S19

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(Rev. 1 1997)
(Rev. 2 Feb. 1998)
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Evaluation of Scantlings of the Transverse Watertight Corrugated Bulkhead between Cargo Holds Nos. 1 and 2, with Cargo Hold No. 1 Flooded, for Existing Bulk Carriers

S19.1 - Application and definitions

These requirements apply to all bulk carriers of 150 m in length and above, in the foremost hold, intending to carry solid bulk cargoes having a density of 1,78 t/m^3, or above, with single deck, topside tanks and hopper tanks, fitted with vertically corrugated transverse watertight bulkheads between cargo holds No. 1 and 2 where:

(i) the foremost hold is bounded by the side shell only for ships which were contracted for construction prior to 1 July 1998, and have not been constructed in compliance with IACS Unified Requirement S18,

(ii) the foremost hold is double side skin construction of less than 760 mm breadth measured perpendicular to the side shell in ships, the keels of which were laid, or which were at a similar stage of construction, before 1 July 1999 and have not been constructed in compliance with IACS Unified Requirement S18 (Rev. 2, Sept. 2000).

The net scantlings of the transverse bulkhead between cargo holds Nos. 1 and 2 are to be calculated using the loads given in S19.2, the bending moment and shear force given in S19.3 and the strength criteria given in S19.4.

Where necessary, steel renewal and/or reinforcements are required as per S19.6.

In these requirements, homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for the two foremost cargo holds, does not exceed 1,20, to be corrected for different cargo densities.

S19.2 - Load model

S19.2.1 - General

The loads to be considered as acting on the bulkhead are those given by the combination of the cargo loads with those induced by the flooding of cargo hold No.1.

The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of the bulkhead, depending on the loading conditions included in the loading manual:

- homogeneous loading conditions;

- non homogeneous loading conditions.

Non homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not to be considered according to these requirements.

Notes:

1. Changes introduced in Revision 2 to UR S19, i.e. the introduction of the first sentence of S19.6 as well as the Annex are to be applied by all Member societies and Associates not later than 1 July 1998.
2. Annex 2 contains, for guidance only, a flow chart entitled “Guidance to assess capability of Carriage of High Density Cargoes on Existing Bulk Carriers according to the Strength of Transverse Bulkhead between Cargo Holds Nos. 1 and 2”.
3. Changes introduced in Rev.4 are to be uniformly implemented by IACS Members and Associates from 1 July 2001.
4. The “contracted for construction” date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of “contract for construction”, refer to IACS Procedural Requirement (PR) No. 29.

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S19.2.2 - Bulkhead corrugation flooding head

The flooding head h_f (see Figure 1) is the distance, in m, measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f, in m, from the baseline equal to:

a) in general:

- D

b) for ships less than 50,000 tonnes deadweight with Type B freeboard:

- $0{,}95 \cdot D$

D being the distance, in m, from the baseline to the freeboard deck at side amidship (see Figure 1).

c) for ships to be operated at an assigned load line draught T_r less than the permissible load line draught T, the flooding head defined in a) and b) above may be reduced by $T - T_r$.

S19.2.3 - Pressure in the flooded hold

S19.2.3.1 - Bulk cargo loaded hold

Two cases are to be considered, depending on the values of d1 and df, d1 (see Figure 1) being a distance from the baseline given, in m, by:

$$d_1 = \frac{M_c}{\rho_c \cdot l_c \cdot B} + \frac{V_{LS}}{l_c \cdot B} + \left(h_{HT} - h_{DB}\right) \cdot \frac{b_{HT}}{B} + h_{DB}$$

where:

M_c = mass of cargo, in tonnes, in hold No. 1

ρ_c = bulk cargo density, in t/m^3

l_c = length of hold No. 1, in m

B = ship's breadth amidship, in m

v_{LS} = volume, in m^3, of the bottom stool above the inner bottom

h_{HT} = height of the hopper tanks amidship, in m, from the baseline

h_{DB} = height of the double bottom, in m

b_{HT} = breadth of the hopper tanks amidship, in m.

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a) $d_f \geq d_1$

At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure $p_{c,f}$, in kN/m^2, is given by:

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

where:

= sea water density, in t/m^3

g = 9,81 m/s^2, gravity acceleration

h_f = flooding head as defined in S19.2.2.

At each point of the bulkhead located at a distance lower than d_1 from the baseline, the pressure $p_{c,f}$, in kN/m^2, is given by:

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

where:

, g, h_f = as given above

c = bulk cargo density, in t/m^3

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/m^3),

h_1 = vertical distance, in m, from the calculation point to a level located at a distance d_1, as defined above, from the base line (see Figure 1)

= 45° -(/2)

= angle of repose of the cargo, in degrees, and may generally be taken as 35° for iron ore.

The force $F_{c,f}$, in kN, acting on a corrugation is given by:

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

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where:

s_1	=	spacing of corrugations, in m (see Figure 2a)
, g, d_1, h_{DB}	=	as given above
d_f	=	as given in S19.2.2
$(p_{c,f})_{le}$	=	pressure, in kN/m^2, at the lower end of the corrugation

h_{LS} = height of the lower stool, in m, from the inner bottom.

b) $d_f < d_1$

At each point of the bulkhead located at a distance between d_f and d_1 from the baseline, the pressure $p_{c,f}$, in kN/m^2, is given by:

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

where:

$_c$, g, h_1, = as given in a) above

At each point of the bulkhead located at a distance lower than d_f from the baseline, the pressure $p_{c,f}$, in kN/m^2, is given by:

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

where:

, g, h_f, $_c$, h_1, perm, = as given in a) above

The force $F_{c,f}$, in kN, acting on a corrugation is given by:

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

where:

s_1, $_c$, g, , $(p_{c,f})_{le}$, h_{LS}	=	as given in a) above
d_1, h_{DB}	=	as given in S19.2.3.1
d_f	=	as given in S19.2.2.

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S19.2.3.2 - Empty hold

At each point of the bulkhead, the hydrostatic pressure p_f induced by the flooding head h_f is to be considered.

The force F_f, in kN, acting on a corrugation is given by:

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

where:

s_1, , g, h_{LS}	=	as given in S19.2.3.1 a)
h_{DB}	=	as given in S19.2.3.1
d_f	=	as given in S19.2.2.

S19.2.4 - Pressure in the non-flooded bulk cargo loaded hold

At each point of the bulkhead, the pressure p_c, in kN/m^2, is given by:

$$p_c = \rho_c \cdot g \cdot h_1 \cdot \tan^2\gamma$$

where:

$_c$, g, h_1, = as given in S19.2.3.1 a)

The force F_c, in kN, acting on a corrugation is given by:

$$F_c = \rho_c \cdot g \cdot s_1 \cdot \frac{(d_1 - h_{DB} - h_{LS})^2}{2} \cdot \tan^2\gamma$$

where:

$_c$, g, s_1, h_{LS},	=	as given in S19.2.3.1 a)
d_1, h_{DB}	=	as given in S19.2.3.1

S19.2.5 - Resultant pressure

S19.2.5.1 - Homogeneous loading conditions

At each point of the bulkhead structures, the resultant pressure p, in kN/m^2, to be considered for the scantlings of the bulkhead is given by:

p = $_{c,f}$ - 0,8 · $_c$

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The resultant force F, in kN, acting on a corrugation is given by:

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

S19.2.5.2 - Non homogeneous loading conditions

At each point of the bulkhead structures, the resultant pressure p, in kN/m^2, to be considered for the scantlings of the bulkhead is given by:

$$p = \quad c,f$$

The resultant force F, in kN, acting on a corrugation is given by:

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

In case hold No.1, in non homogeneous loading conditions, is not allowed to be loaded, the resultant pressure p, in kN/m^2, to be considered for the scantlings of the bulkhead is given by:

$$p = p_f$$

and the resultant force F, in kN, acting on a corrugation is given by:

$$F = F_f$$

S19.3 - Bending moment and shear force in the bulkhead corrugations

The bending moment M and the shear force Q in the bulkhead corrugations are obtained using the formulae given in S19.3.1 and S19.3.2. The M and Q values are to be used for the checks in S19.4.

S19.3.1 - Bending moment

The design bending moment M, in kN·m, for the bulkhead corrugations is given by:

$$M = \frac{F \cdot l}{8}$$

where:

F = resultant force, in kN, as given in S19.2.5

l = span of the corrugation, in m, to be taken according to Figures 2a and 2b

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S19.3.2 - Shear force

The shear force Q, in kN, at the lower end of the bulkhead corrugations is given by:

$$Q = 0{,}8 \cdot F$$

where:

F = as given in S19.2.5

S19.4 - Strength criteria

S19.4.1 - General

The following criteria are applicable to transverse bulkheads with vertical corrugations (see Figure 2a).

Requirements for local net plate thickness are given in S19.4.7.

In addition, the criteria given in S19.4.2 and S19.4.5 are to be complied with.

Where the corrugation angle shown in Figure 2a if less than 50 , an horizontal row of staggered shedder plates is to be fitted at approximately mid depth of the corrugations (see Figure 2a) to help preserve dimensional stability of the bulkhead under flooding loads. The shedder plates are to be welded to the corrugations by double continuous welding, but they are not to be welded to the side shell.

The thicknesses of the lower part of corrugations considered in the application of S19.4.2 and S19.4.3 are to be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than 0,15·l.

The thicknesses of the middle part of corrugations considered in the application of S19.4.2 and S19.4.4 are to be maintained to a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than 0,3·l.

S19.4.2 - Bending capacity and shear stress

The bending capacity is to comply with the following relationship:

$$10^3 \cdot \frac{M}{0{,}5 \cdot Z_{le} \cdot \sigma_{a,le} + Z_m \cdot \sigma_{a,m}} \le 1{,}0$$

where:

M = bending moment, in kN·m, as given in S19.3.1.

Z_{le} = section modulus of one half pitch corrugation, in cm^3, at the lower end of corrugations, to be calculated according to S19.4.3.

Z_m = section modulus of one half pitch corrugation, in cm^3, at the mid-span of corrugations, to be calculated according to S19.4.4.

a,le = allowable stress, in N/mm^2, as given in S19.4.5, for the lower end of corrugations

a,m = allowable stress, in N/mm^2, as given in S19.4.5, for the mid-span of corrugations.

In no case Z_m is to be taken greater than the lesser of $1{,}15 \cdot Z_{le}$.and $1{,}15 \cdot Z'_{le}$ for calculation of the