for $s_1, p_c, g, d_1, \gamma, h_{DB}, h_{LS}$, refer to 2.3 of this Appendix;

for d_f, refer to 2.2 of this Appendix;
$(p_{c,f})_{le}$ = pressure on the level of the lower support section of the bulkhead, in kN/m^2.

2.4.2 Water pressure when a hold containing no cargo is flooded.
For any point on the bulkhead, the hydrostatic pressure pf due to the water head p_f shall be considered which results from hold flooding.
The force *F*, in kN, applied to a corrugation shall be determined by the formula

$$F_f = s_1 \rho g \frac{(d_f - h_{DB} - h_{LS})}{2},$$

where for s_1, g, h_{DB}, h_{LS}, refer to 2.3 of this Appendix;
for ρ, refer to 2.4.1.1 of this Appendix;
for d_f, refer to 2.2 of this Appendix.

2.5 Resultant pressure and resultant force.

2.5.1 Uniform ship loading.

For calculating member scantlings at any point on the bulkhead, the resultant pressure *p*, in kN/m^2, shall be determined by the formula

$$p = p_{c,f} - 0{,}8 p_c.$$

The resultant force *F*, in kN, applied to a corrugation shall be determined by the formula

$$F = F_{c,f} - 0{,}8 F_c$$

2.5.2 Non-uniform ship loading.

For calculating member scantlings at any point on the bulkhead, the resultant pressure p, in kN/m^2, shall be determined by the formula

$$p = p_{c,f}.$$

The resultant force *F*, in kN, applied to a corrugation, shall be determined by the formula

$$F = F_{c,f}.$$

3 BENDING MOMENT AND SHEARING FORCE IN BULKHEAD CORRUGATIONS

In bulkhead corrugations the bending moment *M* and the shearing force *Q* shall be determined by the formulae given in 3.1 and 3.2 of this Appendix. The values of *M* an *Q* shall be used for checks to be undertaken in accordance with 4.5 of this Appendix.

3.1 Bending moment.

For bulkhead corrugations, the design bending moment *M*, in kN/m, shall be determined by the formula:

$$M = \frac{Fl}{8},$$

where *F* = resultant force, in kN (refer to 2.5 of this Appendix);
l = corrugation span, in m (refer to Fig. 2.3 and 3.1 of this Appendix).

3.2 Shearing force.

In the lower supporting sections of bulkhead corrugations, the shearing force, in kN, shall be determined by the formula

$Q = 0{,}8F$

where for F, refer to 2.5 of this Appendix.

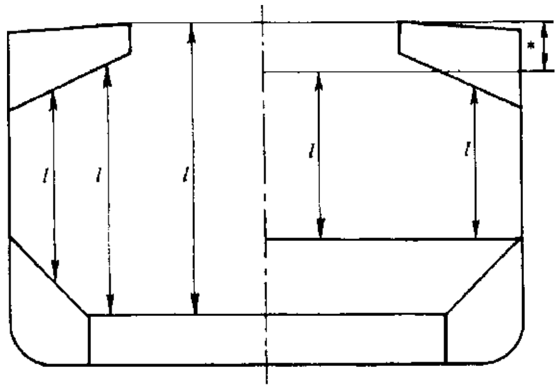


Fig. 3.1:
l – corrugation span;
* – distance, in the centreline plane, between the lowest point of the upper support for the bulkhead and the deck, which, when l is determined, shall be adopted not greater than:
three times the height of corrugation section in the general case;
two times the height of corrugation section where the upper support of the bulkhead has a rectangular cross section

4 STRENGTH CRITERIA

4.1 General.

4.1.1 The strength criteria given below apply to vertically corrugated transverse bulkheads (refer to Fig. 2.3 of this Appendix).

In ships 190 m or above in length, the bulkheads in question shall be attached to the lower support (transverse girder) and, as a rule, to the upper support (transverse girder) below the deck.

In ships less long, the corrugations may be attached to the inner bottom and deck. Where a lower and/or upper support is fitted, the latter shall comply with the requirements of this Chapter.

The corrugation angle shown in Fig. 2.3 of this Appendix shall not be less than 55°.

The requirements for the local net thickness of plates are given in 4.7 of this Appendix. Besides, the requirements given in 4.2 and 4.5 of this Appendix shall be complied with.

The thickness of the lower part of corrugations determined in accordance with 4.2 and 4.3 of this Appendix, shall remain without variation within 0,15l of the inner bottom at least, if a lower support is not fitted for the bulkhead, or from the upper point of the lower support. The thickness of the middle part of corrugations determined in accordance with 4.2 and 4.4 of this Appendix, shall remain without variation within not more than 0,3l of the deck, if an upper support (transverse girder) is not fitted for the bulkhead, or from the lower point of the upper support (transverse girder) for the bulkhead.

The section modulus of corrugations in the remaining upper part of the bulkhead shall not be less than 75 per cent of the value required for the middle part of the bulkhead and shall be corrected proceeding from the tensile strength of the material.

4.1.2 Lower support of bulkhead. The height of the support shall generally be at least equal to three times the height of the corrugation section.

The thickness and material of the upper horizontal/inclined supporting plate (flange plate) shall not be lower than those stipulated under 4.1.1 for the bulkhead plating. In the upper part of vertical or inclined supporting wall, on the height equal to the breadth of corrugation face plate (corrugation face parallel to the bulkhead plane) from the upper supporting plate, the plate thickness and material shall not be lower than required for the face plate in the lower cross section of corrugation to ensure compliance with the requirement for the bulkhead strength. The plate thickness of the supporting wall and the section modulus of stiffeners adjacent to the wall shall not be less than required in 3.3, Part II "Hull" with due regard for the loading model to be determined on the basis of Section 2 of this Appendix. The ends of vertical stiffeners adjacent to the supporting wall shall be connected to brackets at the upper and lower section of the support. The distance between the edge of the upper horizontal/inclined supporting plate (flange plate) and the surface of corrugation face plate shall be in accordance with Fig. 4.1. The lower sections of supporting walls shall be fitted on the plane of double bottom floors and spaced at least 2,5 times the average height of corrugation section. The diaphragms of the support shall be fitted on the plane of longitudinal web girders of double bottom to ensure and efficient attachment of the corrugated bulkhead.

No openings are permitted in brackets and diaphragms in way of attachment to the horizontal supporting plate. If corrugations terminate in way of the support, the former and the supporting walls shall generally be attached to the upper horizontal/inclined supporting plate (flange plate) with a complete penetration weld. The supporting wells and floors shall generally be connected to the inner bottom plating with a complete penetration weld.

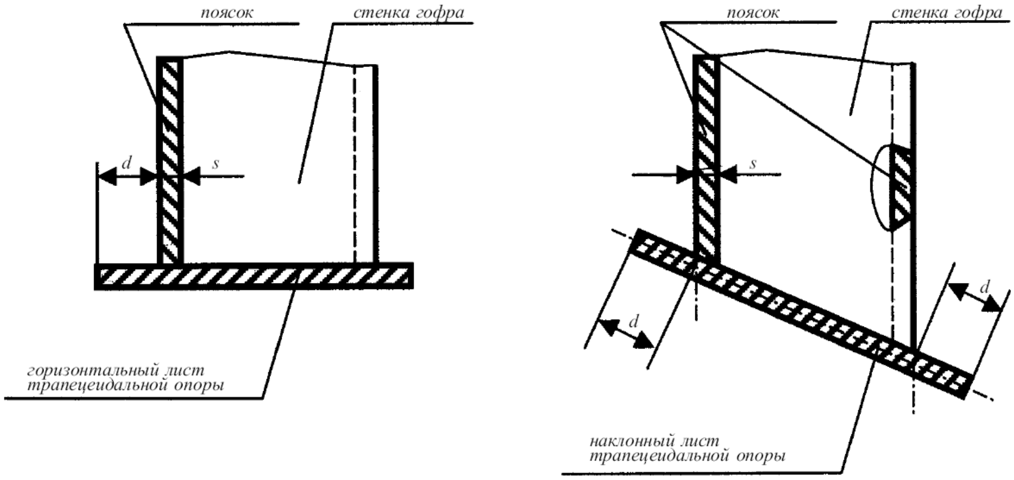


Fig. 4.1: s – as-built flange thickness; $d \geq s$

4.1.3 Upper support of bulkhead.

The upper support, if fitted, shall have a height generally equal to two or three times the height of corrugation section. Support with a rectangular cross section shall have a height equal to two times the height of corrugation section, as measured on deck level and at cargo hatch carling. The support shall be structurally fixed between hatch-end beams by means of carlings or reinforced brackets.

The breadth of the lower horizontal supporting plate (flange plate) shall generally be equal to that of the upper horizontal plate of the lower support (flange). The upper supporting section of a non-rec tangular shape shall have a breadth of at least two times the height of corrugation section.

The thickness and material of the lower horizontal supporting plate (flange plate) shall be the same as those of the adjacent bulkhead plating.

If the same material is used for the wall and bulkhead, the thickness of the lower part of the support wall shall be at least 80 per cent of that required for the upper part of bulkhead plating. The supporting wall thickness and the section modulus of stiffeners adjacent to the supporting wall shall not be less than required by the Register, with due regard for the loading model mentioned in Section 2 of this Appendix. The stiffener ends adjacent to the supporting wall shall be connected to brackets in way of the upper and lower section of the support. To support effectively the corrugated bulkhead, the diaphragms shall be fitted inside the support on the plane of underdeck web longitudinals reaching up to the hatch-end beams. No openings are permitted in brackets and diaphragms in way of attachments to the lower horizontal supporting plate (flange plate).

4.1.4 Alignment.

On deck where no support is fitted, two transverse reinforced beams shall be fitted on the plane of the corrugation face plates of the bulkhead.

On the double bottom where no support is fitted, the face plates of corrugations shall be fitted on the plane of floors.

Corrugations and floors shall generally be attached to the inner bottom plating with a complete

penetration weld. The thickness and properties of the floor material under the corrugations shall not be lower than those of the material used for corrugation face plates.

Besides, the openings for the passage of main framing girders of inner bottom through floors under the corrugations shall be sealed.

Under the corrugations the floors shall be interconnected with special brackets complying with the requirements of 3.3, Part II "Hull". To ensure an adequate load distribution between stiffeners, the lower supporting wall shall be flattened in alignment with the corrugation face plate and vertical stiffeners adjacent to the supporting wall, and their stiffening brackets in the lower support shall be fitted on the plane of main framing girders of inner bottom. The supporting wall shall not have a bend between the inner bottom plating and the upper supporting plate.

4.2 Bearing capacity of bulkhead in bending and the tangential stresses t.

The bearing capacity of a bulkhead in bending shall be in accordance with the following relationship

$$10^3 \cdot \frac{M}{0.5 Z_{le}\sigma_{a,le} + Z_m\sigma_{a,m}} \leq 0.95$$

where M = bending moment, in kN/m (refer to 3.1 of this Appendix);

Z_{le} = section modulus, in cm^3, of a corrugation half-breadth in the lower supporting section of corrugations determined in accordance with 4.3 of this Appendix;

Z_m = section modulus, in cm^3, of the cross-sectional area of a corrugation mid-span, to be determined in accordance with 4.4 of this Appendix;

$\sigma_{a,le}$ = permissible stresses, in N/mm2, for the lower supporting sections of corrugations in accordance with 4.5 of this Appendix;

$\sigma_{a,m}$ = permissible stresses, in N/mm2, for the cross-sectional area of a corrugation mid-span in accordance with 4.5 of this Appendix.

Always when the bearing capacity of a bulkhead in bending is determined, the value of Zm shall not be adopted greater than $1{,}15Z_{le}$ or $1{,}15Z'_{le}$, whichever is the less (Z'_{le} is defined below).

Where

a) shedder plates are fitted in such a way that:

.1 they have no bend;

.2 they are attached to corrugations and to the upper horizontal/inclined plate (flange) of the lower support with a full penetration weld made on one side or by another similar procedure;

.3 they have a minimal inclination of 45° and their lower end is a continuation of the lower supporting wall for the bulkhead;

.4 they have a thickness not less than 75 per cent of the corrugation face plate thickness;

.5 the properties of their material correspond at least to those of the material used for corrugation face plates;

b) or where gasset plates are fitted in such a way that:

.1 if combined with shedder plates, their thickness, properties of their material and their welds are in compliance with the above requirements;

.2 their height is equal to half the breadth of a corrugation face plate at least;

.3 they are fitted on the plane of the supporting wall for the bulkhead;

.4 they are generally attached to the upper horizontal/inclined plate (flange) of the lower support for the bulkhead with a complete penetration weld, and with an incomplete penetration weld on one side or similar weld to corrugations and shedder plates;

.5 thicknesses and properties of their material are at least similar to those of the corrugation face plate material, the section modulus Z_{le}, in cm^3, shall not be less than Z'_{le} , in cm^3, to be determined by the formula

$$Z'_{le} = Z_g + 10^3 \frac{Qh_g - 0.5h_g{}^2 s_1 p_g}{\sigma_a},$$

where Z_g = section modulus, in cm^3, of a corrugation half-breadth in accordance with 4.4 of this Appendix, on the level of the upper ends of shedder or gasset plates, if fitted;
Q = shearing force, in kN (refer to 3.2 of this Appendix);

h_g = height, in m, of shedder or gasset plates (refer to Figs 4.2-1, 4.2-2, 4.2-3 and 4.2-4 of this Appendix);
for s_1, refer to 2.3 of this Appendix;
p_g= resultant pressure, N/m^2, in accordance with 2.5 of this Appendix, determined on the level of mid-length of shedder or gasset plates, if fitted;
σ_a = permissible stresses, in N/mm^2, in accordance with 4.5 of this Appendix.

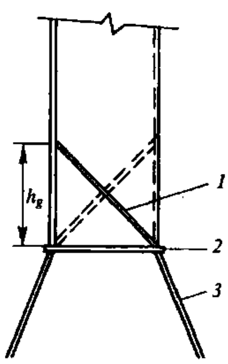


Fig. 4.2-1
Symmetrical shedder plates:
1 – shedder plate;
2 – horizontal/inclined supporting plate (flange plate) of the lower support for the bulkhead;

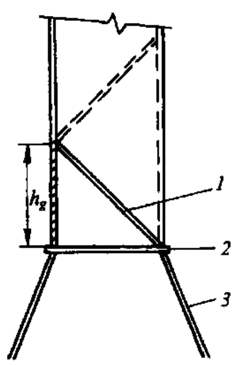


Fig. 4.2-2
Unsymmetrical shedder plates:
1 – shedder plate;
2 – horizontal/inclined supporting plate (flange plate) of the lower support for the bulkhead;

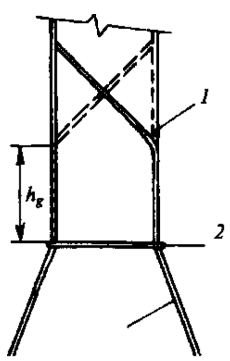


Fig. 4.2.-3
Symmetrial gasset/shedder plates:
1 – gasset/shedder plate;
2 – horizontal/inclined supporting plate (flange plate)

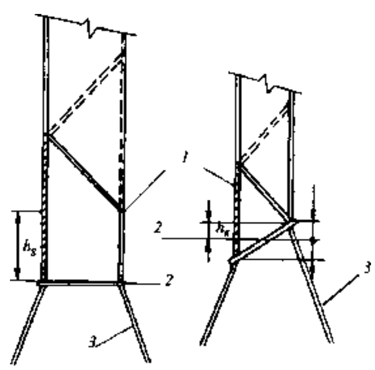


Fig. 4.2-4
Unsymmetrial gasset/shedder plates:
1 – gasset/shedder plate;
2 – horizontal/inclined supporting plate (flange plate)

3 – vertical/inclined supporting wall of the lower support for the bulkhead	3 – vertical/inclined supporting wall of the lower support for the bulkhead	of the lower support for the bulkhead; 3 – vertical/inclined wall of the lower support for the bulkhead.	of the lower support for the bulkhead; 3 – vertical/inclined wall of the lower support for the bulkhead

4.3 Section modulus of the cross-sectional area of corrugations in the lower supporting section.

4.3.1 The section modulus shall be calculated for a compressed corrugation face plate having the effective breadth b_{ef} not grater than mentioned in 4.6 of this Appendix. Where a corrugation wall is not stiffened with brackets fitted under the upper horizontal/inclined plate (flange) of the lower support for the bulkhead (or below the inner bottom), the section modulus of the lower part of corrugations shall be determined proceeding from 30 per cent efficiency of corrugation walls.

4.3.2 If efficient shedder plates are fitted in accordance with 4.2 of this Appendix (refer to Figs. 4.2-1 and 4.2-2), the corrugation face plate area, in cm^2, when determining its section modulus in the lower supporting section, may be increased by

$$(2.5a\sqrt{t_f t_{sh}}), \text{ but not more than by } 2{,}5at_f,$$

where a = corrugation face plate width, in m (refer to Fig. 2.3 of this Appendix);
t_{sh} = net thickness, in mm, of shedder plate;
t_f = net thickness, in mm, of corrugation face plate.

4.3.3 If efficient gusset plates are fitted in accordance with 4.2 of this Appendix (refer to Figs. 4.2-3 and 4.2-4), the corrugation face plate area, in cm^2, may be increased, when determining its section modulus in the lower supporting section, by multiplying it by

$$(7h_g t_{gu}),$$

where h_g = gusset plate height, in m (see Figs 4.2-3 and 4.2-4), with hg4 $\le$ (10/7)sgu;
s_{gu} = gusset plate breadth, in m;
t_f = net thickness, in mm, of a corrugation face plate, as determined proceeding from the building thickness.

4.3.4 Where corrugation walls are welded to an inclined upper plate (flange) of the lower support for the bulkhead, which lies at an angle of not less than 45°to the horizontal, the section modulus of the corrugation cross section may be determined proceeding from full efficiency of corrugation walls. If efficient gusset plates are fitted, the corrugation face plate area can be increased in accordance with 4.3.3 when determining the corrugation section modulus. This does not apply to shedder plates.

For angles less than 45°, the efficiency of corrugation walls may be determined by linear interpolation between 30 per cent for the angle of 08 and 100 per cent for the angle of 45°.

4.4 Corrugation section moduli in areas outside the lower supporting section.

The section modulus shall be determined taking into consideration the corrugation walls completely involved in bending and corrugation face plates having the effective breadth bef not greater than that given in 4.6.1 of this Appendix.

4.5 Verification of permissible stresses.

Normal and tangential stresses σ and τ shall not exceed the permissible values σ_a and τ_a, in

N/mm^2, determined by the formulae:

$$\sigma_a = R_{eH},$$

$$\tau_a = 0.5R_{eH}$$

where R_{eH} = minimal upper yield stress, in N/mm^2, for the material.

4.6 Effective breadth of compressed corrugation face plate and corrugation testing for shear resistance.

4.6.1 Effective breadth of compressed corrugation face plate.

The effective breadth b_{ef}, in m, of a compressed corrugation face plate shall be determined by the formula:

$$b_{ef} = C_e\, a\ ,$$

where;

$C_e = \frac{2.25}{\beta} - \frac{1.25}{\beta^2}$, *for* $\beta > 1.25$;

$C_e = 1.0$, *for* $\beta \leq 1,25$;

t_f = net thickness, in mm, of corrugation face plate;
a = corrugation face plate breadth, in m (refer to Fig. 2.3 of this Appendix);
for R_{eH}, refer to 4.5 of this Appendix;
E = elastic modulus of material, equal to 2,06 · 105 N/mm^2 for steel.

4.6.2 Shear

Corrugation resistance shall be tested for walls in way of supporting sections.
Tangential stresses t shall not exceed critical stresses τ, in N/mm^2, to be determined by the formulae

$$\tau_c = \tau_E \ \text{at} \quad \tau_E \leq \frac{\tau_F}{2},$$

$$\tau_F = \tau_F\,(1 - \frac{\tau_F}{4\tau_E}) \ \text{at} \quad \tau_E \leq \frac{\tau_F}{2},$$

where:

$\tau_F = \frac{R_{eH}}{\sqrt{3}}$;

R_{eH} – refer to 4.5 of this Appendix;

$\tau_E = 0{,}9k_t E(\frac{t}{1000c})^2$, N/mm^2;

$k_t = 6.34$;

E = elastic modulus of material in accordance 4.6.1of this Appendix;
t = net thickness of corrugation wall, in mm;
c = corrugation wall breadth, in mm (refer to Fig. 2.3 of this Appendix).

4.7 Local net thickness of plates.

The local net thickness of bulkhead plates *t,* in mm, shall be determined by the formula

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

where s_w = plate breadth, in m, to be adopted equal to the face plate or corrugation wall breadth, whichever is greater (refer to Fig. 2.3 of this Appendix);
p = resultant pressure, in kN/m^2, in accordance with 2.5 of this Appendix, in the lower part of each bulkhead plating strake; the net thickness of the lowest strake in any case shall be determined under the resultant pressure at the highest point of the lower support for the bulkhead

or in way of inner bottom where the lower support is not fitted, or at the highest point of shedder places where the shedder or the gusset/shedder plates are fitted;
for *ReH*, refer to 4.5 of this Appendix.

In composite corrugated bulkheads, where the thickness of face plate and that of corrugation wall are different, the net thickness of the narrower side shall not be less than t_n, in mm, determined by the formula

$$t_n = 14.9 s_n \sqrt{\frac{1.05p}{R_{eH}}},$$

where s_n = breadth of the narrower corrugation side, in m.

The net thickness of the wider corrugation side, in mm, shall not be less than the greater of the following values:

$$t_w = 14.9 s_w \sqrt{\frac{1.05p}{R_{eH}}},$$

$$t_w = \sqrt{\frac{(440 s_w^2 \cdot 1.05p)}{R_{eH}}} - t_{пр}^2,$$

where t_{np} shall be adopted not greater than the actual net thickness of the narrower corrugation side or $14.9 s\_w \sqrt{(1.05p/R\_eH\ )}$, whichever is the less.

5 LOCAL STRENGTHENING

Local strengthening shall be designed in accordance with the Register requirements, so that forces and moments originating in the bulkheads could be transferred to adjacent structures, among others, to double bottom and crossdeck structures. In particular, the thickness and the types of shedder and gusset plates, determined according to 4.3 of this Appendix, shall comply with the Register requirements, taking due regard of the loading model described in Section 2 of this Appendix. Unless expressly provided otherwise, the type and dimensions of welds shall be chosen according to 1.7, Part II "Hull".

6 CORROSION ALLOWANCE AND MATERIAL REPLACEMENT

Corrosion allowance t_s shall be equal to 3,5 mm.
If the measured thickness is below t_{net} + 0,5 mm, the bulkhead section shall be replaced. Where the measured thickness is between t_{net} + 0,5 mm and t_{net} +1 mm, a protective coating may be applied (the coating being applied in conformity with the manufacturer's recommendations), or the residual thicknesses of the bulkhead section may be measured annually as alternative of bulkhead section replacement.”.