S21
(1997)
(Rev.1 2002)
(Rev.2 Nov 2002)
(Rev.3 April 2003)
(Rev.4 July 2004)
(Corr.1 Oct 2004)
(Rev.5 May 2010)

Evaluation of Scantlings of Hatch Covers and Hatch Coamings of Cargo Holds of Bulk Carriers, Ore Carriers and Combination Carriers ~~(Rev.4)~~

S21.1 Application and definitions

These requirements apply to all bulk carriers, ore carriers and combination carriers, as defined in UR Z11, and are for all cargo hatch covers and hatch forward and side coamings on exposed decks in position 1, as defined in ILLC.

Rev. 3 of this UR applies to ships contracted for construction on or after 1 January 2004.

This UR does not apply to CSR Bulk Carriers.

The strength requirements are applicable to hatch covers and hatch coamings of stiffened plate construction. The secondary stiffeners and primary supporting members of the hatch covers are to be continuous over the breadth and length of the hatch covers, as far as practical. When this is impractical, sniped end connections are not to be used and appropriate arrangements are to be adopted to ~~ensure~~ provide sufficient load carrying capacity.

The spacing of primary supporting members parallel to the direction of secondary stiffeners is not to exceed 1/3 of the span of primary supporting members.

The secondary stiffeners of the hatch coamings are to be continuous over the breadth and length of the hatch coamings.

These requirements are in addition to the requirements of the ILLC.

The net minimum scantlings of hatch covers are to fulfil the strength criteria given in:

- S21.3.3, for plating,
- S21.3.4, for secondary stiffeners,
- S21.3.5 for primary supporting members,

the critical buckling stress check in S21.3.6 and the rigidity criteria given in S21.3.7, adopting the load model given in S21.2.

The net minimum scantlings of hatch coamings are to fulfil the strength criteria given in:

- S21.4.2, for plating,
- S21.4.3, for secondary stiffeners,
- S21.4.4, for coaming stays,

adopting the load model given in S21.4.1.

Note:
1. 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.

S21 (cont)

The net thicknesses, t_{net}, are the member thicknesses necessary to obtain the minimum net scantlings required by S21.3 and S21.4.

The required gross thicknesses are obtained by adding the corrosion additions, t_s, given in S21.6, to t_{net}.

Material for the hatch covers and coamings is to be steel according to the requirements for ship's hull.

S21.2 Hatch cover load model

The pressure p, in kN/m^2, on the hatch covers panels is given by:

For ships of 100 m in length and above

$p = 34.3 + \frac{p_{FP} - 34.3}{0.25}\left(0.25 - \frac{x}{L}\right) \geq 34.3$, for hatchways located at the freeboard deck

where:

p_{FP} = pressure at the forward perpendicular
= 49.1 + (L-100)a

a = 0.0726 for type B freeboard ships
0.356 for ships with reduced freeboard

L = Freeboard length, in m, as defined in Regulation 3 of Annex I to the 1966 Load Line Convention as modified by the Protocol of 1988, to be taken not greater than 340 m

x = distance, in m, of the mid length of the hatch cover under examination from the forward end of L

Where a position 1 hatchway is located at least one superstructure standard height higher than the freeboard deck, the pressure p may be 34.3kN/m^2.

For ships less than 100 m in length

$p = 15.8 + \frac{L}{3}\left(1 - \frac{5}{3} \cdot \frac{x}{L}\right) - 3.6\frac{x}{L} \geq 0.195L + 14.9$, for hatchways located at the freeboard deck

Where two or more panels are connected by hinges, each individual panel is to be considered separately.

S21.3 Hatch cover strength criteria

S21.3.1 Allowable stress checks

The normal and shear stresses σ and τ in the hatch cover structures are not to exceed the allowable values, σ_a and τ_a, in N/mm^2, given by:

$$\sigma_a = 0.8\sigma_F$$

S21
(cont)

$$\tau_a = 0.46\sigma_F$$

σ_F being the minimum upper yield stress, in N/mm^2, of the material.

The normal stress in compression of the attached flange of primary supporting members is not to exceed 0.8 times the critical buckling stress of the structure according to the buckling check as given in S21.3.6.

The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members are to be determined by a grillage or a FE analysis.

When a beam or a grillage analysis is used, the secondary stiffeners are not to be included in the attached flange area of the primary members.

When calculating the stresses σ and τ, the net scantlings are to be used.

S21.3.2 Effective cross-sectional area of panel flanges for primary supporting members

The effective flange area A_f, in cm^2, of the attached plating, to be considered for the yielding and buckling checks of primary supporting members, when calculated by means of a beam or grillage model, is obtained as the sum of the effective flange areas of each side of the girder web as appropriate:

$$A_F = \sum_{nf} \left(10 b_{ef} t\right)$$

where:

nf = 2 if attached plate flange extends on both sides of girder web
= 1 if attached plate flange extends on one side of girder web only

t = net thickness of considered attached plate, in mm

b_{ef} = effective breadth, in m, of attached plate flange on each side of girder web
= b_p, but not to be taken greater than 0.165ℓ

b_p = half distance, in m, between the considered primary supporting member and the adjacent one

ℓ = span, in m, of primary supporting members

S21.3.3 Local net plate thickness

The local net plate thickness t, in mm, of the hatch cover top plating is not to be less than:

$$t = F_p 15.8 s \sqrt{\frac{p}{0.95\sigma_F}}$$

but to be not less than 1% of the spacing of the stiffener or 6 mm if that be greater.

where:

S21
(cont)

F_p = factor for combined membrane and bending response
= 1.50 in general
= 1.90 σ/σ_a, for $\sigma/\sigma_a \geq 0.8$, for the attached plate flange of primary supporting members

s = stiffener spacing, in m

p = pressure, in kN/m^2, as defined in S21.2

σ = as defined in S21.3.5

σ_a = as defined in S21.3.1.

S21.3.4 Net scantlings of secondary stiffeners

The required minimum section modulus, Z, in cm^3, of secondary stiffeners of the hatch cover top plate, based on stiffener net member thickness, are given by:

$$Z = \frac{1000\ell^2 sp}{12\sigma_a}$$

where:

ℓ = secondary stiffener span, in m, to be taken as the spacing, in m, of primary supporting members or the distance between a primary supporting member and the edge support, as applicable. When brackets are fitted at both ends of all secondary stiffener spans, the secondary stiffener span may be reduced by an amount equal to 2/3 of the minimum brackets arm length, but not greater than 10% of the gross span, for each bracket.

s = secondary stiffener spacing, in m

p = pressure, in kN/m^2, as defined in S21.2

σ_a = as defined in S21.3.1.

The net section modulus of the secondary stiffeners is to be determined based on an attached plate width assumed equal to the stiffener spacing.

S21.3.5 Net scantlings of primary supporting members

The section modulus and web thickness of primary supporting members, based on member net thickness, are to be such that the normal stress σ in both flanges and the shear stress τ, in the web, do not exceed the allowable values σ_a and τ_a, respectively, defined in S21.3.1.

The breadth of the primary supporting member flange is to be not less than 40% of their depth for laterally unsupported spans greater than 3.0 m. Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

The flange outstand is not to exceed 15 times the flange thickness.

S21
(cont)

S21.3.6 Critical buckling stress check

S21.3.6.1 Hatch cover plating

The compressive stress σ in the hatch cover plate panels, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, is not to exceed 0.8 times the critical buckling stress σ_{C1}, to be evaluated as defined below:

$$\sigma_{C1} = \sigma_{E1} \qquad \text{when } \sigma_{E1} \le \frac{\sigma_F}{2}$$

$$= \sigma_F \left[1 - \sigma_F / \left(4\sigma_{E1}\right)\right] \qquad \text{when } \sigma_{E1} > \frac{\sigma_F}{2}$$

where:

σ_F = minimum upper yield stress, in N/mm^2, of the material

$$\sigma_{E1} = 3.6E\left(\frac{t}{1000s}\right)^2$$

E = modulus of elasticity, in N/mm^2
  = 2.06 x 10^5 for steel

t = net thickness, in mm, of plate panel

s = spacing, in m, of secondary stiffeners

The mean compressive stress σ in each of the hatch cover plate panels, induced by the bending of primary supporting members perpendicular to the direction of secondary stiffeners, is not to exceed 0.8 times the critical buckling stress σ_{C2}, to be evaluated as defined below:

$$\sigma_{C2} = \sigma_{E2} \qquad \text{when } \sigma_{E2} \le \frac{\sigma_F}{2}$$

$$= \sigma_F \left[1 - \sigma_F / \left(4\sigma_{E2}\right)\right] \qquad \text{when } \sigma_{E2} > \frac{\sigma_F}{2}$$

where:

σ_F = minimum upper yield stress, in N/mm^2, of the material

$$\sigma_{E2} = 0.9mE\left(\frac{t}{1000s_s}\right)^2$$

$$m = c\left[1 + \left(\frac{s_s}{\ell_s}\right)^2\right]^2 \frac{2.1}{\psi + 1.1}$$

E = modulus of elasticity, in N/mm^2
  = 2.06 x 10^5 for steel

S21
(cont)

t = net thickness, in mm, of plate panel

s_s = length, in m, of the shorter side of the plate panel

ℓ_s = length, in m, of the longer side of the plate panel

ψ = ratio between smallest and largest compressive stress

c = 1.3 when plating is stiffened by primary supporting members

c = 1.21 when plating is stiffened by secondary stiffeners of angle or T type

c = 1.1 when plating is stiffened by secondary stiffeners of bulb type

c = 1.05 when plating is stiffened by flat bar

The biaxial compressive stress in the hatch cover panels, when calculated by means of FEM shell element model, is to be in accordance with each classification society's rule as deemed equivalent to the above criteria.

S21.3.6.2 Hatch cover secondary stiffeners

The compressive stress σ in the top flange of secondary stiffeners, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, is not to exceed 0.8 times the critical buckling stress σ_{CS}, to be evaluated as defined below:

$$\sigma_{CS} = \sigma_{ES} \qquad \text{when } \sigma_{ES} \le \frac{\sigma_F}{2}$$

$$= \sigma_F \left[1 - \sigma_F / \left(4\sigma_{ES}\right)\right] \qquad \text{when } \sigma_{ES} > \frac{\sigma_F}{2}$$

where:

σ_F = minimum upper yield stress, in N/mm^2, of the material

σ_{ES} = ideal elastic buckling stress, in N/mm^2, of the secondary stiffener,
= minimum between σ_{E3} and σ_{E4}

$$\sigma_{E3} = \frac{0.001 E I_a}{A \ell^2}$$

E = modulus of elasticity, in N/mm^2
= 2.06 x 10^5 for steel

I_a = moment of inertia, in cm^4, of the secondary stiffener, including a top flange equal to the spacing of secondary stiffeners

A = cross-sectional area, in cm^2, of the secondary stiffener, including a top flange equal to the spacing of secondary stiffeners

ℓ = span, in m, of the secondary stiffener

S21
(cont)

$$\sigma_{E4} = \frac{\pi^2 E I_w}{10^4 I_p \ell^2}\left(m^2 + \frac{K}{m^2}\right) + 0.385E\frac{I_t}{I_p}$$

$$K = \frac{C\ell^4}{\pi^4 E I_w}10^6$$

m = number of half waves, given by the following table:

	0 < K < 4	4 < K < 36	36 < K < 144	$(m-1)^2m^2 < K \le m^2(m+1)^2$
m	1	2	3	m

I_w = sectorial moment of inertia, in cm^6, of the secondary stiffener about its connection with the plating

$= \frac{h_w^3 t_w^3}{36}10^{-6}$ for flat bar secondary stiffeners

$= \frac{t_f b_f^3 h_w^2}{12}10^{-6}$ for "Tee" secondary stiffeners

$= \frac{b_f^3 h_w^2}{12(b_f + h_w)^2}\left[t_f\left(b_f^2 + 2b_f h_w + 4h_w^2\right) + 3t_w b_f h_w\right]10^{-6}$ for angles and bulb secondary stiffeners

I_p = polar moment of inertia, in cm^4, of the secondary stiffener about its connection with the plating

$= \frac{h_w^3 t_w}{3}10^{-4}$ for flat bar secondary stiffeners

$= \left(\frac{h_w^3 t_w}{3} + h_w^2 b_f t_f\right)10^{-4}$ for flanged secondary stiffeners

I_t = St Venant's moment of inertia, in cm^4, of the secondary stiffener without top flange

$= \frac{h_w t_w^3}{3}10^{-4}$ for flat bar secondary stiffeners

$= \frac{1}{3}\left[h_w t_w^3 + b_f t_f^3\left(1 - 0.63\frac{t_f}{b_f}\right)\right]10^{-4}$ for flanged secondary stiffeners

h_w, t_w = height and net thickness, in mm, of the secondary stiffener, respectively

b_f, t_f = width and net thickness, in mm, of the secondary stiffener bottom flange, respectively

s = spacing, in m, of secondary stiffeners

C = spring stiffness exerted by the hatch cover top plating $= \frac{k_p E t_p^3}{3s\left(1 + \frac{1.33 k_p h_w t_p^3}{1000 s t_w^3}\right)}10^{-3}$

S21
(cont)

$k_p = 1 - \eta_p$ to be taken not less than zero;
for flanged secondary sitffeners, k_p need not be taken less than 0.1

$$\eta_p = \frac{\sigma}{\sigma_{E1}}$$

σ = as defined in S21.3.5

σ_{E1} = as defined in S21.3.6.1

t_p = net thickness, in mm, of the hatch cover plate panel.

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/t_W is to be not greater than $15k^{0.5}$, where:

h, t_W = height and net thickness of the stiffener, respectively

k = $235/\sigma_F$

σ_F = minimum upper yield stress, in N/mm^2, of the material.

S21.3.6.3 Web panels of hatch cover primary supporting members

This check is to be carried out for the web panels of primary supporting members, formed by web stiffeners or by the crossing with other primary supporting members, the face plate (or the bottom cover plate) or the attached top cover plate.

The shear stress τ in the hatch cover primary supporting members web panels is not to exceed 0.8 times the critical buckling stress τ_C , to be evaluated as defined below:

$$\tau_C = \tau_E \qquad \text{when } \tau_E \le \frac{\tau_F}{2}$$

$$= \tau_F\left[1 - \tau_F/(4\tau_E)\right] \qquad \text{when } \tau_E > \frac{\tau_F}{2}$$

where:

σ_F = minimum upper yield stress, in N/mm^2, of the material

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

$$\tau_E = 0.9 k_t E \left[\frac{t_{pr,n}}{1000d}\right]^2$$

E = modulus of elasticity, in N/mm^2
= 2.06×10^5 for steel

$t_{pr,n}$ = net thickness, in mm, of primary supporting member

k_t = $5.35 + 4.0 / (a / d)^2$

S21
(cont)

a = greater dimension, in m, of web panel of primary supporting member

d = smaller dimension, in m, of web panel of primary supporting member

For primary supporting members parallel to the direction of secondary stiffeners, the actual dimensions of the panels are to be considered.

For primary supporting members perpendicular to the direction of secondary stiffeners or for hatch covers built without secondary stiffeners, a presumed square panel of dimension d is to be taken for the determination of the stress τ_C. In such a case, the average shear stress τ between the values calculated at the ends of this panel is to be considered.

S21.3.7 Deflection limit and connections between hatch cover panels

Load bearing connections between the hatch cover panels are to be fitted with the purpose of restricting the relative vertical displacements.

The vertical deflection of primary supporting members is to be not more than 0.0056ℓ, where ℓ is the greatest span of primary supporting members.

S21.4 Hatch coamings and local details

S21.4.1 Load model

The pressure p_{coam}, in kN/m^2, on the No. 1 forward transverse hatch coaming is given by:

p_{coam} = 220, when a forecastle is fitted in accordance with UR S28
= 290 in the other cases

The pressure p_{coam}, in kN/m^2, on the other coamings is given by:

p_{coam} = 220

S21.4.2 Local net plate thickness

The local net plate thickness t, in mm, of the hatch coaming plating is given by:

$$t = 14.9s\sqrt{\frac{p_{coam}}{\sigma_{a,coam}}S_{coam}}$$

where:

s = secondary stiffener spacing, in m

p_{coam} = pressure, in kN/m^2, as defined in S21.4.1

S_{coam} = safety factor to be taken equal to 1.15

$\sigma_{a,coam}$ = 0.95 σ_F

The local net plate thickness is to be not less than 9.5 mm.

S21
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S21.4.3 Net scantlings of longitudinal and transverse secondary stiffeners

The required section modulus Z, in cm^3, of the longitudinal or transverse secondary stiffeners of the hatch coamings, based on net member thickness, is given by:

$$Z = \frac{1000 S_{coam} \ell^2 s p_{coam}}{m c_p \sigma_{a,coam}}$$

where:

m = 16 in general
= 12 for the end spans of stiffeners sniped at the coaming corners

S_{coam} = safety factor to be taken equal to 1.15

ℓ = span, in m, of secondary stiffeners

s = spacing, in m, of secondary stiffeners

p_{coam} = pressure in kN/m^2 as defined in S21.4.1

c_p = ratio of the plastic section modulus to the elastic section modulus of the secondary stiffeners with an attached plate breadth, in mm, equal to 40 t, where t is the plate net thickness
= 1.16 in the absence of more precise evaluation

$\sigma_{a,coam}$ = 0.95 σ_F

S21.4.4 Net scantlings of coaming stays

The required minimum section modulus, Z, in cm^3, and web thickness, t_w, in mm of coamings stays designed as beams with flange connected to the deck or sniped and fitted with a bracket (see Figures 1 and 2) at their connection with the deck, based on member net thickness,are given by:

$$Z = \frac{1000 H_C^2 s p_{coam}}{2 \sigma_{a,coam}}$$

$$t_w = \frac{1000 H_C s p_{coam}}{h \tau_{a,coam}}$$

H_C = stay height, in m

s = stay spacing, in m

h = stay depth, in mm, at the connection with the deck

p_{coam} = pressure, in kN/m^2, as defined in S21.4.1

$\sigma_{a,coam}$ = 0.95 σ_F

$\tau_{a,coam}$ = 0.5 σ_F

S21 (cont)

For calculating the section modulus of coaming stays, their face plate area is to be taken into account only when it is welded with full penetration welds to the deck plating and adequate underdeck structure is fitted to support the stresses transmitted by it.

For other designs of coaming stays, such as, for examples, those shown in Figures 3 and 4, the stress levels in S21.3.1 apply and are to be checked at the highest stressed locations.

S21.4.5 Local details

The design of local details is to comply with the Society requirement for the purpose of transferring the pressures on the hatch covers to the hatch coamings and, through them, to the deck structures below. Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

Underdeck structures are to be checked against the load transmitted by the stays, adopting the same allowable stresses specified in S21.4.4.

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

Double continuous welding is to be adopted for the connections of stay webs with deck plating and the weld throat is to be not less than 0.44 t_W, where t_W is the gross thickness of the stay web.

Toes of stay webs are to be connected to the deck plating with deep penetration double bevel welds extending over a distance not less than 15% of the stay width.

S21.5 Closing arrangements

S21.5.1 Securing devices

The strength of securing devices is to comply with the following requirements:

Panel hatch covers are to be secured by appropriate devices (bolts, wedges or similar) suitably spaced alongside the coamings and between cover elements.

Arrangement and spacing are to be determined with due attention to the effectiveness for weather-tightness, depending upon the type and the size of the hatch cover, as well as on the stiffness of the cover edges between the securing devices.

The net sectional area of each securing device is not to be less than:

$A = 1.4\ a / f\ (cm^2)$

where:

a = spacing in m of securing devices, not being taken less than 2 m

f = $(\sigma_Y / 235)^e$

σ_Y = specified minimum upper yield stress in N/mm^2 of the steel used for fabrication, not to be taken greater than 70% of the ultimate tensile strength.

S21
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e = 0.75 for $\sigma_Y > 235$
= 1.0 for $\sigma_Y \leq 235$

Rods or bolts are to have a net diameter not less than 19 mm for hatchways exceeding 5 m^2 in area.

Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weathertightness is to be maintained by the securing devices.

For packing line pressures exceeding 5 N/mm, the cross section area is to be increased in direct proportion. The packing line pressure is to be specified.

The cover edge stiffness is to be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia, I, of edge elements is not to be less than:

$I = 6pa^4$ (cm^4)

p = packing line pressure in N/mm, minimum 5 N/mm.

a = spacing in m of securing devices.

Securing devices are to be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

Where hydraulic cleating is adopted, a positive means is to be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

S21.5.2 Stoppers

Hatch covers are to be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 kN/m^2.

With the exclusion of No.1 hatch cover, hatch covers are to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 kN/m^2.

No. 1 hatch cover is to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 230 kN/m^2.

This pressure may be reduced to 175 kN/m^2 when a forecastle is fitted in accordance with UR S28.

The equivalent stress:

i. in stoppers and their supporting structures, and

ii. calculated in the throat of the stopper welds

is not to exceed the allowable value of 0.8 σ_Y.

S21
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S21.5.3 Materials and welding

Stoppers or securing devices are to be manufactured of materials, including welding electrodes, meeting relevant IACS requirements.

S21.6 Corrosion addition and steel renewal

S21.6.1 Hatch covers

For all the structure (plating and secondary stiffeners) of single skin hatch covers, the corrosion addition t_s is to be 2.0 mm.

For double skin hatch covers, the corrosion addition is to be:

- 2.0 mm for the top and bottom plating
- 1.5 mm for the internal structures.

For single skin hatch covers and for the plating of double skin hatch covers, steel renewal is required where the gauged thickness is less than t_{net} + 0.5 mm. 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. Coating is to be maintained in GOOD condition, as defined in UR Z10.2.1.2.

For the internal structure of double skin hatch covers, thickness gauging is required when plating renewal is to be carried out or when this is deemed necessary, at the discretion of the Society Surveyor, on the basis of the plating corrosion or deformation condition. In these cases, steel renewal for the internal structures is required where the gauged thickness is less than t_{net}.

S21.6.2 Hatch coamings

For the structure of hatch coamings and coaming stays, the corrosion addition t_s is to be 1.5 mm.

Steel renewal is required where the gauged thickness is less than t_{net} + 0.5 mm. 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. Coating is to be maintained in GOOD condition, as defined in UR Z10.2.1.2.

S21
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Figure 1

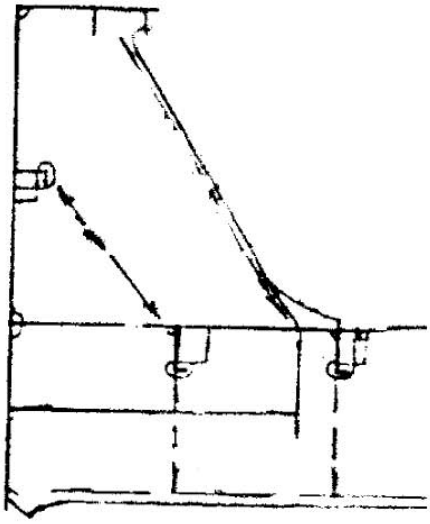


Figure 2

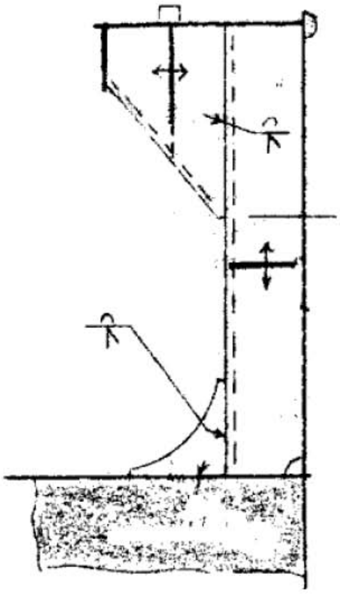


Figure 3

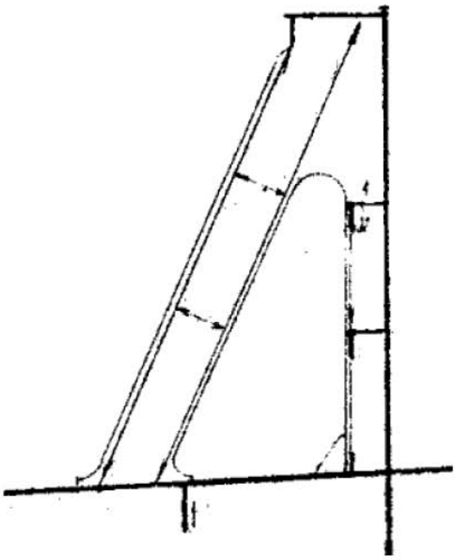
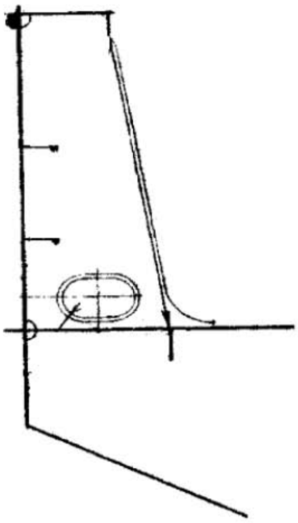


Figure 4



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