RESOLUTION 4

STANDARDS FOR THE EVALUATION OF SCANTLINGS OF THE TRANSVERSE WATERTIGHT VERTICALLY CORRUGATED BULKHEAD BETWEEN THE TWO FOREMOST CARGO HOLDS AND FOR THE EVALUATION OF ALLOWABLE HOLD LOADING OF THE FOREMOST CARGO HOLD

THE CONFERENCE,

HAVING ADOPTED amendments to the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended, concerning the safety of bulk carriers,

CONSIDERING that new SOLAS regulation XII/6 requires that the transverse watertight vertically corrugated bulkhead between the two foremost cargo holds and the double bottom structure in way of the foremost cargo hold of bulk carriers of 150 m in length and upwards of single side skin construction, carrying solid bulk cargoes having a density of 1780 kg/m³ and above, should have sufficient strength, in compliance with the Bulk carrier bulkhead and double bottom standards developed by the Organization, to withstand flooding of the foremost cargo hold, taking also into account dynamic effects,

BEING OF THE OPINION that the implementation by Governments of the said regulation in accordance with the implementation schedule prescribed in new SOLAS regulation XII/3 will greatly contribute to enhancing the safety of existing bulk carriers and safeguarding the lives of those on board,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee of the International Maritime Organization at its sixty-eighth session,

ADOPTS:

.1 the Standards for the evaluation of scantlings of the transverse watertight vertically corrugated bulkhead between the two foremost cargo holds, set out in Annex 1 to the present resolution; and

.2 the Standards for the evaluation of allowable hold loading of the foremost cargo hold, set out in Annex 2 to the present resolution,

for the purpose of application of SOLAS regulation XII/6.

ANNEX 1

STANDARDS FOR THE EVALUATION OF SCANTLINGS OF THE TRANSVERSE WATERTIGHT VERTICALLY CORRUGATED BULKHEAD BETWEEN THE TWO FOREMOST CARGO HOLDS

1 INTRODUCTION

The net scantlings of the transverse watertight vertically corrugated bulkhead between the two foremost cargo holds are to be calculated using the loads given in Section 2, the bending moment and shear force given in Section 3 and the strength criteria given in Section 4.

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

In these standards, 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.

2 LOAD MODEL

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 the foremost cargo hold.

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 standards.

2.2 Bulkhead corrugation flooding head

The flooding head hf (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 df, in m, from the baseline equal to:

(a) in general:

D

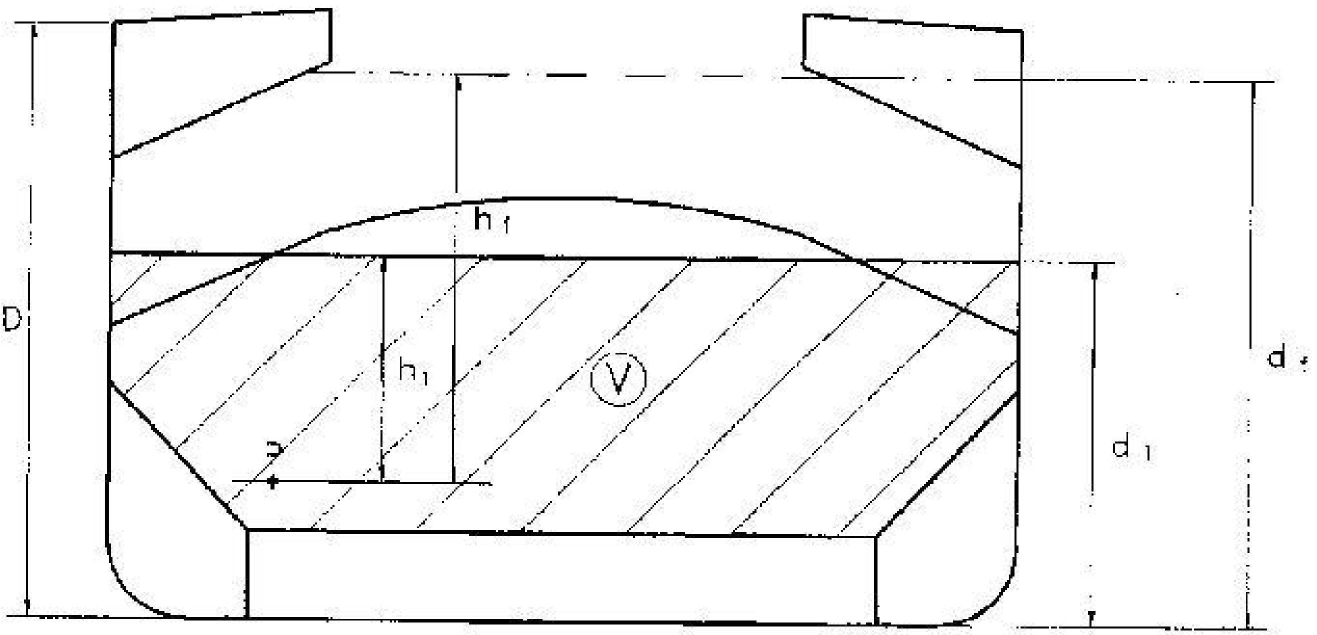
(b) for ships less than 50,000 tonnes deadweight with Type B freeboard:

0.95 x D

where:

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

Figure 1



V = Volume of cargo

P = Calculation point

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

2.3 Pressure in the flooded hold

2.3.1 Bulk cargo loaded hold

Two cases are to be considered, depending on the values of d1 and df, d_1(see figure 1) being a distance from the baseline given, in m, by:

d_1= Mc/(ρ x lc x B) + VLS/(lc x B) + (hHT - hDB) x bHT/B + hDB

where:

Mc = mass of cargo, in tonnes, in the foremost cargo hold

ρc = bulk cargo density, in t/m³

lc = length of the foremost cargo hold, in m

B = ship's breadth amidships, in m

VLS = volume, in m³, of the bottom stool above the inner bottom

hHT = height of the hopper tanks amidship, in m, from the baseline

hDB = height of the double bottom, in m

bHT = breadth of the hopper tanks amidship, in m.

(a) df ≥ d_1

At each point of the bulkhead located at a distance between d1 and df from the baseline, the pressure pc,f, in kN/m², is given by:

ρc,f = p x g x hf

where:

ρ = sea water density, in t/m³

g = 9.81 m/s², gravity acceleration

hf = flooding head as defined in section 2.2.

At each point of the bulkhead located at a distance lower than $d_1$from the baseline, the pressure pc,f, in kN/,m² is given by:

ρc,f = p x g x hf + [pc - p x (1 - perm)] x g x h_1x tan²(gamma)

where:

ρ, g, hf = as given above

ρc = bulk cargo density, in t/m³

perm = permeability of cargo, to be taken as 0.3 for ore (the corresponding bulk cargo density for iron ore may generally be taken as 3.0 t/m³).

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)

gamma = 45 degrees - (φ/2)

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

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

$$Fc,f = s_1 \times [\rho \times g \times ((df - d_1)^2/2) + ((\rho \times g \times (df - d_1) + (pc,f)le)/2) \times (d_1 - hDB - hLS)]$$

where:

s_1 = spacing of corrugations, in m (see figure 2a)

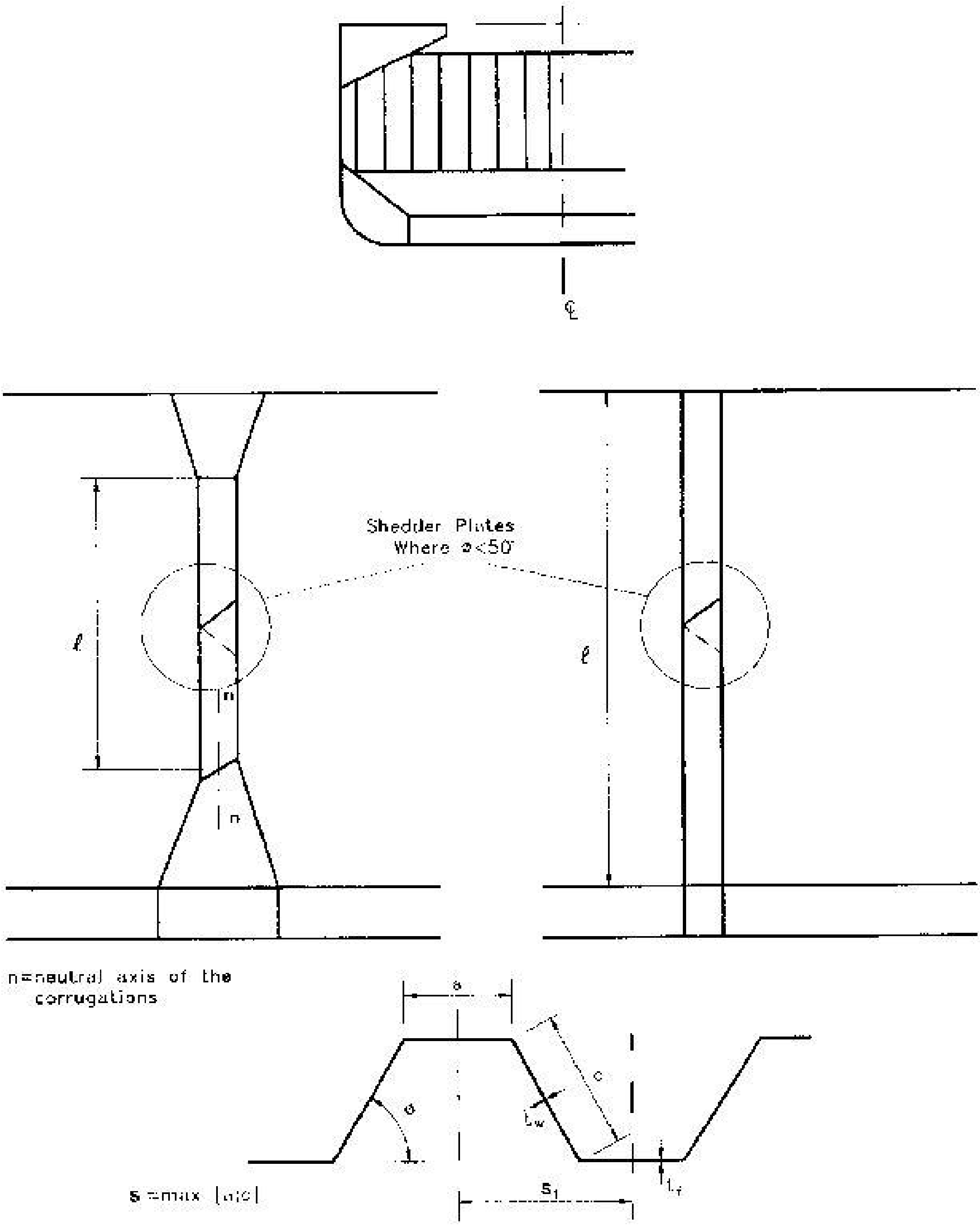
ρ, g, d_1, hDB = as given above

df = as given in 2.2

(pc,f)le = pressure, in kN/m², at the lower end of the corrugation

hLS = height of the lower stool, in m, from the inner bottom.

Figure 2a



(b) df < d_1

At each point of the bulkhead located at a distance between df and d_1 from the baseline, the pressure ρc,f, in kN/m², is given by:

$\rho_{c,f} = \rho \times g \times h_1 \times \tan^2(\gamma)$

where:

ρ, g, h_1, gamma = as given in (a)

At each point of the bulkhead located at a distance lower than df from the baseline, the pressure pc,f, in kN/m², is given by:

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

where:

ρ, g, hf, ρc, h_1, perm, gamma = as given in (a)

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

$$Fc,f = s_1 \times [\rho c \times g \times ((d_1 - df)^2/2) \times \tan^2(\text{gamma}) + ((\rho \times g \times (d_1 - df) \times \tan^2(\text{gamma}) + (pc,f)le)/2) \times (df - hDB - hLS)]$$

where:

s_1, pc, g, gamma, (pc,f)le, hLS = as given in (a)

d_1, hDB, = as given above

df = as given in 2.2.

2.3.2 Empty hold

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

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

$$Ff = s_1 \times \rho \times g \times ((df - hDB - hLS)^2)/2$$

where:

s_1, ρ, g, hLS = as given in 2.3.1 (a)

hDB = as given in 2.3.1

df = as given in 2.2

2.4 Pressure in the non-flooded bulk cargo loaded hold

At each point of the bulkhead, the pressure pc, in kN/m², is given by:

$$pc = \rho c \times g \times h_1 \times \tan^2(\text{gamma})$$

where:

ρc, g, h_1, gamma = as given in 2.3.1 (a)

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

$$Fc = \rho c \times g \times s_1 \times (d_1 - hDB - hLS)^2/2) \times \tan^2(\text{gamma})$$

where:

ρc, g, s_1, hLS, gamma = as given in 2.3.1 (a)

d_1, hDB = as given in 2.3.1.

2.5 Resultant pressure

2.5.1 Homogeneous loading conditions

At each point in the bulkhead structure, the resultant pressure p, in kN/m², to be considered for the scantlings of the bulkhead, is given by:

$$p = p_{c,f} - 0.8 \times p_c$$

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

$$F = F_{c,f} - 0.8 \times F_c$$

2.5.2 Non-homogeneous loading conditions

At each point in the bulkhead structure, the resultant pressure p in kN/m², to be considered for the scantlings of the bulkhead, is given by:

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

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

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

In case the foremost cargo hold, in non-homogenous loading conditions, is not allowed to be loaded, the resultant pressure p, in kN/m², 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:

$$F = F_f$$

3 BENDING MOMENT AND SHEAR FORCE IN THE BULKHEAD CORRUGATIONS

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 3.1 and 3.2. The M and Q values are to be used for the checks in Section 4.

3.1 Bending moment

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

$$M = F \times \ell/8$$

where:

F = resultant force, in KN, as given in 2.5

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

3.2 Shear force

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

$Q = 0.8 \times F$

where:

F = as given in 2.5

4 STRENGTH CRITERIA

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 4.7.

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

Where the corrugation angle φ shown in figure 2a is less than 50 degrees, 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 4.2 and 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 4.2 and 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.

4.2 Bending capacity and shear stress

The bending capacity is to comply with the following relationship:

$10^3 \times (M/(0.5 \times Zle \times \sigma_{a,le} + Zm \times \sigma_{a,m})) \leq 1,0$

where:

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

Zle = section modulus of one half pitch corrugation, in cm³, at the lower end of corrugations, to be calculated according to 4.3.

Zm = section modulus of one half pitch corrugation, in cm³, at the mid-span of corrugations, to be calculated according to 4.4.

$\sigma_{a,le}$ = allowable stress, in N/mm², as given in 4.5, for the lower end of corrugations

$\sigma_{a,m}$ = allowable stress, in N/mm² as given in 4.5, for the mid-span of corrugations.

In no case is Zm to be taken greater than the lesser of 1.15 Zle and 1.15 Z'le for calculation of the bending capacity, Z'le being defined below.

In case effective shedder plates are fitted which:

- are not knuckled;
- are welded to the corrugations and the top of the lower stool by one side penetration welds or equivalent;
- are fitted with a minimum slope of 45 degrees and their lower edge is in line with the stool side plating;

or effective gusset plates are fitted which:

- are fitted in line with the stool side plating;

- have material properties at least equal to those provided for the flanges,

the section modulus Zle, in cm^3, is to be taken not larger than the value Z'le, in cm^3, given by:

$Z'le = Zg + 10^3 \times (Q \times hg - 0.5 \times hg^2 \times s_1 \times pg) / \sigma a$

where:

Zg = section modulus of one half pitch corrugation, in cm^3, according to 4.4, in way of the upper end of shedder or gusset plates, as applicable

Q = shear force, in kN, as given in 3.2

hg = height, in m, of shedders or gusset plates, as applicable (see figures 3a, 3b, 4a and 4b)

s_1 = as given in 2.3.1 (a)

pg = resultant pressure, in kN/m^2, as defined in 2.5, calculated in way of the middle of the shedders or gusset plates, as applicable

σa = allowable stress, in N/mm^2, as given in 4.5.

Figure 3

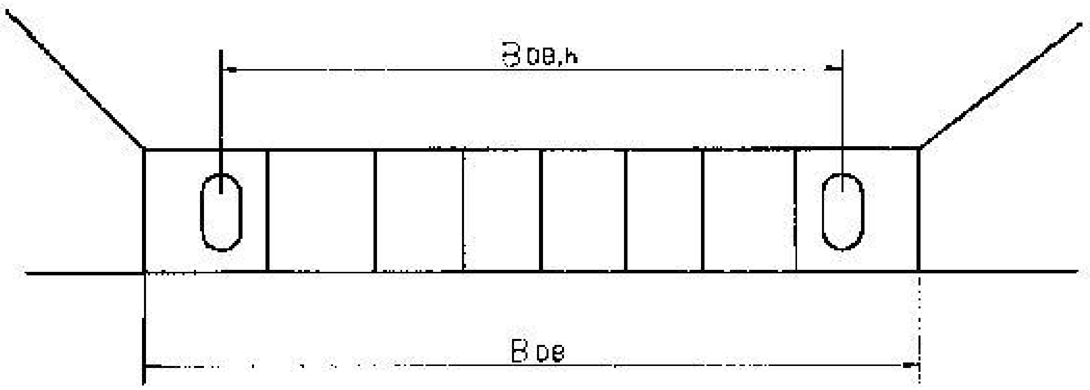


Figure 4a
Symmetric gusset / shedder plates

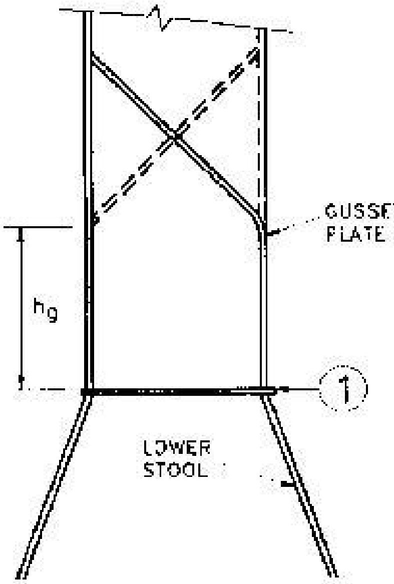
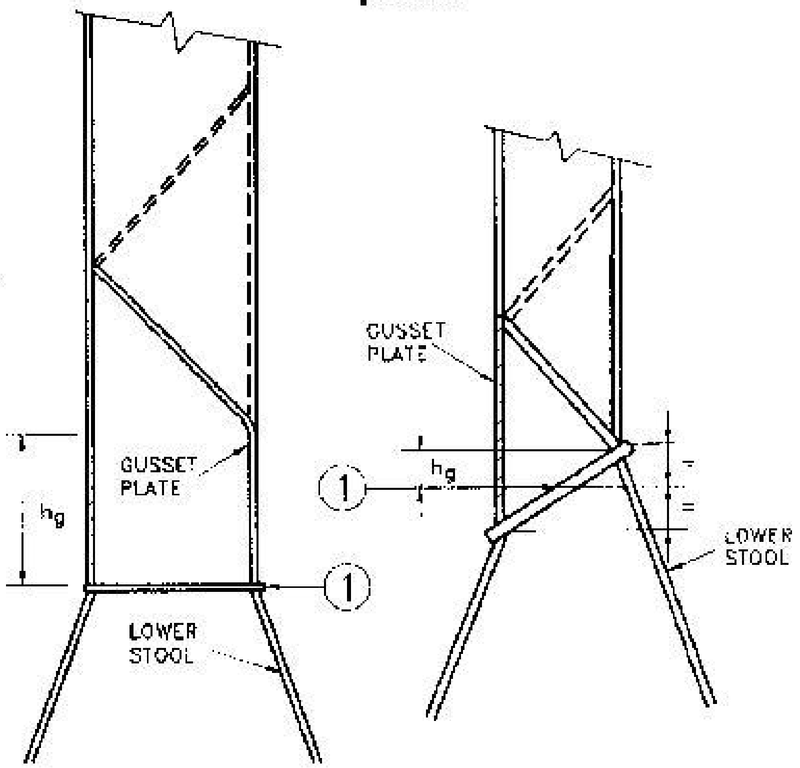


Figure 4b
Asymmetric gusset / shedder plates



Shear stresses τ are obtained by dividing the shear force Q by the shear area. The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin φ), φ being the angle between the web and the flange.

When calculating the section moduli and the shear area, the net plate thicknesses are to be used.

The section moduli of corrugations are to be calculated on the basis of the requirements standards given in 4.3 and 4.4.

4.3 Section modulus at the lower end of corrugations

The section modulus is to be calculated with the compression flange having an effective flange width, bef, not larger than as given in 4.6.1.

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

(a) Provided that effective shedder plates, as defined in 4.2, are fitted (see figures 3a and 3b), when calculating the section modulus of corrugations at the lower end (cross-section (1) in figures 3a and 3b), the area of the flange plates, in cm², may be increased by

$[2.5 \times a \times \sqrt{(tf \times tsh)} \times \sqrt{(\sigma Fsh/\sigma Ffl)}]$ (not to be taken greater than $2.5 \cdot a \cdot tf$)

where:

a = width, in m, of the corrugation flange (see figure 2a)

tsh = net shedder plate thickness, in mm

t_f = net flange thickness, in mm

σ_{Fsh} = minimum upper yield stress, in N/mm², of the material used for the shedder plates

σ_{Ffl} = minimum upper yield stress, in N/mm², of the material used for the corrugation flanges.

(b) Provided that effective gusset plates, as defined in 4.2, are fitted (see figures 4a and 4b), when calculating the section modulus of corrugations at the lower end (cross-section (1) in figures 4a and 4b), the area of flange plates, in cm², may be increased by ($7 \times h_g \times t_{gu}$)

where:

h_g = height of gusset plate in m, see figures 4a and 4b, not to be taken greater than [(10/7) x s_{gu}]

s_{gu} = width of the gusset plates, in m

t_{gu} = net gusset plate thickness, in mm, not to be taken greater than t_f

t_f = net flange thickness, in mm, based on the as built condition.

(c) If the corrugation webs are welded to a sloping stool top plate which is at an angle not less than 45 degrees with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in (b) above. No credit can be given to shedder plates only.

For angles less than 45 degrees, the effectiveness of the web may be obtained by linear interpolation between 30% for 0 degrees and 100% for 45 degrees

4.4 Section modulus of corrugations at cross-sections other than the lower end

The section modulus is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{ef}, not larger than as given in 4.6.1.

4.5 Allowable stress check

The normal and shear stresses σ and τ are not to exceed the allowable values sigma a and τ_a, in N/mm², given by:

$\sigma_a = \sigma_F$

$\tau_a = 0.5 \times \sigma_F$

where:

σ_F = the minimum upper yield stress, in N/mm², of the material.

4.6 Effective compression flange width and shear buckling check

4.6.1 Effective width of the compression flange of corrugations

The effective width b_{ef}, in m, of the corrugation flange is given by:

$b_{ef} = C_e \times a$

where:

$C_e = 2.25/\beta - 1.25/(\beta^2)$ for $\beta > 1.25$

$C_e = 1.0$ for $\beta \le 1.25$

$ß = 10^3 \times a/t_f \times \sqrt{(\sigma_F / E)}$

t_f = net flange thickness, in mm

a = width, in m, of the corrugation flange (see figure 2a)

σ_F = minimum upper yield stress, in N/mm², of the material

E = modulus of elasticity, in N/mm², to be assumed equal to 2.06 x 10**5 N/mm² for steel

4.6.2 Shear

The buckling check is to be performed for the web plates at the corrugation ends.

The shear stress τ is not to exceed the critical value τ_c, in N/mm², as obtained from the following:

$\tau_c = \tau_E$ when $\tau_E \le (\tau_F)/2$

$= \tau [1 - (\tau_F(/(4 \tau_E)]$ when $\tau_E > (\tau_F)/2$

where:

$\tau_F = \sigma_F / \sqrt{3}$

σ_F = minimum upper yield stress, in N/mm², of the material as given in 4.6.1

$\tau_E = 0.9 \times k_t \times E (t/1000c)^2$

k_t, E, t, and c are given by:

$k_t = 6.34$

E = modulus of elasticity of material as given in 4.6.1

t = net thickness, in mm, of corrugation web

c = width, in m, of corrugation web (see figure 2a)

4.7 Local net plate thickness

The bulkhead local net plate thickness t, in mm, is given by:

$t = 14.9 \times s_w \times \sqrt{(p/\sigma_F)}$

where:

s_w = plate width, in m, to be taken equal to the width of the corrugation flange or web, whichever is the greater (see figure 2a)

p = resultant pressure, in kN/m², as defined in 2.5, at the bottom of each strake of plating; in all cases, the net thickness of the lowest strake is to be determined using the resultant pressure at the top of the lower stool, or at the inner bottom, if no lower stool is fitted or at the top of the shedders, if shedder or gusset/shedder plates are fitted.

σ_F = minimum upper yield stress, in N/mm², of the material.

For built-up corrugated bulkheads, when the thicknesses of the flange and web are different, the net thickness of the narrower plating is to be not less than t_n, in mm, given by:

$$t_n = 14.9 \times s_n \times \sqrt{(p/\sigma_F)}$$

s_n = the width, in m, of the narrower plating.

The net thickness of the wider plating, in mm, is not to be taken less than the maximum of the following values:

$$t_w = 14.9 \times s_w \times \sqrt{(p/\sigma_F)}$$

and

$$t_w = \sqrt{[(440 \times s_w^2 \times p)/\sigma_F - t_{np}^2]}$$

where $t_{np} \le$ actual net thickness of the narrower plating and not to be greater than

$$14.9 \times s_w \times \sqrt{(p/\sigma_F)}$$

5 LOCAL DETAILS

As applicable, the design of local details is to comply with the requirements of the Administration or of an organization recognized by the Administration in accordance with the provisions of SOLAS regulation XI/1 (hereinafter referred to as "the Administration") for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures.

In particular, the thickness and stiffening of gusset and shedder plates, installed for strengthening purposes, is to comply with the requirements of the Administration on the basis of the load model in Section 2.

Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the requirements of the Administration.

6 CORROSION ADDITION AND STEEL RENEWAL

(a) Steel renewal is required where the gauged thickness is less than t_{net} + 0.5 mm, t_{net} being the thickness used for the calculation of bending capacity and shear stresses as given in 4.2 or the local net plate thickness as given in 4.7. Alternatively, reinforcing doubling strips may be used providing the net thickness is not dictated by shear strength requirements for web plates (see 4.5 and 4.6.2) or by local pressure requirements for web and flange plates (see 4.7).

Where the gauged thickness is within the range t_{net} + 0.5 mm and t_{net} + 1.0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal.

(b) Where steel renewal or reinforcement is required, a minimum thickness of t_{net} + 2.5 mm is to be replenished for the renewed or reinforced parts.

(c) Gussets with shedder plates, extending from the lower end of corrugations up to 0.1ℓ, or reinforcing doubling strips (on bulkhead corrugations and stool side plating) are to be fitted, when:

$$0.8 \times (\sigma_{Ffl} \times t_{fl}) \ge \sigma_{Fas} \times t_{st}$$

where:

σ_{Ffl}= minimum upper yield stress, in N/mm², of the material used for the corrugation flanges

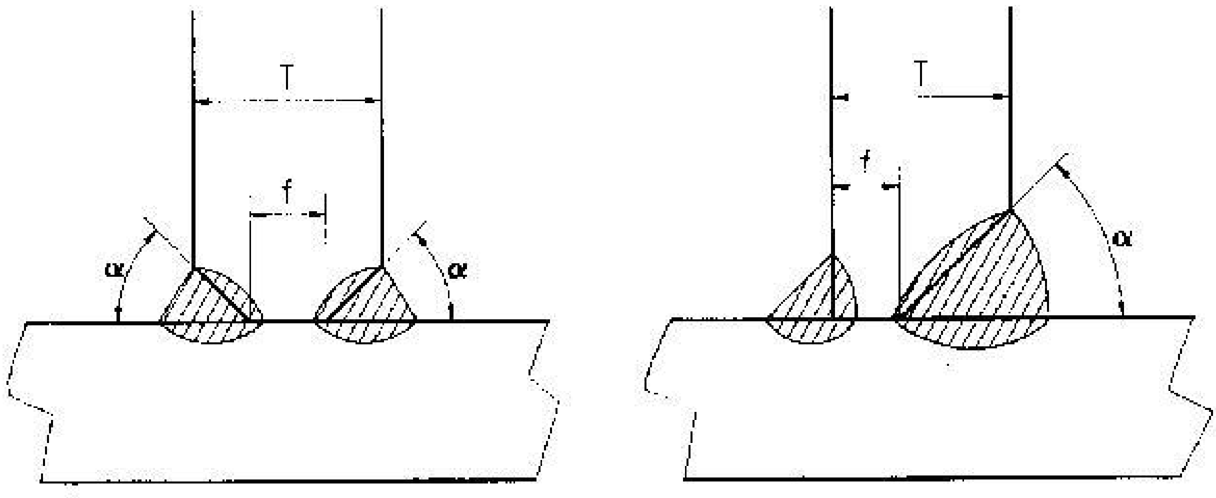
σ_{Fs}= minimum upper yield stress, in N/mm², of the material used for the lower stool side plating or floors (if no stool is fitted)

t_{fl}= flange thickness, in mm, which is found to be acceptable on the basis of the criteria specified in (a) above or, when steel renewal is required, the replenished thickness according to the criteria specified in (b) above. The above flange thickness dictated by local pressure requirements (see 4.7) need not be considered for this purpose

t_{st}= as built thickness, in mm, of the lower stool side plating or floors (if no stool is fitted)

If gusset plates are fitted, the material of such gusset plates is to be the same as that of the corrugation flanges. The gusset plates are to be connected to the lower stool shelf plate or inner bottom (if no lower stool is fitted) by deep penetration welds (see figure 5).

Figure 5



Root Face (f) : 3 mm to T/3 mm
Groove Angle (α) : 40° to 60°

(d) Where steel renewal is required, the bulkhead connections to the lower stool shelf plate or inner bottom (if no stool is fitted) are to be at least made by deep penetration welds (see figure 5).

(e) Where gusset plates are to be fitted or renewed, their connections with the corrugations and the lower stool shelf plate or inner bottom (if no stool is fitted) are to be at least made by deep penetration welds (see figure 5).

***This resolution was adopted on 27 November 1997 by the 1997 SOLAS Conference.**

ANNEX 2

STANDARDS FOR THE EVALUATION OF ALLOWABLE HOLD LOADING OF THE FOREMOST CARGO HOLD

1 INTRODUCTION

The loading in the foremost cargo hold is not to exceed the allowable hold loading in the flooded condition, calculated as per Section 4, using the loads given in Section 2 and the shear capacity of the double bottom given in Section 3.

In no case is the allowable hold loading in the flooding condition to be taken greater than the design hold loading in the intact condition.

2 LOAD MODEL

2.1 General

The loads to be considered as acting on the double bottom of the foremost cargo hold are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of the foremost cargo hold.

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

- homogeneous loading conditions;

- non-homogeneous loading conditions;

- packed cargo conditions (such as steel mill products).

For each loading condition, the maximum bulk cargo density to be carried is to be considered in calculating the allowable hold limit.

2.2 Inner bottom flooding head

The flooding head hf (see figure 1) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance df, in m, from the baseline equal to:

D, in general; or

0.95 D for ships of less than 50,000 tonnes deadweight with Type B freeboard.

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

3 SHEAR CAPACITY OF THE DOUBLE BOTTOM STRUCTURE IN WAY OF THE FOREMOST CARGO HOLD

The shear capacity C of the double bottom structure in way of the foremost cargo hold is defined as the sum of the shear strength at each end of:

- all floors adjacent to both hoppers, less one half of the strength of the two floors adjacent to each stool, or transverse bulkhead if no stool is fitted (see figure 2); and

- all double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

The strength of girders or floors which run out and are not directly attached to the boundary stool or hopper girder is to be evaluated for the one end only.

Note that the floors and girders to be considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom are not to be included.

When the geometry and/or the structural arrangement of the double bottom are such as to make the above assumptions inadequate, to the discretion of the Administration or of an organization recognized by the Administration in accordance with the provisions of SOLAS regulation XI/1 (hereinafter referred to as "the Administration"), the shear capacity C of the double bottom is to be calculated according to the criteria laid down by the Administration.

In calculating the shear strength, the net thickness of floors and girders are to be used. The net thickness tnet, in mm, is given by:

tnet = t - tc

where:

t = as built thickness, in mm, of floors and girders

tc = corrosion diminution, equal to 2 mm, in general; a lower value of tc may be adopted, provided that measures are taken, to the satisfaction of the Administration to justify the assumption made.

3.1 Floor shear strength

The floor shear strength in way of the floor panel adjacent to hoppers Sf_1, in kN, and the floor shear strength in way of the openings in the "outermost" bay (i.e. that bay which is closest to the hopper) Sf_2, in kN, are given by the following expressions:

$Sf_1 = 10^{-3} \times Af \times \tau a / \eta_1$

$Sf_2 = 10^{-3} \times Af,h \times \tau a / \eta_2$

where:

Af = sectional area, in mm², of the floor panel adjacent to the hoppers

Af,h = net sectional area, in mm², of the floor panels in way of the openings in the "outermost" bay (i.e. that bay which is closest to the hopper)

τa = allowable shear stress, in N/mm², to be taken equal to $\sigma F/\sqrt{3}$

σF = minimum upper yield stress, in N/mm², of the material

$\eta_1 = 1.10$

$\eta_2 = 1.20$

η_2 may be reduced, at the discretion of the Administration, down to 1.10 where appropriate reinforcements are fitted to the satisfaction of the Administration.

3.2 Girder shear strength

The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) Sg_1, in kN, and the girder shear strength in way of the largest opening in the "outermost" bay (i.e. that bay which is closest to stool, or transverse bulkhead, if no stool is fitted) Sg_2, in kN, are given by the following expressions:

$Sg_1 = 10^{-3} \times Ag \times \tau a / \eta_1$

$Sg_2 = 10^{-3} \times Ag,h \times \tau a / \eta 2$

where:

Ag = minimum sectional area, in mm², of the girder panel adjacent to the stools (or transverse bulkheads, if no stool is fitted)

Ag,h = net sectional area, in mm², of the girder panel in way of the largest opening in the "outermost" bay (i.e. that bay which is closest to the stool, or transverse bulkhead, if no stool is fitted)

τa = allowable shear stress, in N/mm², as given in 3.1

$\eta_1 = 1.10$

$\eta_2 = 1.15$

$\eta 2$ may be reduced, at the discretion of the Administration, down to 1.10 where appropriate reinforcements are fitted to the satisfaction of the Administration.

4 ALLOWABLE HOLD LOADING

The allowable hold loading W, in tonnes, is given by:

$W = \rho c \times V \times l/F$

where:

F = 1.05 in general 1.00 for steel mill products

ρc = cargo density, in t/m³; for bulk cargoes, see 2.1; for steel products, roc is to be taken as the density of steel

V = volume, in m³, occupied by cargo at a level h_1

h_1 = X/(ρc x g)

X = for bulk cargoes, the lesser of X_1 and X_2 given by

X_1 = (Z + ρ x g (E - hf))/(1+ (ρ/ρc) x (perm -1))

X_2 = Z + ρ x g x (E - hf x perm)

X = for steel products, X may be taken as X_1, using perm = 0

ρ = sea water density, in t/m³

g = 9.81 m/s², gravity acceleration

E = df - 0.1 x D

df, D= as given in 2.2

hf = flooding head, in m, as defined in 2.2

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)

Z = the lesser of Z_1 and Z_2 given by:

Z_1 = Ch/ADB,h Z_2 = Ce/ADBV,e

Ch = shear capacity of the double bottom, in kN, as defined in Section 3, considering, for each floor, the lesser of the shear strengths Sf_1 and Sf_2 (see 3.1) and, for each girder, the lesser of the shear strengths Sg_1 and Sg_2 (see 3.2)

Ce = shear capacity of the double bottom, in kN, as defined in Section 3, considering, for each floor, the shear strength Sf_1 (see 3.1) and, for each girder, the lesser of the shear strengths Sg_1 and Sg_2 (see 3.2)

ADB,h = sum from i=1 to i=n of (Si x BDB,i)

ADB,e = sum from i=1 to I=n of (Si x BDB,i - s)

n = number of floors between stools (or transverse bulkheads, if no stool is fitted)

Si = space of ith-floor, in m

BDB,i = BDB - s for floors whose shear strength is given by Sf_1 (see 3.1)

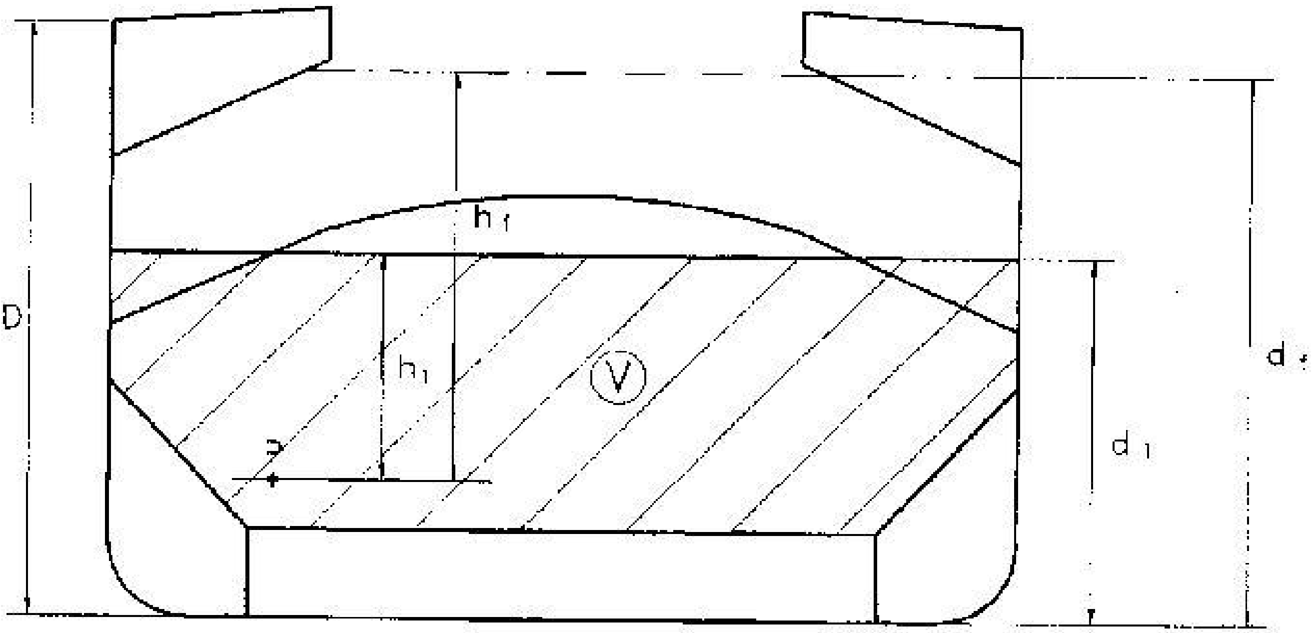
BDB,i = BDB,h for floors whose shear strength is given by Sf_2 (see 3.1)

BDB = breadth of double bottom, in m, between hoppers (see figure 3)

BDB,h= distance, in m, between the two considered opening (see figure 3)

s = spacing, in m, of double bottom longitudinals adjacent to hoppers

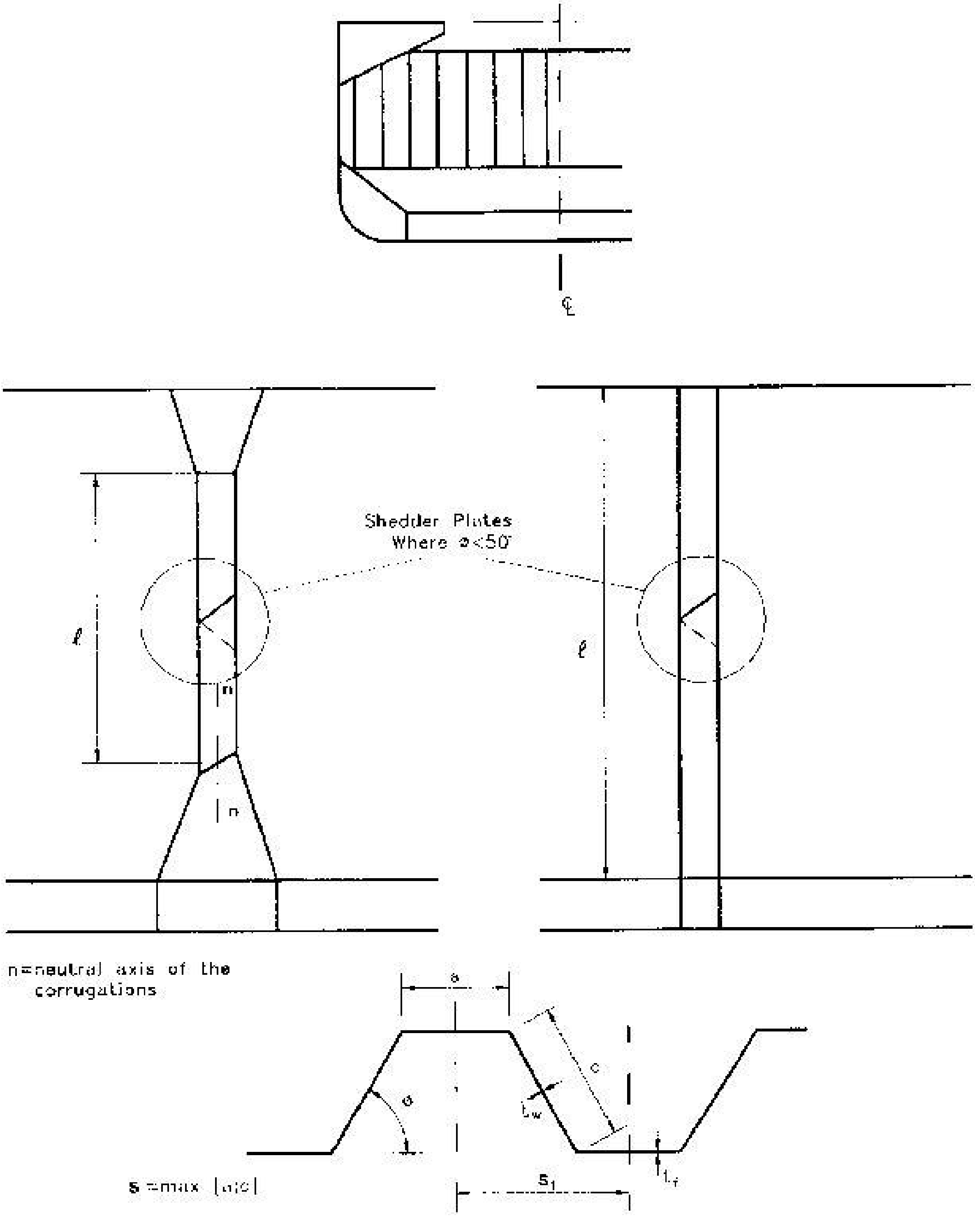
Figure 1



V = Volume of cargo

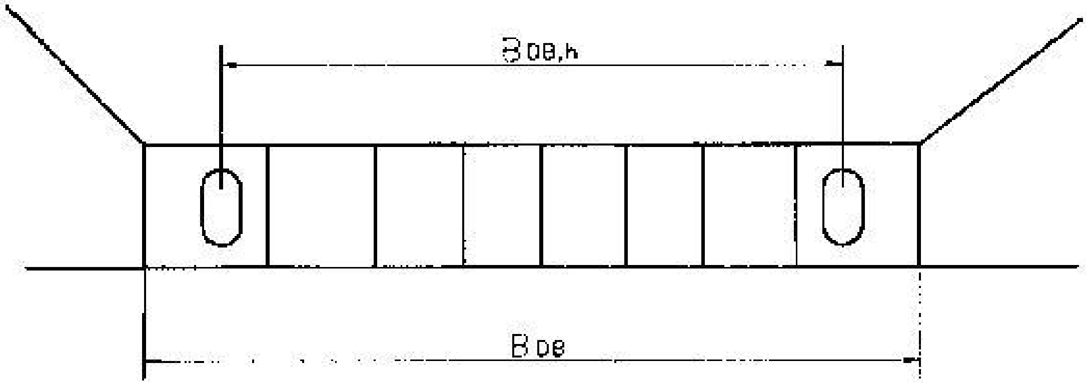
P = Calculation point

Figure 2a



Shedder Plates
Where ø<50°
ℓ
ℓ
n
n
n=neutral axis of the corrugations
a
c
ø
t_w
t_f
s_1
s =max [a;c]

Figure 3



*This resolution was adopted on 27 November 1997 by the 1997 SOLAS Conference.